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Population structure of Chaetognatha in the Atlantic sector of the Southern Ocean (BIOMASS-SIBEX, December 1983 – January 1984)

ABSTRACT: Material for this paper was collected during the BIOMASS-SIBEX research programme, and consisted of 97 samples taken at 47 stations in Drake Passage and Bransfield Strait (Antarctica). The samples were taken by hauling Nansen nets vertically through the 0 – 100, 100 – 300 and 300 – 500 m layers at the end of December 1983 and the beginning of January 1984. Four Chaetognatha species were recorded in the study region: *Eukrohnia hamata, Sagitta gazellae, Sagitta mari* and *Sagitta planctonis*. The population structures of the dominant species *E. hamata* and also *S. gazellae* were analyzed in the context of the region's hydrology. Certain regularities are apparent in the distribution of the developmental stages of *E. hamata* in water column. Mature specimens of this species inhabit deeper waters than juveniles. The highest proportions of juveniles in the entire population of *E. hamata* were recorded in slightly warmer waters.

K e y w o r d s: Antarctica, BIOMASS-SIBEX, Chaetognatha, population structure.

Introduction

Chaetognatha, a predatory, almost exclusively planktonic group of marine animals (except for *Spadella* spp.) occur throughout the World Ocean, and include both cosmopolitan and endemic species. As some species show little tolerance towards hydrological changes in their environment, they can act as bioindicators of waters (David 1965). One of the most numerous groups (9.8% of the overall mesoplankton biomass) after the Copepoda in the Antarctic zooplankton, Chaetognatha directly affect the numbers of Copepoda and Euphausicaea, which are their principal food (Hopkins 1985). Even though the Antarctic Chaetognatha have been studied since the mid 19th century, there is still much to be learnt about the life cycle of these predators. Recently there

were some Polish publications concerning Chaetognatha of the Antarctic waters: Jażdżewski, Kittel and Łotocki (1982), Witek *et al.* (1985) and Bielecka and Żmijewska (1993).

The object of this paper is to analyse the population structure of the two dominant Chaetognatha species in Drake Passage and Bransfield Strait, *Eukrohnia hamata* and *Sagitta gazellae*, during the Antarctic summer, in the context of the interesting hydrological phenomena occurring in this region.

Material and method

Material for this paper was collected during the scientific cruise of r/v "Profesor Siedlecki" from 10 December 1983 to 8 January 1984 within the framework of the BIOMASS-SIBEX research programme. With the use of a Nansen plankton net (ø70 cm; mesh 260 μm), 97 samples were collected at 47 stations (Fig. 1) (Rakusa-Suszczewski and Lipski 1985) from three standard depths (500–300 m, 300–100 m, 100–0 m); at shore stations, nets were hauled from the bottom up to the surface. The samples were immediately preserved in a 4% solution of formalin.

In the laboratory, the Chaetognatha were separated from the rest of the zooplankton, and all specimens subsequently underwent bioanalysis. The species composition and numbers in each sample were established, and the specimens segregated into five developmental stages in accordance with Thomson's general classification (1947):

— juvenile stage — preliminary clusters of gonad cells
— stage I — gonads already formed
— stage II — small eggs visible
— stage III — some eggs large
— stage IV — all egss large — gonad fully developed.

Results and discussion

According to Alvarino (1964), the following Chaetognatha species are typical of Antarctic waters: epiplanktonic (200–0 m) — *Eukrohnia hamata* and *Sagitta gazellae;* mesoplanktonic (600–150 m) — *Sagitta marri, Sagitta maxima* and *Sagitta planctonis;* bathyplanktonic (below 1000 m) — *Eukrohnia bathyantarctica.*

Bioanalysis of the plankton samples caught in Drake Passage and Bransfield Strait in the summer season 1983–84 revealed little specific differentiation among the Chaetognatha (Bielecka and Żmijewska 1993): four species occurred in these waters — *Eukrohnia hamata* Möbius, 1875, *Sagitta gazellae* Ritter-Zahony, 1909, *Sagitta marri* David, 1956 and *Sagitta planctonis* Steinhaus,

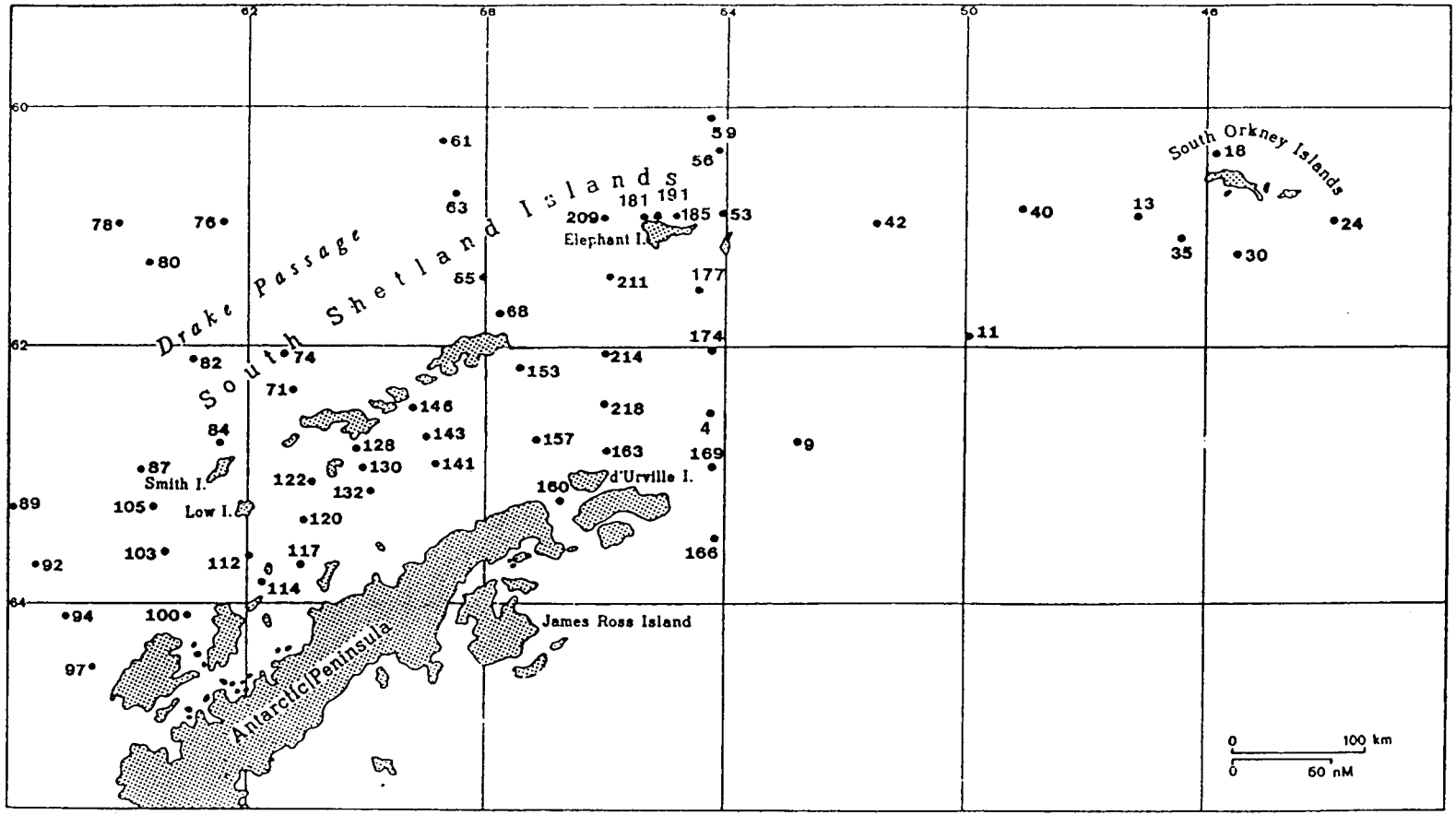

Fig. 1. Map of sampling stations in Drake Passage and Bransfield Strait (December 1983–January 1984; BIOMASS-SIBEX) (Grelowski and Tokarczyk 1985).

Table 1.

Distribution of developmental stages of *Eukrohnia hamata* (number of individuals per sample) in the water column at stations in Drake Passage and Bransfield Strait (December 1983–January 1984; BIOMASS-SIBEX)

Depth	100–0 m					300–100 m					500–300 m				
Stages	juv	I	II	III	IV	juv	I	II	III	IV	juv	I	II	III	IV
Station															
4	4	4													
53*											12	3	3	4	
56*				1		10	10	9	3	1	7	10	3	3	2
59	2					6	7	5	1		34	22	16	4	1
61				1		5	17	15	12	6	2	2	7	8	5
63*		3	11	3		27	48	17	8	4	64	24	15	6	5
65*	1		2	1				1	2						
71						1	1	2	6						
74*						3	5	12	7	13	3	6	10	12	2
76						24	15				4	6	15	7	8
78						45	13				17	15	7	2	2
80						18	10	4	1		38	14	12	13	5
82						70	4	1			69	9	11	7	7
84						9	2	4	14	3	4			1	
87	1										6	4	8	11	8
89	1					1	3	1		1	2		1	6	21
92				3		9	5	6	7						
94						2	2	17	10	9			1	5	5
97						1	4	14	8	8					
100						5	4	30	13	20	2	6	9	9	9
103						6	7	5	2	3					
105	2	7	9		1	2	7	9	6	1					
112			1												
114	1		1	1											
120													1	3	3
122						7		2	5	2					
128									1	4					
130	1						1								
132						6	2	12	11	2	42	37	30	31	13
135			1												
141						2	3	2	2	4	29	12	10	3	5
143					1	5		3	2	5	13	5			3
146	1	5	1		1	2	4	13	8	5					
157		2	2												
163		1				5	4	1							
166	6	3	1	2		9	10	3	1						
169						2									
174	1		1			12	15	5	1	1					
177		4	4	1			4	4	5	2					
209							2	3	1		2	3	8	7	4
211						2	6	11	6	2					
214						1	1	8	2	1		8	12	7	3
218						1	5	2	3	1					

* 500–0 m layer

1826. Two — *S. gazellae* and *S. marri* — are endemic species, while the others are immigrant species, capable of maintaining populations in the cold waters of the Antarctic (David 1965). The absolutely dominant species in both Drake Passage and Bransfield Strait was *E. hamata* (Tab. 1). There it made up ca. 90% of all the Chaetognatha, and at several stations was the only representative of the group (Bielecka and Żmijewska 1993). *E. hamata* is a cosmopolitan species, quite tolerant of changes in hydrological conditions, and is thus regarded as the most numerous Chaetognatha species in the Antarctic and Subantarctic regions. Many workers have already stated its dominant position: David (1965), Boltovskoj (1981), Jażdżewski, Kittel and Łotocki (1982), Hagen (1985), Hopkins (1985), Witek *et al.* (1985), Öresland (1990), and others. In second place as regards to abundance is *S. gazellae* (6%), a species less tolerant of physical and chemical changes in its environment (Hutchinson 1953, Bielecka and Żmijewska 1993). Least numerous (ca. 2%) were *S. marri* and *S. planctonis*, which prefer Subantarctic waters (Alvarino 1964, Bielecka and Żmijewska 1993). Because of the small numbers of the latter species in the study region, a population analysis was only feasible for the dominant *E. hamata* and for *S. gazellae*.

Hydrologically, this region has been divided into a number of zones differing in their temperature, salinity and hydrodynamics (Grelowski and Tokarczyk 1985). Drake Passage has been divided into two zones: a northern, Open-sea zone (Antarctic zone), and a southern, Continental zone. Bransfield Strait is split into three basins: the central basin, the influx zone of waters entering from the Bellingshausen Sea (the western section of the Strait), and the influx zone of waters from the Weddell Sea (the eastern section) (Grelowski and Tokarczyk 1985).

In Drake Passage the population of *E. hamata* is made up largely of juveniles (47%) and stage I (20%) (Fig. 2). Among *S. gazellae*, stage I (35%) and stage II (23%) were most numerous, mature specimens (16%) and stage III (6%) least numerous (Fig. 3). The influence of the Antarctic spring is thus clearly felt here, first in the more northerly basins, later in the southerly ones (Voronina 1970). This is confirmed by the situation in the Continental zone, where numbers of juvenile *E. hamata* are lower (32%) than in the Open-sea zone (47%), and where juvenile forms of *S. gazellae* are absent. The considerable dynamism of the waters flowing through the central basin of Bransfield Strait and the complex system of hydrological fronts — a quasi-front (Grelowski and Tokarczyk 1985) are probably responsible for the fact that specimens of all developmental stages of *E. hamata* are present in roughly the same numbers (around 20%) except juvenile forms, which make up about 30% of the population. The small numbers of *S. gazellae* (Tab. 2), insufficient to determine the population structure in this region, are due to the clear preference of this species for open waters (Dinofrio 1973). In the influx zone of waters from the Bellingshausen Sea, in the western part of the Bransfield Strait, where the temperature is

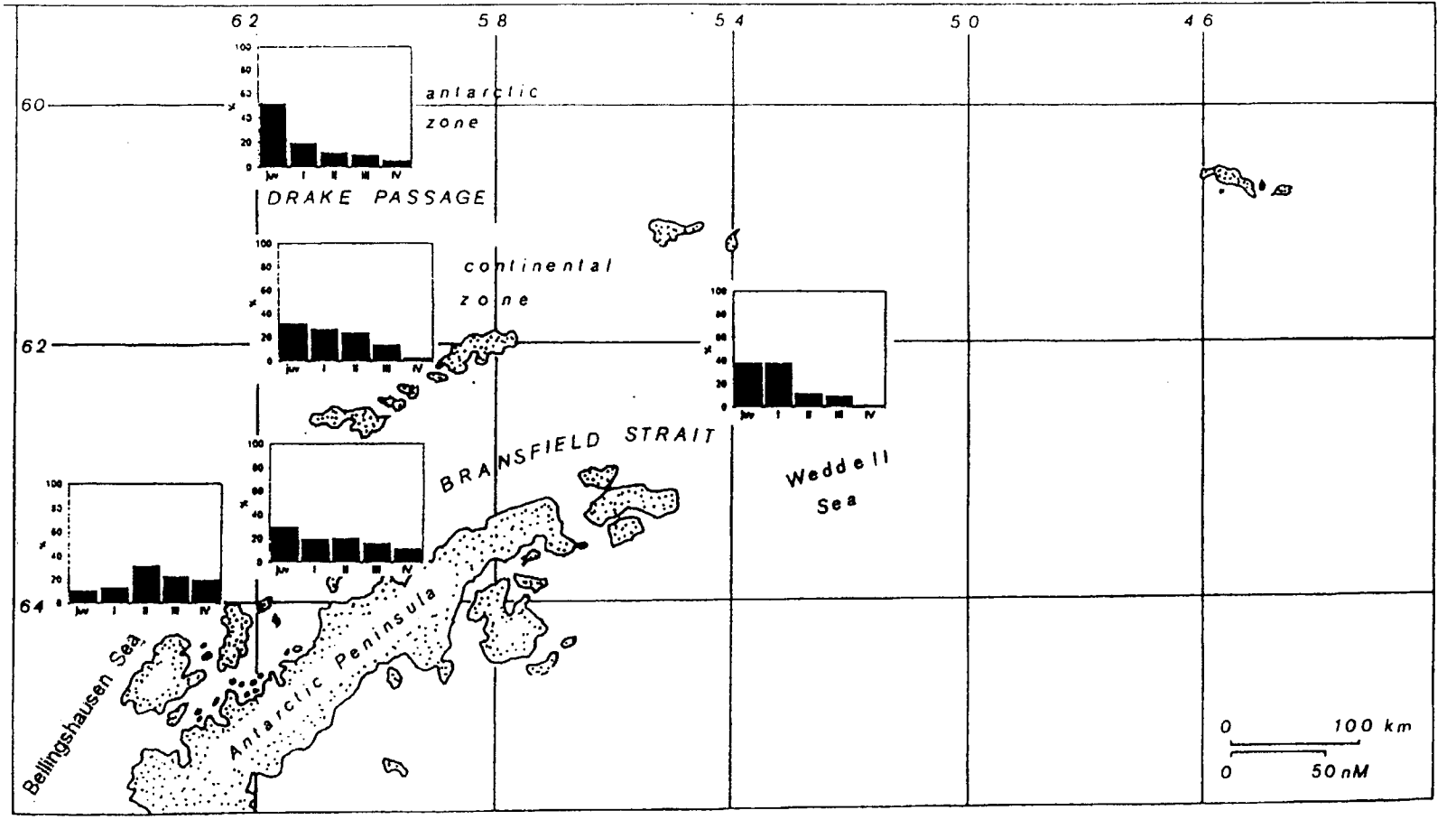

Fig. 2. Population structure of *Eukrohnia hamata* in various study regions [%] (December 1983–January 1984; BIOMASS-SIBEX)

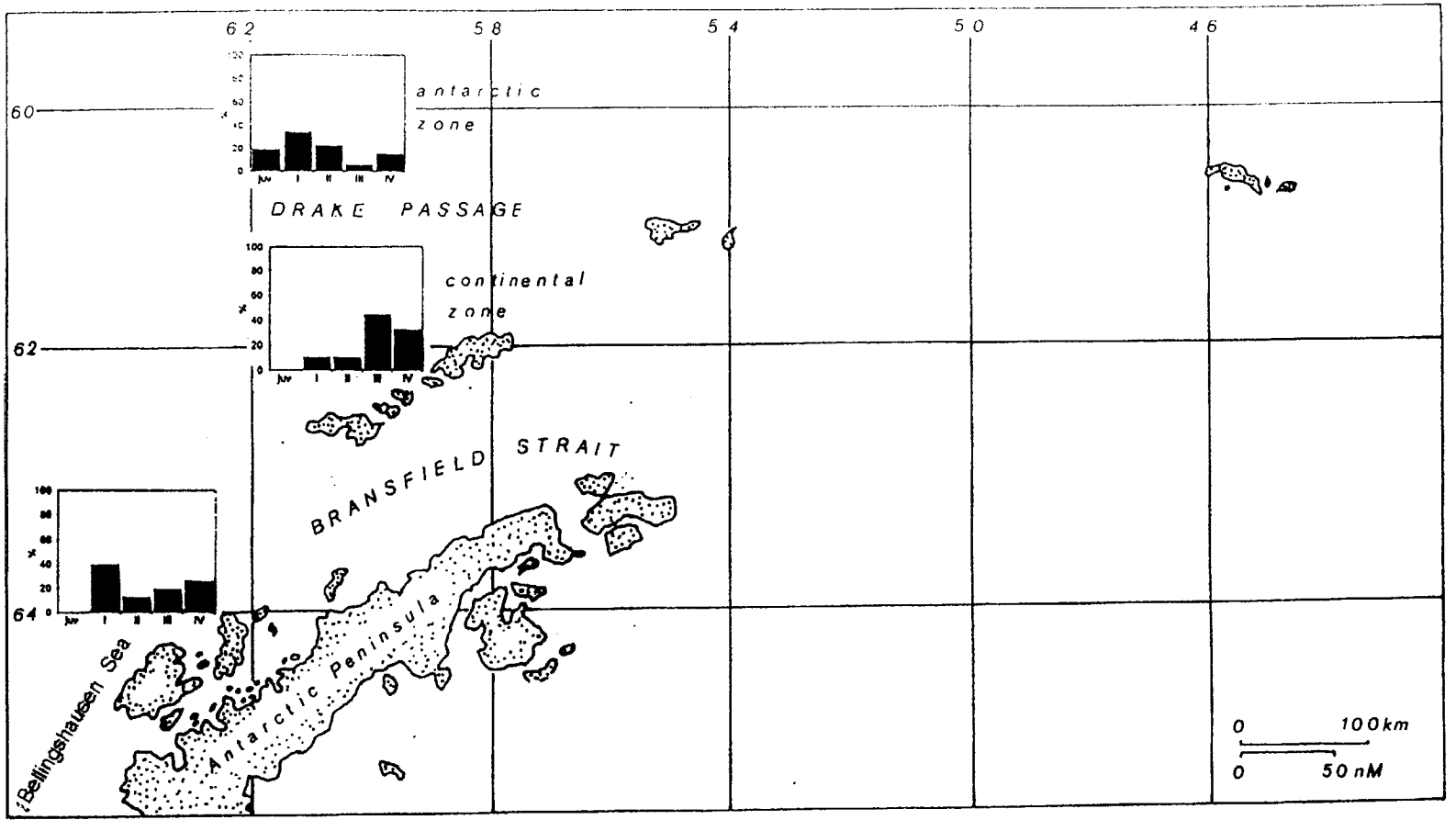

Fig. 3. Population structure of *Sagitta gazellae* in the various study regions [%] (December 1983 – January 1984; BIOMASS-SIBEX)

Table 2.

Distribution of developmental stages of *Sagitta gazellae* (number of individuals per sample) in the water column at stations in Drake Passage and Bransfield Strait (December 1983–January 1984; BIOMASS-SIBEX)

Depth	100–0 m					300–100 m					500–300 m				
Stages	juv	I	II	III	IV	juv	I	II	III	IV	juv	I	II	III	IV
Station															
56*								1	1						1
59									2			3			1
61					1	2	1	1					2	1	
63*		2				1	2	1				2	3	1	
71									1	1					
74*											1	1	2		
76										1	1	2	1		
78								1				4			
80							1	3		1	1	1	1	1	3
82							1			2	5	4	2	1	
84			1						1	1					
89					1				1						2
92					1										
100							3	2				1			
103								2							
105									1						
114									1						
117									1						
130								1							
132												1			2
141														1	
143						1									
146								1							
174		4	7	1			1								
177								1							
209							1						1		
211							1								
214												1			

* 500–0 m layer

slightly higher (from −1°C to 1.9°C) and the salinity lower (33.8–34.5‰) (Grelowski and Tokarczyk 1985), the dominant forms of *E. hamata* are stages II (32%) and III (23%), while juveniles (11%) and stage I (14%) are least numerous. The population living in this region is probably older than that in the Antarctic and Continental zones.

In the *E. hamata* population of the eastern part of Bransfield Strait there are decidedly more juveniles (38%) and stage I specimens (38%) than stages II or III (stage IV is least numerous — 2%). Despite the fact that this is an influx zone of cooler (from −1.8°C to 1.5°C) and more saline (34–34.8‰) waters from the Weddell Sea, these waters were exceptionally inactive during the study

period (Grelowski, Majewicz and Pastuszak 1986). This is probably the reason of the faster development of *E. hamata* in this part of Bransfield Strait. Furthermore, the fact that these samples were taken at the beginning of January 1984, later then anywhere else in the study region, could also have been responsible for such a population structure.

Samemoto (1987) found that the distribution of various developmental stages in the water column displays certain features common to all Chaetognatha species: the maximum concentration of juveniles occurs at shallower depths than that of mature forms. Hagen's (1985) study of Antarctic Chaetognatha also shows that the more mature developmental stages of *E. hamata* inhabit deeper waters than do the juveniles. The same was found by Öresland (1990). This is confirmed by the graphs illustrating the population structure of *E. hamata* at selected stations in the study area in the 300–100 m and 500–300 m layers (Fig. 4 a, b).

The population structure of *E. hamata* at stations 78 and 80 in Drake Passage shows a predominance of juvenile forms in the 300–100 m layer and the simultaneous absence there of mature specimens, and even of stage III individuals. On the other hand numbers of stages III and IV in this population increase in the 500–300 m layer. This may well be an effect of the deep-water reproduction of *E. hamata* (David 1965). Unfortunately, the water layers below 500 m were not sampled, so nothing more then a superficial interpretation of this question is possible here. As Bransfield Strait is hydrologically unstable (Grelowski, Majewicz and Pastuszak 1986), the population of *E. hamata* in the water column at stations 141 and 214 (Fig. 4b) does not display a clear-cut vertical stratification.

According to Öresland (1990), the more advanced developmental forms of *E. hamata* feed principally on *Metridia gerlachei* (copepodites III–IV), *Euchaeta* spp. (copepodites III–V) and *Calanoides acutus* (copepodites III–VI). By contrast, juvenile *E. hamata* feed mainly on the smaller Cyclopoida — *Oithona similis* and *Oncaea* spp. (Sullivan 1980). Öresland's (1990) studies of the food resources available to Chaetognatha show that in Antarctic waters in December *E. hamata* can reduce the copepod biomass by as much as 11%. The results of work on concentrations of Copepoda in the 0–500 m layer performed at the same time and in the same waters indicate that typically Antarctic species are the most numerous — *Metridia gerlachei, Calanoides acutus, Calanus propinquus* and *Rhinacalanus gigas* (Żmijewska 1987). The three last-mentioned species of Copepoda were the most abundant in the 0–100 m depth range, and somewhat less so between 100 and 300 m. This is in agreement with the observations of Samemoto (1987), who reports that the highest densities of Chaetognatha in the water column in the Baffin Bay region of the Arctic are recorded beneath the maximum concentrations of Copepoda. Hence the very small numbers or even lack of *E. hamata* specimens in the surface layer (Tab. 1), as a result of which the population structure of *E. hamata* in the 100–0 m layer is impossible to analyse.

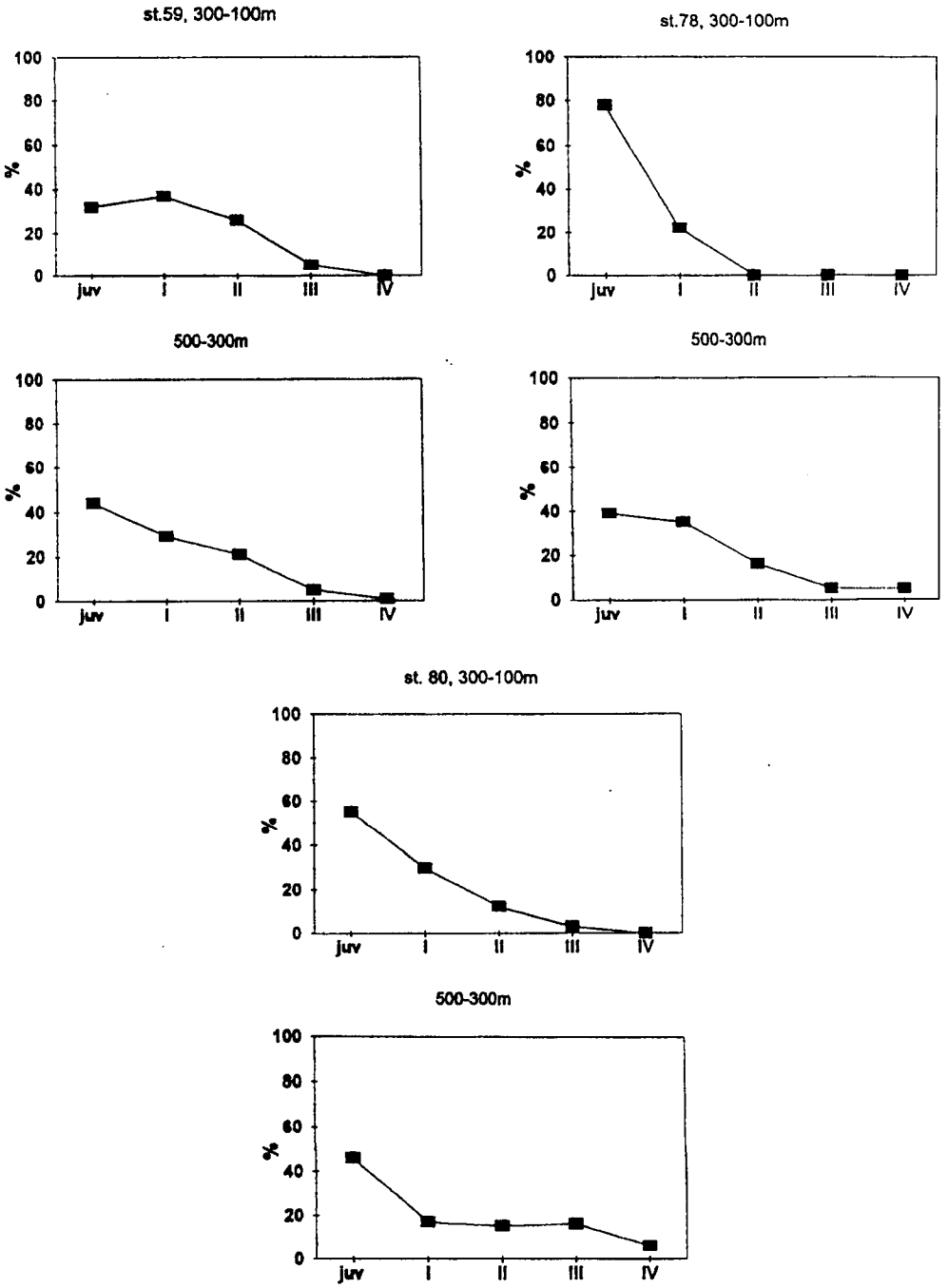

Fig. 4a – Frequencies of developmental stayes of *E. hamata* in the water column in Drake Passage (December 1983–January 1984; BIOMASS–SIBEX).

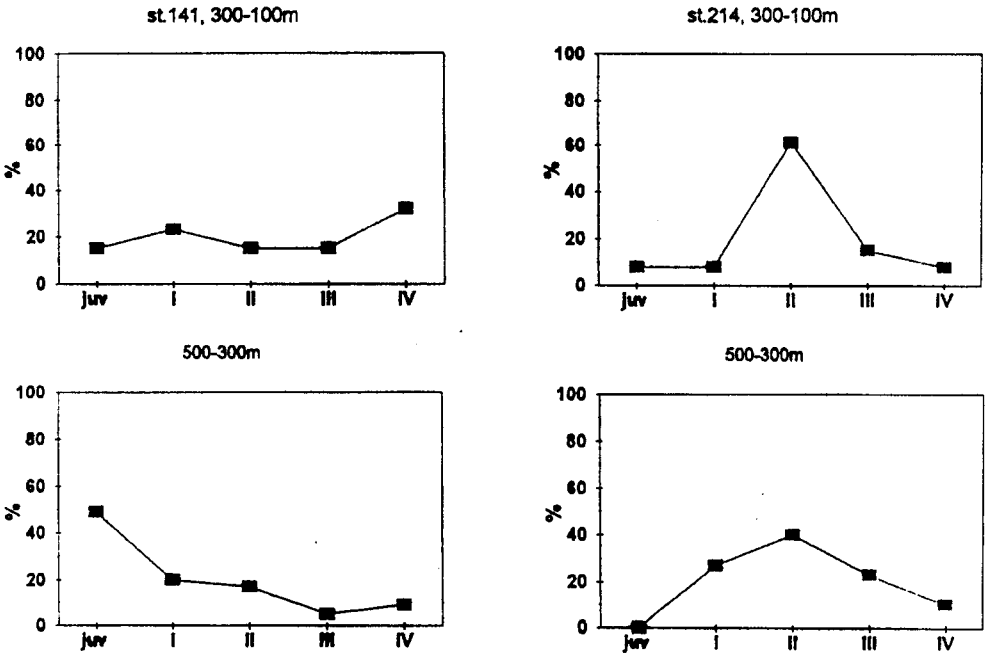

Fig. 4b — Frequencies of developmental stages of *E. hamata* in the water column in Bransfield Strait (December 1983–January 1984; BIOMASS-SIBEX)

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Streszczenie

Materiały Chaetognatha obejmowały 97 prób z 47 stacji rozmieszczonych w Cieśninie Drake'a i Cieśninie Bransfielda (Rys. 1). Próby pobierano pionowymi zaciągami siatki Nansena w warstwach wody 0–100, 100–300 i 300–500 m na przełomie grudnia 1983 i stycznia 1984. Rejon Cieśniny Drake'a i Cieśniny Bransfielda podzielono na kilka stref o różnych warunkach hydrologicznych. Na tle tych interesujących zjawisk fizyko-chemicznych przeprowadzono analizę stanu populacji dwóch (spośród czterech notowanych w tym rejonie) gatunków Chaetognatha: *Eukrohnia hamata* i *Sagitta gazellae*. W wodach o nieco wyższej temperaturze i niższym zasoleniu zaobserwowano dominację osobników juwenilnych w populacji *E. hamata* (Rys. 2). Stan populacji *S. gazellae* przedstawiony został na Rys. 3. Rozmieszczenie przedstawicieli poszczególnych stadiów rozwojowych w populacji *E. hamata* wykazuje pewne prawidłowości. Dojrzalsze stadia tego gatunku zasiedlają głębsze wody niż formy juwenilne (Rys. 4a). Natomiast maksimum koncentracji osobników młodocianych *E. hamata* występuje w kolumnie wody wyżej niż form dojrzałych (Rys. 4 a i b). Niewielkie ilosci *S. gazellae* (Tab. 2) uniemożliwiły analizę stanu populacji tego gatunku w kolumnie wody.