

Polychaete assemblages along a depth gradient in a Spitsbergen Fjord

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ABSTRACT

Samples were taken at five depths in Sassenfjord, Spitsbergen (78°23'N - 16°23'E) during July 1990. Although essentially Arctic in character, this west coast fjord is also affected by the Atlantic water of the West Spitsbergen Current and both influences can be seen when one investigates the biogeographical affinities of the polychaete fauna. Diversity did not differ significantly from analogous sites previously sampled at lower latitudes. Polychaetes were numerical dominants at all stations and biomass dominants at all but one. The shallowest stations (30-95 m) appeared to be influenced by seasonal sediment deposition from an adjacent stream and could be shown to be in an intermediate state of disturbance. At these shallow sites the characteristic species were *Chaetozone setosa*, *Lumbrineris magnidenta*, *Tharyx* sp. indet., *Cossura longocirrata*, *Polycirrus arcticus* and *Chone duneri*. At the deepest site (123 m) the faunal composition of the assemblage changed considerably and the standing crop wet weight biomass increased to in excess of 100 g.m⁻². This substantial increase was largely due to four polychaete species, *Maldane sarsi*, *Spiochaetopterus typicus*, *Terebellides stroemi* and *Pectinaria hyperborea*.

RÉSUMÉ

Assemblages annélidiens le long d'un gradient de profondeur dans un fjord du Spitzberg

Des prélèvements ont été effectués à cinq profondeurs dans le Sassenfjord, Spitzberg (78°23'N - 16°23'E), en juillet 1990. Bien que de caractère essentiellement arctique, cette côte ouest du Spitzberg est aussi sous l'influence des eaux atlantiques du courant du Spitzberg occidental et les deux influences peuvent être constatées lorsqu'on étudie les affinités biogéographiques de la faune de polychètes. La diversité ne diffère pas sensiblement des sites analogues précédemment étudiés à des latitudes plus basses. Les polychètes étaient numériquement dominants dans toutes les stations et leur biomasse aussi, à l'exception d'une station. Les stations les moins profondes (30-95 m) apparaissaient être influencées saisonnièrement par les apports sédimentaires d'un courant adjacent et pourraient être considérées comme présentant un stade intermédiaire d'instabilité. Les espèces caractéristiques de ces sites peu profonds étaient *Chaetozone setosa*, *Lumbrineris magnidenta*, *Tharyx* sp. indet., *Cossura longocirrata*, *Polycirrus arcticus* and *Chone duneri*. A la station la plus profonde, la composition faunistique du peuplement était considérablement changée et la biomasse exprimée en poids humide était supérieure à 100 g. m⁻². Cet accroissement substantiel était essentiellement dû à quatre espèces de Polychètes, *Maldane sarsi*, *Spiochaetopterus typicus*, *Terebellides stroemi* et *Pectinaria hyperborea*.

INTRODUCTION

A number of authors (ABELE & WALTERS, 1979 a, b; WARWICK & RUSWAHYUNI, 1987) have challenged SANDERS (1968) assertion that a gradient in macrobenthic diversity exists between the poles and the tropics. WARWICK & RUSWAHYUNI (1987) suggested that the issue should be re-addressed by the collection of new data sets which should be collected and analysed using fully standardised methods. To this end, they compared the diversity profiles of shallow sediments in Java and in the North Sea and showed no significant difference in a diversity between analogous sites in the two areas. The comparison has been extended to the fauna of Sassenfjord, Spitsbergen (78°N), by KENDALL & ASCHAN (1993) who were also unable to find differences between the three areas in the diversity of the infaunal macrobenthos.

At all of the stations studied in the Sassenfjord, polychaetes were the single most abundant phylum, but in the context of their paper, KENDALL & ASCHAN (1993) were unable to describe their pattern of distribution along the depth gradient which was sampled. One aim of this paper is to redress that shortcoming, as comparatively few data from such high latitudes exist and the comparison of those that do is fraught with difficulties resulting from methodological inconsistencies. In the context of the latitudinal diversity study referred to above, an attempt will be made to determine if the fauna of the area studied can be regarded truly representative of Arctic latitudes.

MATERIAL AND METHODS

Five stations near Gipsvika, a bay in the Sassenfjord (west coast of Spitsbergen), were investigated. Stations will be referred to by their depth (Fig. 1). Samples were collected during July 1991 using a van Veen grab operated from the R.V. Johann Ruud. The sediment at the four shallowest stations was a silt with < 6 % sand, while at the 123 m station the silt contained 13 % sand. KENDALL & ASCHAN (1993) have used the ABC method of WARWICK (1986) to show that there is a disturbance gradient between the 30 m and 123 m sites.

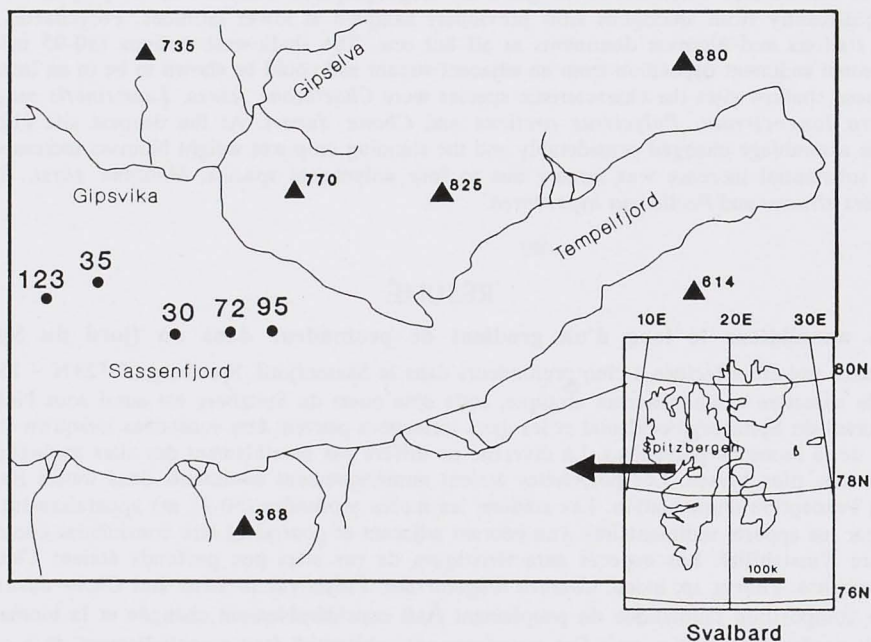
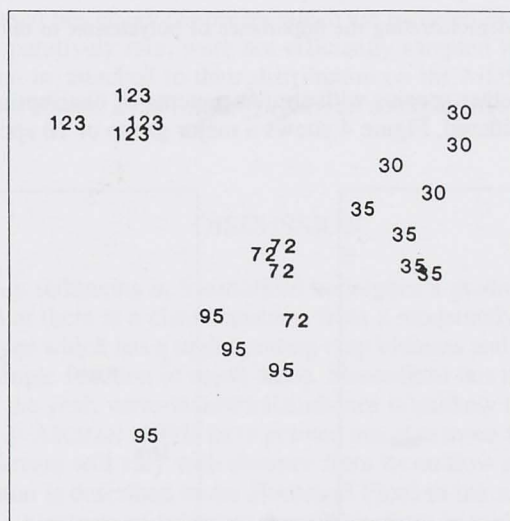


FIG. 1. — The location of the sampling sites in the Sassenfjord. The sites are referred to by their depth. The inset map of the Svalbard Archipelago indicates the position of Sassenfjord.

The fauna was extracted from each of the five replicates taken at each station by gently washing the sediment through a 0.5 mm square aperture sieve. The residue was fixed in formalin and preserved in 70 % ethanol. In the laboratory, all animals were extracted from the residual debris with the aid of a binocular microscope and were identified to putative species. Where possible, species have been named following HOWSON (1987). At all depths the samples contained large numbers of cirratulid polychaetes, many of which were damaged. For the purposes of community analyses the following genera have been grouped together: *Chaetozone*, *Caulleriella* and *Tharyx*. In many other cases complete identification has not yet been possible and so a full species list will not be presented in this paper, full details are available from the author. The blotted wet weight of each putative species was determined, as dry weighing destroys potentially valuable taxonomic material. Instead, dry weights have been estimated as 25 % of the wet weight (WARWICK & RUSWAHYUN, 1987). Species abundance data were subjected to non parametric multidimensional scaling (MDS analysis) using the Bray Curtis measure of similarity and group-average sorting after double square root transformation.

RESULTS

COMMUNITY ANALYSIS. — MDS analysis of the data on taxa from all phyla shows a clear pattern which can be related both to depth and to sediment granulometry. All the replicates taken between 30 m and 95 m lie in order along the central axis of the plot (Fig. 2) with the shallowest sites at the top right-hand side and the deepest sites to the bottom left. This indicates a gradual change in the composition of the fauna with increasing depth. The



MDS Plot for Sassenfjord Macrofauna

FIG. 2. — MDS plot comparing stations at different depths on the basis of all species present. Each replicate is plotted separately.

deepest station was clearly distinct from the shallower sites; on the MDS plot all replicates cluster together in the top left-hand corner. Figure 3 shows that at all depths annelids account for between 46 % and 59 % of all species and between 50 and 67 % of all individuals. Their contribution to the standing crop biomass is more variable (28 % at 73 m to 95 % at 123 m) but nevertheless they can be considered the dominant phylum.

PATTERNS IN ANNELID DISTRIBUTION. — Although there were 69 annelid taxa recorded, 14 of these account for 95 % of the individuals and 17 account for 95 % of the annelid biomass. The mean number of taxa per sample was greatest at the shallowest (30 m) site with a mean of 31 ± 3 (SD) but subsequently fell to between 23 and 24. No more than 36 annelid taxa were recorded in any single grab sample.

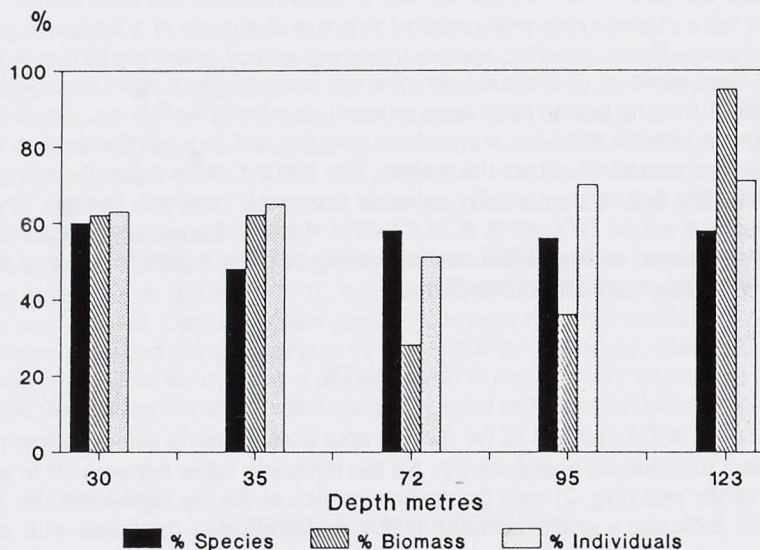


FIG. 3. — Bar histogram demonstrating the importance of polychaetes in the Sassenfjord assemblages.

MDS was used to cluster together species with similar patterns of distribution. For this analysis only the 14 most abundant species were considered. Figure 4 shows a major group of 10 species with four outliers. The two

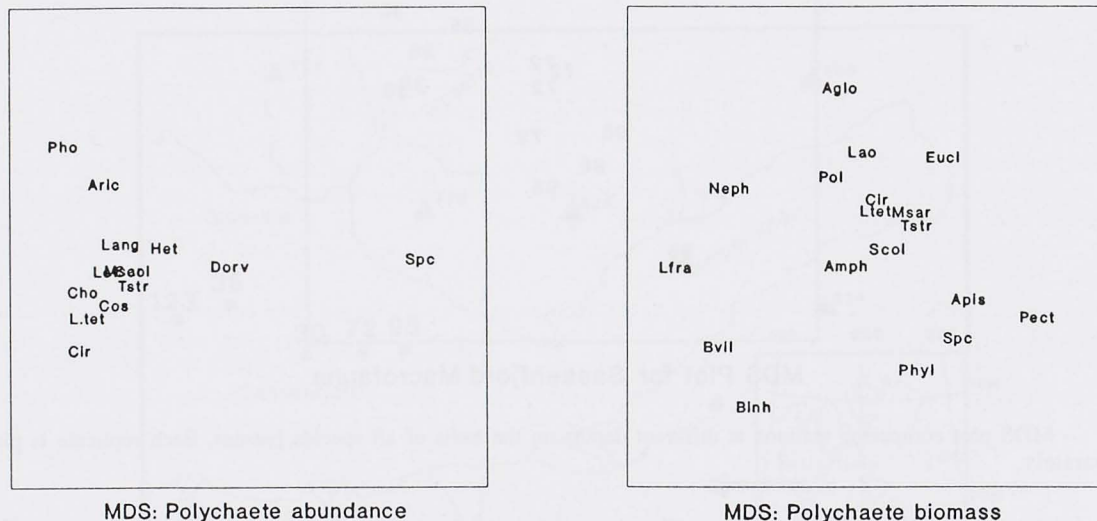


FIG. 4 (left). — MDS plot comparing polychaete species in terms of their abundance at each depth. Key: Agl = *Aglophamus malmgreni*; Amp = *Ampharete finnarchica*; Api = *Apistobranchius tullbergii*; Aric = *Aricidea* indet.; Bin = *Brada inhabilis*; Bvi = *Brada villosa*; Cho = *Chone duneri*; Cir = Cirratulidae; Cos = *Cossura longocirrata*; Dorv = *Dorvillia rubrovittata*; Het = *Heteromastus filiformis*; Lao = *Laonice sarsi*; Lang = *Langerhansia cornuta*; Lev = *Levinsonia gracilis*; Lfr = *Lumbrineris fragilis*; Ltet = *Lumbrineris magnidentia*; Msar = *Maldane sarsi*; Nep = *Nephtys ciliata*; Pec = *Pectinaria hyperborea*; Pho = *Pholoe synophthalmica*; Phyl = *Phyllodoce groenlandica*; Pol = *Polycirrus arcticus*; Sco = *Leitoscoloplos* indet.; Spc = *Spiochaetopterus typicus*; Tstr = *Terebellides stroemi*.

FIG. 5 (right) — MDS plot comparing polychaete species in terms of their biomass at each station. For key see Fig. 4.

species positioned above this group, *Pholoe synophthalmica* and *Aricidea* indet. are shallow water animals with poor penetration to greater depths. *Chone duneri* has a somewhat similar distribution but is more strongly represented below 35 m. The species lying to the right of the main group (*Dorvillia rubrovittata* and *Spiochaetopterus typicus*) are characteristic of deeper water. The remaining taxa were well represented at all depths but *Lumbrineris magnidentata*, the Cirratulidae, *Cossura longocirrata* and *Maldane sarsi* were particularly abundant at the 35 m station. In the latter case, most individuals at such shallow depths were small and immature. *Leitoscoloplos* indet. was evenly distributed between sites but *Terebellides stroemi* showed peaks in abundance at the shallowest and the deepest site. Once again, there was a substantial difference in the size of the animals with depth, the smallest individuals being at the shallowest sites.

A slightly different view of the assemblage emerges when one considers the distribution the various annelid species in terms of their biomass rather than their abundance. Only the 17 species accounting for 95% of the total biomass were included in the analysis. While many species which were considered important on the basis of abundance remain for consideration, they are joined by others which are larger but less common. In the MDS plot based on biomass data (Fig. 5) there is a central grouping of species having a broad depth distribution. This bears similarities to central grouping of the abundance plot (Fig. 4) as it contains the cirratulids, *Lumbrineris magnidentata*, *Maldane sarsi*, *Terebellides stroemi* and *Leitoscoloplos* indet. Above this group lie *Laonice sarsi* and *Polycirrus arcticus*; the first of these was best represented at 72 m while the latter was numerous at the 35 m station. Below the central grouping in Fig. 5 lie species which were characteristic of the 123 m site; *Pectinaria hyperborea*, *Spiochaetopterus typicus* and *Terebellides stroemi*. At this depth polychaetes account for 95 % of the mean community wet weight biomass ($101 \pm 3 \text{ g. m}^{-2}$) and the greatest part of this is due to these three species plus large individuals of *Maldane sarsi*. The remaining species in this grouping, *Phyllodoce groenlandica* occurred throughout the depth range but at shallower sites it was only represented by small individuals. Around the clusters which have already been discussed lies an arc of species which are included in the analysis by virtue of their large body size but, as they are comparatively rare, were not efficiently sampled by the sampling strategy which we employed; little importance can be attached to their distribution on the MDS plot. This group is composed of *Aglophamus malmgreni*, *Nephtys ciliata*, *Lumbrineris fragilis*, an unidentified species of *Euclymene*, *Brada villosa* and *B. inhabilis*.

DISCUSSION

The benthic fauna of muddy sediments in Sassenfjord undergoes a gradual change in composition between 30 m and 93 m but before 123 m there is a clear transition from a moderately diverse community of animals of small body size, to an assemblage which has a high standing crop biomass and is dominated by large polychaetes. This does not appear to be a simple function of depth alone. Sassenfjord lies more than 70 km from the open sea and is ice-covered for much of the year; wave-induced disturbance is unlikely to be significant at any but the most shallow of sites. As KENDALL & ASCHAN (1993) have pointed out, it is more likely that the intensity of sediment deposition from the Gipselva stream will vary with distance from its outflow and with depth and so influence the benthic fauna. A similar situation is described in the Hornsund Fjord in the south of Spitsbergen by GORLISH *et al.* (1987) who suggest that the high rate of sediment deposition close to a glacier dilutes any available organic matter with indigestible material. This condition is exacerbated by low levels of bioturbation in the sediment and low primary production in the turbid water column. As the rate of sediment deposition decreases and bioturbation increases so does the abundance of benthic life. In such situations in the Canadian Arctic, SYVITSKI *et al.* (1989) have described a transition from a shallow assemblage dominated by the bivalve *Yoldiella* to a deeper assemblage characterised by *Maldane sarsi*; such a sequence was observed in the Sassenfjord.

In surveys around Raudfjord (N. Spitsbergen) and van Mijen Fjord (W. Spitsbergen), GULLISKEN *et al.* (1985) found the most abundant fauna outside the fjords with a decrease towards the innermost transects where they recorded no more than 8-10 species of all phyla in each 0.1 m² sample. They attribute this impoverishment to high levels of siltation and poor water exchange. Direct comparison with studies such as this and that of GORLISH *et al.* (1987), is difficult as the sampling methods used were not consistent; while GULLISKEN *et al.* (1985) separated the fauna from the sediment using a 1 mm mesh, GORLISH *et al.* (1987) employed one of 2 mm. It is equally difficult to be sure how the results of their analyses compare with those of the Sassenfjord study. While the larger meshes would tend to underestimate the abundance of species with small body size, there would be little difference in estimates of biomass. Nevertheless, it seems that the Sassenfjord fauna might be unusually rich as GULLISKEN *et al.* (1985) record diversity values similar to those which have been calculated in the present study,

despite the probability that they underestimated the abundance of the smallest individuals. WESLAWSKI *et al.* (1990) consider the area unusually rich in comparison with other Spitsbergen fjords. Although the sampling sites in Sassenfjord were clearly under the influence of suspended matter deposited by the Gipselva stream, if the conditions described by WESLAWSKI *et al.* (1990) are typical (Secchi disc depths of 3-8 m) then it is unlikely that the sedimentation regime is as severe as in the other fjords. It is also possible that local upwelling (WESLAWSKI *et al.*, 1990) may stimulate primary production in the water column to levels greater than those elsewhere in Spitsbergen. Such intermediate levels of disturbance accord well with the ABC plots of KENDALL & ASCHAN (1993) and may well account for the high diversity of this area.

SANDERS (1968) claimed that there was a polar-tropical gradient in the macrobenthic fauna of soft sediments. When the fauna of the 123 m site in Sassenfjord was compared with a similarly disturbed offshore sandy mud in the North Sea, using directly comparable methods, little difference could be observed in their α -diversity profiles (KENDALL & ASCHAN, 1993). The polychaete component of the infauna of the two areas was broadly similar, both in the number of species and in wet weight biomass, although at the Arctic site the mean density of individuals was higher (KENDALL, unpublished). These observations support THORSON's (1957) assertion that the infauna does not show the same degree of latitudinal variability as the epifauna. However, such an inference assumes that both of the locations have a faunal diversity which is typical of their latitude. While there is no cause to question the representativeness of the North Sea site, it is not clear just how well Sassenfjord represents Arctic conditions. Certainly, physical data suggest that the area is a good example; at 78°N the sun is below the horizon from the start of November until the end of February, fjords are ice-covered from 6-10 months of the year (EILERSTEN *et al.*, 1989) and in the Sassenfjord itself the bottom temperature during summer is less than 0.5 °C (WESLAWSKI *et al.*, 1990). On the other hand, faunal evidence suggests that the area is not fully Arctic.

While the composition of the Sassenfjord fauna shows strong Arctic influences, boreal and/or cosmopolitan polychaete species appear to be disproportionately important when their contribution to the total abundance or biomass is considered. Many of the species sampled in the Sassenfjord are also commonly recorded in the North Sea (*cf.* BUCHANAN & MOORE, 1986). This confirms a finding from other fjords on the north and west coasts of Spitsbergen (GULLISKEN *et al.*, 1985). In reporting their study they claim that all the polychaetes they encountered were recorded from both Arctic and boreal waters. STROMBERG (1989) too records the importance of boreal species in this area and attributes their importance to the influence of the Atlantic water of the northern-flowing West Spitsbergen Current. In the Beaufort Sea (71°N), BILYARD & CAREY (1980) have also observed substantial numbers of non-endemic species in water shallower than 300m, but rather than attributing their presence to warming currents they relate their presence to inter-glacial invasions. The real extent of this boreal intrusion into Spitsbergen waters may not, however, be as great as the data immediately suggest. The status of a number of the more important boreal, or cosmopolitan species of the area has been questioned in recent years; among these are *Terebellides stroemi* (WILLIAMS, 1984), *Tharyx* (BLAKE, 1991), *Chaetozone* (CHRISTIE, 1985), *Cossura longocirrata* (FOURNIER & PETERSEN, 1991) while LIGHT (1991) lists four sub-species of *Maldane sarsi*. It is possible that other "species" with very broad ranges might similarly prove to be complexes of sibling species. It is unlikely that the existence of a substantial proportion of non-endemic species in Sassenfjord is in any way unusual for a shallow water Arctic assemblage.

ZENKEVITCH (1963) recognised six major macrofaunal assemblages in the adjacent Barents Sea and none of these had the faunal characteristics recorded in Sassenfjord. In a broad scale study of the Arctic Chukchi Sea and the sub-Arctic Bering Sea, GREBMAIER *et al.*, (1989) have described 11 different assemblages which vary substantially in the identity of the dominant phylum. In doing so, they demonstrated the relationship between the properties of the sediment and the community it supports. Nevertheless, the most northerly mud community which was described, and hence that which was most comparable to that in Sassenfjord, was clearly dominated by amphipods rather than by polychaetes. This serves to emphasise the potential for variation in the structure of Arctic assemblages and so brings the present study into perspective. The comparison between an Arctic site and analogous sites in the North Sea and Java (KENDALL & ASCHAN, 1993) has shown few differences in the α -diversity of either the whole community or the polychaete component of it. On the basis of such a limited comparison it would be unrealistically hasty to dismiss existing hypotheses concerning latitudinal variability in patterns of infaunal diversity. Even in a study in which an effort is made to hold variables such as sediment type and depth as constant as possible, we must expect to encounter a variety of communities each of which will have its own diversity properties. As yet we cannot be sure of the position of the Sassenfjord sites within such a range. For this reason, if we are to address the problem of latitudinal patterns of diversity we must first establish the range of variation within the areas which we are comparing.

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