

GAMMARUS (CRUSTACEA, AMPHIPODA) FROM SVALBARD AND FRANZ JOSEF LAND. DISTRIBUTION AND DENSITY

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The distribution of *Gammarus oceanicus*, *G. setosus* and *G. wilkitzkii* was studied over the period 1981–1991 in the coastal zone of the Svalbard and Franz Josef Land archipelagos. The occurrence of *G. oceanicus* is connected with the presence of Atlantic waters and favourable ice conditions. In the area investigated this species was found on the west and north coasts of the island Vestspitsbergen only. *G. setosus* occurs in most of the investigated localities, being most abundant in the inner fjord basins and other sheltered waters. *G. wilkitzkii* occurs typically in ice-associated plankton, but occurs in the intertidal zone among algae at Franz Josef Land. The maximum densities of gammarids attained 2000 ind/m² at maximum, the mean being about 300 ind/m², the typical site being large stones in sheltered bays at low water.

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INTRODUCTION

Species from the genus *Gammarus* belong to the best known amphipods of the Northern Hemisphere. Numerous papers deal with their taxonomy (SEXTON 1942; SPOONER 1947; SEGERSTRÅLE 1947; SKET 1971; TZVETKOVA 1975; BARNARD & BARNARD 1983), biology (JAŻDZEWSKI 1970; STEELE & STEELE 1970, 1972, 1975; BEK 1972; KOLDING & FENCHEL 1979), distribution and ecology (SEGERSTRÅLE 1948; STEELE & STEELE 1974; BRYAZGIN 1974; TZVETKOVA 1975; SKADSHEIM 1984).

This widely dispersed genus has been extensively investigated in North America, from Massachusetts to Labrador (STEELE & STEELE 1974), and in western Europe from the French and English coasts to the Baltic and White Seas (TZVETKOVA 1975).

Until now, no information has been available on the ecology and biology of this genus from Svalbard, which is located in the centre of the European Arctic. STEPHENSEN (1940) refers to the geographic occurrence of *Gammarus* on Svalbard but due to the uncertain taxonomic status of the genus at that time, the species occurrence has been difficult to establish. Only two papers present data on *Gammarus* from Franz Josef Land (BUSHUEVA 1977; TZVETKOVA 1977).

The intertidal zone, the most sensitive for such environmental stress as oil spills, is insufficiently known in the area. Amphipods are known to be important macrofauna inhabitants of this biotope (LAGARDERE 1968; AMBROSE & LEINAAS 1988; WĘS-

ŁAWSKI 1991). The biochemistry (WOŁOWICZ & SZANIAWSKA 1986) and physiology (ZACHARIASSEN 1989; AARSET & AUNAAS 1990) of *Gammarus* on Svalbard has been studied, but its present ecological status and species distribution are not known. The present paper aims to answer two questions:

How important quantitatively is *Gammarus* in the Arctic littoral?

What is the *Gammarus* species distribution around the Barents Sea islands in the light of recent taxonomy?

MATERIAL AND METHODS

Gammarids described in this study have been collected from the Svalbard archipelago and Franz Josef Land in 1977, 1979–1985, 1988–1991. Most of the material examined has been collected in the intertidal zone, when gammarids can be picked by hand from under stones at low tide. More than 200 localities have been visited, some of them each year of the study period. Gammarids were preserved in 4% formaldehyde solution and examined under a stereomicroscope. Quantitative samples were collected from the intertidal zone, during coastal zone mapping for Norsk Polarinstitut (WĘSŁAWSKI & al. 1993). During low tide, three samples were collected from 25 x 25 cm squares. The upper three centimetres of sediment were dug out of soft ground, vegetation was scraped off on rocks with a knife. Mixed subsamples from one site were washed on a 0.5 mm screen. Plankton samples were collected with a WP-2 net, 60 cm in diameter and 200 µm mesh size. Numerous samples collected by various expeditions were checked for the presence of amphipods, some of the data being published in KWAŚAWSKI & WĘSŁAWSKI (1986). Semi-quantitative sampling was conducted in the shallow sublittoral (1 to 2 m below the low water

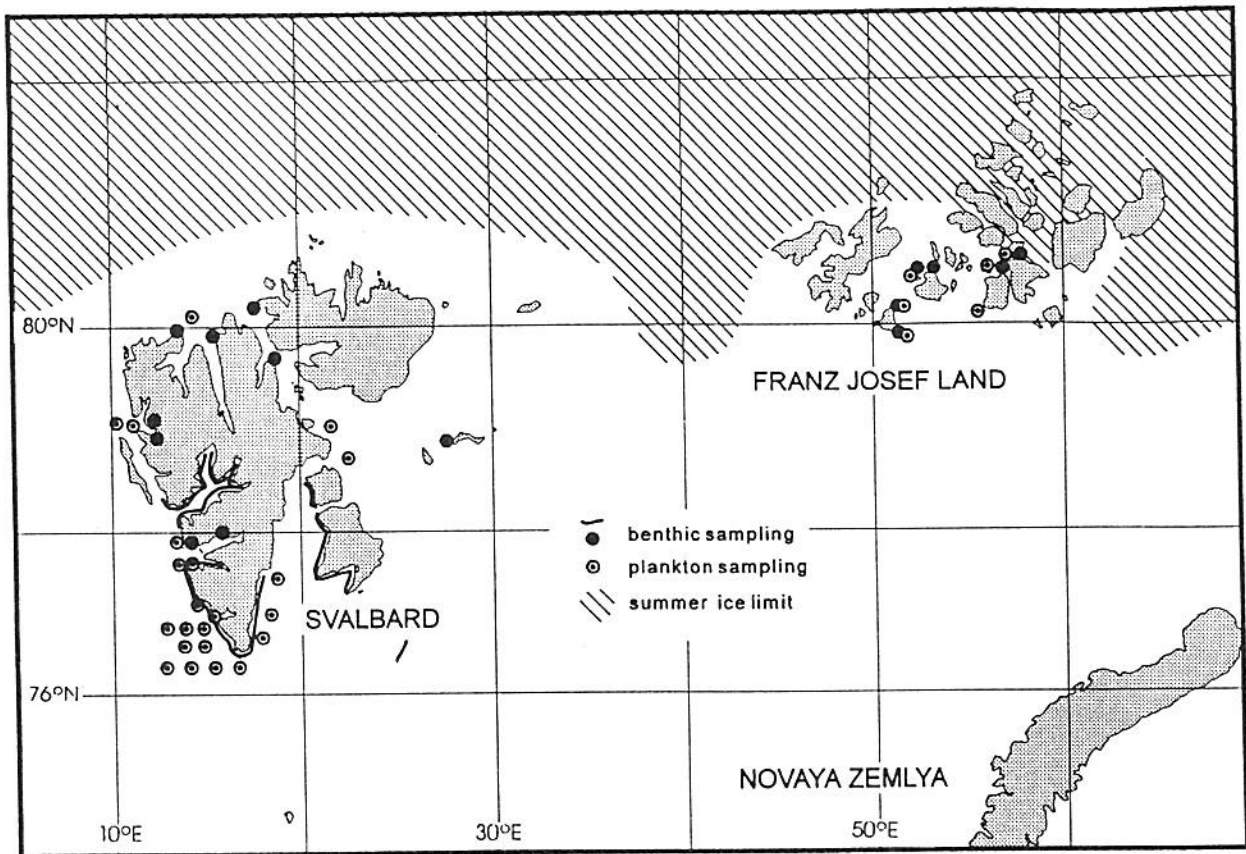


Fig. 1. Sampling stations at Svalbard and Franz Josef Land. Continuous thick black line at Svalbard coasts indicates extensive sampling area.

mark) by dredging using a 0.5 mm mesh net with 1 x 0.3 m mouth opening. The net was man-hauled for 20 m, some of the results being published in WĘSŁAWSKI (1991). Numerous fish, seabirds' and seals' stomachs were examined by the author for the presence of amphipods (LYDERSEN & al. 1989; WĘSŁAWSKI & KULINSKI 1989; WĘSŁAWSKI & KWAŚNIEWSKI 1990).

There were no taxonomic problems during identification of the present material, even small specimens had well developed specific features. Two common phenomena that may be the source of some confusion are worth mentioning. First, the occurrence of periphytic filamentous algae or single diatom cells on *G. oceanicus* setae and spines. In some circumstances it is possible to mistake these algae for feathered setae of *G. setosus*. The second phenomenon was poor setation of some of the young *G. setosus* specimens – a few tiny feathered setae are easily overlooked, especially in older, preserved material.

The physical environment of the area investigated was presented in detail elsewhere (WĘSŁAWSKI & al. 1992). The western and northern Vestspitsbergen coasts are dominated by Atlantic waters from the Vestspitsbergen current, eastern Svalbard is under the influence of local, cold transformed Atlantic waters. Franz Josef Land lies almost entirely within the domain of the Arctic water mass. In summer, the water temperature in the tidal zone range from -1.2 at Franz Josef Land to $+10^{\circ}$ C on the Vestspitsbergen tidal flats. The summer salinity in tidal waters ranged from 0 to 35 ‰, the most common values observed being about 28 ‰. Fast ice is present off the Svalbard

coast for 3–9 months a year (SMITH & LYDERSEN 1991), and off Franz Josef Land for 9–12 months. Fig.1 shows the drifting ice limit.

RESULTS

Gammarus oceanicus SEGERSTRÅLE, 1947

This species was found mainly in intertidal samples. Seventy percent of all specimens collected were found at depths of 0 to 1 m within the tidal zone, the remaining 30 % being found in dredge samples from the shallow sublittoral. *G. oceanicus* was most abundant in sheltered bays with large loose stones and algae (Table 1). Muddy, detrital or gravel bottom was little inhabited by this species. The range of temperature and salinity in habitats of *G. oceanicus* was very wide (Fig. 2). *G. oceanicus* was found on the Vestspitsbergen coast, only a few specimens having been collected on the northern coast of Vestspitsbergen (Fig. 3). There was no *G. oceanicus* in the inner fjord basins of Vestspitsbergen or at Franz Josef Land localities. The density of this species ranged from 0 to 2000 ind/m² at Vestspitsbergen, the mean value at typical sites being 758 ind/m², (Fig. 3, Table 2).

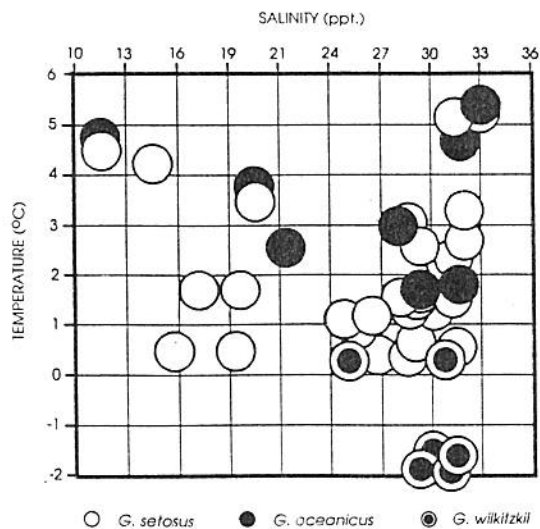


Fig. 2. Water temperature and salinity in localities where particular *Gammarus* species prevailed.

Table 1. Percent frequency of *Gammarus* species on different substrata in the tidal zone at Hornsund, Vestspitsbergen. Data from August 1988 and 1990, with choice of 20 localities with *G. setosus* and 20 with *G. oceanicus* predominance, four at each bottom type.

Type of bottom	<i>G. oceanicus</i>		<i>G. setosus</i>	
	n/m ²	%	n/m ²	%
Stones without algae	400	40	500	51
<i>Fucus</i> on stones	400	40	200	20
Mud	50	5	200	2
Gravel	10	1	10	1
Detritus	150	14	250	26

Gammarus setosus DEMENTIEVA, 1931

Similarly to the previous species *G. setosus* was collected mainly from the tidal zone. More than 90 % of all specimens collected were at depths of less than 1 m depth. The same habitat as for *G. oceanicus* was preferred, but this species was also abundant on muddy flats with detritus (Table 1). It occurred all over the area investigated, except for localities most exposed for direct wave action (Fig. 3). Densities were similar to those of *G. oceanicus*, having attained 3000 ind/m² in some spots. The mean value in the area of occurrence is 396 ind/m² (Fig. 3, Table 2). The vertical occurrence in tidal zone shows that the upper supralittoral was not inhabited. Sites in sublittoral, below low water mark were also poorly inhabited with *G. setosus*. The highest densities of gammarids reached, were at the low water mark (Table 3).

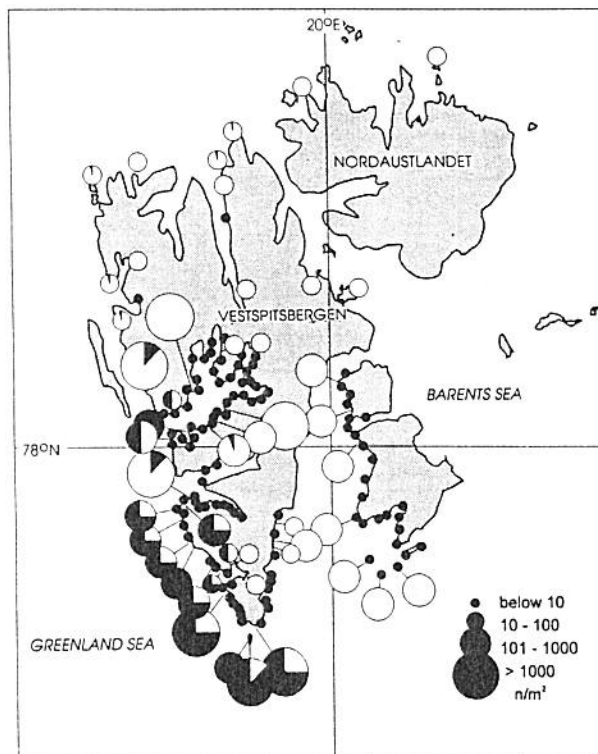


Fig. 3. Density of *Gammarus* species in the tidal zone of Svalbard. Black dots indicate sampling points. Dark area in large circles refers to percentage share of particular species in sample.

Table 2. Density of *Gammarus* species in selected intertidal areas of Svalbard. Data from August 1988, 1989, and 1990.

Area	Number of stations	Mean density (ind/m ²)	Standard deviation
Isfjorden	22	413	461
South Vestspitsbergen	23	758	1185
Edgeøya	7	39	18.2
Hornsund	30	376	503
Total	82	302	357

Gammarus wilkitzkii BIRULA, 1930

In the Svalbard area this species was found only in plankton material. It is usually rare in Vestspitsbergen, it becomes more common only in years with the ice pack advances (Table 4). At Franz Josef Land *G. wilkitzkii* was found in both plankton samples and in the tidal zone together with *G. setosus*. Its density under stones at low tide did not exceed 100 ind/m². Typically observed are *G. wilkitzkii* concentrations under the perennial fast ice, with estimated densities up to 2000 ind/m².

Table 3. Vertical occurrence of *Gammarus setosus* in tidal waters of Adventfjorden, August 1990. Samples collected at low tide, each metre over (+) and below (-) water line.

Sampling level (m)	Number of samples	Density (ind/m ²)	Standard deviation
+4	9	0	0
+3	9	0	0
+2	9	17	29
+1	9	724	751
0	9	431	477
-1	9	332	288
-2	9	729	1053
-3	9	317	302
-4	9	78	80

Table 4. Summer (July–August) occurrence of *Gammarus wilkitzkii* in Hornsund, Vestspitsbergen. Data from plankton sampling.

Year	Number of samples	Number of <i>G. wilkitzkii</i>	Frequency (%)	Remarks
1977	120	2	2	no ice pack
1979	240	15	6	ice in July
1980	100	1	1	no ice
1981	300	3	1	no ice
1982	300	40	13	ice in July
1984	250	1	0.4	no ice
1985	250	2	0.8	no ice
1987	15	0	0	no ice
1988	15	26	6	ice in July
1989	30	1	3	no ice
1990	35	1	3	no ice

DISCUSSION

Most of the *Gammarus* species collections from the European Arctic date back to the turn of the century (STEPHENSEN 1940). The present taxonomic status of this genus was established by SEGERSTRÅLE (1947). Earlier authors quoted *Gammarus locusta* from Svalbard (OLDEVIG 1915), this happened to be *Gammarus oceanicus* in most cases, hence comparison of the present data with older literature is difficult. Some of the older collections from the Arctic was redetermined by STEELE & STEELE (1970, 1972, 1974) and TZVETKOVA (1975). Some of the material were collected in the Svalbard and Franz Josef Land areas.

All three species mentioned in this study were previously noted from Svalbard and Franz Josef Land waters (TZVETKOVA 1975). This study shows that the occurrence of *G. oceanicus* in the Svalbard area is linked with the range of the warm Vestspitsbergen current and favourable ice conditions. This conclusion is in accordance with STEELE & STEELE (1974), who state that the northern limit of *G. oceanicus* occurrence depends on the number of days with positive water temperatures. Both STEELE &

STEELE (1974) and TZVETKOVA (1975) have questioned the occurrence of this species in the High Arctic along the North Greenland and Siberian coasts claimed by other authors (SEGERSTRÅLE 1948; DUNBAR 1954). In the light of the present data the occurrence of *G. oceanicus* in Franz Josef Land is highly doubtful, hence the records marked on the map by TZVETKOVA (1975) are probably incorrect.

The occurrence of *G. setosus* in the area investigated was linked with the colder waters of the eastern part of Svalbard and inner fjord basins along the Vestspitsbergen coast. It was common in all Franz Josef Land localities investigated. The occurrence of this species referred typically to cold, intertidal waters (STEELE & STEELE 1974; AMBROSE & LEINAAS 1990).

G. wilkitzkii was reported by most authors as a typical High Arctic, cryopelagic species, rarely found in the upper littoral – intertidal zone (DUNBAR 1954; BARNARD 1959; STEELE & STEELE 1974; TZVETKOVA 1975; MELNIKOV & KULIKOV 1980). My study shows that *G. wilkitzkii* is distributed mainly in the eastern, ice covered area and only occasionally found elsewhere. Data on the ice fauna and bird feeding studies confirm the predominance of this species in the eastern Svalbard waters (GULLIKSEN 1984; MEHLUM & GJERTZ 1984). The inflow of the ice pack may transport single specimens of *G. wilkitzkii* further south. This was noted in Newfoundland, where this species was collected in years of maximum ice pack range (STEELE & STEELE 1974).

Sympatric occurrence of *Gammarus* species was noted in many subarctic and arctic localities (STEELE & STEELE 1974; TZVETKOVA 1975). In more southern localities sympatric occurrence of five or more *Gammarus* species is common. Through spatial and temporal isolation on a micro-geographical scale, competition is avoided (JAŹDŹEWSKI 1970; VADER 1977; KOLDING & FENCHEL 1979; SKADSHEIM 1984). In the European Arctic three species investigated are isolated by their preferences to different water masses.

The quantitative data on the occurrence *Gammarus* in Arctic are very scarce. BEK (1972) gives a mean density of 400 ind/m² of *Gammarus* from the White Sea. AMBROSE & LEINAAS (1988) observed 1000 ind/m² at Spitsbergen tidal flats, BUSHUEVA (1977) reports from 300 to 3000 ind/m² at Franz Josef Land. This is in accordance with the present values (from 400 at mean to 2000 ind/m² at maximum). Pelagic *G. wilkitzkii* was reported from the ice fields off Svalbard at densities ranging from 200 (LØNNE & GULLIKSEN 1991) to 1000 ind/m² at Franz Josef Land perennial ice (GOLIKOV & AVERINCEV 1977).

In conclusion, it may be stated that two *Gammarus* species are very abundant at the Svalbard littoral, attaining more than 300 ind/m² in many places.

G. oceanicus have been found on the Vestspitsbergen coast only, and are hence classified as an Atlantic water species. *Gammarus setosus* have been found at eastern Svalbard and Franz Josef Land littoral localities, being as abundant as the previous species and described as subarctic.

The arctic *G. wilkitzkii*, rare in Vestspitsbergen, was a typical intertidal and pelagic species at Franz Josef Land.

The question now is, how the three species described will react to the warming up of the European Arctic. Diminishing fast ice cover and increase of sea surface temperature have already been reported from Svalbard (ORHEIM & BREKKE 1989). This may result in the geographical expansion of *G. oceanicus*, a species which can be treated as a valuable indicator of climatic change.

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