ENVIRONMENTAL ATLAS
GIPSDALEN, SVALBARD Vol. II
Reports on the Quaternary Geology, Vegetation, Flora and

Prepared for Northern Resources Ltd.
by the Norwegian Polar Research Institute
Editors: Bente Brekke and Rasmus Hansson

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ENVIRONMENTAL ATLAS
GIPSDALEN, SVALBARD Vol. II

Prepared for Northern Resources Ltd.
by Bente Brekke and Rasmus Hansson
Norwegian Polar Research Institute

With contributions from:

Jon Tolgensbakk, Leif Sørbel and Kirsti Høgvard:
Quaternary Geology and Geomorphology in Gipsdalen, Svalbard.

Hilde Keilen:
Bedrock geology in the Gipsdalen area.

Reidar Elven, May-Britt Eriksen, Arve Elvebakk, Bernt E. Johansen, and Torstein Engelskjøn:
Gipsdalen, Central Svalbard; Flora, Vegetation and Botanical values.

Per Ole Syvertsen:
The Fauna of Gipsdalen, Svalbard.

J. Marcin Weslawski, Slawek Swerpel, Jozef Wiktor, Marek Zajaczkowski, Marek Ostrowski, and Ryszard Siwecki:
Summer Environmental Survey of Gipsvika, Svalbard.

Rasmus Hansson:

Professionally responsible: Fridtjof Mehlum

Norsk Polarinstittuts Bibliotek
Bünsow Land with Gipsdalen, Central Spitsbergen, Svalbard.
This Environmental Atlas is the first product of an Environmental Impact Assessment for a proposed coal mining project in Gipsdalen, Svalbard. The project is carried out by the Norwegian Polar Research Institute on behalf of Northern Resources Ltd. The atlas consists of:

- Volume I: "Sensitivity of the Gipsdalen Environment", including a preliminary impact assessment of the proposed coal mining project, and (in separate cover) a vegetation map (two sheets), a conservation value map for vegetation, and a quaternary geology and geomorphology map. As Volume I contains confidential information its distribution is restricted until further notice.

- Volume II (this Volume): "Reports on the Quaternary Geology, Vegetation, Flora and Fauna of Gipsdalen, and the Marine Ecology of Gipsvika"; full reports from the work carried out in 1989, also includes the above mentioned maps. The fauna report is in Norwegian, with an exhaustive English summary.

The fauna report presented in these volumes is not complete. A winter/spring Svalbard reindeer *Rangifer tarandus platyrhynchus* survey, a Ringed seal *Phoca hispida* marine mammal survey, and a literature study of the reactions of Ringed seals and other marine mammals to disturbance, are being carried out during the spring of 1990, and will be reported during the summer of 1990. A study of Pink-footed geese *Anser brachyrhynchus* including their reaction to disturbance, and additional seabird counts are planned to be carried out during the summer of 1990 and reported early in the autumn of 1990. Based on the complete series of environmental studies and the plans for coal mining in Gipsdalen, an Environmental Impact Assessment of coal mining in Gipsdalen is planned to be prepared during the autumn of 1990.

The vegetation and quaternary geology maps were produced at a higher quality than strictly needed for this project. The production was thus partly funded by the Norwegian Polar Research Institute and the Department of Physical Geography, University of Oslo, respectively. The project is otherwise funded by Northern Resources Ltd.

We thank those who have made contributions to reports and maps (see author list). We also acknowledge the contributions of Fridtjof Mehlum (professionally responsible), Ian Gjertz, Halvar Ludvigsen, and the Governor of Svalbard.

Bente Brekke

Rasmus Hansson
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SUMMER ENVIRONMENTAL SURVEY OF GIPSVIKA, SVALBARD

Summary and conclusions

Introduction

Materials and methods

Results and discussion

Geographical position, area, bathymetry

Sediments

Coasts

Hydrology

Fresh water volume, river plume and circulation

Suspension and water transparency

Benthic fauna

Prominent species and communities

Specific biota

Feeding grounds

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Phytoplankton

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Maps (in separate cover):
- Gipsdalen vegetation map (2 sheets)
- Conservation value map; vegetation (Fig. 7 in Elven et al.: Gipsdalen, Central Svalbard; Flora, vegetation, and botanical values.
- Quaternary geology and geomorphology
Raised beach-ridge system with a distinct pattern of tundra polygons. In the upper center an alluvian fan in front of terrace edges. The upper part of the mountain wall of Templet is scoured by avalanche tracks, while the lower part is covered by talus cones (foto: Jon Tolgensbakk).

by
Leif Sørbel, Kirsti Høgvard and Jon Tolgensbakk *

Including: BEDROCK GEOLOGY OF GIPSDALEN
by Hilde B. Keilen **

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1330 Oslo Lufthavn
SUMMARY AND CONCLUSIONS

Gipsdalen is a typical, dry central Spitsbergen valley. Except for the raised beach forms and De Geer moraines mentioned below, Gipsdalen does not contain forms of particular interest from a geomorphological point of view.

A scale 1:40 000 map of the quaternary geology and geomorphology of Gipsdalen is presented (enclosed). Based on this map and a classification system for vulnerability to wear, the sensitivity of areas in Gipsdalen is identified (Fig. 23).

The areas are classified as

**Group 1 Inulnerable to wear**: surface continuously changing, usually very coarse gravel or exposed bedrock/ice. Traces of wear disappear quickly.

**Group 2 Slightly or moderately vulnerable to wear**: coarse gravel/sediment and little water/ice in upper layers, little vegetation cover. Traces of wear are shallow, no subsequent erosion.

**Group 3 Vulnerable to wear**: fine-grained sediment and relatively high water/ice content in upper layers, continuous vegetation, flat. Traces of wear are prominent and may be extended through subsequent erosion.

**Group 4 Greatly vulnerable to wear and subsequent erosion**: Similar characteristics as Group 3, and additionally; sloping ground, very high water/ice content in flat areas, running water in sloping. Traces of wear are very prominent, and damage will normally increase significantly because of melting, mass movement and erosion by running water.

**Group 5 Worthy of conservation**: e.g. unique land forms, rare plant communities, occurrences of fossils etc. of particular scientific, pedagogical or historical value, important for tourism/recreational experience etc. Not necessarily vulnerable to wear.

Close to the mouth of the valley, between Dalkallen and the river, there are well-developed systems of raised beach forms (Figs. 4 and 13). These are of scientific interest and worthy of conservation (Group 5).

Patterns of large tundra polygons also occur in these areas (front page of this report). Two of the most representative areas are classified in Group 5.

The field of De Geer moraines between Boltonbreen and Methuenbreen is among the most interesting in Svalbard, where such moraines are uncommon. The moraines are classified to Group 5. They are also vulnerable to impact. Between Aitkenfjellet and Ushermjellet, mainly on the eastern side of the river, most of the flat vegetated areas with fine-grained marine or gelification material are vulnerable to wear (Group 3-4). Along both sides of the valley from Gipsvika to Rinkbreen, patches of Group 3 and some Group 4 areas occur. Slope, water and/or vegetation cover make these areas vulnerable.

The raised beach areas are slightly or moderately vulnerable to wear. The areas not classified as Group 5 belong to Group 2.

Steep slopes and talus cones are considered in-vulnerable or moderately vulnerable to wear (Group 1 or 2). This goes for most of the higher parts of the valley slopes. Parts of the fossilized and vegetated alluvial fans are somewhat more vulnerable (Group 2).

Current alluvial plains (e.g. Leirflata) and active alluvial fans (in front of the side valleys), are considered invulnerable (Group 1).

During detail planning and possible implementation of the proposed plans for coal mining, the following factors affecting terrain wear should be taken into consideration:

**Vegetation Cover**: Removal of the vegetation cover will alter the thermal balance in the active layer and may cause erosion.

**Surficial Material**: Fine-grained material has an ice/water content often > 50%. It is unstable and subjected to mass movement and erosion.

**Topography**: Exposure is significant to snow accumulation and thus length of snow-free season and amount of meltwater. Gradient is significant to mass movement and erosion and thus terrain wear.

**Permafrost**: the depth of the active layer influences drainage and the stability of the sediment. Insulative capacity of the vegetation cover, type of material, length of snow-free season and water balance influence the permafrost.

**Water Access**: Accumulation of water on the ground may cause increased permafrost melting (Fig. 19). Tracks on slopes act as water channels and may cause erosion.

The existing vehicle track running through Gipsdalen mainly follows dry areas. The wear is distinct (Fig. 20), but not expanding except in some moist areas (Fig. 21), where new tracks are being made alongside the old and melting and fluvial erosion is extending the damage (Fig. 22).
BEDROCK GEOLOGY IN THE GIPS­
DALEN AREA

The Svalbard Archipelago contains an almost complete geological sequence ranging from the late Precambrian to the Cenozoic, with the largest proportion of sedimentary rocks (basement, about 1000 mill. years old), up to recent Quaternary sediments. The oldest unit exposed in the Gipsdalen area is of the middle Hecla Hoek division (about 800-700 mill. years old). It is exposed in the innermost part of the valley in front of Florabreen (Lauritzen et al. 1989). This unit consists of fine grained, dark phyllite and micaschist, which in some parts are more coarse grained and comparable to sandstone/gravel in texture. The Hecla Hoek rocks were originally sedimentary rocks which during the Caledonian Orogeny (500-400 mill. yeras ago) were subjected to an increase in temperature and pressure (metamorphosed). These rocks were hardened and are today much more resistant against erosion processes and weathering than the surrounding post-Devonian sedimentary rocks. Glacial striae (see enclosed geomorphological map) from the last glaciation are exposed on the surfaces of these Hecla Hoek rocks.

Svalbards tectonic framework is dominated by a number of structural lineaments, mostly N-S to NW-SE oriented. One of these, the Billefjorden Fault Zone (BFZ), had significant influence on the sedimentation regimes certain periods from Devonian time. This lineament is recognized from the Reinland area, Nordenskiöld Land north of Van Mijenfjorden and northward to Austfjorden, in the southern part of Wijdefjorden. The fault zone runs through the Gipsuken area (Fig. 1).

The Billefjorden Fault Zone divided 'high' areas to the west represented by the Nordfjorden Block, and 'low' areas to the east, the Billefjorden Trough, in Lower to Middle Carboniferous time. East of this fault zone a sedimentary basin, the Billefjorden Trough, was developed, and filled up by a large amount of sediments during the Middle Carboniferous time. During Upper Carboniferous and Lower Permian time, the entire area was a part of an extensive, shallow carbonate platform. The total thickness of sediments east of the BFZ is approximately 3500 m (Lauritzen et al. 1989). This sedimentary sequence is today almost horizontally bedded with a gentle NW-SE strike, and a NE-SW dip and lies unconformably on the Precambrian Hecla Hoek basement. (In this case, the older beds dip at a different angle to the younger, upper beds).

The sedimentary sequence is devided lithologically into three main groups; The Billefjorden-, Gipsdalen- and Tempelfjorden Groups. (Cutbill & Challinor, 1965).

The lowermost Billefjorden Group consists of sandstones and coalbearing dark shales which were deposited in a humid, swamp-like environ ment with alluvial fans and river floodplains which built out from the graben edges (Gjelberg & Steel, 1981). Outcrops are seen in the innermost part of the Gipsdalen in the bottom of the valley northwest of Finlayfjellet.

The Gipsdalen Group east of the BFZ is in the lowermost part dominated by sandstones, carbonates and evaporites (limestones, dolomites and gips/anhydrites; mainly sediments resulting from the evaporation of saline water) intercalated by marls and shales. These sediments represents alluvial fan and fan delta environments which built out eastwards into restricted marine and sabkha environments (abroad, salt-encrusted, supratidal surface or coastal flats bordering lagoonal or inner shelf regions). Outcrops are seen in the inner half of the valley bottom in front of Margaretbreen, south of Nordstrømfjellet and northwest of Pyefjellet. The middle unit is exposed along the entire valley floor and is predominantly made up of fossiliferous, light gray to very dark gray/blackish limestones interbedded with marl. These sediments were deposited in restricted and more open marine environments.

The uppermost part of the Gipsdalen Group is made up of interbedded white colored evaporites, yellowish dolomites and dark gray marls with a transition to more grayish limestones towards the top. These sediments were deposited in a sabkha environment which then was transgressed by restricted and more open marine environments. (A trangression means an invasion of a large area of land by the sea in a relatively short space of time, geologically speaking). The main part of the valley slopes and escarpments are made up of these sedimentary rocks. They are the main source for the Quaternary sediments in the valley bottom.

The transition between the lower Gipsdalen Group and the Tempelfjorden Group represents an erosive contact and is very easy to recognize in the field. It is a lithological marker horizon. (A relatively thin layer of rock which because of some peculiarity of lithology, structure, or faunal content is easily recognised). The Tempelfjorden Group which is the youngest exposed sedimentary sequence in this area comprises limestones, cherts, siltstones, sandstones and spiculitic shales with a predominantly dark gray colour. The limestones are interpreted as shoreface deposits. The other sediments represent local shoaling in a deep, distal and shallow shelf environment. Outcrops of these resistant rocks are seen on the top of the mountains surrounding the valley. Gipsukenlitta, Gipsukodden, Gåsodden and Gås­syane consist of blackish dolerite, which is caused by intrusions and volcanic activity during the transition between the Jurassic and Cretaceous (Steel & Worsley, 1984). Glacial strias from the last glaciation are easily seen on these rocks at Gåsodden (Lauritzen et al. 1989).

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GIPSDALEN, Svalbard

Figure 1 The geology of Gipsdalen, Bunzow land, Svalbard. Modified from Lauritzen, Salvigsen and Winsnes 1988. Billefjorden Geological map Svalbard 1:100 000.
GEOMORPHOLOGY AND QUaternary GEOLOGY OF GIPSDALEN, SVALBARD

INTRODUCTION

In the course of the last few years, the Department of Physical Geography, University of Oslo, has undertaken a comprehensive mapping of land forms and surficial deposits on Svalbard. Thematic overview maps of glacial geology and geomorphology (Kristiansen & Sollid 1986) and surficial deposits (Kristiansen & Sollid 1987) have been prepared. Both of these maps cover Svalbard in its entirety (scale 1:1 mill.) and are included in the National Atlas for Norway. A series of maps of Svalbard's coastal zones in a scale of 1:200,000 have also been prepared (Høg­vård & Sollid 1988, 1989a, 1989b, 1990, Ødegård et. al. 1987). The maps include both geo­ and bio-information. In connection with the coastal maps, a data base of videos and photographs, most of which have been taken from helicopter, is in the process of being built. The maps and data base are thought to be of particular use in connection with environmental management, and in the preparation of impact assessments of different types of intervention, i.e. oil prospecting. In addition, detailed mapping in connection with research on erosion, mass movement, and frost processes in specific areas (Sørbel & Tolgensbakk in prep., Tolgensbakk 1987, and Tolgensbakk & Sollid 1987) has been undertaken. This research comprises a part of the scientific basis for this report.

Research on terrain wear and impact assessments of planned development activities has been carried out earlier in many connections, among them, as a part of the MUPS project (Environmental Impact Studies on Svalbard, cf. Hansson et. al. 1990). In cooperation between the Department of Physical Geography and the Norwegian Polar Research Institute, a project on erosion studies and Quaternary geological mapping was initiated in 1984 in Adventdalen. Studies on erosion in reindeer grazing areas, and research on terrain damage caused by human activity have been undertaken. The project was initiated by Professor Nils Are Øritsland from the Norwegian Polar Research Institute and Professor Johan Ludvig Sollid from the Department of Physical Geography. Field research has mainly been carried out by Leif Sørbel and Jon Tolgensbakk from the Department of Physical Geography at the University of Oslo (Sørbel & Tolgensbakk in prep.). In connection with the project, a system for evaluating the vulnerability of different types of terrain with respect to wear damage is being developed. This system is used in the following report from Gipsdalen, and in earlier research, including Sassendalen and Gipsdalen (Sørbel 1987), Agardhdalen (Elvebakk & Sørbel 1988) and Reindalen (Sørbel, Sollid & Etzelmüller 1989). The studies in Sassendalen and Gipsdalen in 1987 (Sørbel op. cit.) were undertaken on behalf of SNSK and Norsk Hydro.

The main part of the field research of this assignment, however, was carried out in Sassendalen, with only four days field work by one individual in Gipsdalen. A general classification of the area in terms of degree of vulnerability was then prepared, but the limited time available did not allow for the undertaking of detailed mapping of land forms and surficial material. The research in Gipsdalen in 1989 emphasized the preparation of a detailed map, thereby laying the groundwork for a more detailed classification in terms of evaluation of vulnerability in relation to terrain damage.

The field research in 1989 was carried out by Jon Tolgensbakk and Kirsti Høgvard between 13. and 20. July. During this period, field mapping of land forms and sediment was undertaken along with soil sampling. In addition, the area was photographed from a helicopter with a 6x6 Hasselblad camera and diapositive colour film. This photo material has been a useful supplement to the black and white aerial photographs. The enclosed Quaternary geological and geomorphological map (Tolgensbakk 1990) is produced on the basis of fieldwork, helicopter photos, and existing aerial photographs. The thematic information on the completed map is transferred photogrammetrically in a stereomosaic (Santoni Stereosimplex G6) from the aerial photo series S61 from the Norwegian Polar Research Institute.

The report initially gives a general overview of the natural conditions in Gipsdalen. Landforms, glaciers, climate, permafrost and bedrock conditions are discussed. Thereafter follows a description of the enclosed Quaternary geological and geomorphological map (Tolgensbakk 1990) with definitions and discussion of the individual elements that are mapped. Finally, an overview of different physical relationships that affect terrain damage is presented, as well as a classification of Gipsdalen in areas according to degree of vulnerability.

Interpretation of aerial photos, drawing of figures, reproduction work and report writing was carried out at the Laboratory of Remote Sensing and Thematic Mapping at the Department of Physical Geography, University of Oslo. Expenses for the field research and the technical preparation of the map and report are partly covered by Northern Resources Ltd.

DESCRIPTION OF THE GIPSDALEN AREA

Gipsdalen is ca. 25 km long, and ca. 3 km by the fjord. The valley floor is broad and flat, outlined by steep mountain slopes (Fig. 2). It is largely covered by sediment, partly by fine-grained marine material, and partly with relatively coarse river material. This material was deposited in a what was a shallow fjord during the deglaciation
phase of the last Ice Age. At that time, the sea level was relatively higher than today, as the landblock was depressed by the weight of the inland ice. The marine limit, i.e. the highest sea level after the inland ice disappeared, is 72 m a.s.l. at three different locations in the outer part of Gipsdalen. Datings of shells and driftwood from Kapp Ekholm shows that the Billefjorden area probably became ice-free around 10,000 years BP (Salvigsen 1984, Lauritzen et al. 1988).

During the period of deglaciation, an uplift of the landblock took place due to the decreasing weight of the ice. The rate of uplift was highest in the beginning and then decreased gradually. The change in the relative height of sea level during postglacial time is shown in a shoreline displacement curve in Fig. 3.

Figure 3 Shoreline displacement curve for the Kapp Ekholm - Ekholmvika area in Billefjorden, based mainly on radiocarbon dates and pumice observations (from Salvigsen 1984).

Around the outlet of Gipsdalselva there is a well-formed system of raised beach ridges (Fig. 4) which shows the subsequent land raising after the last Ice Age. Driftwood, shells, whalebones and pumice found at different heights on the beach ridges can be used for dating of the different sea levels (Salvigsen 1984). The beach ridges consist of coarser material than the fine-grained marine deposits further inland. The finer particles in the beach ridges have been removed by wave activity.

In the lower part of the steep valley sides, colluvium (material from mass movement) is deposited in the form of distinct talus cones (Fig. 5). In the steep mountain walls above, debris is produced regularly because of frost weathering. This material eventually builds up the talus cones. Alluvial fans (river fans) of rather coarse material are built in front of the side valleys. The fans are formed where the water is no longer able to transport the coarser material due to decreasing fall in the river profile. Alluvial fans cover a large part of the valley floor. This is typical for Svalbard. Basically, the main landscape features are dominated by landforms created by weathering, mass wasting, frost processes and fluvial activity. Landforms made by glacial erosion of inland ice are less common on Svalbard than in Fennoscandia.

A series of valley glaciers fill the side valleys of Gipsdalen. In the upper part of a glacier (the accumulation area), the input of snow and ice in the winter is higher than the output by melting in the summer. In the lower part (the ablation area), the summer melting is higher than the input of snow and ice in the winter.

Generally, the glaciers on Svalbard are characterized as subpolar. The ablation area remains below freezing temperature all the way to the bottom, while the accumulation area maintains a temperature at the pressure melting point. Permafrost is therefore seldom found under the accumulation area of the glaciers.

In the cold ablation area of a subpolar glacier, the meltwater drainage is partly running in streams
Figure 4 Raised beach ridges around the outlet of Gipsdalselva. Note the distinct vehicular track crossing the area.

Figure 5 Talus cones and avalanche tracks at Usherfjellet. Many of the cones are scoured by debris-flow channels. View towards N.
at the ice surface, partly in tunnels cut down in the glacier. The outlet of such a tunnel is shown in Fig. 6.

As parts of the glaciers are at the melting point, water may also run from the glacier in the winter. At the front of the glacier this water freezes into large cakes of ice, "icings". These can become so large that parts of them survive the entire melting season. In the summer of 1989 there were two icings in Gipsdalen, one small on top of the ice-cored moraine in front of Margaretbreen (about 50 000 m²), and a larger one in front of Methuenbreen close to the Finncal Development (FCD) camp, covering an area of 0.67 km² (Fig. 7). Assuming a mean thickness of 2 m (probably a low estimate), this represents 1.3 mill. m³ of water. Satellite images were examined to check the dimensions of this icing in the recent past. As shown in Fig. 8, the icing was much larger in 1989 than in 1985 and 1986 (0.67 km² compared to 0.12 and 0.11 km²). If this icing grows slightly in years to come, it may cause damage to the FCD camp.

The lower parts of the glaciers in Gipsdalen have a relatively gentle slope (9° at the lower 2 km at both Methuenbreen, Margaretbreen and Boltonbreen). This can imply that the glaciers are currently relatively inactive. The front of the Methuenbreen and the Margaretbreen has retreated 450 and 150 m respectively since 1961. The enclosed map shows the extent of the glaciers in 1969.

On Svalbard it is common that the glaciers move relatively slowly, partly because the ice is cold and has low plasticity, partly because the glacier is frozen to the ground in the ablation area. Movement thus becomes too small to keep a state of equilibrium between the mass stored in the upper part of the glacier, and that melting off in the lower part. This can create an increasingly steep surface in the upper part of the glacier.

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Figure 6 Meltwater stream from medial moraine at Methuenbreen.
Figure 7 Large icing (0.67 km²) on the alluvial fan in front of Methuenbreen. The location of the Finncoal Development camp is indicated with a white arrow. Photo from helicopter, view towards W.

Icing in front of Methuenbreen

<table>
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<td>28th of August</td>
</tr>
<tr>
<td>1989</td>
<td>19th of July</td>
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Figure 8 The extent of the icing in front of Methuenbreen 1985, 1986 and 1989.
until a certain critical limit is reached. Glacier movement then increases manifold, and the glacier front becomes steeper and moves rapidly forward. This is called a "surge" (Liestøl 1969, 1989, Hagen 1988).

Large moraine ridges lie in front of the current glaciers. As usual on Svalbard, these moraines contain a core of glacial ice covered by till. They are thus called ice-cored moraines. The vegetation cover is relatively thin and discontinuous in large areas of Gipsdalen, except for moist areas with fine-grained marine sediment and a continuous cover of wet tundra vegetation.

The climate in central parts of Spitsbergen is high arctic. The closest meteorological station is in Longyearbyen, approximately 40 km southwest of Gipsdalen. The average annual temperature in Longyearbyen is -5.5°C, and the annual precipitation is about 300 mm.

Svalbard's land regions have continuous permafrost, with the exception of areas under the glaciers. The depth of the permafrost ranges from ca. 150 m in the lower areas up to 500 m in the higher areas (Liestøl 1977). The "active layer", a surface layer of about 0.5 m - 1.5 m, melts in the course of the summer. In the summer of 1989, the depth of the active layer in Gipsdalen was measured to about 70 cm in areas with fine-grained material. In coarse material, the active layer penetrates deeper because the ground contains less ice and water.

COMMENTS ON THE GIPSDALEN QUATERNARY GEOLOGY AND GEOMORPHOLOGY MAP

SURFICIAL MATERIAL

The enclosed map "Gipsdalen, Svalbard; Quaternary Geology and Geomorphology 1:40,000" (Tolgensbakk 1990), shows different types of surficial material portrayed on the map as surfaces with different colour shades. Surface material is classified on the basis of the way they were formed. It can, however, be difficult to determine the genesis completely. Different genetic processes can operate simultaneously, or the original material may be affected at a later date by other processes. In such cases, the colour on the map shows the dominating type of sediment, while occurrences that are small or difficult to delimit are labelled with letters. The different types of surficial material shown on the enclosed map are described in the following section.

Till is debris which is transported and deposited directly from glaciers. The material is angular, unsorted and may contain all grain sizes from clay fragments to large boulders. Till makes up, as a rule, a compact mass without clear layers.

The largest till areas are found in connection with ice-cored moraines in front of current glaciers. Sediment sample 8 (Fig. 9) is collected at a depth of 1 m in a cutting in the ice-cored moraine in front of Methuenbreen.

The till covering ice-cored moraines is deposited by inland ice. As usual on Svalbard, till from inland ice is relatively sparsely represented within the mapped area. This type of till is far more common in Fennoscandia. The reason for this difference may be that earlier glaciations on Svalbard were dominated by cold-based ice (Sollid & Serbel 1988a), while this was less typical in Fennoscandia. In Gipsdalen, till primarily occurs along the valley bottom. A comparatively large till area is found between Methuenbreen and Boltonbreen. Sediment sample 7 (Fig. 9) is collected from one of the De Geer moraines in this area.

Glaciofluvial material is transported by glacial rivers and deposited relatively close to the glacier, in more or less well-sorted layers. Rock fragments are rounded by water transport. Sediment sample 9 (Fig. 9) from a terrace north of Methuenbreen may represent this type of material. As seen from the grain-size curve, however, the sample has a bimodal distribution.

It is often difficult to distinguish between glaciofluvial and fluvial material on Svalbard. On the map, the term glaciofluvial material is only used on terraces clearly deposited by meltwater from inland ice.

Fluvial material, pre-recent refers to fluvial material deposited in areas where there is no river flow at present. This applies to alluvial fans or alluvial plains that are partly overgrown with vegetation, as opposed to active regions where vegetation cannot establish due to continuously changing ground surface.

Fluvial material, recent is transported and deposited by running water in connection with currently active rivers. The material is sorted, often with pronounced layering. The grain size varies depending on the flow rate under the actual deposition process. Grain fragments are often well-rounded. The degree of roundness depends on the length of transport and the type of rock, and the fluvial material in Gipsdalen is generally less rounded than what is otherwise typical. In active alluvial plains the water continually changes its course, and the rate of flow varies greatly throughout the season. Therefore, some parts of the river beds have pockets of fine sand or silt, while other parts are made up of coarse gravel or stone.

Lakustrine material found at Leirflata is not given a separate colour in the map, but is shown together with recent fluvial material. Lakustrine material is deposited in lakes. This means that Leirflata was previously a lake inside a threshold in the valley that was ually filled up by...
sediments. Lakustrine material is, as shown by sample 6 (Fig. 9), well-sorted and finer than fluvial material.

**Marine beach material** is deposited by wave activity either in the current beach zone or in connection with sea levels from earlier post-glacial periods. The material often builds up distinct beach ridges. Beach material is mainly made up of stones, gravel and sand, with rock fragments well rounded by wave activity. Finer grain particles are normally washed away, and deposited in deeper water or in less exposed beach areas. Sediment sample 1 (Fig. 9) shows a typical grain-size curve for beach material, while samples 3 and 4 contain more fine-grained.

**Figure 9** Sampling sites and cumulative grain size distribution curves for 10 sediment samples from Gipsdalen. The table shows Md (median grain size diameter) and So (sorting).

<table>
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</table>
material than what otherwise common for this type of material. This is due to carbonation and to infilling of eolian material.

**Marine material, fine-grained** is deposited by the settling of suspended material in salt or brackish water. The deposits are generally made up of clay and silt (sample 2, Fig. 9). Fine-grained marine material covers large regions of the valley floor in Gipsdalen. In lower regions shell fragments are abundant in the deposits. The material was deposited when Gipsdalen was a shallow fjord after the inland ice retracted.

**Eolian material** is transported and deposited by wind. The grain size normally varies from medium or fine sand to coarse silt. Eolian material is very well sorted. In Gipsdalen, eolian deposits are mainly found north of the river mouth of Gipsdalselva, around Leirflata and in the inner regions of Gipsdalen. The material is more fine-grained than what is otherwise typical for eolian material (samples 5 and 10, Fig. 9) is because the material has its origin in the fine-grained marine material in the valley.

**Weathered material** is formed in situ by weathering of rock surfaces. Under climactic conditions like in Svalbard, frost shattering is the most common weathering process. Weathered material covers relatively large areas in Gipsdalen, particularly on the maountain plateaus.

**Colluvium** is formed through mass movement such as avalanches, slides or rock fall. The material originates primarily through weathering in upper sections of mountain walls, where it is too steep for debris to remain situated. The coarsest fragments fall and roll farthest down in the slope, while finer material remains higher up. The material thus undergoes a sorting. Rock fall

![Figure 10 Earth hummocks on the flat valley bottom west of Aitkenfjellet. View towards NE.](image-url)
material builds up well-formed talus cones along both sides of Gipsdalen (Fig. 5).

**Glacial Striae**. This term is used for a sediment transported by slow downward flowing of water saturated masses. The movement is a few cm per year at most. The term glifluction is limited to permafrost areas, but the process is basically the same as solifluction. Gelifluction material is, as a rule, rich in fines, but it also contains coarser components.

**Organic Material** describes surfaces with a continuous peat cover. This includes moist bog areas with poor drainage in the valley floor (Fig. 10). The peat layer in Gipsdalen is relatively thin, at the most 30-40 cm thick. In such regions, permafrost is often found near the surface due to the good insulative properties of the peat layer. There is also a great deal of water and ice in the ground, and melting therefore requires greater amounts of heat than in dryer areas.

**Exposed Bedrock** indicates surfaces not covered by debris, or at the most only by a very shallow layer. In many places in Gipsdalen the rock surfaces are heavily weathered. The resistant Hecla-Hoek surfaces innermost in the valley are more intact. Exposed bedrock is also found in mountain walls too steep for debris to remain situated.

**Landforms**

In this section, the different types of landforms shown on the enclosed map are described.

**Glacial Striae** are narrow stripes on rock surfaces, seldom wider than a few millimeters. The stripes are caused by sand and rock particles in the basal ice grinding against rock surfaces as the glacier is moving. The stripes are therefore oriented along the direction of ice movement such as this was at the time the stripes were formed. The map symbol for glacial striae is a line indicating the direction of ice movement towards the observation point, which is indicated by a dot.

Glacial striae that occur outside areas that have been covered by current glaciers, and therefore must have been formed by larger glaciers under the last Ice Age, are only observed at the head of Gipsdalen. In this area, southwesterly orientated striae are preserved the resistant Hecla-Hoek surfaces. Rock surfaces in the mapped area are otherwise so heavily weathered that old glacial striae are seldom preserved. Glacial striae with a southerly and southwesterly direction occur on Gipshuksletta west of the mapped area (Lauritzen et al. 1988).

**Terminal and Medial Moraines, mainly ice-cored.** In front of today's glaciers on Svalbard, there are often very large moraine ridges (Fig. 6 and 11). The moraine ridge in front of Methuenbreen is 57 m high, and that in front of Boltonbreen is 48 m. The surface material of ice-cored moraines is generally coarse, often with big, angular boulders. The ice-core makes up the main part of the ridge. The thickness of the till cover varies from a few dm to several meters. The till cover on the ice must, however, be thicker than the active layer (that which thaws during the summer) if the ice-core is to be preserved over a longer period of time. If the ice-core melts, a dead-ice landscape with mounds and ridges will remain (Sollid & Sørbel 1988b).

Debris may also be found on the surface of the glacier higher up, for example where two glacier tongues combine into one. The material is carried downwards with the ice movement, and remains on the surface in the ablation area as long as the till becomes more than a few cm thick. This layer will insulate the ice surface underneath, and a sharp ice ridge (a medial morain) will emerge under the debris (Figs. 6 and 11).

**De Geer Moraines** are relatively small but distinct moraine ridges. Usually several moraines appear close together. De Geer moraines are formed at the front of glaciers that extend into the sea. Here, the material remains unfrozen throughout the year, and moraine ridges can easily be formed by small winter advances of the glacier front.

De Geer moraines often have an asymmetrical cross profile. The side that faces the glacier front (the proximal side) has a more gentle slope than the lee side. The surface of the moraines may be covered by glaciofluvial or marine material. In Gipsdalen, the surface of the de Geer moraines is often covered with eolian (windblown) material. De Geer moraines have been much discussed in Scandinavian scientific literature, and they are therefore of great interest. The moraine type is relatively rare on Svalbard. In Gipsdalen the most distinct ridges are found in the valley bottom between the glaciers Boltonbreen and Methuenbreen (Fig. 12).

**Canyons** are fluvial channels in bedrock, with more or less vertical walls. Only small canyons are found in Gipsdalen.

**Meltwater Channels** are eroded by meltwater streams from glaciers. They area found along current glaciers, or where there were glaciers e.g. during the deglaciation phase of the last Ice Age. Few such old meltwater channels are seen in Gipsdalen today. This is probably due to rapid weathering and mass movement during post-glacial time.

**Washed Surfaces** are areas heavily affected by glaciofluvial erosion, normally without distinct meltwater channels.
Figure 11 Terminal and medial moraines at Methuenbreen, view from the ice-cored moraine in front of Margaretbreen towards SE.

Figure 12 De Geer morains in front of Pyefjellet, The Finncoal Development camp is seen in the left centre of the photo. View towards NW.
Geomorphology and Quaternary Geology of Gipsdalen, Svalbard

Gullies indicate V-shaped cuttings in fine-grained sediment. The gullies are formed through erosion by running water combined with mass movement.

Channels on Alluvial Fans and River Flats show both earlier and current drainage channels. The details in the pattern of the many drainage channels undergo constant change. The main pattern, however, seems to be relatively stable, as seen by a comparison of the current situation with patterns mapped by aerial photos from 1961.

Alluvial Fans are fan-shaped deposits of fluvial material with a dense pattern of drainage channels on the surface. The fans are deposited where rivers or streams from side valleys meet the main valley. Here, the incline of the valley profile decreases and the river is no longer able to transport as much material as in the steeper side valleys. The beds on the surface undergo continual change in the active parts of the fans, especially in flooding periods, and the fans are expanded both on the sides and over the valley floor. As may be seen on the map, alluvial fans cover large regions of Gipsdalen. The slope of the largest fans in Gipsdalen is on an average 3.2°, with extremes of 2.2° and 4.3°.

Eolian Forms are created by wind activity. The term partly refers to erosional hollows where the wind has removed material (deflation hollows), and partly to accumulation forms where wind-blown material create dunes and mounds. The latter forms are primarily found west of and close to the outlet of Gipsdalselva.

Beach Ridges are distinct ridges made up of sorted beach material. They are found either as active forms in the recent beach zone, or as fossil forms created by a relatively higher sea level in the past (Figs. 4, 13 and the front page of this report). Beach ridges are formed through accumulation of sediment due to wave activity, and they are often built up during storms. The top of the ridges can therefore be several meters above the average sea level at the time they were formed. The material in the beach ridges is relatively coarse as the fines are washed away. The grain size may, however, vary according to how exposed the area is to wave activity. In Gipsdalen, beach ridges exposed to the southwest are dominated by coarse gravel and stone, whereas parts facing north-east are made up of finer material such as sand and fine gravel. Well developed system of raised beach ridges on both sides of the outlet of Gipsdalselva show the successive uplift of the land after the last Ice Age.

Strandlines are erosion lines formed by wave activity in the beach zone. Unlike beach ridges, strandlines are erosional forms.

A distinct strandline, 19.5 m.a.s.l. run through the fossil beach ridge system in the lowest region of Gipsdalen. This line is seen on Fig. 13 (marked with an arrow). This strandline is caused by a regional transgression (relative increase in sea level) because of the final melting of the last part of the inland ice over the North American continent. Comparable transgression levels, called Tapes Levels, are found along the coasts of Fennoscandia.

Arêtes are narrow, sharp mountain crests resulting from backward growth of the walls of adjoining cirques or mountain slopes.

Erosion Scarps in Bedrock, large, refers to distinct steep scarps in bedrock that mark the transition from flat regions in top areas to steep slopes below (Fig. 14), or where there are clear scarps (edges) that mark the transition between rocks of different degrees of erosional resistance.

Erosion Scarps in Bedrock, small, are steep slopes a few metres high, usually formed by fluvial or marine erosion (Fig. 15).

Erosion Scarps in Sediment are the same as above, but eroded in sediment. They are all relatively small.

Terrace Edges are slopes outlining distinct, horizontal terrace surfaces (front page). Such surfaces are, as a rule, built up of debris deposited in water. The surface shows a previous water level. The actual steep scarp may either be formed as a frontal slope on a delta under formation, or it may be caused by secondary erosion processes, especially river erosion.

Depression, Thermokarst is a depression caused either by differential melting of ground ice, or by melting of glacier ice covered by sediment.

Most of the landforms described in the following section are periglacial landforms. This is a collective term for landforms directly associated with either permafrost or with freeze-thaw processes. Among the periglacial landforms, a certain group is called patterned ground (Fig. 16). This is a collective term for a characteristic patterning of the surface into forms as polygons, circles and stripes. Such patterns are very common in most arctic areas, and also in high mountain areas at lower latitudes. The forms are termed sorted or nonsorted, dependent on whether or not the pattern is due to a separation of stones and fines. There is no general agreement about whether or not the pattern is due to a separation of stones and fines. There is no general agreement about the different types of patterned ground are formed, except that their formation is connected to frost processes.

Tundra Polygons (ice wedge polygons) are distinct polygon-shaped patterns on the surface, often 10 to 40 meters across (front page). The creation of the polygons is initiated by thermal
contraction. In the winter the tundra surface contracts due to low temperatures, and a pattern of tension cracks in the permafrost is formed. During the summer, water from melting ice and snow freezes in these cracks in the permafrost, creating thin, vertical ice wedges. The wedges are weak zones in the ground, and subsequent cracks tend to follow the same pattern. The ice wedges are thus expanded until they become about 1 m across in the upper section, reach a few meters down in the ground. They create a pattern on the surface, because the growth of the ice wedges pushes debris out towards the sides. The result is a low depression over the actual ice wedge and small ridges on both sides.

Earth Hummocks make up a coalescing pattern of small mounds, generally 20-30 cm high and with a diameter of about 50 cm. Earth hummocks occur in areas of fine grained material and a relatively continuous cover of vegetation. The hummocks are created by repeated freezing and thawing of fine-grained debris. They are not very common in Svalbard, probably because the vegetation cover is generally too thin and discontinuous for them to be formed. They are, however, common on the flat and wet areas of fine-grained marine sediment inside the large beachridge system that crosses Gipsdalen north-west of Dalkallen (Fig. 10).

Nonsorted Polygons and Circles, are patterns formed by factors such as relief differences, a crack system, or a systematic variation between vegetation covered and vegetation-free surfaces. The small unsorted forms in Gipsdalen are generally different types of vegetation-free soil circles on an otherwise vegetation covered field.

Figure 13. Raised beach ridges along Gipsdalselva south of Usherfjellet. View towards SE. A strandline is marked with an arrow. Note also the distinct vehicular track in the background and the less distinct track in the foreground.
Figure 14 Large erosion scarp in limestone south of Gipshuken. View towards W.

Figure 15 Small marine erosion scarp in limestone at Gipvsika. The height of the scarp is 4 m.

Figure 16 Patterned ground of various forms in the foreground. Usherfjellet in the background. View towards N.
They are probably made by differential frost heave on ground rich in fine material.

**Sorted Polygons** are polygonal features with a border of stones surrounding a central area of finer material. The polygons are formed through frost sorting due to repeated freezing and thawing in the active layer. The polygons may in some cases be initiated by a pattern of contraction cracks created by drought or severe frost. The actual formation process is not yet clear.

**Sorted Circles** are circular accumulations of stones surrounding a central area of finer material. These forms are related to stone polygons, but in contrast to the latter, they may be completely circular and may occur individually. Normally, however, sorted circles also occur in groups.

**Stripes, (sorted and unsorted).** Sorted stripes are elongated accumulations of stones with intervening areas of finer material. Sorted stripes are related to sorted polygons, but in contrast to these, they occur on sloping ground. Nonsorted stripes are linear patterns of vegetation and soil. The stripes frequently occur in areas with gelification material.

**Gelifluction Lobes (boulder tongues)** are lobe- or tongue-like forms created through slow flowing of material saturated with water. This flow process is called gelification in areas with permafrost, and solifluction in other climatic zones.

**Rock Glaciers** are landforms connected to permafrost regions. The most common rock glaciers on Svalbard are primarily made up of coarse rock material with ice between the stones. The material is derived from steep mountain walls by frost action. Under the active layer, water freezes, and stones and finer material are cemented by interstitial ice. This leads to a slow downward movement of the whole body of frozen rock and ice, somewhat like the movement known from a normal glacier. The movement is, however, much slower, not more than a few cm or dm a year. The lower front of an active rock glacier is usually very steep (Fig. 17).

Rock glaciers with a core of glacial ice below a cover of rock debris may also occur. This type is formed when glacial ice is covered by large amounts of debris, either through slides from the valley sides, or from till that covers the frontal parts of a glacier. Such rock glaciers are difficult to separate from ice-cored moraines. In Gips-
Avalanche Tracks are distinct channel-like corridors in steep mountain walls along which avalanches move (Fig. 5). They are formed by a combination of weathering and mass movement.

Talus Cones are cone-shaped deposits of colluvium at the base of steep slopes, most often at the continuation of avalanche tracks. The material derives from mountain walls, mainly caused by frost weathering. Talus cones are largely made up of coarse, angular rock material, but may also contain a fair amount of fines. The surface of the talus cones is often scoured by debris flow channels (channels made by rapid flow of debris with a high water content) (Fig. 5).

The lower parts of the mountain slopes on both sides of Gipsdalen are more or less covered by talus cones. The average gradient was measured to 34.7° on 20 randomly selected large talus cones. The extreme values were 28° and 43°. Talus cones with clear signs of fluvial transport on the surface had a more gentle slope, as low as 23.5°. Although those cones clearly consist of a mixture of colluvium and fluvial material, they are classified as colluvium on the map.

Debris Slides, small are landslides of unconsolidated earth, soil and debris. Such slides are common in permafrost areas. They are caused by the upper, water-saturated soul layer sliding on the water impermeable permafrost, particularly during the spring thaw.

Large Boulders are single boulders with a size of several cubic meters are depicted on the map, mostly derived from rock fall and rock slides.

Mounds refer to erosion remnants of unconsolidated deposits at the valley floor. The mounds are low, but stand out clearly due to the flat surroundings (Fig. 18).

Glacial Crevasses are formed because the upper layer of the glacier acts like a stiff crust over an underlying mass of more plastic material. The crust breaks up when subjected to tension. The crevasses rarely penetrate deeper than 20-30 m, where the ice becomes more plastic because of the pressure. Glacial crevasses on the map are derived from aerial photos from 1961. The same applies to the position of the glaciers.

FACTORS THAT AFFECT TERRAIN WEAR

Different areas are to a different degree vulnerable to terrain damage caused by driving, seismic activity, installations or other human encroachments. The vulnerability is, among other things, dependent on vegetation cover, type of
surficial material, topography, permafrost conditions, local climate, and water accessibility. Generally, the vulnerability is much greater for unfrozen ground than for snow covered, frozen ground. An overview is given below of the most important factors that affect terrain wear.

**Vegetation Cover** is important in maintaining the thermal balance in the upper surface layer in a permafrost climate. If parts of the vegetation cover are removed, the thaw will penetrate deeper than in nearby areas. This can bring about local sinking of the ground, channelling of running water and cause removal of the soil and vegetation cover. The damage impact from wear is often greatest in areas with a thick and continuous vegetation cover.

**Type of Surficial Material** is of great importance in evaluating vulnerability. Especially important is the grain size of the sediment. Fine-grained material is frost susceptible, and due to frost heave such material has a high content of segregated ice both in the upper part of the permafrost and in the active layer in the winter. The content of ice in fine grained material is quite often higher than 50%. Such material is therefore more unstable and more subjected to mass movement and erosion processes than coarser material. Deeper thawing may result in depressions in the surface. The composition of the surficial material is largely determined by the mode of transport and the parent rock.

**Topographic Conditions** of consequence are primarily gradient and exposure. Exposure means towards which direction the slope is facing, and whether the terrain surface is convex or concave. Areas with a steep slope are normally more exposed to terrain wear, since wear here may trigger off mass movement and cause serious erosion. The exposure is significant for snow accumulation, and thereby the length of the snow-free season and the amount of meltwater.

**Permafrost Conditions.** The depth of the active layer influences the drainage and the stability of the sediment. The depth is, among other things, determined by the insulation capacity of the vegetation cover, the type of material, the length of the snow-free season, and the moisture conditions. In fine-grained material, permafrost may contain layers and small lenses of ice. There are also larger bodies of ice in tundra polygons and pingos. The ice content is greatly dependent on the grain size in the sediment and on the access to water.

**Water Access.** Factors of significance are the content of water or ice in the upper surface layer, location in relation to melting snow drifts, drainage conditions and permeability. Changes that lead to accumulation of water on the ground may cause increased melting of the permafrost. Water puddles in vehicular tracks increase melting and bring about larger and more lasting damage (Fig. 19). Tracks on slopes act as channels for running water, and this may lead to serious soil erosion.

**CLASSIFICATION SYSTEM FOR THE EVALUATION OF VULNERABILITY**

In the following section the degree of "vulnerability to wear" is used to indicate how likely an area is to suffer terrain damage when exposed to impact from activities like constructions, vehicle driving, seismic explosions, removal of vegetation cover by wear or pollution etc. Not all human activities will necessarily inflict damage to vulnerable areas, but special consideration must be taken in order to avoid negative effects. Driving on frozen, snow-covered areas will normally not lead to any noticeable wear.

It is desireable to find criteria for how to evaluate the vulnerability on the basis of mapping and registrations before activities begin. No complete system exists, but a proposal for vulnerability criteria is discussed by Sørbel & Tolgnsbak (in prep.). In this report, the evaluation of the areas are made on the basis of these proposals.

The vulnerability of an area may be placed in one of the following general categories:

![Figure 19 Permafrost melting and sinking ground due to water accumulation in vehicular track west of Aitkenfjellet. View towards NE.](image-url)
Group 1 - Areas that are invulnerable to wear. This category comprise active alluvial plains and alluvial fans, dry fall regions, etc. where the surface is continuously changing so that tracks will not last for a long time. Glaciers and exposed bedrock also fall under this group. The same applies to vegetation-free surfaces in areas with coarse sediment, e.g. boulder fields and some ice-cored moraines. In such areas, there are normally no significant traces of wear.

Group 2 - Areas that are slightly or moderately vulnerable to wear. The principal criteria for this group are impacts may leave traces of damage on the surface - even lasting traces - but the damage is not particularly prominent. This mainly applies to areas with thin and discontinuous vegetation cover on coarse surface material: coarse gravel, weathered material or till containing sparse amounts of fines. Such areas are relatively dry, and the upper part of the permafrost does not contain much ice. Normally traces of wear will not penetrate deeply into the ground, and further erosion will not occur. The wear does not affect the depth of the active layer to any significant degree.

Group 3 - Areas that are vulnerable to wear. The traces of damage are of a lasting character, and they are particularly prominent on the ground. In some parts the worn areas can be extended through subsequent erosion. These areas are usually characterized by a continuous vegetation cover and fine-grained surficial material, often localized to flat valley regions, wet tundra or plateaus up to medium elevation. These areas are particularly vulnerable because wear may easily alter the thermal balance in the surface layer. This brings about melting of the permafrost and local sinking of the ground surface.

Group 4 - Areas that are greatly vulnerable to wear and subsequent erosion. The traces of wear are of a lasting nature and are highly visible. The extent of the damage will normally increase because of melting, often combined with mass movement and erosion by running water. These areas have many characteristics in common with areas in Group 3. As a rule, the surface material is fine-grained, and most often there is a continuous vegetation cover. Additionally, one or more of the following characteristics occur: sloping ground, an abundance of moisture/running water, and if the areas are flat, there is much ice in the upper part of the permafrost layer. The most important effects of the damage are that subsequent erosion brings about significant extension of the original traces of wear.

Group 5 - Areas worthy of conservation. These are special locations like, for example, unique land forms, rare plant communities, occurrences of fossils etc. that are of special scientific, pedagogical value or in some way of interest to natural history or recreational experience. These areas are not necessarily particularly vulnerable to wear, but it is desirable to protect the areas in their original form without external influences of any kind.

CURRENT TRACKS IN GIPSDALEN

A distinct vehicular track runs through the western side of the valley, mostly along the river. On flat areas with coarse sediment and thin vegetation cover there are lasting traces of wear, but the damage is not very prominent. This applies to marine terraces, other areas with raised beach forms and fossil alluvial fans. These areas are classified in Group 2 with respect to vulnerability (Fig. 20).

Areas with fine-grained surficial material, continuous vegetation cover and good access to moisture have the most distinct traces of damage due to destruction of the vegetation cover and deeper melting of frozen ground (Fig. 21). In addition, damage by vehicular tracks in these areas are often extended as soil destruction by former tracks has forced drivers to repeatedly choose new routes. Most of these areas belong to Group 3. As the road mainly follows the flat valley floor, there is no great danger of further erosion by mass movement. Local areas with sloping ground, however, are seriously damaged due to subsequent erosion, and these areas are classified to Group 4 (Fig. 22).

The distinct "road" in Gipsdalen is presumed to be a result of summer driving with large vehicles. For practical reasons the road generally follows the dryest areas. Comparable vehicular tracks in moist terrain with a steeper slope would have caused comprehensive damage.

CLASSIFICATION OF AREAS IN GIPSDALEN ACCORDING TO VULNERABILITY

Mapping of land forms and surficial material together with the evaluation of damage along the current road are the basis for the classification of vulnerability areas shown on Fig. 23.

At the lower part of the valley there are well-formed systems of raised beach forms (Figs. 4, 13 and front page). These are of scientific interest and clearly considered as worthy of conservation. Some of the areas with raised beach forms have also a well-formed pattern of large tundra polygons on the surface (front page). Two of the most representative areas are classified in Group 5.

A field with De Geer moraines between Boltonbreen and Methuenbreen is also considered worthy of conservation (Group 5). De Geer moraines are scarce on Svalbard, and as the ridges are rather small they may easily be destroyed. Besides the beach ridges and the De
Figure 20 Vehicular track on the fossil part of an alluvial fan south of Leirsletta. Vulnerability Group 2 area due to coarse surface material and scarce vegetation. View towards NE.

Figure 21 Vehicular track on fine-grained marine material south of Leirsletta. Vulnerability Group 3 area. View towards NE.
Geor moraines no other landforms are found worthy of conservation.

Current alluvial plains and active alluvial fans in front of the side valleys are changing continuously and traces of wear will normally disappear. These areas are therefore considered as invulnerable (Group 1). Parts of the alluvial fans that are fossilized and overgrown with vegetation are a little more vulnerable (Group 2). Steep slopes and talus cones are considered invulnerable or moderately vulnerable (Group 1 or 2). The raised beach areas have coarse surface material, the ground is dry and the vegetation is scattered. These areas are accordingly only slightly or moderately vulnerable to wear. Unless classified as worthy of conservation, these areas belong to Group 2.

Along the valley bottom, most of the flat vegetated areas with fine-grained material or gelifluction material are vulnerable to wear and accordingly classified in Group 3 (Fig. 23).

Locally, due to slope, water access or vegetation cover, wear may lead to serious erosion. Those areas are classified to Group 4, and they are marked with a heavy tint on Fig. 23.

It is likely that there are other local areas where the risk of damage through erosion is high, but due to insufficient field data further predictions are not given at present.

*Figure 22* Vehicular track close to the Finncoal Development camp. The damage is severely increased by melting and fluvial erosion. Vulnerability Group 4 area due to fine-grained marine material with high ice/water content. View towards E.
GIPSDALEN, Svalbard  Evaluation of Vulnerability

**GROUP 1** Areas that are invulnerable to wear
**GROUP 2** Areas that are slightly or moderately vulnerable to wear
**GROUP 3** Areas that are vulnerable to wear
**GROUP 4** Areas that are greatly vulnerable to wear and subsequent erosion
**GROUP 5** Areas worth conservation

**Figure 23** Conservation value and vulnerability to wear of areas in Gipsdalen.
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GIPSDALEN, CENTRAL SVALBARD; FLORA, VEGETATION, AND BOTANICAL VALUES
Possible consequences of planned mining activities

by
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Juvenile, but reproductive Braya purpurascens (foto: Reidar Elven).
SUMMARY AND CONCLUSIONS

1) The Gipsdalen area contains botanical values at several levels (see pp. 41-42). Three vascular plants are very rare on a European (Carex amblyrhyncha - buttstarr) or Svalbard scale (Juncus castaneus - kastanjesiv, and Kobresia simpliciuscula - myrtust). Several others are rare on a Svalbard (regional) scale. Many occurrences are marginal in a phytogeographical or ecological context. This is due to the location of the area in an inner fjord zone with warmer climate than anywhere else in the world at this latitude.

2) One of the very few plant species totally protected in Norway - Braya purpurascens (purpurkarse) - occurs in very large populations throughout Gipsdalen (see p. 42). No construction activity can be undertaken without disturbing or destroying parts of the populations. This species is one of those protected by the Norwegian Government to comply with the requirements for ratification of the Bern Convention of 1983. An exception from the protection must be given by the Norwegian Government before any construction activity is undertaken.

3) The nationally and regionally rare and vulnerable species are confined to a few vegetation types of restricted distribution in the area (see p. 43): (a) Sloping, drained marshes of a thermophilic type; (b) open, calcareous, gravelly or sily ridges; (c) sily river margins; and (d) bird-cliffs. Sites of the types (a)-(c) may be influenced by the planned activities. Their location is indicated in Fig. 4.

4) The vegetation pattern of Gipsdalen (see pp. 43-52, Fig. 5 and enclosed vegetation maps) differs from all other investigated areas in the inner fjords by being a virtual limestone semi-desert (or arctic steppe), with low productivity due to lack of nutrients (except Ca, Mg), drought, and selective effects effects of the abundant calcium carbonate. The open vegetation types, resulting from the specialized ecological conditions, are widely distributed in Gipsdalen.

5) The main dangers to the botanical values arising from the planned activities are (see also pp. 60, 63-64):

- Erosion on ridge tops, in the slopes and in the marsh areas along the conveyor system and planned new transport road.

- Changed drainage in marshes (both impeded and enhanced) due to construction and ditching.

- Increase in influx of nutrient from sewage or diffuse seepage from working sites. Such impacts would be very detrimental to the extremely nutrient-poor ecosystems of Gipsdalen. Sewage from the mining site would influence the entire fluvial system of the valley, and threaten several elements of botanical value.

- Impacts on sites of special botanical values.

6) The plans presented are not sufficiently detailed for an analysis of possible consequences. The following conclusions and recommendations are preliminary:

- The mining activity in the Margaretbreen - Methuenbreen area should avoid the local areas with botanical values in the upper part of the valley.

- The conveyor system and transport road should be situated as close to the river as possible in the uppermost parts (from "Leirsletta" and upwards), but should avoid the river margin further down.

- Special care should be taken to avoid the valuable marsh area at Usherfjellet and in crossing the valuable ridge and marsh system to the west of the estuary. It might be possible to cross the Tverråa river fan and follow a major, broad beach ridge to a suitable harbour area.

- No harbour facilities should be located to the innermost parts of Gipsvika, or to Gipshukodden, but could be located between these areas without large conflicts with botanical interests.

- There should be no additional supply of nutrients (sewage) to any part of the ecosystems, and especially not to marshy areas or the river.

- A joint field survey should be undertaken to decide the exact location of the road/conveyor belt and the mining and harbour facilities.

INTRODUCTION

Until recently the botany of Bünsow Land (where Gipsdalen is located) was little known, compared with other areas in the inner parts of Isfjorden. Numerous plant species had been recorded, mainly from coastal areas (see e.g. Rønning 1972), but no systematic survey of the flora had been made. The vegetation types and their distribution were virtually unknown. The situation has changed in recent years, through botanical field investigations in 1985, 1987 and 1989, coupled with use of aerial photos and satellite data.
The investigations in 1985 and 1987 were made by C. Brochmann, A. Elvebakk, R. Elven, T. Engelskjøen, L. Hodin, B. E. Johansen, J. T. Schwenke, and S. Spjelkavik, and supported financially by the University of Tromsø, Institute of Biology and Geology and FORUT. The purposes of these investigations were purely scientific, but relevant results are included in the present report.

The 1985 investigations were mainly floristic including major parts of the main valley of Gipsdalen, the Gipshukodden - Gåsodden plain, and along the Templet mountain east to the Kapp Murdoch area. The areas NW of Gipsdalselva river between Meakinsjellet and Tvrerråa were not investigated. Initial vegetation studies were undertaken in the lower parts of the valley. The 1987 investigations comprised floristic studies and vegetation mapping in the inner parts of the valley between the Methuennbreen and Margaretbreen glaciers.

The 1989 investigations were financed by Northern Resources Ltd. through the Norwegian Polar Research Institute (NP). Field investigations were made by M.-B. Eriksen and A. Cross, with these main purposes:

- Supplementing the floristic registrations, especially on the NW side of Gipsdalselva.
- Undertaking a field control of a satellite-based vegetation map of the area, construed by FORUT/Tromsø from Landsat (TM) data.
- Undertaking a conventional vegetation mapping of the entire valley, based on aerial photographs and field surveys.
- Evaluating the vulnerability of plant populations and vegetation types within the indicated construction areas.

Main purposes of this report are:

- To present a survey of the higher flora (phanerogams and pteridophytes) of the area; to compare it with other inner fjord areas of Svalbard; and to indicate species of value in conservation at several geographical levels: international/national, regional (Svalbard) and local (Bünsow Land).
- To present a vegetation classification suited both for conventional and satellite-based vegetation mapping; to give short descriptions of vegetation types in the area; to compare with other areas; and to indicate elements of interest in a conservation context.
- To indicate areas with location of elements of special botanical value.
- To evaluate the mining plans as to possible conflicts with botanical values.

STUDY AREA

The most important habitat factors for the development of flora and vegetation are: landforms, bedrock and substrates, climate, and geographical position. All place-names refer to the map Billefjorden (Sheet C 8, 1 : 100,000, Norwegian Polar Research Institute, Oslo 1984).

Location and topography

Bünsow Land is surrounded by fjords to SE (Tempelfjorden), SW (Sassenfjorden) and W (Billefjorden), and by large glaciers to E (Tunabreen) and N (Nordenskiöldbreen). It is locally isolated from other land areas, but due to efficient wind dispersal of seeds and fruits across snow and ice this isolation is irrelevant for most plants.

A main topographical feature is the deep trough of Gipsdalen, dissecting the peninsula from SW to NE along a distance of approximately 25 km from the Gipsvika bay to the Florabreen glacier. The valley is broadly U-shaped and of even width (approx. 3 km). The longitudinal profile of the valley floor is also even, with an elevation increase of only 25 m in the first 14 km, and another 75 m in the last 10 km of the valley. The even profiles do not provide much shelter from fjord winds and fall winds from the glaciers.

The valley floor passes evenly into gentle slopes on the sides, ending more or less abruptly in talus screes along all mountains. The heights of the mountains increase from about 700 m a.s.l. in the outer parts to more than 1100 m a.s.l. in the innermost parts. Stable vegetation is confined to the valley floor upwards to the scree slopes and to a few mountain plateaus (see Fig. 6 and Spjelkavik & Elvebakk 1989), while the 3-500 m high, unvegetated scree slopes represent a barrier between the vegetated belts.

A more varied topography is encountered in the lowermost part of the area, where the wide bay of Gipsvika is delimited by the steep Templet mountain to the SE, and by the low plateau of Gipshukodden, Gipshusletta, and Gåsodden to the NW. These areas are all well vegetated.

Raised littoral terraces are characteristic and biologically important features of the Gåsodden-Gipshukodden promontory, the Gipsvika bay area, and of the lowermost 4 km of the valley, providing habitat complexes of dry, nutrient-poor ridges and damp depressions.

The main topographical features of the area were formed by glacial erosion and deposition. The present glaciation is, however, restricted to small ice-caps on some of the mountain plateaus surrounding the valley, to outlet glaciers in the tributary valleys, and to the interior part where Florabreen is an outlet glacier of the extensive ice-cap of the Nordenskiöldbreen and Tunabreen.
glaciers. Only a few of the tributary valley glaciers extend to the main valley (Stenhousebreen, Boltonbreen, Methuenbreen, and Margaretbreen), and recent moraines constitute an insignificant part of the substrate in the main valley.

The main river of Gipsdalselva runs from the Florabreen glacier snout, and receives significant tributaries from all tributary valleys. The river course may be divided into three parts:

1) Along the uppermost 11-12 km the river bed is broadened in most sections, apart from a small canyon below Rinkbreen. River sediments are mostly gravelly or silty. A consolidated river margin vegetation is rarely developed.

2) Leirflata is an about 3 km long and 1 km wide sedimentation basin SW of the tributaries from the Stenhousebreen and Boltonbreen glaciers. Most of the silty banks are devoid of vegetation, but scattered stands of more or less ubiquitous plants are found along the margins and on elevated banks.

3) In the lowermost 7-8 km a distinct river channel has formed, with elevated banks and silty margins. Here a well-developed river margin vegetation is found.

Recent fluvial sediments are a significant part of the substrate in the entire valley.

River fans from the tributary valleys are a distinct feature of biological significance, being covered by an open, unstable vegetation with low competitive power. This vegetation is distinctly different from the mature, stable vegetation between the fans in the lower part of the valley, less so in the upper part. River fans constitute about 20% of the valley floor area.

For botanical purposes the topographical elements and types of substrate types may be divided into the following groups:

- Bottom moraine, covering large parts of the valley floor.
- Recent sedimentation areas along the main river: gravel and silt.
- River fans: gravel.
- Recent moraines: boulders, gravel and silt.
- Talus: boulders and debris.
- Raised beach ridges: mainly gravel, but locally silt.

The distribution of the more deviant types of importance for the development of vegetation is indicated in Fig. 1.

Bedrock

For botanical purposes the bedrock may be divided into three groups (see Lauritzen et al. 1988): The basal, metamorphic Hecla Hoek formation; Devonian, Carboniferous, and Permian sedimentary rocks; and dolerite of Mesozoic age.

An outcrop of the Hecla Hoek formation is found in the uppermost 4 km of the valley. These are the only hard, silicic basement rocks in the lowlands of central Isfjorden, mainly micaschists and quartzites. A study of the vegetation of these outcrops was one of the major aims of the 1985 expedition to Gipsdalen. Most areas are, however, influenced by calcareous fine-textured soil, mainly morainic, partly also aeolian. Only small patches of acidophilic vegetation and species are found.

The bedrocks exposed in most of the valley are calcareous sedimentary rocks of five formations (see Lauritzen et al. 1988): The Lower Carboniferous Billefjorden Group is represented in the upper parts of the valley floor from the Hecla Hoek limit to the Methuenbreen/Margaretbreen area. The Upper Carboniferous Ebbadalen Formation occurs along the valley floor between Methuenbreen/Margaretbreen and Boltonbreen/Stenhousebreen and along the north side of the valley slopes further north. The main parts of the valley floor and lower slopes belong to the Carboniferous to Permian Nordenskiöldbreen Formation. The younger Permian formations, i.e. the Gipshuken and the Kapp Starostin, are confined to the upper slopes and (especially the Kapp Starostin Formation) to the mountain plateaus.

The biological effects of most of the Carboniferous and Permian formations are fundamentally the same: they provide calcareous, dry lithosols. The Kapp Starostin bedrocks differ in being silicified chert, a very hard rock producing coarse, siliceous pebble beds, but intermingled with calcareous fine-textured soils.

Dolerite is restricted to the Gipshukodden - Gåsodden plateau. It is weathering resistant, but contains plagioclase, and produces a circum-neutral soil. Its biological effects are modified by calcareous debris, and they are mostly structural/topographical. The saxicolous lichen vegetation does not include strongly acidophilic species, and acidophilic vascular plants are very rare.

The gypsum, which has given name to the valley, is found as anhydrite horizons in the mountain sides in several formations, and as heaps close to the Margaretbreen moraines. The gypsum weathers very easily. The beds in vertical or very steep mountain sides are totally unvegetated. The outcrops in the valley have a Dryas vegetation similar to the prevailing vegetation on other calcareous ridges, but more open.

Biologically, the single most important feature of the bedrock and morainic material of Gipsdalen is that it is so uniformly calcareous. It has a decisive influence both on the floristic composition (see pp. 34-43) and the vegetation pattern.
Recent moraines.
River sedimentation flats, loamy.
Tributary river fans, gravelly.
Raised beach ridges, calcareous gravel.

Figure 1  Distribution of special landscape features influencing the development of vegetation in Gipsdalen: raised beach ridges, river fans, river sedimentation plains, and recent moraines.
Chemical weathering is restricted in arctic areas, and the physical weathering of limestone results in large fractions, gravel and shingle, and very fine-textured fractions like silt. The coarse substrate is poor in most nutrients except calcium. Excessive drainage inhibits formation of a well-developed humus layer, a prerequisite for capturing and retaining of both water and nutrients. The vegetation is therefore much less developed than one should expect under the prevailing climatic conditions. Large areas might be classified as an 'arctic steppe or semi-desert', a feature known from other areas (see e.g. Scholander 1934). Arctic steppes and semi-deserts are areas with scant vegetation due to low precipitation in combination with a dry substrate and inhibiting effects from excess of lime.

Climate

Zinger et al. (1985) have estimated summer isotherms based on glacioclimatic data. A gradient is found from 2-3°C on the outer coast of western Spitsbergen to 5°C in central fjords. Gipsdalen is here placed in the zone with mean summer temperature between 4°C and 5°C. This corresponds well with mean temperatures at the only weather station in inner Isfjorden (Longyearbyen 1957-1976 and Svalbard airport 1976-1989). July and August means during the period 1976-1989 are, respectively, 6.1°C and 4.8°C (data from Det Norske Meteorologiske Institutt 1989). Only three months have mean temperatures above zero (June-August). Winter temperatures are probably lower in the fjords than on the outer coast. Means of the two coldest months, January and February, are -15.8°C and -16.0°C, for the period 1976-1989. Precipitation is low, with a yearly mean (1976-1988) of 186.5 mm. Mean precipitation amounts in the three summer months are 9.9 mm (June), 12.5 mm (July), and 27.6 mm (August).

A general climate diagramme for Svalbard airport (close to Longyearbyen) is presented in Fig. 2. Gipsdalen probably differs climatically from the Longyearbyen area in some respects: The location in the interior part of a peninsula results in a more continental climate, with less precipitation. Fog may significantly increase the water supply above what is measured by standard meteorological methods. Fog is quite common in Longyearbyen, but rare in the interior parts of Gipsdalen.

A thin snow cover is indicated by the small areas of snowbed vegetation types depending upon a thick snow cover of long duration. This is partly a result of the even topography, and the prevalence of valley winds, but also indicates low winter precipitation. The thin snow cover is a distinct difference between Gipsdalen and e.g. the Sassendalen and Adventdalen valleys. Cold air is transported downwards through the flat valley with no topographical obstacles. This valley wind climate is probably very important in understanding the drought, and it has a distinct cooling effect, especially in the upper part of the valley. The wind effect can easily be seen from the deposits of aeolian silt. Enhanced radiation, however, may compensate for the thermic effects.

Phytogeographical position

The same division with only small modifications has been applied by Brattbakk (1986) in a mapping of the entire islands. His Cassiope tetragona Zone includes the two most favourable zones of Summerhayes & Elton, while he divides their Dryas Zone into a Dryas Zone and a less favourable Salix polaris (polarvier) Zone. Brattbakk's subdivision is too schematic for the inner fjord

Figure 2 Simplified Walter-type climate diagramme of Longyearbyen (Svalbard airport), based on the period 1975-1988. Indicated are monthly means of temperature (a) and precipitation (b), yearly means, and means of temperature for the warmest (c) and coldest (d) months. The hatched area indicates the period where the precipitation is sufficient to prevent drought (all the year at Longyearbyen).
areas. As it is based mainly on the regional (Svalbard) distribution of chosen species, it is not easily compared with other arctic areas.

The recent divisions of the Arctic into phytogeographical areas emphasize the south - north changes in climate, vegetation, and flora at a larger geographical scale (Alexandrova 1980, Elvebakk 1985, 1989a). The conventional division into "Low" and "High Arctic" has been largely replaced by the following scheme (Elvebakk 1985, 1989a & b):

- Hemiarctic Zone (HAZ). - The transition zone between boreal forests and arctic tundra, including the "forest tundra". In N Europe this zone includes parts of Iceland, NE Finnmark in N Norway, and the coastal areas of N Russia.

- South Arctic Tundra Zone (SATZ). - The southern tundras, e.g. with peat-producing mires of a boreal type, and low shrub thickets of Betula nana (dvergbjørk) and shrubby Salices (viere). The zone is virtually absent from N Europe, as this climatic zone is occupied by the Barents Sea, but it is well-developed in Greenland and in N Siberia.

- Middle Arctic Tundra Zone (MATZ). - The middle tundras of dry dwarf-shrub heaths and well-developed marshes (or arctic mires), but no mires of the boreal type. This zone includes Bear Island, Jan Mayen, and the warmer fjord regions of Spitsbergen.

- North Arctic Tundra Zone (NATZ). - The northern tundras, of prostrate shrubs and forb/grass vegetation, and less developed marshes. This is the other major zone of the Spitsbergen island and western parts of Edgeøya and Barentsøya. The inner fjord areas of Nordaustlandet also belong to this zone.

- Arctic Polar Desert Zone (APDZ). - The polar desert, without larger areas of closed vegetation, is widely distributed on the east coasts of the Svalbard islands, and as an altitudinal belt in the mountains.

Elvebakk (1989a) has modified this classification for the Svalbard islands by recognizing a locally more favourable subzone within the Middle Arctic Tundra Zone in the inner fjords. This new version of the Inner Fjord Zone largely corresponds to Summerhayes & Elton (1928), but includes some revisions. It is restricted to the innermost Van Mijenfjorden, the inner half of Isfjorden (including Bünsow Land), Wijdefjorden, and small areas in inner Kongsfjorden and Bockfjorden.

These warm areas are among the northernmost in the world of such comparatively warm sites. They are strongly isolated at present from other northern warm areas (inner fjords of central North Greenland, central Ellesmere Island, Axel Heiberg Island, and southern Novaya Zemlya) by large reaches of sea.

The thermophilic plant species found must have reached their present northern localities either in periods with a warmer climate or by accidental long distance dispersal (birds?). In either case their occurrences on Svalbard are of interest in an international context. The character of Gipsdalen, as an extremely dry, continental calcareous valley, results in a unique concentration of very disjunct thermophilic and/or calciphilic species in the area. It is one of the major arguments for conservation of botanical values in the area.

**Human impact**

The impacts from earlier activities in the valley are restricted, and with few exceptions they are confined to the SE side of the valley. The main human impact is a track (or road) from the sea almost half the way up the valley. It was established by coal industrial activities early in the century, and has been used recently by the Finnish drilling company.

The recent (Finnish) exploration has left disturbances in the beach ridge complex in Gipsvika where equipment was landed and deposited. The transport road from Gipsvika to the exploration site at Methuenbreen has disturbed several beach ridges, parts of the most extensive and valuable marsh area, and silty ridges. The surroundings of the mining camp at Methuenbreen are influenced by tracks and leftovers (oil barrels etc.), but the impacts are restricted to a small area. Scattered tracks from motorized vessels are seen also outside the transport road, on both sides of the valley.

**MATERIALS AND METHODS**

The report is based on a field survey of plant species distributions and vegetation composition and distribution in an area including the entire valley of Gipsdalen from Gipsvika up to the Methuenbreen - Margaretbreen area (vegetation), partly to the end of the valley at Florabreen (floristics), and the coastal areas from Gåsodden in the west to the mountain Templet (vegetation) and the Bjonahamna/Kapp Murdoch area (floristics).

The floristic investigations include a quantitative registration of all vascular plant species in a net of 81 UTM quadrats, each 1 km² large, along Gipsdalen up to Florabreen, and the coastal areas from Gåsodden to Bjonahamna and the Murdoch glacier delta. The investigated quadrats include the majority of the area involved by the planned activities.
In addition, records of the rarer species in the two major Norwegian herbaria with collections from the area (Oslo and Tromsø) have been registered and controlled in 1989. The vegetation investigations include a classification and description of the vegetation types, based on the local variation. Most vegetation types are documented by species lists, but generally not by vegetation analyses. Such documentation would be desirable, but would require more time than available within the project. The methods and criteria applied in the vegetation classification are described on pp. 43, 52-54.

The vegetation classification is used directly in a conventional vegetation mapping of the main parts of Gipsdalen, and in an interpretation of a satellite-based map of the entire Bünsow Land. The conventional vegetation map covers the valley floor of Gipsdalen northeast to Margaretbreen - Methuenbreen, Gipsvika, and the Gásoddan - Gipsuhkodden plain. It is based on field surveys in 1985, 1987, and especially in 1989, and on aerial photographs (Norwegian Polar Research Institute series 1248, 23 August 1961, scale approximately 1:46,000). There are some differences between the aerial photographs and the present-day situation, especially on the river fans where the river courses have changed. Here the map shows the situation in 1985-89.

Field survey for the conventional vegetation map consists of correlation between vegetation in the field and aerial photographs, and registration of occurrences of the rarer and less easily identifiable vegetation types.

The satellite map of Bünsow Land is part of an analysis of a larger area in the interior fjords, also including the areas between Isfjorden and Van Mijenfjorden (e.g. Sassendalen, Adventdalen, the area westwards to Colesbukta, Reindalen, and Lundstrømdalen). It is based on a Landsat TM scene from 5 August 1985 (path 217, row 3, Q4), utilizing the bands 1, 4 and 5. An unsupervised classification (cluster analysis) into 27 classes is used.

Field surveys for the satellite-based vegetation map consist of location of several patches of each of the classes, and description of the content of each class. Such surveys have been undertaken also in other areas within the TM scene (in Sassendalen by A. Elvebakk, R. Elven, B. E. Johansen, and J.-T. Schwenke; in Reindalen by B. E. Johansen). The contents of the classes are found to differ to some degree between the different areas, and the interpretation given below is based mostly on Gipsdalen.

As vegetation density is a main feature reflected in the satellite image, a direct visual interpretation is possible based on a standard false-colour composite. A map based on contrast stretching of a composite of the bands 4, 3 and 2 in the same TM scene as used in the satellite-based vegetation map is reproduced from Spjelkavik & Elvebakk (1989).

**FLORA**

Within the area covered by the floristic investigations (see Fig. 3) we have registered 104 taxa of vascular plant species, plus one hybrid. These are listen in Table 1, and represent about 66 % of the indigenous vascular plants of Svalbard as reported by Rønning (1979). The number is comparable to that of other investigated areas in the inner fjords, e.g. Berzeliusdalen (95 taxa), Reindalen (100 taxa), and Kjellstrømdalen (80 taxa) in the Van Mijenfjord area, and Colesbukta/Colesdalen (99 taxa), Adventdalen (115 taxa) and Sassendalen (113) in the Isfjorden area (unpublished Sassendalen data by Elvebakk and Elven, all others from Engel-skjøn et al. 1986). Most of the differences between the areas seem to be due to differences in size. Adventdalen and Sassendalen may, however, have a slightly higher species diversity than the others.

**Composition**

Even if the number of taxa in the Gipsdalen area is comparable to the other investigated areas in the inner fjords, the composition of the flora is different in several ways. A rough separation into frequency groups is given in Table 2.

The high frequency groups include, in addition to many ubiquitous plants in the Svalbard area, a number of regionally less frequent taxa. The majority of these are restricted to two types of habitats:

1) Calcareous ridges and dry tundra (heaths), e.g. *Draba corymbosa* (puterublom), *Puccinellia vahliana* (fimbulgras), *Braya purpurascens* (purpurkarse), *Pedicularis lanata* ssp. *dasyantha* (ullmyrklegg), *Arenaria pseudofrigida* (kalkarve), and *Festuca baffinensis* (hårsvingel).

2) Shallow, slightly sloping (drained) marshes of a thermophilic type, i.e. *Eriophorum triste* (svartull), *Carex parallela* (smalstarr), and *Saxifraga aizoides* (gulsildre).

Species belonging to these two ecological groups are much more frequent in Gipsdalen than in other inner fjord areas.

The species with low and very low frequencies can also be defined as belonging to certain habitat groups. In addition to plants generally rare in the Svalbard area, there is a significant group of regionally frequent or common, but locally rare taxa. In all cases their restriction can
Figure 3 Vascular plant diversity, given as species number within 1 km squares approximately in the UTM grid. Total numbers of species in each 1 km square are given by dot sizes: 1) 10-14 species, 2) 15-24, 3) 25-34, 4) 35-44, 5) 45-54, and 6) ≥55 species. Squares without symbols have not been investigated. Data from Engelskjaer et al. (1986) supplemented from investigations in 1987 and 1989.
Table 1 Vascular plants (species, subspecies, and hybrids) known from the Gipsdalen area. The taxa are listed in alphabetic order. Latin nomenclature follows Elvebakk et al. (1986), Norwegian vernacular names mainly Rønning (1979).

Regional (Svalbard) rarity (R) is given as by Elvebakk et al. (1986): 1 - very rare, less than 5 known occurrences; 2 - rare, 5-25 known occurrences; 3 - scattered to common.

Phytogeographical patterns are divided into zonal (south/north) and sectional (east/west) types.

Zonal types:

'Arct' - Arctic, not reaching or only reaching the northernmost, coastal parts of Scandinavia;
'Arct-Scand' - Arctic-Scandinavian, reaching the mountain range, sometimes only in the north ('N'), sometimes also reaching the British Isles;
'Arct-Alp' - Arctic-Alpine, reaching south to the C European mountain ranges.

A 'C' denotes that the taxon is entirely or partly coastal.

Sectional types:

'C-pol' - Circumpolar, more or less continuously around the Polar basin;
'W-Arct' - Western Arctic, with main distribution in North America and Greenland. They may reach east to Svalbard or Novaya Zemlya-Jamal.
'E-Arct' - Eastern Arctic, with main distribution in Eurasia, normally not reaching west to Greenland.
'N-Atl' - North Atlantic, distributed on both sides of the North Atlantic, but not in Siberia, Alaska or W Canada.
'End' - Endemic to Svalbard or to Svalbard and neighboring islands (Zemlya Franz Josef, Novaya Zemlya).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>R</th>
<th>S/N-distr</th>
<th>E/W-distr</th>
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<tr>
<td>Alopecurus alpinus Sm. - polarrerumerpe</td>
<td>3</td>
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<td>C-pol</td>
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Table 1 (cont.)

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<td>C-pol</td>
</tr>
<tr>
<td><em>P. nivea</em> L. coll. - snøflågmure</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>P. pulchella</em> R.Br. - tuvearve</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>P. phryganodes</em> (Trin.) Scribn. &amp; Merr. - teppesalattras &quot;Svalbard - Novaya Zemlya type&quot;</td>
<td>3</td>
<td>Arct</td>
<td>End</td>
</tr>
<tr>
<td><em>Puccinellia angustata</em> (R.Br.) Rand. &amp; Redf. - polarsaltgras</td>
<td>3</td>
<td>Arct</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>P. phryganodes</em> (Trin.) Scribn. &amp; Merr. - teppesalattras &quot;Svalbard - Novaya Zemlya type&quot;</td>
<td>3</td>
<td>Arct</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>P. vahliana</em> (Liebm.) Seribn. &amp; Merr. - fimbulgras</td>
<td>3</td>
<td>Arct</td>
<td>End</td>
</tr>
<tr>
<td><em>Pucciphippsia vacillans</em> (Th.Fr.) Tzvelev - svalbardfimbulgras</td>
<td>3</td>
<td>Arct</td>
<td>End</td>
</tr>
<tr>
<td><em>Ranunculus hyperboreus</em> Rottb. - setersoleie</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>R. pedatifidus</em> Sm. - fliksoleie</td>
<td>2</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>R. pygmaeus</em> Wg. - dvergsoleie</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>R. sulphureus</em> C.J.Phipps - polarsoleie</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>Sagina intermedia</em> Fenzl - jekelarve</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td><em>Salix polaris</em> Wg. - polarvier</td>
<td>3</td>
<td>Arct-Scand</td>
<td>E-Arct</td>
</tr>
<tr>
<td><em>S. reticulata</em> L. - rynkevier</td>
<td>3</td>
<td>Arct-Scand</td>
<td>±C-pol</td>
</tr>
<tr>
<td><em>Saxifraga aizoides</em> L. - gulsildre</td>
<td>3</td>
<td>Arct-Scand</td>
<td>W-Arct</td>
</tr>
<tr>
<td><em>S. cespitosa</em> L. - tuvesildre</td>
<td>3</td>
<td>Arct-Scand</td>
<td>±C-pol</td>
</tr>
</tbody>
</table>
Table 1 (cont.).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Saxifraga cernua L. - knoppsildre</td>
<td>3</td>
<td>Arct-Alp</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. flagellaris Sternb. &amp; Wild. - trådsildre</td>
<td>3</td>
<td>Arct</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. hieracifolia Waldst. &amp; Kit. - stivsildre</td>
<td>3</td>
<td>Arct-Alp</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. hirculus L. - myrsildre</td>
<td>3</td>
<td>Arct-Alp</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. hyperborea R.Br. - polarsildre</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. nivalis L. - snøsildre</td>
<td>3</td>
<td>Arct-Alp</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. oppositifolia L. - raudsildre</td>
<td>3</td>
<td>Arct-Alp</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. rivularis L. - bekkesildre</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. svalbarcknsis Øvstedal - svalbardsildre</td>
<td>3</td>
<td>Arct</td>
<td>C-pol</td>
</tr>
<tr>
<td>Silene acaulis (L.) Jacq. - fjellsmelle</td>
<td>3</td>
<td>Arct</td>
<td>W-Arct</td>
</tr>
<tr>
<td>S. furcata Rafin. ssp. furcata - småjonsokblom</td>
<td>3</td>
<td>Arct-Scand</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. uralensis (Rupr.) Bocq. ssp. arctica (Th.Fr.) Bocq. - &quot;arktisk blindurt&quot;</td>
<td>3</td>
<td>Arct</td>
<td>C-pol</td>
</tr>
<tr>
<td>Stellaria humifusa Rottb. - ishavsstjerneblom</td>
<td>3</td>
<td>Arct-Scand (C)</td>
<td>C-pol</td>
</tr>
<tr>
<td>S. longipes Goldie coll. - snøstjerneblom</td>
<td>3</td>
<td>Arct-Scand (N)</td>
<td>C-pol</td>
</tr>
<tr>
<td>Taraxacum arcticum (Trautv.) Dahlst. - arktisløvetann</td>
<td>3</td>
<td>Arct</td>
<td>C-pol</td>
</tr>
<tr>
<td>Trisetum spicatum (L.) K.Richt. - svartaks</td>
<td>3</td>
<td>Arct-Alp</td>
<td>C-pol</td>
</tr>
</tbody>
</table>

Table 2 Frequency groups and ecological preferences of vascular plants in the Gipsdalen area. Frequencies (F%) are given as a percentage of the 81 investigated one km² squares. The taxa are listed in order of decreasing frequencies.

<table>
<thead>
<tr>
<th>Group/taxa</th>
<th>Freq</th>
<th>Habitat type(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High frequency group (70-100%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saxifraga oppositifolia</td>
<td>99±</td>
<td>Ubiquitous</td>
</tr>
<tr>
<td>Salix polaris</td>
<td>95±</td>
<td>Ubiquitous</td>
</tr>
<tr>
<td>Draba corymbosa</td>
<td>92</td>
<td>Open calcareous heath, gravel</td>
</tr>
<tr>
<td>Cerastium arcticum</td>
<td>87±</td>
<td>Ubiquitous</td>
</tr>
<tr>
<td>Polygonum viviparum</td>
<td>87±</td>
<td>Ubiquitous</td>
</tr>
<tr>
<td>Dryas octopetala</td>
<td>84</td>
<td>Heath, mostly calcareous</td>
</tr>
<tr>
<td>Carex misandrea</td>
<td>82</td>
<td>Calcereous heath</td>
</tr>
<tr>
<td>Pedicularis hirsuta</td>
<td>81</td>
<td>Humic heaths and meadows</td>
</tr>
<tr>
<td>Equisetum variegatum</td>
<td>80±</td>
<td>Ubiquitous</td>
</tr>
<tr>
<td>Juncus biglumis</td>
<td>79</td>
<td>Snowbeds, marshes, damp soil</td>
</tr>
<tr>
<td>Puccinellia vahliana</td>
<td>79</td>
<td>Open calcereous heath, silt</td>
</tr>
<tr>
<td>Saxifraga cernua</td>
<td>76±</td>
<td>Ubiquitous</td>
</tr>
<tr>
<td>Saxifraga aizoides</td>
<td>74</td>
<td>Slopes, calcareous and anhydrite</td>
</tr>
<tr>
<td>Brayia purpurascens</td>
<td>72</td>
<td>Calcereous gravel/silt</td>
</tr>
<tr>
<td>Carex rupestris</td>
<td>72</td>
<td>Heath, mostly calcareous</td>
</tr>
<tr>
<td>Stellaria longipes coll.</td>
<td>72±</td>
<td>Ubiquitous</td>
</tr>
<tr>
<td>Minuartia rubella</td>
<td>70±</td>
<td>Ubiquitous, mostly calcareous</td>
</tr>
</tbody>
</table>

| **Intermediate frequency group (30-69%)** | | |
| Draba oxyarpa | 68± | Ubiquitous |
| Luzula arctica | 67 | Heaths to snowbeds |
| Poa alpina var. viviparara | 67 | Meadows, snowbeds |
| Saxifraga cespitosa | 65± | Ubiquitous |
| Equisetum arvense | 63± | Flushed ground |
| Pedicularis lanata ssp. dasyantha | 62 | Calcereous heaths |
| Papaver dahlianum | 59 | Lithosol, debris |
| Deschampsia alpina | 58 | Marshes, wet soil |
| Cerastium regelia | 57 | Snowbeds, wet gravel |
| Poa abbreviata | 55 | Exposed, calc. heaths, silt |
| Poa pratensis ssp. alpigena (viv.) | 55 | Outwash, flushed ground |
| Eriophorum scheuchzeri | 54 | Marshes, silty alluvial plains |
| Silene acaulis | 54 | Heaths, cobble pavements |
| Silene uralensis ssp. arctica | 54± | Ubiquitous |
| Dupontia pelligera | 50 | Sloping marshes etc. |
| Eriophorum triste | 50 | Calcereous marshes |
| Oxyria digyna | 46 | Snowbeds, open soil |
| Cochlearia groenlandica | 43 | Snowbeds, bird cliffs etc. |
### Table 2 (cont.).

<table>
<thead>
<tr>
<th>Group/taxa</th>
<th>Freq</th>
<th>Habitat type(s)</th>
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</thead>
<tbody>
<tr>
<td>Draba subcapitata</td>
<td>43</td>
<td>Exposed ridges</td>
</tr>
<tr>
<td>Carex parallelle</td>
<td>42</td>
<td>Sloping marsh, calcareous</td>
</tr>
<tr>
<td>Draba lactea</td>
<td>40</td>
<td>Marsh hummocks, snowbeds</td>
</tr>
<tr>
<td>Arenaria pseudofragida</td>
<td>38</td>
<td>Calcareous heath, gravel</td>
</tr>
<tr>
<td>Eutrema edwardsi</td>
<td>38</td>
<td>Intermediate to snowbed, calcareous</td>
</tr>
<tr>
<td>Deschampsia brevifolia</td>
<td>37</td>
<td>Marshes and silty plains</td>
</tr>
<tr>
<td>Draba arctica</td>
<td>37</td>
<td>Lithosol, silt</td>
</tr>
<tr>
<td>Potentilla pulchella</td>
<td>37</td>
<td>Exposed heaths, silt</td>
</tr>
<tr>
<td>Saxifraga nivalis</td>
<td>32</td>
<td>Heaths, ledges</td>
</tr>
<tr>
<td>Carex nardina</td>
<td>32</td>
<td>Snowbeds etc.</td>
</tr>
<tr>
<td>Draba alpina</td>
<td>32</td>
<td>Snowbeds, sloping marshes</td>
</tr>
<tr>
<td>Saxifraga hirculus</td>
<td>30</td>
<td>Calcareous heath/slopes</td>
</tr>
<tr>
<td>Festuca baffinensis</td>
<td>30</td>
<td>Calcareous slopes</td>
</tr>
<tr>
<td>Silene furcata ssp. furcata</td>
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</table>

### Low frequency group (5-29 %)

<table>
<thead>
<tr>
<th>Group/taxa</th>
<th>Freq</th>
<th>Habitat type(s)</th>
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<tbody>
<tr>
<td>Ranunculus pygmaeus</td>
<td>29</td>
<td>Snowbeds, slopes</td>
</tr>
<tr>
<td>Carex subspathacea</td>
<td>28</td>
<td>Sloping and stagnant marsh</td>
</tr>
<tr>
<td>Trietum spicatum</td>
<td>26</td>
<td>Warm slopes, early snowbeds</td>
</tr>
<tr>
<td>Cassiope tetragona</td>
<td>25</td>
<td>Heaths and slopes</td>
</tr>
<tr>
<td>Festuca rubra ssp. arctica</td>
<td>24</td>
<td>Slopes, early snowbeds</td>
</tr>
<tr>
<td>Draba daurica</td>
<td>22</td>
<td>Mainly bird-cliffs, scree</td>
</tr>
<tr>
<td>Ranunculus hyperboreus</td>
<td>21</td>
<td>Wet marshes, brooks, dams</td>
</tr>
<tr>
<td>Alopecurus alpinus</td>
<td>20</td>
<td>Mainly damp heath and marsh</td>
</tr>
<tr>
<td>Ranunculus sulphureus</td>
<td>20</td>
<td>Snowbeds, marshes</td>
</tr>
<tr>
<td>Sagina intermedia</td>
<td>18</td>
<td>Snowbeds, open gravel</td>
</tr>
<tr>
<td>Draba adamsii</td>
<td>18</td>
<td>Snowbeds, damp soil</td>
</tr>
<tr>
<td>Festuca hyperbordea</td>
<td>18</td>
<td>Exposed heath, gravel</td>
</tr>
<tr>
<td>Poa pratensis ssp. alpigena (semif.)</td>
<td>18</td>
<td>Mainly warm slopes</td>
</tr>
<tr>
<td>Puccinellia angustata</td>
<td>18</td>
<td>Exposed ridges, bird-cliffs</td>
</tr>
<tr>
<td>Phispa concinna</td>
<td>17</td>
<td>Snowbeds and gravel</td>
</tr>
<tr>
<td>Poa arctica coll.</td>
<td>17</td>
<td>Peaty, stony slopes</td>
</tr>
<tr>
<td>Phispa algida</td>
<td>15</td>
<td>Mainly late snowbeds</td>
</tr>
<tr>
<td>Minuartia rossii</td>
<td>13</td>
<td>Flushed silt</td>
</tr>
<tr>
<td>Poa glauca</td>
<td>13</td>
<td>Ridge crests, scree, bird-cliffs</td>
</tr>
<tr>
<td>Ranunculus pedatifidus</td>
<td>12</td>
<td>Bird-cliff meadow</td>
</tr>
<tr>
<td>Carex saxatilis</td>
<td>11</td>
<td>Sloping marsh</td>
</tr>
<tr>
<td>Polemonium boreale</td>
<td>11</td>
<td>Bird-cliffs, talus</td>
</tr>
<tr>
<td>Salix reticulata</td>
<td>11</td>
<td>Silty, well-drained plains</td>
</tr>
<tr>
<td>Cardamine nymani</td>
<td>9</td>
<td>Sloping marsh</td>
</tr>
<tr>
<td>Saxifraga flagellaris</td>
<td>9</td>
<td>Damp soil, cliffs</td>
</tr>
<tr>
<td>Chrysosplenium tetrandrum</td>
<td>8</td>
<td>Damp soil, snowbed</td>
</tr>
<tr>
<td>Cystopteris fragilis ssp. dickieana</td>
<td>8</td>
<td>Scree, cliffs</td>
</tr>
<tr>
<td>Puccinellia phryganodes</td>
<td>8</td>
<td>Salt marshes</td>
</tr>
<tr>
<td>Potentilla sp.</td>
<td>6</td>
<td>Bird-cliffs, scree</td>
</tr>
<tr>
<td>Carex ursina</td>
<td>5</td>
<td>Salt marshes</td>
</tr>
<tr>
<td>Draba norvegica</td>
<td>5</td>
<td>Scree</td>
</tr>
<tr>
<td>Mertensia maritima</td>
<td>5</td>
<td>Gravelly seashores</td>
</tr>
<tr>
<td>Saxifraga hieracifolia</td>
<td>5</td>
<td>Damp slopes, sloping marsh</td>
</tr>
</tbody>
</table>

### Very low frequency group (1-4 %)

<table>
<thead>
<tr>
<th>Group/taxa</th>
<th>Freq</th>
<th>Habitat type(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carex amblyorhyncha</td>
<td>4</td>
<td>Warm, sloping marshes</td>
</tr>
<tr>
<td>Juncus triglumis</td>
<td>4</td>
<td>Warm, stony marsh</td>
</tr>
<tr>
<td>Luzula arcuata ssp. confusa</td>
<td>4</td>
<td>Peat on silicic ledge</td>
</tr>
<tr>
<td>Potentilla nivea</td>
<td>4</td>
<td>Bird-cliffs, scree</td>
</tr>
<tr>
<td>Saxifraga hyperborea</td>
<td>4</td>
<td>Silicic gravel, peat</td>
</tr>
<tr>
<td>Stellaria humifusa</td>
<td>4</td>
<td>Salt marshes</td>
</tr>
<tr>
<td>Taraxacum arcticum</td>
<td>4</td>
<td>Warm slopes</td>
</tr>
<tr>
<td>Pucciphippsia vacillans</td>
<td>3</td>
<td>Riverbanks, silt/gravel</td>
</tr>
<tr>
<td>Dupontia palmotanaha</td>
<td>3</td>
<td>Stagnant marshes</td>
</tr>
<tr>
<td>Erigeron humilis</td>
<td>3</td>
<td>Warm slopes</td>
</tr>
<tr>
<td>Saxifraga svalbardensis</td>
<td>3</td>
<td>Wet moss carpets, marsh</td>
</tr>
<tr>
<td>Arctophila fulva</td>
<td>1</td>
<td>Pond marginal</td>
</tr>
<tr>
<td>Cardamine bellidifolia</td>
<td>1</td>
<td>Silicic lithosol</td>
</tr>
<tr>
<td>Carex maritima</td>
<td>1</td>
<td>Peaty seashore</td>
</tr>
<tr>
<td>Cerastium arcticum x regelii</td>
<td>1</td>
<td>River fan, open gravel</td>
</tr>
</tbody>
</table>
be explained by demands for habitats that are rare in the study area. The three main ecological groups are:

3) In acidic or neutral dry tundra (heaths): Luzula arcuta ssp. confusa (vardefrytyle), Hierochloë alpina (fjellmarigras), Poa arctica (jervrapp), and Potentilla hyparctica (ragnmure), cf Elvebakk (1982).

4) In acidic or neutral slopes/snowbeds: Ranunculus pygmaeus (dvergsoleie), Trisetum spicatum (svartaks), Cassiope tetragona (kantlyng), Festuca rubra ssp. arctica (raudsvingel), Draba adamsii (polarrublom), Draba norvegica (bergrublom), Cardamine bellidifolia (høgfjells­karse), and Saxifraga rivularis (bekkesildre). Ranunculus sulphureus (polarsoleie) and Phippsia alpida (snøsoleie) are also rare, but this is due to the general scarcity of snowbeds in the valley.

5) In stagnant, very wet marshes: Ranunculus hyperboreus (setersoleie), Dupontia psilosantha (spriketundragras), and Arctophila fulva (hengegras).

Less explicable is the low frequency of one of the most common and edaphically least specialized of Svalbard plants: Alopecurus alpinus (polarr­everumpe - common e.g. in calcareous areas in Sassendalen).

The lists can be supplied with taxa occurring elsewhere in interior fjord areas of Svalbard, but lacking (as far as known) from the Gipsdalen area (ecological groups in parentheses): Arnica angustifolia ssp. alpina - fjellolblom (3), Carex lachenalii - rypestarr (4), Draba fladnizensis - alperublom (3), D. nivalis - snørublom (3), Equisetum scirpoides - dvergsnelle (4), Huperzia selago ssp. arctica - polarlusegras (3-4), Ranunculus nivalis - snøsleie (4), Ranunculus lap­ponicus - lappsoleie (5), R. spitzbergensis - sval­bardsoleie (5), Saxifraga foliolosa - grynsildre (4-5), and Saxifraga tenuis - grannsildre (more or less ubiquitous).

The floristic anomalies suggest the influence of the calcareous substrate on the composition of the local flora. The effects seem to be direct in some cases (e.g. for the calciphiles Arenaria pseudofrigida and Braya purpurascens), indirect in many other cases, either through lack of humification (e.g. Cassiope tetragona and Huperzia selago, and other proved or suspected mycotrophic species), or through lack of peat formation resulting in very shallow marshes (e.g. Arcto­phiIa, Dupontia psilosantha, Ranunculus hyper­boreus, R. lapponicus, and R. spitzbergensis).

**Diversity**

Species diversity is given as species number within the 1 km large UTM quadrats. The number of vascular plants per quadrat ranges from about 10 to about 55, and there is a distinct geographical pattern of variation in species diversity (Fig. 3).

The most species-rich quadrats (>45 species per km) are located in the lowermost parts, reaching from Gipshukodden around Gipsvika and along the lower slopes of Templet mountain to Bjonahamma. The single highest value is found in an area including the western promontory of Templet, i.e. the bird-cliff Skiltvakten. The only inland area with a high value (UTM quadrat WH 3610) contains calcareous ridges, both sloping and stagnant marshes, and a species-rich river bank.

Comparatively high diversities (35-45 species) characterize the rest of the coastal areas and the lower parts of the valley, except for a few quadrats with small land area (e.g. WH 3010, 3408, 3604, 4102), dominated by river fans (e.g. 3608), or very open shore ridges (e.g. 3507, 3709). Further up the valley areas with more than 35 species are restricted to the comparatively well­vegetated slopes between the river fans of the tributary valleys, e.g. between the Stenhousebreen/Boltonbreen valleys and the Margaretbreen/Methuenbreen valleys, and between these valleys and Florabreen.

Low diversities (15-35 species) characterize most of the middle and upper parts of the valley. Quadrats with less than 35 species are also found scattered in the lower parts. Very low diversities (less than 15 species) are found in the few mountain top areas investigated (WH 3210, 3310), and on Leirflata (WH 3912).

The high species diversity in the lowermost part, and especially along the coast, is correlated both with high habitat diversity and with presence of some habitats very rich in species (bird-cliffs, thermophilic sloping marshes, dolerite hills). Each of the high diversity areas contain at least one of those species-rich habitat types.

**Table 2 (cont.).**

<table>
<thead>
<tr>
<th>Group/taxa</th>
<th>Freq</th>
<th>Habitat type(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juncus castaneus</td>
<td>1</td>
<td>Warm, sloping marsh</td>
</tr>
<tr>
<td>Kobresia simpliciuscula</td>
<td>1</td>
<td>Warm, sloping marsh Minuartia stricta 1, Raggedchalk</td>
</tr>
<tr>
<td>Potentilla hyparctica</td>
<td>1</td>
<td>Heath on dolerite</td>
</tr>
<tr>
<td>Saxifraga rivularis</td>
<td>1</td>
<td>Wet, silicic gravel</td>
</tr>
</tbody>
</table>
The decrease in species diversity upwards in the valley is caused both by the scarcity of some species-rich habitats (e.g. bird-cliffs), and by a decrease in species numbers in those habitats which occur along the entire valley.

**Plants of special conservation value**

We have grouped the plant species considered interesting in a conservation context into four value categories:

1) Regionally **very rare**, i.e. very rare on Svalbard.
2) Regionally and locally **rare**.
3) Regionally **rare to infrequent**, but locally **frequent to common**.
4) Locally **rare**, even if they are frequent on Svalbard as a whole.

The regionally rare plants (1-3) are of interest in a Norwegian or larger context, while the locally rare (4) have a more limited interest.

**Regionally rare plants**

Category 1. - Three of the Gipsdalen species are among the rarest vascular plants on Svalbard (see maps in Rønning 1972 and Elvebakk 1989a). They belong to the highest value class, and all their occurrences should be avoided during construction work:

- **Carex amblyrhyncha** (buttstarr). - On Svalbard this species is only known with certainty from Gipsdalen (first found here in 1985) and Sassendalen. It is restricted to shallow, slightly sloping, marshes of the thermophilic type, and may form large stands, often associated with *Eriophorum triste* (svartull), *Carex paralela* (smalstarr), and *C. saxatilis* (blankstarr). In Gipsdalen it has been found both in the lower part (quadrats WH 3409, 3710, 3810), and in one very small stand in the upper part (WH 4318), close to the Finnish mining camp. Its total distribution is circumpolar, with some gaps, and the Svalbard localities are the only ones in N Europe (see Bücher 1952 and Engelskjøn 1986).

- **Juncus castaneus** (kastanjesiv). - Only known from three localities in Adventdalen, Sassendalen, and in Gipsdalen (found here in 1989), where it occurs in a sloping, shallow marsh of the thermophilic type in quadrat WH 3711. The Gipsdalen stand is small, approx. 50 plants (Eriksen, in prep.). Outside Svalbard *Juncus castaneus* has a wide circumpolar and arctic-alpine distribution.

- **Kobresia simpliciuscula** (myrtust). - Three widely separated localities are known, in the Kongsfjord area on the west coast, near Pyramiden on Dickson Land, and in the lower part of Gipsdalen (found here in 1985). The locality is a small sloping, shallow marsh of the thermophilic type (quadrat WH 3409), where several individuals are found within a small area.

Category 2. - Another five taxa are rare or at least restricted on Svalbard, and all their local occurrences should be a matter of concern in conservation:

- **Puccinipissa vacillans** (svalbardfimbulgras). - This taxon is possibly a hybrid between *Puccinellia vahliana* (fimbulgras) and a species of the genus *Phippsia*. Hedberg (1962) proposes *Phippsia algida* (snøgras) as the other parent, based on investigations in arctic Canada, where *P. algida* is the only species of *Phippsia* present. The Svalbard plants differ in several ways, and the differences point towards *P. concinna* (spikesnøgras) rather than *P. algida*. The way of reproduction is unknown, but some kind of seed production is indicated, as the plants often occur in large and well separated stands, without any vegetative means of reproduction and dispersal. Asexual seed production (i.e. agamospermy) is not known previously from this group of genera. The taxon is of high scientific interest. It has been found along the river in the lower part of the valley (quadrats WH 3711, 3811) and in Fuhrmeisterdalen east of Gipsdalen (Rønning & Skifte 1958, Herb. TROM). The Svalbard distribution is shown by Rønning (1972).

- **The Potentilla nivea** (snømure) and the *P. pulchella* (tuveemure) species groups are among the taxonomically most complicated ones in the vascular flora of Svalbard. In addition to the widely distributed *P. pulchella* at least two further taxa occur in the area: a type belonging to *P. nivea* or *P. chamissonis* (flågmure) is frequent in the more or less heavily bird-manured scree slopes along Templet mountain between Gipsvika and Bjonahamna, and a biotype of dubious affinity, possibly related to the West Arctic *P. rubricaulis* (raudstengelmure), occurs frequently in the same area.

On Svalbard *Ranunculus pedatifidus* (fliksoleie), a *R. auricomus* microspecies, is known with certainty from the innermost parts of Isfjorden, in one locality on Oscar II Land north of the mouth of Isfjorden, and around Kongsfjorden, and reported from several other localities in the interior fjords and along the west coast. The Svalbard distribution is mapped by Elvebakk (1989a). In the area it is fairly common along the manured scree slopes of Templet between Gipsvika and Bjonahamna.

- **Minuartia stricta** (grannarve). - There are only six documented Svalbard reports of this species, which has scattered occurrences from Van Keulenfjorden north to Kongsfjorden and Sorg-
fjorden. The Svalbard distribution is mapped by Elvebakk (1989a). An initial revision of the herbarium collections indicates that much of the material may have been misinterpreted, and that the species is very rare on Svalbard. It has at least one substantiated occurrence in the Templet area (WH 3604).

Category 3. - Several regionally infrequent or rare species have unusually large stands in Gipsdalen. Populations of the following species are of conservation interest for that reason:

- **Arenaria pseudoefrigida** (kalkarve). - Dry calcareous gravel and ridges.
- **Braya purpurascens** (purpurtorse). - See below (p. 42).
- **Carex saxatilis** (blankstarr). - Shallow, sloping marshes.
- **Deschampsia brevifolia** (stivbunke). - Shallow marshes and silty outwash.
- **Eriophorum triste** (svartull). - Shallow marshes.
- **Eutrema edwardsii** (polarreddik). - Moist heaths and stony marshes.
- **Festuca baffinensis** (hårsvingel). - Dry tundra and talus.
- **Minuartia rossii** (puteavre). - Flushed slopes and gravel.
- **Pedicularis lanata** ssp. dasyantha (ullmyrklegg). - Calcareous dry tundra.
- **Juncus triglumis** (trillingssiv). - Shallow, sloping marshes.
- **Polemonium boreale** (polarflokk). - Bird-cliff meadows and talus.
- **Saxifraga aizoides** (gulsildre). - Flushed slopes and gravel.
- **Saxifraga svalbardensis** (svalbardsildre). - Wet moss carpest, sloping marshes.

**Locally rare plants**

Category 4. - The following taxa are widely distributed on Svalbard as a whole, but due to their rare occurrences in the area, they have local value in conservation:

- **Arctophila fulva** (hengegras). - One stand in the lower part of the valley (WH 3810).
- **Cardamine bellidifolia** (høgfjellskarse). - Gipsuken, above 400 m (WH 3210).
- **Carex maritima** (buestarr). - One stand at Gåsodden (WH 2909), close to the sea.
- **Cystopteris fragilis** ssp. dickieana (berglok). - Several stands in scree and on warm slopes along Templet and Sindballefjellet, on dolerite at Gipsuhukoden (WH 3209), and on the slope towards Gipsvika (WH 3308).
- **Dupontia psilosantha** (stortundragras). - One stand in a wet marsh in the upper part of the valley (NE of Margaretbreen, WH 4621).
- **Erigeron humilis** (svartbakkestjerne). - Stands in the warm, manured slopes of Templet.

**The Braya problem**

The small crucifer **Braya purpurascens** (purpurkarse, front page of this report) represents a special problem. It is common on Svalbard, but has an uneven distribution because of its demand for calcareous soil. In Gipsdalen it is very common; as seen from Table 2 it is placed in the highest frequency group. Based on counting of individuals in plots of different vegetation types, Elvebakk et al. (unpubl.) estimate the total population size in the valley to be about 200 Mill. individuals. The populations of **Braya** in Gipsdalen may be the largest ones of the species in Europe. It is also very common in other limestone areas in the inner fjords, as in Sassendalen.

**Braya purpurascens** is one of the two plants the Norwegian Government had to protect by law in 1983 to comply with the requirements for signing the Bern Convention on threatened plants and animals in Europe (see Østhagen 1984). The reason why **Braya** had to be protected is its extreme rare occurrence on the European mainland, confined to a small area close to North Cape, North Norway. The legislators did not consider the status of Svalbard as a (legal) part of Norway and Europe. The comparatively common **Braya purpurascens** is thereby the only plant on Svalbard that is totally protected as a species, and not indirectly through area protection.

The taxa covered by the Bern Convention shall be protected against both collection and "unintentional" damage, e.g. technical damage. As an example, one population of the other Norwegian plant given protection in 1983, the extremely rare **Oxytropis deflexa** ssp. norvegiea (masimjelt), was threatened by the Alta-Kautokeino hydroelectric power project. It became necessary with special constructions to safeguard the population.

It is impossible to do any construction work along Gipsdalen without disturbing and partly destroying large populations of **Braya purpurascens**. The mining project depends on an exepption from the protection.
Habitats of rare plants

The regionally and locally rare plants are, with some exceptions, confined to a few habitat types:

1) Eight valuable species, among them the three in the highest value category, are confined to the shallow and fairly warm, sloping marshes typical of the calcareous valley slopes: Carex amblyrhyhchca, Juncus castaneus, Kobresia simpliciuscula, Carex saxatilis, Deschampsia brevifolia (partly), Eriophorum triste, Juncus triglumis, and Saxifraga svalbardensis. These habitats are also among the most species-rich in the area. The sites are mainly confined to the lower part of the valley, but a few smaller patches are also found in the upper valley. Main areas are the hills west of the river mouth, the large marsh area inside the major shore ridges on the east side of the valley, and some areas further up the valley, between the river fans from the tributary valleys. Conservation values in rich marsh areas on the western side of the valley may conflict with construction plans.

2) The second most important habitat of rare plants are the bird-cliff and the bird-manured scree at the mountain Templet east of Gipsvika. Four of the five species in value category 2 are more or less confined to manured sites, as are three in lower categories: Potentilla nivea/chamissonis, P. sp., Ranunculus pedatifidus, Minuartia stricta (in this area), Polemonium boreale, Erigeron humilis (in this area), and Cystopteris fragilis ssp. dickieana (partly). These sites will not be directly influenced by construction as indicated in the plans, but the bird colonies might be disturbed by the activity, with possible long-term deterioration of the bird-cliff vegetation.

3) Calcareous ridges and dry tundra (heaths) contain four species of value category 3 - Arenaria pseudofrigida, Braya purpurascens, Festuca baffinensis, and Pedicularis lanata ssp. dasyantha - and also numerous other low-frequent species. The most varied and valuable ridges are found to the west of the river mouth, and on the large shore terrace system on the east side 1-3 km inland from Gipsvika.

The other listed species are dispersed in various habitats: Pucciphippsia vacillans on the banks of rivers and runnels, Carex maritima on or close to seashores, Arctophila and Dupontia psilosantha in wet, stagnant marshes, Luzula arcula ssp. confusa and Potentilla hyparctica on the rare outcrops of acidic bedrock at Gipsshukodden and in the uppermost valley, and Eutrema edwardsii and Minuartia rossii in several types. The habitats of Cardamine bellidifolia, Saxifraga hyperborea, and S. rivularis are silicic lithosol, which is prevalent elsewhere on Svalbard, and of less interest.

Location of sites of the majority of the rare plants, and their main habitats, are shown in Fig. 4.

Conclusions

- The number of vascular plant species found in Gipsdalen is at level with that found in other inner fjord areas on Svalbard, in spite of the specialized ecological conditions. Many otherwise common acidophilic species are replaced by regionally rare calciphilic species. The species diversity is highest in the lower parts of the valley and along the coast.

- The Gipsdalen area supports several species of international (i.e. European), national (i.e. Norwegian), and/or regional (i.e. Svalbard) interest in a conservation context, among them very large populations of one of the protected species covered by the Bern Convention (Braya purpurascens).

- With few exceptions, the especially valuable species are confined to a few habitat types, all of them with restricted distribution in the valley: sloping shallow marshes, bird-cliffs and bird-manured scree, and calcareous ridges and dry tundra (heaths).

- Areas with concentrations of rare and/or valuable vascular plant occurrences are marked in Fig. 4, with indications of main habitat types. The species are concentrated in six areas: (1) The Gåsodden - Gipsukodden plain and the slopes east of Gipsheken mountain; (2) The inner parts of Gipsvika with surroundings; (3) The large terrace system on the east side of the river, 2 km NE of Gipsvika, with the marshes dammed inside the ridges; (4) The slopes of Templet eastwards to Bjonahamma; (5) Small sloping marshes on the west side of the river between Tverrdalen and Stenhousebreen; (6) A small marsh area close to the transport road and Finnish mining camp at Methuenbreen; and (7) The Hecla Hoek outcrops in the innermost parts of the valley.

- The construction plans may conflict with floristic values in the areas 1, 2, 5, and 6. More detailed plans are needed before a more exact evaluation can be made.

VEGETATION

There is no single classification system available for the description and mapping of arctic vegetation yet, and several systems have been applied both on Svalbard and in other areas. In this report is used a system developed in recent years by A.Elvebakk, B.E.Johansen, and R.Elven. The system is designed so as to be applicable both to conventional vegetation mapping and to inter
Figure 4 Locations of some of species of restricted distribution, either regionally or locally (1-18), and areas with concentrations of valuable species (I-IV).

The species included are: (1) Arctophila fulva (hengegras), (2) Carex amblyorhyncha (buttstarr), (3) C. maritima (buestarr), (4) C. ursina (bjernejarr), (5) Dupontia psilosantha (stortundragras), (6) Erigeron humilis (svartbakkestjerne), (7) Juncus castaneus (kastanjesp), (8) J. triglumis (trilingsiv), (9) Kobresia simpliciuscula (myrjest), (10) Luzula arcuata ssp. confusa (vardefryle), (11) Minuartia stricta (grannarve), (12) Potentilla chamissonis/nivea group (enemure/flågmure), (13) P. hyparctica (raggmure), (14) Pucciphippsia vacillans (svalbardlimbulgras), (15) Saxifraga svalbardenensis (svalbardsgilde), (16) Stellaria humifusa (ishavsstjerneblom), and (17) Taraxacum arcticum (arktisløvetann), and (18) the fruticose race of Xanthoria elegans. The location of the site of No. 18 is very approximate.

The areas where most species with restricted distributions are concentrated are: I - The Gipsvika area with thermophilous marshes and salt-marshes; II - Templet with bird-manured vegetation; III - The large beach ridge system with calcareous gravel vegetation, rich snowbeds, and with associated rich marshes; and IV - The innermost part of the valley with some rich marshes and the less calcareous Heckla Hoek formation. The areas indicated are approximate.
The interpretation of satellite-based maps. The system is discussed and compared with other, alternative systems on pp. 52-54.

The main structure of the system is a differentiation at five levels according to major differences in habitats and floristic composition:

a) Altitude/latitude; in the central fjord areas a division into lowland (Middle Arctic Tundra Zone, MATZ) and upland (North Arctic Tundra Zone, NATZ, and Arctic Polar Desert Zone, APDZ) vegetation.

b) Vegetation density; a differentiation into areas with closed vegetation (with effective competition) and open ones.

c) Main drainage and/or substrate types (groups).

d) Habitat types; e.g. along snow cover gradients or soil water gradients, usually physiographically characterized by distinct life-forms of plants (subgroups).

e) Floristically characterized vegetation types (types).

The entities at levels (a)-(d) are essentially the same in most areas, while the floristically characterized types (e) may differ.

In Gipsdalen the vegetation in the lowlands (MATZ) and uplands (NATZ, APDZ) is separated by usually sterile talus slopes. The upland vegetation has not been investigated within the present project, but has been mapped by Spjelkavik & Elvebakk (1989).

The vegetation groups and types registered in Gipsdalen are listed in Table 3 and used in the aerial photo-based vegetation map. Gaps in the enumeration refer to types found only in other areas in the inner fjords.

**Vegetation types**

_A Lowland areas with more or less closed vegetation cover_

This main group includes habitats with a more or less continuous vegetation, and with at least some interspecific competition. The vegetation is usually stable from year to year. The substrate is more or less stabilized by the vegetation. Plants with extensive vegetative growth usually dominate.

The division between more or less closed and open vegetation cover is easily seen both on aerial photographs and on satellite maps. Along most ecological gradients in the Arctic open vegetation (or no vegetation) is found at the extremes, while the more favourable middle parts are densely vegetated. This is the case along both the snow cover/exposure and moisture/drainage gradients, and partly along the acidic/alkaline and substrate fraction size gradients. As we move further northwards or upwards, smaller parts of the gradients are able to sustain a closed vegetation. In the Middle Arctic Tundra Zone, the major parts of the area will be densely vegetated at sites with more or less normal climatic and/or edaphic conditions.

The areas with more or less closed vegetation are divided into groups according to hydrology.

**Group 1: Well-drained sites**

There are important differences in the composition of life forms and species, and in the ecological conditions, between areas where the topsoil dries out for longer periods during the growth season, and areas where the ground water level is situated near or at the soil surface. Woody plants are usually confined to well-drained areas, as are lichens and the majority of tussock-forming grasses and sedges. Mosses usually play some role, but are rarely dominating.

The main separating factor within the group is duration of snow cover, i.e. the length of the potential growth season. Five of the subgroups (subgroups 11-15) are arranged along this gradient, while the sixth (subgroup 16) is confined to an ecologically deviating situation (bird-cliffs).

**Subgroup 11: Exposed gravely ridges with a discontinuous vegetation cover**

The uppermost parts of ridges and hills usually have a very open vegetation cover, and are described under the next main group. Just beneath the top is normally found a zone where patches of prostrate shrub vegetation alternate with open patches or patches covered with very low-growing lichens, mosses and scattered individuals of forbs, graminids and the prostrate willow _Salix polaris_. Two vegetation types are recognized:

_Type 111: Open Dryas-Carex rupestris type; and Type 112: Open Dryas type._

The open _Dryas_ type (112) covers large areas in Gipsdalen. It is found both on the raised beach ridges in the outer parts and on hills, slopes and partly stabilized river fans in the interior parts of the valley. From the climate alone one should expect a denser vegetation type in these habitats. The type replaces the closed _Dryas_ type (121) on the extremely calcareous, well-drained and dry substrate. In other areas this type is very poor in species; it may often consist of _Dryas octopetala_ alone. Some calciphilic grasses and forbs are, however, common in the type in Gipsdalen, e.g. _Arenaria pseudofrigida_ and...
Table 3 Vegetation groups and types registered in Gipsdalen. The entities are described in the text and used in the vegetation maps (enclosed). The survey is based on a tentative system proposed by Elvebakk, Elven & Johansen.

### A LOWLAND AREAS WITH MORE OR LESS CLOSED VEGETATION COVER

**Group 1** Well-drained sites

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Type 111</th>
<th>Type 112</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dryas-Carex rupestris type</td>
<td>Dryas type</td>
</tr>
</tbody>
</table>

**Subgroup 12** Dry closed heath vegetation of xerophilous vascular plants and partly lichens

<table>
<thead>
<tr>
<th>Type 121</th>
<th>Type 122</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed Dryas and Dryas-Carex rupestris type</td>
<td>Cassiope tetragona and Dryas-Cassiope type</td>
</tr>
</tbody>
</table>

**Subgroup 13** Warm, favourable slopes with closed, thermophilic vegetation

<table>
<thead>
<tr>
<th>Type 132</th>
<th>Type 133</th>
<th>Type 134</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermophilous Festuca rubra type</td>
<td>Trisetum spicatum-Minuartia biflora type</td>
<td></td>
</tr>
</tbody>
</table>

**Subgroup 14** Early snowbed and snowflush vegetation dominated by meso/hygrophilous plants, partly moss-dominated

<table>
<thead>
<tr>
<th>Type 141</th>
<th>Type 142</th>
<th>Type 143</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homalothecium nitens-Dryas type</td>
<td>Salix polaris type and related, poorly defined types</td>
<td>Seasonally hygrophilous Dupontia pelligera type</td>
</tr>
</tbody>
</table>

**Subgroup 15** Late snowbeds

<table>
<thead>
<tr>
<th>Type 151</th>
<th>Type 152</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phippsia concinna type and related types</td>
<td>Cerastium regelii type</td>
</tr>
</tbody>
</table>

**Subgroup 16** Bird-cliffs (not differentiated further)

### Group 2 Poorly drained sites

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Type 211</th>
<th>Type 212</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Homalothecium nitens-Salix polaris-Alopecurus alpinus type</td>
<td>Homalothecium nitens-Salix polaris-Dupontia pelligera type</td>
</tr>
</tbody>
</table>

**Subgroup 22** Wet moss tundra

<table>
<thead>
<tr>
<th>Type 221</th>
<th>Type 223</th>
<th>Type 224</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermophilous Carex parallala-C. saxatilis type</td>
<td>Puccinellia angustata type</td>
<td>Dupontia pelligera-Eriophorum scheuchzeri type</td>
</tr>
</tbody>
</table>

**Type 225** Frost upheaval Dupontia pelligera-forb and Salix polaris-Saxifraga oppositifolia-Poa arctica types

<table>
<thead>
<tr>
<th>Type 227</th>
<th>Type 228</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eriophorum triste-Deschampsia brevifolia type</td>
<td>Probable not represented in Gipsdalen</td>
</tr>
</tbody>
</table>

**Subgroup 24** Swamp

<table>
<thead>
<tr>
<th>Type 241</th>
<th>Type 242</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctophila fulva, Dupontia psilosantha and Ranunculus hyperboreus types</td>
<td>Swamp</td>
</tr>
</tbody>
</table>

### B LOWLAND AREAS WITH OPEN VEGETATION COVER

**Group 3** Very exposed, stable or eroded ridges

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Type 312</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Draba-Saxifraga-Cerastium arcticum type</td>
</tr>
</tbody>
</table>

**Subgroup 32** Ridges with silty substrate

<table>
<thead>
<tr>
<th>Type 321</th>
<th>Type 322</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poa abbreviata-Potentilla pulchella type</td>
<td>Puccinellia angustata type</td>
</tr>
</tbody>
</table>

**Group 4** Sedimentation flats with silty substrate

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Type 411</th>
<th>Type 412</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry Polygonum viviparum type</td>
<td>Homalothecium nitens-Salix polaris-Equisetum arvense type</td>
</tr>
</tbody>
</table>

**Subgroup 42** Flats with discontinuous vegetation

<table>
<thead>
<tr>
<th>Type 421</th>
<th>Type 423</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Salix polaris-Saxifraga oppositifolia type</td>
<td>Open Dupontia pelligera-Deschampsia spp. type</td>
</tr>
</tbody>
</table>

**Group 5** Gravelly river fans

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Type 51</th>
<th>Type 52</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Fans with vegetation cover</td>
<td>Fans with scattered plants</td>
</tr>
</tbody>
</table>

Not differentiated further
Table 3 (cont.).

<table>
<thead>
<tr>
<th>Group 6</th>
<th>Recent moraines</th>
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<tbody>
<tr>
<td></td>
<td>Not differentiated further</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 7</th>
<th>Seashores</th>
</tr>
</thead>
</table>

**Subgroup 71** Salt/brackish marshes on fine-grained substrates
- **Type 711** Puccinellia phryganodes type
- **Type 712** Carex subspathacea and C. ursina types

**Subgroup 72** Gravel shores
- Not differentiated further

**C and D. UPLAND AREAS**
- Not treated in Gipsdalen

**Puccinellia vahliana.** Carex misandra is very common (almost constant) in the type in the area. The open Dryas-Carex rupestris type (111) is very rare in Gipsdalen, mainly confined to some hills near the river mouth. This is usually the most common type of the community in other inner fjord areas. The two types are mapped collectively as 11.

**Subgroup 12: Dry closed heath vegetation**

The closed Dryas and Cassiope tetragona dry tundra types (heaths) are prominent features of most inner fjord areas on Svalbard. They are widely distributed in Gipsdalen on the upper parts of ridges and hills, beneath the preceding zone, and they also cover vast areas on well-drained plains and raised beach ridges. The dominants are prostrate shrubs, and the vegetation types are usually monotonous and poor in species. Two types are recognized in the area:

**Type 121:** Closed **Dryas and Dryas-Carex rupestris type.** The closed prostrate shrub heaths in Gipsdalen are totally dominated by Dryas octopetala. Carex rupestris is common, but not dominating, and is often replaced by Carex misandra. Other very common associates are Salix polaris and Saxifraga oppositifolia. Regionally infrequent calciphiles are locally common. The type is widely distributed in the lower parts of the valley, on more sheltered parts of the raised beach ridges, and on the Gipshukodden-Gåsodden plateau. In the interior parts the type is restricted to favourable places on slopes, often with some accumulation of humus. In the vegetation map the code 121 is used for the common variant in Gipsdalen, while the code 121a is used for a less calciphilic variant found on the dolerite outcrops on the Gipshukodden-Gåsodden plain.

**Type 122:** **Cassiope tetragona and Dryas-Cassiope type.** The beautiful Cassiope heaths are prominent in most inner fjord areas, but not in Gipsdalen. Here they are restricted to a few sheltered (concave) slopes in the Gipshukodden area outermost in the valley and around the moraines of Margaretbreen in the interior. The stands are confined to depressions where humus accumulate and isolate the plants to some degree from the limestone. In the Margaretbreen area the stands may be associated with more acidic moraine transported down the valley from the acidic Hecla Hoek outcrops. The rarity of Cassiope heaths is a characteristic feature of the valley. The stands are too small to be included in the map.

**Subgroup 13: Warm, favourable slopes with closed, thermophilic vegetation**

Steep, warm south- or southwest-facing slopes with some supply of water may have a vegetation dominated by graminids and forbs rather than prostrate shrubs. They are most often found on the slopes of moraine ridges or at the foot of smaller or larger cliffs. Such sites are very rare in Gipsdalen, and the few stands seen do not supply enough material for a local differentiation. The following types are, however, indicated:

**Type 132:** **Thermophilic Festuca rubra type.** The type is characterized by comparatively tall-growing grasses (Poa spp. and especially Festuca rubra ssp. arctica) mixed with some forbs. The type occurs very locally on some ridges, on the upper parts of river-banks in the lower parts of the valley, and in the peripheral parts of the bird-cliff area at Skiltvakten. The areas are too small for mapping.

**Type 133:** **Thermophilic Festuca baffinensis type.** This species-rich meadow is characterized by the distinctive Festuca baffinensis, often associated with other comparatively thermophilic species like F. rubra, Silene furcata, and Saxifraga nivalis. It is restricted to the small hillocks at the mouth of the valley north of Templet, and the slopes along Templet. Both this and the next type are less frequent in Gipsdalen than in neighboring areas (e.g. the Sassendalen and the Kapp Thordsen areas).
They are very rare in Gipsdalen. Only a few
vegetation north side of steep moraine ridges. Two groups
lasting well into July or later in normal years.
The snow cover disappears early in most of Gips­
stands have been found in ravines and on the
valley. Snowflush vegetation, i.e. · irrigated
Subgroup 14: Early snowbed and snowflush
The snow cover disappears early in most of Gips­
Snowbed vegetation is therefore restricted.
Some stands are found in the tributary valleys
ravines in the lower parts, but the larger
areas are confined to the upper, colder parts of
the valley. Snowflush vegetation, i.e. irrigated
during the melting period, is equally rare. Only
a few, weakly characterized types are recognized:
Type 141: Homalothecium nitens-Dryas type.
This slightly irrigated type of Dryas heath is
usually located on slopes beneath hills with
a comparatively late snow cover. It is inter­
mediate between ordinary Dryas heaths and
moss tundra. Distinct stands are only found on
the upper parts of the Gipshukodden -
Gásodden plain beneath Gipshuken mountain.
Type 142: Salix polaris type and related
types. Vegetation types dominated by Salix
polaris are widely distributed in and used to
characterize the North Arctic Tundra Zone
(see Brattbakk 1986). In the Middle Arctic
Tundra Zone they are of less importance,
and mainly confined to unstable sites (see types
412 and 421), moss tundras (types 211-2), or
sites with long-lasting snow cover. Salix
polaris snowbeds are confined to the basal
parts of moraine ridges in the lower parts of
the valley, but an open version covers some
area in the upper valley.
Type 143: Seasonally hygrophilous
Dupontia pelligera type. This is a weakly
characterized irrigated vegetation type,
intermediate between moss tundra and moist
heaths. It is characterized by a combination of
dry tundra (heath and marsh species, and by
a little developed moss cover. Scattered stands
are found on the upper parts of the slopes
from Gipsdalselva to the mountain sides.
Subgroup 15: Late snowbeds
Late snowbeds are areas with a snow cover
lasting well into July or later in normal years.
They are very rare in Gipsdalen. Only a few
stands have been found in ravines and on the
north side of steep moraine ridges. Two groups
of types are recognized:
Type 151: Phippsia concinna type and
related types. The Phippsia snowbeds are
most common in the uplands (most often with
P. algida as the characterizing species), but
small stands are often found at the base of
ridges in the lowlands. A few, very small
stands have been registered along the valley,
too small to be mapped. Larger, deviating
stands are found at the mouth of the valley
north of Templet. These stands are located on
a SE-facing, unstable slope, and Phippsia spp.
are mixed with e.g. Draba adamsii, Cerastium
regelii, and Ranunculus pygmaeus.
Type 152: Cerastium regelii type. This is a
moister type, usually found on upland plateaus
and in shallow depressions on silty substrates.
It is lacking from lower Gipsdalen, but occurs
regularly at the base of slopes beneath low
moraine ridges and cliffs in upper Gipsdalen.
The total area is, however, small, and no
stands are mapped. Cerastium regelii is
usually dominant, and is associated with e.g.
Draba alpina, Saxifraga spp., and Desch­
ampsia alpina.
Subgroup 16: Bird-cliffs
The most luxuriant vegetation in the inner fjord
areas is found below the bird-cliffs, where
manuring both supplies the vegetation with nutr­
ents lacking elsewhere, and helps in building a
humic soil which both stabilizes the scree and
increases the water capacity. The only detailed
study of bird-cliff vegetation on Svalbard (Eurola
& Hakala 1977) is not representative of the inner
fjord sites, and we have not attempted a division
into vegetation types based on the scanty
material available.
In Gipsdalen small stands of bird-cliff vegetation
are found beneath the bird colonies in several
mountains along the valley (e.g. Dalkallen), but
the only site of importance is the mountain
Templet. Bird-manured vegetation is found along
the entire mountain from Skiltvakan to Bjona­
hamna. Concentrated manuring characterizes the
slopes beneath Skiltvakan, diffuse manuring the
rest of the area.
The Skiltvakan bird-cliff vegetation may be
divided into three zones:
The innermost, most heavily manured zone is
composed of one species only, the grass
Puccinellia angustata, growing as a dense,
deep lawn on the uppermost cliff ledges.
The next zone is less heavily manured, and
contains a very varied meadow vegetation of
forbs and grasses, often reaching a height of
0.5 m. In addition to common bird-cliff species
like Cochlearia groenlandica, Oxyria digyna,
The least moist marshes are usually named Subgroup impeding of the drainage. Poorly drained sites many forbs are characteristic. The main differentiating factors within the group Adventdalen, and on Kapp Thordsen. while mat-forming grasses, sedges, rushes, and the moss layer is usually very well developed, except where there is some topographical covering of the drainage. The poorly drained sites are here colfectively associated with open scree. The area is also drier, due to less soil formation than in Skiltvakten. In addition to the species mentioned from Skiltvakten are found e.g. an intricate variation in the Potentilla nivea-chamissonis group, Minuartia stricta, and Erigeron humilis.

**Subgroup 22: Wet moss tundra**

The wet moss tundras are found on flat or very gently sloping ground. The ground water level is situated at or just beneath the soil surface during much of the growth season, but tussocks are common, elevating some plants well above it. These vegetation types have a restricted distribution in Gipsdalen, but a large and varied area is found inside the innermost raised beach ridges on the east side of the river. The beach ridges here have a damming effect. The five types recognized are among the most interesting vegetation types in the valley:

**Type 221: Thermophilic Carex parallela-C. saxatilis type.** The type is usually tussocky in Gipsdalen, with open soil or a very thin moss cover between the tussocks. Precipitation of lime is common. In addition to common marsh species like Dupontia pelligera and Eriophorum triste, this type is characterized by a combination of thermophilic and often rare graminids: Carex parallela, C. saxatilis, C. amblyrhynecha, Juncus triglumis, and in one site each Juncus castaneus and Kobresia simpliciuscula. Except for Carex amblyrhynecha these are species characteristic of rich minerotrophic mires in alpine areas in Scandinavia. Floristically this type is the closest approximation on Svalbard to a boreal mire. The type is found in the most favourable parts of the large marsh complex inside the major beach ridges on the east side, in a small depression on the largest beach ridge, and locally on the slopes beneath the mountains Usherjellet and Gipshukten on the west side.

**Type 222: Homalothecium nitens-Carex subspathacea type.** The type occurs on even ground, usually with a high, stagnant or very slowly moving water table. Tussocks are less frequent than in the preceding type. Carex subspathacea may dominate alone or with Dupontia pelligera and Eriophorum scheuchzeri. The type is important in the large marsh complex on the east side, and around the small lake on the west side of the estuary.
Type 224: *Dupontia pelligera-Eriophorum scheuchzeri* type; and Type 227: *Eriophorum triste-Deschampsia brevifolia* type. These two types are characteristic of flats or gentle slopes with a scant moss cover and weak humus accumulation. The water table is situated close to the surface, and usually moving. The stands are very poor in species, and single species may dominate large patches. Both types are frequent in the middle and inner parts of the valley. The last-mentioned type is a characteristic feature separating Gipsdalen from the other investigated inner fjord areas. The types are mapped collectively as 224/227.

Type 228: Frost upheaval *Dupontia pelligera-forb* and *Salix polaris-Saxifraga oppositifolia-Poa arctica* types. These are restricted to areas with silty sediments combined with a high water table. They are transitorial to group 4. In Gipsdalen they are rare and confined to the transition from marshes to river margin, especially along the large marsh complex. They are not mapped.

**Subgroup 24: Swamp**

The deep swamps characteristic of most other inner fjord valleys (e.g. Reindalen, Adventdalen, and Sassendalen) are lacking from Gipsdalen. Swamp tundra types (Subgroup 23), dominated by *Arctophila fulva, Dupontia psilosantha* and mosses, have not been found, and swamp zones are restricted to the margins of the small lakes (or rather dams). These are collectively placed in a weakly defined type:

Type 241: *Arctophila fulva, Dupontia psilosantha* and *Ranunculus hyperboreus* types. Narrow rims are found at the small lake west of the river mouth (not mapped), at "Dunsapietjønna" on the major beach ridges on the east side (mapped), and in some small hollows near Methuenbreen in the upper valley (not mapped). The characterizing species are all very rare in Gipsdalen.

**B Lowland areas with open vegetation cover**

The distinction between open and continuous vegetation is not as clear-cut in Gipsdalen as in other inner fjord valleys. This is due to the calcareous substrate, not to instability. Several normally closed vegetation types are found as more or less open versions in Gipsdalen, but with the same species composition. They are therefore described in the preceding main group to facilitate comparison with other areas. The present group is reserved for types kept open by some kind of instability or environmental stress (except for excess of lime).

Several factors may be responsible for keeping the vegetation open. Extreme exposure (abrasion) combined with drought is characteristic of the ridge crests, while salinity is a stress factor on the seashores. Instability is a characteristic both of sedimentation plains, river fans, scree, and recent moraines.

**Group 3: Very exposed, stable or eroded ridges**

The crests of raised beach terraces and moraine ridges are free of snow through most of the winter. The vegetation is usually very open due to a combination of drought (both in winter and summer), abrasion by ice crystals and dust, and wind erosion of the substrate. The species composition varies with the type of substrate, but is usually distinctly different from that found in the surrounding discontinuous or closed heaths. The vegetation of the open ridges has previously not been studied in detail on Svalbard. The separation between the three types below is preliminary:

**Subgroup 31: Ridges with gravelly substrate**

In the lower parts of the valley these are mainly raised beach terraces, in the upper part moraine ridges. The substrate is, however, fundamentally the same: calcareous gravel more or less mixed with silt. Only one vegetation type is recognized:

Type 312: *Draba-Saxifraga-Cerastium arcticum* type. The crests of gravelly ridges are almost devoid of vegetation, except for scattered individuals of hardy forbs and grasses, sometimes with small amounts of *Salix polaris*. The most common species are *Saxifraga oppositifolia, S. cespitosa, Draba corymbosa, D. oxycarpa, D. subcapitata, D. arctica, Cerastium arcticum*, and *Poa abbreviata*. The high frequency of *Draba corymbosa* is characteristic of Gipsdalen. The type is frequent in the entire valley, but usually occurs in small stands.

**Subgroup 32: Ridges with silty substrate**

Ridges with a predominantly silty substrate are less resistant to wind erosion than gravelly ridges. Such ridges are rare in Gipsdalen, mainly found close to the river and locally elsewhere (moraines). Two vegetation types are recognized, both in very small stands:

Type 321: *Poa abbreviata-Potentilla pulchella* type. This type is characteristic of ridges with mixed silt and gravel, and is found as small stands in places near the river, and on ridges within the large marsh complex on the east.
The two types are parallels to the preceding vegetation ones, representing earlier developmental stages: Subgroup continuous vegetation stable stages differing in hydrology:

Type 411: Dry *Polygonum viviparum* types. These plains are usually situated on the top of river banks, where the drainage is good. *Polygonum viviparum* may occur alone or mixed with smaller amounts of *Salix polaris*, *Saxifraga oppositifolia*, and mosses. The vegetation may be very monotonous for long stretches, but in Gipsdalen the type is restricted to a few stands along the lower course of the river.

Type 412: *Homalothecium nitens-Salix polaris-Equisetum arvense* type. These plains are damper, and the vegetation cover usually denser. They are often situated at slightly lower levels than the preceding, and may receive more sediments. Only small stands are found in Gipsdalen (not mapped).

Subgroup 42: Plains with discontinuous vegetation

The two types are parallels to the preceding ones, representing earlier developmental stages:

Type 421: Open *Salix polaris-Saxifraga oppositifolia* type. A very common type along most major rivers in the inner fjords. The vegetation usually consists of isolated clones and colonies of *Salix polaris*, *Saxifraga oppositifolia*, and other ubiquitously distributed plants. Lack of hygrophytes separates this type from the next. It occurs along most of Gipsdalselva, and may be considered an initial stage to type 411. The protected species *Braya purpurascens* is especially common in this type (see pp. 42).

Type 423: Open *Dupontia pelligera-Deschampsia spp.* type. This is the regular initial vegetation on the lowermost silty banks along (and in) the river, with a hygrophytic species content, but lacking mosses because of the frequent and often heavy sedimentation. *Deschampsia alpina* is more common than *D. brevifolia* in this vegetation type, and *Eriophorum scheuchzeri* is very common.

Group 5: Gravelly river fans

In Gipsdalen the valley slopes are divided almost equally between areas with a more or less stable bottom moraine, and unstable gravelly river fans from the tributary valleys. On these fans there is a series of developmental stages from sterile gravel to closed *Dryas* and *Salix polaris* heaths. The well stabilized stages are classified to types of closed vegetation, while the unstable ones are recognized as belonging to this group.

The species content seems to be partly random, partly depending upon the species available in the vicinity. Two ecologically defined subgroups are recognized, but no floristically characterized vegetation types, as there is little floristic homogeneity between stands:

Subgroup 51: Fans with vegetation cover

The single most important plant in the stabilization of river fans in the area is *Saxifraga oppositifolia*, weaving a net of long rooting branches through the gravel and silt. Some stabilization is also attained by *Salix polaris*, *Polygonum viviparum*, by mats of *Stellaria longipes* coll., *Poa* spp. and *Equisetum* spp., and by tussocks of e.g. *Draba*, *Saxifraga*, *Minuartia*, *Cerastium*, and *Festuca* spp. Vegetated river fans are among the more species-rich habitats in the area, especially in upper Gipsdalen.

Subgroup 52: Fans with scattered plants

This type is an initial stage to the preceding, with less consolidated substrate and vegetation cover, but with largely the same species content, and often an even higher species number.

Group 4: Sedimentation plains with silty substrate

Silty plains subject to yearly flooding occur along Gipsdalselva river. The vegetation is more or less in balance with this disturbance, but may change rapidly if there is any change in the amounts of sedimentation. Decrease results in a rapid change into closed *Salix polaris* or *Dryas* types, or into marshes. Increased sedimentation may result in destruction of all macro-vegetation. The two groups below represent different (potential) developmental stages.

Subgroup 41: Plains with more or less continuous vegetation

The two types represent well-developed, semi-stable stages differing in hydrology:

Type 411: Dry *Polygonum viviparum* types. These plains are usually situated on the top of river banks, where the drainage is good. *Polygonum viviparum* may occur alone or mixed with smaller amounts of *Salix polaris*, *Saxifraga oppositifolia*, and mosses. The vegetation may be very monotonous for long stretches, but in Gipsdalen the type is restricted to a few stands along the lower course of the river.

Type 412: *Homalothecium nitens-Salix polaris-Equisetum arvense* type. These plains are damper, and the vegetation cover usually denser. They are often situated at slightly lower levels than the preceding, and may receive more sediments. Only small stands are found in Gipsdalen (not mapped).
The two types alternate on the fans, according to the changing courses of rivers and brooks. Stands of both types may be kept in a dynamic equilibrium by a more or less constant amount of inundation and new sedimentation each year.

The river fans are of importance as permanent refuges for a series of weak competitors, and as a meeting place for plants from otherwise separated habitats. They may therefore function as habitats of hybridization between species (e.g. *Cerastium arcticum* × *regelii* and probably some *Draba* hybrids).

**Group 6: Recent moraines**

Recent moraines occur at the mouth of tributary valleys, especially at Boltonbreen, Methuenbreen, Margaretbreen, and Florabreen glaciers. The youngest moraines are sterile, while the older parts contain a vegetation similar to that of the river fans, i.e. comparatively rich in species, and habitats of otherwise non-competitive species.

**Group 7: Seashores**

The shores of Gipsvika and surrounding are predominantly coarse and devoid of vegetation. Driftwalls are found at several places, but they are barren. The seashores are divided upon two ecological groups, but only one of these is vegetated in the area:

**Subgroup 72: Gravel shores**

The gravel shores of Gipsvika are without vegetation, except for a few scattered plants on the uppermost, least saline ridges, where a few shoots of *Saxifraga* spp., *Oxyria* and other ubiquitous plants are found.

Vegetation types may be of conservation value for several reasons:

- Restricted distribution, totally, regionally or locally. The knowledge of arctic vegetation in general is too scant to indicate which vegetation types are rare in a circumpolar context. We have, however, enough information to evaluate the vegetation in a Svalbard context.

- Sites of especially rare and valuable species, or concentrations of several species with restricted distribution. This criterion is common to floristic and vegetational purposes (see p. 43).

- Typical (representative) of the area in question. In Gipsdalen this will be vegetation types characteristic of strongly calcareous substrates, and types of shallow marshes.

- Types of importance for other components of the ecosystem, i.e. for animals; in Gipsdalen reindeer and geese.

Vegetation types considered valuable are listed in Table 4, with indication of the criteria applicable in each case.

**Approaches to classification**

Our knowledge of arctic vegetation types and their ecological relations is still insufficient for many purposes. A fairly detailed classification system is needed for comparison between areas and for evaluation. Entities as broad as e.g. "wet tundra", "dry tundra" and "ridges" occur everywhere, and can scarcely be compared.

Three different approaches have been used in describing and classifying the vegetation of Svalbard in recent years: an approach based mainly on floristic differences (phytosociology), an approach based on series of vegetation types found in different habitats, and a modification of the last one suitable both for conventional mapping and for satellite mapping. A short discussion is given here, to facilitate comparison between the system used in the present report and earlier classifications and vegetation map legends.
The phytosociological approach. This is based on defining and naming vegetation units by use of exclusive or otherwise characterizing species (see Braun-Blanquet 1964). The approach has been used on Svalbard by e.g. Hadac (1946, 1959 - several vegetation types), Hofmann (1968, 1969 - mainly seashores), Thannheiser (1976 - shores and marshes), Thannheiser & Hofmann (1977 - seashores), and partly by Rønning (1965, 1969 - several types), Brattbakk (1979 and 1981 - seashores, 1983 - heaths), Eurola (1971 - "mires"), Eurola & Hakala (1977 - bird-cliffs), and Brossard et al. (1984 - mosaic communities).

There are several problems inherent in a purely floristic approach to arctic vegetation, in addition to a general criticism often raised against the methods in recent decades. (1) The low number of species in arctic areas, compared to the number of habitats, makes it difficult to identify uniquely characterizing species groups for each ecologically different type of habitat. (2) The confinement of a species to a certain habitat is often a result of competition. Decreased competition, as common in arctic areas, often increases the ecological span of many species, and they become less characteristic of single habitats. Some of the widest distributed and least characterizing of Svalbard species - e.g. Salix polaris (polarvier) and Saxifraga oppositifolia (raundsildre) - are restricted to clearly defined ecological niches in more southern areas. (3) The instability of many arctic habitats, due e.g. to cryoturbation, erosion and permanently changing water courses, makes successional or "arrested" stages an important part of the total vegetation pattern. (4) The phytosociological approach has not been applied to more than a part of the total variation, and no surveys exist on vegetation of widely distributed habitats like marshes, "moss tundras", snowbeds, exposed open ridges, and sedimentation plain and river fan habitats, or for upland (mountain) areas.

The series approach. This is a mainly Scandinavian approach based on ecological series of vegetation types: i.e. a "heath", a "meadow" and a "mire/marsh" series. It has been applied most consistently by the Trondheim group of botanists working in the MAB vegetation mapping of large parts of W and N coasts of Spitsbergen and of Adventdalen, and is inherent in the vegetation descriptions of e.g. Brattbakk et al. (1976) and Brattbakk (1980). The entities are described and numbered in a linear sequence, and grouped into the three series independent of the linear sequence. A third grouping is based on vegetation density (cover).

The lack of hierarchy is a drawback of this system. It is "closed" in the sense that new entities either have to be added to the linear sequence, or included as a subtype in an already established type. Another drawback is that the series are adapted from Scandinavian vegetation, and not very well suited to arctic, unstable conditions. The specific, open vegetation types of exposed ridges and sedimentation areas have mostly been treated as open phases of otherwise closed vegetation, or ignored.

It has proved difficult to correlate the vegetation entities on the numerous maps produced by Brattbakk directly with the results of satellite mapping. The picture attained from satellite mapping is sometimes more detailed (especially in wet areas), sometimes less, than the differentiation in the series approach.

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**Table 4** Gipsdalen vegetation types deemed to be of value in a conservational context. The criteria applied are:
1 - Restricted distribution in a Svalbard context (1a) or locally (1b); 2 - Sites of rare species; 3 - Representative of the Gipsdalen area, i.e. characteristics of the special ecological features present; and 4 - Of special importance as pastures for reindeer or geese. The codes of the vegetation types refer to Table 3.

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>112</td>
<td>Exposed, discontinuous heath; open Dryas type</td>
<td>3</td>
</tr>
<tr>
<td>122</td>
<td>Closed heath; Cassiope tetragona type</td>
<td>1b</td>
</tr>
<tr>
<td>133</td>
<td>Warm slopes; thermophilous Festuca baffinensis type</td>
<td>1b, 2</td>
</tr>
<tr>
<td>134</td>
<td>Warm slopes; Trisetum spicatum-Minuartia biflora type</td>
<td>1b</td>
</tr>
<tr>
<td>141</td>
<td>Snowflush vegetation; Homalothecium-Dryas type</td>
<td>1b, 4</td>
</tr>
<tr>
<td>151</td>
<td>Late snowbeds; Hippophaea concinna type</td>
<td>1b</td>
</tr>
<tr>
<td>152</td>
<td>Late snowbeds; Cerastium regelii type</td>
<td>1b, 3</td>
</tr>
<tr>
<td>16</td>
<td>Bird-cliff vegetation</td>
<td>1ab, 2, 4</td>
</tr>
<tr>
<td>21</td>
<td>Moss tundra types</td>
<td>1b, 4</td>
</tr>
<tr>
<td>221</td>
<td>Wet moss tundra; thermophilous Carex paralelo-saxatilis type</td>
<td>1ab, 2, 3, 4</td>
</tr>
<tr>
<td>227</td>
<td>Wet moss tundra; Eriophorum triste-Deschampsia brevifolia type</td>
<td>1a, 2, 3, 4</td>
</tr>
<tr>
<td>24</td>
<td>Swamp vegetation</td>
<td>1b</td>
</tr>
<tr>
<td>321</td>
<td>Exposed silty ridges; Poa abbreviata-Potentilla pulchella type</td>
<td>1ab, 2, 3</td>
</tr>
<tr>
<td>322</td>
<td>Exposed silty ridges; Puccinellia angustata type</td>
<td>1b</td>
</tr>
<tr>
<td>4</td>
<td>Silty sedimentation flats</td>
<td>2, 3</td>
</tr>
<tr>
<td>71</td>
<td>Salt/brackish marshes</td>
<td>1b</td>
</tr>
</tbody>
</table>
The modified series approach. The vegetation classification used in this report has been chosen for use both in interpretation of satellite maps and in conventional description and mapping of vegetation (based on aerial photographs). It is based on the main principle of the series approach, a differentiation according to major ecological habitats, but differs in some respects: (1) It is hierarchical in that it groups the habitats and vegetation entities at several levels. (2) It combines grouping of habitats and of floristically characterized vegetation types in one system. (3) It is "open" in the sense that new habitats or vegetation types may be added without significant change of structure. This facilitates the comparison between different sites, while it retains the possibility to describe entities of local significance.

The system is still in the experimental phase. It has been applied to the vegetation of Agardh-dalen (Elvebakk & Sørbel 1988), Sassendalen and Gipsdalen, and seems to facilitate the use of satellite data in the interpretation of vegetation types and distribution.

Vegetation maps

Three vegetation maps, representing different approaches, are presented: one map based on aerial photos and extensive field survey, one map based on satellite-data and more limited field surveys, and a vegetation density map based on satellite data alone. The relative values of these approaches are evaluated.

Aerial photo-based vegetation map

A conventional vegetation map, based on the classification described above, is enclosed as two sheets.

The map includes 25 vegetation units, given in the legend to the map sheets. Some mapping entities differ from the vegetation description above: Many entities occur in stands too small to be figured in the map. Other entities occur regularly together in mosaic patterns. Such complexes are mapped as a combination of two or more entities, e.g. 11/121, 224/227 and 312/133. In some cases the mapping entities are collective, i.e. including several closely related vegetation types.

Satellite-based vegetation map

A satellite-based map of Bünsow Land is presented in Fig. 5. Of the 27 classes, several represent unvegetated or slightly vegetated areas, e.g. water, snow and ice, shadow effects, and mostly naked silt, gravel and stones. The number of distinctly vegetated classes is 7, while open vegetation may be found in 5 additional classes. An interpretation of the classes, based on studies in Gipsdalen, Sassendalen (B. E. Johansen, A. Elvebakk, J.-T. Schwenke, and R. Elven), and Reindalen (B. E. Johansen), is given in Table 5, with an abbreviated version in the map legend.

Comparison and evaluation of the maps

The classifications behind the two maps are very different, both in the criteria applied and in the classification procedures.

Habitat and floristic criteria are fundamental in the conventional vegetation mapping, while reflection from substrate and vegetation cover, irrespective of single species, is paramount in the classification of satellite data. Even low-frequent species may be highly indicative in the conventional classification (e.g. the thermophilic marsh species). Such species will, of course, have no direct influence on the satellite data.

The classification underlying the conventional map is highly subjective, while the clustering resulting in the satellite-based classes is objective in the sense that it is reproducible when the same parameters are chosen (bands, classification algorithm, number of classes, threshold values).

In spite of these differences, the two maps are surprisingly similar. The same major trends in the landscape are reflected in both maps:

- Separation between non-vegetated and vegetated areas (and between different types of non-vegetated areas). In both types of sources (aerial photos, satellite data) it is difficult to separate between completely naked soil and areas with scattered plants.
- Two mutually independent differentiations are reflected within the vegetated groups: (a) Between closed and open vegetation; and (b) between dry and moist/wet areas.
- The dominant life-forms in each vegetation group influence both classifications, e.g. differentiation between dominance of prostrate shrubs and graminids in the dry tundra (heaths), and between graminids and mosses in the marshes.

The correspondences between the maps are indicated in Table 5. For each class in the satellite map (Fig. 5) are listed the corresponding habitat groups and vegetation types.

There are, however, several interesting differences between the maps:

- A more detailed differentiation is possible in the conventional map, based on field survey of the floristic composition. Purely floristic differences, e.g. between different species of
Table 5 Interpretation of classes in the satellite-based vegetation map (Fig. 6). The interpretation is based on studies in Gipsdalen, Sassendalen and Reindalen. Bernt Johansen, Tromsø (FORUT), is mainly responsible for the Sassendalen and Reindalen interpretation. Reference is made, where possible, to the conventional vegetation types (see Table 5.1).

<table>
<thead>
<tr>
<th>Class</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Unclassified.</td>
</tr>
<tr>
<td>1</td>
<td>Sea water, mostly deep and comparatively pure.</td>
</tr>
<tr>
<td>2</td>
<td>Shadows, with or without vegetation.</td>
</tr>
<tr>
<td>3</td>
<td>Swamp tundra and swamp (subgroups 23 and 24).</td>
</tr>
<tr>
<td>4</td>
<td>Silty sedimentation flats, more or less vegetated (parts of subgroup 42).</td>
</tr>
<tr>
<td>5</td>
<td>Open to partly closed types of wet moss tundra with vegetation cover about 50% (e.g., types 222, 224 and 227).</td>
</tr>
<tr>
<td>6</td>
<td>Luxuriant sloping wet moss tundra with vegetation cover approaching 100% (e.g., type 221 and dense variants of type 224).</td>
</tr>
<tr>
<td>7</td>
<td>Mossy, sometimes graminid-rich Dryas and Salix polaris vegetation, in Gipsdalen with much Carex misandra (includes parts of types 121a, 141 and 142).</td>
</tr>
<tr>
<td>8</td>
<td>A mixture of damp vegetation types with a more or less closed vegetation: moss tundra (types 211-212), salt/brackish marshes (subgroup 71), and some snowbeds.</td>
</tr>
<tr>
<td>9</td>
<td>Closed to partly open heath vegetation with dominance or co-dominance of graminids (e.g., Carex rupestris in the lowlands, Luzula spp. and possibly Alopecurus alpinus in the mountains), including parts of type 121. Bird-cliff meadows (subgroup 16).</td>
</tr>
<tr>
<td>10</td>
<td>Sea water with river sediments.</td>
</tr>
<tr>
<td>11</td>
<td>River and melt water, including the fjord water close to estuaries.</td>
</tr>
<tr>
<td>12</td>
<td>Glaciers, probably with some dust covering.</td>
</tr>
<tr>
<td>13</td>
<td>Gravelly river fans without or with open vegetation (group 5), some talus.</td>
</tr>
<tr>
<td>14</td>
<td>Sedimentation flats with a more or less continuous vegetation (subgroup 41 and parts of type 423).</td>
</tr>
<tr>
<td>15</td>
<td>Closed Dryas heath vegetation (lowlands, type 121) and densely vegetated polygon ground in mountains.</td>
</tr>
<tr>
<td>16</td>
<td>Open Dryas heath vegetation (lowlands, types 111-112) and comparable types (e.g., Luzula types) in mountains.</td>
</tr>
<tr>
<td>17</td>
<td>Sterile fell-fields and talus slopes, stones and gravel; exposed gravel and silty ridges with open vegetation (group 3).</td>
</tr>
<tr>
<td>18</td>
<td>Sea water with especially large amounts of river sediments.</td>
</tr>
<tr>
<td>19</td>
<td>Glaciers.</td>
</tr>
<tr>
<td>20</td>
<td>Glaciers and snow.</td>
</tr>
<tr>
<td>21</td>
<td>Wet sedimentation flats and gravel river fans.</td>
</tr>
<tr>
<td>22</td>
<td>Wet, silty sedimentation flats, probably also shadow effects.</td>
</tr>
<tr>
<td>23</td>
<td>Glaciers and snow.</td>
</tr>
<tr>
<td>24</td>
<td>Wet gravel river fans; the drainage courses.</td>
</tr>
<tr>
<td>25</td>
<td>Non-vegetated fell-fields, mountains.</td>
</tr>
<tr>
<td>26</td>
<td>Glaciers and snow.</td>
</tr>
</tbody>
</table>

- The satellite map reflects hydrology better than both monochromatic aerial photos and superficial field surveys. Hydrology is reflected both in densely vegetated areas and in areas with mostly open soil. This is important for an evaluation of gravel fans and sedimentation areas.
- Vegetation density is very well reflected in the satellite map, while the amounts of vegetation are often exaggerated in field surveys, and under-estimated by use of aerial photos alone. Vegetation types with fundamentally the same species content, but differing in density, may therefore often be split on two or more classes in a satellite-based map. In the present map this is partly compensated for by choice of similar colours for floristically related types.
- There has to be a minimum vegetation cover before it is detected at all in satellite data or aerial photos, while only a few, scattered plants are needed before it is defined as a vegetation type during field surveys. The proportion of non-vegetated ground will therefore be higher in estimates based on satellite data alone than in estimates based on a combination of aerial photos and field surveys.

We conclude that both approaches present an ecologically valuable survey of the area. They are comparable as to the main features, but differ in the degree of detail, in reflection of ecological features (e.g., moisture), and in their relevance for identifying the floristically most valuable vegetation types.
Both approaches must be combined with field surveys ("ground truth data") to give valuable results. A large amount of field survey is needed before a vegetation map based on aerial photos is ecologically and floristically well documented. It is an expensive method, and the results obtained from one area cannot be extrapolated to other areas. A much smaller amount of field work is needed to document a classified satellite scene. Field control of a smaller number of sites of each class is usually sufficient. With certain limitations the results of a field survey of parts of a classified satellite scene can be extrapolated to the remaining, and to other scenes from comparable areas taken at about the same time. Some extrapolations are made below (p. 59).

Vegetation density map
In this satellite-based map (Fig. 6) densely vegetated areas are indicated by red to dark

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**Figure 5** A classified satellite map of Bünsow Land, based on bands 1, 4 and 5 a Landsat TM scene from 5 August 1985 (path 217, row 3, Q4).

The map includes the major parts of Bünsow Land with Gipsdalen, the lower parts of Sassendalen (lower right), and the coast from Sassenelva estuary west to Diabasodden promontory (lower left).

Numbers in parentheses refer to vegetation group/type codes, see Table 5.1.

The map is produced by FORUT, the University of Tromsø, by Bernt E. Johansen, which is also partly responsible for the legend. Further explanations, see Table 5.3 and text.

Legend:

Non-vegetated classes

- 0 Unclassified (residual class)
- 1 Sea water, more or less pure
- 2 Shadow effects, with or without vegetation
- 10 Sea water, with some river sediments
- 11 River and melt water, estuarine water
- 12 Glaciers
- 19 Sea water, with much river sediments
- 20 Glaciers
- 21 Glaciers and snowfields
- 24 Glaciers and snowfields
- 25 Wet gravelly river fans, the drainage courses
- 26 Fell-fields, mountains
- 27 Glaciers and snowfields

Slightly vegetated classes

- 4 Silty sedimentation plains, more or less vegetated (parts of 42)
- 13 Same as 4
- 14 Gravelly river fans, without or with open vegetation (5), some talus
- 18 Exposed gravel and silty ridges (3); also sterile fell-fields and talus slopes, stones and gravel
- 22 Wet sedimentation plains and gravel river fans
- 23 Wet silty sedimentation plains; probably also some shadow effects

Openly to densely vegetated classes

- 3 Swamp tundra and swamps (23 and 24)
- 5 Open to partly closed wet moss tundra, vegetation cover around 50 % (222, 224, 227)
- 6 Dense sloping wet moss tundra, vegetation cover approaching 100 % (221 and dense variants of 224)
- 7 Mossy, sometimes graminid-rich Dryas and Salix polaris vegetation, in Gipsdalen with Carex misandra (parts of 121a, 141 and 142)
- 8 A mixture of damp vegetation types with more or less closed vegetation: moss tundra (211, 212), salt/brackish marshes (71), some snowbeds
- 9 Closed heaths and meadows rich in graminids: Carex rupestris heaths (parts of 121), Luzula heaths and Alopecurus tussock heaths in the mountains, bird-cliff meadows (16)
- 15 Sedimentation plains with more or less continuous vegetation (41, parts of 423)
- 16 Closed Dryas heath (121); densely vegetated polygon fields in the mountains
- 17 Open Dryas heath (111, 112); comparable (Luzula) types in the mountains
Figure 6 Standard false-colour composite map of Bünsow Land with Gipsdalen (upper part), Sassendalen (lower right) and the Adventdalen area (lower left). The map is based on a Landsat TM scene from 5 August 1985, utilizing the bands 2, 3 and 4. The map is produced by FORUT, The University of Tromsø, and has been presented earlier by Spjelkavik & Elvebakk (1989).

Red and brown colours indicate well vegetated areas: dark brown and brownish red - closed Dryas heaths, deep red - moss tundras and marshes, light red - bird-manured meadows.

Further information, see text.
Applications of the maps

The three maps presented (Figs. 6-7 and the enclosed maps) are complementary; each presents information not readily accessible from the others.

Location of productive areas is best made from a vegetation density map (Fig. 6). The map also gives some information about which type of productive vegetation is present, i.e. dry, moist, wet, or manured. Areas of importance as pastures for the larger herbivores present in Svalbard are directly indicated. Maps of this type would be suited for an extensive survey of arctic areas, especially when combined with more intensive confirmatory studies in selected areas. In construction work the densely vegetated, and thereby productive areas should be avoided.

Separation of the main groups of vegetation and their distribution is best seen from the satellite-based map (Fig. 5). From this map we may e.g.: (a) Exactly locate and delimit the valuable marsh areas (green classes 3, 5 and 6); (b) Separate between the closed (and botanically trivial) Dryas heaths (beige and light brown classes 7 and 16), the more open species-rich Dryas heaths (yellowish brown class 17), and the driest parts of the moss tundras (dark brown class 8); (c) Identify the graminid-dominated heaths and bird-cliff meadows important as pastures (yellow class 9); and (d) Separate between gravely and silty areas, and between dry and moist types of these.

The map may be used to locate and to estimate the amounts of pasture and other valuable vegetation types with an accuracy probably not attainable by conventional, aerial photo-based vegetation mapping. Exact location of installations and transport systems in Gipsdalen may, to a large degree, be based on this map.

When comparing Gipsdalen with the other areas included in the map, several important differences are found. Gipsdalen differs, in addition to a much less total area of densely vegetated ground, in a different balance between the classes. Class 9 (yellow) of graminid-rich heaths and meadows is of no significance in Gipsdalen, while it is among the most widely distributed in Sassendalen, both in the valley and in mountains. Marshes and moss tundras (classes 3, 5, 6, and 8) have a much wider distribution both in Sassendalen and in the Vindodden-Diabasodden area than in Gipsdalen. The pattern of classes found south of the fjord is the normal one in the interior fjord on Svalbard.

Neither the vegetation density map nor the satellite-based vegetation map give any information per se about the location of sites of floristically valuable types, or of rare vegetation types. Rare types will normally occur in a few and often small stands. In an unsupervised classification they will either be included in more widely distributed classes or in the residual class (class 0, as seen for some bird-manured slopes in Templet in Fig. 5).

A conventional vegetation map based on floristic criteria and extensive field surveys (the enclosed maps) is still needed to identify: (a) The low-frequency, and thereby vulnerable, elements; and (b) The floristically different types within groups similar in hydrology and life-forms, e.g. in marshes. This is especially the case in an area like Gipsdalen, where such elements are of very local occurrence.

The conventional vegetation map is the base of a derivated map (Fig. 7, enclosed), where the entire mapped area is classified as to conservation value. This map should be used in the future
planning to locate construction activities to the least vulnerable vegetation types.

Conclusions

- The vegetation of Gipsdalen is influenced by the strongly calcareous substrates, resulting in a wide distribution of open vegetation types, more restricted distribution of closed vegetation, and a species content in many habitats different from what is usually found in the interior fjords.

- Large areas are virtual calcareous arctic steppes or semi-deserts, where physical and chemical properties of the substrates restrict the development of vegetation.

- The open and pedologically anomalous conditions favour several species and vegetation types rare on Svalbard as a whole, partly types confined to a calcareous substrate, partly types characterized by low inter-specific competition. A list of such vulnerable vegetation types and groups is given in Table 4.

- The productivity is generally low, and the productive areas are restricted to small parts of the valley. The highest production is probably found in the bird-cliff meadows and in the marshes. The larger areas of productive vegetation are located to the lower parts of the valley.

- By combined use of a conventional vegetation map based on aerial photos (enclosed), a satellite-based vegetation map (Fig. 5), a vegetation density map (Fig. 6), and results of field surveys, it is possible to indicate areas where installation and construction activities will be in minimal conflict with botanical values and generally productive areas.

EVALUATION

Construction work in an arctic environment has several effects, direct and indirect, on the vegetation and flora.

Changes in the species composition may be effected by: (a) introduction of new plants or of new biotypes of plants already present; (b) giving preference to some plants with detrimental effects on others; and (c) by direct decimation or eradication of plants. Introductions of new plants are of little significance in the Middle and North Arctic Tundra Zone of Svalbard, as no single introduced plant has yet become well established in the islands. Genetical "pollution" by foreign biotypes of plants already present may be more dangerous, but such effects have not been studied in the Arctic yet.

The majority of regionally and locally rare plants are restricted to equally rare habitats and vegetation types in the Gipsdalen area. (It is impossible to protect the species without protection of the vegetation.) Impacts on the vegetation types are usually more destructive than impacts on single species populations. The evaluation below will therefore emphasize sites of restricted and valuable habitats and vegetation types, and their vulnerability to different types of impacts, as these are the most relevant dangers in connection with the presented plans.

Location of botanical values

The especially valuable plants and vegetation types are mainly confined to seven local areas:

A The Gipshukodden area
B The western Gipsvika area
C The eastern Gipsvika area
D The Templet area
E The main beach ridge - marsh area
F The marsh area below Usherfjellet
G The Margaretbreen - Methuenbreen area

The geographic positions of these areas are shown in Fig. 7.

A The Gipshukodden area

Gipshukodden is the southeastern promontory of the Gipshusletta plain, the westernmost part of Bünsow Land. The promontory consists of silicic dolerite. This makes parts of the flora and vegetation differ from the rest of the almost uniformly calcareous Gipsdalen, even though a thin layer of calcareous soil mostly cover the dolerite. Plants rare or lacking elsewhere in Gipsdalen are e.g. *Potentilla hyparctica* (raggmure) and *Saxifraga flagellaris* (trådsildre). Dolerite is also a hard, but fractured rock, and the exposed outcrops on Gipshukodden are split into rectangular boulders. Sheltered conditions between boulders, and soil with mixed acidic and calcareous components, cause a luxuriant vegetation with unusually large plant individuals. The closed heath vegetation of the dolerite has been mapped as a separate type (type 121).

Gipshukodden reaches only 46 m a.s.l., and is exposed to sea spray. This may be an additional reason for the well-developed vegetation.

Further inland towards the Gipshukodden mountain the main vegetation type is closed Dryas heath (type 121). This dry tundra is dominated by e.g. *Carex misandra* (dubbestarr), *Salix polaris* (polarvier) and *Saxifraga oppositifolia* (rådsildre), in addition to *Dryas octopetala* (reinrose). Some small, moist areas, dominated by mosses ("moss tundra"), are south-facing and warm, and support weakly thermophilic species like *Dupontia pelligera* (småtundragras), *Carex subspathacea*
(ishavsstarr) and Saxifraga hirculus (myrsildre), type 141.

In 1985 a fruticose Xanthoria (a lichen of an otherwise foliose genus) was found 1-2 km NE of the summit of Gipshukodden. The occurrence is located within a 10 by 50 m large area on a raised beach terrace, approximately 2-300 m from the sea. Other collections from arctic Canada have recently been published as modifications of Xanthoria elegans (Fahselt & Krol 1989). This modification is of a high systematic, evolutionary and ecological interest. The stand NE of Gipshukodden is the only one known outside Canada, and should by no means be destroyed.

Other species and vegetation types of the Gipshukodden area are rare on a local scale, and contribute significantly to the general diversity of Gipsdalen. They are, however, common on a regional (Svalbard) scale.

**B The western Gipsvika area**

The area is located to the west of the mouth of Gipsdalselva and delimited by the Tverråa river fan to the northeast, Gipshuken mountain to the northwest, and the Gipshukodden area to the west.

The landscape is characterized by plains and low ridges with distinct shore-line patterns, clearly marked because the vegetation is confined to the shallow depressions between the ridges. Two of the three small lakes in Gipsdalen are dammed behind beach ridges, as are several marshy depressions. The beaches towards Gipshukodden are narrow (often only 1-2 m wide), coarse and devoid of vegetation (type 72). Beaches of more fine-grained materials, and supporting fragments of salt marsh vegetation, are found towards the estuary (type 71).

The raised shore terraces are mostly covered by open Dryas heath (type 11), usually with less than 50 % vegetation cover, and by open ridge vegetation of forbs and graminids (type 312). The slopes are snow covered during winter, and habitat a weakly developed snowbed vegetation with high species diversity (with e.g. Trisetum spicatum - svartaks - and Minuartia biflora - tuvearve, type 134). At the bottom of the slopes fragments of Phippsia snowbeds are found (type 151).

The two dams are without higher vegetation. The southernmost is brackish and influenced by rotting algal drift material. The other is surrounded by a slightly brackish marsh dominated by Carex subspathacea - ishavsstarr (type 222). Thermophilic plants are found in the uppermost parts, e.g. Carex amblyrhynea (buttstarr).

An important thermophilic, drained marsh area is met with between the uppermost beach ridge and the slope of Gipshuken, with occurrence of e.g. Kobresia simpliuscula (myrtust, regionally very rare) and Juncus triglumis (trillingsiv), type 221.

A great species diversity, coupled with habitat diversity, is the main reason for the value of this area. The dams and marshes make it interesting on a local scale, and two species occurrences are of regional/national value.

**C The eastern Gipsvika area**

The area E of the estuary is delimited to the N by the fan of a river N of Temple, to the E by Temple. It consists of a very low, but distinct beach ridge system between the fan, the Gipsdalselva river, and the sea, and botanically varied slopes towards Temple and the valley north of the mountain.

The beach is coarse, partly covered by algal drift, but devoid of vegetation (type 72). It borders directly on dry Dryas-Carex misandra heath on the beach ridges (types 11 and 121), and on a slightly less dry Salix polaris-Saxifraga oppositifolia vegetation in the depressions (type 142).

The best developed shore vegetation of Gipsdalen is found in small bays at the lower course of Gipsdalselva, where a Puccinellia phryganodes salt marsh (type 711) is followed by Carex subspathacea salt marsh, Carex ursina salt marsh (type 712), and a slightly halophytic forb vegetation of e.g. Sagina intermedia (jøkelarve), Minuartia rubella (nålearve), and Draba arctica ("hårrublom"), mixed with Saxifraga spp.

The slopes to the east are partly dry with a grassy heath vegetation (where Festuca baffensis - härsvingel - is locally common, complex of types 133 and 312), partly moist to wet with a species-rich drained marsh vegetation (complex of types 221 and 224). Several species of interest occur, e.g. the Svalbard endemic Saxifraga svalbardensis (svalbardsildre).

The eastern Gipsvika area is of special interest because of the well developed raised beach terrace system, the salt marsh, and the sloping marshes. Parts of the beach plain are heavily disturbed by the Finnish mining exploration: by tracks and by the depot for materials.

**D The Temple area**

The Temple area consists of the slopes of Temple mountain from Skiltvakan in the northwest to Bjonasletta in the southeast, a distance of about 6 km. This is the most important bird-cliff area of Bünsow Land.

Temple reaches a height of 770 m a.s.l, but the rim of the summit plateau is mostly situated at 5-600 m. The upper parts are steep cliffs and
buttresses, while the lower 200 metres are talus. The most concentrated bird colony is found at Skiltvakten, where a well-developed zonation of bird-cliff vegetation is found (type 16). The uppermost part, close to the nesting sites, is a pure *Puccinellia angustata* (polarsaltgras) meadow, while a species-rich meadow covers the lower slopes. Several species of interest occur, e.g. *Polemonium boreale* (polarflokk), *Ranunculus pedatifidus* (fliksoleie), and several *Potentilla* spp. (mure), in addition to large populations of very tall-growing *Cochlearia groenlandica* (polarskær-buksurt), *Oxystegus fragilis* (fjellsyre), *Papaver dahlianum* (svalbardvalmue), and a mixture of *Poa* spp. and *Festuca* spp. Stones and cliffs are covered by ornithocoprophilous lichens, e.g. *Xanthoria elegans* and *Caloplaca saxicola*.

The slopes between Skiltvakten and Bjonasletta are more diffusely manured, and an open vegetation is developed. This is the main site of the taxonomically intricate *Potentilla* spp. in the area, and also contains small populations of e.g. *Erigeron humilis* (svartbakkestjerne) and *Cystopteris fragilis* ssp. *dickieana* (berglok), which are locally rare, and of *Minuartia stricta* (grannnarve), which is regionally rare.

The beach rampart along Templet is steep, stony, and without higher vegetation.

Templet including the pinnacle Skiltvakten is one of the most important bird-cliff sites in the Iafjorden area. Each bird-cliff usually has its own characteristic. During studies in 1986-89 we have made some comparison with the nearby Fjordnibba bird-cliff (Sassendalen area). The two sites represent clearly different types. There are both floristic and vegetational differences, probably caused by different aspect: Templet is facing W to SW, Fjordnibba facing NE. Together the two sites represent the bird-cliff vegetation in the interior fjords well.

**E The main beach ridge - marsh area**

The area is located on the SE side of Gipsdalen river. It is delimited to the southwest by the fan from the river north of Templet, to the northeast by the river fan from Aitkenfjellet, and to the southeast by the mountain slopes of Dalkallen-Aitkenfjellet.

This is the botanically most varied part of Gipsdalen. It contains the innermost and largest raised beach ridge system, the largest and most varied marsh areas, one of the very few ponds in the valley ("Dunsapietjønna"), and a species-rich river margin along Gipsdalselva.

The crests of the beach ridges are only slightly vegetated, mostly by an open to closed *Dryas* heath (types 11 and 121), and the two types of open ridge vegetation. The calcareous gravel ridges have a *Saxifraga-Draba* vegetation (type 312), while raised silty ridges within the marsh areas contains a regionally rare *Poa abbreviata-Potentilla pulchella* vegetation (type 321). The slope towards the river north of Templet is one of the relatively best snow covered sites in the valley, and supports a well-developed and species-rich snowbed vegetation (type 151).

The diffuse drainage from the Dalkallen and Aitkenfjellet mountains is dammed by the beach ridges, and supplies an approx. 4 km large marsh complex drained to the river by a brook just north of the highest ridge. The marsh area is a complex: Very open, shallow marsh with e.g. *Eriophorum triste* (svartull) and *Deschampsia brevifolia* (stivbunke), almost without moss cover (type 227); deeper drained marsh dominated by *Dupontia pelligera* (småtundragras) and mosses (types 224 and 226); and hummocky, thermophilic marsh characterized by e.g. *Carex pararella* (smaístarr), *C. saxatilis* (blankstarr), *C. amblyrhyncha* (buttsstarr), and *Juncus triglumis* (trilingsv), in addition to numerous other graminids, forbs and mosses (type 221).

A smaller site of the same types is found in a depression on the main ridge, close to the transport road. Shallow, wet marshes are surrounding the pond "Dunsapietjønna", the only place in Gipsdalen where a lake marginal vegetation of e.g. *Ranunculus hyperboreus* (setersolje) and *Arctophila* (hengegras) was seen (type 241).

The marshes are the most important grazing areas of geese in the valley, and also important summer pastures of reindeer. Grazing, manuring and dispersal of seeds and fruits may have some influence on the composition of the vegetation.

The river margin along most of Gipsdalselva is silty, with a scattered pioneer vegetation of widely distributed, not very competitive species (e.g. *Deschampsia* spp., *Eriophorum scheuchzeri*-sneull, open stands of *Dupontia pelligera*-småtundragras, *Juncus biglumis* - tvillingsv; types 421 and 423). More varied margins are found bordering this area, with stands of distinct forms of *Puccinellia angustata* (polarsaltgras) and *Potentilla pulchella* (tuvemure), type 323, large amounts of *Braya purpurascens* (purpurbare), and important populations of *Minuartia rossii* (puteave) and *Pucciphiopsis vacillans* (svalbard-fimbulgras).

This area has the highest concentration of regionally and locally restricted taxa in the Gipsdalen area, and the best developed and most varied ecological gradients.

**F The marsh area below Usherfjellet**

The marsh area below Usherfjellet is situated on the NW side of the river, and borders on the preceding area. It is delimited by the river to the SE, S and SW, and by the river fan from the
These marshes have a favourable aspect (SE), and are probably among the most thermophilic in the valley (type 221). A concentration of thermophilic species is found, with the regionally very rare Juncus castaneus (kastanjevis) as the most important, but also with Carex parallelæ (small-starr), C. sasatilis (blankstarr), and Juncus triglumis (trillingsiv). The major parts are composed of Eriophorum scheuchzeri and E. triste marsh (type 227), moss tussocks (fragments of type 212), and shallow Carex subspathacea marsh between the tussocks (type 222). The complex is ecologically varied, due to drainage and stagnation determined by small ridges dissecting the area. The wettest part, close to the mountain, is stagnant due to damming by a rigde parallel to the mountain, and composed of a series of small ponds in a wet marsh.

This marsh area is important both because of its ecological variation, and the concentration of relatively thermophilic marsh species.

G The Margaretbreen - Methuenbreen area

The uppermost parts of the valley have an open, scattered vegetation. In areas with stable substrates is found a monotonous change between open Dryas-Carex misandra heath on the drier parts (type 112), a forb-grass vegetation with some Salix polaris on moister soil, a shallow marsh vegetation mostly consisting of Eriophorum triste and Juncus biglumis on wet slopes (near to type 227), and a snowbed vegetation of Cerastium regelli (polararve) and both Phippsia spp. (snoegras) in depressions beneath ridges (type 152). Unstable areas - the moraines and river fans of the two glaciers - have a more species-rich but little structured grass/forb vegetation. The more varied sites are very local:

1) A small stagnant marsh besides the road a short distance from the mining camp, with e.g. Carex amblyrhyhyncha (buttstarr, the only known site in the upper valley) and Juncus triglumis (trillingsiv).

2) Small hills of the silicic Hecla Hoek formation E of the Margaretbreen moraines, with sites of acidophiles like Luzula arcuata ssp. confusa (vardefrytle).

3) The hills bordering on the Margaretbreen moraines, with small areas of Cassiope tetragona heath (type 122).

4) Small wet marsh areas just to the northeast of the river fan from Methuenbreen, with a slightly thermophilic character.

The deviating sites are of interest because they indicate what ecological factors are of importance in causing diversity in this part of the valley that functionally is close to a calcareous desert.

Vulnerability

A species or vegetation type may be vulnerable for several reasons: it may be very rare and vulnerable because small changes will concern large parts of the total amount; it may be generally unstable and easily influenced by environmental changes; or it may be selectively susceptible to some type(s) of impact.

Several habitat and vegetation types of Gipsdalen are vulnerable to almost any type of activity, due to the inherent instability caused by the structure and nutrient content of special substrate and to the open vegetation:

- Exposed calcareous gravel ridges with open vegetation (subgroup 31).
- Exposed silty ridges with open vegetation (subgroup 32).
- All types of marshes and intermediates between dry tundra (heath) and marsh (group 2).
- Silty river banks (parts of group 4).

Others are vulnerable because of a very restricted distribution in the Gipsdalen area, with few and/or small stands:

- Cassiope tetragona heath (type 122).
- Thermophilic slope vegetation (subgroup 13).
- Moss tundra vegetation of Homalothecium and Dryas (type 14).
- Late snowbeds (subgroup 15).
- Moss tundra vegetation of Homalothecium and Salix polaris (subgroup 21).
- Thermophilic marshes (type 221).
- Swamps (subgroup 24).
- Silty ridges (subgroup 32).
- Salt/brackish marshes (subgroup 71).

Vulnerability and concentrations of rare species are the criteria applied in the derived map of botanical values (Fig. 7). Generally speaking, the vegetation types and plant species of Gipsdalen are supposed to be vulnerable mainly to impacts from the following types of activities planned in the future:

1) Erosion as a result of construction work or of unintentional damage by trampling or motorized traffic:

Substrate instability is a permanent feature of several habitats in the Gipsdalen area, especially in talus, river fans, most river margins, and recent moraines. The species inventory in such sites is adapted to the instability. Increased instability will probably result in a
decrease in species number and vegetation density, but will not be very destructive when the entire area is taken into consideration.

Instability is a potential feature of most drier areas of the valley, as the substrate is only slightly stabilized by finer fractions and by vegetation cover. This is the case of beach ridges, moraine ridges, and the gentle slopes between the river fans. Erosion may occur both in open, discontinuous and continuous vegetation, with the most dramatic changes in the last-mentioned. The additional stability given by a closed vegetation may cover a larger potential instability in the substrate, e.g. on steep slopes.

2) Changed drainage as a result of damming or ditching along roads and conveyor belt:

The marshes of Gipsdalen are uniformly shallow, with a very thin or almost lacking peat layer. The marsh vegetation depends upon a permanent influx of water, and a stable ground water table. Damming by e.g. roads will destroy the present vegetation. Increased drainage, by ditching or by erosion channels, will decrease the water table and result in a change to more trivial heath vegetation.

The unstable and often coarse substrates make the shallow Gipsdalen marshes especially susceptible to erosion.

3) Increased nutrient levels:

The special biological features of Gipsdalen is connected with the general level of nutrients: a surplus of lime and a deficiency in almost every other nutrient. A supply of nutrients will have clear detrimental effects, i.e. increased opportunities for several ubiquitous plants, a more closed vegetation, and probably a decrease in the populations of lime-demanding but weakly competitive species like Braya purpurascens (purpurkarse) and most of the regionally rare marsh plants.

Increased productivity will be of no value in the Gipsdalen area. The importance of the area from a conservation point of view is its character as a calcareous arctic steppe or semi-desert. There is no potential utilizer of the increased productivity. The only important herbivore is the reindeer, and its population is probably restricted by the very scant winter pastures located in the mountains.

Proposals

It is not possible to evaluate exactly the possible consequences of the planned activities, due to inexact information about location and extent of installations. Only some tentative conclusions and proposals may be given.

Permanent installations are planned located in the valuable areas B and G. The conveyor belt and road will run through the valuable area F. The other valuable areas will be little influenced.

Impacts from the planned activity may be grouped into:

1) Disturbance of vegetation and substrate at and around the main construction sites.
2) Disturbance as a result of increased trampling and by use of motorized vehicles.
3) Erosion and changes in drainage as result of construction of conveyor system and roads.
4) Seepage and sewage from installations.

1) Construction activities will be located to the mining site in area G and the harbour facilities in area B. In both places the botanical values are confined to small areas, and a conflict can be avoided by careful location of installations.

In the Margaretbreen - Methuenbreen area (G) care should be taken to avoid the small marsh site near the Finnish camp, and the outcrops of Hecla Hoek bedrock. A more detailed field survey is needed in this area when exact plans for the mining is presented.

In the Gipsvika area (B) the harbour construction should avoid both the Gipshukoden area and the areas next to the estuary. The areas between are of less botanical value. Construction materials should, however, be brought from the mining site (as indicated in the plans), and not taken from the surroundings. The slopes between Gipsvika and Gipshuken mountain is susceptible to erosion. The location of the conveyor belt and transport road northwards from the harbour may conflict with botanically important sites (see below). A field survey is needed when exact plans are available.

2) As much of the vegetation types and the substrates have very low durability, the activities should be confined within clearly delimited areas. Use of motorized vehicles outside the delimited roadways should be strictly banned.

3) The conveyor belt and transport road between Gipsvika and the mine will influence large parts of the valley, especially as it is planned located on the other side of the valley from the existing track. A location to the existing track, on the east side, would be preferable for landscape estetic reasons, but not for biological ones. The existing track cuts across the most valuable beach ridge system, and through a part of the most valuable marshes. Visible effects are erosion and (locally) changed drainage. The location of the road/conveyor
belt should be decided in the field during a joint survey with biologists.

During the construction care should be taken both to avoid erosion in loose gravel slopes (upslope effects) and damming of drainage (downslope effects). The last can be avoided by locating the systems close to the river.

A road/conveyor system on the west side will only have small botanical effects in the upper parts of the valley, if certain requirements are fulfilled: It should be placed close to the river; the materials needed should be taken from the mines or from non-vegetated parts of river fans; and changes in wet areas should be neutralized by use of bridges. In the area southwest of Leirflata care must be taken to avoid the small areas of valuable marsh, and the species-rich river margin (both in area F). Care must also be taken in crossing the area between the Tverrelva river fan and Gipsvika, where valuable marshes and dams are located on both sides of a large beach terrace. Here the system should be located in the middle of the terrace, avoiding erosion down to the marshes.

4) The sewage from the mining site should not be allowed to reach the terrain, and especially not the river. Detrimental effects are also expected from oil spillage, which both will damage and destroy the vegetation directly, and increase the supply of nutrients. A proposal for handling sewage and spillage should be presented and evaluated.

Conclusions

1) The proposed mining project will in any case be detrimental to the Gipsdalen area as a comparatively undisturbed biological system, and as an area with botanical elements special to the Svalbard islands as far as known.

2) The features making Gipsdalen especially valuable in a botanical context are at the same time the ones making the area vulnerable, i.e. the unconsolidated calcareous substrate, the open and vulnerable vegetation, and the generally very low level of other nutrients than lime.

3) Harbour facilities and mining constructions might be located without loss of important botanical values, if care is taken.

4) The road/conveyor belt between Gipsvika and the mining area may easily come into conflict with important botanical values, if care is not taken.

5) Exact location of harbour and mining installations, and of the road/conveyor belt, should be decided during a joint survey by representatives of the mining company, biologists, and representatives of the local authorities of Svalbard (the nature conservation supervisor).

6) The mining company should present plans to indicate how they will cope with the sewage and spillage from installations.

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THE FAUNA OF GIPSDALEN, SVALBARD

Pink-footed geese *Anser brachyrhynchus* (foto: Fridtjof Mehlum).

by
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ENGLISH SUMMARY

SUMMARY AND CONCLUSIONS

Faunal composition, status and conservation interests

The principal conservation interests among birds and mammals at Svalbard concern rare or endangered species (e.g. Pink-footed and Barnacle goose Anser brachyrhynchus and Branta leucopsis), endemic species (Svalbard ptarmigan Lagopus mutus hyperboreus and Svalbard reindeer Rangifer tarandus platyrhynchus), some high-arctic species (King eider Somateria spectabilis, Sanderling Calidris alba and Ivory gull Pagophila eburnea, among others), and those internationally important populations of seabirds (in particular Fulmar Fulmarus glacialis and alcids) and marine mammals.

We recorded a total of 22 bird species in the study area (see the species account pp. 70-73). All except four were found breeding: Barnacle goose, Long-tailed duck Clangula hyemalis, Ivory gull and Black guillemot Cepphus grylle. At least Black guillemot probably breeds in the area as well, while Ivory gull is unlikely to do so. Barnacle goose breeds at Gåsøyane, and could possibly breed at Bünnow Land proper.

No population or occurrence of particular interest were found for any bird species in Gipsdalen. Sanderling and Turnstone Arenaria interpres are scarce and locally distributed at Svalbard. Both species breed in Gipsdalen, but a population was found for Turnstone only. However, uncertainty exists regarding this species’ vulnerability, and its status at the archipelago is probably underrated. Gipsvika and Gipsdalen are also utilized by moulting Pink-footed and Barnacle goose, but the numbers recorded in 1989 constitute only 1-2 % of the Svalbard populations. Most other species occurred in insignificant numbers.

The total seabird population at Temple was censused to be in excess of 10,000, pairs, the dominant species being Fulmar, Kittiwake Rissa tridactyla and Brünnich’s guillemot Uria lomvia. The populations of Little auk Alle alle and Puffin Fratercula arctica remain unknown. This puts Temple in the lower range of a previous rough estimate (10,000 - 100,000 pairs), but nonetheless makes it one of the seabird colonies in the Isfjorden area with the highest number of species and individuals.

The only marine mammals we recorded in the area were Bearded seal Erignathus barbatus and White whale Delphinapterus leucas, but both Ringed seal Phoca hispida and Polar bear Ursus maritimus were encountered in neighbouring areas during the fieldwork period. Bünnow Land may well come to serve a vital role in the continued spontaneous expansion of Svalbard reindeer in the Isfjorden area, but apart from this no significant aspect of mammal distribution was found.

All species legally hunted at Spitsbergen were recorded in the study area in 1989.

Preliminary environmental impact assessment

The most vulnerable species in the Gipsdalen area are Red-throated diver Gavia stellata, Pink-footed and Barnacle, Eider Somateria mollissima, Turnstone, Kittiwake and Brünnich’s guillemot. The two goose species in particular are very sensitive to human disturbances, and it must be feared they will abound Gipsdalen, at least as moulting and rearing areas, if current mining plans are realised. Red-throated diver and Turnstone will respond negatively to disturbance caused by traffic (particularly hiking) on the breeding grounds, while Eider, Kittiwake and Brünnich’s guillemot may be affected by increased disturbance from aerial traffic.

Areas most sensitive are the northern part of Gipsvika (moulting geese, breeding waders), Gipsdalselva and the whole valley bottom up to and inclusive of the clay deposits at Leirflata (moulting geese, breeding Red-throated diver), the lower parts of the side valleys on the eastern side of Gipsdalen (breeding Pink-footed goose), Temple (breeding seabirds), and Gåsøyane Bird Sanctuary (breeding geese, Eider and Arctic tern Sterna paradisaea).

No zoological qualities of particular interest were found in the planned mining area, and the upper reaches of Gipsdalen are in general very poor in animal life. Though Pink-footed goose occur here as well, the importance of these areas is small compared to Gipsdalen downstream from Leirflata.

The valley bottom between Gipsvika and Leirflata is important as moulting and rearing grounds for geese, particularly Pink-footed, and are also important to Svalbard reindeer during summer. Leirflata is utilized by Pink-footed goose. Other breeding species of significance are Red-throated diver, King eider and Arctic skua Stercorarius parasiticus. It is conceivable that mining in the area will not be totally detrimental to other species than the geese, given that all transport is done along the western side of Gipsdalen. The distances between most breeding areas in Gipsdalen and planned installations are sufficient for the geese to continue breeding, according to studies from Greenland, but they will probably not accept this level of disturbance after hatching. It is not known whether or not suitable moulting and rearing grounds are available in nearby areas.

The beach ridges in the northern part of Gipsvika, where a harbour with associated cargo
facilities are planned, is the single most important wader locality within the study area, and is also of importance to Barnacle geese. There is little doubt that installations here would have serious consequences for the tiny goose population at Gåsøyane, unless other foraging areas are available (e.g. along Billefjorden). The consequences for the local Turnstone population are uncertain. Ringed plover Charadrius hiaticula, Purple sandpiper Calidris maritima and Arctic tern will probably be able to cope with the new situation.

The proximity to Gåsøyane Bird Sanctuary and the seabird colonies in Templet give arguments in favour of establishing an aerial corridor for all such traffic to and from the installations.

Local spills or leakages of oil and fuel from boats or permanent installations may have consequences for all or most species. The risk is particularly high for seabirds, ducks and geese. The short distance from Gipsvika to one of the major seabird colonies in Isfjorden and a bird sanctuary makes this even more alarming.

The most vulnerable time of the year, as far as birds are concerned, is the summer months June to August. However, oil spills are a real threat throughout the icefree months of the year, and in some years several species can be established at the breeding grounds already in May. The Svalbard reindeer is most vulnerable to disturbances in late winter and in June.

INTRODUCTION

The valley Gipsdalen and surrounding areas at Bünsow Land, Spitsbergen were faunistically mapped during summer 198, by Halvar Ludvigsen and Per Ole Syvertsen. The primary aim was to document the occurrence of birds and terrestrial mammals (species, numbers and local distribution) in the area as part of an environmental impact assessment brought about by plans of coal mining in Gipsdalen. The report presents a preliminary analysis based on the fieldwork and a literature survey.

Under each species entry, sections on distribution and status put the data from Gipsdalen in perspective. Some previously published records from the study area are briefly presented. Studies on the various species' vulnerability to human activities are summarised. However, for many species no such studies have been undertaken, and generalisations sometimes have to be made.

MATERIAL AND METHODS

Comprehensivness of the fieldwork

The fieldwork was done in the period 7 July - 14 August 1989. Emphasis was placed on recording geese and the two indigenous species of terrestrial mammals (Arctic fox and Svalbard reindeer), and on censusing seabirds in the bird-cliffs at Templet. Limitation of the study area is shown in Fig. 1. Gåsøyane Bird Sanctuary was not visited due to the landing ban 15 May - 15 August.

We were stationed in Gipsvika almost throughout the study period. Gipsdalen above Leirflata was largely surveyed 26 - 30 July, but the innermost parts of Gipsdalen were also visited on 11 July and 13 August. The work in Templet was carried out 15 - 18 July and 23 - 25 July, while populations in Bjonadal were not done until 6 August. The break in the survey work in Templet was due to a spell of misty days.

Weather description

The weather was often clouded and chilly the first two weeks, sometimes also with rain or fog. Day temperatures during this period varied in the range of +2-8°C. The mountain tops were covered by a thin layer of snow in the evening of 25 July, but the snow melted the next day when bright sunshine appeared. This new weather situation remained the dominant one for the period up to 2 August, during which the day temperature often reached +20°C. The last two weeks of the fieldwork had a somewhat unstable weather situation, and frequent mist. Wind would periodically hamper fieldwork, particularly when censusing in Templet, but the weather rarely prevented data collecting.

Methods

The fieldwork was primarily a faunistic mapping. All parts of the study area was visited on foot. In Gipsdalen care was taken to cover as complete as possible all areas up to approximately the 150 m a.s.l. contour. Both observers were usually working together. Special emphasis was put on censusing geese in Gipsdalen, by systematically searching for nests in suitable habitats and counting foraging groups. During this work, an eye was kept sharp for reindeer and foxes as well. Binoculars or telescopes with up to 10x or 45x magnification, respectively, were applied.

The breeding seabirds in Templet were censused from the shoreline or from plateaus in the slopes beneath the cliffs. The steep cliffs are stratified and frequently show deep crevices, making it easy to define smaller areas to count. Telescopes were always applied. The fieldworkers worked simultaneously but independently. Upon completion of each predefined area, the two results were compared. New counts were made if deviations were judged significant (except for Little auk and Puffin). However, the results were usually fairly identical, and repetitions rarely necessary.
SPECIES ACCOUNTS

Red-throated diver *Gavia stellata*

Wide holarctic distribution; breeding summer visitor to Svalbard, but numbers unknown. One pair bred in Gipsdalen in 1989 and produced one chick; possibly a second pair in the area (Fig. 2).

Leaves its nest temporarily when approached by humans, hence susceptible to nest predation by Arctic fox or Glaucous gull. Vulnerable to oil pollution during moulting.

**Fulmar** *Fulmarus glacialis*

Breeds along northern shores of the Atlantic and Pacific Oceans; very numerous at Svalbard. The 1989 census in Templet concluded with a population in excess of 6,000 pairs; insufficient methodology makes this a low estimate. Also recorded breeding (low numbers) in Dalkallen, Storholen, Usherfjellet, Grahamkammen, Pyefjellet and Finlayfjellet in 1989 (Fig. 3).

Feeding habits makes it vulnerable to pollution and littering at sea, e.g. through consumption of plastic items. Oil spills may conceivably have serious effects on Fulmar populations, directly or indirectly (e.g. through reduced food availability).

**Pink-footed goose** *Anser brachyrhynchus*

Picture on front page of this report. Breeds in Iceland, eastern Greenland and Svalbard only. Svalbard population numbers approximately 25,000 birds (mid 1980's), with wintering areas along North Sea coasts from Denmark to northern France.

Six separate nesting areas found in Gipsdalen in 1989, comprising 19 recorded nests (Fig. 4). The most important area was the mouth of the side valley near Dalkallen, were ten nest were located along a 200-250 m long stretch of the river. Obviously, all nests were not found. The species is also known to breed at Gåsøyane, where 10 pairs were reported in 1982 and 30-50 pairs in 1983.

The most important area for moulting and grazing was Gipsdalen between Dalkallen and the northern part of Leirflata (Fig. 4). River beds and associated land downstream along Gipsdalselva were also regularly utilized, as well as wetlands and beaches in the inner part of Gipsvika, particularly in August. Gipsdalen between Leirflata and Margaretbreen/Methuennbreen was less used.

Attempts to conduct total counts of geese revealed a population of at least 400 birds in mid August 1989, compared to a minimum of 180 birds four or five weeks before. Approximately two thirds of individuals in studied groups in August were young birds, giving an estimated production of 270 young. Based on July and August counts, the breeding population was estimated to be in the range 34 - 65 pairs. However, some birds could be non-breeding or post-breeding dispersing individuals.

Although capable of defending themselves against predators, pairs leave their nests when approached by humans, hence rendering them susceptible to predation by Arctic fox or Glaucous gull. Not very affected by helicopter traffic and other distant noise at nesting grounds, but reacts strongly to helicopters passing kilometers away when moulting and rearing young. Studies at Greenland conclude that no helicopter activities should be allowed less than 10 km away from important moulting areas. Geese are also particularly vulnerable to oil spills during moulting, when they congregate near water. Population increase of Arctic fox and Glaucous gull due to improved food availability from human waste may cause local goose populations to come under increased predatory stress.

**Barnacle goose** *Branta leucopsis*

Three populations, which are isolated from each other throughout the year: Eastern Greenland, Svalbard and western Siberia. The Svalbard population (approximately 10,000 birds in mid 1980's) winters in Solway Firth (SW Scotland), and is dependent on staging areas in northern Norway (Helgelandskysten) during spring migration and (to a lesser degree) at Bear Island during autumn.

No nesting areas found during 1989 fieldwork, but Gipsvika and Gipsdalen as far up as Aitkenfjellet is used for moulting, with up to 100 adult birds recorded regularly (Fig. 4). Also a few families rear their young here, probably coming from Gåsøyane where the species is known to breed (3 pairs in 1982, 6-8 pairs in 1983).

What was said about Pink-footed goose and vulnerability is in general true for Barnacle goose as well, but this species is somewhat less affected by helicopter noise. Observance of reserve regulations is vital to the species' breeding success.

**Eider** *Somateria mollissima*

Wide holarctic distribution, and the most numerous duck species at Svalbard with 20,000 - 25,000 pairs. Regular in small numbers on Isfjorden and in lower parts of Gipsdalen in 1989 (Fig. 5). Only eight broods were seen, and two deserted nests found, but the species also breeds at Gåsøyane.

Vulnerable to disturbance when breeding. Only females incubate and they rarely leave the nests
for feeding. Stress and repeated heating of eggs when returning to the nests may reduce their physical capability to successfully complete breeding, or render them vulnerable to nest predation. Eiders breeding in colonies seems to be more anxious than single-nesting females. The effect of helicopter traffic on the former (huge numbers of Eiders at Svalbard breed in colonies) has not been studied. Also vulnerable to oil pollution at all times, but particularly during moult. Sinking oil may kill bottom-living invertebrates, its main food.

**King eider Somateria spectabilis**

A high-arctic, circumpolar species. Less numerous than Eider at Svalbard; numbers unknown, but mostly found in western and southern parts of Spitsbergen.

Observations of single females in Gipsdalen in 1989 as far up as Leirflata indicate a small breeding population in the area, and one female with a brood of three was seen in a pond near Gipsvika (Fig. 5). A few more records were made of groups of females and single males.

Probable vulnerable to oil pollution and disturbance during breeding season similar to what has been said about Eider.

**Long-tailed duck Clangula hyemalis**

Circumpolar distribution in arctic and northern alpine areas. Fairly widespread at Svalbard, but population size unknown. Seen occasionally in small numbers (up to approximately 50 birds) in Gipsvika in 1989. No sign of breeding in the area, but breeding is known from Gåsøyane. Vulnerable to oil pollution, as most other ducks.

**Svalbard ptarmigan Lagopus mutus hyperboreus**

The Svalbard ptarmigan is confined to the archipelagoes of Svalbard and Franz Josef Land. It is common at Svalbard, where it is the only non-migratory plant-eating bird.

Recorded very scarcely but widely distributed in Gipsdalen in 1989 (Fig. 6). Hens with chicks were encountered only twice, but the species is probably more numerous than the scanty records indicate, particularly on the mountain plateaus. They are very confident in people, and hens leave their nests only after very strong provocations.

**Ringed plover Charadrius hiaticula**

Widely distributed in the northern Palearctic. Several hundred pairs breed scattered around Svalbard.

Main breeding area found in 1989 was the beach ridges in the inner part of Gipsvika, where 5-8 pairs were recorded (Fig. 7). One pair was probably breeding below Norstrømfjellet, and it could possibly be the odd pair other places in Gipsdalen as well.

Many wader species are not particularly vulnerable to human disturbance, but breeding failure may result from cooling of unattended eggs or young, or from predation.

**Sanderling Calidris alba**

A high-arctic species breeding in Canada, Greenland, Siberia and on some Arctic Ocean islands. Scarce at Svalbard; the population is not well known here. Breeding was recorded in Gipsdalen in 1989 through behavior of single adult bird at the beach ridges immediately west of Gipsdalselva river outlet (Fig. 7), but nest or young were not found. Juveniles and one adult seen in August may have been birds on passage.

**Purple sandpiper Calidris maritima**

Holarctic distribution, in Europe south to Scandinavia. The most common wader species at Svalbard, numbering several thousand pairs. Common and widespread in Gipsdalen in 1989, recorded virtually throughout the study area (Fig. 2). A rather rough estimate of the breeding population concludes with at least 30 - 40 pairs.

**Turnstone Arenaria interpres**

Circumpolar distribution in arctic and northern temperate areas. Rather scarce and local at Svalbard, but occurrence here not well known. A small breeding population (3-5 pairs) was found at the beach ridges in the inner part of Gipsvika in 1989; probably one pair also in the eastern part of Gipsvika (Fig. 7). More sensitive to disturbance when breeding than most waders.

**Arctic skua Stercorarius parasiticus**

Circumpolar distribution, and common and widespread at Svalbard. Five territories defended in Gipsdalen and west to Gipshukoden in 1989 (Fig. 8). Three nests were located, but one clutch did not hatch. At least three young were produced.

Skuas in general are vulnerable to oil pollution at sea. Aggressive against intruders at breeding grounds, but leaves nest at longer distance than most species on the Svalbard tundra.
Glaucous gull *Larus hyperboreus*

An arctic, circumpolar species. Common along the coasts of Svalbard, sometimes breeding in colonies of several hundred pairs, it is a very important predator on wildfowl and other seabirds.

Bred scattered among other seabirds at Templet in 1989, where at least nine pairs were found along 5 km shoreline (Fig. 8). Small groups (up to approximately 30 individuals) were often recorded.

Gulls are in general vulnerable to oil spills near breeding areas, due to inshore feeding habits that expose them to sullying. Disturbance on breeding grounds may also be a negative factor of importance, however, the Glaucous gull has not been specifically studied. Furthermore, it is an opportunistic species that benefits from many human activities at Svalbard.

Kittiwake *Rissa tridactyla*

Breeds along northern coasts of the Atlantic and Pacific Oceans. The most numerous gull species at Svalbard, breeding in small to huge colonies, but total population not known.

Two colonies in Templet in 1989 (Fig. 9), both closely associated with colonies of Brünnich's guillemots. Direct counts of occupied nests gave populations of 339 pairs and 917 pairs, respectively, hence a total of 1,256 pairs. However, this figure is known to be too low due to incomplete survey of the larger colony. An estimated minimum of 1,500 pairs is considered conservative.

When a colony is suddenly approached by a passing helicopter, eggs or young may get lost when adults hurriedly leave the nests. Presence of people on foot near the colony has no apparent effect. The Kittiwake is not particularly vulnerable to littering at sea (see Fulmar p. 70).

Ivory gull *Pagophila eburnea*

A high-arctic species only known to breed in Canada, Greenland and on some Arctic Ocean islands. Several small colonies are known at Svalbard, and the species occurs throughout the archipelago. Three observations in Gipsvika in 1989, comprising four adult birds. Unlikely to breed within the study area, but a small colony is known near Ebbabreen at the bottom of Billefjorden.

No data on vulnerability. Possibly competing with Kittiwakes about nesting cliffs, and likely to be susceptible to local oil spills etc around human settlements, where it often forage.

Arctic tern *Sternula paradisae*

Wide holarctic distribution. Common throughout Svalbard, sometimes in colonies of several hundred pairs. Recorded regularly in very small numbers along the shores of Isjorden in 1989, and scattered pairs breed in Gipsvika and (probably) at Gipsukletta (Fig. 8). Arctic terns also breed at Gåsøyane, but no population estimate is available.

Though terns usually do not come in direct contact with oil on the sea, spills will have serious indirectly effects on feeding, due to their specialised steep-diving fishing technique. They are vulnerable to disturbance when breeding, but can also breed very close to human activities. Defence is offered through colonial breeding and aggressive behaviour (see Arctic skua p. 71).

Brünnich's guillemot *Uria lomvia*

Breeds along arctic and sub-arctic coasts. Very numerous at Svalbard, where colonies may consist of several hundred thousand pairs. Seven colonies in Templet in 1989 (Fig. 9), the larger two also holding Kittiwakes. The population was clearly in excess of 3,000 adult birds as even our higher figures gave underestimates, see colony-wise breakdown in Table 1.

Breeding birds studied at Svalbard responded to helicopter traffic, sometimes at distances up to 6 km. Helicopters approaching or overpassing the birdcliffs caused more reactions than those passing parallel to the cliffs. Noise level (desibel) and bird response was correlated, while low-frequency infra-sound clearly also is of importance. It was concluded that aerial traffic should not be allowed closer than 2 km to breeding colonies, and 6 km in areas with many and/or large colonies.

All auks are vulnerable to oil pollution, and moulting populations and young of species that perform swim migrations (e.g. Brünnich's guillemot) particularly so. Oil is a hazard to survival in terms of direct as well as indirect (e.g. reduced food availability) effects.

### Table 1  Breeding colonies of Brünnich's guillemot *Uria lomvia* in Templet, July 1989 (number of adult birds present).

<table>
<thead>
<tr>
<th>Colony no.</th>
<th>Lower count</th>
<th>Higher count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>322</td>
<td>358</td>
</tr>
<tr>
<td>2</td>
<td>164</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>5</td>
<td>198</td>
<td>199</td>
</tr>
<tr>
<td>6</td>
<td>366</td>
<td>379</td>
</tr>
<tr>
<td>7</td>
<td>1,506</td>
<td>1,657</td>
</tr>
<tr>
<td>SUM</td>
<td>2,685</td>
<td>2,952</td>
</tr>
</tbody>
</table>
Black guillemot *Cepphus grylle*

Holarctic distribution, mostly in the north Atlantic Ocean. Widespread at Svalbard, but numbers unknown. Not recorded breeding in the study area in 1989, although likely to do so (e.g. at Templet or Gipshukodden); small numbers always present.

The effect of disturbance to breeding success is not well known for cave-nesting species like Black guillemot, Little auk and Puffin. They may, however, be less vulnerable to oil pollution than other auk species, because their young fledge fully capable of flight.

Little auk *Alle alle*

An arctic species, confined to the Atlantic Ocean and some islands in the Arctic Ocean. Apparently the most numerous breeding bird at Svalbard, but their number is unknown.

Common in Templet in 1989, where they were fairly evenly distributed (fig. 10); also found in Sindballefjellet. Our count of 427 adults in Templet is beyond any doubt an underestimate of this hard-censused species. Vulnerability, see Black guillemot.

Puffin *Fratercula arctica*

Breeds along north Atlantic Ocean coasts. Less numerous than other breeding auk species at Spitsbergen, and similarly difficult to census as the Little auk.

The result obtained in Templet in 1989 (893 adults counted) is an underestimate. Almost half the birds were found at Templet’s SE corner, near Bjonapynten (fig. 10). A few Puffins might breed between boulders at Gipshukodden; the species was also present in Sindballefjellet, and it was seen in Dalkallen in September 1989 (R. Hansson pers. comm.). Vulnerability, see Black guillemot p. 73.

Snow bunting *Plectrophenax nivalis*

A holarctic species with wide breeding distribution in arctic and high-alpine temperate regions. The only widely occurring passerine at Svalbard. Recorded virtually throughout the study area in 1989 (Fig. 6). Breeding population estimated to be at least 15-20 pairs (8-10 fledged clutches encountered, and adults seen on at least 8-10 more localities). Not particularly vulnerable to human activities.

Arctic fox *Alopex lagopus*

Holarctic distribution in arctic and high-alpine areas. Common at Svalbard, where it is found throughout the archipelago as well as in the pack-ice.

Two dens were located in the study area in 1989, both underneath Templet and approximately 5 km apart (Fig. 11). Recurring observations of one adult fox in summer plumage in Gipsdalen between Dalkallen/Usherfjell and Leirflata may possibly indicate a den in that area as well. Adult foxes or signs of foxes were occasionally seen almost throughout the study area, but mostly downstream of Leirflata. A total of 3-6 animals are believed to have been involved (excluding observations from the dens), judged by individual fur characters.

Hunted and trapped at Svalbard throughout the period 1 November - 15 March, evidently without affecting the population significantly. It is, however, likely that oil pollution in Svalbard waters may affect local fox survival, since seabirds constitute a major prey.
Limitation of the study area.

Bird-cliff census area.

Figure 1 Limitation of the study area in Gipsdalen, Svalbard 1989.
Figure 2 Observations of Red-throated diver *Gavia Stellata* and confirmed breeding of Purpel Sandpiper *Calidris maritima* in Gipsdalen 1989.
Figure 3  Approximate, observed breeding areas of Fulmar Fulmarus Glacialis in the Gipsdalen area 1989.
Pink-footed goose, breeding record.

Pink-footed goose, breeding area.

Barnacle goose, observation of adult/juvenile (no breeding indication).

Pink-footed goose, important grazing and chick-rearing area.

Barnacle goose, grazing, chick-rearing and moulting area.

Pink-footed goose, uncertain status (tracks seen, but no birds).

Figure 4 Breeding and moulting areas of Pink-footed goose *Anser brachyrhynchus* and Barnacle goose *Branta leucopsis* in Gipsdalen 1989.
Figure 5  Observations of breeding and breeding indications of Eider *Somateria mollissima* and King eider *Somateria spectabilis* in Gipsdalen/Gipsvika 1989.
Svalbard ptarmigan observation (no breeding indication).

Svalbard ptarmigan brood.

Svalbard ptarmigan breeding record.

Snow bunting, pairs and fledglings.

Figure 6 Observations of Svalbard ptarmigan *Lagopus mutus hyperboreus* and breeding records of Snow bunting *Plectrophenax nivalis* in Gipsdalen 1989.
Observations and breeding areas of Ringed plover *Charadrius hiaticula*, Sanderling *Calidris alba*, and Turnstone *Arenaria interpres* in Gipsdalen 1989.
Figure 8 Breeding of Arctic skua *Stercorarius parasiticus*, Glaucous gull *Larus hyperboreus*, and Arctic tern *Sterna paradisaea* in Gipsdalen and Templet 1989.
Figure 9  Observed breeding areas of Kittiwake *Rissa tridactyla* and Brünnich's Guillemot *Uria lomvia* in the Gipsdalen area 1989.
Figure 10  Observed breeding areas of Little auk *Alle alle* and Puffin *Fratercula arctica* in the Gipsdalen area 1989.
Figure 11  Dens and possible denning areas of Arctic fox Alopex lagopus in the Gipsdalen area 1989.
OPPSUMMERING OG KONKLUSJONER

Faunistikk, status og verneverdi

De største verneverdiene blant fugl og pattedyr på Svalbard knytter seg til sjeldne eller sårbare arter (bl.a. kortnebbgås *Anser brachyrhynchus* og hvitkinngås *Branta leucopsis*), særpregede lokale former (svalbarddrype *Lagopus mutus hyperboreus* og svalbardrein *Rangifer tarandus platyrhynchus*), enkelte høyartiske arter (praktærfugl *Somateria spectabilis*, sandløper *Calidris alba* og ismåke *Pagophila eburnea* m.fl.), og de internasjonalt viktige forekomstene av sjøfugl (særlig havhest *Fulmarus glacialis* og alkefugl) og sjøpattedyr.

Vi observerte i alt 22 fuglearter i undersøkelsesområdet (se artsgjennomgangen). Bare fire av disse ble ikke påvist hekkende: hvitkinngås, havhelle *Clangula hyemalis*, ismåke og teist *Cepphus grylle*. Det er sannsynlig at i det minste teist også hekker i området, mens ismåke neppe gjør det. Hvitkinngåsa hekker på Gåsøyane, og kan muligens hekke på Bünsow Land.


Den totale sjøfuglbestanden i Templet ble taksert til i overkant av 10.000 par, og var dominert av havhest, krykkje *Rissa tridactyla* og polarlomvi *Uria lomvia*. Bestandene av alkefugl *Aukia parallela* og andre *Charadrius hiatula* er ukjente. Dette plasserer Templet i nedre del av den størrelsesorden (10.000 - 100.000 par) som ble antatt av Norderhaug et al. (1977), men gjør det like fullt til et av de fuglefjell i Isfjorden som har høyest arts- og individantall.

Foruten de to landpattedyra (fjellrev *Alopex lagopus* og svalbardrein) observerte vi bare storkobbe *Erignathus barbatus* og hvitfjærev *Delphinapterus leucas* i området, men både ringels *Phoca hispida* og isbjørn *Ursus maritimus* ble påtatt i tilgrensende områder under feltoppholdet. Bünsow Land kan komme til å spille en avgjørende rolle for videre spontan spredning av svalbardrein i Isfjordområdet, men det ble ellers ikke funnet spesielt viktige forekomster av pattedyr.

Alle viltarter som er jaktbare på Spitsbergen ble påtatt i undersøkelsesområdet.

Foreløpig miljøkonsekvensvurdering

Mest sårbare for forstyrrelser i Gipsdalsområdet er smålom *Gavia stellata*, kortnebbgås, hvitkinngås, ærfugl *Somateria mollissima*, steinvender, krykkje og polarlomvi. De to gåseartene er så følsomme overfor forstyrrelser at det er grunn til å frykte nærmest total oversvingelse av Gipsdalen, i det minste som myte- og oppvekstområde, dersom gruveplanene settes ut live i området. Problemene for smålom og steinvender er knyttet til ferdsel og trafikk i selve hekkområdene, mens ærfugl, krykkje og polarlomvi kan bli berørt av eventuell økt lufttrafikk i området.

De mest sensitive områdene er Gipsvika nord (mytende gjevs, hekkende vadere), Gipsalselva og dalbunnen opp til og med Leirflata (mytende gjess, hekkende smålom), munningene av side­dalene på østsida av Gipsdalen (hekkende kort­nebbgås), fuglefjellene i Templet (hekkende sjøfugl), og Gåsøyane fuglereservat (hekkende gjev, ærfugl og rødnebbberne *Sterna paradisaea*). I selve det planlagte gruveområdet ble det ikke funnet spesielle zoologiske kvaliteter, og området er generelt svært fattig på dyreliv. Selv om kortnebbgjess var å finne også i de øvre deler av Gipsdalen, er betydeningen av området liten sammenlignet med arealene lengre nede i dalen.

Dalbunnen mellom Gipsvika og Leirflata er sær­lykt av interesse for smålom og polarlomvi. Bestandene av polarlomvi er så følsomme overfor forstyrrelser at det er grunn til å frykte nærmest total oversvingelse av Gipsdalen, i det minste som myte- og oppvekstområde, dersom gruveplanene settes ut live i området.

Strandvollene i Gipsvika nord, hvor lasteanlegg og utskippingshavn er tenkt plassert, er den viktigste vaderlokaliteten i undersøkelsesområdet, og området er også viktig for hvitkinngass. Med mindre andre beitearealer kan også det viktigste for steinvenderen fortsette at kunne hekke her, men det er uvisst om bestanden vil kunne finne nye myte­ og oppvekstområde i nærheten.

The Fauna of Gipsdalen, Svalbard
Nærheten til Gåsøyane og sjøfuglkolonierne i Tempel kan gjøre det aktuelt å opprette særskilt korridorer for eventuell lufttrafikk til og fra de planlagte anleggene.


For fuguilevitet i området vil den mest sårbare tida på året være perioden juni - august. Øljeforeuren-inger er imidlertid en trussel hele den isfrie del av året, og i år med tidlige vårer kan flere arter etablere seg på hekkeplassene allerede i mai.

Svalbardreinen er mest sårbar for forstyrrelser på ettervinteren og i juni.

**INNLEDNING**

Gipsdalen og deler av omliggende områder på Bünsow Land, Spitsbergen ble sommeren 1989 faunistisk undersøkt på oppdrag fra Norsk Polarinstitutt. Feltarbeidet ble utført av Halvar Ludvigsen og Per Ole Syvertsen. Den primære målsettingen var å dokumentere forekomsten av fugl og landpattedyr (arter, bestandstall og -taksering av sjøfuglene i Templet. MATERIALE OG METODER

Materialet om utbredelse og status på og utenom Svalbard setter informasjonen fra Gipsdalen i perspektiv. Det later til å foreligge svært lite faunistisk informasjon om undersøkselsesområdet fra før. Viktige biologiske egenskaper av de enkelte arterne og en del studier over deres sårbarhet er kortfattet presentert. For mange arter er slike studier såvidt vites aldri foretatt, og det har i en del tilfeller vært nødvendig å omtale slike forhold i nokså generelle vendinger.

**MATERIALE OG METODER**

**Undersøkselsens omfang**


Været var ofte skyet og kjølig de første to ukene av oppholdet, iblant også med regn eller tåke. Dagtemperaturen lå i denne perioden for det meste på +2-8°C. Et tynt snedekke lå seg i fjellene på kvelden 25.7, men allerede et døgn et tid seinere satte det inn med strålende solskinn. Dette kom til å dominere værsituasjonen fram til 2.8, og dagtemperaturen lå ofte på rundt +20°C i denne perioden. De siste to ukene av feltoppholdet var været noe veleskende, iblant med en del tåke. Vinden kunne fra tid til annen hemme felterbeidet, særlig under tellingene i Tempet, men det var svært få dager været satte en stopper for datainnsamlingen.

**Metoder**

Undersøkslene dreide seg primært om faunistisk kartlegging. Alle deler av studieområdet ble oppsøkt ved fots til fots i terrenget. I Gipsdalen ble det lagt vekt på å gi store stivalplasser slik at både dalbunn og fjellsider (opp til ca. 150 m koten) ble dekket. Som regel arbeidet to man sammen. Spesiell vekt ble lagt på å tallfeste gjennem gipset i Gipsdalen, gjennom systematisk søk etter reir i egnede habitat og etappings av betydelige flokker. Under dette arbeidet ble det også holdt spesiell utkikk etter reir og fjellrev. Kikkerter med inntil 10x forstørrelse ble benyttet, ofte også teleskoper med inntil 45x forstørrelse.

Sjøfuglene i Tempet ble taksjø fra standplasser i fjøra eller på platåer i rasliene nedenfor fjellet. Fjellet var lagedelt og ofte kraftig oppsprukket, så det falt seg naturlig å avgrense områder for oppetting. Teleskop ble alltid benyttet. To man arbeidet parallelt og uavhengig. Etter oppetting av hvert delareal ble de to resultatene sammenlagt, og ved store avvik ble de nye opptellingene foretatt (bortsett fra for alkekonge og lunde). Overensstemmelsen var som regel god, og det var sjelden det var nødvendig å gjenta tellingene.

**ARTSGJENNOMGANG**

**SMÅLØM Gavia stellata**

**Utbredelse og vandring**

Holarktisk utbredelse i arktiske og nordlige tempererte strøk. I Europa hekker arter fra Svalbard, Frans Josefs land og Novaja Semlja sør til Island, Skottland, det nordlige Irland (Eire) og Sør-Sverige, og om vinteren er den å finne i kystnære farvann fra norskekysten til Middelhavet.
Forekomst og status på Svalbard

Hekker spredt ved ferskvann og på tundraen langs kysten av øygruppa, inkludert Bjørnøya. Ankommer i løpet av mai, og kan observeres til slutten av september eller begynnelsen av oktober. Svalbardbestandens størrelse og vandringsveier er ikke kjent.

Biologi og levevis

En dyktig svømmer og dykker, som for det meste lever av fisk hentet opp fra 2-9 m dyp, men tar også endel leddormer, muslinger, krepsdyr og vanninsekter. Henter næring både i saltvann og ferskvann; på Svalbard hovedsakelig knyttet til marine næringskjeder.


Status i Gipsdalen / Temple

Smålam er tidligere funnet hekkende i Gipsdalen og på Gåsøyane (Lovenskiold 1964). Ett par påvist hekkende i 1989 (Fig. 2): Foreldre fugler med to dununger på dalbunnen nedenfor Aitkenfjellet 22.7; bare en unge lot til å vokse opp (observert 8.8 og 13.8). Artens hovedsakelige utbredelse ligger langs kysten av Verdensende ved tempelet, nord for Gipsdalen. Smålammer er tidligere funnet i Gipsdalen, på vei til og fra samlet bestandsstørrelse i Nord-Europa, bl.a. på norskekysten.

Sårbarhet


Diverse

Det er sannsynlig at tapet av en unge i Gipsdalen skyldes predasjon fra fjerrellere eller polarmåke. En rev gjorde 22.7 et utfall mot kullet, men en straks opp forsøket da fuglene la seg midt ute på dammen. Ifølge skotske undersøkelser vil bare ca. 20 % av eggene føre fram til flyvedyktige unger (Cramp & Simmons 1977). De viktigste årsakene til den lave hekkesuksessen er predasjon og forstyrrelser.

HAVHEST Fulmarus glacialis

Utbredelse og vandringer


Forekomst og status på Svalbard

En av de mest tallrike fugleartene på Svalbard. Hekker for det meste på smale berghyller i bratte fjellvegger, både langs kysten og inne i landet, men også på andre steder på bru eller langs kystene etter uver; dens pelagisk utbredelse går i det østlige Atlanterhavet sør til Biskaya. Havhesten har økt i antall og utvidet sitt utbredelsesområde i Nord-Europa, bl.a. på norskekysten, i dette århundre.

Biologi og levevis

Sjøfugler har i sin alminnelighet svært sein kjønnsmodning, men også lav årlig voksendelighet (ca. 5 %) slik at de kan bli meget gamle og reproduisere mange ganger. Havhøsten hekker første gang 6-10 år gammel, men voksne blir i snitt 15-20 år gamle og kan bli atskillig eldre. Paret holder sammen i flere år. Normalt legges bare ett egg, på Svalbard oftest i slutten av mai. Egget ruges av begge foreldrene i ca. 50 døgn. Den gråaktige dunungen blir de første to ukene alltid passet av en av foreldrene. Etter rundt 7 uker i reiret er den flyvedyktig og selvstendig.

**Status i Gipsdalen / Templet**

Løvenskiold (1964) oppgir at det er hekkekolonier i Templet og nær Gipsuhken.

Opptelling i Templet 15.- 25.7.89 (Bjonadalen ikke før 6.8) ga som resultat 4.936 par og 5.886 par for to uavhengige observatører. Templet har derfor sannsynligvis huset godt over 6.000 par i 1989. I Sindballefjellet vis-à-vis Bjonadalen ble det talt opp 221 par 6.8.89. Arten hekker også i mindre antall i de fleste fjell som omgir Gipsdalen, og ble sommeren 1989 påvist i Dalkallen, Storholen, Usherfjellet, Grahamkammen, Pyefjellet og Finlayfjellet (Fig. 3).

**Sårbarhet**


**Diverse**


**KORTNEBBGÅS Anser brachyrhynchus**

**Utbredelse og vandringer**


**Forekomst og status på Svalbard**


**Biologi og levevis**


De voksne gjesene feller (myter) alle svingfjærer samtidig. De mister derfor fullstendig evnen til å fly i ca. 25 døgn i juli - august. Tidsrommet faller sammen med når de har unger, og i denne perioden er de svært vare og følsomme overfor forstyrrelser (se nedenfor). Myteområdene er alltid nær vann hvor fuglene kan søke tilflukt ved behov.
Status i Gipsdalen / Temple

a) Opplysninger fra tidligere år


b) Reirområder og reirplassering i 1989

Hekking påvist i seks separate områder i Gipsdalen/Tempel (Fig. 4).

Område 1: 2 par (en nå rugsender) ved munningen av sidedalen ved Dalkallen 9.- 10.7. Ved ny kontroll av området 19.7 ble det funnet i alt tre årsreir på sørsida og sju årsreir på nordsida av elva, foruten flere reir fra tidligere år. Minst ett reir var plyndret, og rev hadde vært og rovet i flere. Samtlige reir lå i nær tilknytning til elv, begrenset til et område av 200-250 m lengde. Seks av reirene på nordsida av elva lå innenfor en strekning av ca. 60 m.

Område 2: Ett årsreir og to reir fra tidligere år på nordsida av Aitkendalen 28.7; ett årsreir på sørsida av Aitkendalen 10.8. Alle reirene lå i nær tilknytning til elv, ved sidedalsen munning til Gipsdalen.


Område 4: Ett årsreir ved Margaretbreen 29.7 var plassert i dalsida uten nær tilknytning til elv eller annen våtmark. Reir av denne type beliggenhet er klart vanskeligst å registrere, i det minste etter at klekkning har funnet sted.

Område 5: To årsreir ved flerskvannt fra elveterrassene innerst i Gipsvika 20.7 er de eneste reirene funnet på myr.

Område 6: To årsreir ble funnet innunder fuglefjellene i Tempel 16.7. Reirene var plassert tett inntil fjellveggen der denne steilt reiser seg overfor ur og rasmark. Hovedproblemet med å lokalisere reir av denne typen er den vanskelige framkommeligheten i området.

En kortnebbgås varset i dalsida nedenfor Pyefjellet 11.7, men hekking ble ikke påvist i området. Videre ble to reir fra tidligere år funnet i dalsida ved Stenhousebreen; reirplassering som for område 4.

Det ble altså totalt funnet 19 reir av året. Det viktigste registrerte reirområdet var munningen av sidedalen ved Dalkallen, hvor 10 av reirene lå. Dannelse av trangt elvevei med stupbratte sider og hyller eller terrasser nær elvehøyde hvor gjessene kan plassere reirene, er her mer utpreget enn andre steder i Gipsdalen. Også områdene 2 og 3 var av denne karakter. Antall registrerte årsreir med slik beliggenhet utgjør 14 av 19 (74 %).

c) Ungeproduksjon og bruk av beite- og myteområder i 1989

De viktigste beite- og myteområdene var dalbunnen mellom Dalkallen og nordlige deler av Leirflata (Fig. 4). Også områdene langs Gipsdalselva videre ned til Gipsvika, samt våtmarkene og strendene innerst i Gipsvika ble benyttet, spesielt i august. Overfor Leirflata ble arten bare sporadisk observert, men leirepartiene nedenfor Nordstrømfjellet var fulle av sportegn (sporavtrykk, ekskrementer og fjær) som bevitnings bruk av området. Langs Gipsdalselva mellom Leirflata og linja Margaretbreen/Methuenbreen ble gjess bare observert mot slutten av feltoppholdet.

Det er oppløst at ikke samtlige kortnebbgåsreir i området ble funnet. For å kunne si noe om hekkingen var det mulig å få presise tall på, men leirepartiene nedenfor Nordstrømfjellet var fulle av sportegn når fjellhekket påviste. Situasjonen på to valgte tidspunkter, atskilt med en måned, var som følger:


Gipsdalen mytebestand av kortnebbgås rundt midten av august 1989 lå således på minst ca. 400 individer, mot minst ca. 180 individer 4-5 uker tidligere. De 34 familiene 11.7 kan oppfattes som et nedre bestandsområde, mens de 400 gjessene i midten av august gir grunnlag for beregning av et estimattak. Det var ikke alltid
mulig å fastslå andelen unger i flokkene, men for de flokker hvor unge og gamle fugler kunne telles separat (ca. 40 % av kortnebbgjessene 12.-13.8) lå ungfuglandelen på rundt 2/3. Dette gir en ungerproduksjon på rundt 270 dersom totalbestanden settes til 400 individer, og følgelig ca. 130 voksne gjess, eller ca. 65 par. Den lokale hekkebestanden i Gipsdalen/Tempelområdet ansås derfor til 34-65 par i 1989.

Selv om det totale antall observerte kortnebbgjess i Gipsdalen ble mer enn fordoble fra midten av juli til midten av august, økte ikke den registrerte frekvensen i luft (Fjeld et al. 1988).

b) Forstyrrelser i myteområdene

Det er derfor mulig at Gipsdalen fungerer som myteplass for et noe større antall gjess enn den lokale bestanden. Det er også kjent at familier med dununger kan vandre minst 24 km (Cramp & Simmons 1977). En gruppe på ca. 30 kortnebbgjess (årsunger og voksne) ble 12.8 påtruffet i Billefjorden vest av Svalgrunnane.

Sårbarhet

a) Forstyrrelser i hekkeområdene

Det later ikke til å være utført omfattende studier over kortnebbgåsas sårbarhet på reirplas
den. Det er imidlertid kjent at den forlater reiret ved forstyrrelser, og de ubeskyltede eeggene er da ett bytte for fjellrev og polarmåke (Mehlum 1989). Hanne i de to parene som ble funnet på hekkeplass i Gipsdalen 9.7.89 varslet når observereren befant seg ca. 150 m fra reitere, men hunnene avbrøt ikke rugingen og hennene forlot ikke reirområdet.

Mosbech et al. (1989) fant i et studium på Grønland ikke påviselige effekter av helikoptertrafikk og baseaktiviteter på valg av reirplas
ering eller antall hekke bestemte par. Nærmeste gåsekolonialigner i forhold til reiret kan f. eks. skremme gjess bort fra vann eller flyhøyde innenfor intervallet 0-500 m over bakken. På disse avstander vil derfor et lavtflyende helikopter forstyrre mindre enn et høytflyende. Bare på svært korte avstander (ca. 2-3 km for Bell 212 i åpent terrenng) forstyrret høyflytning mindre enn lavtflytning (Spinder 1984, ifølge Mosbech et al. 1989). Kom til samme konklusjon for rastende snøgjess (Anser caerulescens) i Alaska: Det forstyrer gjessene mindre å passere over dem med fly i 30 m høyde enn i større høyder. Likeledes øker helikopterstøyen med hastigheten og med tungeness av helikopteren. Kortnebbgjessenes på Grønland reagerte sterkest på helikoptre som kom rett imot dem. Dette er også i overensstemmelse med observasjoner gjort ved en polarlovmvikoloni på Svalbard (Fjeld et al. 1988).

Som en konsekvens av studiene på Grønland er det etablert en ordring som holder helikoptertrafikk minst 10 km vekk fra de viktigste myteområdene på Jameson Land (Mosbech et al. 1989).

Mytende gjess, spesielt kortnebbgjess, er også svært sårbar for bakkeforstyrrelser. Ferdsel i terrenget kan f.eks. skremme gjess bort fra vann og tvinge dem til å krysse tundraen hvor risikoen for predasjon fra fjellrev øker (Madsen 1984).

Det var vår erfaring i Gipsdalen at fuglene var mer sky etter klekking enn før. Mytende kortnebbgjess med små unger kunne reagere panikkartet på opp til 1-2 km avstand når to personer kom til fots opp dalen. Under slike omstendigheter, når hele flokkene løp avgårde i et vilt tempo, hendte det at enkelte unger ikke klarte å holde følge med foreldre og søsken. Ved to anledninger (10.-11.7.89) fant vi etterlatte dununger i områder hvor vi hadde støkket kortnebbgjess på dette viset tidligere på dagen. Som regel løp flokkene ned til elva og fulgte denne opp eller nedstrøms, avhengig av hvor vi befant oss. De tok seg imidlertid også ofte opp dalsidene, og ved en anledning (10.7) forsvant to familier inn Aitkendalen. Det forekom til og med at fuglene...
ikke bare løp ned til elva, men også krysset den og fortsatte et stykke opp lia på motsatt side. Det er således klart at kortnebbggjessene i Gipsdalen er svært vare for forstyrrelser, spesielt tidlig i mytetida når de har små unger. Den relativt smale dalbunnen og det trange elveløpet tilfredsstiller ikke artens behov for trygghet og fluktavstand overfor mennesker.

c) Forurensning og forøvelse


Industrielle aktiviteter og turisme vil ofte medføre forøvelse og dermed god matdeling for polarmåke og fjellrev. Økt reproduksjon og lavere dødelighet vil igjen føre til større bestander av disse artene. Gjennom predasjon på egg og unger kan de påvirke hekkesuksess og bestandsituasjon for flere andre arter. En økning i bestandene av disse predatorene (bytteeterene) kan derfor komme til å true lokale gåsebestander på Svalbard (Hansson et al. 1989).


d) Jakt


Vi registrerte så seint som 13.8.89 fortsatt mange kortnebbgjess som ikke kunne fly, bare åtte dager før jaktstart. Dette gjaldt både unger og voksne fugler.

Hvitkinnkjess Branta leucopsis

Utbredelse og vandringer

Tre bestander: (1) En bestand hekker på Øst-Grenland, og trekker via Island til overvintrings-områder i Irland og langs Skottlands vestkyst; (2) en Svalbardbestand som overvintrer i Solway Firth, på grensa mellom Skotland og England, og trekker langs norskekysten; og (3) vestlibiske hekkekugler (Novaja Smlja og Vaigach), som følger en sørvestlig trekkrute over Kvitajøen, Gotland og det sørlige Østersjøområdet til vinter- kvarterene, som først og fremst ligger i Nederland. Totalt fantes det rundt 70.000 hvitkinnkjess i begynnelsen av 1970-årene, med Svalbard- bestanden som den minste (Cram & Simmons 1977, Norderhaug 1981).

Forekomst og status på Svalbard

De fleste hvitkinnkjessene på Svalbard hekker på mindre øyer langs vestkysten av Spitsbergen, men arten benytter også utilgjengelige klippeav- satser og lignende, og kan hekke flere kilometer inn i landet. Innlandslocaliteter var viktige ifølge eldre litteratur. Arten brer seg i vår tid til stadig nye hekkeplasser, b.l.a. søropt i øygruppen, og har kolonisert Kongsfjorden i 1980-årene (Mehlum 1989).


Biologii og levevis

Livnærer seg på hekkeplassene av et vidt spekter av planter.


Status i Gipsdalen / Templet


Ingen reirområder ble funnet i 1989, men Gips­vika og Gipsdalselva opp til Atkenfjellet ble benyttet som oppvekst- og myteområde (Fig. 4). Opptil rundt 100 voksne hvitkinngjessene tilstod studie­området som mytepllass, og minst seks familier hadde tilhold her. Det antas at fuglene kom fra hekkepllasser på Gåsøyane 8-12 km unna.


Fra slutten av juli økte antallet hvitkinngjess som benyttet området. Således ble ca. 110 individer (9 dununger) observert 20.7, i det alt vesentlige i Gipsvika; rundt 60 voksne hadde tilhold i ferskvannet vest for elveoset 31.7; tilsammen mer enn 80 individer (vesentlig voksne) 10.8, fordelt hovedsakelig mellom ferskvannet ved elveoset og dammen på elveterrasene nedenfor Dalkallen; endelig talt opp 90-97 voksne og 11 årsunger totalt i området 12-13.8 (men dammen ved Dalkallen eller Gipsvika ble ikke besøkt).

Sårbarhet


Diverse


ÆRFUGL Somateria mollissima

Utbredelse og vandringer


Forekomst og status på Svalbard


Svalbardbestanden utgjør nå 20.000 - 25.000 par (Mehlum 1989), men var i tidligere tider trolig langt høyere. Gjennom utforsiktig egg- og dunsan­king og ukontrollert jakt ble den sterkt redusert.
Artsfredning i 1963 og senere opprettelse av 15 reservater for de viktigste hekkeplassene (i 1973) har ikke vært tilstrekkelig for å bygge bestanden opp til det antatte tidligere nivå på minst 100.000 par (Norderhaug 1982).

**Biologi og levevis**

Ernærer seg på bunndyr i fjæresonen, vesentlig muslinger, men tar også små krepsdyr og pigghuder. Maten hentes opp både ved dykking (vanligvis 2-4 m) og ved at hode og forkropp stikkes under overflaten på svært grunt vann. Hunnene tar nesten ikke til seg næring gjennom hele rugetida, og må tære på opplagrede næringsreserver.


**Status i Gipsdalen / Tempel**


**Sårbarhet**


Gabrielsen (1987) beskriver også to observasjoner av hvordan enslige rugende ærfugler reagerte på overflyende helikoptre. Fuglene forlot ikke reirene når et helikopter passerte over reireområdet i en høyde av 50-100 m. Energiforbruk og eventuelle langtidsvirkninger ved stadige forstyrrelser i ruguperioden, selv om fuglene ikke går av reirene, er likevel ufullstendig kjent. Kolonihekkende ærfuglens reaksjon på helikopterforstyrrelser er heller ikke studert (Gabrielsen 1987).

Ærfuglen er i likhet med andre marine dykkere f.eks. praktaerfugl og havelle) utsatt for oljeforurensninger i sjøen (Anker-Nilssen 1988). Ekstra utsatte er de i mytetida når de ikke kan fly, men de er sårbare til alle tider. Oljeforurensninger kan også ramme ærfuglen gjenom forringelse av næringsgrunnlaget, ved at olje som synker skader bunnsfaunaen (Anker-Nilssen 1988).

De relativt nyetablerte og ekspanderende standene av storjo (Stercorarius skua) og svartbak (Larus marinus) har også blitt framhevet som mulige framtidige påvirkningsfaktorer overfor ærfuglen på Svalbard (Norderhaug 1983).
**PRAKTÆRFUGL Somateria spectabilis**

Utbredelse og vandringer


Forekomst og status på Svalbard


**Biologi og levevis**


**Status i Gipsdalen / Templet**


**Sårbarhet**


**HAVELLE Clangula hyemalis**

Utbredelse og vandringer


Forekomst og status på Svalbard

Utbredt over store deler av syggruppen, men er mest tallrik i de vestlige kyststrøkene og på Bjørnøya, hvor den hekker på holmers langs kysten eller ved ferskvann på tundraen. Noen haveller ses langs iskanten i store antall langs kysten av Nord-Norge.

**Biologi og levevis**

Spiser mest krepsdyr og muslinger, i ferskvann dessuten insekter og insektlarver. Dykker normalt ned til 3-10 m dyp.


**Sårbarhet**


HAVELLE Clangula hyemalis

Utbredelse og vandringer

Cirkumpolar utbredelse i arktiske og nordlige tempererte (alpine) strøk. I Europa hekker havella på Island, Svalbard og Novaja Semlja, og i et belte fra Fennoskandia videre øst gjennom arktisk Sovjet. Overvintrer fåttalig i isfrie farvann sør til Nordsjøen, i vår del av verden i store antall på ferskvann og langs kysten av Nord-Norge.

**Biologi og levevis**

Spiser mest krepsdyr og muslinger, i ferskvann dessuten insekter og insektlarver. Dykker normalt ned til 3-10 m dyp.

Monogam, men sterkt tendens til flokkdannelse utenom hekkesesongen. Nyparet etablerer hver vinter, hekker første gang to år gammel. Hekker parvis eller flere par i nærheten av hverandre (ikke kolonier). Reiret bygges av hunnen, det ligger på takken og er en grunn grop fØret med litt plantemateriale og dun. De 5-9 eggene legges på Svalbard som regel i siste halvdel av juni, og rugses av hunnen i ca. 26 døgn. Hun avbryter rugingen i korte perioder flere ganger om dagen. Hannene forlater hekkeplassen kort tid etter at kullene er fullagte, og samles i myteflokker langs kysten. Ungene følger mora til nærmeste ferskvannsdam, hvor de tilbringer noe tid før de
fortsetter til saltvann. Ungene kan fly etter 5-6 uker, og blir samtidig selvstendige.

**Status i Gipsdalen / Temple**

Havelle er tidligere funnet hekkende på Gåsøyane (Løvenskiold 1964).

Observert sporadisk i lite antall i Gipsvika sommeren 1989, oftest i august. Det ble ikke gjort observasjoner som tydet på at fuglene hekket i området. Største antall var ca. 50 individer 14.8.

**Sårbarhet**

Som andre marine dykkender ekstra utsatt for oljeforurensninger til havs, spesielt i mytetida (Anker-Nilssen 1988, se ærfugl s. 92).

**SVALBARDRYPE Lagopus mutus hyperboreus**

**Utbredelse og vandringer**


Fjellrypa, og dermed svalbardrypa, er hovedsakelig en standfugl. I deler av utbredelsesområdet, som i Island, ser det imidlertid ut til at fjellryper opptrer syklisk med ca. ti års svingninger, og høystarme bestander som de i det nordlige Grønland trekker til områder sør for hekkeplassenene om vinteren. Tilsvarvende forhold er ikke kjent fra Svalbard.

**Forekomst og status på Svalbard**

Tallrik over det meste av øygruppa, men sparsom i nordøst. I hekketida holder den mest til høyt opp i fjellskråninger og på fjellplatåer. En forflytning til lavere deler av terrenget finner sted på ettersommeren. Mange tilbringer vinteren langs vestkysten av Spitsbergen, men vandringsmønsteret er dårlig forstått. Svalbardrypa er den eneste planteetende fugl som ikke forlater øygruppen om vinteren.

**Biologi og levevis**

Lever hele året av plantekost, men kyllingene tar trolig også endel insekter. Harerug *Polygonum viviparum* er en særlig viktig næringsplante på seinsommeren og høsten (Mehlum 1989).


Fjærskiftet er komplisert og varierer mellom kjønn og alderskategorier (Unander 1987). Hønebegynner å myte i april og har full sommerdrakt (hekkedrakt) i slutten av mai. Eldre høner myter ca. 10 dager tidligere enn ettåringer. Steggene har helt hvit drakt til begynnelsen av juli, hvoretter den brune sommerdrakten gradvis utvikles fram til midten av august. Myting til vinterdrakten foregår samtidig hos begge kjønn i løpet av september.

**Status i Gipsdalen / Temple**

Løvenskiold (1964) nevner observasjoner (men ikke hekkefunn) fra Temple og Gåsøyane.

Observert meget spredt og fåtallig over så godt som hele Gipsdalen sommeren 1989 (Fig. 6), som regel i dalsidene, og helst parvis eller enkeltindivider. Arten er sannsynligvis mer tallrik enn de få funnene gir inntrykk av. Trolig befant mange individer seg fremdeles høyre i terrenget. Et klekket reir oppunder Margaretbreen 29.7, og skallrester funnet på dalbunnen innunder Aitkenfjellet 10.7. Høner med kyllinger ble påtruffet ved to anledninger: på dalbunnen nedenfor Rinkbreen 30.7 (3 kyllinger), og i dalsida innunder Aitkenfjellet 10.8 (2 kyllinger). Begge kullene anslått til å være 1-2 uker gamle.

**Sårbarhet**

Diverse

SANDLO Charadrius hiaticula
Utbredelse og vandringer

Forekomst og status på Svalbard

Biologi og levevis

Status i Gipsdalen / Templet

I 1989 ble hekking påvist på strandvollene i Gipsvika fra Gipsdalselva vest til Gipshukodden (Fig. 7), hvor bestanden anslås til 5-8 par. I alt ble fire unger ringmerket, tilhørende 3-4 kull. Det ble dessuten observert flere nylig flydyktige unger i dette området.

Sannsynlig hekking også ved leirflaten innunder Norstrømfjellet, hvor enkeltindivider ble registrert 27.7 (varsleende) og 30.7, og to individer 13.8 (varsleende).

Enkeltindivider ble observert i den østlige delen av Gipsvika ved et par anledninger 8.-16.7, og på elveterrasene nedenfor Dalkallen og ved Leirflata i samme tidsrom. Det kan ikke utelukkes at hekking har funnet sted også i disse områdene.

Sårbarhet
Mange vaderarter er svært lite redde for mennesker. Av de arter som hekker på Svalbard er det særlig fjæreplytten som er kjent for å være tillitsfull. De fleste vaderne her aksepterer forstyrrelser i sine hekkeområder i større eller mindre grad. Dersom mennesker oppholder seg for lenge i områder hvor det hekker vaderfugl kan imidlertid egg eller unger bli kraftig avkjølt, og slike forstyrrelser øker også predasjonsfaren. Dersom dfiglene hekker kolonipreget, slik tilfellet er i Gipsvika, kan følgene for lokale bestander bli store. De viktigste predatorene på Svalbard er fjellrev, polarmåke og tyvjo.


SANDLØPER Calidris alba
Utbredelse og vandringer

Forekomst og status på Svalbard
Sandløperen er påtruffet fåtallig som hekkefugl i vestre og nordvestre deler av Spitsbergen, men utbredelsen på Svalbard er sannsynligvis større enn det som er kjent (Mehlum 1989). Kålås &

**Biologi og levevis**

Ernærer seg hovedsakelig på små virvelløse dyr. I hekketida spiser den først og fremst insekter på tundraen, men den fanger også smådyr i fjæra. Nebbet stikkes ned i sand eller mudder; det relativt kraftige nebbet gjør den i stand til å hente fram byttedyr fra hardere grunn enn andre småvadere med tilsvarende matsøkteknikk.

Hekker første gang trolig som toåring. Til hekkeplass velges steinete, vegetasjon sfattige og helst tørre tundraområder. Reiret er en grunn grop i vegetasjonen eller på bar mark, ofte fØret med småblader. Eggleggingen finner sted fra midten av juni til et stykke ut i juli, avhengig av når tundraen blir snøbar. Kullet består vanligvis av fire egg, og ruges i minst 23 døgn. I Canada er det påvist at sandløperparet kan ha to reir samtidig, slik at hannen og hunnen ruger fram hvert sitt kull, mens arten på Grønland bare har ett kull som råder begge foreldrene. Det er ukjent hvordan forholdene er på Svalbard (Mehlum 1989).

Ungene passes av hannen til de blir flyvedyktige etter ca. 17 døgn.

**Status i Gipsdalen / Templet**

Ingen opplysninger fra litteraturen. Malcolm A. Ogilvie (upubl.) så to individer ved munningen av Gipsdalselva 13.7.83, men fant ingen her under et nytt besøk 26.7.83. Han mener at fuglene ikke hekket på lokaliteten.

Ett par hekket i Gipsvika i 1989: En voksen fugl med typisk hekkeadferd (iheldig varsling, spilte skadd) på elveterrassene rett vest for Gipsdalselvas utløp 20.7 (Fig. 7). Reir eller unger ble imidlertid ikke lokalisert, og ved ny kontroll av området 31.7 ble arten ikke observert.

Noen individer observert i Gipsvikfjæra i august 1989 antas å ha vært fugler på høsttrek: to ungfugler 7-8.8 og ett individ 9.8; dessuten en voksen ved Gipsdalselva noen få hundre meter fra oset 8.8.

**Sårbarhet**

Se sandlo (s. 96) for en generell framstilling om vadefugler. Sandløperen er fåttallig på Svalbard, og kunnskap om hekkeplasene er derfor viktig for den nasjonale forvaltning av arten.

**FJÆREPLYTT Calidris maritima**

**Utbredelse og vandringer**


**Forekomst og status på Svalbard**


Lite er kjent om hvor Svalbards fjæreplytter overvintrer. Nylig er to fugler ringmerket på den svenske vestkysten i april gjenmeldt fra Svalbard (Elin Pearce pers. med., egen obs.).

**Biologi og levevis**

Spiser et allsidig utvalg av små virvelløse dyr som krepsdyr, insekter og edderkopper, og tar i hekketida også noe plantemateriale. Ungene spiser vesentlig insekter og edderkopper på tundraen (Mehlum 1989).
Status i Gipsdalen / Templet

Hekkesøkemotkom i Gipsdalen er oppgitt av Løvenskiold (1964), som også nevner at arten er obser­
vert ved Templet og på Gåsøyane.

Påtruffet og påvist hekkeende over så godt som
hele undersøkelsesområdet i 1989 (Fig. 2).

Sårbarhet

Se sandlo (s. 96) for en generell framstilling om
vadefugler.

STEINVENDER Arenaria interpres

Utbredelse og vandringer

Cirkumpolar utbredelse i arktiske og nordlige
tempererte strøk. Hekker i Østersjøen og fra
Sør-Skandinavia nord til Svalbard, rundt Nord­is havets kyster, i store deler av arktisk Canada og på Grønland. Sterkt kysttilknyttet i den
sørlige delen av utbredelsesområdet, mens den i
Arktis også fins på tundraen. Trekkfugl, som
utehvor hekkeende nesten utelukkende er i
flydende unger i ca. 22 døgn. Hunnen ruger
mer enn hannen, særlig mot slutten av ruge­
tiden. Ungene blir flydyktige etter ca. 3 uker, og
passes i denne tiden av foreldrene. Hannen er
iblant alene om oppgaven i siste del av perioden.

STEINVENDER Stercorarius parasiticus

Utbredelse og vandringer

Cirkumpolar utbredelse i arktiske og nordlige
tempererte strøk. I Europa hekker parvis eller
i løse kolonier. Kjønnsmoden to år gammel.
Steinvenderne er monogame, og paret kan holde
Resultatet kan lett bli

En sosial art som ofte går i grupper under
matøk også om sommeren. Hekker parvis eller
i løse kolonier. Kjønnsmoden to år gammel.

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En sosial art som ofte går i grupper under
matøk også om sommeren. Hekker parvis eller
i løse kolonier. Kjønnsmoden to år gammel.
Afrikas vestkyst, men artens vandringer er relativt dårlig kartlagt.

Forekomst og status på Svalbard

Hekker spredt langs kysten over mesteparten av øygruppen, minst tallrik i nordøst. Opptør også i omliggende farvannene om sommeren. Lite er kjent om når tyvjoene ankommer og forlater Svalbard, men trolig er mange tilstede fra slutten av mai og ut august måned.

Biologi og levevis


Monogam og territoriell. Parbindingen er vanligvis livsvarig etter to til tre hekkinger, og par er tro mot territoriet. Første hekking finner sted i en alder av 3-5 år, tidligst hos nordlige bestander. Reiret plasse res på tørr mark, gjeme på stranden ut mot Gipshukodden i Templet og i Gipsvika, men ikke under området.

Territorium 1: Gipsdalen øst for Gipsdalselva, reitte sør for elvevirvel nedenfor Dalkallen. Reir m/2 egg 10.7 og 19.7; to dununger ringmerket 5.8 og 8.8.


Sårbarhet

Joer er sårbare overfor oljeforurensninger, spesielt de mer pelagiske artene polarjo (Stercorarius Pomarinus) og fjelljo (Stercorarius Longicaudus) (Anker-Nilssen 1988). På hekkeplass vil tyvjoen spille skadd eller opptre aggressivt overfor innrengre, og ofte er dette tilstrekkelig beskyttelse for egg og unger. Overfor mer landlige forstyrrelser er den imidlertid sårbar, fordi den har lengre fluktavstand enn andre arter som hekker enkeltvis på tundraen, f.eks. fjærøye.

POLARMÅKE Larus hyperboreus

Utbredelse og vandringer


Status i Gipsdalen / Templet

Løvenskiold (1964) nevner at arten er observert i Gipsdalen og ved Gåsøyne, men ikke påvist hekkende.

Fem territorier ble lokaliseret i Gipsdalen og langs stranda ut mot Gipshukodden i 1989 (Fig. 8). Tre reir ble funnet (ett med ubefruktet egg) og tre unger fra to ulike kull ringmerket. Tyvjo ble også ved flere anledninger registrert nær fuglefjellene i Templet og i Gipsvika, men ikke under omstendigheter som tydet på hekking eller stasjonsnrere par. To voksne på dalbunnen i nordenden av Leirflata 28.7, men fuglene viste ikke tegn til å hekke og ble ikke observert under andre besøk i området.
100 Environmental Atlas Gipsdalen, Svalbard

Forekomst og status på Svalbard


Biologi og levevis


Status i Gipsdalen /Templet

Løvenskiold (1964) oppgir hekkeplasser i Templet og på Gåsøyane, foruten en rekke andre steder i de indre delene av Isfjorden.

Minst ni par hekket i tilknytning til fuglefjellene i Templet i 1989, spredt over en strekning av ca. 5 km lengde (Fig. 8). Tallet omfatter bare par som vi fra våre lave standplasser i terrenget kunne påvise hekkende gjennom observasjoner av rugende fugler, unger eller varslende foreldre.

Det var ingen kolonioptreden i området. De første flydyktige ungene ble observert i Gipsvika 5.8, noe som betyr eggelegging seinest rundt 21.5.

Det ble ikke observert polarmåker under omstendigheter som tydet på hekking andre steder i Gipsdalsområdet i 1989. Enkeltindivider og flokker på opptil ca. 30 fugler hadde ofte tilhold ved ferskvannsforekomster i Gipsdalen inntil 4 km fra fjæra. Lenger opp i dalen bare notert to individer ved Boltonbreen 28.7 og ett på Leirflata 29.7.

Sårbarhet


KRYKKJE Rissa tridactyla

Utbredelse og vandringer

Krykkja har vidt atskilte bestander i de nordligste deler av både Atlantehavet og Stillehavet. I den atlantiske delen av Arktis fins den på Svalbard og mange av de sovjetiske øyene i Nordishavet, rundt det meste av Grønlands kyster, og i de nordøstre delene av artiksk Canada. Krykkja er vanlig utbredt langs Nord- og Vest-Europas kyster sør til Frankrike, og har nylig ekspandert til Spania og Portugal (Cramp & Simmons 1983). En tallrik hekkefugl langs mye av norskekysten.

Pelagisk utbredelse utenom hekkesesongen strekker seg over så godt som alle isfrie havområder sør til ca. 30-40°N, men normalt ikke Østersjøen eller Middelhavet sør for Sicilia. Opptør ofte svært tallrik langs kyster etter kraftig vind, og forekommer også i innlandet. Europeiske krykkjer overvintrer på begge sider av Atlantehavet.

Forekomst og status på Svalbard

Svalbards vanligste måkeart. Hekker i fuglefjell over det meste av øygruppen, enten alene eller i blandingssosialiserende med andre sjøfugler, særlig polarlomvi. Kolonier fins fra Bjørnøya i sør til Sjusøyan i nord og Kong Karls land i øst, men bestandsstørrelsen er ikke kjent. Påtreffes overalt i Svalbards farvann i tidsrommet mars-september.
Biologi og levevis

Krykkjene henter det meste av sin nærings frå overflaten eller øvre vannlag i sjøen. De spiser småfisk og pelagiske virvelløse dyr, i Svalbardområdet mest polartorsk *Boreogadus saida*, lodde *Mallotus villosus*, krill og amfipoder (Mehlum & Giersz 1984). De opptrer ofte i flokk og følger gjerne fiskefartøyer.


Status i Gipsdalen / Temple

Løvenskiold (1964) oppgir at det er en stor koloni i Temple, og nevner også hekkeforekomster ved Gipshuken og Cowantoppen. Ingen av disse koloniene later til å være talt opp tidligere (Mehlum & Fjeld 1987).

To atskilte kolonier i Temple i 1989 (Fig. 9), begge assosiert med polarlomvier. Koloniene ble talt opp 23.-24.7, og funnet å huse henholdsvis 339 par (koloni 1) og 917 par (koloni 2), tilsammen 1.256 par. Tallene gjelder de høyeste av to uavhengige opptellinger. Opptellingene ble foretatt fra standplasser på sjøsida innunder koloniene, ved et ringmerkingsbesøk i den største av partiene omfattet minst 5-6 uker. Ofte vokser bare en unge opp. Ungene blir værende i reiret fram til de er flydyktige etter 5-6 uker, og blir selvstendige kort tid etter.

**Sårbarhet**

Gabrielsen (1987) studerte krykkjers reaksjoner i rugetida på provokasjon med lyd og mennesker nær kolonien. To enkeltindivider inngikk i undersøkelsen.

Våpenkudd (avstand fra kolonien ikke oppgitt) fikk mange krykkjer (men langt fra alle) til å fly av reirene. Provokasjon av flere personer som ankom stranden nedenfor kolonien eller av en person rett under den resulterte ikke i noen synbar endring av fuglene adferd, men telemetriske EKGl målinger viste vedvarende høy hjertefrekvens (Gabrielsen 1987).

Ved provokasjon med helikopter i avstand av 50-100 m fra fuglefjellet ble det ikke registrert noen endring i adferd eller hjertefrekvens før helikopteret var like over kolonien (Gabrielsen 1987). Responsen som da oppsto (urolig adferd, økt hjertefrekvens) var av kort varighet hos fugler som ikke fløy av reiret. De fleste tok imidlertid til gingene. Det er uklart om reaksjonen skyldtes lyden eller synet av helikopteret. Når krykkjer flyr av reirene fordi de skremmes av et overflytende helikopter oppstår det risiko for at egg eller unger kan rives med og gå tapt i panikken som oppstår. Provokasjoner med helikopter i en avstand av 500 m eller mer fra kolonien ga ingen registrering av endret adferd eller hjertefrekvens.

Krykkja har i likhet med havhesten for vane å følge bartøy i sjøen, men det er ikke påvist samme tendens til å forsyne seg av fremmedelementer fra forsyning. Se også polarmåke (s. 99) for generell beskrivelse av måkerfuglers sårbarhet overfor oljeforurensninger.

**ISMÅKE Pagophila eburnea**

Utbredelse og vandringer

En høyarktisk art som bare er kjent som hekkefugl i artisk Canada, på Grønland, Svalbard, Frans Josefs land, Karskoje More, Severnaja Semlja og Nysibirøyene; hekker trolig også på Novaja Semlja. Ismåka er hele året i stor grad knyttet til drivis, men utenom hekkesesongen foretar den utvislomt også forflytninger til områder sør for driviskanten, og er en regelmessig vintergjest i lite antall til Island. Vandringerne er imidlertid dårlig kjent.

**Forekomst og status på Svalbard**

Eller antall små kolonier er kjent, de fleste i østlige deler av øygruppa. Koloniene på Svalbard er vanligvis på 10-20 par. Ses også regelmessig ved bosettingene på Svalbard. Fuglenes vandringer er nærmest totalt ukjent. Ismåker er vanlige i isfylte farvann omkring Svalbard til alle årstider.

**Biologi og levevis**

Ismåkas biologi er dårlig kjent. Den spiser hovedsakelig virvelløse dyr og fisk, men selkadaver og andre åtsler er også viktige. Ekskrementer fra sel og isbjørn inngår også i kostholdet, foruten avfall fra båter og ved bosettinger. Reiret plasseres vanligvis i bratte fjell ved kysten eller på nunatakker i innlandet, men også hekking på
flat mark forekommer. Reiret består av plantedeler og fjær, og bygges av begge foreldrene. Kullet har vanligvis av to egg, som ruges i ca. 25 døgn. Ungene føres av foreldrene inntil de blir flydyktige etter ca. 7 uker.

**Status i Gipsdalen / Temple**


**Sårbarhet**

Ingen informasjoner. Arten opptrer ofte nær bebyggelse og generell beskrivelse av måkefuglers sårbarhet overfor oljeforurensninger. Observasjoner på Svalbard i senere år tyder ellers på et relativt sikkert liv.

**RØDNEBBTERNE Sterna paradisaea**

Utbredelse og vandringer


**Biologi og levevis**

Rødnebbterne er også sårbare overfor forurensninger, særlig oljeforurensninger. De er generelt vurdert som svært betydelige for terners og ungene.

**Sårbarhet**

De direkte konsekvenser av oljeforurensninger er generelt vurdert som svært betydelige for terners, selv om fuglene normalt ikke kommer direkte i kontakt med oljen (Anker-Nilssen 1988). De er svært utsatt for direkte kontakt med oljen.

**Forekomst og status på Svalbard**

Vanlig hekkefugl på strand og tundra nær sjøen og på holmer og skjær langs kysten over hele Svalbard. Arten er i tillegg til befolkningene i områder nord for 80°N.

**Status i Gipsdalen / Temple**


**Sårbarhet**

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**Rødnebbterne**

Sterna paradisaea

Utbredelse og vandringer


**Biologi og levevis**

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Sterna paradisaea

Utbredelse og vandringer


**Biologi og levevis**

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på avstand. Ved større forstyrrelser kan stor skade påføres ved at samtlige egg og unger blottlegges samtidig. Rødnebbterner hekker likevel ofte i nær tilknytning til menneskelig virksomhet. Eksempelvis ble unger registrert i et tankområde nær havna i Longyearbyen 17.8.89 (egen obs.), og det er en koloni også midt i Ny-Ålesund (R. Hansson pers. med.).

POLARLOMVI *Una lomvia*

**Utbredelse og vandringer**


**Forekomst og status på Svalbard**

En svært tallrik hekkefugl på klippehyller i bratte fjellvegger over hele øygruppa. "Danner kolonier i størrelse fra noen få hundre par til flere hundre tusen par. De største koloniene er på Bjørnøya, Hopen, langs vestkysten av Spitsbergen, og i Storfjorden- og Hinlopenområdet. Polarlomviene ankommer hekkeplassene på Svalbard i april, og forlater dem igjen i løpet av august. Resten av året tilbringer de trolig i farvannene sørvest for Grønland og i Barentshavet.

**Biologi og levevis**

Ernærer seg hovedsakelig på fisk, men tar også endel virvelløse dyr. Fisk er dominerende i kostholdet i hekkesesongen, mens virvelløse dyr trolig har størst betydning om vinteren. Byttedyrene fanges under dykk fra overflate (regelmessig ned til minst 30 m dyp). Fisker alene eller i løse flokker.

Som hos annen sjøfugl er den årlige dødeligheten hos voksne svært lav (9 % i et kanadisk stadium). Eldste ringmerkede fugl som er gjenfunnet ble over 23 år gammel, men arten kan sikkert bli atskillig eldre. Hos den nær beslektede lomvien (*Uria aalge*) påvist (Cramp 1985).


**Status i Gipsdalen / Templet**

Polarlomvien var svært tallrik ("immense numbers") i Templet i 1957 (Løvenskiold 1964), men bestanden later ikke til å være talt opp tidligere (Mehlum & Fjeld 1987).

Koloniene i Templet (Fig. 9) ble talt opp 15.-25.7.89. Polarlomviene heket i fem små og artsrene kolonier (koloni 1-5) og i to mindre klart avgrensede hvor det også hekket krykkjer (koloni 6,7). Tabell 1 gir resultatene for to uavhengige opptellinger. Høyeste telleresultat ligger ca. 10 % over laveste, både for totalbestanden og for den største enkeltpopolasjonen alene. I sum ble Tempelts polarlomvibestand opptalt til 2.952 individer. Ved et nytt besøk i koloni 7 for ringmerking 11.8 ble det oppdaget at deler av kolonien hadde vært i skjul for oss under takseringen. Tempelts totalbestand av polarlomvier i 1989 var følgelig klart i overkant av 3.000 individer.

**Tabell 1**

<table>
<thead>
<tr>
<th>Koloni</th>
<th>Minimum</th>
<th>Maksimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>322</td>
<td>358</td>
</tr>
<tr>
<td>2</td>
<td>164</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>5</td>
<td>198</td>
<td>199</td>
</tr>
<tr>
<td>6</td>
<td>366</td>
<td>379</td>
</tr>
<tr>
<td>7</td>
<td>1.506</td>
<td>1.657</td>
</tr>
<tr>
<td>SUM</td>
<td>2.685</td>
<td>2.952</td>
</tr>
</tbody>
</table>

Koloniene 1-2 og 7 lå i umiddelbar nærhet av revehi. Især ungene fra koloni 1 ville være svært utsatt for predasjon når de hopper, idet dem lå i en fjellvegg som vender bort fra sjøen.

**Sårbarhet**

Fjeld et al. (1988) studerte effekten av helikoptertrafikk og simulert helikopterstøy på hekke-sukess og fuglenes adferd i en mindre polarlomvikoloni ved Ny-Ålesund. De kunne ikke

Undersøkelsen konkluderer med at eksisterende bestemmelser med nedre tillatt flyavstand på 500 m fra sjøfuglkolonier bør økes til 2 km. I områder hvor det er mange eller store kolonier bør helikoptertrafikk dirigeres til spesielle traser i minst 6 km avstand fra koloniene (Fjeld et al. 1988).


**Diverse**


**TEIST Cephus grylle**

**Utbredelse og vandringer**


**Forekomst og status på Svalbard**

Hekker spredt langs kystene over det meste av Svalbard, trolig tallrikest i nord og øst. Opptrer flere steder i løse kolonier på flere hundre par. De fleste er tilstede i kystfarvannene fra midt i mars til seinhøstes, og en del individer kan observeres i åpne råker omkring øygruppa om vinteren.

**Biologi og levevis**

En opportunistisk fiske- og krepsdyrspiser, som raskt skifter nærings etter tilgjengelighet. På Svalbard tar den i stor grad bunnsfisk som ulker, i drivisen mest polartorsk og krepsdyr (Mehlum 1989). Fisker ved dykk fra overflaten, før det meste ned til 10 m dyp, og nesten alltid alene.

**Teisten**

En monogam, og parbindingen varer som regel flere år. Første hekking vanligvis fire år gammel. Alder på opptil 20 år er kjent. Som reirplass velges utilgjengelige sprekker i fjell, steinur er andre naturlige eller menneskeskapte hulrom, parvis eller i løse kolonier. Hekker som regel nær sjøen, men iblant opp til 2-3 km inne i landet. De to eggen legges direkte på underlaget, på Svalbard trolig fra slutten av mai, og rugs av begge kjønn i 28-31 døgn. Ungene føres i reiret inntil de blir flydyktige ca. 40 døgn gamle.

**Status i Gipsdalen / Templet**

Løvenskiold (1964) gir ikke konkrete opplysninger om hekking i området, men nevner at arten opptrer på Gåsøyane.

Hekking ble ikke påvist i 1989, men små antall kunne ses langs strendene i Gipsvika og ved Templet. Det antas at enkelte par kan ha hekket ved Templet og Gipshukodden, hvor mulighetene for å gjemme bort reir i fjellsprekker og mellom steinblokker var gode.

**Sårbarhet**

Teist, alkekonge og lunde hukker bortgjømt i hulrom, og løper derfor ikke den samme risikoen for tap av egg og unger som polarlomvien når de flyr opp fra sine smale åpne hyller i stupbratte fjellvegger. De tre artenes adfærdsmessige reaksjoner ved forstyrrelser på hekkeplassene kan slå opp til å være studert. Videre er deres unger flydyktige allerede når de forlater reiret. Dette kan bidra til å redusere risikoen for oljetilgrising fordi fuglene er mer mobile. En generell beskrivelse av konsekvenser av oljesol for alkefugl er gitt under polarlomvi.
Teist, alkekonge og lunde kan jaktes på Svalbard i perioden 1. september - 31. oktober (Prestrud 1989).

ALKEKONGE

Allerkonge

Utbredelse og vandringer


Forekomst og status på Svalbard


Biologi og levevis

Ernærer seg hovedsakelig på planktoniske krepsdyr, voksne alkekonger spiser dessuten bl.a. noe fiskelarver. Dykker som andre alkefugler fra svømmende stilling i overflaten, og holder seg nær overflaten. Maten fraktes til ungene i en stor strupepose.

Monogam; alder for første hekking ikke kjent. En utpreget kolonial art. Reirene plasseres skjult iurer, mellom steinblokker eller i fjellprekker. Alkekongen legger bare ett egg, på Svalbard i annen halvdel av juni og i begynnelsen av juli, som rukes av begge kjønn i 29 døgn. Ungen føres i reiret inntil den kan fly etter ca. 4 uker. De fleste ungene forlater gjerne kolonien i løpet av bare 2-3 dager.

Status i Gipsdalen / Templet

Hekker i Templet (Løvenskiold 1964).

Alkekongen er en vanskelig art å taksere, og våre tellinger i Templet i 1989 gir ikke noe godt grunnlag for et bestandsestimat. Vi registrerte 427 voksne alkekonger i Templet under opp tetning 15.-25.7 (Bjonadalen ikke før 6.8). De to uavhengige observatørene kom ofte til vidt forskjellige resultater; høyeste telleresultat lå rundt 150% over laveste. Arten var også noenlunde jevnt fordelt i fjellet, men færre fugler ble observert rett øst for Skiltvakten enn generelt i Templet. Svært få alkekonger ble registrert i Bjonadalen og på nordsida av dalen nord for Skiltvakten. Arten ble også observert i Sindballe-fjellet 6.8 (Fig. 10).

Det ble ikke funnet hekkeplasser i fjellene rundt selve Gipsdalen. Ved fosen av Storholen, mellom Sandbreen og Macleanbreen, var det tilsynelatende egne hekkeplasser i en talus, men arten ble ikke observert her under et besøk 9.7.89. På dalbunnen nær ørenden av Leifthlata spiste et tyvjon på en voksen alkekonge 11.7.89. Det er lite sannsynlig at joene selv hadde fraktet et så stort bytte mer enn 5 km inn fra fjorden.

Sårbarhet

En generell beskrivelse av oljeforurensning og alkefugl er gitt under polarlomvi. Se også teist (s. 104).

LUNDE

Fratercula arctica

Utbredelse og vandringer


Forekomst og status på Svalbard


Biologi og levevis

Lever hovedsakelig av fisk, men de voksne spiser også en del virvelløse dyr, særlig krepsdyr og vingesnegl. Fisken hekkesesongen ofte i løse flokker, helst nokså nær kolonien (2-10 km).
Dykker trolig ikke dypere enn 15 m. Lunden kan fange flere fisker på under ett dykk, og holder disse på tvers når den flyr tilbake til kolonien.

Monogam; fast parbinding. Kjønnsmoden 4-5 år gammel. Lundene hekker i større eller mindre kolonier som vanligvis vender ut mot sjøen; reirplass i grønnskledde skråninger hvor de selv graver en reirgang (i områder hvor det ikke er permafrost), blant steinblokker eller i fjellsprekker. Hekkebiologien er lite studert på Svalbard. Det enslige egget ruges av begge foreldrene i rundt 40 døgn, og ungen fores i reiret omtrent like lenge. Ungen er dårlig i stand til å fly når den forlater reiret, men den er selvstendig med det samme.

Status i Gipsdalen / Templef


De forbehold som er gitt for alkekongen gjelder også lunden. I alt ble det registrert 893 voksne lunder i Templef 15.-25.7.89 (Bjonadalen 6.8). Tallet ligger 41.5 % over vårt laveste telleresultat. Fordelingen i fjellet var annerledes enn for alkekongen: Svært få fugler ble sett rundt Templefs vestre hjørne og rett øst for Skiltvakten; noen flere lunder hadde tilhold i dalen nord for Skiltvakten, ettersom de selv reirplasser i gresskledde skråninger; mens 477 lunder (46 % av totalen) ble opptalt i fjellets sørøstre hjørne ved Bjonapnten. Lunder ble også observert i Sindballefjellet 6.8.89, og i den sørøstre eggen av Dalkallen i september 1989 (R. Hansonn pers. med.; Fig. 10).

En mindre lundeflokke hadde tilhold på sjøen rett utenfor Gipshukodden og Gåsodden 20.7.89. Noen få par kan muligens hekke mellom steinblokkene på Gipshukodden.

Sårbarhet

En generell beskrivelse av oljefurensning og alkefugl er gitt under polarlomvi. Se også teist (s. 104).

SNØSPURV Plectrophenax nivalis

Utbredelse og vandringer


Forekomst og status på Svalbard


Biologi og levevis

De voksne er hovedsakelig frøspisere, men tar også en del insekter, særlig som for til ungene.

Territoriell. Hekker parvis, på Svalbard i steinet tundraterreng, i fjellområder og i fjellområder Bayerns områder, og ved fuglefjell og bebyggelse. Reir plasser seg skjult i fjellområder, under steinheller, i urer eller bygninger. Det er også isolert, gjerne med fjær og hår. Legger 4-7 (som regel 5-6) egg i juni, men kan ha flere kull i løpet av sommeren. Eggen ruges av hunnen i 12-14 døgn. Ungene mates av begge foreldrene. De er ofte lite flydyktige når de etter 12-14 døgn forlater reiret.

Status i Gipsdalen / Templef

Løvenskiold (1964) nevner forekomster i Templef og på Gåsøyane.

Snøspurver ble observert over så godt som hele studieområdet sommeren 1989 (Fig. 6). Det ble ikke funnet reir, men 8-10 kull ble registrert i perioden 9.7-9.8. Par eller enkeltindivider ble sett på ytterligere minst 8-10 lokaliteter. Hekke­bestanden i området antas derfor å ha ligget på minst 15-20 par. De fleste observasjonene ble gjort i Gipsdalen eller dens sidedaler fra Aitkenfjellet til Gipsvika og Templef. En ung hunn ble ringmerket.

Sårbarhet

Snøspurven er tallrik på Svalbard og vel tilpasset det barske klimaet i Arktis. Arten er ikke spesielt hensynskrevende ved menneskelig virk­somhet. Et tilfelle av en oljetilgriset snøspurv er beskrevet fra Svalbard (Ree 1986).

FJELLREV Alopex lagopus

Utbredelse og vandringer

Holarktisk utbredelse i arktiske og høyalpine områder. Vanlig på Svalbard, Island, Grønland, i arktisk Canada og Sovjet, og i nordlige deler av Alaska; fåtalig i Fennoskandia. Massevandringer mot sør og langt inn i de kanadiske og sovjetiske
barskogssonene forekommer i år med store bestander, og det er også vanlig å treffe på arten ute i drivisen.

Forekomst og status på Svalbard

Vanlig. Forekommer over hele øygruppa, også i de høyeste fjellpartiene og i drivisen. Tallrikest i områder med god mattilgang, dvs. der det hekker konsentrasjoner av sjøfugl, ærfugl og gjess på vestkysten av Spitsbergen, og i gode reindistrakter i sentrale deler av Spitsbergen og på Edgeøya/Barentsøya.

Biologi og levevis


Status i Gipsdalen / Templet

To hi ble funnet sommeren 1989 (Fig. 11). Begge lå i tilknytning til fuglefjellene i Templet, og var plassert innunder steinblokker på "moreneterlå i tilknytning til fuglefjellene i Templet, og var på døde fjellside, men hi kunne ikke lokaliseres. En fjellrev i sommerpels ble i jul og august 1989 flere ganger sett på dalbunnen mellom Dalkallen/Usherfjell og Leirflata, og eventuell yngling i dette området kan ikke utelukkes.


Sårbarhet


Diverse


Sårbarhet


Diverse


En fjellrev i sommerdrakt ble 26.7.89 observert
mens den utvungent la på svøm over Gipsdals-sør for 74°30'N.

REFERANSER


SUMMER ENVIRONMENTAL SURVEY OF GIPSVIKA, SVALBARD

THE MOST PROMINENT MACROFAUNA

by

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SUMMARY AND CONCLUSIONS

The marine ecological survey was conducted at 30 sampling stations situated in Gipsvika, the largest bay of Sassenfjorden, in August 1989. The bay covers 3.2 km² and its water volume amounts to 6x10⁷ m³. Its coasts are of low, gravel and stony beaches with small spots of rocks and two river mouths. Surrounding mountains and the opening towards Isfjorden cause the prevailing wind directions SW and NW. The bottom of the bay is covered by stones on eastern, shallow parts, while deeper down mud and silt occur. The hydrology of Gipsvika is governed by local waters of Sassenfjorden. No direct inflow from the open sea was found during our study. In the centre of the bay local upwelling and temporal eddies occur, which might be responsible for zooplankton aggregations. Benthic fauna consisted of over 160 species grouped in three main communities. Macrobenthos density was low; only one species was found in more than 1000 ind/m². The occurrence frequency was also low for all species. Only 3 species were found in more than 50% of collected samples. The Shannon-Wiener diversity coefficients were exceptionally high ranging from 2 to 8. Phytophenthos occurrence was restricted to the shallower and sheltered part of the bay, 14 common and widely distributed taxa were noticed. The meiofauna from the tidal zone of Gipsvika was similar to that of other Svalbard localities with regard to its abundance and taxonomical composition. Zooplankton communities were typical for inner fjord pools, dominated by small copepods. Unusually high concentrations of Bivalvia larvae were found in the centre of the bay. The amount of phytoplankton was high despite late summer sampling. It was dominated by minor flagellates resembling the post bloom assemble. Gipsvika might be described as a subarctic bay with rich and very diversified marine fauna. It includes potential feeding grounds for ringed and bearded seals as well as for seabirds.

Gipsvika is a subarctic bay under indirect influence of the West Spitsbergen Current. It has rich and diversified fauna compared to other Svalbard fjords. Low density, few dominants and a great number of rare species in the benthos shows an untypical pattern for an Arctic ecosystem. The fresh and cold water runoff with suspensions is not as stressing here as in other fjord pools. Cooled brackish and muddy waters of fjord pools usually reduce both the pelagic and benthic life. An illustration of what we observed summer 1989 is shown on the front page.

It is difficult to establish the role of Gipsvika for the neighbouring areas since we do not know much about the marine ecology of Isfjorden. However, we can state that Gipsvika serves as a nursery ground for numerous Bivalvs, and some areas within the bay are of importance as feeding grounds for seabirds and seals. The key areas of the Gipsvika ecosystem are:

1) the deep water channel supporting the bay with highly saline transformed atlantic waters carrying plankton from the Spitsbergen shelf,
2) the outflow channel along Tempelfjellet, where the majority of fresh-water runoff goes.

There investigations of the summer of 1984, left three important gaps in our knowledge:

- The hard bottom fauna; we suggest that this is investigated with SCUBA technics.
- Seasonal patterns of the Gipsvika ecosystem. In particular we suggest an early spring study to investigate how the bay is influenced by open sea waters.
- A deeper understanding of Gipsvikas position within the Isfjord ecosystem. We suggest a marine ecological survey throughout the Isfjorden.

INTRODUCTION

The present study is one of few marine-ecological surveys performed in Svalbard coastal waters. So far, the majority of marine biological studies in Svalbard have been faunistic (Stephensen 1935-1938-1942, Birula 1907, Bruggen 1907, Hognestad 1961, Christiansen & Christiansen 1962). The exception was a study performed in Hornsund, where extensive ecological investigations were conducted by polish expeditions (review in Swerpel & Weslawski 1989). Marine biological data about Gipsvika are absent in the literature. However, some studies have been conducted nearby in Billefjorden (Stott 1936) and Sassenfjorden (Wiktor and Bancer in prep., Weslawki et al. 1989a). The aim of the present work is to give background information about hydrology, marine life, and the most important processes of Gipsvika - the harbour of the planned mining area.

MATERIALS AND METHODS

Materials were collected 3. and 4. of August 1989 from the r/v "Oceania", and later between 30. of August to 5. of September by a team equipped with a small boat based in Gipsvika. Observations gathered during fieldwork carried out in spring 1987 and 1988 were also included in the discussion of the 1989 data. Bathymetry and coast line data were based on the Sea Chart of Isfjorden, edited by Norwegian Polar Research Institute, Oslo.

Sediments were collected with a Petersen grab, described macroscopically in the field, and 100 g samples were dried, and burned at 600°C to obtain their organic matter contents. Coastal
geomorphology was studied in September 1989 and described according to the system proposed in Weslawski et al. 1988a.

Hydrology was sampled using a CTD Guideline 8770 system and a Rosette water sampler. Suspension amount was established in samples of 1 dm$^3$ surface water, sieved through a 0.45 um Millipore filter, dried at 120°C and weighted to get the dry weight of suspensions in mg per dm$^3$. Transparency was measured with a Secchi disc.

Bottom fauna was sampled quantitatively using a Petersen grab (31 per 30 cm). Three samples were taken from each locality, mixed and sieved through a 0.5 mm mesh sieve. Animals were fixed in a 4% formaldehyde solution and weighed wet to 1 mg accuracy. Altogether 26 quantitative benthos samples were analyzed. Qualitative samples were obtained from a rectangular light dredge (80x30cm mouth size and 0.5 gauze mesh size). Faunal fixation was as described above. 14 dredgings were analyzed.

Meiofauna was sampled by use of a steel tube sampler of 2.38 cm$^2$ diameter during low tide from three points: low, mean and high water mark. Samples were taken down to 5 cm depth and fixed with a 4% solution of formaldehyde. These samples were later stained with Rose Bengal, elutriated, and the animals were collected in a set of sieves of 0.5 mm, 0.2 mm, 0.1 mm and 0.057 mm mesh sizes.

Phytoplankton was collected within 0-50 m water depth with 10 m intervals. A Rosette sampler of 12 l bottles was used. Subsamples from each layer were fixed with a Lugol solution. 16 samples were collected at three chosen stations at the entrance to the bay.

Zooplankton samples were collected by use of a WP-2 net with 200 µm mesh size gauze, equipped with a closing device. Hauls were made vertically, through the layers determined by previous temperature and salinity measurements. The layers distinguished were: 1) from bottom to the lower limit of thermo- and halocline (referred to as BL in text), 2) within thermo/halocline (IL in the text), and 3) from 2) up to the surface (SL in the text).

RESULTS AND DISCUSSION

Geographical position, area, bathymetry.

Gipsvika, 78°25′N (Fig. 1), is the largest bay in Sassenfjorden. Its surface covers 3.2 km$^2$. Gips-

Figure 1 The geographical position of Gipsvika, sampling stations and bathymetry.
vik is widely exposed to SW, towards the inner part of Isfjorden. There is no sill or other structure isolating the bay from Sassenfjorden waters. A shallow spot with some rocks (Ministergrunnen) is located further into Sassenfjorden, outside the Gipsvika area. The water volume of Gipsvika (Fig. 1) is approximately $6 \times 10^7$ m$^3$, within the borderline of two peninsulas. Most of the bay area lays between 5-25 m contour lines. Along the entrance to the bay a channel of 60-70 m depth occurs. Orography of the Gipsvika area indicates the predominant wind directions; NW along the river valley, and SW from the mouth of Isfjorden.

Sediments

Shallower and coastal parts of the bay is covered with stones and gravel. At greater depth mud and silt prevailed, usually above a layer of stones or boulders. The amount of organic matter ranged between 5 and 20% of soft sediments (Fig. 2).

Coasts

Most of Gipsvikas shoreline consists of low, gravel, semiexposed beaches. Near the peninsulas and river mouths there are spots of rocks and skjerra. Towards west, finer sediments occur on the low beaches (Fig. 2).

Hydrology

Basic temperature and salinity values are given in Table 1. The following hydrological phenomena occur in the bay:

- generally temperature decreased and salinity increased from surface to bottom in all examined stations. There was no clear temperature or salinity inversion as earlier observed in Svalbard fjords (Swerpel 1985, TROMURA 1986),
- sampling stations at the western and eastern outermost part of Gipsvika had higher bottom salinity values than those in Gipsvika, thermo-and halocline was present in the centre and western part of the area,
- water density was strongly connected to salinity (typical for arctic and subarctic waters),
- only strong salinity gradients existed at the

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**Figure 2** Coast types and bottom sediments in Gipsvika.

- 1 slit
- 2 mud
- 3 sand
- 4 gravel
- 5 stones
- 6 low beach
- 7 abrasive cliff
- 8 cliff, rock slide
- 9 river mouth

A organic
B mineral matter
surface; strong temperature gradients were typical for the lower layers. Surface and near bottom T and S fields are presented in Fig. 3

Strong influence of runoff was observed at the surface, especially along the coast. In the outside parts a channel effect appeared. The direction of runoff was parallel to the Gipsvika Channel axis and caused a strong hydrological front in the outer, eastern part of the bay.

The bottom distribution of temperature and salinity were typical for Spitsbergen fjords. Isolines were almost parallel to isobathes. Temperature increased and salinity decreased towards the coasts. The bottom effect gave some perturbations in T and S distributions - in the eastern part of the bay high salinity water flowed in through the small bottom hollow, separated from the western part by a small ridge. The ridge also gave some hydrological effects (upwelling). High salinity values near the bottom were observed in the inner part of the bay. Fig. 3 (the sections across the bay and the channel) gives a picture of hydrological situations during the measurements. Strong surface salinity gradients appeared all over the area. The most cool and salty waters occurred outside Gipsvika in the western part of the area.

The horizontal course of isolines is disturbed in the centre of the section (station (st.) 6; Fig. 3 and Fig. 4). On the surface there was a strong salinity gradient (runoff tongue) and at the depth of 10-15 m an isoline hump existed, were deep waters sloped upwards. Fig. 5 shows the T and S water analysis of those waters. The basic water masses of the west coast of Spitsbergen are the Atlantic and Local Waters (AW and LW). Atlantic waters (AW) are connected with the West Spitsbergen Current and dominate along the continental slope. They are often present in Spitsbergen fjords. The Local Waters (LW) mainly occupy the Spitsbergen and Barents Sea Shelf, and their origin is connected with transformation of the Atlantic Waters (AW), particularly during the winter season (Swerpel 1985, Tseclotksaya & Zlobin 1977). For Isfjorden the following para-

| Table 1 Values of T and S parameters in Gipsvika during fieldwork in August 1989. |
|---------------------------------|----------|----------|----------|
| Depth (m)                      | West st. 1 | Center st. 5 | East st. 11 |
| Surface temp. (°C)             | 7.13      | 6.45      | 6.06      |
| Surface salin. (ppt)           | 26.61     | 29.10     | 30.15     |
| Max. salin. (ppt)              | 33.38     | 31.87     | 33.13     |
| Min. depth (°C)                | 2.52      | 4.79      | 2.64      |
| Subsurface depth (m)           | 14-15     | 5-6       | ...       |

Figure 3 Temperature and salinity sections in Gipsvika, August 3-4 1989.
meters can be determined from those waters: AW T>0.5, S>34.0, LW T<0.5 and S>34.0. It is seen from the T/S diagram (Fig. 5) that deep waters in Sassenfjorden and Tempelfjorden have characteristics of both AW and LW. All measuring points from Gipsvika lie beyond the AW range (Fig. 5). The water in Gipsvika can be divided into three characteristic water layers:

1) SURFACE LAYER: T>6, S<31.5: temperature is almost constant, salinity increases very quickly with depth,

2) INTERMEDIATE LAYER: 0.5<T<6.0, 31.5<S<34.0: temperature decreases and salinity increases with depth,

3) LOCAL WATERS LAYER: T<0.5, S>34: salinity is almost constant and temperature decreases with depth.

**Fresh water volume, river plume and circulation.**

Fresh water volume (FWW). Runoff caused strong temperature and salinity gradients in the Gipsvika waters. On basis of field observations of salinity, the FWV can be estimated in various layers of the bay for the time of observation. The volume of water in the levels used in the calculations was determined by planimetry. Average salinity was calculated from the STD data applied to appropriate segments within these levels.

![Figure 4](image)

**Figure 4** Temperature and salinity distributions on the surface and near the bottom in Gipsvika, August 3-4 1989.

![Figure 5](image)

**Figure 5** Temperature and salinity diagram of waters in the Sassenfjorden area.

- **Gipsvika**
- **Tempelfjorden** (based on TROMURA 1986)
- **Gåsøyane** (based on TROMURA 1986)
- **AW Atlantic waters**
- **LW Local waters**
The fresh water fraction (FWF) of each segments can be calculated by the formula:

$$\text{FWF} = \frac{(S_o - S)}{S_o}$$

or

$$F_i = \text{FWF} \times 100\%$$

where S is the base salinity of the source water and So is the observed average salinity of the water. The highest value of the salinity recorded during observations was used in the calculations. By multiplying the FWF by the volume of each segment, the actual quantity of FWV in the segments was determined. The total value within each level was obtained by summing the fresh water in each segment. Percent part of fresh water volume in Gipsvika is 10 %. Obviously the highest quantity of freshwater occurs in the upper 10 m layer (14 %).

**River Plumes.** In Gipsvika, water from Gipselva is the main source of runoff. We observed a typical mechanism of plume formation due to river discharge. The state of plume fronts in the bay is determined by tidal phase, quantity of discharge and wind driven circulation as is characteristic at sea coastal areas (Bowman & Iverson 1978). The feature of Gipselva's plume was observed during hydrological observations August 3-5 1989, at nearly the same time between 14 and 18 GMT, and 04 and 06 GMT. Beyond these periods the brackish water was confined to the close vicinity of the river mouth. The pattern is shown in Fig. 6. The plume curved along the shoreline on the eastern side of the river mouth with the transverse extent ranging between 200 and 300 meters. After leaving the eastern end of the bay the plume did not spread over the open waters but continued southwards. In the second case the plume advanced westwards from the river mouth and spread over most of the bay. The difference between salinity of the samples taken at the surface across the plume boundary, ranged between 4 and 6 parts per thousand (ppt). The average surface salinity of 25-28 ppt was typical in the plume, and that of 19 ppt was typical near the river mouth. On August 5., a strong surface front, extending over a mile along the eastern edge of the plume was formed in less than 15 minutes. A distinguished foam line indicated the presence of the convergent velocities on each side of the front. At this time the water level at Gipselva's mouth was high, and a strong ebb current was pushing waters out into the bay. After approximately one hour, this current died out and the plume was gradually depleted. The general pattern of the bay water and circulation remarks are drafted in Fig. 7. An isometric perspective seemed to be the best fit. Notice the plotting of three different water layers and their changeable thickness in the bay. The most interesting part of the bay was the centre. Deep waters flow upwards above the small bottom ridge, giving strong pincnocline on the interaction with surface waters (sts. 5 and 6). Nearby surface water tongues fell down (st. 7). So there were specific conditions to form vertical structures.

**Circulation.** The circulation pattern changed with time, depending on tidal phase and wind conditions. The density data from the moored ship, obtained at locations in the central part of the bay are depicted in Fig. 8. The leftmost curve (0) represents low runoff conditions; there was no pronounced pincnocline and density increased evenly with depth. At one time the density interface developed at a depth of about twenty meters. Curve 4, obtained at the onset of the plume discharge (GMT 0445) indicates transformation of the surface layer towards the intermediate layer.

**Suspensions and water transparency.**

The amount of suspended matter ranged from 8 to 40 mg/dm³, usually 10 mg/dm³. The sechhi disc was visible down to 3 m, although at some spots 8 m transparency was observed. Table 2 shows data on suspended matter amount.

Sediments were most abundant in the eastern part of the bay, suggesting that a main stream of suspensions flows in this direction.

**Benthic fauna**

The biomass exceeded 100g/m² in most stations (Fig. 9). No clear pattern was found in relation to the depth, substrate or distance from shore, although higher values were found at stations where large animals occurred (sea urchins, large decapods). Compared to other coastal regions of Svalbard the Gipsvika benthic biomass was high, like the richest stations in Hornsund or entrance to Kongsfjorden (Gorlich et al. 1987, Weslawski et al. 1989a). The density of benthos was not especially high. The highest values found were

**Figure 6** The approximate location of the plume in Gipsvika.

1 - August 4-5 1989, 04:06 GMT
2 - August 3-4 1989, 13:18 GMT
### Table 2  Suspensions amount in Gipsvika’s surface waters, August-September 1989.

<table>
<thead>
<tr>
<th>St. no.</th>
<th>3. Aug. mg/dm³</th>
<th>31. Aug. mg/dm³</th>
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<tr>
<td>1</td>
<td>8.3</td>
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<tr>
<td>2</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>13.1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11.0</td>
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<td>7</td>
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<td>9</td>
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<td>11</td>
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</tr>
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<tr>
<td>20</td>
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</table>

**Figure 7** Isometric perspective of the waters in Gipsvika, and a general scheme of water layers and circulation.

**Figure 8** Density plots of water from stations 5 and 6 from Gipsvika, August 4-5 1989.

- 0 - 23:17 GMT  3 - 03:11 GMT
- 1 - 00:39 GMT  4 - 04:19 GMT
- 2 - 02:20 GMT
for *Gammarus setosus* in the tidal zone (over 2000 individuals (ind) per m²). The mean densities of Polychaets and Molluscs did not exceed 20-60 ind/m². Overall benthic fauna density ranged from 100 to 700 ind/m² (Fig. 10, Table 3, Table 4).

These values are lower than density data from other coastal localities in Svalbard, where single species commonly have been observed in great amounts (Gromisz 1983, Gulliksen et al. 1984, Legezynska et al. 1984, Weslawski et al.)

**Figure 9** The biomass of benthic fauna from Gipsvika. Data from triplicate Petersen grab samples, August 1989.

1 < 1 g/m²

2 1.1 - 10 g/m²

3 10.1 - 100 g/m²

4 > 100.1 g/m²

**Figure 10** The relation between depth and number of species in benthos in Gipsvika.
Table 3 Characteristic of benthic stations sampled in Gipsvika in August 1989.

<table>
<thead>
<tr>
<th>St. no.</th>
<th>S-W coeff.</th>
<th>Biomass g/m²</th>
<th>Depth m</th>
<th>Substrate</th>
<th>Density ind/m²</th>
<th>St. no.</th>
<th>S-W coeff.</th>
<th>Biomass g/m²</th>
<th>Depth m</th>
<th>Substrate</th>
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</table>

Table 4 The most prominent species of Gipsvika.

**GRAB SAMPLES:**

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Freq %</th>
<th>Density ind/m²</th>
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<tr>
<td><em>Polychaeta</em></td>
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<td>Chaetozone setosa</td>
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<td>Lumbrineris fragilis</td>
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<td>40</td>
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**DREDGE SAMPLES:**

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unpubl.). The species list of Gipsvika August 1989 contains 162 taxa found in 26 triplicate grab samples and 14 dredgins (Table 5). 59 species were Polychaets species (35 %), 50 were Crustaceans (32 %) and 23 were Molluscs (20%). The majority of the benthic fauna was of borearctic origin and widely distributed forms. Atlantic species like *Sclerocrangon boreas* were numerous. Arctic species like *S. ferox* were also present, particularly in shallower parts of the bay.

Different feeding types of benthic fauna are indicated in Table 5, and their distributionshown in Fig. 11. The herbivores were restricted to the shallower, western part of the bay, filter feeders were most numerous on the outer and eastern stations, while deposit feeders were dominant in areas with heavy sedimentation.

**Prominent species and communities.**

10 species were considered to be of biological importance; the taxa with highest frequency and dominance values in the quantitative samples. Their characteristics are given in Table 4. The results from a cluster analyses of species co-occurrence is shown in Fig. 12, where three major assemblies have been distinguished. The similarity between sampling stations shows the distribution of faunal assemblies in the bay (Fig. 13). The shallow hard bottom community associated with *Caprella septentrionalis* and *Margarites groenlandica*. Soft bottom communities were distinguished on low sedimentation areas with Foraminifers and Ophiurids, and heavy sedimentation areas with large Molluscs and sedentary Polychaets. The deepest parts of the bay with more stable sediments were occupied with *Maldane sarsi* communities, characteristic for most deep fjord biota of Spitsbergen (Gromisz 1983).

**Specific biota.**

The "ryzoid communities" were observed on stones covered with laminarians. Such microbiota are considered to be important as shelter and nursery ground for numerous benthic species (Rozycki & Gruszczynski 1986). Of the examined ryzoids, 50 % were without any attached animals, others were inhabited rather scarcely (Table 6). This supports the assumption that there are no large and old macrophytes in Gipsvika, due to the heavy waving and semiexposed character of the bay.
Table 5  List of benthic species obtained from grab and dredge samples in Gipsvika August-September 1989.

Legends:
A  arctic
AB  arctic-boreal
BA  boreo-arctic
B  boreal
Ko  cosmopolitan
Ca  carnivore
Fi  filter feeder
De  deposit feeder
Om  omnivore
He  herbivore
1  high importance
2  medium importance
3  low importance

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### Feeding grounds.

Some key species were investigated to estimate their biomass and density distribution within the bay. Fig. 14 shows the results from these estimations for hyperbenthic Amphipods, *Mysis oculata* and Decapods. The most important areas for these species were the grounds in the central and eastern part of the bay.

### Phytobenthos

On the hard bottom of the western part of the bay, a rich phytal zone occurred, dominated with *Laminaria saccharina* and 12 other species (Table 7). In shallow water *Fucus distichus* prevails. Very rich assemblies of periphytic diatoms were found on tiny brown algae (*Polysiphonia, Pylayella*). Since the SW winds create heavy
Table 6  Inhabitants of laminarian cyzoids sampled in 0-5 m depth range in Gipsvika, stations 13 and 14.

<table>
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<tr>
<th>Epiphytic taxon</th>
<th>Freq.(%)</th>
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<td>2 Periphiton red algae</td>
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</tr>
<tr>
<td>3 Periphiton brown algae</td>
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</tr>
<tr>
<td>4 Bryozoa n.d. 1</td>
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</tr>
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<td>5 Bryozoa n.d. 2</td>
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<td>6 Bryozoa n.d. 3</td>
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<tr>
<td>8 Foraminifera</td>
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</tr>
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<tr>
<td>17 Diastylis sp.</td>
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<td>18 Onisimus sp.</td>
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<td>20 Empty</td>
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</table>

Table 7  List of the most common phytobenthic taxa found in dredging samples from Gipsvika.

Chlorophyta
- Cladophora rupestris
- Monostroma sp.

Phaeophyta
- Alaria asculenta
- Laminaria digitata
- Fucus distichus
- Laminaria saccharina
- Desmarestia aculeata
- Pilayella littoralis
- Sphacellaria arctica

Rhodophyta
- Phycodrys plumosa
- Polysyphonia nigrescens
- Ceramium sp.
- Ptilota plumosa

Figure 11  The distribution of feeding types among benthos in Gipsvika. Expressed as % of density (individuals/m²).
Figure 12  Macrobenthos co-occurrence calculated according to Canberra distance. Grab samples only.

Figure 13  Benthic fauna assemblages according to the cluster grouping of stations in Gipsvika (see Fig. 13).
1 soft bottom, low sedimentation area with Foraminifera.
2 soft bottom, high sedimentation area with Serripes groenlandicus.
3 brackish shallow area with vegetation on hard bottom.
4 deep, soft bottom with Maldane sarsi.
5 zones in tidal and subtidal zones with Gammarus spp.
6 oligotrophic gravel beaches without macrofauna.
Figure 14 Gipsvika as a feeding ground for vertebrates, estimation of prey item density.

A  1  < 10 ind/100 m²
    2  11 - 100
    3  101 - 1000
    4  > 1000

B  1  < 1 ton/km²
    2  1.1 - 10
    3  10.1 - 50
    4  > 50

C  1  < 10 kg/km²
    2  10.1 - 100
    3  100.1 - 1000
    4  > 1000
waving, no rich macrophytes were found on the windward side of the bay, and algae deposits on the shore were scarce compared to sheltered coasts off West Spitsbergen (Weslawski et al. 1988b).

The species given in Table 6. are among the most common and abundant algae of Svalbard's coasts (Svendsen 1959, Florczyk & Latala 1989).

Phytoplankton

Along with the 14 taxa of phytoplankton representatives of Ciliata were also considered (Table 8).

Nannoplanktonic algae constituted the dominant fraction of the examined material, with the minor admixture of pyrrophytes and diatoms. Density ranged from 85 mln cells/m³ in st. 10, to 1000 mln cells/m³ in st. 3.

The density and taxonomic set of species are similar to phytoplankton assemblages observed near the mouth of Hornsund (Wiktor and Baner in prep.) and coastal localities on the open west coast of Spitsbergen under the direct influence of the sea (Weslawski et al. 1988a). Densities of the most prominent species are shown in Fig. 15.

The high amount of *Phaeocystis pouchetti*, *Dinobryon baltica* and minor flagellates resemble the post bloom phytoplankton assemblage observed in Sassenfjorden in late May 1987 (Wiktor and Bancer in prep.). St. 3 is situated at the border between Sassenfjorden and Billefjorden. This may cause a "frontal effect" and explain the enrichment of algae observed there.

Meiofauna.

A list of taxa found in 18 samples is given in Table 9, together with data frequency-data of the taxon, and their abundance values (minimum, maximum and average).

The most important taxa were Nematoda, Turbellaria and Oligochaeta. Concerning frequency and abundance parameters of the remaining taxa, Acarina should be noticed. The estimated densities of the total meiofauna and the proportion of taxa for each station are shown at Fig. 16.

Only an introductory description of the meiofauna of Gipsvika is possible from these samples, but the data presented are ascertained in the literature of intertidal zones of Spitsbergen.

Table 8 Phytoplankton taxa found in the examined samples from Gipsvika, in 1x10^3 ind./m³.

<table>
<thead>
<tr>
<th>Station/Taxon</th>
<th>St.3</th>
<th>St.7</th>
<th>St.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Flagellatae non det.3um</td>
<td>135.9</td>
<td>182.9</td>
<td>47.0</td>
</tr>
<tr>
<td>2 Cryptomonas sp.small</td>
<td>40.8</td>
<td>53.8</td>
<td>5.9</td>
</tr>
<tr>
<td>3 Pyramimonas sp.</td>
<td>54.4</td>
<td>10.8</td>
<td>17.6</td>
</tr>
<tr>
<td>4 Phaeocystis pouchetti</td>
<td>27.2</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td>5 Nitzchia delicatissima</td>
<td>1.6</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>6 Tintinide</td>
<td>0.4</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>7 Dinobryon baltica</td>
<td>462.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Flagellatae non det.3-7</td>
<td>258.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Gymnodinium simplex</td>
<td>27.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Cryptomonas pelagica</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Navicula sp.</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Nitzchia longissima</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Gyrodinium sp.</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Dinophysis rotundatum</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>1009.1</td>
<td>247.5</td>
<td>85.2</td>
</tr>
</tbody>
</table>

Table 9 The characteristic of taxa composition of meiofauna from Gipsvika’s tidal zone.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Freq.</th>
<th>Min.</th>
<th>Max.</th>
<th>Avg.</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ind/10cm²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foraminifera</td>
<td>16.67</td>
<td>3</td>
<td>10</td>
<td>6.33</td>
<td>2.87</td>
</tr>
<tr>
<td>Nematoda</td>
<td>72.22</td>
<td>3</td>
<td>579</td>
<td>104.08</td>
<td>193.05</td>
</tr>
<tr>
<td>Turbellaria</td>
<td>77.78</td>
<td>3</td>
<td>107</td>
<td>31.50</td>
<td>31.52</td>
</tr>
<tr>
<td>Oligochaeta</td>
<td>55.56</td>
<td>3</td>
<td>1487</td>
<td>171.30</td>
<td>439.94</td>
</tr>
<tr>
<td>Harpacticoida</td>
<td>16.67</td>
<td>3</td>
<td>8</td>
<td>5.33</td>
<td>2.05</td>
</tr>
<tr>
<td>Ostracoda</td>
<td>16.67</td>
<td>3</td>
<td>3</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>Acarina</td>
<td>50.00</td>
<td>3</td>
<td>22</td>
<td>7.78</td>
<td>7.25</td>
</tr>
<tr>
<td>Rotatoria</td>
<td>27.78</td>
<td>3</td>
<td>8</td>
<td>4.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Tardigrada</td>
<td>5.56</td>
<td>3</td>
<td>3</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>Bivalvia veliger</td>
<td>27.78</td>
<td>3</td>
<td>37</td>
<td>14.00</td>
<td>12.62</td>
</tr>
</tbody>
</table>

Figure 15 The phytoplankton abundance on three stations in Gipsvika, August 1989.
It seems that the pattern of density-distribution and proportions of meiofaunal organisms is a reflection of types of habitats observed in Gipsvika. Stations with low densities of meiofauna were sts. 25, 26, 27 and 30. The two first sites are situated on very exposed gravel beaches. The remaining two were localized at exposed places: st. 27 was a cliff with abrasive shelfs, st. 30 was a rock slide cliff. These places are not favourable for meiofauna, because the bottom sediments are too coarse and almost continuously moving. The more organic matter that is present at a place, the higher is the proportion of Nematoda (sts. 27, 30). If not, the proportion of Turbellaria increases. The two stations with highest densitis of meiofaunal organisms were localized at the shore line, sheltered from the prevailing waves action. Detritus deposition at these places is more effective and substratum not so moving. This is preferred by Nematoda and Oligochaeta.

Similer patterns of distribution of the meiofauna are testified in the tidal zone in South Spitsbergen National Park (Kwasniewski 1988) and in the intertidal zone of Recherche Fjorden (Radziejewska & Stankowska-Radziun 1979).

Mesozooplankton.

In the analyzed samples from Gipsvika 15 taxa of mesozooplankton organisms were present (Table 10).

In the bay, mesozooplankton dominated the holoplanktonic Copepoda, typical for the fjord waters of the Western Spitsbergen. Of greatest importance were Calanus finmarchicus/glacialis, Pseudocalanus minutus and Oithona similis. Acartia longiremis, Microcalanus pygmaeus, Calanus hyperboreus, Metridia longa and Oncaea borealis, plus two not determined species of Harpacticoida are the other copepod found in Gipsvika. Other groups of animals represented in the samples, were (apart from juveniles of Pteropoda Limacina helicina) exclusively meroplanktonic, developmental stages of benthic Bivalvia, Polychaeta and Echinodermata, and parasitic Isopoda. The total abundances of the mesozooplankton organisms estimated for the samples are shown in Fig. 17.

The abundance values differed greatly and varied from 1160 ind/m³ (st. 3, BL) to 19981 ind/m³ (st.
7, SL), with the surface layers having the highest values. Among the determined taxa the most abundant were: veliger larvae of Bivalvia (9340 ind/m³ at st. 7, SL), Pseudocalanus minutus (4360 ind/m³ at st. 12, SL), Oithona similis (3780 ind/m³ at st. 7, SL) and Calanus finmarchicus/glacialis (1901 ind/m³ at st. 7, SL). These four taxa always constituted more than 68% of the abundance proportion in the analyzed samples (Fig. 18).

Results of the cluster analyses are shown at Figs. 19 and 20. The analyses show clear differentiation of the samples. The values of abundance as a feature characterizing the samples resulted in division into two groups. The values of proportion taken as a feature, distinguished three groups, at the 75% level of similarity among the samples. The group of samples from all surface layers and intermediate layers at st. 7, separated in both clustering is characterized by 1) high abundance values of mesozooplankton, amounting for the four major taxa, i.e. Calanus finmarchicus/glacialis, Pseudocalanus minutus, Oithona similis and Bivalvia veliger at 1082, 2571, 2481, 5224 ind/m³ in average, respectively, and 2) the high proportion of Bivalvia larvae (39.88% in average), and the proportions of the remaining taxa as follows: Calanus finmarchicus/glacialis 10.30%, Pseudocalanus minutus 21.20% and Oithona similis 23.08% (in average). In that group of samples Echinodermata larvae and Limacina helicina juveniles also play an impor-

![Figure 17](image1.png)  
Figure 17 The abundance of mesozooplankton in Gipsvika, August 1989.

![Figure 18](image2.png)  
Figure 18 The proportion of mesozooplankton taxa in Gipsvika, August 1989.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Abundance of taxa</th>
<th>Proportion of taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calanus finm./gl. tot.</td>
<td>100.00</td>
<td>159</td>
</tr>
<tr>
<td>Calanus hyperboreus</td>
<td>53.33</td>
<td>1</td>
</tr>
<tr>
<td>Pseudocalanus min. tot.</td>
<td>100.00</td>
<td>131</td>
</tr>
<tr>
<td>Microcalanus spp.</td>
<td>60.00</td>
<td>8</td>
</tr>
<tr>
<td>Metridia longa</td>
<td>33.33</td>
<td>12</td>
</tr>
<tr>
<td>Acartia longiremis</td>
<td>100.00</td>
<td>18</td>
</tr>
<tr>
<td>Oithona similis</td>
<td>100.00</td>
<td>355</td>
</tr>
<tr>
<td>Oncaea borealis</td>
<td>53.33</td>
<td>9</td>
</tr>
<tr>
<td>Harpacticoida</td>
<td>6.67</td>
<td>12</td>
</tr>
<tr>
<td>Copepoda nauplii</td>
<td>46.67</td>
<td>6</td>
</tr>
<tr>
<td>Isopoda juv.</td>
<td>6.67</td>
<td>9</td>
</tr>
<tr>
<td>Bivalvia veliger</td>
<td>100.00</td>
<td>38</td>
</tr>
<tr>
<td>Limacina helicina juv.</td>
<td>100.00</td>
<td>6</td>
</tr>
<tr>
<td>Polychaeta larvae</td>
<td>46.67</td>
<td>6</td>
</tr>
<tr>
<td>Echinodermata larvae</td>
<td>93.33</td>
<td>10</td>
</tr>
</tbody>
</table>
The quantitative composition of mesozooplankton from Gipsvika did not differ very much from that known for mesozooplankton of other arctic and subarctic waters of the Canadian Arctic, coasts of Greenland, White Sea, Hornsund (Digby 1954, Kosztemy & Kwasniewski 1989, Kwasniewski in press, Prygunkova 1974, Smidt 1979, Ussing 1938), and from our unpublished data from Hornsund and Kongsfjorden. Probably, the hydrological regime prevailing in a particular locality, creates the proportion of taxa in the water body, appropriately bringing in open sea plankton or removing them by means of not suitable environmental conditions. The composition of mesozooplankton in Gipsvika seems typical for inner fjord waters with small inflow from open sea, at the time of investigation. The proportion of the main component of open sea mesozooplankton of West Spitsbergen (Calanus finmarchicus/glacialis) is higher than 60% (eslawski et al. unpublished data). This results in a proportion of the above mentioned species lower than or equal to that of Pseudocalanus minutus. A proportionally high percentage of Oithona similis (in all cases in intermediate layers) seems typical for this cosmopolitan species, which is very resistant to variable environmental conditions. Very noticeable, and different from our former observations from West Spitsbergen, is a higher proportion of Bivalvia veliger. It might be that we accidentally came upon the bloom of that larvae, which take place at the end of the arctic summer (Smidt 1979, Vinogradov 1977). Except for some values from the surface layer for Bivalvia veliger and Calanus finmarchicus/glacialis, the estimated abundance of mesozooplankton taxa is similar to that presented in the works cited above, and our data from West Spitsbergen fjords. It might be that the pattern of water circulation in Gipsvika, governed by bottom contours, tides and winds, resulted in ascending of amounts of plankton organisms by creating small, local upwellings and eddies.

The cluster analysis showed clear differentiation of mesozooplankton in the vertical axis. The water layers described on the basis of salinity-temperature measurements is reflected in the structure of the distribution of both features of plankton communities, i.e. abundance and quantitative composition. The surface layer, characterized by high abundance of plankton organisms and a high proportion of Bivalvia veliger, Pseudocalanus minutus and noticeably proportion of Echinodermata larvae and Limacina helicina juvenes, is strictly limited to the isothermal surface layer. The exception is the intermediate layer at st. 7. This layer has the same features as the
surface layer, which might be evidence of diverging surface waters in this local area. The intermediate layers are linked to the hydrologically described thermo- and halocline layers, and might be described as layers of low abundance, with high proportion of Oithona similis and Pseudocalanus minutus. The bottom layers, with much lower temperatures and much higher salinities, are populated mostly by Calanus finmarchicus/glacialis, Acaria longiremis and Microcalanus pygmaeus, as well as by Calanus hyperboreus and Polychaeta larvae. The abundance of organisms in that layer is very small. The qualitative and quantitative structure of mesozooplankton in Gipsvika indicates that the area, and the surface layer in particular, is important to the neighbouring marine ecosystem, because it might be a breeding ground of larvae of bottom organisms, and a feeding ground for sea birds, especially in the eddy area.

ACKNOWLEDGEMENTS

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