THE BIOLOGY OF CHAETOGNATHA IN THE BERING SEA
AND THE NORTHERN NORTH PACIFIC OCEAN,
WITH EMPHASIS ON SAGITTA ELEGANS*

Moriyuki Kotori**

Faculty of Fisheries, Hokkaido University, Hakodate, Japan

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introduction</td>
<td>96</td>
</tr>
<tr>
<td>II. Previous work</td>
<td>97</td>
</tr>
<tr>
<td>III. Distribution and abundance of chaetognaths in the Bering Sea and the northern North Pacific Ocean</td>
<td>99</td>
</tr>
<tr>
<td>1. Materials and methods</td>
<td>100</td>
</tr>
<tr>
<td>2. Temperature and salinity distribution in the epipelagic domain</td>
<td>103</td>
</tr>
<tr>
<td>3. Vertical section of temperature, salinity and dissolved oxygen content from Lat. 35°N to 50°N on the line of Long. 155°W.</td>
<td>105</td>
</tr>
<tr>
<td>4. Results and discussion</td>
<td>108</td>
</tr>
<tr>
<td>(1) Chaetognath species in the area</td>
<td>108</td>
</tr>
<tr>
<td>(2) Areal distribution of chaetognaths</td>
<td>110</td>
</tr>
<tr>
<td>(3) Areal variation in the abundance of the chaetognath biomass</td>
<td>114</td>
</tr>
<tr>
<td>(4) Vertical distribution of chaetognaths</td>
<td>115</td>
</tr>
<tr>
<td>(5) Diel vertical migration of Sagitta elegans</td>
<td>121</td>
</tr>
<tr>
<td>(6) Vertical variation in the abundance of the total population of chaetognaths</td>
<td>121</td>
</tr>
<tr>
<td>(7) Possible factors controlling the distribution of chaetognath species</td>
<td>123</td>
</tr>
<tr>
<td>IV. On the biology of Sagitta elegans Verrill</td>
<td>127</td>
</tr>
<tr>
<td>1. Materials and methods</td>
<td>127</td>
</tr>
<tr>
<td>2. Results and discussion</td>
<td>130</td>
</tr>
<tr>
<td>(1) Developmental processes of Sagitta elegans through its life span</td>
<td>130</td>
</tr>
<tr>
<td>(2) Respiration</td>
<td>138</td>
</tr>
<tr>
<td>(3) Metabolants</td>
<td>139</td>
</tr>
<tr>
<td>(4) Relationship between body-dry weight and body length</td>
<td>141</td>
</tr>
<tr>
<td>(5) Conversion from wet weight to the amount of carbon in the mixed species of zooplankton in the subarctic seas</td>
<td>141</td>
</tr>
<tr>
<td>V. Ecological importance of a chaetognath community in the Bering Sea</td>
<td>142</td>
</tr>
<tr>
<td>VI. Summary</td>
<td>147</td>
</tr>
<tr>
<td>VII. Acknowledgments</td>
<td>149</td>
</tr>
<tr>
<td>References</td>
<td>150</td>
</tr>
<tr>
<td>Explanation of Plate I</td>
<td>156</td>
</tr>
<tr>
<td>Appendix</td>
<td>157</td>
</tr>
</tbody>
</table>

* This work was submitted in partial fulfillment of the requirements for the degree of Doctor of Fisheries Science at Hokkaido University in 1973.
** Present address: Hokkaido Central Fisheries Experimental Station, Yoichi, Hokkaido 046, Japan.
I. Introduction

Chaetognaths (Phylum Chaetognatha) are carnivorous marine zooplankton which have a practically world-wide distribution. About 60 species have been reported from the world oceans (Tokioka, 1965a; Alvarino, 1967b). Most of them are known to be useful as an index of the character or origin of the water masses in the sea (Huntsman, 1919; Russell, 1932b; Tokioka, 1940a, 1959; Sund, 1959a; Bieri, 1959; LeBrasseur, 1959; Kitou, 1966a; Marumo, 1966; Kotori and Hara, 1972, etc.). The body of the fully matured animals is elongated torpedo-like in shape, with head, trunk, and tail regions. They dart about, like arrows in the water, so that they are commonly called arrow worms, and the principal genus of the animals is named Sagitta (L., arrow). Almost all living chaetognaths are transparent, and some of the species become opaque when they are fixed with formalin-seawater. Being transparent, they are also called glass worms. The phylum name refers to the bristles (hooks) about the mouth (Gr., chaeton, bristle; gnathos, jaws).

All species belonging to this phylum are hermaphrodites which possess not only ovaries on their trunk but also testes on the tail region. Chaetognaths are euplanktonic animals except the species referring to the genus Spadella which lives in shallow neritic waters, often clinging to rocks and algae by adhesive papillae near the tail (John, 1933). The size of the matured chaetognaths varies with the species from about 5 to over 90 mm long (Tokioka, 1940a; David, 1955; Alvarino, 1962), so that the animal group belongs to macroplankton in the marine environment. Chaetognaths are ordinarily second in abundance to copepods in offshore seas (Ryther, 1969; Reeve, 1970a). The biomass of chaetognaths compared to the total mass of zooplankton, in wet weight, occupies approximately 10% in the oceanic waters averaging from epipelagic to bathypelagic domains in the northern North Pacific Ocean and the Bering Sea in summer (Kotori, 1972). In the upper 500 m in the Sargasso Sea near Bermuda, the fraction is about 15% of the total zooplankton weight (Menzel and Ryther, 1961 Ms., cited from Beers, 1964). Furthermore, observations on the nature of the food of chaetognaths based on gut contents of preserved or freshly-caught material indicated that they were voracious carnivores. They have most frequently been observed to take copepods, as well as euphausiids, amphipods, fish larvae and other prey animals (Lebour, 1922, 1923; David, 1955; Murakami, 1959; Della Croce, 1963; Reeve, 1970a; Takano, 1971; Reeve and Walter, 1972; Nagasawa and Marumo, 1972; Pearre, 1973). On the other hand, chaetognaths are known to be prey organisms for some fishes and other carnivores (David, 1955; Wickstead, 1962; Inoue et al., 1967; Rakusa-Suszczewski, 1968; Angel, 1970; Kubota, 1971; Takeuchi, 1972; Sekiguchi et al., 1974). Therefore, chaetognaths should be situated ecologically between the secondary and higher trophic levels in the food webs of the sea.

In the present studies some biological aspects of chaetognaths in the Bering Sea and the northern North Pacific Ocean were investigated in an attempt to ascertain the hypothesis that the chaetognaths are situated ecologically between
the secondary and higher trophic levels, playing an important rôle in the food webs in the sea: in the first place the areal and vertical distribution of chaetognath species in the actual area in summer was observed quantitatively, and the relationship between the distribution and its limiting factors was discussed; secondarily the developmental processes of *Sagitta elegans* Verrill, which were suggested to be the most dominant chaetognath in the upper 150 m deep in the present area, were examined, and the rates of respiration in this species were determined; and finally the rôle played by a chaetognath community in the upper 150 m deep was discussed, our study being based on the calculation of carbon requirement of the community in the Bering Sea in summer.

II. Previous work

Until today chaetognaths have been considered to be taxonomically similar to the cases of the other zooplankton groups. Regular taxonomical studies on chaetognaths were started in the latter part of the nineteenth century. In Japan, Aida (1897) examined chaetognaths and reported 12 chaetognath species from the materials collected in Misaki Harbor. The monographic work by Ritter-Zihony (1911) may be regarded as the base for the taxonomy of this phylum which has been accepted so far. Other important and well-known contributors to the taxonomy of the animal group may be listed as follows: Fowler (1905, 1906), Michael (1911), Huntsman (1919), Grey (1930), Thiel (1938), Tokioka (1939, 1940a, b, 1957, 1959, 1965a, b), Lea (1955), David (1958), Sund (1959a, b), Alvarino (1962, 1967b), Kitou (1966c), Marumo and Kitou (1966), Dawson (1968), Park (1970), and so forth. However, the affinities of this phylum and the phylogenetic position of the chaetognath species are still obscure. Tokioka (1965b) suggested that the position and length of corona ciliata and the relative length of the tail region will be keys to the discussion on the phylogeny of chaetognath species. Ghirardelli (1968) suggested that chaetognaths have similarities in morphological characteristics to annelids and nematodes rather than to other animal groups, although the morphological differences among these phyla are not less important for us to determine the affinities of chaetognaths.

One of the main objects of the plankton studies is to disclose the principles which underlie the distribution of the oceanic organisms. One method of approaching the problems is to work out as fully as possible the zoogeographical distribution of a number of species. Fowler (1906) is one of the representative investigators who actively engaged in the zoogeography of chaetognaths in the first two decades of our own century. He described, not only taxonomically but also zoogeographically, 10 species referring to 3 genera of chaetognaths from the samples collected during the Siboga cruise to the North Pacific Ocean, the South Pacific Ocean, and the Indian Ocean. Huntsman (1919) observed the vertical and horizontal distribution of 10 species of the animal group collected off the Canadian Eastern Coast in the North Atlantic Ocean. He pointed out that chaetognaths were very prominent in the zooplankton catches, sometimes forming more than half of the entire catch, and that their distribution would depend upon temperature,
salinity, light, oxygen, currents, and food. Michael (1911) investigated the vertical distribution of chaetognath species off San Diego in the North Pacific Ocean. He (1919) also examined the distribution of the animal group collected in the western North Pacific Ocean during the Philippine Expedition by the U.S. Steamer "Albatross."

It appears quite reasonable that such contributions to the zoogeography on chaetognaths, as described above, aroused deeper interest in the study on the animal group during the twenties and thirties of this century: Lebour (1922, 1923) examined the food of plankton organisms including chaetognaths; Russell (1932a, b, 1933a, b) rigidly investigated the breeding, growth, and natural history of *Sagitta elegans* and *S. setosa* in the Plymouth area; and Thiel (1938) made such accurate and extensive observations on the distribution of chaetognaths and water temperature in the Atlantic Ocean as that he found that *Eukrohnia hamata* is to be a cold-water cosmopolite occurring frequently in the high-arctic part of the Norwegian Sea, off northwestern Greenland and Spitsbergen, commonly in low arctic, temperate, and tropical latitudes in the Atlantic, although in small numbers, in deeper water, and abundantly again south of the tropical zone with the maximum in shallow water. This becomes the accepted theory as to the cause of other cold-water zooplankton migration to the deep water in low latitudes.

Accordingly, the biological studies on chaetognaths were diversified into several fields dealing with life history of a species, the relationship between the distribution of the species and its environmental factors, abundance, food habits, and other behavior of the animal: Parry (1944) anatomically investigated the function of the gut of *Spadella cephaloptera* and *Sagitta setosa*; David (1955) reported such biological problems as distribution, life history, and gut contents of *S. gazdlae*; Murakami (1959, 1966) was first to rear *Sagitta crassa* successfully in the laboratory for as long as three months in maximum to examine its endurance to changing temperature and chlorinity, developments in the early stages of its life span, and so on; Owre (1960) studied the relative abundance of species, the seasonal variation in abundance and the vertical distribution, and the breeding periods of chaetognaths collected off Miami in the Atlantic Ocean; Dunbar (1962) indicated that *S. elegans arctica* Aurivillius, a cold-water variant of *S. elegans* Verrill, of the Canadian eastern Arctic water has a life span of two years; the predator relationship in the plankton community through chaetognaths were qualitatively observed by Della Croce (1963), who illustrated *Sagitta* attacking copepods, thaliaceans and chaetognaths, or being attacked by a copepod *Candacia*; Sherman and Schaner (1968) suggested that *Sagitta elegans* breeds once annually in the coastal waters of the Gulf of Maine facing the northern North Atlantic Ocean; and experiments made by Horridge (1966) and Horridge and Boulton (1967) in *Spadella cephaloptera* showed an accurate feeding movement toward any source vibrating at 9–20 Hz with an amplitude of 100–500 μm at a distance of 1–3 mm.

The scientific knowledge on the distribution and abundance of chaetognaths has been largely accumulated by several workers especially after the fifties. For instance, Chindonova (1955) observed the vertical distribution of 7 chaetognath species including *Heterokrohnia mirabilis*, which had been supposed to be endemic
in the Antarctic Ocean, by hauls to depths of 6,000 m. David (1958) showed that the maximum concentrations of the five most common species of *Sagitta* are either vertically or horizontally separated in the Antarctic Ocean. Bieri (1959) clearly indicated the geographic extents of 27 species of chaetognaths in the Pacific Ocean in relation to the water masses. Tokioka (1959) also made such careful taxonomical observations on the animal group collected in the North Pacific Ocean and adjacent seas as to discuss the relationship between zoogeographical distribution of the species and the water masses. Dawson (1968) observed 4 species of chaetognaths in the Arctic Ocean and found the seasonal changes in the vertical distribution of the maturity stages of *Eukrohnia hamata*. The vertical distribution of chaetognaths in the Pacific Ocean was also laboriously studied by Furuhashi (1953, 1961), Hida and King (1955), Marumo et al. (1958), Alvarino (1962, 1964, 1967a), Kitou (1963, 1966a, b, c, d, 1967a), Vinogradov (1968), Kotori (1969, 1972), Tagetti (1972), and so forth, after the fifties.

These contributions to the biology of chaetognaths described above have given the animal group a position of primary carnivores, respecting its world-wide distribution, abundance, and food habits, among the marine macrozooplankton. This awoke so much interest among the marine ecologists that they began the study of feeding, respiration, excretion, nutrition, chemical composition of the body, and reproduction of the animals to determine the rôle played by chaetognaths in the marine environment by means of rearing them in the laboratory (Murakami, 1959, 1966; Beers, 1964, 1966; Reeve, 1964, 1966, 1970a, b; Reeve et al., 1970; Ikeda, 1970, 1972, 1974; Takano, 1971; Reeve and Walter, 1972; Sameoto, 1971, 1972; Pearre, 1973; Cosper and Reeve, 1975; Reeve et al. 1975; Kotori, 1975a, b; Reeve and Cosper, in press).

The biology of chaetognaths was reviewed by Ghirardelli (1968), who gave special attention to the biology of reproduction and to some organs and functions that had not been previously studied. A review on studies of chaetognaths in general, up to the early sixties, was also presented by Alvarino (1965).

III. Distribution and abundance of chaetognaths in the Bering Sea and the northern North Pacific Ocean

The distribution of chaetognaths in the Bering Sea and the northern North Pacific Ocean was investigated by several workers (Chindonova, 1955; Lea, 1955; Marumo et al., 1958; Sund, 1959a; LeBrasseur, 1959; Bieri, 1959; Tokioka, 1959; Alvarino, 1962, 1964; Kitou, 1966d, 1967a, b; Kotori, 1969, 1972; Kotori and Hara, 1972). However, more detailed observations for many samples collected through the vast areas of the seas are needed in order to make clear the distribution and abundance of chaetognaths in whole parts and depths of the Bering Sea and in the northern North Pacific Ocean.

A large number of zooplankton samples were collected by vertical hauls of 0 to 150-m with Norpac nets during the cruises of the T.S. “Oshoro Maru,” Hokkaido University, to the Bering Sea and the northern North Pacific Ocean every summer since 1955. In addition, samples were accumulated by simultaneous
horizontal tows with several closing nets.

This chapter deals with more detailed and comparable information on the abundance of chaetognaths and their areal and vertical distribution in the actual area to relate their environment.

1. Materials and methods

_Cruises and stations_: The twelve sea trips during which the present samples were obtained include 3 cruises of the T.S. “Oshoro Maru II” of the Faculty of Fisheries, Hokkaido University, in 1957, 1959 and 1960, one cruise of her successor the T.S. “Oshoro Maru III” in 1968, and one cruise of the R.V. “Hakuhō Maru” of the Ocean Research Institute, University of Tokyo in 1969. During the four “Oshoro Maru” cruises, zooplankton samples were collected with a North Pacific standard net (Norpac net, 45-cm mouth diameter, 180-cm side length, Motoda, 1957, 1961) at a total of 168 stations distributed over almost the whole area of the Bering Sea and the northern North Pacific Ocean, and during the “Hakuhō Maru”

Table 1. _Areas, number of stations at which plankton sampling was carried out, and related data on the cruises of T.S. “Oshoro Maru” of Hokkaido University and R.V. “Hakuhō Maru” of the University of Tokyo in the Bering Sea and northern North Pacific Ocean._

<table>
<thead>
<tr>
<th>Vessel, cruise number</th>
<th>Area</th>
<th>Number of station</th>
<th>Period</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North Pacific</td>
<td>17</td>
<td>June-July, 1959</td>
<td>Fac. Fish., Hokkaido Univ., 1960</td>
</tr>
<tr>
<td></td>
<td>Western parts of the Bering Sea</td>
<td>6</td>
<td>June, 1960</td>
<td>Fac. Fish., Hokkaido Univ., 1961</td>
</tr>
<tr>
<td></td>
<td>Northwestern North Pacific</td>
<td>10</td>
<td>June, 1960</td>
<td>Fac. Fish., Hokkaido Univ., 1961</td>
</tr>
<tr>
<td></td>
<td>Western parts of the Bering Sea</td>
<td>10</td>
<td>June, 1960</td>
<td>Fac. Fish., Hokkaido Univ., 1961</td>
</tr>
<tr>
<td></td>
<td>South of Aleutian Islands</td>
<td>10</td>
<td>June, 1960</td>
<td>Fac. Fish., Hokkaido Univ., 1961</td>
</tr>
<tr>
<td></td>
<td>Gulf of Alaska</td>
<td>7</td>
<td>July, 1960</td>
<td>Fac. Fish., Hokkaido Univ., 1961</td>
</tr>
<tr>
<td></td>
<td>Off the southern coast of Alaska</td>
<td>8</td>
<td>July, 1968</td>
<td>Fac. Fish., Hokkaido Univ., 1969</td>
</tr>
</tbody>
</table>
cruise, samples were obtained by simultaneous horizontal tows with nine or ten closing nets (MTD 56-cm net, Motoda, 1969) distributed from the surface to a depth of about 700 m at 4 stations in the northern North Pacific Ocean (Table 1).

Norpac net samples: One sample was collected at each station, and is shown in Appendix IA and Fig. 1, so a total of 168 Norpac net samples was collected and used in the present study. The samples were obtained mostly by vertical hauls, from a depth of 150 m to the surface, but sometimes from the near sea bottom to the surface when the bottom was shallower than 150 m.

The nets used in 1957, 1959 and 1960 were made of Japanese silk bolting cloth GG 54 (0.33-mm mesh aperture); those used in 1968 were made of pylen No. 60 (0.35-mm mesh aperture). However, the difference in catch efficiency between bolting silk net and pylen net was found to be insignificant (Morioka, 1965).

All samples were fixed in a 10% neutral formalin sea water solution. The total wet weight of the samples was measured immediately on board after removing large organisms such as shrimps, jellyfish, etc. (Fac. Fish., Hokkaido Univ., 1959, 1960, 1961, 1969). In the laboratory, the chaetognaths were separated. Species were identified and counted under a microscope. Then, the total wet weight of chaetognaths was measured by species. The results are given in Appendix IA-B. A flow meter attached to the center of the mouth ring of the nets recorded the water volume filtered, so that the biomass or individual number of the zooplankton and chaetognaths was expressed as g wet weight/1,000 m$^3$ or individuals/1,000 m$^3$ water filtered.

MTD 56-cm net samples: The samples in the present study were collected at 4 stations (Stas. KH691-KH694, Appendix II and Fig. 1) located on Long. 155° W from Lat. 50° to 35°N on the Cruise KH-69-4 of the "Hakuho Maru" in the northern summer of 1969 (Motoda and Kotori, 1970). Six series of sampling were collected by simultaneous horizontal tows with nine or ten closing nets attached to a single cable. The nets made of pylen No. 60 (0.35-mm mesh aperture) were conical, 56 cm in diameter, 150 cm in side length, and fixed to triangular frames.
The depths of collection were estimated from the wire angle. The volume of water filtered in the hauls was computed from an experimented mean value of 394 m³/hr. Two series of sampling were made at Sta. KH691 during daytime and at night from the 23rd to the 25th of August, 1969; one series at Sta. KH692 during daytime on the 29th of August; two series at Sta. KH693 during daytime and at night from the 31st of August to the 1st of September; and one series at Sta. KH694 during daytime on the 6th September, only a surface sample of which was examined in the present study, as Sta. KH694 was not situated in the Subarctic Water but in the Western North Pacific Central Water (Marumo, 1970 ed.). Accordingly, a total of 46 MTD 56-cm net samples was used in the present study.

The procedure for the samples in the laboratory and the one for the Norpac net samples are much similar, but the species were identified and counted in subsamples obtained by using a plankton splitter (Motoda, 1959), because the amount of a MTD 56-cm net sample is very large.

Data processing: In the present study zooplankton collectings with a Norpac net were all made in the northern summer. However, the samples were not collected in one year but in four different years as mentioned above. Therefore, the author is afraid the comparison of abundance of the animals in the whole area as shown in the present study would be impossible if the yearly variations of abundance of the chaetognaths were larger than the areal variations of abundance in the summer only. Table 2 gives the variabilities and means of chaetognath biomass (g wet weight/1,000 m³) collected at the same locations in the Bering Sea in different months and years. It appears that all of the mean values of biomass collected on the going and returning trips in 1968 and the value in 1960 were not so different. The difference in the mean biomass of chaetognaths in the area between 1960 and 1968 was about 5–10%. However, the values observed individually at stations located even in approximately the same area occupied by a vessel during the period of a few days apparently varies from one to three orders of magnitude (e.g. 3.6–183.8 g wet weight/1,000 m³ through Stas. 682830, 32–37, 39 and 40 from 23 to 26 June 1968, Table 2). Motoda and Anraku (1955), making

<table>
<thead>
<tr>
<th>No. of station</th>
<th>682830, 32–37, 39, 40 (9 stas.)</th>
<th>682860–64 (5 stas.)</th>
<th>604634–40 (7 stas.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>June 23–26, 1968</td>
<td>July 26–27, 1968</td>
<td>July 6–11, 1960</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>3.7–7.5</td>
<td>10.2–12.8</td>
<td>3.7–7.7</td>
</tr>
<tr>
<td>Salinity (%)</td>
<td>31.37–32.03</td>
<td>31.80–32.02</td>
<td>31.56–32.07</td>
</tr>
<tr>
<td>Chaetognath biomass (g/1000 m³)</td>
<td>Range 3.6–183.8</td>
<td>1.9–87.3</td>
<td>17.2–151.0</td>
</tr>
<tr>
<td></td>
<td>Mean 60.3</td>
<td>50.8</td>
<td>65.2</td>
</tr>
</tbody>
</table>

Table 2. Variabilities and means of the chaetognath biomass (g wet weight per 1,000 m³) collected with a Norpac net at the same locations in the Bering Sea in different months and years.
a series of five replicate hauls from a depth of 150 m to the surface with a Standard Marutoku Net (45 cm in mouth diameter, 100 cm in side length, 0.327-mm mesh aperture), pointed out that the percentage of standard deviation of a single observation of the net was 47%, and the 95% fiducial limits are 46% and 217%.

Consequently, the variance in abundance of the samples collected in the present area was expressed by using such major scales as “more than 10,000,” “9,999–5,000,” “4,999–2,000,” “1,999–1,000,” “999–500,” “499–1,” and “0” individuals/1,000 m³, and the minor variances in abundance were neglected so as to illustrate the areal distribution of chaetognaths.

All samples collected by vertical hauls from 150-m depth to the surface with a Norpac net at the daytime and night stations (a total of 168 stations) were compared with each other irrespective of the time of collection because the range of diel vertical migration of *Sagitta elegans*, the predominant chaetognath in the epipelagic domain, is likely to be 0–150 m, and because *Eukrohnia hamata*, the predominant chaetognath in the mesopelagic domain, inhabits most abundantly at a depth of about 200 m and is unlikely to be a diurnal vertical migrant as mentioned later.

2. Temperature and salinity distribution in the epipelagic domain

The oceanographical data such as temperature and salinity collected on the cruises of the “Oshoro Maru II and III” have been published in “Data Record of Oceanographic Observations and Exploratory Fishing,” Nos. 3–5 and 13 (Faculty of Fisheries, Hokkaido University, 1959–1961 and 1969). On the basis of these data the general hydrographic conditions of the area can be identified:

The temperature at the surface in the actual area ranged from 2.8 to 17.8°C. It is impossible to identify the water masses in the area by the surface temperature not only because of the non-simultaneity of the observations but also the irregularity of the seasonal change of the surface temperature every year. The temperature at a depth of 100 m is more stable than the surface one, so that a pattern of the distribution of temperature can be illustrated as shown in Fig. 2, which indicates the discontinuity of temperature between Lat. 40 and 45°N. Namely, from 45 to 40°N, the temperature of the water at a depth of 100 m rapidly ascended from 2 to 5°C in the area off the east coast of Hokkaido toward Long. 150°E, and from 4 to 9°C in the eastern area beyond Long. 150°E from 45 to 40°N. The discontinuity of the water temperature at a depth of 100 m across the North Pacific Ocean along Lat. 40–45°N shown in the present study is likely to be the Polar Front Region. According to Uda (1963), the Polar Front Region lies generally between Lat. 40 and 45°N in the mid part of the North Pacific Ocean.

It is evident that the region from the northern parts of the Bering Sea to the eastern coast of the Kurile Islands through the area off the Kamchatka Peninsula was covered by waters lower than 2°C in temperature at a depth of 100 m. This region apparently coincides with the Western Subarctic Domain previously identified by Dodimead et al. (1963). Further, the southern region off the Aleutian Islands covered by waters lower than 4°C in temperature at a depth of 100
Fig. 2. Distribution of the temperature at the depth of 100 m in the Bering Sea and northern North Pacific Ocean in summer. All the data obtained in 1957, 1959, 1960 and 1968 were combined.
The schematic representation of surface water masses in the Bering Sea and northern North Pacific Ocean presented by Dodimead et al. (1963) is shown in Fig. 3. A pattern of the distribution of surface salinity in the present area can be illustrated, because the salinity is more stable than the temperature. Moreover, the contours of the surface salinity well agree with those at a depth of 100 m in the present area. Therefore, the present area may be divided into the following 3 regions on the basis of surface salinity: Region A covered the area over the continental shelf of the eastern parts of the Bering Sea, the Bay of Olyutorskiy, off the southern coast of Kodyak in Siberia, and the coastal area off Alaska, which were characterized by a salinity lower than 32% at the surface; Region B covered the Bering Sea Gyre, the Western Subarctic Gyre (Dodimead et al., 1963), the regions off the eastern coast of the Kamchatka Peninsula, the Kurile Islands and Hokkaido, on the southern coast of the Aleutian Islands, and the area from Lat. 44 to 54°N between Long. 170 and 175°E, all of which were characterized by a salinity from 32 to 33% at the surface; and Region C included the parts of the northern North Pacific Ocean others than Regions A and B, and being characterized by a salinity higher than 33% at the surface (Fig. 4).

It is suggested that Region B approximately corresponded to the Western Subarctic Domain and the Central Subarctic Domain. In the former Domain the temperature was lower than 2°C and in the latter Domain it was lower than 4°C.

3. Vertical section of temperature, salinity and dissolved oxygen content from Lat. 35°N to 50°N on the line of Long. 155°W

The vertical distribution of temperature, salinity, and dissolved oxygen
Fig. 4. Distribution of the salinity at the surface in the Bering Sea and northern North Pacific Ocean in summer. All the data obtained in 1957, 1959, 1960 and 1968 were combined.

Fig. 5. Distribution of the temperature in a vertical section along long. 155°W from 50°N to 35°N during the summer of 1969.
content at 4 stations (KH691, KH692, KH693 and KH694) are shown in Figs. 5, 6, and 7, respectively. All the data given were obtained during the KH–69–4 Cruise, and have been already published in the "Preliminary Report of the Hakuho Maru Cruise KH–69–4" (Marumo, 1970 ed.). The general hydrographic conditions at these stations were identified mainly on the basis of the temperature-salinity analysis by Marumo et al. (1970) in the "Preliminary Report" as follows: Stas. KH691 and KH692 are positioned in the Pacific Subarctic Water; Sta. KH693 in the mixture of the Pacific Subarctic Water and the Western North Pacific Central Water; and Sta. KH694 in the boundary of the Western North Pacific Central Water and the Equatorial Water. This view is supported in the present study (Fig. 8, cf. Sverdrup et al., 1942). However, the oceanographic characteristics of Stas. KH691 and KH692 in the Subarctic Water somewhat differed from one another: The thermocline was distinct in the shallow thin layer between 30 and 75 m (11.78–3.99°C) at Sta. KH691 but indistinct at Sta. KH692 where the temperature lower than 4°C appeared in the water deeper than 500 m (Fig. 5).
Fig. 7. Distribution of the dissolved oxygen content in a vertical section along long.
155°W from 50°N to 35°N during the summer of 1969.

Between Stas. KH692 and KH693 the surface temperature ascended rapidly from lower than 16°C to higher than 20°C, and so did the surface salinity from lower than 33.00% to higher than 33.50% (Fig. 6). These are also indicative of the existence of the Polar Front Region between Stas. KH692 and KH693. Moreover, it was noted that the high saline water of more than 34.50% was found in the upper 30–m depths at Sta. KH694, while the salinity was less than 34.10% through the whole depths at Sta. KH693.

4. Results and discussion

(1) Chaetognath species in the area

Fig. 8. Temperature-salinity curves at 4 stations where the vertical distribution of chaetognaths was examined.


Seven of these species have their habitat in the Bering Sea: *S. scrippsae*, *S. maxima*, *S. elegans*, *S. macrocephala*, *E. hamata*, *E. bathypelagica*, and *E. fowleri*. They have been listed up already (Chindonova, 1955; Alvarino, 1962; Kotori and Hara, 1972). Only three species, *S. maxima*, *S. elegans* and *E. hamata*, were collected by 0–150 m vertical hauls in the Bering Sea in the present study, while *S. scrippsae*, *S. macrocephala*, *E. bathypelagica* and *E. fowleri* were not collected by the hauls. This may confirm the previous results that *S. macrocephala*, *E. bathypelagica* and *E. fowleri* were distributed in the meso- or bathypelagic layers in the Bering Sea (Alvarino, 1962; Kotori, 1972). *S. scrippsae* was recorded only once from the depths of 335–669 m in the Bering Sea by Kotori and Hara (1972).

In the Subarctic Water of the northern North Pacific Ocean, nine species *S.*

* The asterisked seven species were collected by 0–150 m vertical hauls with a Norpac net during the present research.
lyra, S. scrippsi, S. elegans, S. macrocephala, S. zetesios, S. nagae, S. minima, E. hamata, E. bathypelagica were collected from the depths shallower than 700 m. They are recorded in the present study. The results corresponded to those found by Chindonova (1955) in the Kurile-Kamchatka Trench, by Kitou (1967a) at 42°N 155°E in the northern North Pacific Ocean, and by Kotori (1972) in the Subarctic Water of the Pacific Ocean, although E. fowleri and Heterokrohnia mireabilis were not collected in the present study, because they are known to be bathypelagic chaetognaths living in waters deeper than 1,000 m (Chindonova, 1955; Kitou, 1967a).

(2) Areal distribution of chaetognaths

The areal distribution of 7 species collected by 0–150 m vertical hauls with a Norpac net is considered here (Figs. 9, 10, 11 and 12).

*Sagitta elegans*: This is the most abundant and widely distributed species in the present area: it appeared at 165 stations over a total of 168; it was also the predominant chaetognath at 139 stations in the present observation (Figs. 9 and 10). The maximum abundance (197,000 individuals/1,000 m³) was recorded at Sta. 604640 (58°10'N 164°42'W, Appendix IA-B),* and the average number of individuals was 10,000/1,000 m³ throughout the 168 stations in the present study. Chindonova (1955) suggested, however, that the abundance of *S. elegans* was 500–1,500 individuals/1,000 m³ in the upper 350-m waters in the Kurile-Kamchatka Trench. The discrepancy between the results obtained by Chindonova (1955) and those in the present observation seems to be due to the facts that *S. elegans* is concentrated vertically from 70 to 200 m (Kotori, 1972), and that the present materials were collected by the upper 150-m vertical hauls, while Chindonova's (1955) materials were collected from the upper 350-m waters.

It should be noted that *S. elegans* appeared most abundantly in the eastern part of the Bering Sea: the average individual number of the species was 25,000/1,000 m³ through the 52 stations on the continental shelf in the eastern part of the Bering Sea, that number being more than twice the average individuals throughout

* The present values of the standing stocks of chaetognaths obtained in the waters shallower than 150 m on the continental shelf in the eastern part of the Bering Sea must be somewhat overestimated. Motoda and Minoda (1974) and Motoda (1973) pointed out that the vertical gradient in the zooplankton biomass was sometimes so large that the standing stocks based on different-depth vertical hauls could not be compared. They also suggested that the zooplankton biomass in the upper 80 m corresponded to about 80% of the biomass in the upper 150 m in the Bering Sea. The present high values of the standing stocks obtained on the continental shelf in the eastern part of the Bering Sea are based mainly on the upper 80-m vertical hauls (Appendix IA). Therefore, it may be safe to assume that the rate of overestimation in the present study on the continental shelf would be about 20%. Accordingly, it appears that the feature of the areal distribution presented here is not so distorted by this overestimation as to be abandoned (see also pp. 102–103 in the text). Motoda and Minoda (1974) also found high values of the zooplankton biomass on the continental shelf in the southern parts of the eastern Bering Sea in summer.
Fig. 9. Distribution of *Sagitta elegans* (individuals per 1,000 m³) in the upper 150-m water column in the Bering Sea and northern North Pacific Ocean in summer. All the data obtained in 1957, 1959, 1960 and 1968 were combined.

Fig. 10. Dominant species of chaetognaths in the upper 150 m in the Bering Sea and northern North Pacific Ocean in summer. All the data obtained in 1957, 1959, 1960 and 1968 were combined.

the 168 stations for the present sampling, and more than 8 times the average number of individuals (3,000/1,000 m³) found at 116 stations situated on the other parts of the present area.* *S. elegans* was also distributed abundantly in the area off the eastern coast of Kamchatka, the Kurile Islands, and Hokkaido. However, the species was only scarcely distributed on the southern coast of Alaska, the average number of individuals through Stas. 682851-54, and 56-59 in the area being less than 100/1,000 m³ in the present observation, although Bieri (1959) indicated that *S. elegans* was abundant in the central parts of the Gulf of Alaska. Sund (1959a) recorded that the number of individuals of *S. elegans* was 130-7,540 /1,000 m³ in the Gulf of Alaska in August and September.
In the southern region below the latitude of 50°N, the species diminished rapidly, especially in the eastern sea from the longitude of 165°E, where the influence of the southward current of the Oyashio is not as strong as in the western parts of the North Pacific Ocean (Uda, 1963); the average number of individuals collected through the 15 stations in the area being less than 1,000/1,000 m³ in the present observation. It has been already suggested that *S. elegans* is a typical indicator species for the Subarctic Water in the North Pacific Ocean by several authors, namely Bieri (1959), Tokioka (1959) and Furuhashi (1961). The present results described above also strongly support the view presented by the previous workers (Bieri, 1959; Tokioka, 1959; Furuhashi, 1961).

*Eukrohnia hamata*: It has been already recorded that *E. hamata* is distributed in the large vertical range from the surface to a depth of about 2,000 m with the maximal abundance at 120–270 m in the northern North Pacific Ocean and the Bering Sea in summer (Chindonova, 1955; Kotori, 1972; Kotori and Hara, 1972). As was already pointed out by Lea (1955), who observed some chaetognaths collected in the coastal waters of British Columbia, western Canada, *E. hamata* was next to *S. elegans* in abundance in the upper 150 m in most parts of the present area: *E. hamata* appeared at 121 stations over a total of 168 stations in the present study (Fig. 11), distributed predominantly at 27 stations (Fig. 10). The maximum abundance (14,000 individuals/1,000 m³) was recorded at Sta. 594449 (58°18'N 169°58'E, Appendix IA-B), and the average number of individuals was 2,000/1,000 m³ throughout a total of 168 stations for the present sampling. The present results for the abundance of *E. hamata* corresponded to those described by Sund (1959a).

It is interesting to note that *E. hamata* did not appear in the eastern part of the Bering Sea (Fig. 11), where *S. elegans* was distributed most abundantly according to the present observation. *E. hamata* was suggested to be mesoplanktonic in the Bering Sea and the northern North Pacific Ocean in the northern summer.
Fig. 12. Occurrence of *Sagitta lyra*, *S. scrippsi*, *S. maxima*, *S. nagae* and *S. minima* in the upper 150 m in the Bering Sea and northern North Pacific Ocean in summer. Cross indicates negative stations for these species. All the data obtained in 1957, 1959, 1960 and 1968 were combined.

(Chindonova, 1955; Alvarino, 1964; Kotori, 1969, 1972; Kotori and Hara, 1972); the present results described above may confirm the fact that the species is mesopelagic in the present area in summer, because *E. hamata* did not appear at the stations situated on the continental shelf shallower than 98 m in the eastern part of the Bering Sea. Moreover, it may be pointed out from the result of the present observation that *E. hamata* was somewhat more abundant off the eastern coast of the Kamchatka Peninsula and the Kurile Islands than in the other parts of the present area. However, the areal variation in abundance of *E. hamata* in the upper 150 m was not as obvious as in the case of *S. elegans* in the present observation. This may be also due to the fact that *E. hamata* inhabits more abundantly in the mesopelagic layers of the Bering Sea and the northern North Pacific Ocean during the northern summer than in the epipelagic layers.

*Sagitta minima*: In the present observation the species was found at only 5 stations situated west of the longitude of 165°E (Fig. 12). The maximum abundance (200 individuals/1,000 m³) was recorded at Sta. 573924 (43°41'N 152°00'E, Appendix IA-B). *S. minima* is an inhabitant of the intermediate area between two different water masses, i.e., the Pacific Subarctic Water and the North Pacific Central Water (Bieri, 1959; Tokioka, 1959).

*Sagitta lyra*, *S. scrippsi*, and *S. maxima*: *S. lyra* was found at 12 stations widely distributed across the North Pacific Ocean along the latitude of 45°N, but was limited to the south of 50°N in the present observation (Fig. 12). The species was a predominant chaetognath at Stas. 604653 (43°09'N 170°30'W) and 604654 (42°09'N 179°42'W) for the present sampling (Fig. 10). Especially, as many as 3,000 individuals/1,000 m³ were found at Sta. 604654.

*Sagitta scrippsi* was found at 4 stations from 160°E to 170°W, south of 46°N, where *S. lyra* also occurred, in the present observation (Fig. 12). *S.
scrippsaee was less in abundance than S. lyra, the maximum abundance of S. scrippsaee being only 50 individuals/1,000 m³ at Sta. 604653 (43°09'N 170°30'W, Appendix IA-B) in the present observation.

Alvarino (1962) suggested that S. lyra is a tropical-subtropical species, the distribution of which overlaps the southern edges of the S. scrippsaee boundaries, which lie along the 40°N parallel in the North Pacific Ocean. The present results also indicate that S. lyra is a species of warm water inhabitants.

Sagitta maxima was found only at Sta. 594448 (59°19'N 172°20'E) in the northwestern part of the Bering Sea, the number of individuals of this species being 40/1,000 m³ in the present observation (Fig. 12). Alvarino (1962) previously suggested that the species was a cold water inhabitant.

Sagitta nagae: In the present observation the species appeared only at Stas. 573908 (46°00'N 168°00'E) and 573919 (43°49'N 162°00'E), and the maximum abundance (140 individuals/1,000 m³) of this species recorded at Sta. 573919 (Fig. 12). S. nagae has been suggested to be a species of inhabitants of the mixed water between the cold and the warm water in the off-shore seas (Tokioka, 1959; Alvarino, 1967b).

(3) Areal variation in the abundance of the chaetognath biomass

The areal variation in abundance of the total chaetognath biomass in the present area is illustrated in Fig. 13. Large amounts, i.e., more than 10 g wet weight/1,000 m³ were found in the eastern part of the Bering Sea, in the area off the eastern coast of Kamchatka, the Kurile Islands and Hokkaido, and in the southern coastal waters along the Aleutian Islands in the North Pacific Ocean. Especially in the eastern part of the Bering Sea and the coastal area on the Kurile Islands in the North Pacific Ocean, the chaetognath biomass sometimes reached

![Fig. 13. Areal distribution of the total chaetognath biomass in the upper 150 m (g wet weight per 1,000 m³) in the Bering Sea and northern North Pacific Ocean. All the data obtained in 1957, 1959, 1960 and 1968 were combined.](image-url)

* See footnote on page 110.
Table 3. Biomass of all the chaetognaths, Sagitta elegans and Eukrohnia hamata (g wet weight per 1,000 m³), and percentage of the chaetognaths with regard to the whole of zooplankton in the biomass in the Bering Sea and northern North Pacific Ocean in the summers of 1957, 1959, 1960 and 1968.

<table>
<thead>
<tr>
<th>Area</th>
<th>Bering Sea</th>
<th>Northern North Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of stations</td>
<td>87</td>
<td>76</td>
</tr>
<tr>
<td>Mean biomass (Range) (g/1000 m³)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total chaetognaths</td>
<td>31.0 (0.0-183.8)</td>
<td>13.7 (0.0-55.6)</td>
</tr>
<tr>
<td><em>Sagitta elegans</em></td>
<td>27.1 (0.0-151.0)</td>
<td>9.8 (0.0-46.5)</td>
</tr>
<tr>
<td><em>Eukrohnia hamata</em></td>
<td>1.9 (0.0-23.7)</td>
<td>3.5 (0.0-28.9)</td>
</tr>
<tr>
<td>Percentage of wet weight of chaetognaths to whole zooplankton (%)</td>
<td>8.1 (0.4-60.5)</td>
<td>9.5 (0.0-100.0)</td>
</tr>
</tbody>
</table>

40–180 g wet wt/1,000 m³. On the other hand, only small amounts of the total number of chaetognaths, i.e., less than 10 g wet wt/1,000 m³ were observed mostly in the central parts of the Bering Sea and in the area south of about 50°N in the North Pacific Ocean. The average chaetognath biomass (31.0 g/1000 m³) through a total of 87 stations in the Bering Sea was higher than the one found (13.7 g/1000 m³) through 76 stations in the northern North Pacific Ocean (Table 3).

The fraction of the total chaetognath biomass in comparison with the total amount of zooplankton in wet weight was expressed as an average of 8.1% through the 87 stations in the Bering Sea, and 9.5% through the 76 stations in the northern North Pacific Ocean (Table 3). Although the present figures of 8.1–9.5% are lower than that (15%) reported by Menzel and Ryther (1961 Ms., cited from Beers, 1964) in the upper 500 m in the Sargasso Sea, they may be sufficient to support the opinion that chaetognaths play an important rôle as a primary carnivore in the food webs in the Bering Sea and in the northern North Pacific Ocean.

It is clearly indicated that *S. elegans* was the most important constituent of all chaetognaths, also in biomass, in the upper 150 m in the present area.

(4) Vertical distribution of chaetognaths

Chaetognaths can be placed in three categories according to the depths of their habitat, i.e., epipelagtonic (upper 150–200 m), mesoplanktonic (200–1,000 m), and bathypelagtonic species (below 1,000 m) (Alvarino, 1964). The vertical distribution of 13 species is considered here mainly from the materials collected at 4 stations (KH691, KH692, KH693, and KH694) by simultaneous horizontal tows with nine or ten MTD 56-cm nets.

*Sagitta elegans*: This species appeared abundantly in the upper 200 m at Stas. KH691 and KH692 in the Subarctic Water. In the daytime collection, the maximum abundance (5,700 individuals/1,000 m³) was observed at a depth of 25 m at Sta. KH691, where this species also had a marked secondary concentration (3,700 individuals/1,000 m³) at 70 m. The tendencies in the vertical distribution of this species observed at Sta. KH691 were the same at Sta. KH692: the maximum
abundance (about 250 individuals/1,000 m³) was in the upper 25 m, and a marked secondary concentration was from 80 to 200 m (Fig. 14). In the present observation, the shallower concentration of this species mainly consisted of small *S. elegans*, less than about 10 mm, as was pointed out earlier by the present author (Kotori, 1972). Consequently, all of these results support the opinion that *S. elegans* is an epipelagic chaetognath (Chindonova, 1955; Furuhashi, 1961; Alvariño, 1964; Kitou, 1967a). However, it is noteworthy that *S. elegans* may be able to live in waters deeper than 200 m, because the present results indicate this species is distributed at about 600 m at Stas. KH691 and KH692. The information that *S. elegans* reached the deep layers of 700 m in the subarctic waters has been reported by Kotori (1969, 1972) and Kotori and Hara (1972).

On the other hand, *S. elegans* was completely absent at Sta. KH693, which was identified to be in the mixture of the Pacific Subarctic Water and the Western North Pacific Central Water. Marumo (1966) previously indicated that *S. elegans* can be transported by the Oyashio undercurrent so as to be found in the intermediate water of Sagami Bay at depths exceeding 300 m in winter. Moreover,
this species was suggested to be able to live at a depth of 700 m as was already described. At Sta. KH693, however, *S. elegans* did not appear even at the depths of more than 300 m. Therefore, this finding suggests that the water below 300 m at Sta. KH693 did not have the character of the Subarctic Water in view of the biological oceanography (Motoda et al., 1950; Parsons and Takahashi, 1973). *S. elegans* did not appear at the surface at Sta. KH694 situated at the boundary of the Western North Pacific Central Water and the Equatorial Water.

*Eukrohnia hamata*: The maximum abundance of this species was found at 190 m at Sta. KH691 (50°N), at 320 m at Sta. KH692 (45°N), and below 580 m at Sta. KH693 (40°N) (Fig. 15). *E. hamata* has been reported to occur frequently in the high-arctic part of the Norwegian Sea off northwestern Greenland and Spitsbergen, commonly in the low arctic, temperate, and tropical latitudes in the Atlantic, although in small numbers, in deeper water, and abundantly again south of the tropical zone with the maximum in the shallow water (Thiel, 1938). This holds generally for the Pacific Ocean (Alvarino, 1964).

---

Fig. 15. Distribution of *Eukrohnia hamata* (individuals per 1,000 m³) in the vertical section along long. 155°W from 50°N to 35°N in the daytime in the summer of 1969.
According to Alvaríno (1964), the maximum abundance of the species was at a depth of 225 m at 47°35.7'N 167°44.8'E in the northern North Pacific Ocean. Kotori (1972) reported that the maximum abundance of this species was found at 120–270 m in the Bering Sea and the northern North Pacific Ocean in summer. The greatest depth of occurrence was assumed to be 1,000–2,000 m (Chindonova, 1955). Tokioka (1959) reported *E. hamata* to be rare in 0 to 50-m vertical hauls in the Oyashio water from August to September.

In the daytime collection, this species did not appear in the upper 24 m at Sta. KH691, nor at the surface at Sta. KH692, nor in the upper 230 m at Sta. KH693. However, at night, they appeared at the surface at Sta. KH691. It has been suggested that *E. hamata* did not appear at the surface during daytime or at night in the subarctic waters in summer according to a previous work by the present author (Kotori, 1972). However, Kotori and Hara (1972) found a small number of this species at the surface of the Bering Sea at night, late in June. This may be indicative of the diel vertical migration of *E. hamata*. However, the maximum abundance of the species was at a depth of 190 m during the daytime, and at 230 m at night at Sta. KH691 for the present sampling. Therefore, the diel vertical migration of this species was probably not as conspicuous as that of *S. elegans* if *E. hamata* would migrate diurnally vertically. Kitou (1967b) noted that this species was abundant in shallow water in the western region of the northern North Pacific Ocean in May, and that conspicuous seasonal variations near the surface were related to its ontogenetic migration.

*Sadigetta scrippae*: This species appeared below 470 m in small numbers (20 individuals/1,000 m³) at Sta. KH691, and below 30 m with the maximum abundance of 2,800 individuals/1,000 m³ at a depth of 90 m at Sta. KH693 (Fig. 16). This suggests that *S. scrippae* was much more abundant in the mixture of the Pacific Subarctic Water and the North Pacific Central Water with the vertical concentration in the epipelagic layers of this region, so as to confirm the previous information on the distribution of this species provided by Alvaríno (1962, 1964) and Kotori (1972). Alvaríno (1964) noted that *S. scrippae* occurred primarily in the upper 200 m (epipelanktonic), and went deeper near the southern boundary of the California Current. Kotori (1972) suggested that the range of the vertical distribution of the species was 50–390 m in the northern North Pacific Ocean in summer.

*Sadigetta minima*: This species was found from the surface down to 580 m only at Sta. KH693 (Fig. 17). It may be suggested that *S. minima* can inhabit not only in the epipelagic but also in the mesopelagic layers in the present area. *S. minima* appears to be epipelagic (Marumo et al., 1958; Furuhashi, 1961). However, Alvaríno (1964) stated that some specimens of *S. minima* larger than the average were found from 700 to 280 m at 38°20'N 127°05'W in the North Pacific Ocean.

*Eukrohnia bathypelagica*: This species was found below 190 m at Sta. KH 691, somewhat increasing in number from 380 to 470 m. At Sta. KH692, it appeared only below 530 m (Fig. 17). Neither could Kitou (1966b) obtain this species in the upper 500 m south of 38°N, but he (Kitou, 1967a) found a large
population between the surface and 700 m at 42°N 155°E, east of Hokkaido. Kotori (1972) noted that the species was distributed below 150 m in the northern North Pacific Ocean. For the present sampling, *E. bathypelagica* was completely absent at Stas. KH693 and KH694. These findings support the opinion that *E. bathypelagica* is an inhabitant of the meso- and bathypelagic layers in the northern North Pacific Ocean (Alvariño, 1962).

*Sagitta macrocephala*: Alvariño (1964) stated that this species extended from the lower levels of the mesopelagic domain to the upper part of the bathypelagic domain in the Pacific Ocean. Chindonova (1955) reported it below 500 m in the Kurile-Kamchatka Trench. Kitou's (1963, 1966b, 1967a) results, however, showed that the species was bathyplanktonic in the Japan Trench, because he could not collect them in the upper 1,000 m in this Trench. In the present observation, *S. macrocephala* was found below 700 m only at Sta. KH693 (Fig. 17). The author (Kotori, 1972) previously reported that the species was found in the meso- and bathypelagic layers of the Bering Sea and the northern North
Fig. 17. Occurrence of 12 species of chaetognaths, *Sagitta enflata*, *S. hexaperta*, *S. lyra*, *S. nagae*, *S. pacifica*, *S. neglecta*, *S. minima*, *S. neodecipiens*, *S. zetesios*, *S. macrocephala*, *Pterosagitta draco* and *Eukrohnia bathypelagica* in the vertical section along long. 155°W from 50°N to 35°N in the summer of 1969. The data obtained in the daytime and at night were combined.

Pacific Ocean. All the results described above, except for Kitou's (1963, 1966b, 1967a), support the Alvariño's (1964) opinion. Kitou's (1963, 1966b, 1967a) results are probably indicative of the latitudinal variation in the vertical distribution of this species. As mentioned before, it has been established as a well-known fact for *Eukrohnia hamata* (Thiel, 1938; Alvariño, 1964).

*Sagitta lyra*, *S. hexaperta*, *S. nagae*, *S. enflata*, *S. neodecipiens* and *Krohnitta subtilis*: All of these six species appeared only at Sta. KH693 for the present sampling (Fig. 17).

*S. lyra* appeared above the 340-m depth, *S. hexaperta* was distributed from 88 to 120 m, and *S. enflata* appeared only at the surface in the present observation.
The findings confirm that these species are epipelagic (Alvariño, 1964; Kitou, 1966a; Fagetti, 1972).

*S. nagae* was found at the surface and at a depth of 450 m in the present study. In Suruga Bay, Nagasawa and Marumo (1972) reported that this species was usually distributed in the upper 100 m.

*S. neodecipiens* was distributed from 230 to 340 m. It confirms that the species is epipelagic and mesoplanktonic (Kitou, 1966a).

*Krohnitta subtilis* appeared in the surface and at a depth of 350 m in the present observation, and is therefore an epipelagic mesoplanktonic chaetognath. The result corresponds to the Fagetti's (1972) findings.

(5) Diel vertical migration of *Sagitta elegans*

It has been suggested that *S. elegans* performs a diel vertical migration (Kotori, 1972; Pearre, 1973). However, the present author suggested in his previous paper that the small *S. elegans*, less than 9 mm, did not migrate diurnally vertically (Kotori, 1972). He also suggested that a thermocline at 10-50 m impedes the upward nocturnal migration of *S. elegans* which are longer than 20 mm.

At Sta. KH691, a marked secondary concentration of *S. elegans* was observed at 70 m during daytime, and this concentration could be observed at the same depth also at night (Fig. 18A). Meanwhile, the lower part of the thermocline at this station was situated at about 70 m (Fig. 18B). Therefore, the result supports the opinion that a thermocline impedes the upward migration of *S. elegans* inhabiting in the lower parts of the thermocline (Kotori, 1972). On the other hand, the present result indicates that *S. elegans* appeared most abundantly at the surface at night, and that the maximum abundance was at 25 m during daytime. This may confirm the diurnal vertical migration of the species. Fig. 18B also shows the upper part of a thermocline situated at a depth of 30 m.

Many of the individuals of this species occurring at the surface during daytime were small *S. elegans*, as it was previously pointed out by Kotori (1972).

(6) Vertical variation in the abundance of the total population of chaetognaths

The vertical distribution of the total chaetognath biomass in the Subarctic Water can be summarized as follows:

According to Chindonova (1955), the maximum abundance is at around 150 m in the Kurile-Kamchatka Trench. Kotori (1972) mentioned that the maximum abundance in the Subarctic Water during daytime was at a depth of 100 to 300 m in spring and summer.

In the present observation, the maximum abundance was at a depth of 100 to 300 m, where *Eukrohnia hamata* was a predominant chaetognath. A marked secondary concentration was also found at a depth of 25 to 100 m, where *Sagitta elegans* predominantly appeared in the present study (Fig. 19). It confirms the view previously presented by Chindonova (1955) and Kotori (1972).
Fig. 18A-C. Vertical distribution of *Sagitta elegans* (A) and *Eukrohnia hamata* (C) (individuals per 1,000 m³) in the daytime and at night, and vertical profiles of the temperature, salinity, and dissolved oxygen (B) at Sta. KH69 (50° N 155° W) in the northern North Pacific Ocean in August 1969.
Fig. 19. Distribution of the total chaetognath biomass (g wet weight per 1,000 m³) in the vertical section along long. 155°W from 50°N to 35°N during daytime in the summer of 1969.

(7) Possible factors controlling the distribution of chaetognath species

As factors directly affecting areal and vertical distribution of chaetognaths, such phenomena as submarine light intensity, temperature, salinity, hydrostatic pressure, number of prey, concentration of dissolved oxygen, and the interaction of two or more factors should be considered. The behavioral response differs with the species, and with their developmental stage. Immature *S. elegans* are less sensitive to light than the adults, which are distributed deeper than younger animals (Russell, 1933b; Kotori, 1972). Similar differences have been reported for *Eukrohnia hamata* (Fowler, 1905; Alvarino, 1964; Kitou, 1967b), *Sagitta gazellae* (David, 1955), *S. marri* (Devid, 1958), *S. lyra* (Kitou, 1966b) and others.

In the present observation the areal and vertical distribution of temperature, salinity and dissolved oxygen were examined as parameters possibly related to the distribution of *Sagitta elegans* and *Eukrohnia hamata*.
Temperature and salinity: It was obviously illustrated that *Sagitta elegans* appeared most abundantly, while few individuals of *Eukrohnia hamata* appeared (Fig. 11), in the eastern part of the Bering Sea, which is characterized by a salinity lower than 32%o at the surface in the present observation (Figs. 6, 9 and 11). The area is over the continental shelf of the eastern parts of the Bering Sea. Next to the area described above, many *S. elegans* were distributed in the regions off the eastern coast of the Kamchatka Peninsula, the Kurile Islands and Hokkaido, and the coastal area south of the Aleutian Islands, where the salinity was from 32 to 33%o at the surface. On the other hand, only a few *S. elegans* were distributed in the region south of 50°N, west of 165°E, which was characterized by a salinity higher than 33%o at the surface.

These facts described above suggest that the salinity was one of the possible factors controlling the distribution of *Sagitta elegans*.

In Fig. 20, the density of *Sagitta elegans* (individuals per 1,000 m³) in the upper 150 m was plotted against the temperature and the salinity at the surface at each sampling station. The surface temperature at the present stations where *S. elegans* appeared ranged from 2.8 to 17.8°C. An occurrence of *S. elegans* exceeding 10,000 individuals/1,000 m³ could be observed more frequently in the areas of lower surface salinity (less than 32.20%o) than in the areas where it was higher (more than 32.20%o). These trends, in which a few exceptions were included, may also indicate that *S. elegans* prefers areas of low salinity. This view was supported by Shimura (1975 Ms.). However, Sund (1959a) maintained that *S. elegans* was most abundant in the areas of high salinity (32.8%o) and moderately warm temperature (12–13°C) in the Gulf of Alaska. Chindonova (1955) reported that the individuals of *S. elegans* increased in number with the salinity in the Kurile-Kamchatka Trench.

On the other hand, Bieri (1959) noticed that *Sagitta elegans* appeared to be most abundant near the shore. Lea (1955) also maintained that *S. elegans* decreased in abundance as she went seaward. These phenomena may suggest that *S. elegans* prefer coastal waters of low salinity to offshore waters of high salinity. Moreover, the comparison between the vertical distribution of salinity and *S. elegans* as it is carried out in the present study may also confirm the salinity preference of *S. elegans*: This species did not appear south of Sta. KH693, which was characterized by a high salinity (more than 33.5%o); and the occurrence of more than 400 individuals/1,000 m³ of *S. elegans* was restricted to the upper 100 m at Sta. KH691, which was characterized by low salinity (less than 33%o). These results obtained previously and confirmed in the present study all suggest that *S. elegans* prefers a low salinity of around 32%o.

In the case of the vertical distribution of *Eukrohnia hamata*, the upper limits of appearance of this mesoplanktonic species (Fig. 15) corresponded to the 8°C contour of the temperature profile (Fig. 5). Moreover, the occurrence of more than 1,000 individuals/1,000 m³ of this species was limited to the waters of low temperature (less than 5°C) in the present study. Therefore, the temperature probably affects the distribution of this species, as Thiel (1938) previously demonstrated.
Fig. 20. Density of *Sagitta elegans* (individuals per 1,000 m³) in the upper 150 m plotted against the temperature and the salinity at the surface at sampling stations during summer. All the data obtained in 1957, 1959, 1960 and 1968 were combined.
Dissolved oxygen: According to Alvarino (1964), the distribution of Sagitta elegans is limited by a concentration of oxygen below 6 ml/l in the northern North Pacific Ocean. However, Marumo (1966) collected many individuals of this species below 300 m in Sagami Bay, where the oxygen content was less than 4 ml/l. Further, Kotori (1972) found some specimens of S. elegans in depths containing dissolved oxygen as low as 1 ml/l in the northern North Pacific Ocean.

In the present observation, the surface water at Stas. KH691, KH692, KH693 and KH694 contained dissolved oxygen of more than 6 ml/l, but Sagitta elegans was distributed only at Sta. KH691 and KH692. Moreover, this species was distributed in layers deeper than 150 m where dissolved oxygen was less than 6 ml/l at Stas. KH691 and KH692 for the present sampling (Figs. 7 and 14).

In order to determine the endurance in waters of low oxygen content, a preliminary experiment was conducted in the land laboratory in the present study. Experimental animals were obtained about 1 km off the Usujiri shore, Minamikayabe, southern Hokkaido facing the northern North Pacific Ocean, about 1 hr after sunset from May 28-31, 1971. The low oxygen content water was prepared as follows: The seawater had been filtered with a Whatman glass filter (GF/C), and then it was refiltered with a HA Milipore filter (0.45 μm pore), so as to keep the oxygen contents as low as 2.03–2.54 ml/l. Details of the net used in the sampling of the experimental animals and the rearing technique employed will be presented later in the next Chapter (see pp. 127–129).

Table 4 shows the survival percentage of Sagitta elegans in the seawaters containing from 5.82 to 6.62 ml O₂/l, and in the low oxygen content water of 2.03 to 4.36 ml O₂/l. S. elegans was able to survive for at least 24 hrs under the conditions of dissolved oxygen contents as low as 2.21 and 2.54 ml/l under a low

<table>
<thead>
<tr>
<th>Exp. No.</th>
<th>Number of animals experimented</th>
<th>Time after capture (days)</th>
<th>Duration of maintenance (hours)</th>
<th>Temperature (°C)</th>
<th>Initial O₂ concentration of water (ml/liter)</th>
<th>Survival percentage during the maintenance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>2</td>
<td>24</td>
<td>8.6-11.0</td>
<td>5.93</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>4</td>
<td>24</td>
<td>9.2-11.0</td>
<td>6.62</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>10</td>
<td>48</td>
<td>8.1-12.2</td>
<td>6.06</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>13</td>
<td>24</td>
<td>11.8-14.8</td>
<td>5.92</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>16</td>
<td>24</td>
<td>2.0-4.0</td>
<td>6.39</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>19</td>
<td>48</td>
<td>3.5-4.0</td>
<td>5.82</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>14</td>
<td>48</td>
<td>2.0-3.0</td>
<td>6.18</td>
<td>83</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>21</td>
<td>24</td>
<td>3.5</td>
<td>2.54</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>16</td>
<td>24</td>
<td>4.0</td>
<td>2.21</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>19</td>
<td>29</td>
<td>14.1-15.4</td>
<td>2.03</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>4</td>
<td>24</td>
<td>3.0</td>
<td>2.52</td>
<td>100</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>5</td>
<td>24</td>
<td>3.0</td>
<td>3.51</td>
<td>100</td>
</tr>
<tr>
<td>13</td>
<td>6</td>
<td>6</td>
<td>24</td>
<td>13.0</td>
<td>4.36</td>
<td>100</td>
</tr>
</tbody>
</table>
temperature of 3.5–4.0°C. However, at a high temperature of 14.1–18.4°C, animals could not be kept alive for more than 29 hrs in the low oxygen content water of 2.03 ml/l. On the other hand, they were alive for about 2 weeks in the waters containing 5.93–6.62 ml O₂/l at 8.1–14.8°C.

It is therefore probable that the low oxygen contents do not affect the distribution of Sagitta elegans as much as the increase in temperature. The low oxygen content is probably non-effective at a temperature as low as 4°C, but becomes effective at about 15°C.

IV. On the biology of Sagitta elegans Verrill

The preceding chapters in the present study emphasized that the fraction of chaetognaths was about 10% of the total zooplankton weight in the Bering Sea and the northern North Pacific Ocean, and that Sagitta elegans was the most important constituent in the epipelagonic chaetognath community in these regions. Meanwhile, there is very little information on the development, life history, metabolisms, and other ecological problems in the biology of S. elegans in the present regions.

This Chapter, therefore, deals with such aspects of the biology of this species as development, life history, and respiration mostly by means of the rearing of this species in the laboratory. Successful experimental works in the laboratory on neritic chaetognaths in the temperate and tropical regions have been carried out by several authors in the recent years. The maintenance of very fragile and delicate planktonic animals such as Sagitta crassa has been accomplished successfully by Murakami (1959, 1966) and Takano (1971), and S. hispida by Beers (1964), Reeve (1964, 1966, 1970a, b), Cosper and Reeve (1975), Reeve et al. (1975), and Reeve and Cosper (in press). The maintenance of S. elegans, an oceanic and subarctic species, was reported by Ikeda (1970), Sameoto (1972), and Kotori (1975a, b).

In the present studies, live specimens of Sagitta elegans were collected off Usujiri in southern Hokkaido, where it faces the northern North Pacific Ocean, in late May 1971, and in or off Oshoro Bay in western Hokkaido, where it faces the northern part of the Japan Sea, from February to March 1972. They were kept alive successfully for more than two weeks under starvation conditions in the laboratory.

1. Materials and methods

Animals: Zooplankton samples were obtained about 1 km off Usujiri shore, Minami-kayabe, in southern Hokkaido where it faces the northern North Pacific Ocean in May, 1971, and in or off Oshoro Bay, on the west coast of Hokkaido where it faces the northern part of the Japan Sea in February and March, 1972. The sampling of the material was made with an Ikeda net (Ikeda, 1971, 1974; 0.35-mm mesh aperture, 56 cm in diameter, 100 cm in length, with a specially designed large polyethylene tail bucket, 15 cm in diameter, 25 cm in length), which was towed through the surface layer from 0 to 20 m approximately, for about 10 minutes about 1 hour after sunset. The chaetognaths collected with this net were
almost vigorous and healthy in the present observation.

Experimental seawater: The seawater dipped from the surface of the sea where materials were collected was filtered through Whatman glass fiber filters (GF/C) and stored in polyethylene tanks for less than one week. Before it was used, the filtered water was aerated by means of an air compressor. No antibiotics were added to the water. This is the water which was used as the experimental seawater for the maintenance of the animals.

Rearing procedure of Sagitta elegans: The zooplankton collected with an Ikeda net was diluted in large polyethylene buckets filled with raw seawater on the boat, transported to the land laboratory (Usujiri Fisheries Laboratory or Oshoro Marine Biological Station, Hokkaido University) and then individuals of Sagitta elegans were carefully sorted from the composite samples with a large bore pipette (0.8 mm in diameter) in 5-liter glass containers filled with experimental seawater. The time required from the sampling to the completion of sorting was not longer than 1.5 hour. The five-liter glass containers with sorted animals were dipped in a water bath for about one day. The temperature of the water bath was kept close to natural temperature for animals by pumping seawater into the land laboratory. Then, the sorted animals in the 5-liter containers were transferred into 1-liter glass bottles filled up with the experimental seawater, and they were stocked up for the following experiments under the conditions of starvation and darkness. The bottles were placed in a refrigerator kept at about 4°C during the period of the maintenance.

The rearing was continued for 45 days until the last animal died. About one-third of the experimental seawater in the bottles was renewed every two or three days. At the same time, dead individuals, if present, were removed from the bottles. Quite recently, Reeve et al. (1975) demonstrated photographically the formation of membranes which surround the faecal materials produced by Sagitta hispida. However, the present author could not confirm whether S. elegans excreted faecal pellets or not during the experiment.

Development of Sagitta elegans: Nineteen individuals of all the Sagitta elegans, which were collected off Usujiri on May 30, 1971, were kept together in a 5-liter glass container set in a refregerator, under the conditions of starvation and darkness. The glass container was filled with the experimental seawater. The oxygen of the experimental seawater was 5.82–6.62 ml/l in the present study.

Some of the reared animals spawned eggs in the glass container at 20:00 hrs on June 4, 1971. The eggs were transferred to a 1-liter glass bottle that was filled with the experimental seawater and kept under the same conditions as the 19 reared animals. After 3 days (15:30 hrs, June 7), larvae were hatched out from the eggs and found swimming in the bottle (Kotori, 1975a).

At times during the rearing of these larvae, some of them were fixed and preserved in a 3% formalin-seawater solution for later morphological observations. The larvae survived for 11 days at most. In all, 25 larvae were obtained in the laboratory (Kotori, 1975b).

To determine the later developmental processes of Sagitta elegans, all 83 individuals of this species ranging from about 2 to 27 mm in length were sorted...
from the zooplankton materials collected at Stas. 682834, 682837, 682861, 682862 and 682868 for the present study in the eastern Bering Sea, and they were observed morphologically.

Respiration: The water bottle method described by Marshall et al. (1935), Conover (1956) and Ikeda (1970, 1971, 1974) was adopted to measure respiration. From the stocked animals in the 1-liter glass bottles, about 5 individuals (4-6 individuals) were transferred into a 1-liter well stopped glass bottle filled with the conditioning experimental seawater. Then, a rubber stopper with an outlet tube and an inlet tube, the former covered with a fine mesh net to prevent the escape of animals, the latter being connected to a large reservoir of the conditioning experimental seawater, was fitted firmly at the mouth of the bottle. The conditioning experimental seawater was flowed gently through the bottle containing animals, about 2–3 times the volume of the bottle, to replace its content with the conditioning experimental seawater. At the same time another bottle without animals was prepared the same way, to serve as control. Each bottle was covered with a black vinyl bag as soon as the replacement of the conditioning experimental seawater had been completed and immersed into the water bath. The time required for the preparation of one series of two bottles was about an hour. The time of incubation varied with the water temperature, from 24 to 51 hours, but mostly 24 hours.

At the end of the incubation, the conditioning experimental seawater in each bottle was siphoned to a 300-ml BOD bottle for the determination of dissolved oxygen. When dead animals were observed at the end of the incubation period, the results were not taken into account. The animals remaining with a small volume of the experimental seawater were picked up with a pipette on blotting paper and the excess of sea water adhering to the animal’s body was removed. The body length of the animals was measured, and the body was transferred into an air-tight plastic pot, the bottom being covered with a glass fiber filter. The pots were kept in a desiccator (desiccant: silica gel) in a deep freezer for later measurement of weight.

The dissolved oxygen was analyzed following the Winkler method described by Strickland and Parsons (1968). The rates of respiration were calculated by the difference of the concentration between the experimental and the control bottles.

Determination of the conversion factor from wet weight to amount of carbon in mixed zooplankton: The materials were collected with a Shark high-speed plankton sampler (Motoda, 1967: 15 cm in mouth diameter, 0.35-mm mesh aperture) at the surface in the northern North Pacific Ocean during the KH–69–4 cruise of the “Hakuhō Maru,” from August 16 to 29, 1969. The materials collected were weighed on board and then washed briefly with distilled water. The materials were placed on a glass filter and dried in an oven for 24 hours at 40°C, and then stored in a deep freezer at −20°C. In the land laboratory, the preserved samples were desiccated at the room temperature until a constant weight was attained. The total amount of carbon was determined with the Hitachi 026 CHN analyzer for an aliquot of ground material for a single determination.
2. Results and discussion

(1) Developmental processes of *Sagitta elegans* through its life span

As far as the individuals of *Sagitta elegans* longer than 7 mm are concerned, there have been many contributions as to its morphology (e.g. Huntsman, 1919; Russell, 1932a; Tokioka, 1940a; Lea, 1955; Dunbar, 1962; Park, 1970). Meanwhile, Huntsman and Reid (1921), Zo (1973), and quite recently Kotori (1975a, b) presented some information on the morphology of such small individuals as about 1.5 mm in length.

Information on the morphological characteristics of *Sagitta elegans* through its life span is very important to understand the life history and population dynamics of this chaetognath. In the present study, information on the developmental processes of this species through its life span are given on the basis of the results given by the present author in his previous work for the larval stages (Kotori, 1975b) and by the present observations on the materials collected in the eastern part of the Bering Sea for the elder forms of *S. elegans* (Appendix III).

As mentioned above, the morphological remarks on the larvae of *Sagitta elegans* in the early stages of development have been published elsewhere (Kotori, 1975b). They are summarized here as follows: The eggs immediately after spawning are spherical, about 0.3 mm in diameter, and most are in such an advanced state that an embryo in the eggs can be easily seen through the membrane (Plate IA). The embryo is found enclosed within the egg, with the tail overlapping the head (Fig. 21). The results of this observation on both the egg and the embryo correspond to those reported by Huntsman and Reid (1921) and Zo (1973).

![Fig. 21. Egg of *Sagitta elegans* spawned under artificial conditions in laboratory (EM; embryo).](image)

The body length (from the tip of the head to the base of the tail) of larvae, from time of hatching to 2-days old, ranged from 1.23 to 1.42 mm long for 6 individuals. The larva is provided with a pair of posterior fins, but not yet furnished with the anterior fin; the existence of eye pigments (Huntsman and Reid, 1921) cannot be confirmed because of the thick collarette extending nearly all over the body; no hooks are developed yet; the median vertical septum is found already in the posterior portion of the body, though the tail septum is not yet formed (Fig. 22 and Plate IB-D).

Through the rearing of larvae for 12 days, it was found that most of the seven-day old larvae, 1.47-1.65 mm in length, were provided with the tail.
Fig. 22. Newly-hatched larva of *Sagitta elegans* (Larval Stage I), dorsal view (C; collarette. VG; ventral ganglion. PF; posterior fin. MVS; median vertical septum).

Fig. 23. Eight-day old larva of *Sagitta elegans* (Larval Stage III), dorsal view (h; hook. ts; tail septum).
Fig. 24. Eight-day old larva of *Sagitta elegans* (Larval Stage III), ventral view of the head (h; hook).

Mem. Fac. Fish. Hokkaido Univ. [XXIII, 2]

Septum (Plate IF), but had neither hooks nor eyes, while eight to eleven-day old larvae, 1.69–2.20 mm in length, were furnished with eight hooks on each side (Figs. 23, 24 and Plate IE), but had no eyes on the dorsal surface of the head.

These features indicate that the early morphological development of *Sagitta elegans* is similar to that of *S. crassa* observed by Murakami (1959), but somewhat different from those of *S. enflata* observed by Doncaster (1902), *S. hispida* by Reeve and Cosper (in press), and *Spadella cephaloptera* by John (1933).

On the basis of the observations on the plankton materials collected in the eastern part of the Bering Sea, the developmental processes of the elder forms of *Sagitta elegans* will be summarized as follows:

The tail percentage (percentage of the tail length to the body length) of 19 individuals from 2.05 to 4.94 mm in length decreased from 45.4 to 24.2% with the increase in body length, while the percentage was 37.7–45.6% in 13 individuals of 7-day old larvae and 40.2–44.3% in 5 individuals of 8–to 11-day old larvae (Kotori, 1975b). This suggests that the trunk of the body of *S. elegans* developed rapidly during the period of this stage, so that the tail percentage approached closer those of the older animals. This is also confirmed in *S. hispida* by Reeve and Cosper (in press). *S. elegans* from 2.05 to 4.94 mm in length had seven or eight hooks on each side, but they did not have a pair of anterior fins in the present study. The eye pigments could be observed first in these specimens (Fig. 25).

The smallest *Sagitta elegans* having the anterior fins (No. F25 Animal in Appendix III) was 5.10 mm in length in the present study. However, even specimens longer than this, 5.20 mm (1 individual), 5.50 mm (1 individual), 6.05 mm (2 individuals) and 6.45 mm (1 individual) in length, lacked a pair of anterior fins. Therefore, it is probable that *S. elegans* obtains its anterior fins during the period of development when it is 5 or 6 mm in length.

The body length of the specimens furnished with a pair of anterior fins and having no sexual products in the body according to the microscopical observ-
Fig. 25A-B. *Sagitta elegans*, Juvenile Stage I (3.41 mm long specimen). A: Dorsal view of the body. B: Dorsal view of the head (ep; eye pigment).

The ovarian products were first recognized in a specimen of 7.91 mm in length (No. F44 Animal in Appendix III) in the present study (Fig. 27). The seminal vesicles, however, did not develop until *S. elegans* reached 18.20 mm in length. The tail percentage of the specimens from 7.91 to 18.15 mm in length was 15.8-21.2% for 23 individuals in the present study. This approached the figures: 16.9-18.1% in the eldest specimens being 18.20-27.66 mm long for all of the 14 individuals collected in the present observation.

The smallest one of the specimens that had their seminal vesicles was 18.20 mm in length (Fig. 28A1-2, No. F71 Animal in Appendix III) in the present study. The seminal vesicles became fully developed in a specimen of 23.09 mm in length (No. F78 Animal in Appendix III), which is a maximum size for a 0.15-mm thickness. On the other hand, the ovaries developed more and more after that, increasing their length in the trunk of the body (Fig. 28B-C). It is interesting to note that the hooks of the head increased from 7 or 8 to 11 or 12 in number on each side when the seminal vesicles were built up: *S. elegans* longer than 22.95 mm in...
Fig. 26. *Sagitta elegans*, Juvenile Stage II (6.95 mm long specimen), dorsal view (vg; ventral ganglion. af; anterior fin).

Fig. 27. *Sagitta elegans*, Adult Stage I (8.45 mm long specimen), dorsal view (ov; ovary).
length (Fig. 29, Nos. F77-F83 Animals in Appendix III) had a pair of 11 or 12 hooks in the present study (Fig. 30).

The following 5 stages of development are proposed for the prematuring *Sagitta elegans* according to the developmental processes described above in the present study: (1) Larval Stage I is from newly-hatched larvae to the point when young animals are just about to have their tail septum; less than 1.5 mm in length in the present observation (Fig. 22); (2) Larval Stage II is reached when the animals have their tail septum, but no hooks yet, 1.5–1.7 mm in length (Plate IF); (3) Larval Stage III includes those animals in which a set of 8 hooks appear on the
Fig. 30A-B. Head of *Sagitta elegans* (Adult Stage III). A: Dorsal view. B: Ventral view.

Fig. 29. *Sagitta elegans*, Adult Stage III (25.58 mm long specimen), dorsal view (hd; head. tr; trunk. t; tail. h; hook. ep; eye pigment. int; intestine. vg; ventral ganglion. af; anterior fin. ov; ovary. v; vagina. pf; posterior fin. mvs; median vertical septum. ts; tail septum. test; testis. sv; seminal vesicle. cf; caudal fin).

<table>
<thead>
<tr>
<th>Developmental stages</th>
<th>Body length (mm)</th>
<th>Percentage of tail length to body length (%)</th>
<th>Number of hooks on one side of head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larval Stage I</td>
<td>1.2-1.5</td>
<td>—</td>
<td>None</td>
</tr>
<tr>
<td>Larval Stage II</td>
<td>1.5-1.7</td>
<td>37.8-45.2</td>
<td>None</td>
</tr>
<tr>
<td>Larval Stage III</td>
<td>1.7-2.2</td>
<td>40.2-44.3</td>
<td>8</td>
</tr>
<tr>
<td>Juvenile Stage I</td>
<td>2.1-5.0</td>
<td>24.2-45.4</td>
<td>7-8</td>
</tr>
<tr>
<td>Juvenile Stage II</td>
<td>5.1-7.9</td>
<td>18.3-25.1</td>
<td>7-8</td>
</tr>
<tr>
<td>Adult Stage I</td>
<td>7.9-18.2</td>
<td>15.8-21.2</td>
<td>7-8</td>
</tr>
<tr>
<td>Adult Stage II</td>
<td>18.2-27.7</td>
<td>17.3-17.7</td>
<td>7-8</td>
</tr>
<tr>
<td>Adult Stage III</td>
<td>23.1&lt;</td>
<td>16.9-18.1</td>
<td>8-12</td>
</tr>
</tbody>
</table>
head, but in which eye pigments have not appeared on the head, and the larvae are 1.7–2.2 mm in length (Figs. 23 and 24); (4) Juvenile Stage I is when animals get eye pigments on the head, but do not have anterior fins; they are from 2.1–5.0 mm in body length (Fig. 25); (5) Juvenile Stage II furnishes a pair of anterior fins, but no sexual products are detected in these animals by microscopic observation, and the juveniles are from 5.1 to 7.9 mm in length (Fig. 26).

For the elder forms of Sagitta elegans, the following three stages of maturity were presented by Russell (1932a): his Stage I includes all the youngest animals in which not a single sperm mother cell is seen lying loose in the tail cavity; Stage II ranges between those individuals with the first appearance of spermatocytes and those in which the tail segment is packed with spermatocytes and spermatozoa, but in which the ovaries show little sign of swelling eggs; Stage III includes those individuals in which the ovaries are fully ripe or ripening.

All of the five stages, Larval Stages I-III, Juvenile Stages I and II, proposed in the present study corresponds to Russell's (1932a) Stage I of maturity. S. elegans of 7.9–18.2 mm in length with the small ovaries being less than 8% of the length of the ovary in the body length in the present observation corresponds to Russell's (1932a) Stage II. At this stage, seminal vesicles begin to appear on each side of the tail segment in the present observation. According to the present observation, it is suggested that Russell’s (1932a) Stage II be divided into two stages. Because, individuals longer than 23 mm in length with fully-developed seminal vesicles had a set of 11 or 12 hooks on the head, while most individuals ranging from 18 to 23 mm in body length had a set of only 7 or 8 hooks, and their seminal vesicles were not fully-developed in the present study. Therefore, it may be suggested that Russell's (1932a) maturity stages II and III be rearranged into the following three stages of development based on the present observation: (1)

---

### Sagitta elegans through its life span.

<table>
<thead>
<tr>
<th>Percentage of ovary length to body length (%)</th>
<th>Height of seminal vesicle from its base (mm)</th>
<th>Anterior fin</th>
<th>Eye pigments</th>
<th>Other remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>No trunk-tail septum. Collarette covers large parts of the body.</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Trunk-tail septum is present.</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td></td>
</tr>
<tr>
<td>&lt;7.99</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>5.00-20.62</td>
<td>≤0.14</td>
<td>Present</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>6.51-24.82</td>
<td>0.15</td>
<td>Present</td>
<td>Present</td>
<td>Number of hooks is almost 11 or 12.</td>
</tr>
</tbody>
</table>
Adult Stage I includes individuals with the first appearance of the ovarian products and those in which there are no seminal vesicles on each side of the tail segment (Fig. 27); (2) Adult Stage II includes those individuals in which the seminal vesicles are developing and in which hooks are only 7 or 8 in number on each side of the head (Fig. 28); and (3) Adult Stage III includes the animals with 11 or 12 hooks on each side of the head and in which the seminal vesicles ripen to the maximum size of 0.15 mm in thickness (Fig. 29). It was suggested in the previous paragraph that the length of the body varied from 7.9 to 18.2 mm in Adult Stage I; 18.2–27.7 mm in Adult Stage II; and it is more than 23.1 mm in Adult Stage III in the present study.

Accordingly, it may be right to conclude that the developmental processes of *Sagitta elegans* are represented by the 8 stages shown in Table 5 in the present study. Quite recently, Reeve and Cosper (in press) noted that a more constant indication of maturity in *S. hispida* was the appearance of seminal vesicles. This view is supported in the case of *S. elegans* so as to divide the maturing phase into Adult Stages I, II and III in the present study. Moreover, Reeve and Cosper (in press) divided the entire life history of *S. hispida* into four stages (Larva, Juvenile, Immature, and Mature) for the sake of convenience. Their classification schemes correspond essentially to those given in the present study.

(2) Respiration

The results of the study on the respiration of *Sagitta elegans* are shown in Table 6 in the present report.

The rate of respiration ranged between 0.196 and 5.989 µl O₂/animal/hour at 2.0–4.0°C, in a total of 16 experiments in the present observation. In the other 8 experiments, the rate was between 0.354 and 6.252 µl O₂/animal/hour at 8.1–14.8°C.

According to Ikeda (1970), the respiration rate in *Sagitta elegans* (1.13–4.83 mg in body dry weight) was 0.827–1.180 µl O₂/animal/hour at 5.3–8.2°C. Sameoto (1972) reported that the rate of respiration of this species in Bedford Basin was 5.1–30.0 µl O₂/animal/24 hours, namely 0.2–1.3 µl O₂/animal/hour at 1.0–16.0°C. Accordingly, on the magnitude of order in the values, these values given by Ikeda (1970) and Sameoto (1972) correspond to those described above in the present study.

The metabolic rate (respiration rate) of organisms is the power function of the body weight (Prosser, 1961; Ikeda, 1974). For instance, this relationship is expressed mathematically as follows;

\[ R = aW^b \]  

where \( R \) is the weight specific respiration rate (µg-at O₂/mg body weight/hr), \( W \) is the body dry weight (µg/animal), \( b \) is an exponential constant and \( a \) is a constant of proportionality. In terms of logarithmic form, equation (1) is rewritten as;

\[ \log R = b \cdot \log W + \log a \]  

Fig. 31 shows a scatter diagram of the weight specific respiration rate and the
Table 6. Respiration rates of *Sagitta elegans* under various experimental conditions.

<table>
<thead>
<tr>
<th>Exp. No.</th>
<th>Number of animal experimented</th>
<th>Time after capture (days)</th>
<th>Duration of incubation (hours)</th>
<th>Temperature (°C)</th>
<th>Oxygen concentration (ml/l)</th>
<th>Animal dry weight (mg/animal)</th>
<th>Respiration rate (μl O₂/hr mg dry wt/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>2</td>
<td>24</td>
<td>8.6-11.0</td>
<td>5.83</td>
<td>0.954</td>
<td>1.438</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>4</td>
<td>24</td>
<td>9.2-11.0</td>
<td>6.62</td>
<td>0.936</td>
<td>1.320</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>10</td>
<td>48</td>
<td>8.1-12.2</td>
<td>6.05</td>
<td>0.967</td>
<td>1.722</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>13</td>
<td>24</td>
<td>11.8-14.8</td>
<td>5.92</td>
<td>0.987</td>
<td>1.753</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>16</td>
<td>24</td>
<td>2.0-4.0</td>
<td>6.39</td>
<td>0.888</td>
<td>0.234</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>21</td>
<td>24</td>
<td>3.5</td>
<td>2.54</td>
<td>0.888</td>
<td>0.700</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>14</td>
<td>48</td>
<td>2.0-3.0</td>
<td>6.18</td>
<td>0.406</td>
<td>0.805</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>1</td>
<td>24</td>
<td>3.0</td>
<td>7.64</td>
<td>0.152</td>
<td>0.196</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>4</td>
<td>24</td>
<td>3.0</td>
<td>7.28</td>
<td>0.152</td>
<td>0.476</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>3</td>
<td>24</td>
<td>3.0</td>
<td>7.22</td>
<td>0.108</td>
<td>0.319</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>1</td>
<td>48</td>
<td>3.0</td>
<td>7.62</td>
<td>0.743</td>
<td>1.744</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>3</td>
<td>48</td>
<td>3.0</td>
<td>8.21</td>
<td>0.697</td>
<td>1.668</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>1</td>
<td>24</td>
<td>3.0</td>
<td>7.66</td>
<td>0.106</td>
<td>0.448</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>1</td>
<td>24</td>
<td>3.0</td>
<td>7.73</td>
<td>0.133</td>
<td>1.239</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>5</td>
<td>31</td>
<td>3.0</td>
<td>7.68</td>
<td>0.133</td>
<td>0.460</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>10</td>
<td>48</td>
<td>13.0</td>
<td>6.78</td>
<td>0.27</td>
<td>6.269</td>
</tr>
<tr>
<td>17</td>
<td>5</td>
<td>1</td>
<td>24</td>
<td>3.0</td>
<td>7.27</td>
<td>1.138</td>
<td>0.710</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>3</td>
<td>24</td>
<td>3.0</td>
<td>6.93</td>
<td>1.358</td>
<td>1.575</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>5</td>
<td>24</td>
<td>3.0</td>
<td>7.56</td>
<td>0.447</td>
<td>5.989</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>5</td>
<td>24</td>
<td>3.0</td>
<td>7.36</td>
<td>0.447</td>
<td>1.167</td>
</tr>
<tr>
<td>21</td>
<td>3</td>
<td>6</td>
<td>24</td>
<td>3.0</td>
<td>7.03</td>
<td>0.282</td>
<td>0.813</td>
</tr>
<tr>
<td>22</td>
<td>5</td>
<td>1</td>
<td>24</td>
<td>13.0</td>
<td>6.36</td>
<td>0.282</td>
<td>1.343</td>
</tr>
<tr>
<td>23</td>
<td>5</td>
<td>2</td>
<td>24</td>
<td>13.0</td>
<td>6.61</td>
<td>0.282</td>
<td>0.354</td>
</tr>
<tr>
<td>24</td>
<td>5</td>
<td>3</td>
<td>24</td>
<td>13.0</td>
<td>3.61</td>
<td>1.268</td>
<td>10.059</td>
</tr>
<tr>
<td>25</td>
<td>5</td>
<td>6</td>
<td>24</td>
<td>13.0</td>
<td>4.36</td>
<td>0.260</td>
<td>1.789</td>
</tr>
</tbody>
</table>

The fact that the weight specific respiration rate decreases with the increase in body weight for many zooplankton (Ikeda, 1974) is confirmed for *S. elegans* by equation (3).

(3) Metabolants

If protein alone is being metabolized (45% carbon, 16% nitrogen), approximately 8 atoms of oxygen are proportional to 1 of nitrogen theoretically. As this
protein substrate becomes progressively mixed with non-nitrogen substrates, so the ratio increases, ultimately (where no nitrogen-containing material is involved), to infinity. Therefore, the ratio of oxygen respired and nitrogen excreted by *S. elegans* would be an indication of metabolants of this species.

Ikeda (1974) reported the O:N ratio in *Sagitta elegans* was 7–15, while in a tropical chaetognath *S. hispida*, the O:N ratio was found to be always approximately 7 during either starvation and non-starvation conditions (Reeve et al., 1970). The O:N ratio higher than 7 was also obtained in *S. elegans* during starvation conditions by the present author (Kotori, in preparation).

On the other hand, the highest percentage of protein (dry weight basis) in the body was found in *Sagitta elegans* (84.0%) in the planktonic animals from the Bering Sea in summer; lipid accounts for 6.7% and carbohydrate, 0.7% of the body dry weight of this species (Ikeda, 1972). In the zooplankton other than chaetognaths, carbohydrate is the least of the three constituents of the body (Raymont, 1963). The results obtained by Reeve et al. (1970) on the biochemical composition of *S. hispida* showed that protein constituted about 1/2 of the dry weight (52.9%), with lipid and carbohydrate 17.0 and 3.5%, respectively. Beers (1966) also suggested that carbohydrate was the least of these three constituents of the body, being only 0.31% for mixed species of chaetognaths. All of these described above support the results of Raymont and Krishnaswamy (1960) and Raymont and Conover (1961).

Since the O:N ratio in *Sagitta elegans* was found to be more than 7 by Ikeda (1974) and Kotori (in preparation), and carbohydrate in the body of *S. elegans* was the least of the three constituents as reviewed above and based on previous works, it may be safe to assume that the metabolants of *S. elegans* contain not only
protein but also lipid of the body.

In the case of Sagitta hispida, however, the fact that the O:N ratio was found to be approximately 7, is indicative of pure protein metabolism (Reeve et al., 1970). It appears that the difference in the source of metabolites found in these two species may be a resultant of the difference in the zoogeographical distribution and metabolic activities between S. hispida and S. elegans. The former is an inhabitant of the temperate-tropical seas, having a shorter life span than the latter: S. hispida takes only 19-45 days to complete its life span according to the rearing experiments at 17-31°C in the laboratory (Reeve, 1970b; Reeve and Walter, 1972); a boreal chaetognath S. elegans takes 40-180 days to complete its life span off Plymouth (Russell, 1932a) and 2 years in the Arctic Sea (Dunbar, 1962). Therefore, it is probable that S. elegans metabolizes not only its bodily protein but also the lipid preserved in the body so as to endure starvation and survive during the long period of scarce food supply in winter.

(4) Relationship between body dry weight and body length

The correlation diagram of log weight specific respiration rate-log dry weight for Sagitta elegans was shown at the experimental temperature of 2.0-4.0°C in Fig. 31 in Section (2) of this Chapter. Therefore, the oxygen consumption of a chaetognath community of S. elegans of various sizes could be calculated by only measuring the body length of this species individually collected in the sea, if the relationship between body dry weight and body length of this species were indicated.

Relationship between log body dry weight and log body length of Sagitta elegans is illustrated in Fig. 32 in the present study. The equation of regression line was calculated to be

\[ \log W = -3.6862 + 2.8500 \log L \]

\[ (r=0.9257) \]  

where L is the body length in mm from the tip of the head to the base of the tail and W is the body dry weight in mg.

(5) Conversion from wet weight to the amount of carbon in the mixed species of zooplankton in the subarctic seas

The results of the determination...
Table 7. Wet weight, dry weight, and carbon content of mixed zooplankton collected with Ocean in the summer of 1969. Ratios of dry weight to wet weight and of carbon

<table>
<thead>
<tr>
<th>No. of station</th>
<th>Position</th>
<th>Date</th>
<th>Time (LZT)</th>
<th>Volume of water filtered (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shark 3</td>
<td>41°01.1'N, 165°10.1'E</td>
<td>Aug. 16, 1969</td>
<td>2342-2309</td>
<td>188.2</td>
</tr>
<tr>
<td>4</td>
<td>42°32.6'N, 171°17.2'E</td>
<td>17</td>
<td>2122-2155</td>
<td>190.7</td>
</tr>
<tr>
<td>5</td>
<td>43°46.7'N, 176°41.9'E</td>
<td>18</td>
<td>2030-2206</td>
<td>208.1</td>
</tr>
<tr>
<td>6</td>
<td>44°57.8'N, 176°50.5'W</td>
<td>18</td>
<td>2232-2303</td>
<td>189.1</td>
</tr>
<tr>
<td>7</td>
<td>46°23.3'N, 170°55.5'W</td>
<td>19</td>
<td>2122-2156</td>
<td>176.2</td>
</tr>
<tr>
<td>8</td>
<td>47°58.0'N, 164°08.0'W</td>
<td>20</td>
<td>2919-2242</td>
<td>162.1</td>
</tr>
<tr>
<td>9</td>
<td>49°28.1'N, 157°30.1'W</td>
<td>21</td>
<td>2220-2254</td>
<td>161.1</td>
</tr>
<tr>
<td>10</td>
<td>49°33.7'N, 154°31.1'W</td>
<td>27</td>
<td>2006-2044</td>
<td>227.6</td>
</tr>
<tr>
<td>11</td>
<td>44°59.8'N, 155°02.0'W</td>
<td>28</td>
<td>1909-1938</td>
<td>194.8</td>
</tr>
<tr>
<td>12</td>
<td>44°23.5'N, 154°59.0'W</td>
<td>29</td>
<td>2007-2039</td>
<td>185.8</td>
</tr>
</tbody>
</table>

of wet and dry weight, total carbon, and nitrogen in the mixed species of zooplankton collected at a total of 10 stations for the present observation in the northern North Pacific Ocean in summer are summarized in Table 7.

The results indicate that the dry-weight/wet-weight ratio ranged from 0.06 to 0.17, and averaged 0.12; the carbon/dry-weight ratio ranged from 0.27 to 0.68, and averaged 0.47 in the present study. Therefore, a factor of 0.06 will be used in the following discussion to convert wet weight to carbon in the mixed species of zooplankton in the present study. Omori’s (1969) data suggested that the factor of 0.06 proposed in the present study will be acceptable in converting wet weight to carbon amount in the mixed species of zooplankton in the subarctic seas.

V. Ecological importance of a chaetognath community in the Bering Sea

It is generally recognized that the biological production in the sea occurs in the epipelagic layers (Taniguchi, 1972). This means that the epipelagic layers are a main board of energy flow in the sea. It may be reasonable to think that the oceanic food chain in the epipelagic layers of the Bering Sea involves four trophic levels from the photosynthetic plankton (primary producer) to zooplanktivorous fishes (tertiary consumer). In the present study, it has been emphasized that Sagitta elegans, a member of
the typical carnivorous zooplankton (secondary consumer), was abundantly distributed in the epipelagic layers of the Bering Sea. It will be generally accepted that *S. elegans* plays an important rôle in the energy flow in the sea since it constitutes about 10% of the macrozooplankton biomass in the upper 150-m layers in the Bering Sea, as shown in the present study. However, there have been few attempts to estimate quantitatively the function of *S. elegans* as a secondary consumer.

In this chapter, the ecological importance of a chaetognath community composed of *Sagitta elegans* will be described quantitatively and our research will be based on the data presented previously in this study.

The correlation of log weight specific respiration rate-log dry weight in *Sagitta elegans* at the experimental temperature of 2.0-4.0°C was described in equation (3) as shown in Chapter IV of this text. Needless to say, a population of *S. elegans* consists of individuals of various body weight. Therefore, it is necessary, for the calculation of the oxygen consumption of a chaetognath community composed of a single species of *S. elegans*, to understand the weight composition of the population, which can be estimated by equation (4) described previously in Chapter IV from the measurement of *S. elegans* (Table 8).

It is a common knowledge that the respiration quotient (RQ, \( \text{CO}_2: \text{O}_2 \) ratio in volume) varies with the metabolants from 1.0 to 0.7 (Ashida, 1965). Therefore, the volume of carbon dioxide produced as the result of respiration by the chaetognath community could be estimated if the respiration quotient of *Sagitta elegans*
Table 8. Composition of the body length of Sagitta elegans collected at 24 stations

<table>
<thead>
<tr>
<th>No. of station</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>689211</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>142</td>
<td>127</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>29</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>34</td>
<td>26</td>
<td>41</td>
<td>38</td>
<td>38</td>
<td>28</td>
<td>38</td>
<td>51</td>
<td>35</td>
<td>23</td>
<td>21</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>36</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>37</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>15</td>
<td>61</td>
<td>83</td>
<td>58</td>
<td>56</td>
<td>46</td>
<td>35</td>
<td>27</td>
<td>14</td>
</tr>
<tr>
<td>39</td>
<td>0</td>
<td>11</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>41</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>12</td>
<td>25</td>
<td>23</td>
<td>30</td>
<td>40</td>
<td>28</td>
<td>26</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>61</td>
<td>0</td>
<td>5</td>
<td>13</td>
<td>16</td>
<td>36</td>
<td>23</td>
<td>35</td>
<td>30</td>
<td>34</td>
<td>34</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>62</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>36</td>
<td>42</td>
<td>43</td>
<td>33</td>
<td>21</td>
<td>30</td>
<td>53</td>
<td>44</td>
<td>59</td>
</tr>
<tr>
<td>63</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>31</td>
<td>85</td>
<td>74</td>
<td>48</td>
<td>17</td>
<td>36</td>
<td>17</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>64</td>
<td>0</td>
<td>15</td>
<td>87</td>
<td>185</td>
<td>158</td>
<td>89</td>
<td>41</td>
<td>30</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>67</td>
<td>17</td>
<td>32</td>
<td>22</td>
<td>29</td>
<td>64</td>
<td>77</td>
<td>90</td>
<td>78</td>
<td>72</td>
<td>37</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>68</td>
<td>0</td>
<td>12</td>
<td>33</td>
<td>40</td>
<td>45</td>
<td>39</td>
<td>26</td>
<td>23</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>69</td>
<td>1</td>
<td>6</td>
<td>15</td>
<td>10</td>
<td>19</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>20</td>
<td>28</td>
<td>26</td>
<td>27</td>
<td>13</td>
<td>16</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>71</td>
<td>1</td>
<td>6</td>
<td>29</td>
<td>56</td>
<td>57</td>
<td>23</td>
<td>10</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>74</td>
<td>4</td>
<td>11</td>
<td>12</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>17</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>75</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>76</td>
<td>0</td>
<td>2</td>
<td>16</td>
<td>38</td>
<td>38</td>
<td>51</td>
<td>45</td>
<td>17</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>78</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>13</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

were defined. By the way, it is also generally accepted that carbon, a component of the organic matter taken by an animal as its food and source of energy, is to be released wholly in the form of carbon dioxide as the result of respiration (Ashida, 1965). It is therefore reasonable that the oxygen consumption should be converted into carbon utilization (Menzel and Ryther, 1961).

In the present study, the tentative estimation of carbon requirement by a chaetognath community composed of a single species of *Sagitta elegans* in the eastern Bering Sea in summer conduces to emphasize the ecological importance of the chaetognath community in the boreal waters, on the assumption that the metabolant of *S. elegans* is mainly composed by lipid, so that the respiration quotient is fitted to be 0.7 of lipid metabolism. Moreover, the calculation was undertaken on the assumption that the environmental temperature of the habitat of this species in the eastern Bering Sea was 2.0--4.0°C, since the experiments on the relationship between respiration and body weight of *S. elegans* were carried out at 2.0–4.0°C. Therefore, the present result of the calculation for the carbon requirement of this species shown in Table 9 appears to be somewhat underestimated, because the environmental temperature was actually a little higher than the experimental temperature of 2.0–4.0°C in some cases.

According to this estimation (Table 9), a chaetognath community composed of a single species of *Sagitta elegans* in the eastern Bering Sea in summer required 0.01–15.17 mg C/m²/day, averaged 4.71 mg C/m²/day. It is noteworthy that the
in the eastern Bering Sea in the summer of 1968 (individuals per haul).

<table>
<thead>
<tr>
<th>length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 14 15 16 17 18 19 20 21 22 23 24 25 26 27</td>
</tr>
<tr>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 0 0 0 1 1 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 2 2 0 4 1 0 1 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>3 1 0 0 1 1 1 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 1 4 2 3 0 0 4 7 6 6 2 2 1 1</td>
</tr>
<tr>
<td>0 3 5 9 10 5 1 4 2 0 0 1 0 0 0</td>
</tr>
<tr>
<td>4 0 12 12 12 14 11 6 4 5 2 0 2 0 0</td>
</tr>
<tr>
<td>3 5 2 2 4 3 2 2 2 0 1 0 0 0 0</td>
</tr>
<tr>
<td>27 16 14 7 9 6 4 3 2 8 6 5 6 0 0</td>
</tr>
<tr>
<td>55 43 33 24 9 9 5 8 6 3 0 2 1 0 0</td>
</tr>
<tr>
<td>8 10 16 14 19 16 8 11 6 3 1 0 1 0 0</td>
</tr>
<tr>
<td>3 3 9 6 15 19 12 25 14 10 6 4 5 0 1</td>
</tr>
<tr>
<td>0 0 0 1 0 0 0 1 0 0 2 1 0 0 0 0</td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 7 6 4 8 14 4 8 0 2 2 2 1 0 0</td>
</tr>
<tr>
<td>7 4 5 8 6 6 5 1 1 2 1 1 0 1 0 0</td>
</tr>
<tr>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>3 1 2 0 1 1 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

The calculation of the value was based on the experimental results obtained not only under a temperature somewhat lower than that of the actual environment of the eastern part of the Bering Sea, but also under starvation. It is evident that the value reflects the basal metabolisms of *S. elegans*. Therefore, it may be safe to assume that the estimated results represent the basal and minimum carbon requirement of the chaetognath community in the epipelagic layers in the eastern part of the Bering Sea in summer.

It is reported that the primary productivity in the euphotic layers of the Bering Sea in summer was 490 mg C/m²/day (Taniguchi, 1972); consequently, the carbon requirement of a chaetognath community tentatively calculated here (4.71 mg C/m²/day) corresponds to about 1% of the primary productivity. On the other hand, the macrozooplankton biomass other than chaetognaths in the epipelagic domain in the eastern part of the Bering Sea was recorded to be 32.2–2,682.7 g wet weight/1,000 m² in the present study (Appendix IV), averaged 2,689.4 mg C/m² using the conversion factor of 0.06 previously indicated (see, pp. 141–142). Therefore, the daily carbon requirement (4.71 mg C/m²) corresponds to about 0.2% of the macrozooplankton biomass other than chaetognaths in the eastern part of the Bering Sea.

Moreover, if the 10% of the ecological efficiency factor is adopted in the Bering Sea (Ryther, 1969), the secondary productivity of the Bering Sea in
Table 9. Respiration rate and carbon requirement of a chaetognath community in the eastern Bering Sea in the summer of 1969.

<table>
<thead>
<tr>
<th>No. of station</th>
<th>Maximum depth of collection (m)</th>
<th>Respiration by a chaetognath community ($\mu$l $O_2$/1000 m$^3$/hr)</th>
<th>Carbon required by a chaetognath community (mg/m$^3$/hr)</th>
<th>Carbon required by a chaetognath community (mg/m$^3$/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>688312</td>
<td>159</td>
<td>59.16</td>
<td>0.000022</td>
<td>0.003058</td>
</tr>
<tr>
<td>14</td>
<td>80</td>
<td>1975.64</td>
<td>0.00743</td>
<td>0.086570</td>
</tr>
<tr>
<td>15</td>
<td>68</td>
<td>2061.73</td>
<td>0.00761</td>
<td>0.081748</td>
</tr>
<tr>
<td>30</td>
<td>40</td>
<td>28.76</td>
<td>0.009011</td>
<td>0.009440</td>
</tr>
<tr>
<td>34</td>
<td>83</td>
<td>16934.73</td>
<td>0.006011</td>
<td>0.489913</td>
</tr>
<tr>
<td>36</td>
<td>110</td>
<td>110.07</td>
<td>0.000411</td>
<td>0.004510</td>
</tr>
<tr>
<td>37</td>
<td>87</td>
<td>19372.90</td>
<td>0.007264</td>
<td>0.066870</td>
</tr>
<tr>
<td>39</td>
<td>55</td>
<td>5298.05</td>
<td>0.001938</td>
<td>0.129220</td>
</tr>
<tr>
<td>40</td>
<td>45</td>
<td>7426.04</td>
<td>0.002768</td>
<td>0.135700</td>
</tr>
<tr>
<td>41</td>
<td>53</td>
<td>13077.28</td>
<td>0.004905</td>
<td>0.255660</td>
</tr>
<tr>
<td>50</td>
<td>29</td>
<td>8827.44</td>
<td>0.003199</td>
<td>0.262918</td>
</tr>
<tr>
<td>61</td>
<td>103</td>
<td>10927.87</td>
<td>0.004999</td>
<td>0.422197</td>
</tr>
<tr>
<td>62</td>
<td>83</td>
<td>15157.85</td>
<td>0.005685</td>
<td>0.471855</td>
</tr>
<tr>
<td>63</td>
<td>75</td>
<td>4417.43</td>
<td>0.001658</td>
<td>0.194350</td>
</tr>
<tr>
<td>64</td>
<td>67</td>
<td>18557.39</td>
<td>0.006960</td>
<td>0.465330</td>
</tr>
<tr>
<td>67</td>
<td>44</td>
<td>29097.24</td>
<td>0.010913</td>
<td>0.480172</td>
</tr>
<tr>
<td>68</td>
<td>35</td>
<td>7763.22</td>
<td>0.002910</td>
<td>0.101350</td>
</tr>
<tr>
<td>69</td>
<td>30</td>
<td>3159.03</td>
<td>0.001188</td>
<td>0.055550</td>
</tr>
<tr>
<td>70</td>
<td>44</td>
<td>8999.00</td>
<td>0.003375</td>
<td>0.148500</td>
</tr>
<tr>
<td>71</td>
<td>50</td>
<td>11598.95</td>
<td>0.004350</td>
<td>0.217500</td>
</tr>
<tr>
<td>74</td>
<td>106</td>
<td>2536.32</td>
<td>0.009449</td>
<td>0.100594</td>
</tr>
<tr>
<td>75</td>
<td>86</td>
<td>82.51</td>
<td>0.000050</td>
<td>0.002880</td>
</tr>
<tr>
<td>76</td>
<td>84</td>
<td>2977.49</td>
<td>0.001118</td>
<td>0.033912</td>
</tr>
<tr>
<td>78</td>
<td>29</td>
<td>511.99</td>
<td>0.000191</td>
<td>0.017672</td>
</tr>
</tbody>
</table>

Table 10. Primary productivity, secondary productivity, and amount of carbon required by a chaetognath community in the Bering Sea in summer.

| Primary productivity (observed, Taniguchi, 1972) | 490 mg C/m$^3$/day |
| Secondary productivity (estimated, present study*) | 49 mg C/m$^3$/day |
| Amount of carbon required by chaetognath community (calculated, present study) | 4.71 mg C/m$^3$/day |

* 10% of ecological efficiency factor is adopted.

summer can be calculated from the primary productivity of 490 mg C/m$^3$/day to be 49 mg C/m$^3$/day. This value corresponds to 10 times that of the carbon required by a chaetognath community in the area. It can be emphasized here that the carbon requirement of a chaetognath community corresponds to about 10% of the secondary productivity in the Bering Sea in summer (Table 10). This strongly suggests that chaetognaths play an essential role as a secondary consumer in the energy flow of the seas.

--- 146 ---
VI. Summary

(1) The biology of chaetognaths in the Bering Sea and the northern North Pacific Ocean in summer was investigated in order to ascertain the hypothesis that chaetognaths play an important rôle in the food webs in the sea: first, the areal and the vertical distribution of chaetognath species in the actual area were investigated quantitatively, and the relationship between the distribution and its limiting factors was discussed; second, the developmental processes of *Sagitta elegans*, which are suggested to be the most dominant chaetognath in the epipelagic layers in the present area, were examined, and the rates of respiration in this species were determined; and finally the rôle played by a chaetognath community in the epipelagic layers was discussed on the basis of the tentative estimation of carbon requirement of the community in the eastern part of the Bering Sea in summer.

(2) Out of a total of 214 samples collected by 0-m to 150-m vertical hauls with a Norpac net and by simultaneous horizontal tows to a depth of about 500 m with several MTD 56-cm closing nets, the following 17 species in 4 genera of chaetognaths were identified: *Sagitta enflata* Grassi, *S. hexaperta* d'Orbigny, *S. lyra* Krohn, *S. scrippae* Alvarino, *S. maxima* (Conant), *S. elegans* Verrill, *S. nagae* Alvarino, *S. pacifica* Tokioka, *S. neglecta* Aida, *S. minima* Grassi, *S. neodecipiens* Tokioka, *S. zetesios* Fowler, *S. macrocephala* Fowler, *Pterosagitta draco* (Krohn), *Eukrohnia hamata* (Mobius), *E. bathypelagica* Alvarino, and *Krohnitta subtilis* (Grassi). In the upper 150 m of the present area, *Sagitta elegans* is distributed most abundantly and widely. The average number of individuals was 10,000/1,000 m$^3$ throughout 168 stations. *Eukrohnia hamata* was next to *S. elegans* in abundance in the upper 150 m in most parts of the present area. Its average number of individuals was 2,000/1,000 m$^3$ throughout 168 stations for the present sampling.

(3) *Sagitta elegans* appeared most abundantly in the eastern part of the Bering Sea (25,000 individuals/1,000 m$^3$ on the average through 52 stations), where *Eukrohnia hamata* did not appear. This shows a marked contrast between the two species in their areal distribution in the Bering Sea. *S. elegans* was also distributed abundantly in the area off the eastern coast of Kamchatka, the Kurile Islands, and Hokkaido. It appeared to be relatively abundant in the southern coastal waters along the Aleutian Islands. On the other hand, this species decreased rapidly in the southern region beyond the latitude of 50°N in the central parts of the northern North Pacific Ocean. This fact suggests that the species is a typical biological indicator for the Subarctic Water. It was confirmed that *S. elegans* is epipelagic with the maximum abundance in the upper 25 m, and that it mainly consists of small individuals less than 10 mm in length, and with a marked secondary concentration at a depth of 100–200 m in the subarctic waters, although this species may range to a depth of 700 m in the present area.

(4) *Eukrohnia hamata* was somewhat more abundant off the eastern coast of the Kamchatka Peninsula and the Kurile Islands than in the other parts of the present area. However, this species did not appear in the eastern part of the
Bering Sea. Vertically, the maximum abundance of this species in the daytime was found at 190 m at 50°N, at 320 m at 45°N, and below 580 m at 40°N. This confirms the fact that the species is distributed in the deeper waters in the lower latitudes.

(5) It was suggested that salinity was one of the possible factors controlling the distribution of *Sagitta elegans* because of its low salinity preference, whereas temperature probably affects the distribution of *Eukrohnia hamata*, because the upper limit of the vertical distribution of this mesoplanktonic species corresponded to the 8°C contour of the temperature profile. The results of the field observations and a preliminary experiment in the land laboratory suggest that the low dissolved oxygen contents have less effect than the increase in temperature as a limiting factor of distribution of *S. elegans*.

(6) The distributions of *Sagitta lyra*, *S. scrippsei*, *S. minima*, and *S. nagae* were all limited zoogeographically to the south of 49°N in the present area, where *S. elegans* occurred only in small numbers. *S. lyra* predominated sometimes in the southernmost parts of the present area. *S. maxima* was collected only once from the northern part of the Bering Sea in the present samplings. *S. pacifica*, *S. neglecta* and *Pterosagitta draco* appeared only in the North Pacific Central Water. Vertically, it was recognized that *S. scrippsei* and *S. minima* were distributed from the epipelagic layers to the upper domain of the mesopelagic layers, and that *Eukrohnia bathypelagica* was below 150-200 m in the subarctic waters. *Sagitta macrocephala* and *S. zetesios* were suggested to have their habitat below 500-600 m deep. Some information on the depth preference of *S. lyra*, *S. hexaptera*, *S. nagae*, *S. enfleta*, *S. neodecipiens* and *Krohnitta subtilis* is also presented.

(7) Large amounts of the total number of chaetognaths, more than 10 g wet weight/1,000 m³, occurred in the eastern part of the Bering Sea, in the area off the eastern coast of Kamchatka, the Kurile Islands and Hokkaido, and in the southern coastal waters along the Aleutian Islands. The chaetognath biomass sometimes counted up to 40-180 g wet weight/1,000 m³. Moreover, *Sagitta elegans* was the most important constituent of chaetognaths in biomass in the upper 150 m of the present area.

(8) The maximum abundance of the total chaetognath biomass was vertically at a depth of 100 to 300 m, where *Eukrohnia hamata* was predominant. A marked secondary concentration of biomass was at 25 to 100 m, where *Sagitta elegans* was predominant. In the upper 150 m, the fraction of the total chaetognath biomass compared to the whole zooplankton weight was put as an average of 8.1% through 87 stations in the Bering Sea, and 9.5% through 76 stations in the northern North Pacific Ocean.

(9) The following 8 stages of development are proposed for *Sagitta elegans* through its life span: 1) Larval Stage I is from newly-hatched larvae to the young animals just prior to have their tail septum, less than 1.5 mm in body length, from the tip of the head to the base of the tail; 2) Larval Stage II takes in the animals having their tail septum, but not having any hooks, 1.5-1.7 mm in body length; 3) Larval Stage III includes those animals in which a set of 8 hooks first appear on the head, but have no eye pigments on the head; the larvae are
1.7–2.2 mm in body length; 4) Juvenile Stage I is when animals get eye pigments on the head, but do not have anterior fins; they are 2.1–5.0 mm in body length; 5) Juvenile Stage II furnishes a pair of anterior fins, but no sexual products are detected yet in these animals by a microscopic observation, and the animals are 5.1–7.9 mm in body length; 6) Adult Stage I includes individuals with the first appearance of the ovarian products and those in which there are no seminal vesicles on each side of the tail segment, and the length of the body varied from 7.9 to 18.2 mm; 7) Adult Stage II includes those individuals in which seminal vesicles are developing and in which hooks are only 7–8 in number on both sides of the head; the length of the body is 18.2–27.7 mm; 8) Adult Stage III includes the animals with 11–12 hooks on both sides of the head and in which the seminal vesicles were ripened to the maximum size of 0.15 mm in thickness, and it is more than 23.1 mm in length of the body.

(10) For *Sagitta elegans* with W mg dry weight at the habitat temperature of 2.0–4.0°C, the respiration rate R (µg-at O₂/mg body dry weight/hour) is given as; log R=0.8252–0.5990 log W. Meanwhile, for *S. elegans* with L mm in body length from the tip of the head to the base of the tail, the body dry weight W mg is given as; log W=–3.6862+2.8500 log L. Therefore, the oxygen consumption of a chaetognath community consisting of individuals, different in body size, of a single species of *S. elegans* can be calculated with these two equations only from the measurement of the length composition of *S. elegans* in the community.

(11) It was assumed that the metabolant of *Sagitta elegans* contains not only protein but also lipid of the body. Therefore, the oxygen consumption by a chaetognath community composed of a single species of *S. elegans* can be converted into carbon utilization on the basis of the assumption that the metabolant of *S. elegans* is mainly composed of lipid, and that the respiration quotient is fitted to be 0.7 of lipid metabolism.

(12) The tentative estimation suggests that a chaetognath community composed of a single species of *Sagitta elegans* in the eastern part of the Bering Sea in summer requires 0.01–15.17 mg C/m²/day, averaged 4.71 mg C/m²/day. This corresponds to about 1% of the primary productivity, and about 10% of the secondary productivity in the area, so as to emphasize the ecological importance of the chaetognath community in the boreal waters. Moreover, it is suggested that the daily carbon requirement (4.71 mg C/m²) by a chaetognath community corresponds to about 0.2% of the macrozooplankton biomass (other than chaetognaths) in the eastern part of the Bering Sea in summer.

VII. Acknowledgments

The author would like to express his sincere thanks to Professor Teruyoshi Kawamura of the Faculty of Fisheries, Hokkaido University, for his kind and continuous guidance throughout this study. The author is very grateful to Professor Shun Okada, Professor Eijiro Niyyama and Dr. Takashi Minoda of the Faculty of Fisheries, Hokkaido University, for their valuable suggestions. The author is particularly indebted to Dr. Sigeru Motoda, Professor Emeritus of Hok-
Mem. Fac. Fish. Hokkaido Univ. [XXIII, 2

kaido University, for the encouragement given during this study. Thanks are due to Dr. Akira Taniguchi, Dr. Shiroh Uno, Dr. Akio Koyama, Dr. Tsutomu Ikeda, Dr. Satoru Taguchi, Mr. Naonobu Shiga and other colleagues, for their courtesy during the work. The collaboration given by the research staff on board the "Hakuho Maru" was also greatly appreciated.

References


— 150 —


KOTORI: Biology of Chaetognatha


Russell, F.S. (1932b). On the biology of Sagitta. II. The breeding and growth of Sagitta setosa J. Müller in the Plymouth area, 1930–31, with a comparison with that


Mem. Fac. Fish. Hokkaido Univ. [XXIII, 2


Explanation of Plate I

**ABBREVIATIONS**

hd; head. co; collarette. tr; trunk. vg; ventral ganglion. pf; posterior fin. h; hook. ts; tail septum.

A. Eggs of *Sagitta elegans* spawned under artificial conditions in laboratory (photographed by Dr. T. Ikeda).
B. Newly-hatched larva of *Sagitta elegans* (Larval Stage I), dorsal view (see also Fig. 22 in the text).
C. Dorsal view of the head and trunk of a two-day old larva (Larval Stage I) of *Sagitta elegans*; eyes and hooks are not developed.
D. Posterior portion of the trunk in the same specimen shown in figure C; the tail septum is not developed yet.
E. Eight-day old larva of *Sagitta elegans* (1.94 mm long specimen, Larval Stage III), dorsal view of the head.
F. Tail septum just appeared in Larval Stage II of *Sagitta elegans* (1.47 mm long specimen).
KOTORI: Biology of Chaetognatha
**Appendix IA. Data on zooplankton sampling with a Norpac net at 168 stations in the Bering Sea and northern North Pacific Ocean.**

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Position</th>
<th>Date</th>
<th>Time</th>
<th>Estimated depth of haul (m)</th>
<th>Volume of water filtered (m³)</th>
<th>Wet weight of sample (g/1000 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>575901</td>
<td>46°01'N 154°00'E</td>
<td>Aug. 26, 1957</td>
<td>1410</td>
<td>24.0</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>02</td>
<td>46°01' 156°00'</td>
<td>0700</td>
<td>20.4</td>
<td>255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>03</td>
<td>46°01' 158°00'</td>
<td>0710</td>
<td>24.0</td>
<td>83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>04</td>
<td>46°00' 160°00'</td>
<td>0835</td>
<td>25.8</td>
<td>147</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>05</td>
<td>46°10' 161°58'</td>
<td>2030</td>
<td>24.9</td>
<td>92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>06</td>
<td>46°00' 164°00'</td>
<td>0735</td>
<td>28.3</td>
<td>49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>07</td>
<td>46°00' 168°00'</td>
<td>1810</td>
<td>28.5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>08</td>
<td>46°00' 170°00'</td>
<td>0545</td>
<td>26.4</td>
<td>41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>09</td>
<td>46°00' 175°00'</td>
<td>1700</td>
<td>36.1</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>46°00' 174°00'</td>
<td>1300</td>
<td>28.2</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>13</td>
<td>44°00' 174°00'</td>
<td>1090</td>
<td>26.9</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>16</td>
<td>44°00' 168°39'</td>
<td>1015</td>
<td>22.9</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>17</td>
<td>44°00' 166°00'</td>
<td>0730</td>
<td>47.2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>19</td>
<td>43°49' 162°00'</td>
<td>1300</td>
<td>29.4</td>
<td>34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>44°00' 159°58'</td>
<td>0330</td>
<td>20.8</td>
<td>58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>21</td>
<td>44°00' 158°00'</td>
<td>1500</td>
<td>30.7</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>22</td>
<td>43°41' 155°41'</td>
<td>2000</td>
<td>45.3</td>
<td>154</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>23</td>
<td>43°41' 154°00'</td>
<td>0800</td>
<td>36.2</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>24</td>
<td>43°41' 152°00'</td>
<td>1900</td>
<td>26.3</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>594401</td>
<td>49°00' 146°00'</td>
<td>June 9, 1959</td>
<td>1640</td>
<td>20.7</td>
<td>614</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>02</td>
<td>49°55' 146°47'</td>
<td>0535</td>
<td>26.2</td>
<td>543</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>03</td>
<td>44°04' 149°40'</td>
<td>2025</td>
<td>21.7</td>
<td>233</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>04</td>
<td>45°03' 151°32'</td>
<td>0855</td>
<td>20.7</td>
<td>625</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>05</td>
<td>46°00' 153°15'</td>
<td>120</td>
<td>20.7</td>
<td>625</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>06</td>
<td>46°35' 164°50'</td>
<td>0855</td>
<td>13.5</td>
<td>126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>07</td>
<td>48°00' 159°59'</td>
<td>June 12</td>
<td>2335</td>
<td>20.9</td>
<td>244</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>08</td>
<td>48°00' 159°15'</td>
<td>1040</td>
<td>24.8</td>
<td>350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>09</td>
<td>48°00' 161°29'</td>
<td>2305</td>
<td>21.3</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>10</td>
<td>47°49' 163°31'</td>
<td>1635</td>
<td>30.2</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>11</td>
<td>48°00' 165°46'</td>
<td>1915</td>
<td>13.5</td>
<td>126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>12</td>
<td>48°00' 169°00'</td>
<td>0700</td>
<td>27.6</td>
<td>769</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>14</td>
<td>49°40' 170°00'</td>
<td>0645</td>
<td>28.7</td>
<td>769</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>15</td>
<td>51°48' 171°20'</td>
<td>1010</td>
<td>31.9</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>16</td>
<td>53°14' 171°20'</td>
<td>0050</td>
<td>21.0</td>
<td>445</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix IA. Continued.

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Position</th>
<th>LZT Date</th>
<th>LZT Time</th>
<th>Estimated depth of haul (m)</th>
<th>Volume of water filtered (m$^3$)</th>
<th>Wet weight of sample (g/1000 m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>594440</td>
<td>57°01'N 174°30'W</td>
<td>July 8, 1959</td>
<td>1650</td>
<td>147</td>
<td>20.4</td>
<td>174</td>
</tr>
<tr>
<td>36</td>
<td>41</td>
<td>57°00'W 176°22'</td>
<td>9</td>
<td>0200</td>
<td>141</td>
<td>23.2</td>
<td>270</td>
</tr>
<tr>
<td>37</td>
<td>42</td>
<td>57°00'W 179°10'</td>
<td>9</td>
<td>1430</td>
<td>143</td>
<td>23.4</td>
<td>450</td>
</tr>
<tr>
<td>38</td>
<td>43</td>
<td>57°35'N 177°59'E</td>
<td>11</td>
<td>1150</td>
<td>150</td>
<td>26.4</td>
<td>830</td>
</tr>
<tr>
<td>39</td>
<td>44</td>
<td>57°32'W 176°30'</td>
<td>11</td>
<td>2035</td>
<td>154</td>
<td>34.2</td>
<td>404</td>
</tr>
<tr>
<td>40</td>
<td>45</td>
<td>56°56'W 174°30'</td>
<td>12</td>
<td>2050</td>
<td>166</td>
<td>33.6</td>
<td>820</td>
</tr>
<tr>
<td>41</td>
<td>46</td>
<td>56°19'W 174°50'</td>
<td>13</td>
<td>1445</td>
<td>173</td>
<td>37.0</td>
<td>527</td>
</tr>
<tr>
<td>42</td>
<td>47</td>
<td>55°54'W 172°07'</td>
<td>14</td>
<td>0350</td>
<td>158</td>
<td>28.1</td>
<td>665</td>
</tr>
<tr>
<td>43</td>
<td>48</td>
<td>59°19'W 170°20'</td>
<td>14</td>
<td>1135</td>
<td>118</td>
<td>27.0</td>
<td>693</td>
</tr>
<tr>
<td>44</td>
<td>49</td>
<td>58°18'W 169°58'</td>
<td>14</td>
<td>2135</td>
<td>144</td>
<td>21.4</td>
<td>771</td>
</tr>
<tr>
<td>45</td>
<td>50</td>
<td>57°19'W 169°38'</td>
<td>15</td>
<td>1150</td>
<td>148</td>
<td>17.6</td>
<td>853</td>
</tr>
<tr>
<td>46</td>
<td>51</td>
<td>56°20'W 168°03'</td>
<td>16</td>
<td>1500</td>
<td>150</td>
<td>19.9</td>
<td>407</td>
</tr>
<tr>
<td>47</td>
<td>52</td>
<td>56°20'W 169°58'</td>
<td>16</td>
<td>2010</td>
<td>137</td>
<td>20.4</td>
<td>325</td>
</tr>
<tr>
<td>48</td>
<td>53</td>
<td>55°29'W 164°21'</td>
<td>17</td>
<td>0415</td>
<td>132</td>
<td>20.2</td>
<td>684</td>
</tr>
<tr>
<td>49</td>
<td>54</td>
<td>56°29'W 164°20'</td>
<td>17</td>
<td>1465</td>
<td>129</td>
<td>22.0</td>
<td>474</td>
</tr>
<tr>
<td>50</td>
<td>55</td>
<td>55°29'W 164°20'</td>
<td>17</td>
<td>1450</td>
<td>123</td>
<td>20.3</td>
<td>438</td>
</tr>
<tr>
<td>51</td>
<td>56</td>
<td>54°28'W 164°20'</td>
<td>17</td>
<td>2045</td>
<td>145</td>
<td>17.4</td>
<td>201</td>
</tr>
<tr>
<td>52</td>
<td>57</td>
<td>53°54'W 164°16'</td>
<td>18</td>
<td>1355</td>
<td>150</td>
<td>18.1</td>
<td>44</td>
</tr>
<tr>
<td>53</td>
<td>58</td>
<td>53°09'W 164°16'</td>
<td>18</td>
<td>2035</td>
<td>147</td>
<td>19.7</td>
<td>82</td>
</tr>
<tr>
<td>54</td>
<td>60</td>
<td>51°09'W 164°18'</td>
<td>19</td>
<td>2030</td>
<td>142</td>
<td>19.6</td>
<td>122</td>
</tr>
<tr>
<td>55</td>
<td>61</td>
<td>51°11'W 102°49'</td>
<td>20</td>
<td>1215</td>
<td>147</td>
<td>17.6</td>
<td>92</td>
</tr>
<tr>
<td>56</td>
<td>62</td>
<td>51°11'W 161°33'</td>
<td>20</td>
<td>2055</td>
<td>124</td>
<td>24.0</td>
<td>148</td>
</tr>
<tr>
<td>57</td>
<td>64</td>
<td>50°35'W 159°00'</td>
<td>21</td>
<td>2025</td>
<td>124</td>
<td>20.8</td>
<td>488</td>
</tr>
<tr>
<td>58</td>
<td>65</td>
<td>49°35'W 159°00'</td>
<td>22</td>
<td>1230</td>
<td>128</td>
<td>24.0</td>
<td>376</td>
</tr>
<tr>
<td>59</td>
<td>66</td>
<td>48°35'W 159°00'</td>
<td>22</td>
<td>2030</td>
<td>159</td>
<td>18.9</td>
<td>507.6</td>
</tr>
<tr>
<td>60</td>
<td>67</td>
<td>47°45'W 157°10'</td>
<td>23</td>
<td>2035</td>
<td>150</td>
<td>26.4</td>
<td>247.3</td>
</tr>
<tr>
<td>61</td>
<td>604601</td>
<td>46°49'W 158°55'</td>
<td>June 11, 1960</td>
<td>0900</td>
<td>150</td>
<td>150</td>
<td>36.4</td>
</tr>
<tr>
<td>62</td>
<td>02</td>
<td>47°10'W 161°16'</td>
<td>11</td>
<td>2015</td>
<td>150</td>
<td>18.6</td>
<td>46.3</td>
</tr>
<tr>
<td>63</td>
<td>03</td>
<td>48°09'W 164°02'</td>
<td>12</td>
<td>2000</td>
<td>145</td>
<td>21.6</td>
<td>35.7</td>
</tr>
<tr>
<td>64</td>
<td>04</td>
<td>48°36'W 165°58'</td>
<td>13</td>
<td>0950</td>
<td>157</td>
<td>20.0</td>
<td>10.0</td>
</tr>
<tr>
<td>65</td>
<td>05</td>
<td>49°06'W 173°33'</td>
<td>13</td>
<td>2055</td>
<td>149</td>
<td>25.7</td>
<td>123.4</td>
</tr>
<tr>
<td>66</td>
<td>07</td>
<td>52°00'W 170°10'</td>
<td>15</td>
<td>1930</td>
<td>152</td>
<td>24.9</td>
<td>269.1</td>
</tr>
<tr>
<td>67</td>
<td>08</td>
<td>53°44'W 170°10'</td>
<td>16</td>
<td>0945</td>
<td>168</td>
<td>23.7</td>
<td>122.4</td>
</tr>
<tr>
<td>68</td>
<td>09</td>
<td>55°00'W 170°30'</td>
<td>16</td>
<td>2055</td>
<td>153</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix IA. Continued.

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Position</th>
<th>LST</th>
<th>Estimated depth of haul (m)</th>
<th>Volume of water filtered (m³)</th>
<th>Wet weight of sample (g/1000 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69</td>
<td>604610</td>
<td>57°00' N 170°30' E</td>
<td>June 17, 1960</td>
<td>1955</td>
<td>152</td>
<td>28.2</td>
</tr>
<tr>
<td>70</td>
<td>11</td>
<td>57°00' 175°03'</td>
<td>18</td>
<td>1500</td>
<td>152</td>
<td>25.7</td>
</tr>
<tr>
<td>71</td>
<td>12</td>
<td>55°05' 175°07'</td>
<td>19</td>
<td>2055</td>
<td>153</td>
<td>14.4</td>
</tr>
<tr>
<td>72</td>
<td>13</td>
<td>53°00' 175°05'</td>
<td>20</td>
<td>2090</td>
<td>149</td>
<td>20.0</td>
</tr>
<tr>
<td>73</td>
<td>14</td>
<td>53°00' 175°06'</td>
<td>21</td>
<td>1945</td>
<td>145</td>
<td>25.6</td>
</tr>
<tr>
<td>74</td>
<td>15</td>
<td>52°40' N 179°48' W</td>
<td>21</td>
<td>0955</td>
<td>170</td>
<td>37.8</td>
</tr>
<tr>
<td>75</td>
<td>16</td>
<td>52°36' 179°09'</td>
<td>21</td>
<td>1830</td>
<td>168</td>
<td>37.1</td>
</tr>
<tr>
<td>76</td>
<td>17</td>
<td>52°54' 178°54'</td>
<td>22</td>
<td>1445</td>
<td>150</td>
<td>24.3</td>
</tr>
<tr>
<td>77</td>
<td>18</td>
<td>51°00' 179°31'</td>
<td>23</td>
<td>2110</td>
<td>162</td>
<td>23.7</td>
</tr>
<tr>
<td>78</td>
<td>19</td>
<td>49°55' 179°32'</td>
<td>24</td>
<td>0515</td>
<td>149</td>
<td>20.2</td>
</tr>
<tr>
<td>79</td>
<td>20</td>
<td>49°01' 179°26'</td>
<td>24</td>
<td>1345</td>
<td>148</td>
<td>21.4</td>
</tr>
<tr>
<td>80</td>
<td>21</td>
<td>48°16' 179°32'</td>
<td>24</td>
<td>1932</td>
<td>149</td>
<td>19.3</td>
</tr>
<tr>
<td>81</td>
<td>22</td>
<td>48°19' 176°45'</td>
<td>25</td>
<td>1030</td>
<td>147</td>
<td>24.9</td>
</tr>
<tr>
<td>82</td>
<td>23</td>
<td>48°25' 175°11'</td>
<td>25</td>
<td>1835</td>
<td>147</td>
<td>29.4</td>
</tr>
<tr>
<td>83</td>
<td>24</td>
<td>48°23' 172°00'</td>
<td>25</td>
<td>1418</td>
<td>147</td>
<td>27.2</td>
</tr>
<tr>
<td>84</td>
<td>25</td>
<td>48°59' 171°59'</td>
<td>26</td>
<td>2145</td>
<td>147</td>
<td>28.9</td>
</tr>
<tr>
<td>85</td>
<td>26</td>
<td>50°01' 171°59'</td>
<td>27</td>
<td>0635</td>
<td>150</td>
<td>26.3</td>
</tr>
<tr>
<td>86</td>
<td>27</td>
<td>51°16' 171°56'</td>
<td>27</td>
<td>1918</td>
<td>147</td>
<td>26.0</td>
</tr>
<tr>
<td>87</td>
<td>28</td>
<td>53°31' 171°58'</td>
<td>28</td>
<td>0940</td>
<td>147</td>
<td>23.0</td>
</tr>
<tr>
<td>88</td>
<td>29</td>
<td>55°30' 171°59'</td>
<td>29</td>
<td>1690</td>
<td>148</td>
<td>20.9</td>
</tr>
<tr>
<td>89</td>
<td>30</td>
<td>56°00' 171°44'</td>
<td>30</td>
<td>1605</td>
<td>150</td>
<td>24.0</td>
</tr>
<tr>
<td>90</td>
<td>31</td>
<td>57°40' 171°50'</td>
<td>July 1</td>
<td>1645</td>
<td>89</td>
<td>11.0</td>
</tr>
<tr>
<td>91</td>
<td>32</td>
<td>57°41' 174°28'</td>
<td>2</td>
<td>1755</td>
<td>144</td>
<td>30.8</td>
</tr>
<tr>
<td>92</td>
<td>33</td>
<td>58°09' 173°32'</td>
<td>5</td>
<td>1850</td>
<td>99</td>
<td>18.8</td>
</tr>
<tr>
<td>93</td>
<td>34</td>
<td>61°01' 173°39'</td>
<td>6</td>
<td>1155</td>
<td>70</td>
<td>11.9</td>
</tr>
<tr>
<td>94</td>
<td>35</td>
<td>61°00' 170°00'</td>
<td>6</td>
<td>1930</td>
<td>50</td>
<td>7.5</td>
</tr>
<tr>
<td>95</td>
<td>36</td>
<td>59°55' 170°00'</td>
<td>7</td>
<td>1330</td>
<td>40</td>
<td>5.6</td>
</tr>
<tr>
<td>96</td>
<td>37</td>
<td>59°25' 169°13'</td>
<td>7</td>
<td>1850</td>
<td>40</td>
<td>5.9</td>
</tr>
<tr>
<td>97</td>
<td>38</td>
<td>58°45' 167°54'</td>
<td>8</td>
<td>0850</td>
<td>38</td>
<td>6.5</td>
</tr>
<tr>
<td>98</td>
<td>39</td>
<td>58°20' 166°32'</td>
<td>11</td>
<td>1320</td>
<td>40</td>
<td>4.7</td>
</tr>
<tr>
<td>99</td>
<td>40</td>
<td>58°10' 164°43'</td>
<td>11</td>
<td>2118</td>
<td>40</td>
<td>4.9</td>
</tr>
<tr>
<td>100</td>
<td>41</td>
<td>57°46' 162°01'</td>
<td>12</td>
<td>2090</td>
<td>40</td>
<td>4.1</td>
</tr>
<tr>
<td>101</td>
<td>42</td>
<td>56°50' 165°04'</td>
<td>13</td>
<td>1322</td>
<td>65</td>
<td>6.3</td>
</tr>
<tr>
<td>102</td>
<td>43</td>
<td>55°04' 165°56'</td>
<td>13</td>
<td>2120</td>
<td>81</td>
<td>9.9</td>
</tr>
</tbody>
</table>
Appendix IA. Continued.

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Position</th>
<th>LZT</th>
<th>Estimated depth of haul (m)</th>
<th>Volume of water filtered (m³)</th>
<th>Wet weight of sample (g/1000 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>604644</td>
<td>55°07'N 164°59'W</td>
<td>July 14, 1960</td>
<td>0500</td>
<td>98</td>
<td>17.6</td>
</tr>
<tr>
<td>104</td>
<td>46</td>
<td>54°06' 163°34'</td>
<td>14</td>
<td>1910</td>
<td>101</td>
<td>14.3</td>
</tr>
<tr>
<td>105</td>
<td>46</td>
<td>54°15' 160°40'</td>
<td>15</td>
<td>0918</td>
<td>150</td>
<td>19.8</td>
</tr>
<tr>
<td>106</td>
<td>47</td>
<td>54°14' 165°57'</td>
<td>15</td>
<td>2055</td>
<td>150</td>
<td>19.5</td>
</tr>
<tr>
<td>107</td>
<td>48</td>
<td>54°38' 156°02'</td>
<td>16</td>
<td>1922</td>
<td>150</td>
<td>20.0</td>
</tr>
<tr>
<td>108</td>
<td>49</td>
<td>55°07' 153°25'</td>
<td>17</td>
<td>0940</td>
<td>149</td>
<td>27.0</td>
</tr>
<tr>
<td>109</td>
<td>50</td>
<td>55°54' 149°24'</td>
<td>18</td>
<td>1118</td>
<td>150</td>
<td>26.6</td>
</tr>
<tr>
<td>110</td>
<td>51</td>
<td>56°53' 145°22'</td>
<td>19</td>
<td>0900</td>
<td>150</td>
<td>21.4</td>
</tr>
<tr>
<td>111</td>
<td>52</td>
<td>48°14' 146°32'</td>
<td>Aug. 10</td>
<td>1637</td>
<td>150</td>
<td>21.6</td>
</tr>
<tr>
<td>112</td>
<td>53</td>
<td>45°09' 170°30'</td>
<td>16</td>
<td>1620</td>
<td>149</td>
<td>18.8</td>
</tr>
<tr>
<td>113</td>
<td>54</td>
<td>42°09' 179°42'</td>
<td>18</td>
<td>1650</td>
<td>150</td>
<td>26.3</td>
</tr>
<tr>
<td>114</td>
<td>682805</td>
<td>53°39' 178°30'</td>
<td>June 13, 1968</td>
<td>1720</td>
<td>-</td>
<td>52.6</td>
</tr>
<tr>
<td>115</td>
<td>68</td>
<td>54°30' 178°30'</td>
<td>14</td>
<td>0105</td>
<td>-</td>
<td>47.5</td>
</tr>
<tr>
<td>116</td>
<td>07</td>
<td>55°30' 178°30'</td>
<td>14</td>
<td>1000</td>
<td>-</td>
<td>46.8</td>
</tr>
<tr>
<td>117</td>
<td>10</td>
<td>58°26' 178°31'</td>
<td>16</td>
<td>0030</td>
<td>-</td>
<td>41.4</td>
</tr>
<tr>
<td>118</td>
<td>11</td>
<td>59°30' 178°30'</td>
<td>16</td>
<td>0920</td>
<td>-</td>
<td>30.0</td>
</tr>
<tr>
<td>119</td>
<td>12</td>
<td>59°26' 176°29'</td>
<td>17</td>
<td>1300</td>
<td>139</td>
<td>20.2</td>
</tr>
<tr>
<td>120</td>
<td>13</td>
<td>59°18' 174°30'</td>
<td>17</td>
<td>2014</td>
<td>-</td>
<td>15.4</td>
</tr>
<tr>
<td>121</td>
<td>14</td>
<td>59°07' 173°00'</td>
<td>18</td>
<td>0441</td>
<td>90</td>
<td>9.4</td>
</tr>
<tr>
<td>122</td>
<td>15</td>
<td>58°59' 169°07'</td>
<td>18</td>
<td>1350</td>
<td>68</td>
<td>7.5</td>
</tr>
<tr>
<td>123</td>
<td>16</td>
<td>58°05' 172°00'</td>
<td>18</td>
<td>2050</td>
<td>-</td>
<td>15.7</td>
</tr>
<tr>
<td>124</td>
<td>17</td>
<td>57°27' 173°29'</td>
<td>19</td>
<td>0350</td>
<td>-</td>
<td>18.2</td>
</tr>
<tr>
<td>125</td>
<td>18</td>
<td>56°27' 178°31'</td>
<td>19</td>
<td>1050</td>
<td>-</td>
<td>9.7</td>
</tr>
<tr>
<td>126</td>
<td>19</td>
<td>55°59' 174°03'</td>
<td>20</td>
<td>1200</td>
<td>-</td>
<td>31.3</td>
</tr>
<tr>
<td>127</td>
<td>21</td>
<td>55°00' 171°59'</td>
<td>20</td>
<td>2250</td>
<td>-</td>
<td>43.8</td>
</tr>
<tr>
<td>128</td>
<td>22</td>
<td>54°35' 168°45'</td>
<td>21</td>
<td>2100</td>
<td>-</td>
<td>28.9</td>
</tr>
<tr>
<td>129</td>
<td>23</td>
<td>55°30' 168°28'</td>
<td>22</td>
<td>1130</td>
<td>-</td>
<td>47.1</td>
</tr>
<tr>
<td>130</td>
<td>24</td>
<td>58°00' 168°30'</td>
<td>23</td>
<td>0650</td>
<td>-</td>
<td>10.8</td>
</tr>
<tr>
<td>131</td>
<td>25</td>
<td>59°00' 168°32'</td>
<td>23</td>
<td>1310</td>
<td>-</td>
<td>2.7</td>
</tr>
<tr>
<td>132</td>
<td>26</td>
<td>58°47' 166°52'</td>
<td>23</td>
<td>1830</td>
<td>40</td>
<td>1.2</td>
</tr>
<tr>
<td>133</td>
<td>27</td>
<td>57°31' 164°59'</td>
<td>24</td>
<td>0715</td>
<td>-</td>
<td>6.3</td>
</tr>
<tr>
<td>134</td>
<td>28</td>
<td>57°00' 164°44'</td>
<td>24</td>
<td>1150</td>
<td>-</td>
<td>8.3</td>
</tr>
<tr>
<td>135</td>
<td>29</td>
<td>56°20' 164°03'</td>
<td>24</td>
<td>3150</td>
<td>83</td>
<td>9.3</td>
</tr>
<tr>
<td>136</td>
<td>30</td>
<td>55°05' 165°07'</td>
<td>25</td>
<td>1150</td>
<td>-</td>
<td>15.4</td>
</tr>
</tbody>
</table>
## Appendix IA. Continued.

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Position</th>
<th>LZT</th>
<th>Estimated depth of haul (m)</th>
<th>Volume of water filtered (m³)</th>
<th>Wet weight of sample (g/1000 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>137</td>
<td>682836</td>
<td>54°59'N 164°59'W</td>
<td>June 25, 1988</td>
<td>1715</td>
<td>110</td>
<td>14.7</td>
</tr>
<tr>
<td>138</td>
<td>37</td>
<td>55°50'N 163°00'</td>
<td></td>
<td>26</td>
<td>1020</td>
<td>87</td>
</tr>
<tr>
<td>139</td>
<td>39</td>
<td>57°02'N 163°02'</td>
<td></td>
<td>26</td>
<td>1100</td>
<td>65</td>
</tr>
<tr>
<td>140</td>
<td>40</td>
<td>57°50'N 163°00'</td>
<td></td>
<td>26</td>
<td>1600</td>
<td>45</td>
</tr>
<tr>
<td>141</td>
<td>41</td>
<td>57°30'N 163°00'</td>
<td></td>
<td>26</td>
<td>2030</td>
<td>52</td>
</tr>
<tr>
<td>142</td>
<td>50</td>
<td>56°35'N 164°59'</td>
<td>July 3</td>
<td>1340</td>
<td>82</td>
<td>14.4</td>
</tr>
<tr>
<td>143</td>
<td>51</td>
<td>58°15'N 137°32'</td>
<td></td>
<td>14</td>
<td>0630</td>
<td>115</td>
</tr>
<tr>
<td>144</td>
<td>52</td>
<td>57°37'N 137°10'</td>
<td></td>
<td>14</td>
<td>1000</td>
<td>185</td>
</tr>
<tr>
<td>145</td>
<td>53</td>
<td>59°04'N 139°48'</td>
<td></td>
<td>15</td>
<td>0830</td>
<td>100</td>
</tr>
<tr>
<td>146</td>
<td>54</td>
<td>58°52'N 139°52'</td>
<td></td>
<td>15</td>
<td>1100</td>
<td>192</td>
</tr>
<tr>
<td>147</td>
<td>56</td>
<td>58°32'N 139°36'</td>
<td></td>
<td>16</td>
<td>1030</td>
<td>—</td>
</tr>
<tr>
<td>148</td>
<td>57</td>
<td>59°25'N 141°10'</td>
<td></td>
<td>17</td>
<td>0630</td>
<td>173</td>
</tr>
<tr>
<td>149</td>
<td>58</td>
<td>59°35'N 146°58'</td>
<td></td>
<td>18</td>
<td>1700</td>
<td>—</td>
</tr>
<tr>
<td>150</td>
<td>59</td>
<td>58°50'N 149°03'</td>
<td></td>
<td>19</td>
<td>0615</td>
<td>185</td>
</tr>
<tr>
<td>151</td>
<td>60</td>
<td>55°00'N 164°58'</td>
<td></td>
<td>26</td>
<td>1600</td>
<td>—</td>
</tr>
<tr>
<td>152</td>
<td>61</td>
<td>55°52'N 164°54'</td>
<td></td>
<td>26</td>
<td>2245</td>
<td>103</td>
</tr>
<tr>
<td>153</td>
<td>62</td>
<td>56°30'N 164°58'</td>
<td></td>
<td>37</td>
<td>1850</td>
<td>83</td>
</tr>
<tr>
<td>154</td>
<td>63</td>
<td>67°00'N 165°00'</td>
<td></td>
<td>27</td>
<td>1900</td>
<td>75</td>
</tr>
<tr>
<td>155</td>
<td>64</td>
<td>57°30'N 165°00'</td>
<td></td>
<td>27</td>
<td>2200</td>
<td>67</td>
</tr>
<tr>
<td>156</td>
<td>67</td>
<td>60°00'N 165°00'</td>
<td></td>
<td>31</td>
<td>0630</td>
<td>44</td>
</tr>
<tr>
<td>157</td>
<td>68</td>
<td>61°00'N 168°37'</td>
<td>Aug. 1</td>
<td>1230</td>
<td>35</td>
<td>7.7</td>
</tr>
<tr>
<td>158</td>
<td>69</td>
<td>62°00'N 167°59'</td>
<td></td>
<td>1800</td>
<td>30</td>
<td>6.5</td>
</tr>
<tr>
<td>159</td>
<td>70</td>
<td>62°14'N 170°00'</td>
<td></td>
<td>2045</td>
<td>44</td>
<td>6.3</td>
</tr>
<tr>
<td>160</td>
<td>71</td>
<td>63°30'N 172°00'</td>
<td></td>
<td>1645</td>
<td>50</td>
<td>8.9</td>
</tr>
<tr>
<td>161</td>
<td>73</td>
<td>61°30'N 175°00'</td>
<td></td>
<td>1215</td>
<td>91</td>
<td>7.3</td>
</tr>
<tr>
<td>162</td>
<td>74</td>
<td>62°01'N 176°31'</td>
<td></td>
<td>1730</td>
<td>106</td>
<td>31.9</td>
</tr>
<tr>
<td>163</td>
<td>75</td>
<td>63°01'N 177°00'</td>
<td></td>
<td>1230</td>
<td>96</td>
<td>30.5</td>
</tr>
<tr>
<td>164</td>
<td>76</td>
<td>65°00'N 175°00'</td>
<td></td>
<td>1900</td>
<td>84</td>
<td>26.3</td>
</tr>
<tr>
<td>165</td>
<td>77</td>
<td>63°50'N 175°00'</td>
<td></td>
<td>6030</td>
<td>—</td>
<td>21.6</td>
</tr>
<tr>
<td>166</td>
<td>78</td>
<td>63°50'N 177°00'</td>
<td></td>
<td>6030</td>
<td>92</td>
<td>38.7</td>
</tr>
<tr>
<td>167</td>
<td>79</td>
<td>63°49'N 179°01'</td>
<td></td>
<td>1110</td>
<td>—</td>
<td>22.4</td>
</tr>
<tr>
<td>168</td>
<td>80</td>
<td>63°00'N 179°01'</td>
<td></td>
<td>0445</td>
<td>—</td>
<td>69.9</td>
</tr>
</tbody>
</table>
Appendix IB. Full data on chaetognath species collected by vertical hauls with a Norpac net Ocean during four summer cruises of "Oshoro Maru" in 1957, 1959, 1960 and

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Wet weight of sample (g/1000 m³)</th>
<th>Wet weight of chaetognaths (g/1000 m³)</th>
<th>Percentage of weight of chaetognaths to whole zooplankton (%)</th>
<th>Sagitta lyra</th>
<th>S. scrippsae</th>
<th>S. maxima</th>
<th>S. elegans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>573901</td>
<td>216</td>
<td>47.7</td>
<td>22.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7958</td>
</tr>
<tr>
<td>2</td>
<td>02</td>
<td>255</td>
<td>12.0</td>
<td>4.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4853</td>
</tr>
<tr>
<td>3</td>
<td>03</td>
<td>83</td>
<td>8.0</td>
<td>2.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5542</td>
</tr>
<tr>
<td>4</td>
<td>04</td>
<td>147</td>
<td>11.0</td>
<td>7.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2403</td>
</tr>
<tr>
<td>5</td>
<td>05</td>
<td>92</td>
<td>11.2</td>
<td>12.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4593</td>
</tr>
<tr>
<td>6</td>
<td>06</td>
<td>49</td>
<td>5.2</td>
<td>10.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2614</td>
</tr>
<tr>
<td>7</td>
<td>07</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>281</td>
</tr>
<tr>
<td>8</td>
<td>08</td>
<td>41</td>
<td>2.1</td>
<td>5.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>341</td>
</tr>
<tr>
<td>9</td>
<td>09</td>
<td>8</td>
<td>0.6</td>
<td>7.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>39</td>
<td>2.6</td>
<td>6.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>674</td>
</tr>
<tr>
<td>11</td>
<td>13</td>
<td>26</td>
<td>1.3</td>
<td>5.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>149</td>
</tr>
<tr>
<td>12</td>
<td>16</td>
<td>39</td>
<td>2.8</td>
<td>7.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>349</td>
</tr>
<tr>
<td>13</td>
<td>17</td>
<td>6</td>
<td>0.2</td>
<td>3.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>14</td>
<td>19</td>
<td>34</td>
<td>2.1</td>
<td>6.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1701</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>58</td>
<td>4.2</td>
<td>7.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>529</td>
</tr>
<tr>
<td>16</td>
<td>21</td>
<td>13</td>
<td>3.4</td>
<td>26.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>977</td>
</tr>
<tr>
<td>17</td>
<td>11</td>
<td>154</td>
<td>18.3</td>
<td>11.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2530</td>
</tr>
<tr>
<td>18</td>
<td>23</td>
<td>39</td>
<td>8.6</td>
<td>22.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1547</td>
</tr>
<tr>
<td>19</td>
<td>24</td>
<td>150</td>
<td>32.9</td>
<td>21.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4995</td>
</tr>
<tr>
<td>20</td>
<td>594481</td>
<td>614</td>
<td>35.1</td>
<td>4.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1739</td>
</tr>
<tr>
<td>21</td>
<td>02</td>
<td>543</td>
<td>55.6</td>
<td>10.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2495</td>
</tr>
<tr>
<td>22</td>
<td>03</td>
<td>233</td>
<td>17.0</td>
<td>7.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2258</td>
</tr>
<tr>
<td>23</td>
<td>04</td>
<td>625</td>
<td>60.2</td>
<td>9.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3092</td>
</tr>
<tr>
<td>24</td>
<td>05</td>
<td>158</td>
<td>16.9</td>
<td>10.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>635</td>
</tr>
<tr>
<td>25</td>
<td>06</td>
<td>522</td>
<td>34.6</td>
<td>6.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1710</td>
</tr>
<tr>
<td>26</td>
<td>07</td>
<td>244</td>
<td>10.9</td>
<td>4.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>636</td>
</tr>
<tr>
<td>27</td>
<td>08</td>
<td>350</td>
<td>36.2</td>
<td>10.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1895</td>
</tr>
<tr>
<td>28</td>
<td>09</td>
<td>128</td>
<td>10.3</td>
<td>8.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>677</td>
</tr>
<tr>
<td>29</td>
<td>10</td>
<td>150</td>
<td>17.2</td>
<td>11.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>986</td>
</tr>
<tr>
<td>30</td>
<td>11</td>
<td>88</td>
<td>2.3</td>
<td>2.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>132</td>
</tr>
<tr>
<td>31</td>
<td>12</td>
<td>128</td>
<td>5.9</td>
<td>4.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>444</td>
</tr>
<tr>
<td>32</td>
<td>14</td>
<td>106</td>
<td>8.7</td>
<td>1.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2482</td>
</tr>
<tr>
<td>33</td>
<td>15</td>
<td>85</td>
<td>4.7</td>
<td>5.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>289</td>
</tr>
<tr>
<td>34</td>
<td>16</td>
<td>445</td>
<td>17.6</td>
<td>4.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2810</td>
</tr>
<tr>
<td>35</td>
<td>40</td>
<td>174</td>
<td>8.0</td>
<td>4.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7647</td>
</tr>
<tr>
<td>36</td>
<td>41</td>
<td>19</td>
<td>4.4</td>
<td>23.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7457</td>
</tr>
<tr>
<td>37</td>
<td>42</td>
<td>270</td>
<td>4.8</td>
<td>1.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4188</td>
</tr>
<tr>
<td>38</td>
<td>43</td>
<td>461</td>
<td>10.1</td>
<td>2.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6970</td>
</tr>
<tr>
<td>39</td>
<td>44</td>
<td>404</td>
<td>20.9</td>
<td>5.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7954</td>
</tr>
<tr>
<td>40</td>
<td>45</td>
<td>820</td>
<td>17.1</td>
<td>2.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5685</td>
</tr>
<tr>
<td>41</td>
<td>46</td>
<td>527</td>
<td>21.4</td>
<td>4.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4407</td>
</tr>
<tr>
<td>42</td>
<td>47</td>
<td>663</td>
<td>13.3</td>
<td>2.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3132</td>
</tr>
<tr>
<td>43</td>
<td>48</td>
<td>693</td>
<td>13.6</td>
<td>2.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2111</td>
</tr>
<tr>
<td>44</td>
<td>49</td>
<td>771</td>
<td>44.5</td>
<td>5.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15374</td>
</tr>
<tr>
<td>45</td>
<td>50</td>
<td>292</td>
<td>19.0</td>
<td>5.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5688</td>
</tr>
<tr>
<td>46</td>
<td>51</td>
<td>407</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3679</td>
</tr>
<tr>
<td>47</td>
<td>52</td>
<td>395</td>
<td>19.0</td>
<td>5.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2929</td>
</tr>
<tr>
<td>48</td>
<td>53</td>
<td>634</td>
<td>44.4</td>
<td>7.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9703</td>
</tr>
<tr>
<td>49</td>
<td>54</td>
<td>474</td>
<td>13.6</td>
<td>2.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4138</td>
</tr>
</tbody>
</table>
1976] KOTORI: Biology of Chaetognatha

from the upper 150-m water column in the Bering Sea and northern North Pacific 1968.

per 1000 m³ | S. nagae | S. minima | Eukrohnia hamata | Unidentified | Total |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>500</td>
<td>42</td>
<td>8500</td>
<td>46.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>736</td>
<td>490</td>
<td>6079</td>
<td>10.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>458</td>
<td>542</td>
<td>4542</td>
<td>7.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4574</td>
<td>426</td>
<td>7403</td>
<td>6.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1566</td>
<td>482</td>
<td>4056</td>
<td>8.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>550</td>
<td>177</td>
<td>3215</td>
<td>4.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>211</td>
<td>0</td>
<td>562</td>
<td>0.4</td>
</tr>
<tr>
<td>38</td>
<td>0</td>
<td>3409</td>
<td>379</td>
<td>4281</td>
<td>0.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>332</td>
<td>0</td>
<td>387</td>
<td>0.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2092</td>
<td>213</td>
<td>3131</td>
<td>1.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>223</td>
<td>74</td>
<td>669</td>
<td>0.7</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3406</td>
<td>87</td>
<td>3842</td>
<td>1.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>254</td>
<td>21</td>
<td>359</td>
<td>0.0</td>
</tr>
<tr>
<td>156</td>
<td>156</td>
<td>102</td>
<td>646</td>
<td>3183</td>
<td>1.2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>96</td>
<td>0</td>
<td>635</td>
<td>4.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>130</td>
<td>293</td>
<td>1453</td>
<td>5.1</td>
</tr>
<tr>
<td>0</td>
<td>66</td>
<td>66</td>
<td>0</td>
<td>2362</td>
<td>18.1</td>
</tr>
<tr>
<td>0</td>
<td>55</td>
<td>359</td>
<td>221</td>
<td>2182</td>
<td>8.1</td>
</tr>
<tr>
<td>0</td>
<td>228</td>
<td>4601</td>
<td>228</td>
<td>9962</td>
<td>24.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>5131</td>
<td>0</td>
<td>6860</td>
<td>10.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>12977</td>
<td>0</td>
<td>15382</td>
<td>30.0</td>
</tr>
<tr>
<td>0</td>
<td>48</td>
<td>9710</td>
<td>0</td>
<td>13850</td>
<td>31.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>7961</td>
<td>0</td>
<td>8586</td>
<td>5.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4301</td>
<td>0</td>
<td>6011</td>
<td>24.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>291</td>
<td>0</td>
<td>837</td>
<td>10.7</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>5333</td>
<td>0</td>
<td>7218</td>
<td>26.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1226</td>
<td>0</td>
<td>1935</td>
<td>7.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3350</td>
<td>0</td>
<td>4366</td>
<td>14.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2981</td>
<td>0</td>
<td>3013</td>
<td>0.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>5259</td>
<td>0</td>
<td>5703</td>
<td>3.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>5217</td>
<td>0</td>
<td>7645</td>
<td>1.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3041</td>
<td>0</td>
<td>3323</td>
<td>1.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>8905</td>
<td>0</td>
<td>11715</td>
<td>0.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>66</td>
<td>0</td>
<td>7467</td>
<td>8.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>35</td>
<td>0</td>
<td>7643</td>
<td>4.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2692</td>
<td>0</td>
<td>6880</td>
<td>2.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1780</td>
<td>0</td>
<td>8750</td>
<td>2.7</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>7438</td>
<td>83</td>
<td>15455</td>
<td>14.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4673</td>
<td>89</td>
<td>10447</td>
<td>13.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>9556</td>
<td>111</td>
<td>14074</td>
<td>8.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>6904</td>
<td>36</td>
<td>10072</td>
<td>6.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4556</td>
<td>74</td>
<td>6778</td>
<td>6.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>14486</td>
<td>0</td>
<td>29860</td>
<td>20.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>8546</td>
<td>0</td>
<td>15114</td>
<td>—</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>12111</td>
<td>0</td>
<td>15880</td>
<td>—</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4314</td>
<td>0</td>
<td>7206</td>
<td>14.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>390</td>
<td>0</td>
<td>10693</td>
<td>43.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2716</td>
<td>0</td>
<td>6634</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Wet weight (g/1000 m³)

<table>
<thead>
<tr>
<th>S. elegans</th>
<th>Eukrohnia hamata</th>
<th>Other chaetognaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>46.5</td>
<td>1.2</td>
<td>0.0</td>
</tr>
<tr>
<td>10.6</td>
<td>1.2</td>
<td>0.2</td>
</tr>
<tr>
<td>7.5</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>6.3</td>
<td>4.0</td>
<td>0.1</td>
</tr>
<tr>
<td>8.4</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>4.3</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>4.7</td>
<td>1.1</td>
<td>0.2</td>
</tr>
<tr>
<td>0.4</td>
<td>1.6</td>
<td>0.1</td>
</tr>
<tr>
<td>0.4</td>
<td>1.6</td>
<td>0.1</td>
</tr>
<tr>
<td>1.0</td>
<td>1.5</td>
<td>0.2</td>
</tr>
<tr>
<td>0.7</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>1.1</td>
<td>1.6</td>
<td>0.2</td>
</tr>
<tr>
<td>0.0</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>1.3</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4.3</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>5.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>18.1</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>8.1</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>24.9</td>
<td>7.7</td>
<td>0.5</td>
</tr>
<tr>
<td>19.9</td>
<td>14.2</td>
<td>0.0</td>
</tr>
<tr>
<td>30.0</td>
<td>25.6</td>
<td>0.0</td>
</tr>
<tr>
<td>2.8</td>
<td>14.6</td>
<td>0.0</td>
</tr>
<tr>
<td>31.5</td>
<td>28.9</td>
<td>0.0</td>
</tr>
<tr>
<td>5.6</td>
<td>11.3</td>
<td>0.0</td>
</tr>
<tr>
<td>24.5</td>
<td>10.1</td>
<td>0.0</td>
</tr>
<tr>
<td>10.7</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>26.0</td>
<td>10.2</td>
<td>0.0</td>
</tr>
<tr>
<td>7.4</td>
<td>2.9</td>
<td>0.0</td>
</tr>
<tr>
<td>14.9</td>
<td>2.3</td>
<td>0.0</td>
</tr>
<tr>
<td>0.3</td>
<td>2.1</td>
<td>0.0</td>
</tr>
<tr>
<td>3.1</td>
<td>2.8</td>
<td>0.0</td>
</tr>
<tr>
<td>1.3</td>
<td>7.4</td>
<td>0.0</td>
</tr>
<tr>
<td>1.8</td>
<td>2.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0.9</td>
<td>16.7</td>
<td>0.0</td>
</tr>
<tr>
<td>8.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4.3</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>2.4</td>
<td>2.4</td>
<td>0.0</td>
</tr>
<tr>
<td>2.7</td>
<td>1.4</td>
<td>0.0</td>
</tr>
<tr>
<td>14.9</td>
<td>6.0</td>
<td>0.0</td>
</tr>
<tr>
<td>13.9</td>
<td>3.1</td>
<td>0.0</td>
</tr>
<tr>
<td>8.6</td>
<td>12.8</td>
<td>0.0</td>
</tr>
<tr>
<td>6.1</td>
<td>7.1</td>
<td>0.1</td>
</tr>
<tr>
<td>6.4</td>
<td>7.0</td>
<td>0.2</td>
</tr>
<tr>
<td>20.8</td>
<td>23.7</td>
<td>0.0</td>
</tr>
<tr>
<td>0.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>0.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>0.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>0.0</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

- 163 -
## Appendix

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Wet weight of sample (g/1000 m³)</th>
<th>Wet weight of chaetognaths (g/1000 m³)</th>
<th>Percentage of weight of chaetognaths to whole zooplankton (%)</th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sagitta lyra</td>
<td>S. saccata</td>
</tr>
<tr>
<td>50</td>
<td>59455</td>
<td>41</td>
<td>1.5</td>
<td>3.7</td>
<td>0</td>
</tr>
<tr>
<td>51</td>
<td>56</td>
<td>438</td>
<td>11.9</td>
<td>2.7</td>
<td>0</td>
</tr>
<tr>
<td>52</td>
<td>57</td>
<td>201</td>
<td>17.5</td>
<td>8.7</td>
<td>0</td>
</tr>
<tr>
<td>53</td>
<td>58</td>
<td>44</td>
<td>4.2</td>
<td>9.5</td>
<td>0</td>
</tr>
<tr>
<td>54</td>
<td>60</td>
<td>82</td>
<td>3.2</td>
<td>3.9</td>
<td>0</td>
</tr>
<tr>
<td>55</td>
<td>61</td>
<td>122</td>
<td>7.9</td>
<td>6.5</td>
<td>0</td>
</tr>
<tr>
<td>56</td>
<td>62</td>
<td>92</td>
<td>35.5</td>
<td>38.6</td>
<td>0</td>
</tr>
<tr>
<td>57</td>
<td>64</td>
<td>148</td>
<td>26.2</td>
<td>17.7</td>
<td>0</td>
</tr>
<tr>
<td>58</td>
<td>65</td>
<td>483</td>
<td>19.5</td>
<td>4.0</td>
<td>0</td>
</tr>
<tr>
<td>59</td>
<td>66</td>
<td>—</td>
<td>5.9</td>
<td>—</td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>67</td>
<td>376</td>
<td>45.7</td>
<td>12.2</td>
<td>0</td>
</tr>
<tr>
<td>61</td>
<td>604601</td>
<td>507.6</td>
<td>40.3</td>
<td>7.9</td>
<td>0</td>
</tr>
<tr>
<td>62</td>
<td>02</td>
<td>247.3</td>
<td>33.3</td>
<td>13.5</td>
<td>0</td>
</tr>
<tr>
<td>63</td>
<td>03</td>
<td>46.3</td>
<td>6.0</td>
<td>13.0</td>
<td>0</td>
</tr>
<tr>
<td>64</td>
<td>04</td>
<td>35.7</td>
<td>10.0</td>
<td>28.0</td>
<td>0</td>
</tr>
<tr>
<td>65</td>
<td>05</td>
<td>10.0</td>
<td>10.0</td>
<td>100.0</td>
<td>0</td>
</tr>
<tr>
<td>66</td>
<td>07</td>
<td>163.4</td>
<td>38.9</td>
<td>23.8</td>
<td>0</td>
</tr>
<tr>
<td>67</td>
<td>08</td>
<td>269.1</td>
<td>14.0</td>
<td>5.2</td>
<td>0</td>
</tr>
<tr>
<td>68</td>
<td>09</td>
<td>122.4</td>
<td>5.0</td>
<td>4.1</td>
<td>0</td>
</tr>
<tr>
<td>69</td>
<td>10</td>
<td>290.8</td>
<td>18.4</td>
<td>6.3</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>11</td>
<td>540.9</td>
<td>9.9</td>
<td>1.8</td>
<td>0</td>
</tr>
<tr>
<td>71</td>
<td>12</td>
<td>319.4</td>
<td>24.9</td>
<td>7.8</td>
<td>0</td>
</tr>
<tr>
<td>72</td>
<td>13</td>
<td>455.0</td>
<td>22.7</td>
<td>5.0</td>
<td>0</td>
</tr>
<tr>
<td>73</td>
<td>14</td>
<td>594.5</td>
<td>25.2</td>
<td>4.2</td>
<td>0</td>
</tr>
<tr>
<td>74</td>
<td>15</td>
<td>108.5</td>
<td>2.1</td>
<td>1.9</td>
<td>0</td>
</tr>
<tr>
<td>75</td>
<td>16</td>
<td>301.9</td>
<td>6.9</td>
<td>2.3</td>
<td>0</td>
</tr>
<tr>
<td>76</td>
<td>17</td>
<td>209.9</td>
<td>3.1</td>
<td>1.5</td>
<td>0</td>
</tr>
<tr>
<td>77</td>
<td>18</td>
<td>329.4</td>
<td>21.9</td>
<td>6.6</td>
<td>0</td>
</tr>
<tr>
<td>78</td>
<td>19</td>
<td>123.8</td>
<td>0.1</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>79</td>
<td>20</td>
<td>205.6</td>
<td>1.1</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>80</td>
<td>21</td>
<td>72.5</td>
<td>11.1</td>
<td>15.3</td>
<td>0</td>
</tr>
<tr>
<td>81</td>
<td>22</td>
<td>176.7</td>
<td>8.6</td>
<td>4.9</td>
<td>0</td>
</tr>
<tr>
<td>82</td>
<td>23</td>
<td>227.9</td>
<td>10.4</td>
<td>4.6</td>
<td>0</td>
</tr>
<tr>
<td>83</td>
<td>24</td>
<td>161.8</td>
<td>5.3</td>
<td>3.3</td>
<td>0</td>
</tr>
<tr>
<td>84</td>
<td>25</td>
<td>214.5</td>
<td>24.4</td>
<td>11.4</td>
<td>0</td>
</tr>
<tr>
<td>85</td>
<td>26</td>
<td>254.8</td>
<td>7.6</td>
<td>3.0</td>
<td>0</td>
</tr>
<tr>
<td>86</td>
<td>27</td>
<td>326.9</td>
<td>10.6</td>
<td>3.2</td>
<td>0</td>
</tr>
<tr>
<td>87</td>
<td>28</td>
<td>291.3</td>
<td>10.9</td>
<td>3.7</td>
<td>0</td>
</tr>
<tr>
<td>88</td>
<td>29</td>
<td>210.5</td>
<td>10.5</td>
<td>5.0</td>
<td>0</td>
</tr>
<tr>
<td>89</td>
<td>30</td>
<td>504.2</td>
<td>27.4</td>
<td>5.4</td>
<td>0</td>
</tr>
<tr>
<td>90</td>
<td>31</td>
<td>723.7</td>
<td>2.9</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>91</td>
<td>32</td>
<td>172.1</td>
<td>12.8</td>
<td>7.4</td>
<td>0</td>
</tr>
<tr>
<td>92</td>
<td>33</td>
<td>271.3</td>
<td>11.4</td>
<td>4.2</td>
<td>0</td>
</tr>
<tr>
<td>93</td>
<td>34</td>
<td>92.4</td>
<td>30.1</td>
<td>33.6</td>
<td>0</td>
</tr>
<tr>
<td>94</td>
<td>35</td>
<td>296.7</td>
<td>137.1</td>
<td>60.5</td>
<td>0</td>
</tr>
<tr>
<td>95</td>
<td>36</td>
<td>107.1</td>
<td>30.4</td>
<td>28.4</td>
<td>0</td>
</tr>
<tr>
<td>96</td>
<td>37</td>
<td>406.8</td>
<td>151.0</td>
<td>37.1</td>
<td>0</td>
</tr>
<tr>
<td>97</td>
<td>38</td>
<td>107.7</td>
<td>17.2</td>
<td>16.0</td>
<td>0</td>
</tr>
<tr>
<td>98</td>
<td>39</td>
<td>127.7</td>
<td>40.0</td>
<td>31.3</td>
<td>0</td>
</tr>
</tbody>
</table>

---

- 164 -
IB. Continued.

<table>
<thead>
<tr>
<th>S. naga</th>
<th>S. minima</th>
<th>Eukrohnia hamata</th>
<th>Unidentified</th>
<th>Total</th>
<th>Sagitta elegans</th>
<th>Eukrohnia hamata</th>
<th>Other chaetognaths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>273</td>
<td>0</td>
<td>1046</td>
<td>1.4</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1576</td>
<td>0</td>
<td>3990</td>
<td>11.2</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4158</td>
<td>0</td>
<td>6437</td>
<td>10.3</td>
<td>7.3</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>55</td>
<td>0</td>
<td>276</td>
<td>4.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1905</td>
<td>0</td>
<td>3290</td>
<td>2.6</td>
<td>0.6</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1378</td>
<td>0</td>
<td>3735</td>
<td>6.9</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2750</td>
<td>0</td>
<td>10417</td>
<td>30.6</td>
<td>4.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3068</td>
<td>0</td>
<td>14773</td>
<td>21.0</td>
<td>5.2</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2692</td>
<td>0</td>
<td>8125</td>
<td>13.3</td>
<td>6.2</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>542</td>
<td>0</td>
<td>1334</td>
<td>5.3</td>
<td>0.6</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>11927</td>
<td>0</td>
<td>14921</td>
<td>33.9</td>
<td>11.8</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>9886</td>
<td>38</td>
<td>11477</td>
<td>23.6</td>
<td>16.4</td>
<td>0.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>7654</td>
<td>54</td>
<td>8925</td>
<td>17.4</td>
<td>15.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>46</td>
<td>0</td>
<td>879</td>
<td>6.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>110</td>
<td>0</td>
<td>1072</td>
<td>9.9</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>800</td>
<td>10.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3269</td>
<td>272</td>
<td>11206</td>
<td>34.9</td>
<td>3.6</td>
<td>0.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>1446</td>
<td>14.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1097</td>
<td>0</td>
<td>2194</td>
<td>3.8</td>
<td>1.2</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>816</td>
<td>0</td>
<td>3121</td>
<td>18.0</td>
<td>0.4</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3385</td>
<td>156</td>
<td>8210</td>
<td>7.8</td>
<td>2.0</td>
<td>0.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>7917</td>
<td>208</td>
<td>11944</td>
<td>15.8</td>
<td>2.0</td>
<td>0.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>750</td>
<td>250</td>
<td>6400</td>
<td>22.3</td>
<td>0.4</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3504</td>
<td>276</td>
<td>10945</td>
<td>23.3</td>
<td>1.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1085</td>
<td>185</td>
<td>2487</td>
<td>0.6</td>
<td>1.3</td>
<td>0.2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1536</td>
<td>270</td>
<td>5984</td>
<td>5.0</td>
<td>1.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>41</td>
<td>82</td>
<td>2798</td>
<td>3.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>422</td>
<td>127</td>
<td>6963</td>
<td>21.6</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>3911</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>561</td>
<td>140</td>
<td>5374</td>
<td>0.9</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1256</td>
<td>155</td>
<td>7409</td>
<td>10.4</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>80</td>
<td>6546</td>
<td>8.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1803</td>
<td>68</td>
<td>8198</td>
<td>8.8</td>
<td>1.5</td>
<td>0.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2941</td>
<td>37</td>
<td>6544</td>
<td>2.2</td>
<td>3.1</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>761</td>
<td>0</td>
<td>2976</td>
<td>23.5</td>
<td>0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>837</td>
<td>76</td>
<td>7467</td>
<td>6.7</td>
<td>0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>192</td>
<td>77</td>
<td>3654</td>
<td>10.4</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>44</td>
<td>130</td>
<td>9304</td>
<td>10.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>287</td>
<td>144</td>
<td>8421</td>
<td>10.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>6650</td>
<td>250</td>
<td>15458</td>
<td>21.5</td>
<td>5.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>33</td>
<td>195</td>
<td>5033</td>
<td>12.6</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>213</td>
<td>2979</td>
<td>11.0</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>84</td>
<td>17143</td>
<td>30.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>37467</td>
<td>137.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>53929</td>
<td>30.4</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21356</td>
<td>151.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>104615</td>
<td>17.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>164681</td>
<td>40.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
### Appendix

<table>
<thead>
<tr>
<th>No.</th>
<th>No. of station</th>
<th>Wet weight of sample (g/1000 m³)</th>
<th>Wet weight of chaetognaths (g/1000 m³)</th>
<th>Percentage of weight of chaetognaths to whole zooplankton (%)</th>
<th>Sagitta lyra</th>
<th>Sagitta scrippae</th>
<th>Sagitta maxima</th>
<th>Sagitta elegans</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>604640</td>
<td>336.5</td>
<td>50.6</td>
<td>15.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>196531</td>
</tr>
<tr>
<td>100</td>
<td>41</td>
<td>170.7</td>
<td>7.6</td>
<td>4.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>34878</td>
</tr>
<tr>
<td>101</td>
<td>42</td>
<td>333.3</td>
<td>23.5</td>
<td>7.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15235</td>
</tr>
<tr>
<td>102</td>
<td>43</td>
<td>40.4</td>
<td>5.4</td>
<td>13.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11010</td>
</tr>
<tr>
<td>103</td>
<td>44</td>
<td>85.2</td>
<td>0.6</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1259</td>
</tr>
<tr>
<td>104</td>
<td>45</td>
<td>21.0</td>
<td>0.5</td>
<td>2.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2378</td>
</tr>
<tr>
<td>105</td>
<td>46</td>
<td>237.4</td>
<td>3.4</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3199</td>
</tr>
<tr>
<td>106</td>
<td>47</td>
<td>253.9</td>
<td>35.2</td>
<td>13.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11347</td>
</tr>
<tr>
<td>107</td>
<td>48</td>
<td>395.0</td>
<td>22.0</td>
<td>5.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7600</td>
</tr>
<tr>
<td>108</td>
<td>49</td>
<td>255.6</td>
<td>20.4</td>
<td>8.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19650</td>
</tr>
<tr>
<td>109</td>
<td>50</td>
<td>872.2</td>
<td>11.6</td>
<td>1.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5586</td>
</tr>
<tr>
<td>110</td>
<td>51</td>
<td>4.7</td>
<td>8.5</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1402</td>
</tr>
<tr>
<td>111</td>
<td>52</td>
<td>304.8</td>
<td>3.7</td>
<td>370</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>972</td>
</tr>
<tr>
<td>112</td>
<td>53</td>
<td>154.3</td>
<td>15.6</td>
<td>10.1</td>
<td>1649</td>
<td>53</td>
<td>0</td>
<td>745</td>
</tr>
<tr>
<td>113</td>
<td>54</td>
<td>148.3</td>
<td>7.4</td>
<td>5.0</td>
<td>3156</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>114</td>
<td>55</td>
<td>278.5</td>
<td>12.0</td>
<td>4.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>541</td>
</tr>
<tr>
<td>115</td>
<td>56</td>
<td>570.5</td>
<td>15.0</td>
<td>2.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1705</td>
</tr>
<tr>
<td>116</td>
<td>57</td>
<td>386.7</td>
<td>7.7</td>
<td>2.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>769</td>
</tr>
<tr>
<td>117</td>
<td>58</td>
<td>1032.7</td>
<td>42.1</td>
<td>4.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2418</td>
</tr>
<tr>
<td>118</td>
<td>59</td>
<td>356.8</td>
<td>6.7</td>
<td>1.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>119</td>
<td>60</td>
<td>714.3</td>
<td>2.6</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>120</td>
<td>61</td>
<td>1115.4</td>
<td>31.7</td>
<td>2.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1232</td>
</tr>
<tr>
<td>121</td>
<td>62</td>
<td>1946.0</td>
<td>14.0</td>
<td>1.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33547</td>
</tr>
<tr>
<td>122</td>
<td>63</td>
<td>15</td>
<td>39.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6560</td>
</tr>
<tr>
<td>123</td>
<td>64</td>
<td>1700.7</td>
<td>118.6</td>
<td>7.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20084</td>
</tr>
<tr>
<td>124</td>
<td>65</td>
<td>1880.8</td>
<td>12.0</td>
<td>0.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3963</td>
</tr>
<tr>
<td>125</td>
<td>66</td>
<td>2154.6</td>
<td>12.1</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1609</td>
</tr>
<tr>
<td>126</td>
<td>67</td>
<td>1513.1</td>
<td>6.0</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3679</td>
</tr>
<tr>
<td>127</td>
<td>68</td>
<td>1588.3</td>
<td>13.0</td>
<td>0.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2743</td>
</tr>
<tr>
<td>128</td>
<td>69</td>
<td>1101.5</td>
<td>12.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>692</td>
</tr>
<tr>
<td>129</td>
<td>70</td>
<td>148.6</td>
<td>2.3</td>
<td>1.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>319</td>
</tr>
<tr>
<td>130</td>
<td>71</td>
<td>499.5</td>
<td>60.0</td>
<td>12.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>51852</td>
</tr>
<tr>
<td>131</td>
<td>72</td>
<td>25</td>
<td>35.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10189</td>
</tr>
<tr>
<td>132</td>
<td>73</td>
<td>30</td>
<td>62.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5785</td>
</tr>
<tr>
<td>133</td>
<td>74</td>
<td>571.4</td>
<td>32.3</td>
<td>5.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17302</td>
</tr>
<tr>
<td>134</td>
<td>75</td>
<td>216.4</td>
<td>34.7</td>
<td>16.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6130</td>
</tr>
<tr>
<td>135</td>
<td>76</td>
<td>813.7</td>
<td>72.6</td>
<td>8.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>42937</td>
</tr>
<tr>
<td>136</td>
<td>77</td>
<td>921.5</td>
<td>13.0</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19468</td>
</tr>
<tr>
<td>137</td>
<td>78</td>
<td>260.6</td>
<td>3.6</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>391</td>
</tr>
<tr>
<td>138</td>
<td>79</td>
<td>2773.4</td>
<td>96.7</td>
<td>3.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>49248</td>
</tr>
<tr>
<td>139</td>
<td>80</td>
<td>248.9</td>
<td>45.6</td>
<td>17.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10714</td>
</tr>
<tr>
<td>140</td>
<td>81</td>
<td>183.8</td>
<td>183.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11732</td>
</tr>
<tr>
<td>141</td>
<td>82</td>
<td>566.6</td>
<td>140.7</td>
<td>24.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15156</td>
</tr>
<tr>
<td>142</td>
<td>83</td>
<td>1183.8</td>
<td>52.9</td>
<td>4.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>18176</td>
</tr>
<tr>
<td>143</td>
<td>84</td>
<td>110.1</td>
<td>0.3</td>
<td>0.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>76</td>
</tr>
<tr>
<td>144</td>
<td>85</td>
<td>74.3</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>145</td>
<td>86</td>
<td>1.1</td>
<td>1.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>128</td>
</tr>
<tr>
<td>146</td>
<td>87</td>
<td>1.1</td>
<td>1.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>57</td>
</tr>
<tr>
<td>147</td>
<td>88</td>
<td>66.3</td>
<td>0.9</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>131</td>
</tr>
</tbody>
</table>

- 166 -
### IB. Continued.

<table>
<thead>
<tr>
<th>S. nagae</th>
<th>S. minima</th>
<th>Eukrohnia hamata</th>
<th>Unidentified</th>
<th>Total</th>
<th>Wet weight (g/1000 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Saigita elegans</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Eukrohnia hamata</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Other chaetognaths</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>196531</td>
<td>50.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>34878</td>
<td>7.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10238</td>
<td>23.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11010</td>
<td>5.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>114</td>
<td>0</td>
<td>1564</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>70</td>
<td>0</td>
<td>2445</td>
<td>0.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2131</td>
<td>0</td>
<td>4520</td>
<td>1.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3990</td>
<td>207</td>
<td>5544</td>
<td>27.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7600</td>
<td>22.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2889</td>
<td>222</td>
<td>29741</td>
<td>17.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>790</td>
<td>263</td>
<td>10639</td>
<td>11.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>187</td>
<td>94</td>
<td>1683</td>
<td>0.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3565</td>
<td>0</td>
<td>4907</td>
<td>8.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1330</td>
<td>53</td>
<td>3830</td>
<td>3.2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1553</td>
<td>1458</td>
<td>3352</td>
<td>5.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>358</td>
<td>253</td>
<td>2316</td>
<td>15.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1816</td>
<td>0</td>
<td>2565</td>
<td>6.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1814</td>
<td>169</td>
<td>4401</td>
<td>38.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>87</td>
<td>1333</td>
<td>1400</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>2.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>65</td>
<td>195</td>
<td>1492</td>
<td>23.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>496</td>
<td>33973</td>
<td>14.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>134</td>
<td>584</td>
<td>21341</td>
<td>118.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>248</td>
<td>62</td>
<td>4273</td>
<td>11.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1340</td>
<td>103</td>
<td>3402</td>
<td>5.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>416</td>
<td>160</td>
<td>4255</td>
<td>2.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1600</td>
<td>229</td>
<td>4573</td>
<td>9.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>3599</td>
<td>104</td>
<td>4855</td>
<td>—</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>212</td>
<td>43</td>
<td>574</td>
<td>0.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>9870</td>
<td>3333</td>
<td>58055</td>
<td>56.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4151</td>
<td>1133</td>
<td>15473</td>
<td>28.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>240</td>
<td>240</td>
<td>4273</td>
<td>11.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>318</td>
<td>0</td>
<td>5785</td>
<td>62.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>200</td>
<td>1820</td>
<td>44647</td>
<td>68.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>167</td>
<td>3050</td>
<td>22953</td>
<td>12.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2870</td>
<td>3333</td>
<td>58055</td>
<td>56.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4151</td>
<td>1133</td>
<td>15473</td>
<td>28.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>240</td>
<td>240</td>
<td>4273</td>
<td>11.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>318</td>
<td>0</td>
<td>5785</td>
<td>62.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>200</td>
<td>1820</td>
<td>44647</td>
<td>68.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>167</td>
<td>3050</td>
<td>22953</td>
<td>12.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2870</td>
<td>3333</td>
<td>58055</td>
<td>56.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4151</td>
<td>1133</td>
<td>15473</td>
<td>28.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>240</td>
<td>240</td>
<td>4273</td>
<td>11.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>318</td>
<td>0</td>
<td>5785</td>
<td>62.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>200</td>
<td>1820</td>
<td>44647</td>
<td>68.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>167</td>
<td>3050</td>
<td>22953</td>
<td>12.6</td>
</tr>
</tbody>
</table>
Appendix I

<table>
<thead>
<tr>
<th>No. of station</th>
<th>Wet weight of sample (g/1000 m³)</th>
<th>Wet weight of chaetognaths (g/1000 m³)</th>
<th>Percentage of weight of chaetognaths to whole zooplankton (%)</th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>148</td>
<td>682857</td>
<td>198.9</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>149</td>
<td>58</td>
<td>239.1</td>
<td>4.7</td>
<td>2.0</td>
</tr>
<tr>
<td>150</td>
<td>59</td>
<td>1078.9</td>
<td>3.3</td>
<td>0.3</td>
</tr>
<tr>
<td>151</td>
<td>60</td>
<td>187.5</td>
<td>1.9</td>
<td>1.0</td>
</tr>
<tr>
<td>152</td>
<td>61</td>
<td>478.0</td>
<td>67.2</td>
<td>14.1</td>
</tr>
<tr>
<td>153</td>
<td>62</td>
<td>897.2</td>
<td>74.7</td>
<td>8.3</td>
</tr>
<tr>
<td>154</td>
<td>63</td>
<td>554.7</td>
<td>23.0</td>
<td>4.1</td>
</tr>
<tr>
<td>155</td>
<td>64</td>
<td>371.3</td>
<td>87.3</td>
<td>23.5</td>
</tr>
<tr>
<td>156</td>
<td>67</td>
<td>599.7</td>
<td>34.2</td>
<td>5.7</td>
</tr>
<tr>
<td>157</td>
<td>68</td>
<td>365.1</td>
<td>17.5</td>
<td>4.8</td>
</tr>
<tr>
<td>158</td>
<td>69</td>
<td>201.2</td>
<td>33.9</td>
<td>16.9</td>
</tr>
<tr>
<td>159</td>
<td>70</td>
<td>603.2</td>
<td>23.5</td>
<td>3.9</td>
</tr>
<tr>
<td>160</td>
<td>71</td>
<td>269.1</td>
<td>83.9</td>
<td>31.2</td>
</tr>
<tr>
<td>161</td>
<td>73</td>
<td>-</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>162</td>
<td>74</td>
<td>122.3</td>
<td>12.1</td>
<td>9.9</td>
</tr>
<tr>
<td>163</td>
<td>75</td>
<td>32.8</td>
<td>0.6</td>
<td>1.8</td>
</tr>
<tr>
<td>164</td>
<td>76</td>
<td>136.7</td>
<td>9.1</td>
<td>6.7</td>
</tr>
<tr>
<td>165</td>
<td>77</td>
<td>306.0</td>
<td>15.2</td>
<td>5.0</td>
</tr>
<tr>
<td>166</td>
<td>78</td>
<td>95.7</td>
<td>4.0</td>
<td>4.2</td>
</tr>
<tr>
<td>167</td>
<td>79</td>
<td>152.1</td>
<td>7.7</td>
<td>5.1</td>
</tr>
<tr>
<td>168</td>
<td>80</td>
<td>527.7</td>
<td>34.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Appendix IIA-F. Full data on chaetognath species collected by simultaneous horizontal tows from 50°N to 35°N on Cruise KH-69-4 of "Hakuhō Maru" in the summer of August 1969.

<table>
<thead>
<tr>
<th>No. of station/Position/Date /Time (LZT) /Volume filtered (m³)</th>
<th>KH691/49°53.8’N 154°51.8’W/August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated depth of collection (m)</td>
<td>0</td>
</tr>
<tr>
<td>Wet weight of sample (g/haul) (g/1000 m³)</td>
<td>387.9</td>
</tr>
<tr>
<td>Wet weight of chaetognaths (g/haul) (g/1000 m³)</td>
<td>984.5</td>
</tr>
<tr>
<td>Percentage of weight of chaetognaths to whole zooplankton</td>
<td>0.28</td>
</tr>
<tr>
<td>Individuals per 1000 m³</td>
<td>0.7</td>
</tr>
</tbody>
</table>

- 168 -
IB. Continued.

<table>
<thead>
<tr>
<th>S. nagae</th>
<th>S. minima</th>
<th>Eukrohnia hamata</th>
<th>Unidentified</th>
<th>Total</th>
<th>Sagitta elegans</th>
<th>Eukrohnia hamata</th>
<th>Other chaetognaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1065</td>
<td>32</td>
<td>1323</td>
<td>0.8</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>649</td>
<td>0</td>
<td>842</td>
<td>0.4</td>
<td>2.9</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>44</td>
<td>0</td>
<td>1310</td>
<td>1.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20516</td>
<td>67.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>888</td>
<td>27477</td>
<td>70.3</td>
<td>0.0</td>
<td>4.4</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1574</td>
<td>11055</td>
<td>23.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1407</td>
<td>51282</td>
<td>85.8</td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1349</td>
<td>81859</td>
<td>34.3</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>261</td>
<td>30378</td>
<td>5.7</td>
<td>0.0</td>
<td>11.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>929</td>
<td>12384</td>
<td>18.3</td>
<td>0.0</td>
<td>14.1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23492</td>
<td>25.3</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>561</td>
<td>29621</td>
<td>83.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>63</td>
<td>4831</td>
<td>11.1</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>164</td>
<td>426</td>
<td>0.3</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1291</td>
<td>11166</td>
<td>7.2</td>
<td>0.0</td>
<td>1.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>93</td>
<td>695</td>
<td>14.4</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>517</td>
<td>1655</td>
<td>1.1</td>
<td>0.0</td>
<td>2.9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>134</td>
<td>313</td>
<td>4.7</td>
<td>0.4</td>
<td>2.6</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1258</td>
<td>844</td>
<td>30.8</td>
<td>1.5</td>
<td>3.2</td>
</tr>
</tbody>
</table>

with 9–10 MTD 56-cm nets from the upper 700 m at 4 stations located on long. 155°W 1969.

IIA.

<table>
<thead>
<tr>
<th>88</th>
<th>120</th>
<th>230</th>
<th>350</th>
<th>470</th>
<th>590</th>
<th>700</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.6</td>
<td>39.4</td>
<td>39.8</td>
<td>19.6</td>
<td>2.5</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>72.6</td>
<td>100.0</td>
<td>101.0</td>
<td>49.7</td>
<td>6.3</td>
<td>42.4</td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>1.87</td>
<td>2.11</td>
<td>1.06</td>
<td>0.03</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>4.7</td>
<td>5.4</td>
<td>2.7</td>
<td>1.1</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>4.7</td>
<td>5.3</td>
<td>5.4</td>
<td>1.6</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 96 | 30 | 0 | 6 | 6 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |

— 169 —
### Appendix

#### KH691/49°53.8'N 154°51.8'W/August

<table>
<thead>
<tr>
<th>Estimated depth of collection (m)</th>
<th>0</th>
<th>29</th>
<th>59</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individuals per 1000 m³</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sagitta zetesios</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. macrocephala</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pterosagitta draco</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Eukrohnia hamata</td>
<td>80</td>
<td>16</td>
<td>330</td>
</tr>
<tr>
<td>E. bathypelagica</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Krohnitta subtilis</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Damaged and unidentified</td>
<td>142</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1115</td>
<td>189</td>
<td>386</td>
</tr>
</tbody>
</table>

#### KH691/49°58.5'N 155°24.0'W/August

<table>
<thead>
<tr>
<th>Estimated depth of collection (m)</th>
<th>0</th>
<th>24</th>
<th>47</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wet weight of sample (g/haul)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>12.7</td>
<td>290.0</td>
<td>322.0</td>
</tr>
<tr>
<td>Wet weight of chaetognaths (g/haul)</td>
<td>32.2</td>
<td>736.0</td>
<td>817.3</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>0.01</td>
<td>0.52</td>
<td>1.73</td>
</tr>
<tr>
<td>Percentage of weight of chaetognaths to whole zooplankton</td>
<td>0.03</td>
<td>1.3</td>
<td>4.4</td>
</tr>
<tr>
<td><strong>Individuals per 1000 m³</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sagitta enflata</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. hexastera</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. lyra</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. scrippae</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. elegans</td>
<td>487</td>
<td>5706</td>
<td>3096</td>
</tr>
<tr>
<td>S. nagae</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. pacifica</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. neglecta</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. minima</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. neodecipiens</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. zetesios</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S. macrocephala</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pterosagitta draco</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Eukrohnia hamata</td>
<td>0</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>E. bathypelagica</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Krohnitta subtilis</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Damaged and unidentified</td>
<td>0</td>
<td>0</td>
<td>162</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>487</td>
<td>5706</td>
<td>3278</td>
</tr>
</tbody>
</table>

---
### IIA. Continued.

**23-24, 1969/2345-0045/394**

<table>
<thead>
<tr>
<th>88</th>
<th>120</th>
<th>230</th>
<th>350</th>
<th>470</th>
<th>590</th>
<th>700</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>1117</td>
<td>1299</td>
<td>7629</td>
<td>3041</td>
<td>822</td>
<td>58</td>
<td>513</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>995</td>
<td>16</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1213</td>
<td>1319</td>
<td>7659</td>
<td>3057</td>
<td>1823</td>
<td>78</td>
<td>763</td>
</tr>
</tbody>
</table>

### IIB.

**25, 1969/0910-1010/394**

<table>
<thead>
<tr>
<th>71</th>
<th>94</th>
<th>190</th>
<th>290</th>
<th>380</th>
<th>470</th>
</tr>
</thead>
<tbody>
<tr>
<td>64.1</td>
<td>46.5</td>
<td>145.3</td>
<td>167.6</td>
<td>242.7</td>
<td>143.9</td>
</tr>
<tr>
<td>162.7</td>
<td>118.0</td>
<td>368.0</td>
<td>425.4</td>
<td>616.0</td>
<td>362.7</td>
</tr>
<tr>
<td>1.69</td>
<td>1.38</td>
<td>4.04</td>
<td>1.80</td>
<td>1.10</td>
<td>1.86</td>
</tr>
<tr>
<td>4.3</td>
<td>3.5</td>
<td>10.3</td>
<td>4.6</td>
<td>2.8</td>
<td>3.5</td>
</tr>
<tr>
<td>2.6</td>
<td>3.0</td>
<td>2.3</td>
<td>1.1</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3731</th>
<th>350</th>
<th>360</th>
<th>40</th>
<th>80</th>
<th>152</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>294</td>
</tr>
<tr>
<td>482</td>
<td>4765</td>
<td>9964</td>
<td>1476</td>
<td>8772</td>
<td>5479</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>66</td>
<td>5025</td>
<td>10330</td>
<td>4766</td>
<td>9012</td>
<td>5945</td>
</tr>
</tbody>
</table>
**Appendix**

### No. of station/Position/Date /Time (LZT)/Volume filtered (m³) KH092/45°00.7’N 154°57.2’W/August

<table>
<thead>
<tr>
<th>Estimated depth of collection (m)</th>
<th>0</th>
<th>26</th>
<th>53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet weight of sample (g/haul)</td>
<td>23.0</td>
<td>39.5</td>
<td>29.4</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>100.0</td>
<td>171.7</td>
<td>127.8</td>
</tr>
<tr>
<td>Wet weight of chaetognaths (g/haul)</td>
<td>—</td>
<td>0.05</td>
<td>0.16</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>—</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Percentage of weight of chaetognaths to whole zooplankton (%)</td>
<td>—</td>
<td>0.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individuals per 1000 m³</th>
<th>Sagitta enflata</th>
<th>S. hexaptera</th>
<th>S. lyra</th>
<th>S. scrippsei</th>
<th>S. elegans</th>
<th>S. naga</th>
<th>S. pacifica</th>
<th>S. neglecta</th>
<th>S. minima</th>
<th>S. neodecipiens</th>
<th>S. zetesios</th>
<th>S. macrocephala</th>
<th>Pterosagitta draco</th>
<th>Eukrohnia hamata</th>
<th>E. bathypelagica</th>
<th>Krohnitta subtulis</th>
<th>Damaged and unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>809</td>
<td>991</td>
<td>1348</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### No. of station/Position/Date /Time (LZT)/Volume filtered (m³) KH093/39°53.2’N 154°36.8’W/August

<table>
<thead>
<tr>
<th>Estimated depth of collection (m)</th>
<th>0</th>
<th>28</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet weight of sample (g/haul)</td>
<td>33.6</td>
<td>113.0</td>
<td>34.9</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>85.3</td>
<td>286.8</td>
<td>88.6</td>
</tr>
<tr>
<td>Wet weight of chaetognaths (g/haul)</td>
<td>0.26</td>
<td>0.00</td>
<td>0.36</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>0.7</td>
<td>0.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Percentage of weight of chaetognaths to whole zooplankton (%)</td>
<td>0.8</td>
<td>0.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individuals per 1000 m³</th>
<th>Sagitta enflata</th>
<th>S. hexaptera</th>
<th>S. lyra</th>
<th>S. scrippsei</th>
<th>S. elegans</th>
<th>S. naga</th>
<th>S. pacifica</th>
<th>S. neglecta</th>
<th>S. neodecipiens</th>
<th>S. zetesios</th>
<th>S. macrocephala</th>
<th>Pterosagitta draco</th>
<th>Eukrohnia hamata</th>
<th>E. bathypelagica</th>
<th>Krohnitta subtulis</th>
<th>Damaged and unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>66</td>
<td>0</td>
<td>10</td>
<td>112</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
### IIC.

<table>
<thead>
<tr>
<th>79</th>
<th>110</th>
<th>210</th>
<th>320</th>
<th>420</th>
<th>530</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.4</td>
<td>—</td>
<td>7.3</td>
<td>14.5</td>
<td>10.9</td>
<td>12.7</td>
</tr>
<tr>
<td>127.8</td>
<td>—</td>
<td>31.7</td>
<td>65.0</td>
<td>47.4</td>
<td>55.2</td>
</tr>
<tr>
<td>0.20</td>
<td>—</td>
<td>0.22</td>
<td>0.09</td>
<td>0.14</td>
<td>0.16</td>
</tr>
<tr>
<td>0.9</td>
<td>—</td>
<td>1.0</td>
<td>0.4</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>0.7</td>
<td>—</td>
<td>3.2</td>
<td>0.6</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>78</td>
<td>—</td>
<td>78</td>
<td>34</td>
<td>70</td>
<td>17</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>43</td>
<td>—</td>
<td>791</td>
<td>1340</td>
<td>1243</td>
<td>517</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1299</td>
<td>—</td>
<td>391</td>
<td>156</td>
<td>87</td>
<td>57</td>
</tr>
<tr>
<td>1330</td>
<td>—</td>
<td>1260</td>
<td>1530</td>
<td>1400</td>
<td>595</td>
</tr>
</tbody>
</table>

### IID.

<table>
<thead>
<tr>
<th>84</th>
<th>110</th>
<th>220</th>
<th>340</th>
<th>450</th>
<th>560</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.5</td>
<td>14.5</td>
<td>5.3</td>
<td>5.5</td>
<td>21.5</td>
<td>15.0</td>
</tr>
<tr>
<td>90.1</td>
<td>36.8</td>
<td>13.5</td>
<td>14.0</td>
<td>54.6</td>
<td>35.1</td>
</tr>
<tr>
<td>1.40</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
<td>0.38</td>
<td>0.44</td>
</tr>
<tr>
<td>3.6</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>4.0</td>
<td>0.3</td>
<td>0.7</td>
<td>0.7</td>
<td>1.8</td>
<td>2.9</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>—</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>922</td>
<td>—</td>
<td>20</td>
<td>20</td>
<td>234</td>
<td>142</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

— 173 —
### Appendix

#### KH693/39°33.2’N 154°36.8’W/August

<table>
<thead>
<tr>
<th>Estimated depth of collection (m)</th>
<th>0</th>
<th>28</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals per 1000 m²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sagitta minima</strong></td>
<td>3411</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. neodiciiens</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. zetes</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. macrocephala</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Pterosagitta draco</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Eukrohnia hamata</strong></td>
<td>0</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td><strong>E. bathypelagica</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Krohnitta subtilis</strong></td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Damaged and unidentified</td>
<td>279</td>
<td>0</td>
<td>569</td>
</tr>
<tr>
<td>Total</td>
<td>3944</td>
<td>0</td>
<td>1751</td>
</tr>
</tbody>
</table>

#### KH693/40°00.1’N 154°29.4’W/September

<table>
<thead>
<tr>
<th>Estimated depth of collection (m)</th>
<th>0</th>
<th>29</th>
<th>58</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wet weight of sample (g/haul)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g/1000 m²)</td>
<td>12.5</td>
<td>77.6</td>
<td>118.0</td>
</tr>
<tr>
<td>Wet weight of chaetognaths (g/haul)</td>
<td>31.7</td>
<td>797.0</td>
<td>299.5</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Percentage of weight of chaetognaths to whole zooplankton (%)</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Individuals per 1000 m³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sagitta enflata</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. hexaperta</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. lyra</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. scrippseae</strong></td>
<td>0</td>
<td>91</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. elegans</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. nagae</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. pacifica</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. neglecta</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. minima</strong></td>
<td>1457</td>
<td>122</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. neodiciiens</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. zetes</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>S. macrocephala</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Pterosagitta draco</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Eukrohnia hamata</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>E. bathypelagica</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Krohnitta subtilis</strong></td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Damaged and unidentified</td>
<td>234</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>1696</td>
<td>259</td>
<td>0</td>
</tr>
</tbody>
</table>
### IID. Continued.

31-September 1, 1969/2315-0015/394

<table>
<thead>
<tr>
<th></th>
<th>84</th>
<th>110</th>
<th>220</th>
<th>340</th>
<th>450</th>
<th>560</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>—</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>102</td>
<td>107</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>—</td>
<td>0</td>
<td>41</td>
<td>66</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>342</td>
<td>—</td>
<td>117</td>
<td>86</td>
<td>264</td>
<td>178</td>
<td></td>
</tr>
<tr>
<td>1290</td>
<td>706</td>
<td>249</td>
<td>269</td>
<td>599</td>
<td>340</td>
<td></td>
</tr>
</tbody>
</table>

### IIE.

1, 1969/0853–0953/394

<table>
<thead>
<tr>
<th></th>
<th>88</th>
<th>120</th>
<th>230</th>
<th>350</th>
<th>470</th>
<th>580</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0</td>
<td>15.5</td>
<td>7.1</td>
<td>20.4</td>
<td>20.1</td>
<td>18.3</td>
<td></td>
</tr>
<tr>
<td>48.2</td>
<td>39.6</td>
<td>18.0</td>
<td>51.8</td>
<td>51.0</td>
<td>46.4</td>
<td></td>
</tr>
<tr>
<td>0.82</td>
<td>0.82</td>
<td>0.06</td>
<td>0.10</td>
<td>0.10</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>1.6</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td>4.0</td>
<td>1.1</td>
<td>0.6</td>
<td>0.6</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>66</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2751</td>
<td>1147</td>
<td>41</td>
<td>137</td>
<td>117</td>
<td>173</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3301</td>
<td>670</td>
<td>1792</td>
<td>1046</td>
<td>0</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>56</td>
<td>25</td>
<td>127</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>436</td>
<td>91</td>
<td>15</td>
<td>279</td>
<td>132</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>6639</td>
<td>1979</td>
<td>1853</td>
<td>1604</td>
<td>274</td>
<td>391</td>
<td></td>
</tr>
</tbody>
</table>
Appendix II.

<table>
<thead>
<tr>
<th>No. of station/Position/Date</th>
<th>KH694/35°01.0'N 154°51.5'W/September 6, 1969/1543-1643/394</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated depth of collection (m)</td>
<td>0</td>
</tr>
<tr>
<td>Wet weight of sample (g/haul)</td>
<td>19.4</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>49.2</td>
</tr>
<tr>
<td>Wet weight of chaetognaths (g/haul)</td>
<td>1.33</td>
</tr>
<tr>
<td>(g/1000 m³)</td>
<td>3.4</td>
</tr>
<tr>
<td>Percentage of weight of chaetognaths to whole zooplankton (%)</td>
<td>6.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individuals per 1000 m³</th>
<th>Sagitta enflata</th>
<th>S. hezopera</th>
<th>S. lyra</th>
<th>S. scrippae</th>
<th>S. elegans</th>
<th>S. nagae</th>
<th>S. pacifica</th>
<th>S. neglecta</th>
<th>S. minima</th>
<th>S. neodeciptiens</th>
<th>S. zetesios</th>
<th>S. macrocephala</th>
<th>Pterosagitta draco</th>
<th>Eukrohnia hamata</th>
<th>E. bathypelagica</th>
<th>Krohnitta subtilis</th>
<th>Damaged and unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10056</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>76</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>107</td>
</tr>
</tbody>
</table>

Appendix III. Full data on the measurements of Sagitta

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Body length (mm)</th>
<th>Tail length (mm)</th>
<th>Percentage of tail length to body length (%)</th>
<th>Length of ventral ganglion (mm)</th>
<th>Percentage of length of ventral ganglion to body length (%)</th>
<th>Number of hooks</th>
</tr>
</thead>
<tbody>
<tr>
<td>L18</td>
<td>1.285</td>
<td>Absent</td>
<td>–</td>
<td>0.376</td>
<td>30.69</td>
<td>Absent</td>
</tr>
<tr>
<td>L20</td>
<td>1.395</td>
<td>Absent</td>
<td>–</td>
<td>0.288</td>
<td>23.01</td>
<td>Absent</td>
</tr>
<tr>
<td>L22</td>
<td>1.356</td>
<td>Absent</td>
<td>–</td>
<td>0.333</td>
<td>24.56</td>
<td>Absent</td>
</tr>
<tr>
<td>L13</td>
<td>1.374</td>
<td>Absent</td>
<td>–</td>
<td>0.455</td>
<td>33.11</td>
<td>Absent</td>
</tr>
<tr>
<td>L9</td>
<td>1.385</td>
<td>Absent</td>
<td>–</td>
<td>0.229</td>
<td>30.37</td>
<td>Absent</td>
</tr>
<tr>
<td>L6</td>
<td>1.42</td>
<td>Absent</td>
<td>–</td>
<td>0.45</td>
<td>31.69</td>
<td>Absent</td>
</tr>
<tr>
<td>L17</td>
<td>1.444</td>
<td>Absent</td>
<td>–</td>
<td>0.405</td>
<td>27.91</td>
<td>Absent</td>
</tr>
<tr>
<td>L25</td>
<td>1.470</td>
<td>0.665</td>
<td>45.24</td>
<td>0.315</td>
<td>21.43</td>
<td>Absent</td>
</tr>
<tr>
<td>L8</td>
<td>1.479</td>
<td>0.665</td>
<td>44.96</td>
<td>0.411</td>
<td>27.79</td>
<td>Absent</td>
</tr>
<tr>
<td>L21</td>
<td>1.505</td>
<td>0.665</td>
<td>44.19</td>
<td>0.368</td>
<td>24.45</td>
<td>Absent</td>
</tr>
<tr>
<td>L23</td>
<td>1.505</td>
<td>0.569</td>
<td>37.81</td>
<td>0.298</td>
<td>19.80</td>
<td>Absent</td>
</tr>
<tr>
<td>L24</td>
<td>1.514</td>
<td>0.683</td>
<td>45.11</td>
<td>0.324</td>
<td>21.40</td>
<td>Absent</td>
</tr>
</tbody>
</table>
elegans from newly-hatched larvae to adult forms.

<table>
<thead>
<tr>
<th>Anterior fin</th>
<th>Eye pigments</th>
<th>Length of collarette (mm)</th>
<th>Percentage of length of collarette to body length (%)</th>
<th>Ovary length (mm)</th>
<th>Percentage of ovary length to body length (%)</th>
<th>Height of seminal vesicle (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.015</td>
<td>73.87</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.050</td>
<td>75.92</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.02</td>
<td>71.83</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.199</td>
<td>81.07</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
</tbody>
</table>

— 177 —
<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Body length (mm)</th>
<th>Tail length (mm)</th>
<th>Percentage of tail length to body length (%)</th>
<th>Length of ventral ganglion (mm)</th>
<th>Percentage of length of ventral ganglion to body length (%)</th>
<th>Number of hooks</th>
</tr>
</thead>
<tbody>
<tr>
<td>L10</td>
<td>1.523</td>
<td>0.665</td>
<td>43.66</td>
<td>0.464</td>
<td>30.47</td>
<td>Absent</td>
</tr>
<tr>
<td>L12</td>
<td>1.533</td>
<td>0.61</td>
<td>40.05</td>
<td>0.455</td>
<td>28.88</td>
<td>Absent</td>
</tr>
<tr>
<td>L2</td>
<td>1.540</td>
<td>0.679</td>
<td>44.09</td>
<td>0.376</td>
<td>24.42</td>
<td>Absent</td>
</tr>
<tr>
<td>L15</td>
<td>1.575</td>
<td>0.665</td>
<td>42.32</td>
<td>0.385</td>
<td>24.44</td>
<td>Absent</td>
</tr>
<tr>
<td>L1</td>
<td>1.584</td>
<td>0.700</td>
<td>44.19</td>
<td>0.525</td>
<td>33.14</td>
<td>Absent</td>
</tr>
<tr>
<td>L4</td>
<td>1.601</td>
<td>0.648</td>
<td>40.47</td>
<td>0.405</td>
<td>25.17</td>
<td>Absent</td>
</tr>
<tr>
<td>L19</td>
<td>1.619</td>
<td>0.726</td>
<td>44.54</td>
<td>0.405</td>
<td>24.89</td>
<td>Absent</td>
</tr>
<tr>
<td>L11</td>
<td>1.645</td>
<td>0.700</td>
<td>42.55</td>
<td>0.376</td>
<td>22.86</td>
<td>Absent</td>
</tr>
<tr>
<td>L7</td>
<td>1.69</td>
<td>0.68</td>
<td>40.24</td>
<td>0.52</td>
<td>18.93</td>
<td>8</td>
</tr>
<tr>
<td>L14</td>
<td>1.759</td>
<td>0.735</td>
<td>41.79</td>
<td>0.411</td>
<td>23.37</td>
<td>—</td>
</tr>
<tr>
<td>L3</td>
<td>1.873</td>
<td>0.770</td>
<td>41.11</td>
<td>0.403</td>
<td>21.52</td>
<td>—</td>
</tr>
<tr>
<td>L26</td>
<td>1.94</td>
<td>0.86</td>
<td>44.53</td>
<td>—</td>
<td>—</td>
<td>8</td>
</tr>
<tr>
<td>L5</td>
<td>2.20</td>
<td>0.95</td>
<td>43.18</td>
<td>0.48</td>
<td>21.82</td>
<td>—</td>
</tr>
<tr>
<td>F1</td>
<td>2.045</td>
<td>0.900</td>
<td>44.01</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>F2</td>
<td>2.065</td>
<td>0.900</td>
<td>45.35</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>F4</td>
<td>2.508</td>
<td>0.84</td>
<td>35.49</td>
<td>—</td>
<td>—</td>
<td>8</td>
</tr>
<tr>
<td>F3</td>
<td>3.010</td>
<td>1.005</td>
<td>33.29</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>F8</td>
<td>3.516</td>
<td>1.00</td>
<td>30.06</td>
<td>0.50</td>
<td>15.82</td>
<td>—</td>
</tr>
<tr>
<td>F7</td>
<td>3.35</td>
<td>1.00</td>
<td>29.85</td>
<td>0.40</td>
<td>11.94</td>
<td>—</td>
</tr>
<tr>
<td>F6</td>
<td>3.41</td>
<td>1.02</td>
<td>29.91</td>
<td>0.45</td>
<td>13.20</td>
<td>7</td>
</tr>
<tr>
<td>F5</td>
<td>3.75</td>
<td>1.10</td>
<td>29.33</td>
<td>0.52</td>
<td>13.87</td>
<td>—</td>
</tr>
<tr>
<td>F17</td>
<td>4.00</td>
<td>1.10</td>
<td>27.50</td>
<td>0.55</td>
<td>13.75</td>
<td>—</td>
</tr>
<tr>
<td>F10</td>
<td>4.16</td>
<td>1.12</td>
<td>26.92</td>
<td>0.58</td>
<td>13.94</td>
<td>—</td>
</tr>
<tr>
<td>F12</td>
<td>4.55</td>
<td>1.10</td>
<td>24.18</td>
<td>0.64</td>
<td>14.07</td>
<td>7</td>
</tr>
<tr>
<td>F9</td>
<td>4.60</td>
<td>1.14</td>
<td>24.78</td>
<td>0.64</td>
<td>13.91</td>
<td>—</td>
</tr>
<tr>
<td>F18</td>
<td>4.66</td>
<td>1.19</td>
<td>25.54</td>
<td>0.60</td>
<td>12.88</td>
<td>7</td>
</tr>
<tr>
<td>F14</td>
<td>4.72</td>
<td>1.15</td>
<td>24.36</td>
<td>0.60</td>
<td>12.71</td>
<td>7</td>
</tr>
<tr>
<td>F11</td>
<td>4.75</td>
<td>1.20</td>
<td>25.36</td>
<td>0.60</td>
<td>12.63</td>
<td>—</td>
</tr>
<tr>
<td>F19</td>
<td>4.79</td>
<td>1.19</td>
<td>24.84</td>
<td>0.64</td>
<td>13.36</td>
<td>—</td>
</tr>
<tr>
<td>F15</td>
<td>4.90</td>
<td>1.20</td>
<td>25.00</td>
<td>0.60</td>
<td>13.50</td>
<td>7</td>
</tr>
<tr>
<td>F13</td>
<td>4.85</td>
<td>1.25</td>
<td>25.77</td>
<td>0.64</td>
<td>13.20</td>
<td>8</td>
</tr>
<tr>
<td>F16</td>
<td>4.94</td>
<td>1.33</td>
<td>26.72</td>
<td>0.65</td>
<td>15.16</td>
<td>—</td>
</tr>
<tr>
<td>F25</td>
<td>5.10</td>
<td>1.25</td>
<td>24.51</td>
<td>0.60</td>
<td>11.76</td>
<td>—</td>
</tr>
<tr>
<td>F20</td>
<td>5.30</td>
<td>1.30</td>
<td>25.00</td>
<td>0.70</td>
<td>13.46</td>
<td>7</td>
</tr>
<tr>
<td>F29</td>
<td>5.30</td>
<td>1.26</td>
<td>24.04</td>
<td>0.72</td>
<td>13.85</td>
<td>—</td>
</tr>
<tr>
<td>F28</td>
<td>5.41</td>
<td>1.26</td>
<td>23.29</td>
<td>0.57</td>
<td>10.54</td>
<td>—</td>
</tr>
<tr>
<td>F24</td>
<td>5.50</td>
<td>1.25</td>
<td>22.73</td>
<td>0.60</td>
<td>10.91</td>
<td>7</td>
</tr>
<tr>
<td>F26</td>
<td>5.70</td>
<td>1.35</td>
<td>23.53</td>
<td>0.75</td>
<td>13.16</td>
<td>—</td>
</tr>
<tr>
<td>F21</td>
<td>5.75</td>
<td>1.35</td>
<td>21.74</td>
<td>0.70</td>
<td>12.17</td>
<td>8</td>
</tr>
<tr>
<td>F22</td>
<td>5.82</td>
<td>1.30</td>
<td>22.34</td>
<td>0.75</td>
<td>13.89</td>
<td>8</td>
</tr>
<tr>
<td>F42</td>
<td>6.05</td>
<td>1.30</td>
<td>21.49</td>
<td>0.64</td>
<td>10.53</td>
<td>8</td>
</tr>
<tr>
<td>F38</td>
<td>6.05</td>
<td>1.35</td>
<td>23.31</td>
<td>0.65</td>
<td>10.74</td>
<td>8</td>
</tr>
<tr>
<td>F27</td>
<td>6.10</td>
<td>1.40</td>
<td>22.95</td>
<td>0.54</td>
<td>8.85</td>
<td>—</td>
</tr>
<tr>
<td>F23</td>
<td>6.15</td>
<td>1.40</td>
<td>22.76</td>
<td>0.70</td>
<td>11.38</td>
<td>7</td>
</tr>
</tbody>
</table>
III. Continued.

<table>
<thead>
<tr>
<th>Anterior fin</th>
<th>Eye pigments</th>
<th>Length of collarette (mm)</th>
<th>Percentage of length of collarette to body length (%)</th>
<th>Ovary length (mm)</th>
<th>Percentage of ovary length to body length (%)</th>
<th>Height of seminal vesicle (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.190</td>
<td>78.14</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.138</td>
<td>74.72</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.155</td>
<td>75.00</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.103</td>
<td>70.03</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.208</td>
<td>76.36</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.225</td>
<td>76.51</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.225</td>
<td>74.47</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.30</td>
<td>71.01</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.313</td>
<td>74.64</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.418</td>
<td>75.71</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
<td>1.429</td>
<td>64.55</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>--</td>
<td>--</td>
<td>Absent</td>
<td>--</td>
<td>Absent</td>
</tr>
</tbody>
</table>
### Appendix

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Body length (mm)</th>
<th>Tail length (mm)</th>
<th>Percentage of tail length to body length (%)</th>
<th>Length of ventral ganglion (mm)</th>
<th>Percentage of length of ventral ganglion to body length (%)</th>
<th>Number of hooks</th>
</tr>
</thead>
<tbody>
<tr>
<td>F41</td>
<td>6.30</td>
<td>1.45</td>
<td>23.02</td>
<td>0.75</td>
<td>11.90</td>
<td>7</td>
</tr>
<tr>
<td>F30</td>
<td>6.31</td>
<td>1.40</td>
<td>22.19</td>
<td>0.75</td>
<td>11.89</td>
<td>7</td>
</tr>
<tr>
<td>F43</td>
<td>6.35</td>
<td>1.45</td>
<td>22.33</td>
<td>0.72</td>
<td>11.34</td>
<td>7</td>
</tr>
<tr>
<td>F35</td>
<td>6.40</td>
<td>1.32</td>
<td>20.63</td>
<td>0.75</td>
<td>10.73</td>
<td>7</td>
</tr>
<tr>
<td>F32</td>
<td>6.45</td>
<td>1.45</td>
<td>23.48</td>
<td>0.65</td>
<td>10.00</td>
<td>7</td>
</tr>
<tr>
<td>F40</td>
<td>6.50</td>
<td>1.63</td>
<td>25.08</td>
<td>0.65</td>
<td>10.00</td>
<td>7</td>
</tr>
<tr>
<td>F33</td>
<td>6.83</td>
<td>1.30</td>
<td>19.03</td>
<td>0.75</td>
<td>10.98</td>
<td>7</td>
</tr>
<tr>
<td>F34</td>
<td>6.85</td>
<td>1.50</td>
<td>21.90</td>
<td>0.75</td>
<td>10.95</td>
<td>7</td>
</tr>
<tr>
<td>F31</td>
<td>6.95</td>
<td>1.50</td>
<td>21.58</td>
<td>0.70</td>
<td>10.07</td>
<td>8</td>
</tr>
<tr>
<td>F37</td>
<td>7.10</td>
<td>1.30</td>
<td>18.31</td>
<td>0.70</td>
<td>9.86</td>
<td>8</td>
</tr>
<tr>
<td>F45</td>
<td>7.64</td>
<td>1.51</td>
<td>19.76</td>
<td>0.85</td>
<td>11.13</td>
<td>8</td>
</tr>
<tr>
<td>F46</td>
<td>7.75</td>
<td>1.45</td>
<td>18.71</td>
<td>0.80</td>
<td>10.32</td>
<td>8</td>
</tr>
<tr>
<td>F36</td>
<td>7.85</td>
<td>1.50</td>
<td>18.11</td>
<td>0.75</td>
<td>9.55</td>
<td>7</td>
</tr>
<tr>
<td>F39</td>
<td>7.91</td>
<td>1.45</td>
<td>18.33</td>
<td>0.81</td>
<td>10.24</td>
<td>7</td>
</tr>
<tr>
<td>F44</td>
<td>7.91</td>
<td>1.60</td>
<td>20.23</td>
<td>0.80</td>
<td>10.11</td>
<td>7</td>
</tr>
<tr>
<td>F48</td>
<td>7.95</td>
<td>1.55</td>
<td>19.50</td>
<td>0.80</td>
<td>10.06</td>
<td>7</td>
</tr>
<tr>
<td>F47</td>
<td>8.00</td>
<td>1.55</td>
<td>19.38</td>
<td>0.80</td>
<td>10.00</td>
<td>7</td>
</tr>
<tr>
<td>F49</td>
<td>8.15</td>
<td>1.65</td>
<td>20.25</td>
<td>0.75</td>
<td>9.20</td>
<td>7</td>
</tr>
<tr>
<td>F52</td>
<td>8.25</td>
<td>1.75</td>
<td>21.21</td>
<td>0.83</td>
<td>10.06</td>
<td>7</td>
</tr>
<tr>
<td>F51</td>
<td>8.45</td>
<td>1.62</td>
<td>19.17</td>
<td>0.85</td>
<td>10.06</td>
<td>7</td>
</tr>
<tr>
<td>F50</td>
<td>8.80</td>
<td>1.70</td>
<td>19.32</td>
<td>0.80</td>
<td>9.09</td>
<td>7</td>
</tr>
<tr>
<td>F53</td>
<td>9.35</td>
<td>1.75</td>
<td>18.72</td>
<td>0.85</td>
<td>9.09</td>
<td>7</td>
</tr>
<tr>
<td>F55</td>
<td>10.10</td>
<td>1.60</td>
<td>15.84</td>
<td>0.80</td>
<td>7.92</td>
<td>7</td>
</tr>
<tr>
<td>F56</td>
<td>10.36</td>
<td>1.92</td>
<td>16.64</td>
<td>0.80</td>
<td>7.77</td>
<td>7</td>
</tr>
<tr>
<td>F54</td>
<td>10.50</td>
<td>1.70</td>
<td>17.14</td>
<td>0.82</td>
<td>7.81</td>
<td>8</td>
</tr>
<tr>
<td>F58</td>
<td>11.25</td>
<td>2.10</td>
<td>18.67</td>
<td>0.80</td>
<td>7.11</td>
<td>7</td>
</tr>
<tr>
<td>F57</td>
<td>11.35</td>
<td>2.38</td>
<td>19.92</td>
<td>0.95</td>
<td>7.99</td>
<td>7</td>
</tr>
<tr>
<td>F60</td>
<td>12.10</td>
<td>2.38</td>
<td>18.84</td>
<td>0.95</td>
<td>7.85</td>
<td>7</td>
</tr>
<tr>
<td>F59</td>
<td>12.70</td>
<td>2.36</td>
<td>18.58</td>
<td>0.84</td>
<td>6.61</td>
<td>7</td>
</tr>
<tr>
<td>F61</td>
<td>12.85</td>
<td>2.43</td>
<td>18.91</td>
<td>0.90</td>
<td>7.00</td>
<td>7</td>
</tr>
<tr>
<td>F62</td>
<td>13.75</td>
<td>2.40</td>
<td>17.45</td>
<td>0.90</td>
<td>6.55</td>
<td>8</td>
</tr>
<tr>
<td>F63</td>
<td>13.75</td>
<td>2.36</td>
<td>17.16</td>
<td>0.90</td>
<td>6.55</td>
<td>8</td>
</tr>
<tr>
<td>F64</td>
<td>14.65</td>
<td>2.65</td>
<td>18.09</td>
<td>1.00</td>
<td>6.83</td>
<td>8</td>
</tr>
<tr>
<td>F66</td>
<td>15.85</td>
<td>2.80</td>
<td>17.67</td>
<td>0.85</td>
<td>5.36</td>
<td>8</td>
</tr>
<tr>
<td>F67</td>
<td>16.75</td>
<td>3.00</td>
<td>17.91</td>
<td>0.87</td>
<td>5.19</td>
<td>8</td>
</tr>
<tr>
<td>F69</td>
<td>17.07</td>
<td>3.07</td>
<td>17.98</td>
<td>0.95</td>
<td>5.55</td>
<td>8</td>
</tr>
<tr>
<td>F68</td>
<td>18.15</td>
<td>3.00</td>
<td>16.53</td>
<td>0.95</td>
<td>5.33</td>
<td>8</td>
</tr>
<tr>
<td>F71</td>
<td>18.20</td>
<td>3.20</td>
<td>17.58</td>
<td>1.10</td>
<td>6.04</td>
<td>7</td>
</tr>
<tr>
<td>F70</td>
<td>18.75</td>
<td>3.25</td>
<td>17.35</td>
<td>1.00</td>
<td>5.87</td>
<td>8</td>
</tr>
<tr>
<td>F72</td>
<td>19.40</td>
<td>3.35</td>
<td>17.27</td>
<td>1.06</td>
<td>5.41</td>
<td>8</td>
</tr>
<tr>
<td>F74</td>
<td>20.49</td>
<td>3.60</td>
<td>17.65</td>
<td>1.05</td>
<td>5.15</td>
<td>8</td>
</tr>
<tr>
<td>F73</td>
<td>21.55</td>
<td>3.80</td>
<td>17.63</td>
<td>1.10</td>
<td>5.10</td>
<td>8</td>
</tr>
<tr>
<td>F75</td>
<td>22.55</td>
<td>3.90</td>
<td>17.39</td>
<td>1.10</td>
<td>4.88</td>
<td>8</td>
</tr>
<tr>
<td>F77</td>
<td>22.95</td>
<td>4.01</td>
<td>17.47</td>
<td>1.25</td>
<td>5.45</td>
<td>12</td>
</tr>
<tr>
<td>F78</td>
<td>23.09</td>
<td>4.02</td>
<td>17.41</td>
<td>1.10</td>
<td>4.76</td>
<td>11</td>
</tr>
</tbody>
</table>
### III. Continued.

<table>
<thead>
<tr>
<th>Anterior fin</th>
<th>Eye pigments</th>
<th>Length of collarette (mm)</th>
<th>Percentage of length of collarette to body length (%)</th>
<th>Ovary length (mm)</th>
<th>Percentage of ovary length to body length (%)</th>
<th>Height of seminal vesicle (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>Absent</td>
<td>—</td>
<td>Absent</td>
</tr>
</tbody>
</table>
Appendix

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Body length (mm)</th>
<th>Tail length (mm)</th>
<th>Percentage of tail length to body length (%)</th>
<th>Length of ventral ganglion (mm)</th>
<th>Percentage of length of ventral ganglion to body length (%)</th>
<th>Number of hooks</th>
</tr>
</thead>
<tbody>
<tr>
<td>F76</td>
<td>23.90</td>
<td>4.10</td>
<td>17.15</td>
<td>1.10</td>
<td>4.60</td>
<td>8</td>
</tr>
<tr>
<td>F79</td>
<td>24.05</td>
<td>4.35</td>
<td>18.09</td>
<td>1.35</td>
<td>5.20</td>
<td>11</td>
</tr>
<tr>
<td>F80</td>
<td>24.98</td>
<td>4.40</td>
<td>17.61</td>
<td>1.25</td>
<td>4.60</td>
<td>11</td>
</tr>
<tr>
<td>F81</td>
<td>25.68</td>
<td>4.51</td>
<td>16.85</td>
<td>1.25</td>
<td>4.89</td>
<td>11</td>
</tr>
<tr>
<td>F82</td>
<td>27.15</td>
<td>4.90</td>
<td>18.05</td>
<td>1.35</td>
<td>4.60</td>
<td>12</td>
</tr>
<tr>
<td>F83</td>
<td>27.66</td>
<td>4.80</td>
<td>17.35</td>
<td>1.25</td>
<td>4.52</td>
<td>11</td>
</tr>
</tbody>
</table>

Appendix IV. Biomass of zooplankton other than chaetognaths in the eastern Bering Sea in the summer of 1968.

<table>
<thead>
<tr>
<th>No. of station</th>
<th>Maximum depth of collection (m)</th>
<th>Standing stock of zooplankton other than chaetognaths (g wet wt/1000 m³)</th>
<th>(mg C/m³)</th>
<th>(mg C/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>687812</td>
<td>139</td>
<td>711.7</td>
<td>42.7</td>
<td>5935.3</td>
</tr>
<tr>
<td>14</td>
<td>90</td>
<td>1232.0</td>
<td>73.9</td>
<td>6631.0</td>
</tr>
<tr>
<td>15</td>
<td>68</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>30</td>
<td>40</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>34</td>
<td>83</td>
<td>741.1</td>
<td>44.5</td>
<td>3693.5</td>
</tr>
<tr>
<td>36</td>
<td>110</td>
<td>237.0</td>
<td>15.4</td>
<td>1964.0</td>
</tr>
<tr>
<td>37</td>
<td>87</td>
<td>2682.7</td>
<td>161.0</td>
<td>14907.0</td>
</tr>
<tr>
<td>39</td>
<td>65</td>
<td>205.3</td>
<td>12.3</td>
<td>799.5</td>
</tr>
<tr>
<td>40</td>
<td>45</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>41</td>
<td>53</td>
<td>435.9</td>
<td>25.6</td>
<td>1331.2</td>
</tr>
<tr>
<td>50</td>
<td>83</td>
<td>1130.9</td>
<td>67.9</td>
<td>5567.8</td>
</tr>
<tr>
<td>61</td>
<td>103</td>
<td>410.8</td>
<td>24.6</td>
<td>2533.8</td>
</tr>
<tr>
<td>62</td>
<td>83</td>
<td>832.5</td>
<td>49.3</td>
<td>4091.9</td>
</tr>
<tr>
<td>65</td>
<td>75</td>
<td>531.7</td>
<td>31.9</td>
<td>2392.5</td>
</tr>
<tr>
<td>64</td>
<td>67</td>
<td>284.0</td>
<td>17.0</td>
<td>1139.0</td>
</tr>
<tr>
<td>67</td>
<td>44</td>
<td>565.5</td>
<td>33.9</td>
<td>1491.0</td>
</tr>
<tr>
<td>68</td>
<td>35</td>
<td>347.6</td>
<td>20.9</td>
<td>731.5</td>
</tr>
<tr>
<td>69</td>
<td>30</td>
<td>167.3</td>
<td>10.0</td>
<td>300.0</td>
</tr>
<tr>
<td>70</td>
<td>44</td>
<td>579.7</td>
<td>34.8</td>
<td>1531.2</td>
</tr>
<tr>
<td>71</td>
<td>50</td>
<td>185.2</td>
<td>11.1</td>
<td>555.0</td>
</tr>
<tr>
<td>74</td>
<td>106</td>
<td>110.2</td>
<td>6.6</td>
<td>699.6</td>
</tr>
<tr>
<td>75</td>
<td>96</td>
<td>32.2</td>
<td>1.9</td>
<td>182.4</td>
</tr>
<tr>
<td>76</td>
<td>84</td>
<td>137.6</td>
<td>7.7</td>
<td>646.8</td>
</tr>
<tr>
<td>78</td>
<td>92</td>
<td>91.7</td>
<td>5.5</td>
<td>506.0</td>
</tr>
</tbody>
</table>
III. Continued.

<table>
<thead>
<tr>
<th>Anterior fin</th>
<th>Eye pigments</th>
<th>Length of collarette (mm)</th>
<th>Percentage of length of collarette to body length (%)</th>
<th>Ovary length (mm)</th>
<th>Percentage of ovary length to body length (%)</th>
<th>Height of seminal vesicle (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>4.85</td>
<td>20.29</td>
<td>0.14</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>3.80</td>
<td>15.80</td>
<td>0.15</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>2.55</td>
<td>10.21</td>
<td>0.10</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>6.35</td>
<td>24.82</td>
<td>0.15</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>3.20</td>
<td>11.79</td>
<td>0.15</td>
</tr>
<tr>
<td>Present</td>
<td>Present</td>
<td>—</td>
<td>—</td>
<td>1.80</td>
<td>6.61</td>
<td>0.14</td>
</tr>
</tbody>
</table>