ENVIRONMENTAL ATLAS
GIPSDALEN, SVALBARD Vol. II

Reports on the Quaternary Geology, Vegetation, Flora and Fauna of Gipsdalen, and the Marine Ecology of Gipsvika.

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Reports on the Quaternary Geology, Vegetation, Flora,
and Fauna of Gipsdalen, and the Marine Ecology of Gipsvika.

Prepared for Northern Resources Ltd.
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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.
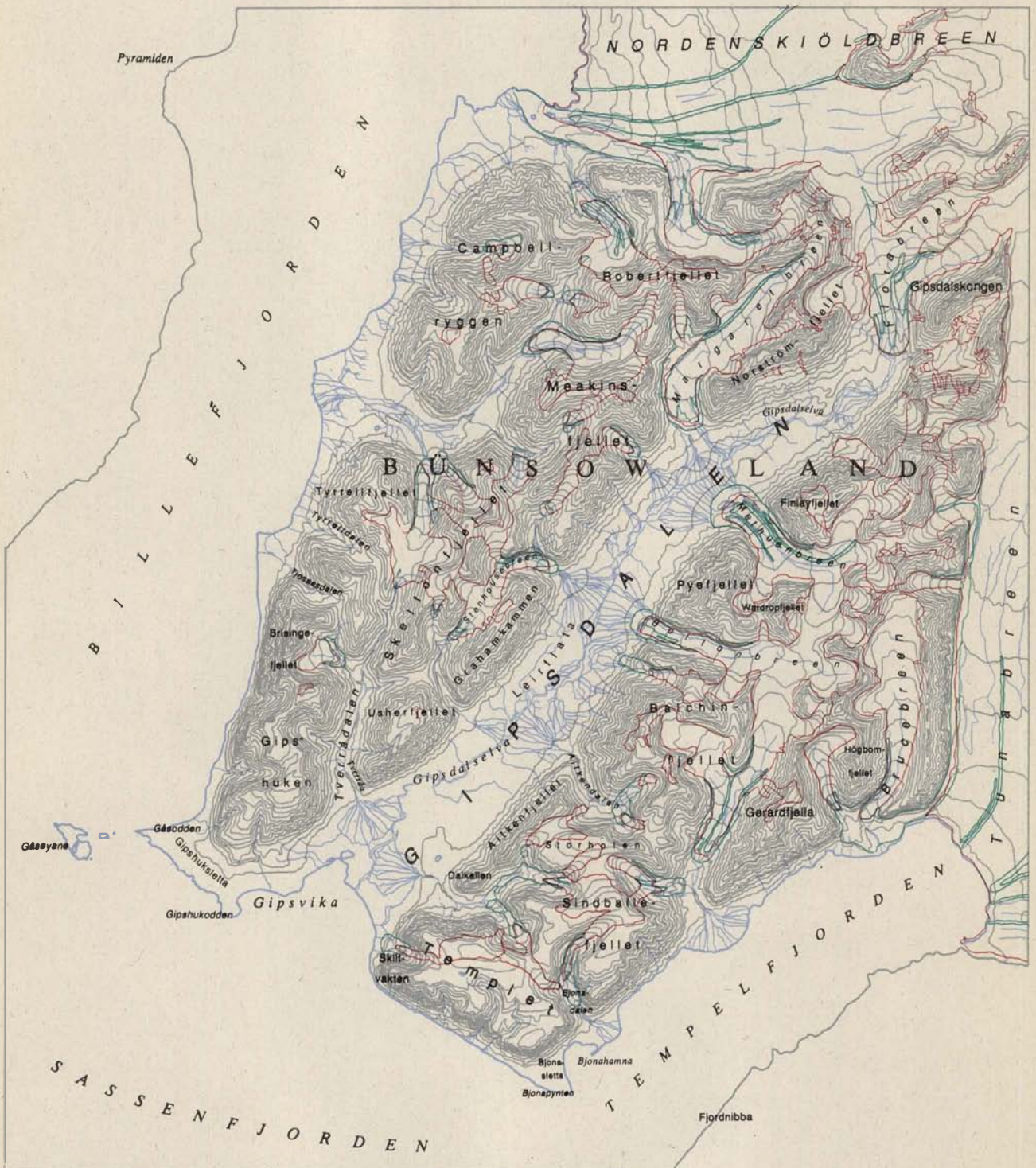
Per Ole Syvertsen:
The Fauna of Gipsdalen, Svalbard.

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

Rasmus Hansson:
Sensitivity of the Gipsdalen Environment (Vol. I).

Professionally responsible: Fridtjof Mehlum

Bünsow Land with Gipsdalen, Central Spitsbergen, Svalbard.

PREFACE

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 dis turbance, 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

TABLE OF CONTENTS

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

GEOMORPHOLOGY AND QUATERNARY GEOLOGY OF GIPSDALEN, SVALBARD

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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SUMMARY AND CONCLUSIONS

Gipsdalen is a typical, dry central Spitsbergen vally. Exept 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 *Invulnerable to wear:* surface continously changing, usually very coarse gravel or exposed bedrock/ ice. Traces of wear disappears 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, occurances 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 Usherfjellet, mainly on the eastern side of the river, most of the flat vegetated areas with fine-grained marine or gelifluction 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 invulnerable 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 exept 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 GIPSDALEN AREA

The Svalbard Archipelago contains an almost complete geological sequence ranging from the late Precambrian socalled Hecla Hoek metamorphic rocks (basement, about 1000 mill. years old), up to recent Quarternary 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 Reindalen area, Nordenskiøld Land north of Van Mijenfjorden and northward to Austfjorden, in the southern part of Wijdefjorden. The fault zone runs through the Gipshuken 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 plattform. 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 consits 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 andstones, 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, supratdal 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 invation 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 Quarternary 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 pecularity 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 sorrounding the valley. Gipshuksletta, Gipshukodden, Gåsodden and Gåsøyane concist 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).

GIPSDALEN, Svalbard   Geology

1 : 100,000

Groups (Gr), Formations (Fm)

Ebbadalen Fm Sandstone, conglomerate, shale and evaporite	Gipsdalen Gr	Carboniferous
Billefjord Gr Sandstone and coalbearing dark schist		Carboniferous
Hecla-Hoek, middle division Micaschist, dark phyllite and quartzite		Precambrium

Kapp Starostin Fm Chert, siltstone, siliceous sandstone and spiculitic shale	Tempelfjorden Gr	Permian
Gipshuken Fm Interbedded anhydrite and dolomite (lower), dolomite and calcite (upper) and sandstone	Gipsdalen Gr	Permian
Nordenskiöldbreen Fm Mainly limestone	Gipsdalen Gr	Permian

Billefjorden Fault Zone		
Quaternary deposits		
Dolerite		Jurassic-Cretaceous

Modified from Lauritzen, Salvigsen and Winsnes 1988.
Billefjorden Geological map Svalbard 1:100,000

Figure 1 The geology of Gipsdalen, Bunzow land, Svalbard. Modified from Lauritzen, Salvigsen and Winsnes 1988. Billefjorden Geological map Salbard 1:100 000.

GEOMORPHOLOGY AND QUATERNARY GEOLOGY OF GIPSDALEN, SVALBARD

INTRODUCTION

In the corse 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 (Høgvard & 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 availible 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 stereoautograph (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 to day, 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.
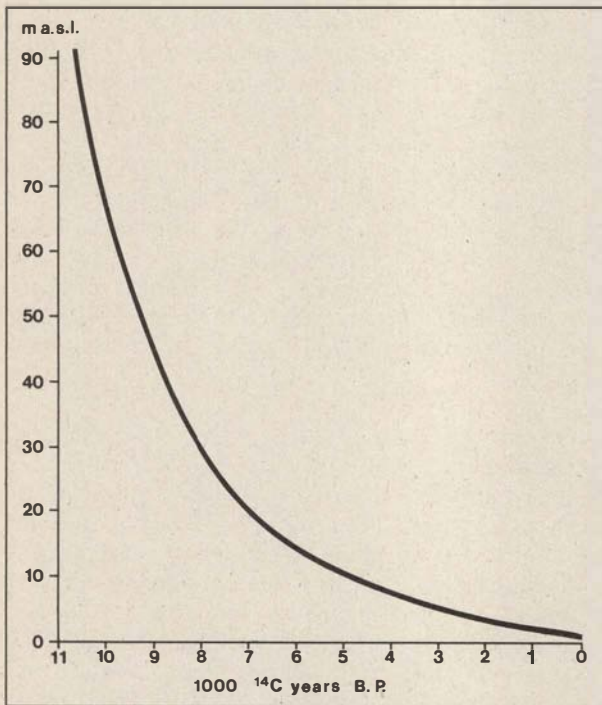
Figure 3 Shorline displacement curve for the Kapp Ekholm - Ekholmvika area in Billefjorden, based mainly on radiocarbon dates and pumice obserations (from Salvigsen 1984).

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 Fennoskandia.

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
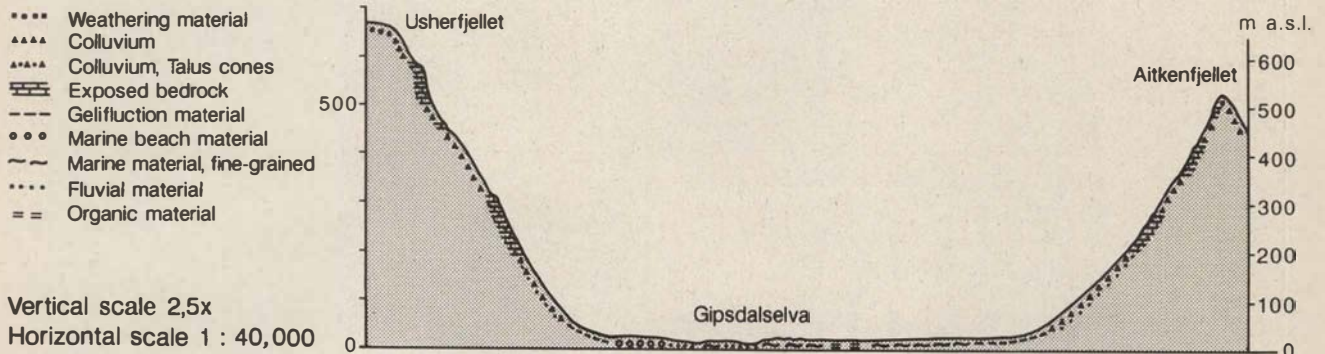
Figure 2 Cross profile from Usherfjellet in NW to Aitkenfjellet in SE, 5 km from the fjord.

Figure 4 Raised beach ridges around the outlet of Gipsdalselva. Note the distinct vehicular track crossing the area.
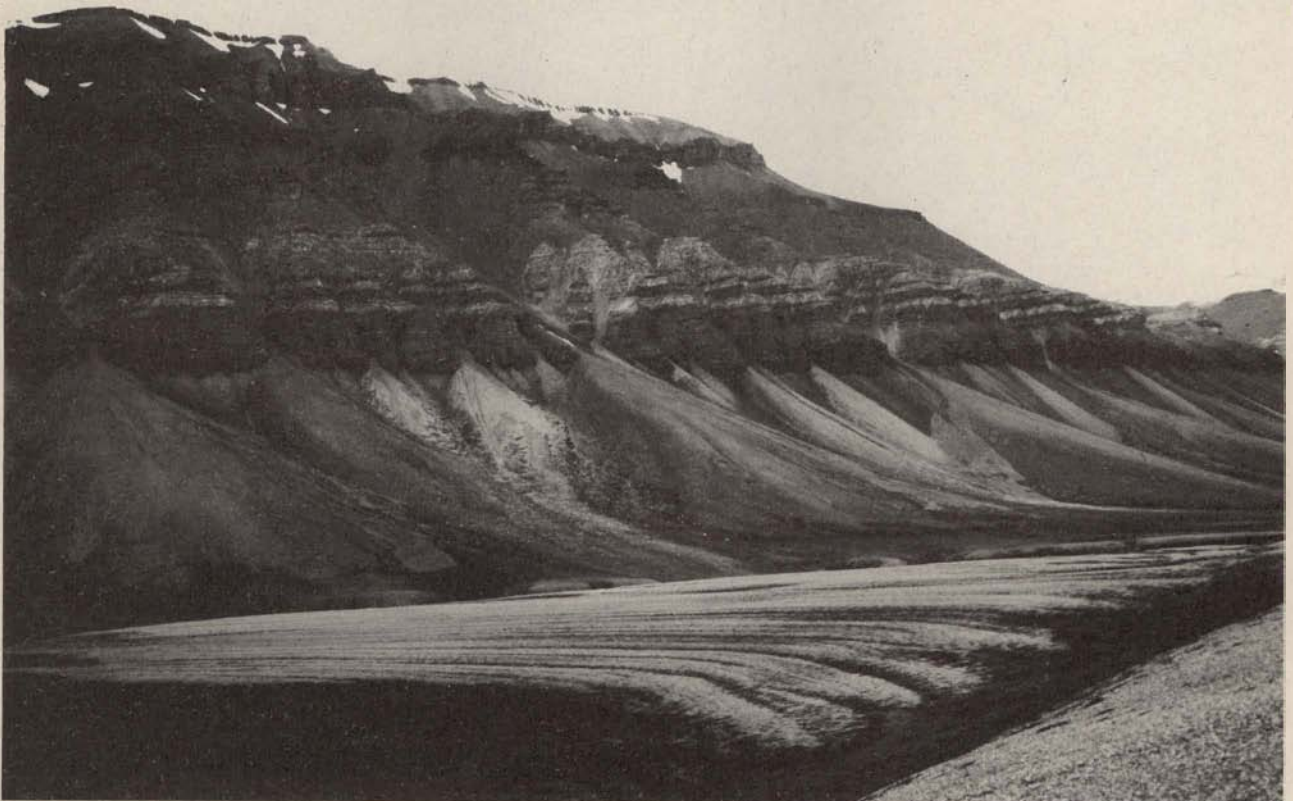
Figure 5 Talus cones and avalanche tracks at Usherfjellet. Many of the cones are scoured by debris-flow channels. View towards N.

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 m^2), and a larger one in front of Methuenbreen close to the Finncoal Development (FCD) camp, covering an area of 0.67 km^2 (Fig. 7). Assuming a mean thickness of 2 m (probably a low estimate), this represents 1.3 mill. m^3 of water.   Satellite images were examined to check the dimentions 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 km^2 compared to 0.12 and 0.11 km^2). 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

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

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).
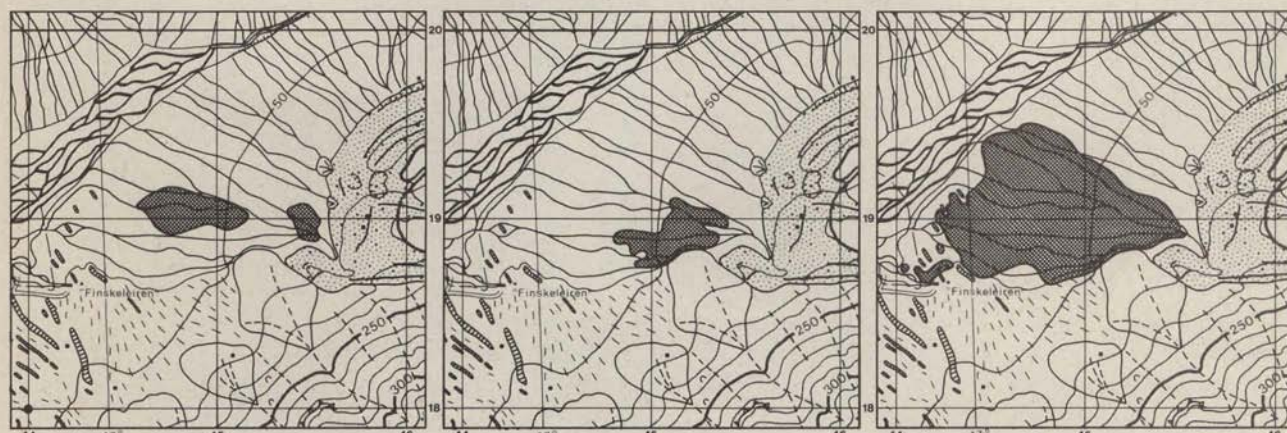
Large moraine ridges lie in front of the current glaciers. As usual on Svalbard, these moraines contain a core of glacial ice covered by till. They are thus called ice-cored moraines. The vegetation cover is relatively thin and discontinuous in large areas of Gipsdalen, except for moist areas with fine-grained 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 occurences 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 & Sørbel 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 can not establish due to continously changing ground surface.

Fluvial material, recent is transported and deposited by running water in connection with currently active rives. 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 postglacial 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

GIPSDALEN, Svalbard
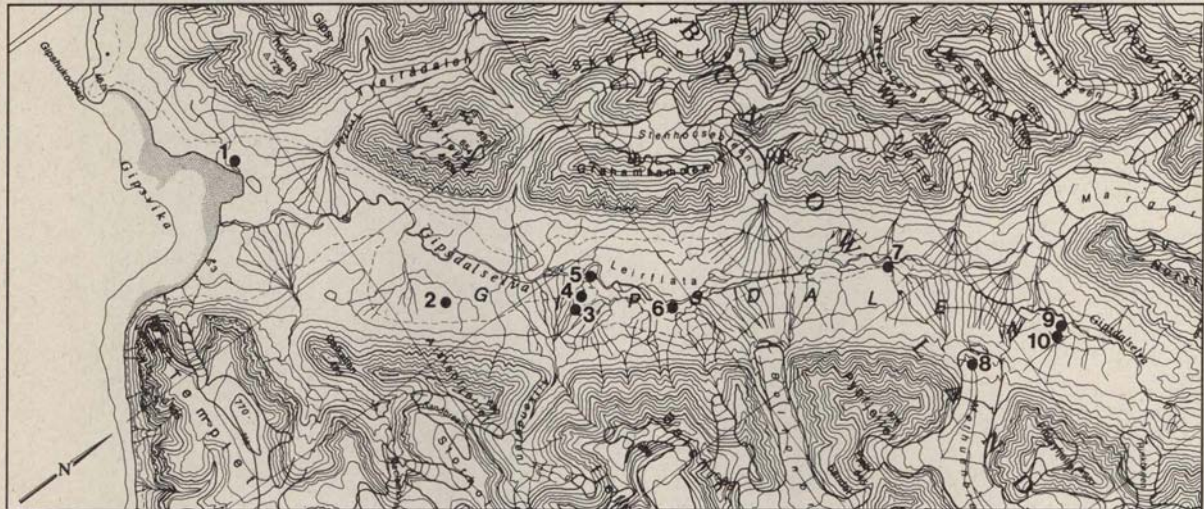
● Localities for sediment samples

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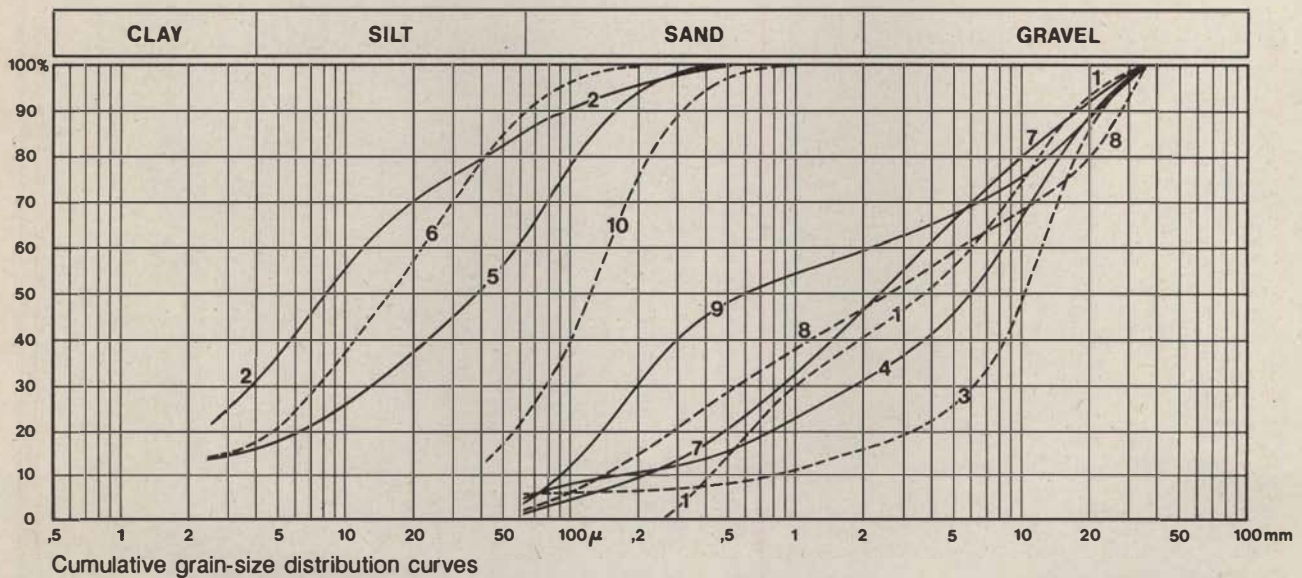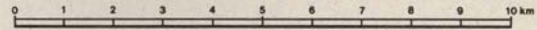
Figure 9 Sampling sites and cumulative grain size distribution curves for 10 sediment samples from Gipsdalen. The table shows Md (median grain size diameter) and So (sorting).

Sample no.	MD (in mm)	So
1	3,7	1,14
2	0,0085	0,96
3	9,7	0,51
4	5,5	1,00
5	0,040	1,07
6	0,016	0,74
7	2,3	1,08
8	2,5	1,62
9	0,64	1,75
10	0,126	0,49

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, particulatrly 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.

material builds up well-formed talus cones along both sides of Gipsdalen (Fig. 5).

Gelifluction material. 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 gelifluction 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 resitant 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 are 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 resistent Heckla-Hoek surfaces. Rock surfaces in the mapped area are otherwise so heavily weathered that old glacial striae are seldom preserved. Glacial stria 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.

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 stripes of till in the glacier's longitudinal direction. If the thickness of the till becomes more than a few cm, 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 litterature, 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, whith 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 postglacial time.

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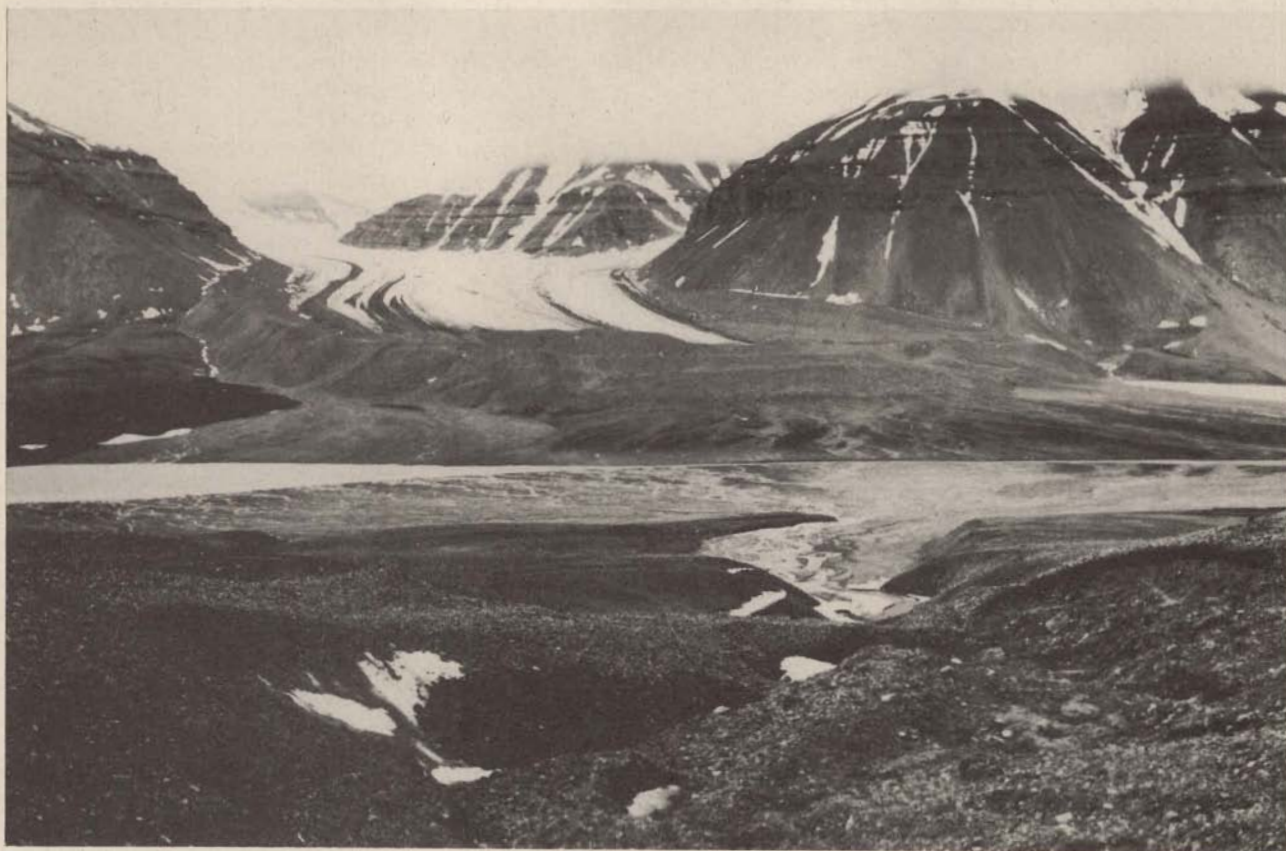
Figure 11 Terminal and medial moraines at Methuenbreen, view from the ice-cored moraine in front of Margaretbreen towards SE.

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.

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 8 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 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 heigh, 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 assosiated 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 characteristical 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 how 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 hum

mocks 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 beach-ridge 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.
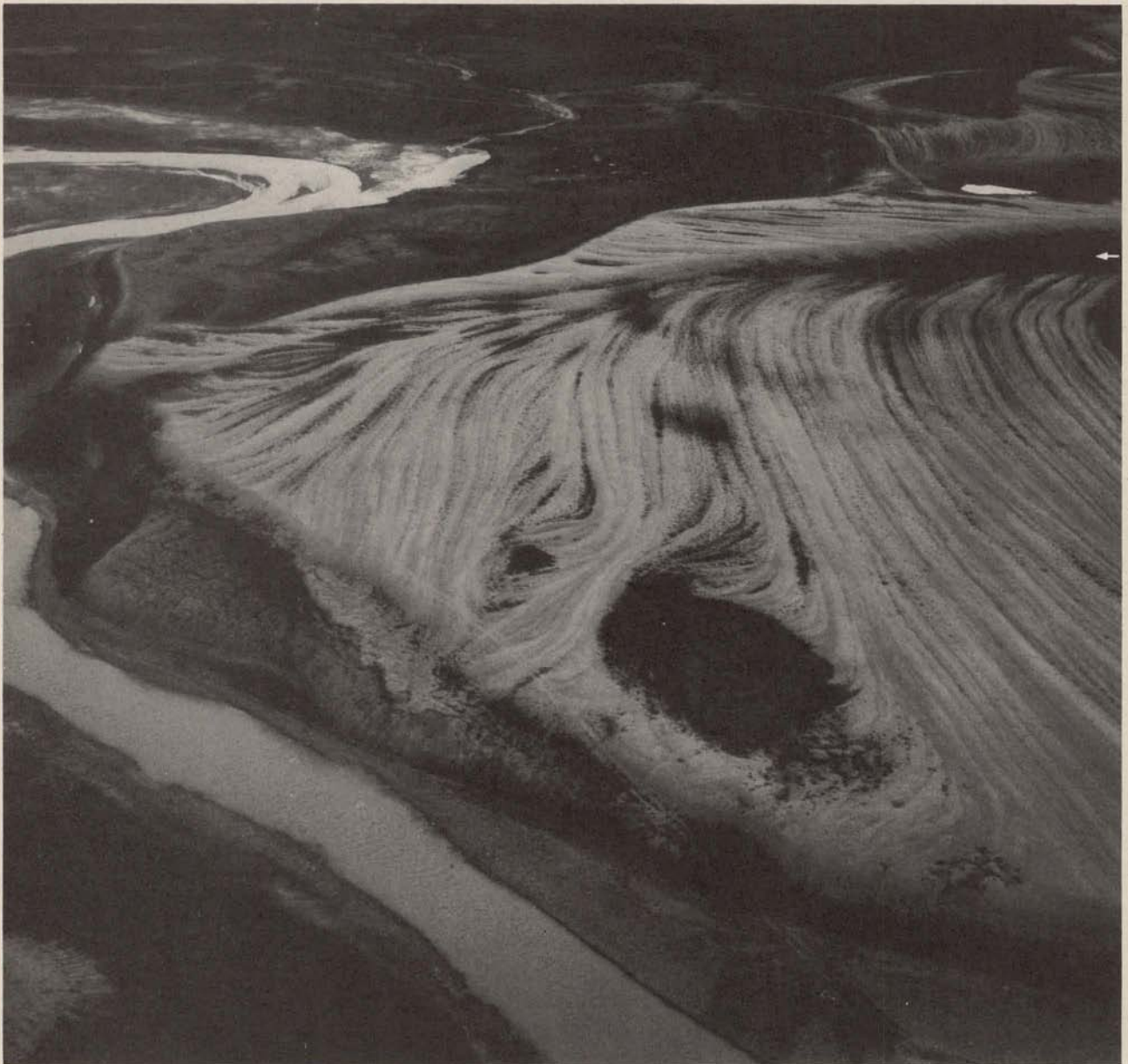
Figure 13 Raised beach ridges along Gipsdalselva south of Usherfjellet. View towards SE. A strandline is marked with an arrow. Note also the distinct vehicular track in the background and the less distinct track in the foreground.
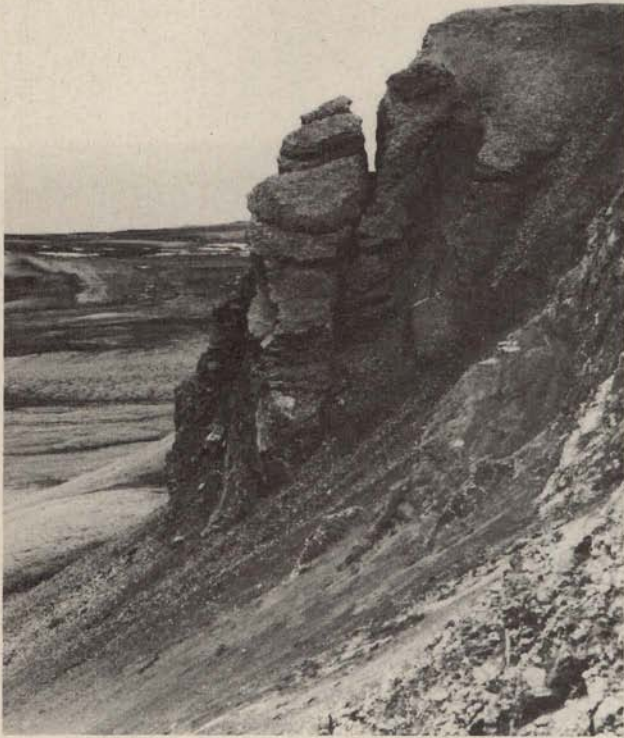
Figure 14 Large erosion scarp in limestone south of Gipshuken. View towards W.
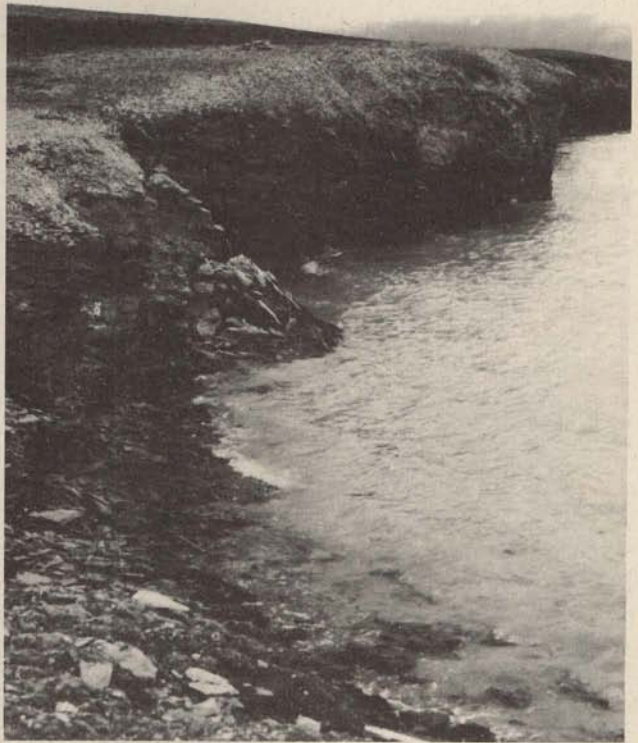
Figure 15 Small marine erosion scarp in limestone at Gipvsika. The height of the scarp is 4 m.

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 servere frost. The actual formation process is not yet clear.

Sorted Cicles 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 gelifluction 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 gelifluction 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 seperate from ice-cored moraines. In Gips-
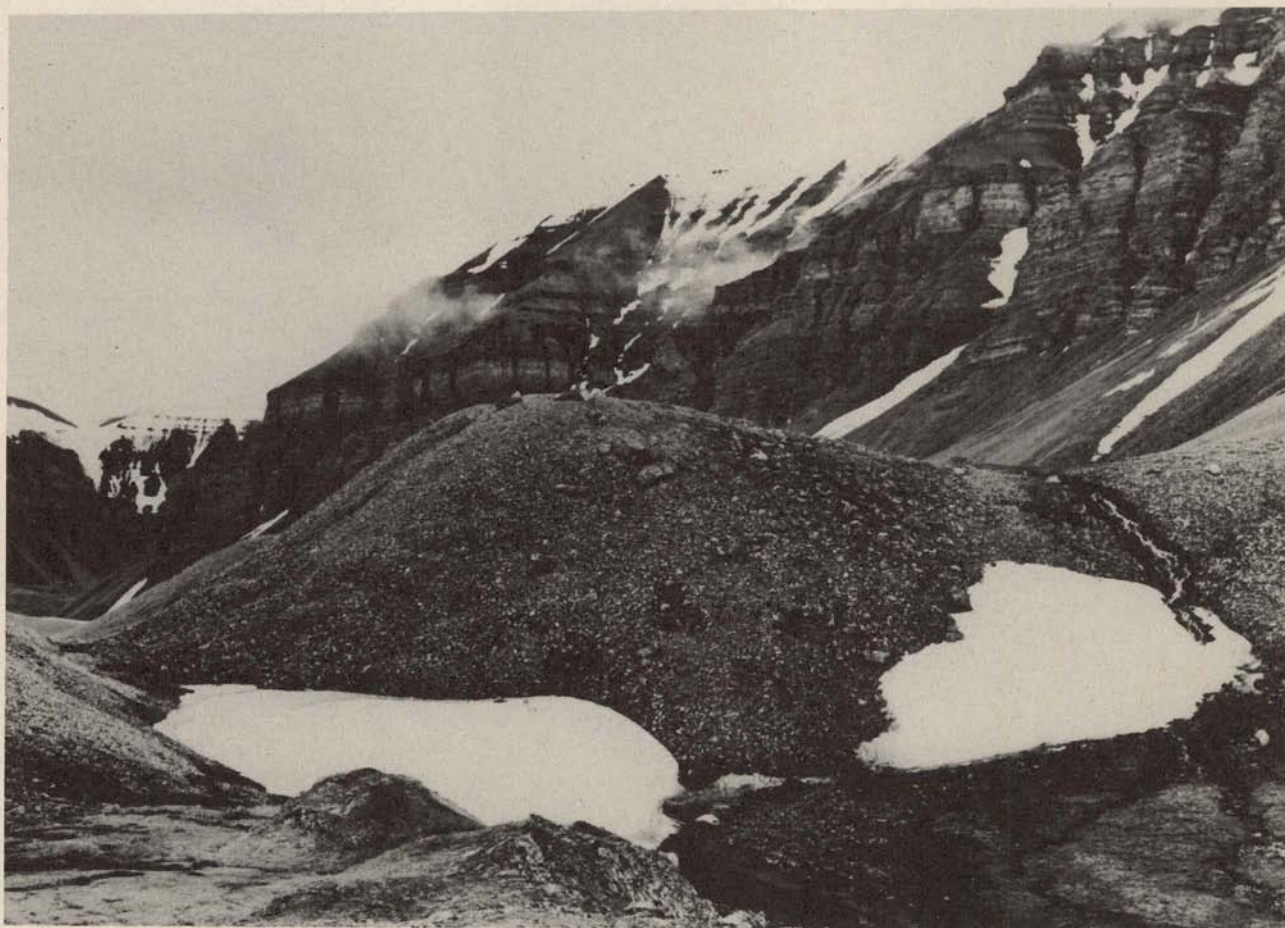
Figure 17 Rock glacier north of Templet. The front is about 20 m high. View towards E.

dalen, however, rock glaciers of this type do not occur.

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
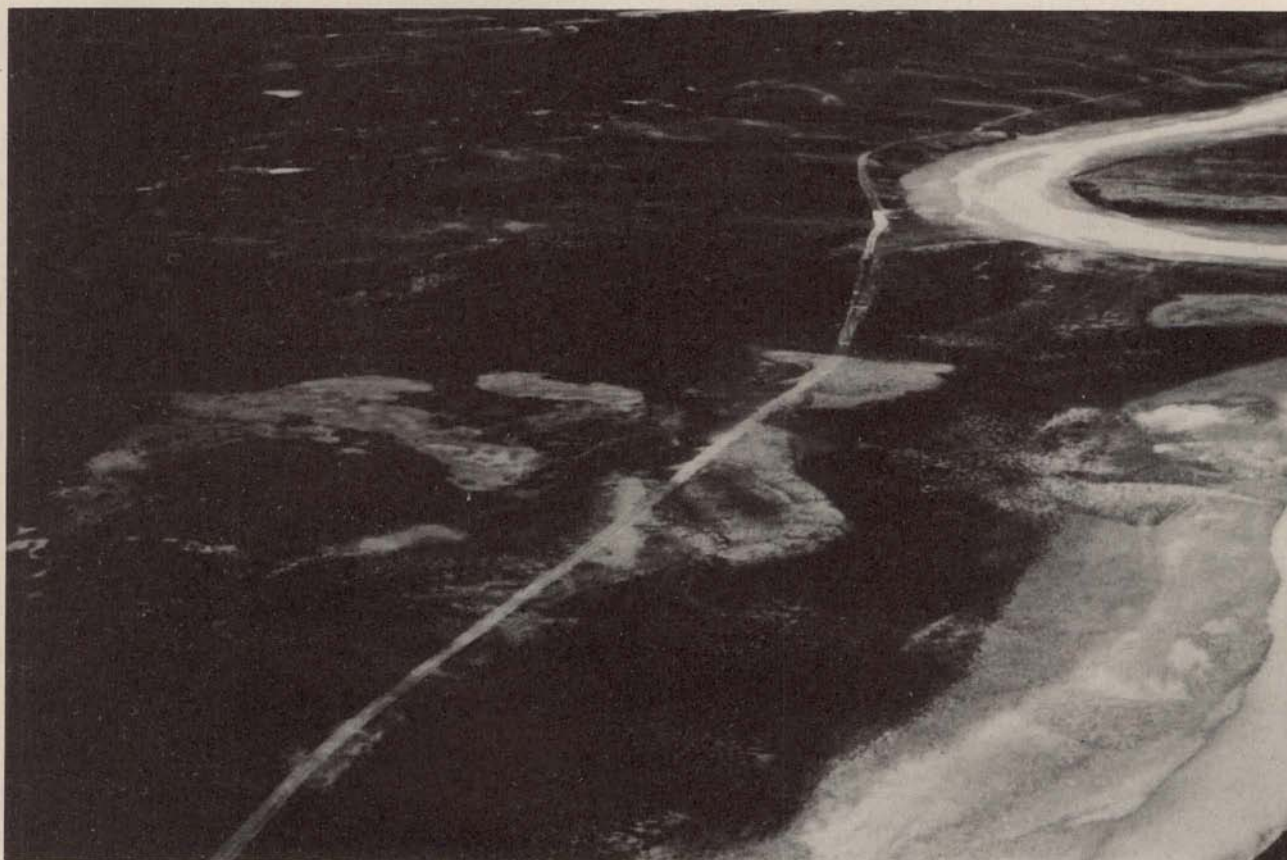
Figure 18 Mounds (erosion remnants consisting of fine-grained marine material) close to Gipsdalselva SE of Usherfjellet. Note vehicular track crossing the mounds. View towards SW.

surficial material, topography, permafrost con-
-
ditions, 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 ex-
posed to terrain wear, since wear here may trig-
ger off mass movement and cause serious erosion.
The exposure is significant for snow accumu-
lation, 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 con-
ditions. 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 melt-

ing and bring about larger and more lasting
damage (Fig. 19). Tracks on slopes act as chan-
nels 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 "vulnera-
bility 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 vul-
nerable 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 evalu-
ate 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 & Tolgensbakk (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.

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 continously 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 sparce 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 loclized 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, occurances 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.

Geer moraines no other landforms are found worthy of conservation.

Current alluvial plains and active alluvial fans in front of the side valleys are changing continously 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.
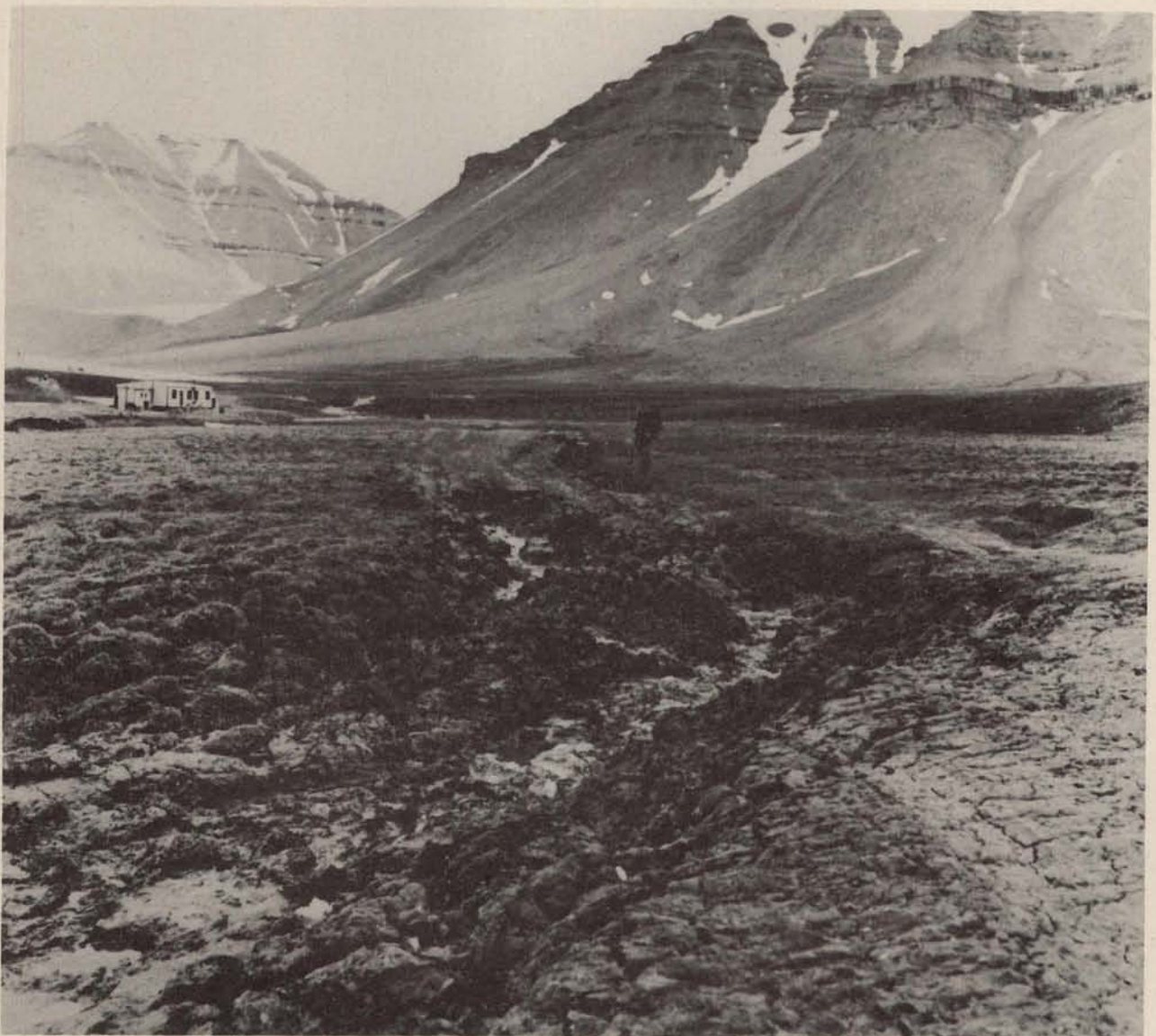
Figure 22 Vehicular track close to the Finncoal Development camp. The damage is severely increased by melting and fluvial erosion. Vulnerability Group 4 area due to fine-grained marine material with high ice/water content. View towards E.

GIPSDALEN, Svalbard   Evaluation of Vulnerability

1 : 100,000

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

Juvenlie, but reproductive *Braya purpurascens* (foto: Reidar Elven).

by
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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 exeption 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 silty ridges; (c) silty 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 botanmical 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. Engelskjøn, 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 Meakinsfjellet and Tverråa 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 Methuenbreen 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, Gipshuksletta, 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 prodvide 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 circumneutral 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.

Tributory river fans, gravelly.

Raised beach ridges, calcarcous 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.

(see pp. 60). 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

The general climate of Svalbard is arctic-oceanic (see Walter 1973, Walter-type IX), but with large local differences.

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 bee seen from the deposits of aeolian silt. Enhanced radiation, however, may compensate for the thermic effects.

Phytogeographical position

The earliest subdivision of Svalbard into phytogeograpical areas was made by Summerhayes & Elton (1928). They divided the coastal areas of the islands into four zones: the climatically most favourable Inner Fjord Zone, the somewhat less favourable *Cassiope tetragona* (kantlyng) zone, the very widely distributed *Dryas octopetala* (reinrose) Zone, and the Barren Zone (mostly polar deserts). Bünsow Land is located in the most favourable part, the Inner Fjord Zone.

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
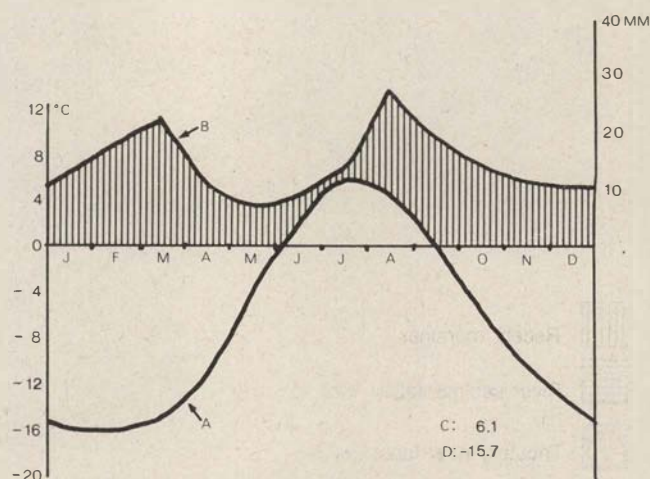
Figure 2 Simplified Walter-type climate diagramme of Longyearbyen (Svalbard airport), based on the period 1975-1988. Indicated are monthly means of temperature (a) and precipitation (b), yearly means, and means of temperature for the warmest (c) and coldest (c) months. The hatched area indicates the period where the percipitation is sufficient to prevent drough (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 phyto-geographical areas emphasize the south - north changes in climate, vegetation, and flora at a larger geographical scale (Alexandrova 1980, Elvebakk 1985, 1989b). 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 km^2 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 Gåsodden - Gipshukodden 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 Lundströmdalen). 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 Engelskjøn 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
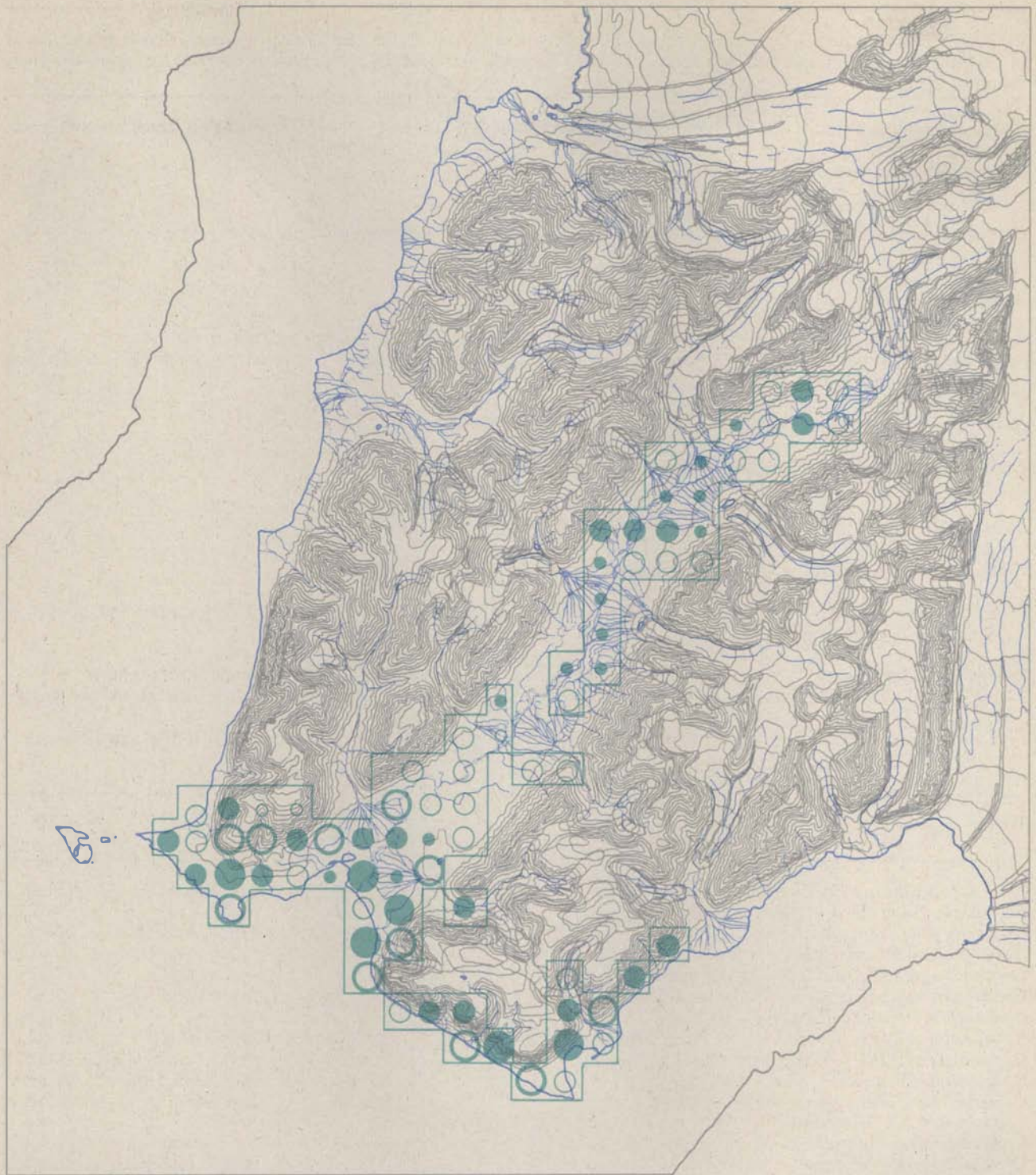
Figure 3 Vascular plant diversity, given as species number within 1 km squares approximatly in the UTM grid. Total numbers of species in each 1 km square are given by dot sizes: 1) 10-14 species, 2) 15-24, 3) 25-34, 4) 35-44, 5) 45-54, and 6) =55 species. Squares without symbols have not been investigated. Data from Engelskjøn 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 Franza Josifa, Novaya Zemlya).

Taxon	R	S/N-distr.	E/W-distr.
Alopecurus alpinus Sm. - polarreverumpe	3	Arct-Scand	C-pol
Arctophila fulva (Trin.) N.J.Anderson - hengegras	3	Arct	C-pol
Arenaria pseudofrigida (Ostenf. & Dahl) Juz. - kalkarve	3	Arct-Scand (N)	N-Atl
Braya purpurascens (R.Br.) Bunge - purpurkarse	3	Arct	C-pol
Cardamine bellidifolia L. - høgfjellskarse	3	Arct-Scand	C-pol
Cardamine pratensis L. ssp. *polemonioides* - polarkarse	3	Arct-Scand	C-pol
Carex amblyrhyncha V.Krecz. - buttstarr	1	Arct	C-pol
C. maritima Gunn. - buestarr	3	Arct-Alp (C)	C-pol
C. misandra R.Br. - dubbestarr	3	Arct-Scand	C-pol
C. nardina Fr. - skjeggstarr	3	Arct-Scand (N)	W-Arct
C. parallela (Læst.) Sommerf. - smalstarr	3	Arct-Scand	N-Atl
C. rupestris All. - bergstarr	3	Arct-Alp	C-pol
C. saxatilis L. - blankstarr	3	Arct-Scand	N-Atl
C. subspathacea Wormsk. - ishavsstarr	3	Arct-Scand (C)	C-pol
C. ursina Dewey - bjørnestarr	3	Arct (C)	C-pol
Cassiope tetragona (L.) D.Don - kantlyng	3	Arct-Scand (N)	C-pol
Cerastium arcticum Lange - snøarve	3	Arct-Scand	N-Atl
C. arcticum x regelii	?	Arct	?
C. regelii Ostenf. - polararve	3	Arct	C-pol
Chrysosplenium tetrandrum (N.Lund) Th.Fr. - dvergmaigull	3	Arct-Scand (N)	C-pol
Cochlearia groenlandica L. - polarskjørbuksurt	3	Arct	C-pol
Cystopteris fragilis (L.) Bernh. ssp. *dickieana* (Sim) Hyl. - berglok	3	Arct-Alp	C-pol
Deschampsia alpina (L.) Roem. & Sch. - fjellbunke	3	Arct-Scand	±C-pol
D. brevifolia R.Br. - stivbunke	3	Arct	C-pol
D. adamsii Ledeb. - polarrublom	3	Arct	C-pol
D. alpina L. - gullrublom	3	Arct-Scand	C-pol
D. arctica J.Vahl - "hårrublom"	3	Arct	C-pol?
D. corymbosa R.Br. - puterublom	3	Arct	C-pol
D. daurica DC. - skredrublom	3	Arct-Scand	C-pol

Table 1 (cont.)

Taxon	R	S/N-distr.	E/W-distr.
Deschampsia lactea Adams - lapprublom	3	Arct-Scand	C-pol
D. micropetala Hook. - tundrarublom	?	Arct	?
D. norvegica Gunn. - bergrublom	3	Arct-Scand	N-Atl
D. oxycarpa Sommerf. - bleikrublom	3	Arct-Scand	N-Atl
D. subcapitata Simmons - halvkulerublom	3	Arct	C-pol
Dryas octopetala L. - reinrose	3	Arct-Alp	E-Arct
Dupontia pelligera Rupr. - småtundragras	3	Arct	C-pol
D. psilosantha Rupr. - spriketundragras	3	Arct	C-pol
Equisetum arvense L. ssp. *boreale* (Bong.) Á.Löve - "polarsnelle"	3	Arct-Scand	C-pol
E. variegatum Schleich. - fjellsnelle	3	Arct-Alp	C-pol
Erigeron humilis Grah. - svartbakkestjerne	3	Arct-Scand (N)	W-Arct
Eriophorum scheuchzeri Hoppe - snøull	3	Arct-Alp	C-pol
E. triste (Th.Fr.) Á.Löve & Hadač - svartull	3	Arct	C-pol
Eutrema edwardsii R.Br. - polarreddik	3	Arct	C-pol
Festuca baffinensis Polunin - hårsvingel	3	Arct	W-Arct
F. hyperborea Holmen - polarsvingel	3	Arct	C-pol
F. rubra L. ssp. *arctica* (Hack.) Govor. - raudsvingel	3	Arct-Scand	C-pol
Hierochloë alpina (Sw.) R.Br. - fjellmarigras	3	Arct-Scand (N)	C-pol
Juncus biglumis L. - tvillingsiv	3	Arct-Scand	C-pol
J. castaneus Sm. - kastanjesiv	1	Arct-Alp	C-pol
J. triglumis L. - trillingsiv	2	Arct-Alp	C-pol
Kobresia simpliciuscula (Wg.) Mack. - myrtust	1	Arct-Alp	C-pol
Luzula arctica Blytt - snøfrytle	3	Arct-Scand	C-pol
L. arcuata Sw. ssp. *confusa* (Lindeb.) Blytt - vardefrytle	3	Arct-Scand	C-pol
Mertensia maritima (L.) S.F.Gray - østersurt	3	Arct-Scand (C)	W-Arct
Minuartia biflora (L.) Sch. & Th. - tuvearve	3	Arct-Alp	C-pol
M. rossii (R.Br.) Graebn. - putearve	3	Arct	W-Arct
M. rubella (Wg.) Hiern - nålearve	3	Arct-Scand	C-pol
M. stricta (Sw.) Hiern - grannarve	2	Arct-Alp	C-pol
Oxyria digyna (L.) Hill - fjellsyre	3	Arct-Alp	C-pol
Papaver dahlianum Nordh. - svalbardvalmue	3	Arct	N-Atl
Pedicularis hirsuta L. - lodnemyrklegg	3	Arct-Scand (N)	N-Atl
P. lanata Cham. & Schlecht. ssp. *dasyantha* (Trautv.) Hult. - ullmyrklegg	3	Arct	E-Arct
Phippsia algida (Sol.) R.Br. - snøgras	3	Arct-Scand	C-pol
P. concinna (Th.Fr.) Lindeb. - sprikesnøgras	3	Arct-Scand	E-Arct
Poa abbreviata R.Br. - jøkelrapp	3	Arct	C-pol
P. alpina L. var. *vivipara* L. - fjellrapp	3	Arct-Alp	±C-pol
P. arctica R.Br. coll. - jervrapp	3	Arct-Scand (N)	C-pol
P. glauca J.Vahl - blårapp	3	Arct-Alp	C-pol
P. pratensis L. ssp. *alpigena* (Fries) Hiit. - seterrapp			
viviparous biotype	3	Arct	C-pol
seminiferous biotype	3	Arct-Scand	C-pol
Polemonium boreale Adams - polarflokk	3	Arct	C-pol
Polygonum viviparum L. - harerug	3	Arct-Alp	C-pol
Potentilla hyparctica Malte - raggmure	3	Arct-Scand (N)	C-pol
P. nivea L. coll. - snø/flågmure	3	Arct-Alp	C-pol
P. pulchella R.Br. - tuvemure	3	Arct	C-pol
P. sp.	?	Arct?	W-Arct?
Puccinellia angustata (R.Br.) Rand. & Redf. - polarsaltgras	3	Arct	C-pol
P. phryganodes (Trin.) Scribn. & Merr. - teppesaltgras "Svalbard - Novaya Zemlya type"	3	Arct	End
Puccinellia vahliana (Liebm.) Scribn. & Merr. - fimbulgras	3	Arct	C-pol
Pucciphippsia vacillans (Th.Fr.) Tzvelev - svalbardfimbulgras	2	Arct	End?
Ranunculus hyperboreus Rottb. - setersoleie	3	Arct-Scand	C-pol
R. pedatifidus Sm. - fliksoleie	2	Arct	C-pol
R. pygmaeus Wg. - dvergsoleie	3	Arct-Alp	C-pol
R. sulphureus C.J.Phipps - polarsoleie	3	Arct-Scand (N)	C-pol
Sagina intermedia Fenzl - jøkelarve	3	Arct-Scand	C-pol
Salix polaris Wg. - polarvier	3	Arct-Scand	E-Arct
S. reticulata L. - rynkevier	3	Arct-Alp	±C-pol
Saxifraga aizoides L. - gulsildre	3	Arct-Alp	W-Arct
S. cespitosa L. - tuvesildre	3	Arct-Scand	±C-pol

Table 1 (cont.).

Taxon	R	S/N-distr.	E/W-distr.
Saxifraga cernua L. - knoppsildre	3	Arct-Alp	C-pol
S. flagellaris Sternb. & Willd. - trådsildre	3	Arct	C-pol
S. hieracifolia Waldst. & Kit. - stivsildre	3	Arct-Alp	C-pol
S. hirculus L. - myrsildre	3	Arct-Alp	C-pol
S. hyperborea R.Br. - polarsildre	3	Arct	C-pol
S. nivalis L. - snøsildre	3	Arct-Scand	C-pol
S. oppositifolia L. - raudsildre	3	Arct-Alp	C-pol
S. rivularis L. - bekkesildre	3	Arct-Scand	C-polS.
S. svalbardensis Øvstedal - svalbardsildre	3	Arct	End
Silene acaulis (L.) Jacq. - fjellsmelle	3	Arct-Alp	W-Arct
S. furcata Rafin. ssp. *furcata* - småjonsokblom	3	Arct	C-pol
S. uralensis (Rupr.) Bocq. ssp. *arctica* (Th.Fr.) Bocq. - "arktisk blindurt"	3	Arct	C-pol
Stellaria humifusa Rottb. - ishavsstjerneblom	3	Arct-Scand (C)	C-pol
S. longipes Goldie coll. - snøstjerneblom	3	Arct-Scand (N)	C-pol
Taraxacum arcticum (Trautv.) Dahlst. - arktisløvetann	3	Arct	C-pol
Trisetum spicatum (L.) K.Richt. - svartaks	3	Arct-Alp	C-pol

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 km squares. The taxa are listed in order of decreasing frequencies.

Group/taxa	Freq	Habitat type(s)

High frequency group (70-100 %)

Saxifraga oppositifolia	99	Ubiquitous
Salix polaris	95	± Ubiquitous
Draba corymbosa	92	Open calcareous heath, gravel
Cerastium arcticum	87	± Ubiquitous
Polygonum viviparum	87	± Ubiquitous
Dryas octopetala	84	Heath, mostly calcareous
Carex misandra	82	Calcareous heath
Pedicularis hirsuta	81	Humic heaths and meadows
Equisetum variegatum	80	± Ubiquitous
Juncus biglumis	79	Snowbeds, marshes, damp soil
Puccinellia vahliana	79	Open calcareous heath, silt
Saxifraga cernua	76	± Ubiquitous
Saxifraga aizoides	74	Slopes, calcareous and anhydrite
Braya purpurascens	72	Calcareous gravel/silt
Carex rupestris	72	Heath, mostly calcareous
Stellaria longipes coll.	72	± Ubiquitous
Minuartia rubella	70	± Ubiquitous, mostly calcareous

Intermediate frequency group (30-69%)

Draba oxycarpa	68	± Ubiquitous
Luzula arctica	67	Heaths to snowbeds
Poa alpina var. *vivipara*	67	Meadows, snowbeds
Saxifraga cespitosa	65	± Ubiquitous
Equisetum arvense	63	Flushed ground
Pedicularis lanata ssp. *dasyantha*	62	Calcareous heaths
Papaver dahlianum	59	Lithosol, debris
Deschampsia alpina	58	Marshes, wet soil
Cerastium regelii	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	Calcareous marshes
Oxyria digyna	46	Snowbeds, open soil
Cochlearia groenlandica	43	Snowbeds, bird cliffs etc.

Table 2 (cont.).

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

Low frequency group (5-29 %)

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

Very low frequency group (1-4 %)

Carex amblyorhyncha	4	Warm, sloping marshes
Juncus triglumis	4	Warm, stony marsh
Luzula arcuata ssp. *confusa*	4	Peat on silicic ledge
Potentilla nivea	4	Bird-cliffs, scree
Saxifraga hyperborea	4	Silicic gravel, peat
Stellaria humifusa	4	Salt marshes
Taraxacum arcticum	4	Warm slopes
Pucciphippsia vacillans	3	Riverbanks, silt/gravel
Dupontia psilosantha	3	Stagnant marshes
Erigeron humilis	3	Warm slopes
Saxifraga svalbardensis	3	Wet moss carpets, marsh
Arctophila fulva	1	Pond marginal
Cardamine bellidifolia	1	Silicic lithosol
Carex maritima	1	Peaty seashore
Cerastium arcticum x *regelii*	1	River fan, open gravel

Table 2 (cont.).

Group/taxa	Freq	Habitat type(s)
Juncus castaneus	1	Warm, sloping marsh
Kobresia simpliciuscula	1	Warm, sloping marsh*Minuartia stricta* 1 Peaty llbed
Potentilla hyparctica	1	Heath on dolerite
Saxifraga rivularis	1	Wet, silicic gravel

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 arcuata* ssp. *confusa* (vardefrytle), *Hierochloë alpina* (fjellmarigras), *Poa arctica* (jervrapp), and *Potentilla hyparctica* (raggmure), 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 algida* (snøgras) 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* - fjellsolblom (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* - snøsoleie (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. *Arctophila*, *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 Bjonahamna. The single highest value is found in the 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 well-vegetated 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.

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 parallela* (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 (se Böcher 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:

Pucciphippsia 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* (sprikesnøgras) 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* (tuvemure) 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 pseudofrigida* (kalkarve). - Dry calcareous gravel and ridges.
> *Braya purpurascens* (purpurkarse). - 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* (putearve). - Flushed slopes and gravel.
> *Pedicularis lanata* ssp. *dasyantha* (ullmyrklegg). - Calcareous dry tundra.
> *Juncus triglumis* (trillingsiv). - 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). - Gipshuken, 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 Gipshukodden (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.
> *Luzula arcuata* ssp. *confusa* (vardefrytle). - On the dolerite at Gipshukodden (WH 3109), and

on the Hecla Hoek quartzite in the uppermost valley (WH 4822 a.o.); calcifuge.
> *Potentilla hyparctica* (raggmure). - On the dolerite at Gipshukodden (WH 3107); calcifuge.
> *Saxifraga hyperborea* (polarsildre). - Gipshuken, above 400 m (WH 3310, 3311).
> *Saxifraga rivularis* (bekkesildre). - Below Cooperbreen (WH 3807).
> *Taraxacum arcticum* (arktisløvetann). - Gipshukodden - Gåsodden area; one locality on Gipshukodden not exactly localized (H. Resvoll-Holmsen 1908, Herb. TROM).

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. *norvegica* (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 exeption 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 amblyrhyncha, 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 arcuata* ssp. *confusa* and *Potentilla hyparctica* on the rare outcrops of acidic bedrock at Gipshukodden 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 - Gipshukodden plain and the slopes east of Gipshuken 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 Bjonahamna; (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* (bjørnestarr), (5) *Dupontia psilosantha* (stortundragras), (6) *Erigeron humilis* (svartbakkestjerne), (7) *Juncus castaneus* (kastanjesiv), (8) *J. triglumis* (trillingsiv), (9) *Kobresia simpliciuscula* (myrtust), (10) *Luzula arcuata* ssp. *confusa* (vardefrytle), (11) *Minuartia stricta* (grannarve), (12) *Potentilla chamissonis/nivea* group (snømure/flågmure), (13) *P. hyparctica* (raggmure), (14) *Pucciphippsia vacillans* (svalbardfimbulgras), (15) *Saxifraga svalbardensis* (svalbardsildre), (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.

pretation 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 physiognomically 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 gravelly 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

Subgroup 11   Exposed gravelly ridges with discontinuous vegetation cover
    Type 111   Open *Dryas-Carex rupestris* type
    Type 112   Open *Dryas* type
Subgroup 12   Dry closed heath vegetation of xerophilous vascular plants and partly lichens
    Type 121   Closed *Dryas* and *Dryas-Carex rupestris* type
    Type 122   *Cassiope tetragona* and *Dryas-Cassiope* type
Subgroup 13   Warm, favourable slopes with closed, thermophilic vegetation
    Type 132   Thermophilous *Festuca rubra* type
    Type 133   Thermophilous *Festuca baffinensis* type
    Type 134   *Trisetum spicatum-Minuartia biflora* type
Subgroup 14   Early snowbed and snowflush vegetation dominated by meso/hygrophilous plants, partly moss-dominated
    Type 141   *Homalothecium nitens-Dryas* type
    Type 142   *Salix polaris* type and related, poorly defined types
    Type 143   Seasonally hygrophilous *Dupontia pelligera* type
Subgroup 15   Late snowbeds
    Type 151   *Phippsia concinna* type and related types
    Type 152   *Cerastium regelii* type
Subgroup 16   Bird-cliffs (not differentiated further)

Group 2 Poorly drained sites

Subgroup 21   Moss tundra
    Type 211   *Homalothecium nitens-Salix polaris-Alopecurus alpinus* type
    Type 212   *Homalothecium nitens-Salix polaris-Dupontia pelligera* type
Subgroup 22   Wet moss tundra
    Type 221   Thermophilous *Carex parallela-C. saxatilis* type
    Type 222   *Homalothecium nitens-Carex subspathacea* type
    Type 224   *Dupontia pelligera-Eriophorum scheuchzeri* type
    Type 226   Frost upheaval *Dupontia pelligera-forb* and *Salix polaris-Saxifraga oppositifolia-Poa arctica* types
    Type 227   *Eriophorum triste-Deschampsia brevifolia* type
Subgroup 23   Swamp tundra
    Probably not represented in Gipsdalen
Subgroup 24   Swamp
    Type 241   *Arctophila fulva, Dupontia psilosantha* and *Ranunculus hyperboreus* types

B LOWLAND AREAS WITH OPEN VEGETATION COVER

Group 3 Very exposed, stable or eroded ridges

Subgroup 31   Ridges with gravelly substrate
    Type 312   *Draba-Saxifraga-Cerastium arcticum* type
Subgroup 32   Ridges with silty substrate
    Type 321   *Poa abbreviata-Potentilla pulchella* type
    Type 323   *Puccinellia angustata* type

Group 4 Sedimentation flats with silty substrate

Subgroup 41   Flats with more or less continuous vegetation
    Type 411   Dry *Polygonum viviparum* type
    Type 412   *Homalothecium nitens-Salix polaris-Equisetum arvense* type
Subgroup 42   Flats with discontinuous vegetation
    Type 421   Open *Salix polaris-Saxifraga oppositifolia* type
    Type 423   Open *Dupontia pelligera-Deschampsia* spp. type

Group 5 Gravelly river fans

Subgroup 51   Fans with vegetation cover
    Not differentiated further
Subgroup 52   Fans with scattered plants
    Not differentiated further

Table 3 (cont.).

Group 6 Recent moraines
Not differentiated further

Group 7 Seashores

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).

Type 134: *Trisetum spicatum-Minuartia biflora* **type.** The type is characteristic of the sheltered slopes of moraine ridges, with a stable snow cover during winter, but an early snow-melt in spring. The substrate may be unstable, and characteristic plants are the two above together with *Oxyria digyna, Erigeron humilis* (very rare in Gipsdalen), and *Ranunculus pygmaeus*. The type has been found in several places in the lower parts of the valley, but most stands are too small to be mapped.

Subgroup 14: Early snowbed and snowflush vegetation

The snow cover disappears early in most of Gipsdalen. Snowbed vegetation is therefore restricted. Some stands are found in the tributary valleys and 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 intermediate between ordinary *Dryas* heaths and moss tundra. Distinct stands are only found on the upper parts of the Gipshukodden - Gåsodden 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 *Deschampsia 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 nutrients 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 Skiltvakten to Bjonahamna. Concentrated manuring characterizes the slopes beneath Skiltvakten, diffuse manuring the rest of the area.

The Skiltvakten 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,*

Saxifraga hieracifolia, Poa pratensis ssp. *alpigena, P. glauca, Draba arctica, D. daurica,* and *Ranunculus sulphureus*, this is the site of less frequent species like *Polemonium boreale, Ranunculus pedatifidus*, and a *Potentilla* sp.

The third zone is diffusely manured, and the vegetation is a species-rich *Dryas-Salix polaris* heath with deep moss carpet, changing gradually into a normal *Dryas* heath further from the cliffs.

The more diffusely manured area between Skiltvakten and Bjonahamna has a fragmented vegetation, where well vegetated meadow slopes alternate 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*.

Group 2: Poorly drained sites

The poorly drained sites are here collectively referred to as "marshes", and separated in earlier versions of the system into moss tundra, wet moss tundra, and swamp. This separation is kept here, but in the future a more consistent set of terms should be found. Some of the types are clearly related to boreal-alpine mires (e.g. type 221), while others are specific arctic communities.

These are sites where the ground water level is situated at or a short distance beneath the soil surface for most of the growth season. The spring is delayed compared with well-drained sites, but the season may be prolonged in late summer. The moss layer is usually very well developed, while most lichens are lacking. Woody plants (except for *Salix polaris*) are of small importance, while mat-forming grasses, sedges, rushes, and many forbs are characteristic.

The main differentiating factors within the group are the depth of the active layer, the depth of the ground water level during the main parts of the growth season, and the drainage conditions.

The coarse, well-drained substrates in many parts of Gipsdalen prevent formation of marshes, except where there is some topographical impeding of the drainage. Poorly drained sites cover a much smaller fraction of the area than in neighboring areas like Sassendalen, Adventdalen, and on Kapp Thordsen.

Subgroup 21: Moss tundra

The least moist marshes are usually named "moss tundra" on Svalbard. They are often dominated by the moss *Homalothecium nitens* associated with *Salix polaris* and grasses, and are usually found on gently sloping ground.

Type 211: *Homalothecium nitens-Salix polaris-Alopecurus alpinus* type; and **Type 212**: *Homalothecium nitens-Salix polaris-Dupontia pelligera* type. The two types are weakly characterized and only fragmentarily developed in Gipsdalen (not mapped). The first-mentioned is often tussocky, the other more even. They are found on the upper parts of slopes, mostly in the lower parts of the valley, or as margins around wetter marshes. In spite of the small areas, they seem to be heavily used for winter grazing by reindeers (indicated by a high concentration of winter feces). This is explained by the dense vegetation cover and the thin ice/snow cover.

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. amblyrhyncha, Juncus triglumis*, and in one site each *Juncus castaneus* and *Kobresia simpliciuscula*. Except for *Carex amblyrhyncha* 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 Usherfjellet and Gipshuken 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 226: 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

side. Characteristics, in addition to the naming species, are e.g. *Festuca hyperborea, Puccinellia vahliana, Draba arctica*, and scattered other Drabas and Saxifragas.

Type 323: *Puccinellia angustata* type. The type is characterized by very open stands of *Puccinellia angustata*, often the depauperate type (var. *depauperata*). It occurs on low silty ridges close to the lower course of the river. The stands are very small.

Both types have been very little investigated, but seem to occur regularly in the valleys of the inner fjord region, especially on calcareous substrates.

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).

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.

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* x *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 71: Salt/brackish marshes on fine-grained substrates

Salt marshes are restricted to the lower parts and estuary of Gipsdalselva. The vegetation may be divided into several types according to elevation (i.e. frequency of inundation by saline water), and degree of freshwater influence. Two types are found in Gipsdalen:

Type 711: *Puccinellia phryganodes* **type.** The lowermost zone, consisting of the creeping grass *P. phryganodes* alone or in association with the creeping forb *Stellaria humifusa.* Small stands are found in the lower river course, especially in bays on the eastern shore.

Type 712: *Carex subspathacea* **and** *Carex ursina* **types.** The upper zones, with a slightly more diversified vegetation dominated by the low-growing sedges *Carex subspathacea* (mat-forming) and/or *C. ursina* (tussocks), usually associated with *Stellaria humifusa, Draba arctica,* and some mosses. Small borders are found in the same area as the preceding.

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 typesfound 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.

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.

Code	Type	Criteria
112	Exposed, discontinuous heath; open *Dryas* type	3
122	Closed heath; *Cassiope tetragona* type	1b
133	Warm slopes; thermophilous *Festuca baffinensis* type	1b, 2
134	Warm slopes; *Trisetum spicatum-Minuartia biflora* type	1b
141	Snowflush vegetation; *Homalothecium-Dryas* type	1b, 4
151	Late snowbeds; *Phippsia concinna* type	1b
152	Late snowbeds; *Cerastium regelii* type	1b, 3
16	Bird-cliff vegetation	1ab, 2, 4
21	Moss tundra types	1b, 4
221	Wet moss tundra; thermophilous *Carex parallela-saxatilis* type	1ab, 2, 3, 4
227	Wet moss tundra; *Eriophorum triste-Deschampsia brevifolia* type	1a, 2, 3, 4
24	Swamp vegetation	1b
321	Exposed silty ridges; *Poa abbreviata-Potentilla pulchella* type	1ab, 2, 3
322	Exposed silty ridges; *Puccinellia angustata* type	1b
4	Silty sedimentation flats	2, 3
71	Salt/brackish marshes	1b

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, 1989 - 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* (raudsildre) - 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 distri buted 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.

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 Agardhdalen (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 parametres 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).

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

graminids in the marshes or in graminid-dominated dry tundra, is reflected in this approach only. The satellite-based map generally reflects entities at the three higher (ecological and physiognomical) levels in the conventional classification (Table 3), while the fourth, floristic level must be registered and mapped based on field surveys in any case.

- 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 toother 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
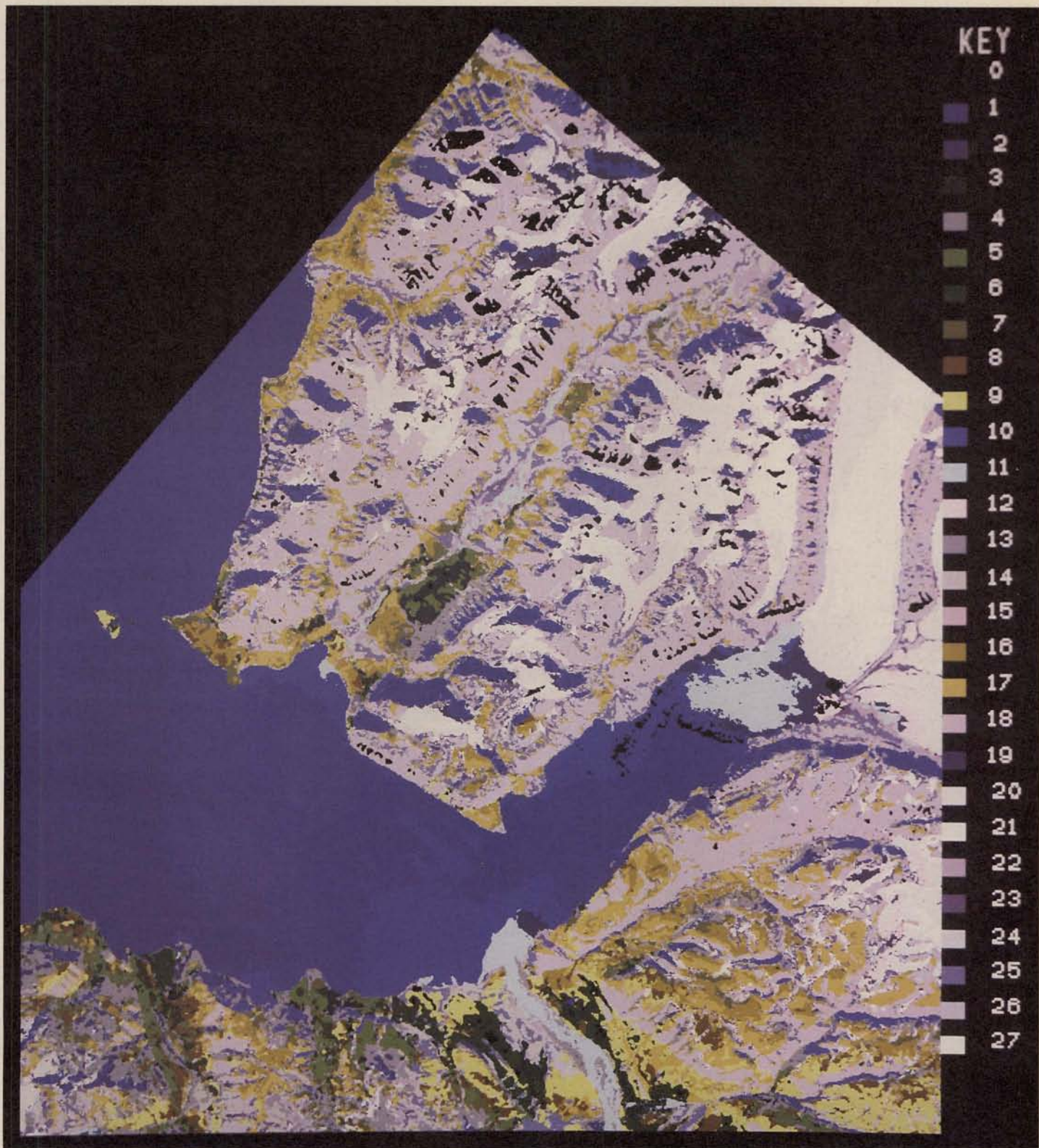
Figure 6 Standard false-colour composite map of Bünsow Land with Gipsdalen (upper part), Sassendalen (lower right) and the Adventdalen area (lower left). The map is based on a Landsat TM scene from 5 August 1985, utilizing the bands 2, 3 and 4. The map is produced by FORUT, The University of Tromsø, 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.

brown colours, while little vegetated or unvegetated areas are indicated by light brown colours. Glaciers and snow fields are white and blue, sea and lakes black to bluish (when rich in sediments).

We may separate between four types of well vegetated areas in the Gipsdalen part of the map:

1) Dark brown areas are closed dry tundra (heaths), mainly of the *Dryas* types. Lighter brown colours characterize the more open heaths of ridges and partly stabilized river fans.

2) Deep red areas are moss tundras and marshes, with the most intense colours in the most luxuriant types. These are the only important summer pastures of reindeer and geese in Gipsdalen.

3) Two small "red" areas in the mountains, on the plateaus of Gipshuken and Sindballefjellet, are the only important winter pastures of reindeer in the Gipsdalen area (see discussion by Spjelkavik & Elvebakk 1989).

4) Intense light red areas indicate the bird-cliff vegetation around the slopes of Templet and on the southern parts of Sindballefjellet.

When comparing Gipsdalen (uppermost in Fig. 6) and the neighboring areas Sassendalen (lower right) and Adventdalen (lower left), several important differences appear. Vegetated areas cover a much smaller proportion of the total area of Gipsdalen than in the other valleys. The differences are most marked in the moss tundra and marsh fractions and in the mountains. Densely vegetated mountain plateaus, like the Coloradofjella and Flatkollen areas in Sassendalen and Platåberget close to Longyearbyen, are absent from Gipsdalen. The features of an open calcareous arctic steppe or semi-desert in Gipsdalen are directly observable from this map.

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 gravelly 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-frequent, 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 Gipshuksletta 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 121a).

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 Gipshuken 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* (raudsildre), 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 habit 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 amblyrhyncha* (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 Templet mountain, to the E by Templet. 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 Templet 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 baffinensis* - hårsvingel - 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 Templet area

The Templet area consists of the slopes of Templet mountain from Skiltvakten 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.

Templet 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* (polarskjørbuksurt), *Oxyria digyna* (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* (grannarve), 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 Isfjorden area. Each bird-cliff usually has its own character. 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 Aitkendalen, 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 parallela* (smalstarr), *C. saxatilis* (blankstarr), *C. amblyrhyncha* (buttstarr), and *Juncus triglumis* (trillingsiv), 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* (setersoleie) 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* - snøull, open stands of *Dupontia pelligera* - småtundragras, *Juncus biglumis* - tvillingsiv; 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* (purpurkarse), and important populations of *Minuartia rossii* (putearve) and *Pucciphippsia vacillans* (svalbardfimbulgras).

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

valley NE of Usherfjellet to the E.

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* (kastanjesiv) as the most important, but also with *Carex parallela* (smalstarr), *C. saxatilis* (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 regelii* (polararve) and both *Phippsia* spp. (snøgras) 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 transport road a short distance from the mining camp, with e.g. *Carex amblyrhyncha* (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 a 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 Gipshukodden 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 substrate 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 both 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).

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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 geese *Anser brachyrhynchus* and *Branta leucopsis*), endemics (Svalbard ptarmigan *Lagopus mutus hyperboreus* and Svalbard reindeer *Rangifer tarandus platyrhychus*), 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 Bünsow 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 geese, 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 Templet 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 *Fratercule arctica* remain unknown. This puts Templet in the lower range of a previous rough estimate (10,000 - 100,000 pairs), but nontheless makes it one of the seabird colonies in the Isfjord 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. Bünsow 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 geese, 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), Templet (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 geese 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 geese, and are also important to Svalbard reindeer during summer. Leirflata is utilized by Pink-footed geese. 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 fouraging 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 is 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 Bjonadalen 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 fouraging 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 moult.

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 further 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/Methuenbreen 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 moult, 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.

Probably 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 occassionally 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. Vulnarable 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 Norströmfjellet, 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 behaviour 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 north 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 Gipshukodden 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. Agressive 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, hovewer, the Glaucous gull has not been specifically studied. Furthermore, it is an oportunistic 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 fourage.

Arctic tern *Sterna paradisaea*

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 Gipshuksletta (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 colonywise 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 parallell to the cliffs. Noise level (desibel) and bird response was correlated, while lowfrequency 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 survivle 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).

Colony no.	Lower count	Higher count
1	322	358
2	164	200
3	60	90
4	69	69
5	198	199
6	366	379
7	1,506	1,657
SUM	2,685	2,952

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 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.
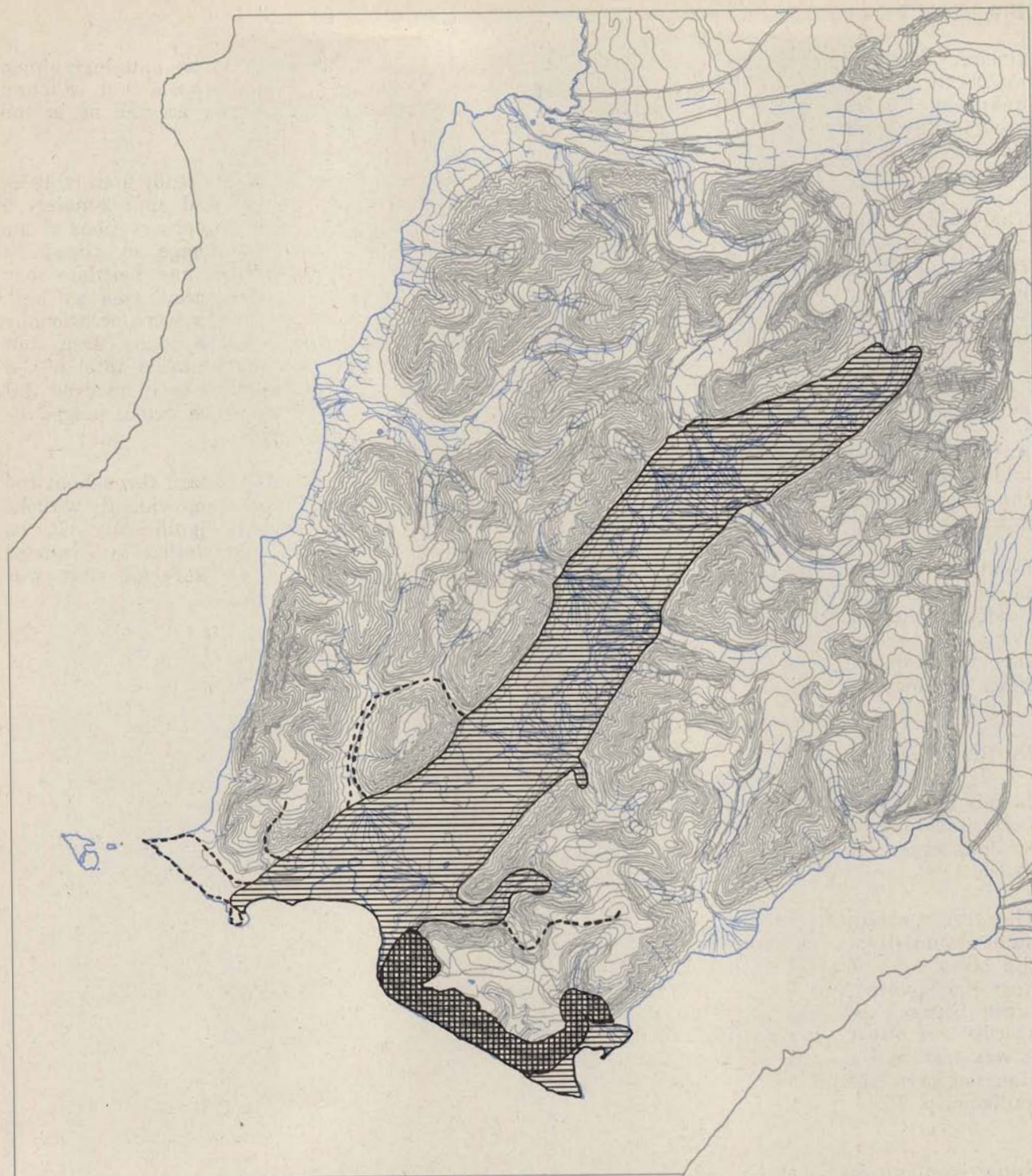
Limitation of the study area.

Bird-cliff census area.

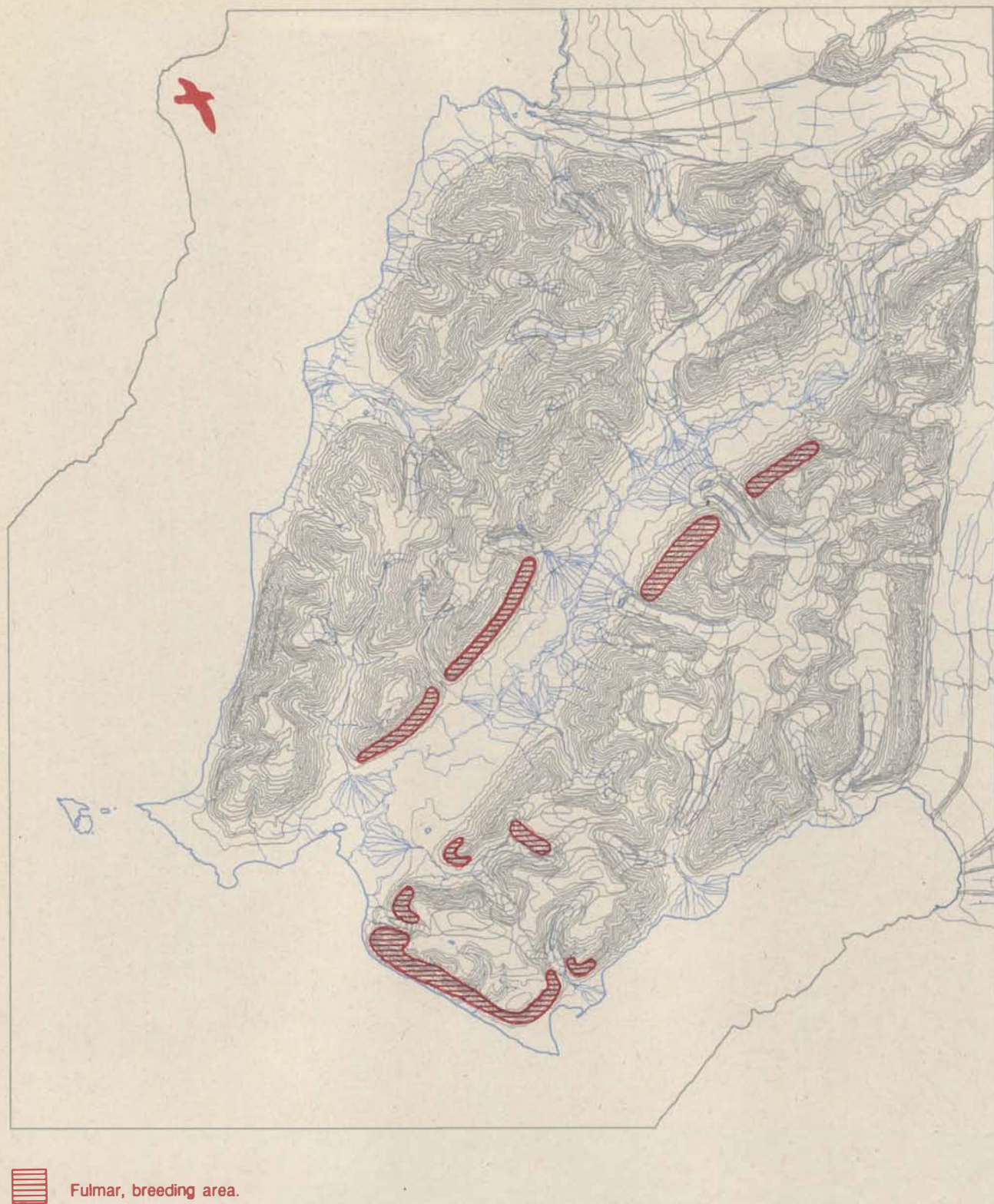**Figure 1** Limitation of the study area in Gipsdalen, Svalbard 1989.

Red-throated diver observation (no breeding indication).

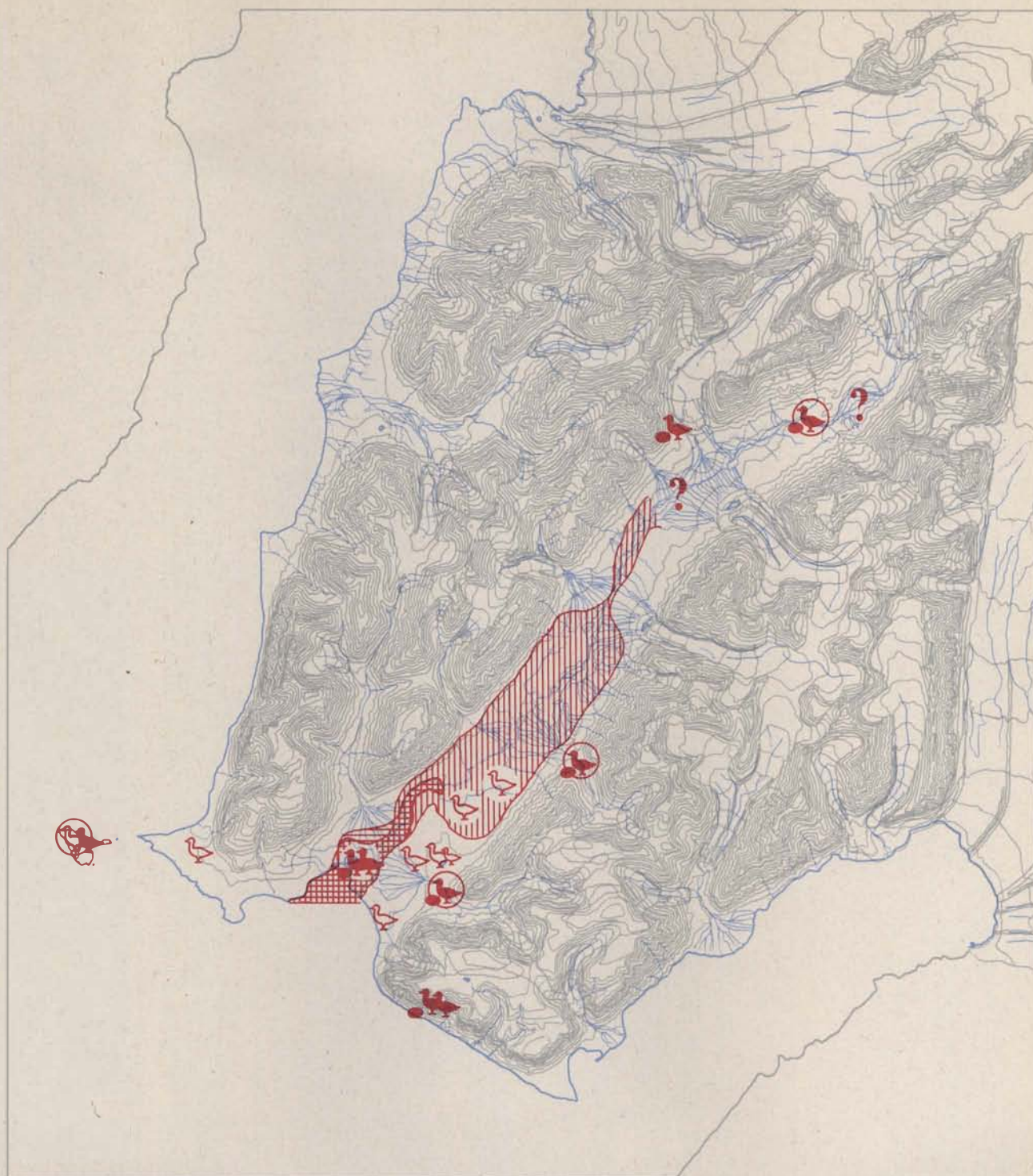Purple sandpiper, observation of adult/chick.

Breeding record.

Figure 2 Observations of Red-throated diver *Gavia Stellata* and confirmed breeding of Purpel Sandpiper *Calidris maritima* in Gipsdalen 1989.

Fulmar, breeding area.

Figure 3 Approximate, observed breeding areas of Fulmar *Fulmarus Glacialis* in the Gipsdalen area 1989.

**Figure 4** Breeding and moulting areas of Pink-footed goose *Anser brachyrhynchus* and Barnacle goose *Branta leucopsis* in Gipsdalen 1989.
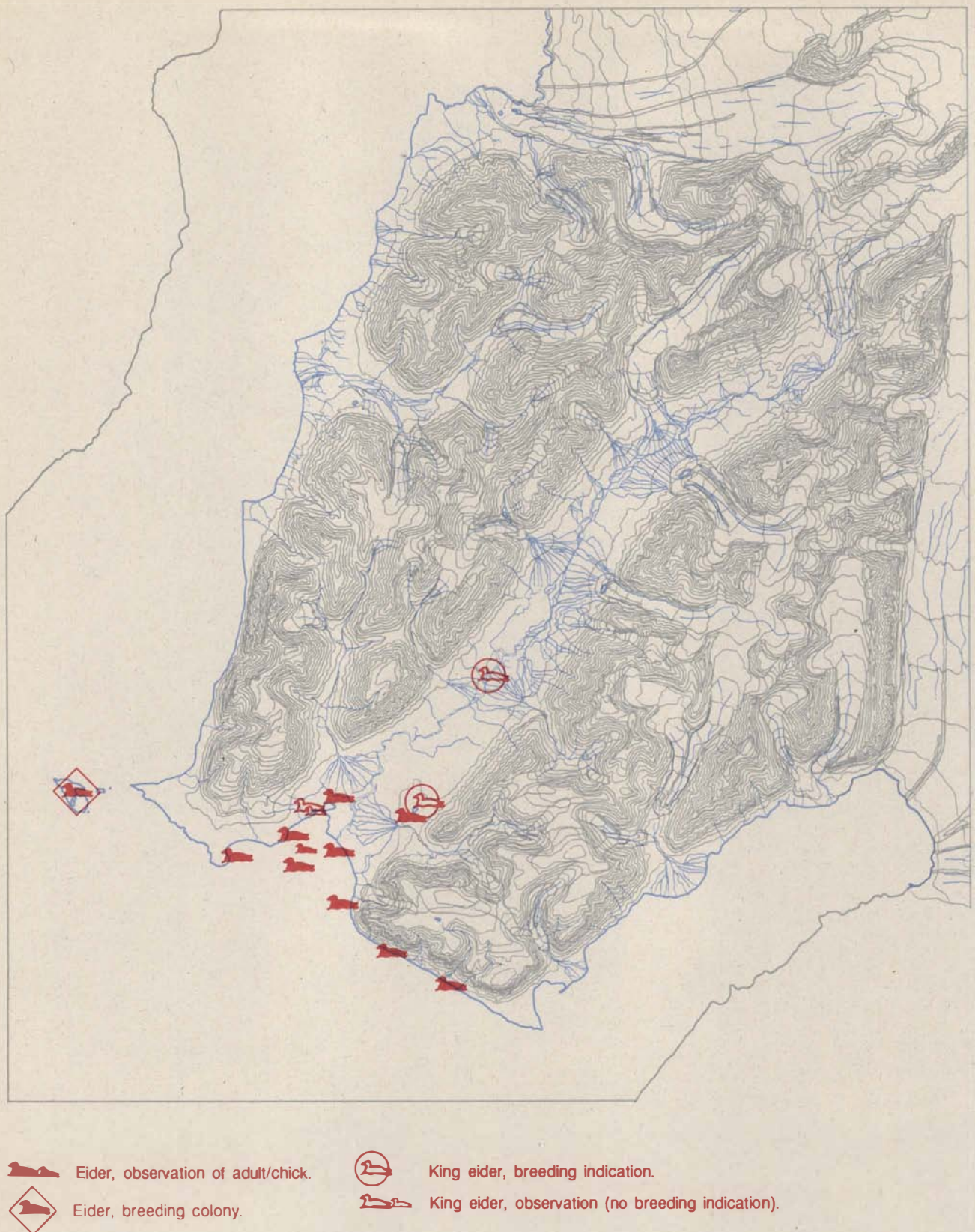
Figure 5 Observations of breeding and breeding indications of Eider *Somateria mollissima* and King eider *Somateria spectabilis* in Gipsdalen/Gipsvika 1989.

Figure 6 Observations of Svalbard ptarmigan *Lagopus mutus hyperboreus* and breeding records of Snow bunting *Plectrophenax nivalis* in Gipsdalen 1989.

Ringed plover observation.

Turnstone observation.

Sanderling observation.

Breeding indication.

Ringed·plover, breeding area.

Turnstone, breeding area.

Figure 7 Observations and breeding areas of Ringed plover *Charadrius hiaticula*, Sanderling *Calidris alba*, and Turnstone *Arenaria interpres* in Gipsdalen 1989.
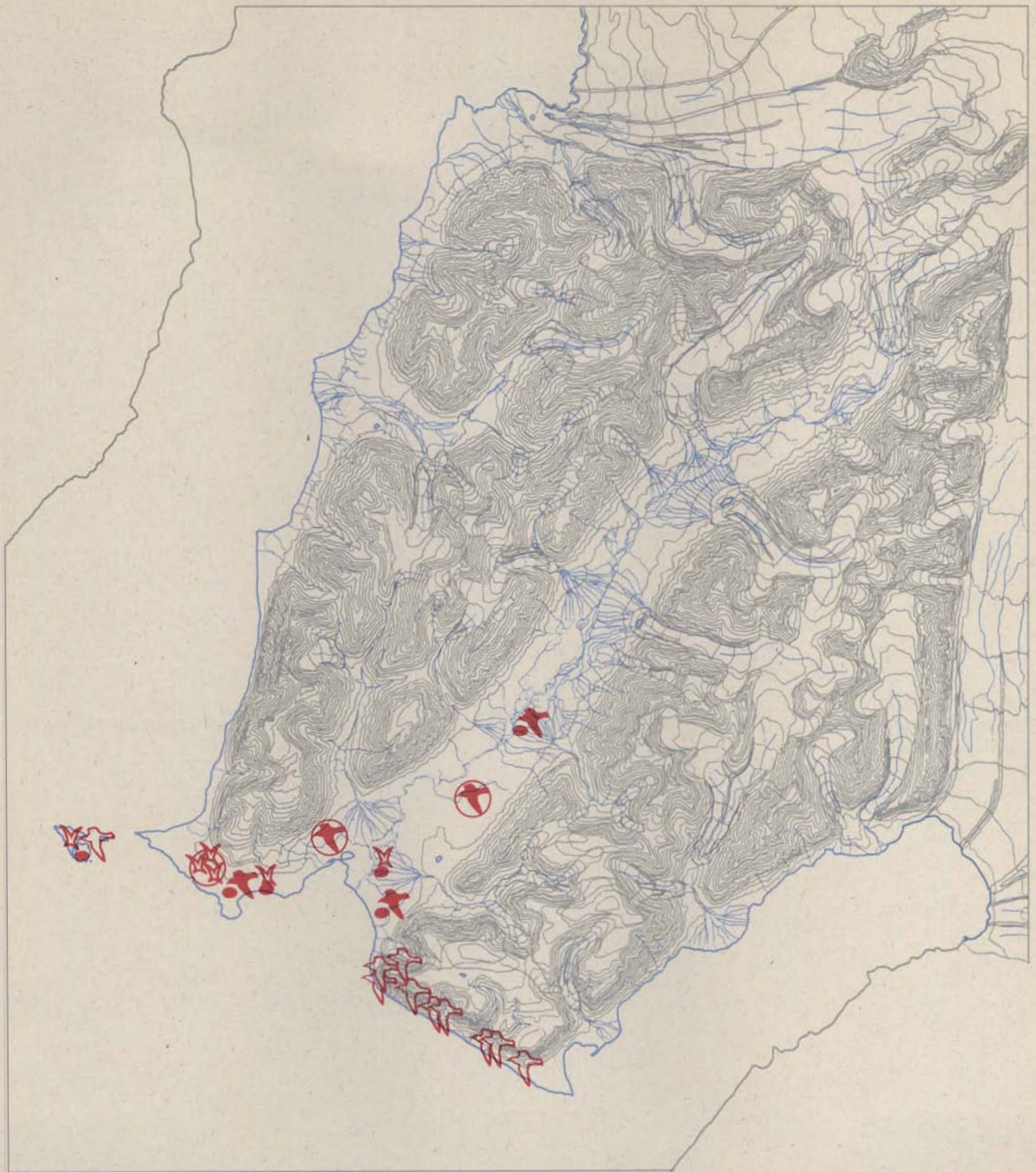
Figure 8 Breeding of Arctic skua *Stercorarius parasiticus*, Glaucous gull *Larus hyperboreus*, and Arctic tern *Sterna paradisaea* in Gipsdalen and Templet 1989.
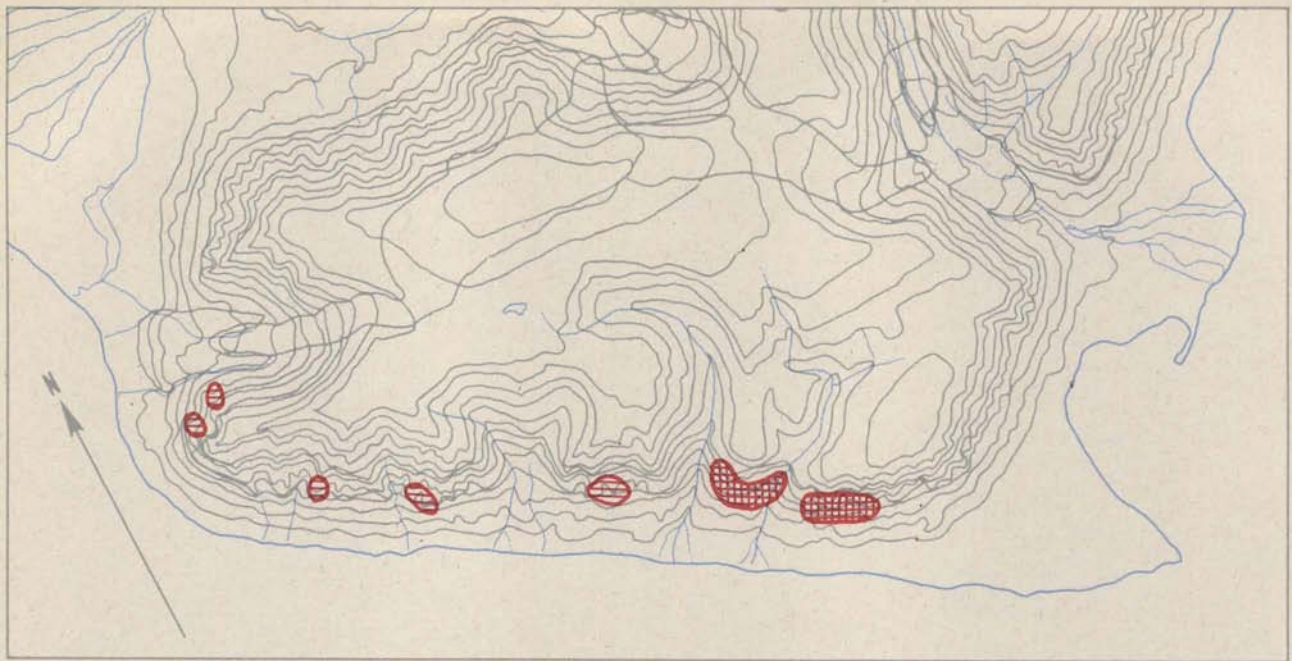
Kittiwake and Brünnich's guillemot, breeding area.

Brünnich's guillemot, breeding area.

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.
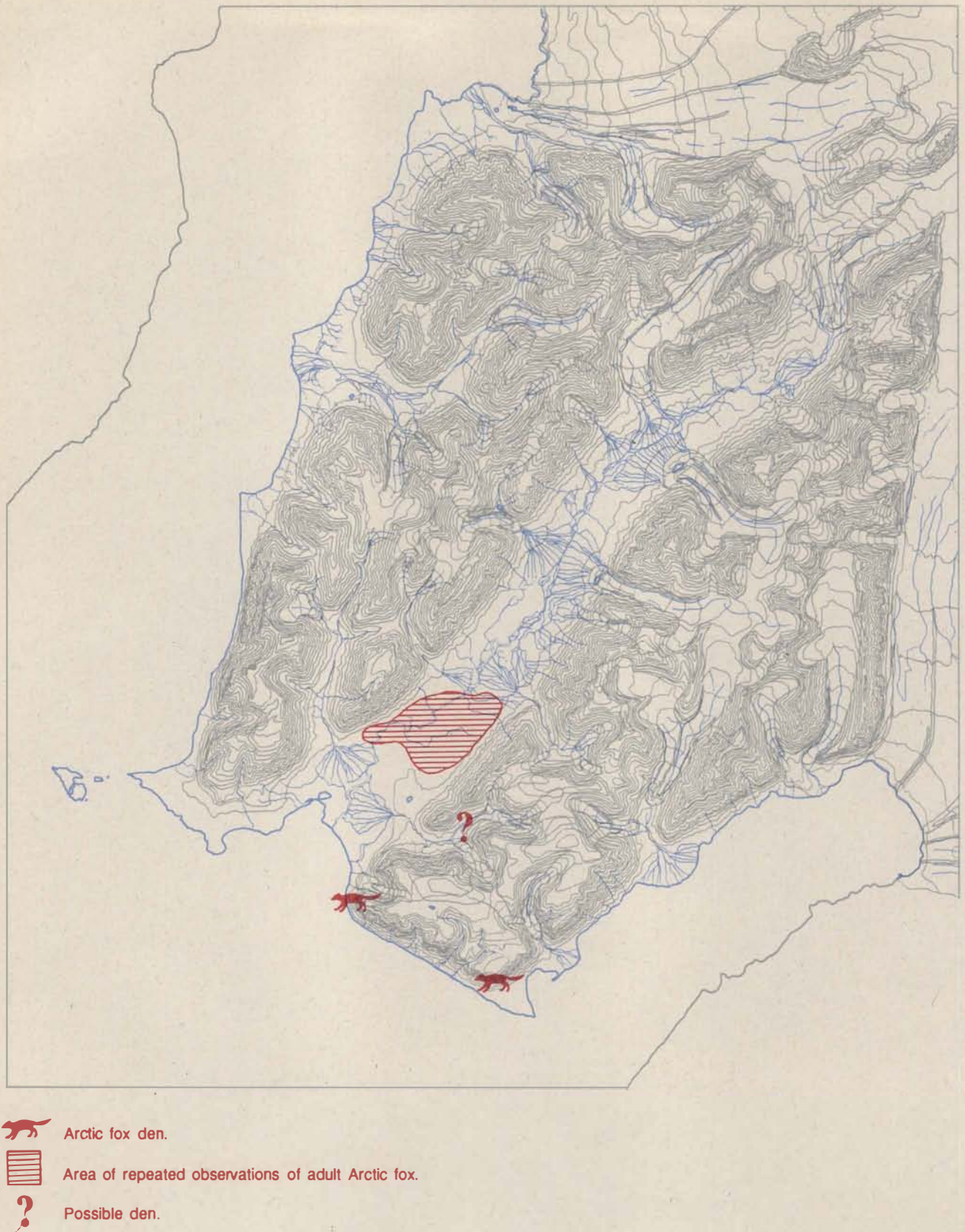
Figure 11 Dens and possible denning areas of Arctic fox *Alopex lagopus* in the Gipsdalen area 1989.

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 (svalbardrype *Lagopus mutus hyperboreus* og svalbardrein *Rangifer tarandus platyrhynchus*), enkelte høyarktiske 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, havelle *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.

Gipsdalen ble ikke funnet å huse spesielt betydningsfulle forekomster av noen fugleart. Sandløper og steinvender *Arenaria interpres* er fåtallig og lokalt utbredt på Svalbard. Begge artene ble funnet hekkende, men bare for steinvenderens del ble det påvist en bestand i området. Det er likevel uvisst i hvilken grad denne vil bli skadelidende ved det planlagte inngrepet, samtidig som artens status på øygruppa trolig er undervurdert. Gipsvika og Gipsdalen benyttes også av mytende kortnebb- og hvitkinngjess, men de observerte gjessene utgjør bare 1-2 % av bestandene på Svalbard. De fleste andre arter opptrådte i svært små antall i Gipsdalen i 1989.

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 alkekonge *Alle alle* og lunde *Fratercula arctica* 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 *Erigathus barbatus* og hvithval *Delphinapterus leucas* i området, men både ringsel *Phoca hispida* og isbjørn *Ursus maritimus* ble påtruffet 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 påtruffet 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 overgivelse av Gipsdalen, i det minste som myte- og oppvekstområde, dersom gruveplanene settes ut live slik de er framlagt. Problemene for smålom og steinvender er knyttet til ferdsel og trafikk i selve hekkeområdene, mens ærfugl, krykkje og polarlomvi kan bli berørt av eventuell økt lufttrafikk i området.

De mest sensitive områdene er Gipsvika nord (mytende gjess, hekkende vadere), Gipsdalselva 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 gjess, ærfugl og rødnebbterne *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 betydningen av området liten sammenlignet med arealene lenger ned i dalen.

Dalbunnen mellom Gipsvika og Leirflata er viktig som myte- og oppvekstområde for gjess, spesielt kortnebbgås, og er også viktige beitearealer for svalbardrein om sommeren. Hele Leirflata benyttes av kortnebbgås. Andre hekkearter av interesse er smålom, praktærfugl og tyvjo *Stercorarius parasiticus*. Dersom all transport legges til vestsida av Gipsdalen er det mulig at inngrepet ikke vil ha avgjørende betydning for andre arter enn gjessene. Erfaringer fra Grønland tilsier at avstanden mellom flertallet av reirplassene i Gipsdalen og de planlagte inngrepene er tilstrekkelig til at kortnebbgjessene fortsatt skal kunne hekke her, men de vil sannsynligvis ikke akseptere forstyrrelsene etter klekking. Det er uvisst om bestanden vil kunne finne nye myte- og oppvekstområder i nærheten.

Strandvollene i Gipsvika nord, hvor lasteanlegg og utskipningshavn er tenkt plassert, er den viktigste vaderlokaliteten i undersøkelsesområdet, og området er også viktig for hvitkinngjess. Med mindre andre beitearealer er tilgjengelige (f.eks. ved Billefjorden) vil anleggene i Gipsvika trolig få svært uheldige følger for den lille gåsebestanden i Gåsøyane fuglereservat. Det er uvisst hvilke følger inngrepene vil få for steinvenderne i området. Sandlo *Charadrius hiaticula*, fjæreplytt *Calidris maritima* og rødnebbterne vil trolig kunne tilpasse seg aktivitetene.

Nærheten til Gåsøyane og sjøfuglkoloniene i Templet kan gjøre det aktuelt å opprette særskilt korridor for eventuell lufttrafikk til og fra de planlagte anleggene.

Ved lokale utslipp eller lekkasjer av olje og drivstoff fra båter eller installasjoner vil i praksis så godt som samtlige arter i området kunne bli skadelidende. Risikoen er spesielt stor for sjøfugl og andefugl. Gipsvikas nære beliggenhet til både et av Isfjordens viktigste fuglefjell og et fuglereservat gjør dette ekstra betenkelig.

For fuglelivet i området vil den mest sårbare tida på året være perioden juni - august. Oljeforurensinger 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 arealbruk) i området som ledd i arbeidet med å frambringe nødvendig lokalkunnskap for en miljøkonsekvensvurdering ved eventuell oppstarting av kullgruvedrift i Gipsdalen. Herværende rapport presenterer en foreløpig analyse basert på resultatene fra 1989 og et litteraturstudium.

Avsnittene om utbredelse og status på og utenom Svalbard setter informasjonen fra Gipsdalen i perspektiv. Det later til å foreligge svært lite faunistisk informasjon om undersøkelsesområdet fra før. Viktige biologiske egenskapene ved de enkelte artene 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

Undersøkelsens omfang

Feltarbeidet ble utført i tidsrommet 7. juli - 14. august 1989. Hovedvekt ble lagt på registreringer av gjess og de to artene av naturlig forekommende landpattedyr på Svalbard (fjellrev og svalbardrein), og taksering av sjøfuglene i Templet. Avgrensningen av studieområdet framgår av Fig. 1. Gåsøyane fuglereservat ble ikke besøkt på grunn av ferdselsforbudet 15. mai - 15. august (Prestrud 1989).

Vi var for det meste stasjonert i Gipsvika. Gipsdalen ovenfor Leirflata ble i hovedsak kartlagt i

dagene 26.- 30.7 da vi hadde vår base i FCD's leir nedenfor Methuenbreen, men de indre delene av Gipsdalen ble også besøkt 11.7 og 13.8. Arbeidet i Templet ble utført 15.- 18.7 og 23.- 25.7, mens bestandene i Bjonadalen ikke ble talt opp før 6.8. Pausa i tellingene i Templet skyldes at det lå tåke i fjellet disse dagene.

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 snødekke la seg i fjellene på kvelden 25.7, men allerede et døgns 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 vekslende, iblant med en del tåke. Vinden kunne fra tid til annen hemme feltarbeidet, særlig under tellingene i Templet, men det var svært få dager været satte en stopper for datainnsamlingen.

Metoder

Undersøkelsene dreide seg primært om faunistisk kartlegging. Alle deler av studieområdet ble oppsøkt ved ferdsel til fots i terrenget. I Gipsdalen ble det lagt vekt på å gjøre stivalget slik at både dalbunn og fjellsider (opp til ca. 150 m koten) ble dekket. Som regel arbeidet to mann sammen. Spesiell vekt ble lagt på å tallfeste gjessene i Gipsdalen, gjennom systematisk søk etter reir i egnede habitater og opptellinger av beitende flokker. Under dette arbeidet ble det også holdt spesiell utkikk etter rein og fjellrev. Kikkerter med inntil 10x forstørrelse ble benyttet, ofte også teleskoper med inntil 45x forstørrelse.

Sjøfuglene i Templet ble taksert fra standplasser i fjæra eller på platåer i rasliene nedenfor fjellet. Fjellet var lagdelt og ofte kraftig oppsprukket, så det falt seg naturlig å avgrense arealer for opptelling. Teleskop ble alltid benyttet. To mann arbeidet parallelt og uavhengig. Etter opptelling av hvert delareal ble de to resultatene sammenlignet, og ved store avvik ble nye opptellinger foretatt (bortsett fra for alkekonge og lunde). Overensstemmelsen var som regel god, og det var sjelden det var nødvendig å gjenta tellingene.

ARTSGJENNOMGANG

SMÅLOM *Gavia stellata*

Utbredelse og vandringer

Holarktisk utbredelse i arktiske og nordlige tempererte strøk. I Europa hekker arten 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.

Hekker trolig første gang 2-3 år gammel, og kan oppnå en alder av minst 23 år. Paret holder sammen gjennom hele hekkesesongen. Reiret plasseres alltid meget nær vannkant, som regel mindre enn 0,5 m fra bredden eller på ei torvøy, slik at den rugende fuglen lett kan gli ut i vannet. Legger 1-3 egg (vanligvis 2), på Svalbard straks isen forsvinner fra hekkeplassene i juni - juli. Kan stå over hekking dersom våren er ekstremt sein. Eggene ruges i 26-28 døgn. Begge foreldrene deltar i ruging og ungepass. Ungene kan svømme og forlater reiret kort tid etter klekking. De er imidlertid fortsatt avhengig av foreldrene og føres inntil de blir flyvedyktig etter 6-7 uker.

Status i Gipsdalen / Templet

Smålom er tidligere funnet hekkende i Gipsdalen og på Gåsøyane (Løvenskiold 1964). .

Ett par påvist hekkende i 1989 (Fig. 2): Foreldrefugler med to dununger på dalbunnen nedenfor Aitkenfjellet 22.7; bare en unge lot til å vokse opp (observert 8.8 og 13.8). Arten ble ellers flere ganger sett i ferskvannet på elveterrassene innerst i Gipsvika og i tilliggende deler av Gipsdalselva uten at hekking eller hekkeforsøk kunne påvises. Også to voksne i Gipsdalselva ved sørenden av Leirflata 13.8, samtidig med at hekkeparet var på sin hekkeplass. Smålommer ble flere ganger observert i flukt over de nedre delene av Gipsdalen, på vei til og fra næringssøk i Isfjorden.

Sårbarhet

Smålommen er i sin alminnelighet en forholdsvis sky fugl på hekkeplassen, og går raskt av reiret når mennesker kommer i nærheten (Mehlum 1989). Redusert hekkesuksess gjennom økt predasjon fra fjellrev og polarmåke kan derfor lett bli resultatet av ferdsel i hekkeområder. Den er likevel ganske tolerant overfor begrensede forstyrrelser, og kan f.eks. ruge synlig fra veier (Cramp & Simmons 1977). Lommene er i mytetida ekstra utsatt for oljeforurensninger til havs (Anker-Nilssen 1988).

Diverse

Det er sannsynlig at tapet av en unge i Gipsdalen skyldes predasjon fra fjellrev eller polarmåke. En rev gjorde 22.7 et utfall mot kullet, men ga 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

Hekker langs nordlige kyster av Atlanterhavet og Stillehavet. I Europa fins havhesten på Svalbard, Frans Josefs land og Novaja Semlja, og fra Island, Jan Mayen og norskekysten sør til Frankrike (Bretagne). De viktigste europeiske koloniene er på Island, De britiske øyer og Svalbard med Bjørnøya. En pelagisk art som utenom hekkesesongen for det meste treffes langt til havs eller langs kystene etter uvær; 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.

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 flate holmer og øyer eller i gresskledte skråninger. Tallrikest på Spitsbergens vestkyst og fjordstrøk, og på Bjørnøya. Ankommer hekkeplassene flere måneder før egglegging tar til, og ses på Svalbard til mørketida inntrer; er registrert på hekkeplass så tidlig som i januar (Frantzen et al. 1986). Metodiske takseringsproblemer og den vide utbredelsen gjør at samlet bestandsstørrelse ikke er kjent. Koloniene i Templet later til ikke tidligere å være opptalt (Mehlum & Fjeld 1987).

Biologi og levevis

Spiser hovedsakelig pelagiske smådyr som bløtdyr (blekksprut og vingesnegl), børstemark, krepsdyr og småfisk. Det meste av næringen hentes fra overflatelagene mens fuglen ligger på sjøen. Følger ofte etter fiskebåter for å nyttiggjøre seg avfall og fiskerester. Mange anser økningen i fiskeriene i dette århundre som en mulig forklaring på artens ekspansjon.

Sjøfugler har i sin alminnelighet svært sein
kjønnsmodning, men også lav årlig voksendødelig-
het (ca. 5 %) slik at de kan bli meget gamle og
reprodusere mange ganger. Havhesten 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 Gipshuken.

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 Gips-
dalen, og ble sommeren 1989 påvist i Dalkallen,
Storholen, Usherfjellet, Grahamkammen, Pyefjel-
let og Finlayfjellet (Fig. 3).

Sårbarhet

Nokså tolerant overfor mennesker på hekkeplas-
sen. Artens næringsøkologi gjør imidlertid hav-
hesten sårbar overfor forsøpling og forurensning
til havs. Det er påvist at de fleste havhester i
nordlige farvann får i seg plastpartikler og annet
menneskeskapt avfall. Potensielt kan slike frem-
medelementer i kråsen forhindre fordøyelse og
føre til forgiftning (Mehlum & Giertz 1984). Det
er videre fryktet at oljeforurensninger til havs
kan få alvorlige konsekvenser for Barentshavets
havhestbestander, både direkte og som følge av
forringelse av næringsgrunnlaget, sosialt be-
tingede effekter, og annet (Anker-Nilssen 1988).

Diverse

Havhesten er på Svalbard jaktbar i perioden 1.
september - 31. oktober (Prestrud 1989).

KORTNEBBGÅS *Anser brachyrhynchus*

Utbredelse og vandringer

To bestander, som i det vesentlige er geografisk
skilt også i vinterkvarterene: (1) Islandske og
øst-grønlandske kortnebbgjess overvintrer i
Skottland, England og Irland, mens (2) Svalbard-
bestanden trekker til Nordsjøkystene fra Dan-
mark til Nord-Frankrike. Tellinger i vinterhalv-
året har gitt som resultat 70.000 - 85.000
individer fra Island og Grønland, og rundt 25.000

individer fra Svalbard (Madge & Burn 1988).
Bestandene har vært økende i 1980-årene.
Trekket gjennom Norge er ufullstendig kjent,
særlig om høsten. Vårtrekket går trolig i
hovedsak opp langs dalene i det sørøstlige Norge,
og videre langs kysten fra Trøndelag til Lofoten
og Vesterålen. En viktig rasteplass i midten av
mai er Andøya (Ekker 1981, Rikardsen 1982).

Forekomst og status på Svalbard

Utbredt hovedsakelig langs vestkysten og i
fjordstrøkene på Spitsbergen, hvor den hekker på
tundra, innunder fuglefjell, i vegetasjonskledte
skråninger, og på holmer i fjordene. Myteplassene
er også i stor grad kystbundne. Hekker parvis
eller i løse kolonier. Både reir- og myteområder
er de samme fra år til år. Ankommer øygruppa
i slutten av mai, og trekker bort igjen i septem-
ber - oktober. Den tallrikeste av de tre gåse-
artene på Svalbard, og også den som har videst
utbredelse.

Biologi og levevis

Bilde på forsiden av denne rapporten. Spiser om
sommeren et vidt spekter av tundraplanter, både
grønne og underjordiske plantedeler. Oppbygging
av fett- og proteinreserver forut for vår- og
høsttrekkene er viktig. Ifølge studier på Grønland
benyttes ca. 40 % av tida i myteperioden til
beiting (Madsen 1984).

Hekker første gang trolig normalt i en alder av
tre år, iblant som toåring. Voksne har en for-
ventet levealder på 3,3 år, men kan oppnå en
alder av minst 21 år. Paret holder sammen hele
livet, men kan inngå nye parforhold dersom en
av makene faller bort. Reiret plasseres på bak-
ken, i flatt lende, i bratte skråninger eller på
berghyller, og fôres med planter og dun. Svært
eksponerte steder i sør- og vestvendte områder er
oppgitt som typisk (Ekker 1981). Egglegging
finner sted straks hekkeplassene blir snøbare, på
Svalbard vanligvis ikke før i begynnelsen av juni.
Hunnen ruger i 26-27 døgn, mens hannen holder
vakt like ved. Familien forlater reirplassen kort
tid etter klekking, og flere familier samles i
større eller mindre grupper i felles oppvekst- og
myteområder. Ungene blir flyvedyktige etter
omtrent 8 uker, men tar hele tiden til seg
næring selv. De er likevel avhengig av forel-
drenes beskyttelse under oppveksten, og familiene
holder sammen helt til kort tid før hekkestart
året etter.

De voksne gjessene feller (myter) alle sving-
fjærene 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 / Templet

a) Opplysninger fra tidligere år

Løvenskiold (1964) nevner at kortnebbgjess har blitt sett ved stranda innunder Templet, foruten hekking i Gipsdalen og trolig (tidligere) på Gåsøyane. Gipsdalen var den første lokalitet på Spitsbergen hvor det ble ringmerket gjess, idet en britisk ekspedisjon merket 42 unge kortnebbgjess her i 1952 (Larsen & Norderhaug 1963). Prestrud & Børset (1984) rapporterte at 10 par hekket på Gåsøyane i 1982 og 30-50 par i 1983. Lokaliteten ble ikke undersøkt i 1989.

b) Reirområder og reirplassering i 1989

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

Område 1: 2 par (ennå rugende) 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 rotet 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 sidedalens munning til Gipsdalen.

Område 3: Ett årsreir og to fjorårsreir på sørsida av Gipsdalselva der denne danner en liten canyon nedenfor Norströmfjellet 30.7; ett årsreir og ett reir fra tidligere år på nordsida av elva 13.8.

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 klekking har funnet sted.

Område 5: To årsreir ved ferskvannet på elveterrassene innerst i Gipsvika 20.7 er de eneste reir funnet på myr.

Område 6: To årsreir ble funnet innunder fuglefjellene i Templet 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 varslet 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 elvegjel med stupbratte sider og hyller eller terrasser nær elvebredd 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 Norströmfjellet var fulle av sportegn 27.7 (sporavtrykk, ekskrementer og fjær) som bevitnelse om bruk av området. Langs Gipsdalselva mellom Leirflata og linja Margaretbreen/Methuenbreen ble gjess bare observert mot slutten av feltoppholdet.

Det er opplagt at ikke samtlige kortnebbgåsreir i området ble funnet. For å kunne si noe om hekkebestandens størrelse må derfor også ungetall trekkes inn i vurderingen. Hele eller vesentlige deler av dalen ble ved flere anledninger gått over på 1-2 dager, og observasjoner og tellinger av gjess utført. Situasjonen på to valgte tidspunkter, atskilt med en måned, var som følger:

11. juli: Mellom Dalkallen og Leirflata 7 familier med tilsammen minst 22 dununger; på Leirflata og dalsida østafor 27 familier med tilsammen 84 dununger. Disse 34 familiene hadde altså tilsammen minst 106 unger, med et gjennomsnitt på 3,2 unger/kull for de familier hvor presist ungetall kunne fastslås. Tilsammen ble ca. 75 voksne kortnebbgjess registrert.

12.-13. august: Spaserte opp hele Gipsdalen vest for elva, og ned øst for elva. Kortnebbgjess ble funnet i alle deler av dalen, fra ferskvannet ved Gipsvika til nedenfor Nordstrømfjellet. Det var imidlertid ikke alltid mulig å få presise tall på unge og gamle fugler. På tur opp ble det registrert minst 57 voksne og minst 122 unger, mens 99-154 individer ikke ble aldersbestemt, totalt minst 278-333 individer; på nedtur minst 43 voksne og minst 93-99 unger, foruten ca. 250 ikke aldersbestemte, totalt minst 386-392 individer.

Gipsdalens 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 bestandsestimat, 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 ungeproduksjon på rundt 270 dersom totalbestanden settes til 400 individer, og følgelig ca. 130 voksne gjess, eller ca. 65 par. Den lokale hekkebestanden i Gipsdalen/Templet-området anslås derfor til 34-65 par i 1989.

Selv om det totale antall observerte kortnebbgjess i Gipsdalen ble mer enn fordoblet fra midten av juli til midten av august, økte ikke den registrerte ungfuglandelen med mer enn 15 %. 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 Svalisgrunnane.

Sårbarhet

a) Forstyrrelser i hekkeområdene

Det later ikke til å være utført omfattende studier over kortnebbgåsas sårbarhet på reirplassen. Det er imidlertid kjent at den forlater reiret ved forstyrrelser, og de ubeskyttede eggene er da et lett bytte for fjellrev og polarmåke (Mehlum 1989). Hannene i de to parene som ble funnet på hekkeplass i Gipsdalen 9.7.89 varslet når observatøren befant seg ca. 150 m fra reirene, men hunnene avbrøt ikke rugingen og hannene forlot ikke reirområdet.

Mosbech et al. (1989) fant i et studium på Grønland ikke påviselige effekter av helikoptertrafikk og baseaktiviteter på valg av reirplassering eller antall hekkende par. Nærmeste gåsekoloni lå 1-1,5 km fra basen, på samme sted som før basen ble etablert. De kunne heller ikke påvise forstyrrende effekter på kullstørrelse eller hekkesuksess, men deres materiale er lite. I et større islandsk studium (Sigurdsson 1974 ifølge Mosbech et al. 1989) ble det konkludert med at gjennomsnittlig kullstørrelse gikk ned hos en hekkebestand som ble forstyrret av mennesker eller fjellrev.

b) Forstyrrelser i myteområdene

Kortnebbgåsas og hvitkinngåsas reaksjoner på helikoptertrafikk og bakkeferdsel i mytetida er studert på Grønland (Madsen 1984, Mosbech et al. 1989). To typer helikoptre inngikk i undersøkelsene, den store og tunge Bell 212 og den mindre og lettere Bell 206. Bell 212 produserer spesielt mye lavfrekvent lyd (under 20 Hz). Lavfrekvent lyd dempes mindre enn høyere frekvenser i luft (Fjeld et al. 1988).

De to gåseartene behandles her under ett. Gjessene viste seg å være svært følsomme overfor forstyrrelser i mytetida. Begge arter hadde en gjennomsnittlig reaksjonsavstand overfor Bell 212 på ca. 10 km. I spesielle situasjoner kunne kortnebbgjess reagere på helikopterstøy på rundt 20 km avstand. Ved forstyrrelser tidlig i mytetida, mens gjessene ennå kunne fly, forlot de myteplassene (begge arter). Forstyrrelser seinere i sesongen vil kunne påvirke fuglenes kondisjon gjennom redusert beitetid. Kortnebbgåsa var mer sky overfor Bell 206 enn hvitkinngåsa. Gjennomsnittlige reaksjonsavstander overfor denne typen helikopter var henholdsvis ca. 5 km og ca. 2,5 km (Mosbech et al. 1989).

I tillegg til helikoptertypen spiller også en rekke andre faktorer inn ved vurdering av helikopterforstyrrelser. Topografi, værforhold og helikopterets oppførsel (flyhøyde, flyretning, hastighet og lastmengde) vil ha betydning for lydforplantningen. Mosbech et al. (1989) fant at ved de avstander hvor gjessene begynte å reagere på helikopterstøy øker støynivået med stigende 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 terreng) forstyrret høytflying mindre enn lavtflying. Spinder (1984, ifølge Mosbech et al. 1989) kom til samme konklusjon for rastende snøgjess (Anser caerulescens) i Alaska: Det forstyrrer gjessene mindre å passere over dem med fly i 30 m høyde enn i større høyder. Likeledes øker helikopterstøyen med hastigheten og med tung last. Kortnebbgjessene på Grønland reagerte sterkest på helikoptre som kom rett imot dem. Dette er også i overensstemmelse med observasjoner gjort ved en polarlomvikoloni på Svalbard (Fjeld et al. 1988).

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

Mytende gjess, spesielt kortnebbgjess, er også svært vare overfor 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 flokken 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 kortnebbgjessene 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 forsøpling

Gjess samles i større grupper etter at eggene er klekket for å søke felles beskyttelse gjennom den sårbare myteperioden. Slike myteflokker har alltid tilhold nær vann, ofte sjøen, og de er derfor ekstra utsatte for oljetilgrising i denne perioden. Oljen ødelegger fjærdraktas isolasjonsevne, og fuglene må derfor øke energiforbruket for å opprettholde kroppstemperaturen. Dette fører lett til utmattelse og død. Dersom de får oljen i seg kan sykdom og død følge av forgiftning (Anker-Nilssen 1988, Hansson et al. 1989).

Industrielle aktiviteter og turisme vil ofte medføre forsøpling og dermed god mattilgang 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 bestandssituasjon 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).

Under normale forhold (når de er uforstyrret) klarer kortnebbgjessene å beskytte reir, unger og seg selv mot reveangrep (Ekker 1981, Prestrud & Børset 1984). I Gipsdalen ble det sommeren 1989 to ganger observert konfrontasjon mellom fjellrev og kortnebbgås, og ved en anledning lyktes reven i å nedlegge ei gås, som trolig var voksen.

d) Jakt

Kortnebbgåsa er den eneste gåseart det er lov å jakte på Svalbard, med jakttid 21. august - 31. oktober (Prestrud 1989). Arten jaktes også i fastlands-Norge og i Danmark under høsttrekket. Bestandsøkningen i seinere år tyder imidlertid på at dagens jaktpress er innenfor rammene av hva bestanden på Svalbard kan tåle (Ogilvie 1984).

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.

HVITKINNGÅS *Branta leucopsis*

Utbredelse og vandringer

Tre bestander: (1) En bestand hekker på Øst-Grønland, og trekker via Island til overvintringsområder i Irland og langs Skottlands vestkyst; (2) en Svalbardbestand som overvintrer i Solway

Firth, på grensa mellom Skottland og England, og trekker langs norskekysten; og (3) vestsibirske hekkefugler (Novaja Semlja og Vaigach), som følger en sørvestlig trekkrute over Kvitsjøen, Gotland og det sørlige Østersjøområdet til vinterkvarterene, som først og fremst ligger i Nederland. Totalt fantes det rundt 70.000 hvitkinngjess i begynnelsen av 1970-årene, med Svalbardbestanden som den minste (Cramp & Simmons 1977, Norderhaug 1981).

Forekomst og status på Svalbard

De fleste hvitkinngjessene på Svalbard hekker på mindre øyer langs vestkysten av Spitsbergen, men arten benytter også utilgjengelige klippeavsatser og lignende, og kan hekke flere kilometer inn i landet. Innlandslokaliteter var viktige ifølge eldre litteratur. Arten brer seg i vår tid til stadig nye hekkeplasser, bl.a. sørøst i øygruppa, og har kolonisert Kongsfjorden i 1980-årene (Mehlum 1989).

Bestandsutviklingen for hvitkinngjessene på Svalbard er meget godt kjent siden slutten av 1940-årene da bestanden var nede i rundt 300 individer (Owen 1984). De neste tredve år ble en rekke forvaltningstiltak iverksatt, bl.a. jaktforbud og vern av hekke- og vintertilholdssteder, og i midten av 1980-årene var høstbestanden opp i rundt 10.000 fugler (Magde & Burn 1988, Mehlum 1989). Trolig hekket mer enn 70 % av parene i reservater i 1982 (Prestrud & Børset 1984).

Hvitkinngjessene er tilstede på Svalbard fra slutten av mai til september/oktober. Vår- og høsttrekkene mellom Svalbard (Spitsbergen) og vintertilholdsstedet i Solway foregår i to etapper: På våren stopper gjessene opp 2-3 uker på Helgelandskysten for å bygge opp nye fett- og proteinreserver før de trekker videre, og på høsten har Bjørnøya en tilsvarende funksjon. Sikring av disse områdene er helt avgjørende for bestandens overlevelse og hekkesuksess (Gullestad et al. 1984, Owen & Gullestad 1984).

Biologi og levevis

Livnærer seg på hekkeplassene av et vidt spekter av planter.

Hvitkinngåsa kan hekke første gang 2-3 år gammel, og oppnå en alder av minst 18 år. Owen (1984) fant en årlig dødelighet på rundt 10 %. Dødeligheten var høyere hos ungfugler bare i enkelte år, mens toåringer hadde lavere årlig dødelighet enn eldre fugler. Prop et al. (1984) kom til at rundt halvparten av alle klekte unger når vinterkvarteret. Som andre gåsearter lever hvitkinngåsa monogamt i livsvarige parforhold. Pardannelsen finner sted på våren i gjessenes andre leveår.

Hekker i kolonier, ofte sammen med ærfugl. Kullet består vanligvis av 4-5 egg. Leggetidspunktet er svært avhengig av de lokale snøforholdene, og gjessene kan la være å hekke i år med svært sein snøsmelting. Eggene ruges i 24-25 døgn av hunnen, mens hannen holder seg i nærheten. Etter klekking forflytter familien seg til vegetasjonsrik, fuktig mark ved ferskvannsdammer, hvor også myteflokkene samles. Ungene er flydyktige etter 40-45 døgn, men familien oppløses først rett før neste års hekkestart.

Under myteperioden, som varer fra midten av juli til midten av august, mister de voksne evnen til å fly i 3-4 uker. Ikke-hekkende fugler myter noe tidligere enn de hekkende. I denne perioden holder de fleste hvitkinngjessene seg på de flate tundraområdene langs vestkysten av Spitsbergen.

Status i Gipsdalen / Templet

Prestrud & Børset (1984) rapporterte 3 hekkende par på Gåsøyane i 1982 og 6-8 par i 1983. Lokaliteten ble ikke besøkt i forbindelse med Gipsdalsstudiene i 1989. De nevner også at arten er kjent som klippehekker ved Gipshuken. Løvenskiold (1964) har ingen opplysninger fra denne delen av Isfjorden. Gåsøyane ble i 1973 vernet som fuglereservat med ferdselsforbud om sommeren (Prestrud 1989).

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

Hvitkinngjess var tilstede i området under hele vårt opphold sommeren 1989, for det meste voksne fugler. Høyeste antall unger som ble observert var 14-15 (bare en flydyktig, samt 32 voksne) 8.8, 14 dununger (og 24 voksne) 18.7, og minst 12 dununger (6 familier, tilsammen 38 voksne) 10.7.

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 elveterrassene nedenfor Dalkallen; endelig talt opp 90-97 voksne og 11 årsunger totalt i området 12.-13.8 (men dammen ved Dalkallen eller Gipsvika vest ble ikke besøkt).

Sårbarhet

I hovedsak gjelder det samme som for kortnebbgås (s. 88). Hvitkinngåsa er mindre sky enn kortnebbgåsa og reagerer ikke på helikoptertrafikk i like stor grad (Madsen 1984, Mosbech et al. 1989). En økning i bestandene av store flyende predatorer ved bedret mattilgang, bl.a. gjennom forsøpling, vil kunne få uheldige følger for lokale gåsebestander (Norderhaug 1983). Ved unødvendige forstyrrelser på hekkeplassene, f.eks. dersom reservatbestemmelser ikke overholdes, kan store deler av bestanden få en dårlig hekkesesong (Prestrud 1989).

Diverse

I årene 1973 - 1983 har rundt 3.300 hvitkinngjess fra Svalbardbestanden blitt utstyrt med fotringer i farget plast for individuell identifikasjon i felt. Fangst og merking har funnet sted både på hekkeplassene og i overvintringsområdet i Skottland (Owen 1984). Under feltarbeidet i Gipsdalen i 1989 ble det ikke registrert fargemerkede individer.

ÆRFUGL *Somateria mollissima*

Utbredelse og vandringer

Holarktisk utbredelse i arktiske og nordlige tempererte strøk. Arten hekker i Europa på Island, Færøyane, Svalbard, Frans Josefs land, Novaja Semlja og Vaigach, og langs kystene fra Kaninhalvøya sør til Østersjøen, Nordsjøen, Frankrike (sjelden) og nordlige deler av De britiske øyer. De enkelte bestander trekker i ulik grad; fuglene fra Barentshavområdet til Nord-Europas kyster. Hos noen bestander finner det dessuten sted et utpreget mytetrekk på sommeren. Fuglene samles da i spesielle myteområder for fjærfelling før de fortsetter til vinterkvarterene.

Forekomst og status på Svalbard

Svalbards mest tallrike andefugl. Hekker i større og mindre kolonier på holmer over det meste av øygruppa, men i størst antall langs vestkysten av Spitsbergen. Spredte par hekker også inne på tundraen på de store øyene. Etablering på hekkeplassene skjer straks snøen smelter og dét blir isfri sjø omkring holmene i slutten av mai eller i juni. Koloniene forlates umiddelbart når eggene er klekket, og ærfuglene samles da i gruntvannsområder ytterst ved kysten, hvor de holder seg inntil de forlater øygruppa i løpet av høsten. Store myteansamlinger fins langs vestkysten av Spitsbergen og Prins Karls Forland (Karlsen 1984, Karlsen & Mehlum 1986). Ærfugler ringmerket på Svalbard er gjenfunnet i Nord-Norge og Island.

Svalbardbestanden utgjør nå 20.000 - 25.000 par (Mehlum 1989), men var i tidligere tider trolig langt høyere. Gjennom uforsiktig egg- og dunsanking og ukontrollert jakt ble den sterkt redusert.

Artsfredning i 1963 og seinere 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.

Ærfuglen er monogam, men danner nytt par hvert år. Paretableringen begynner allerede om høsten. De fleste hunner hekker første gang tre år gamle, noen som toåringer. Reiret plasseres på bakken, gjerne helt åpent, og er godt foret med dun. Ved kolonihekking er eggleggingga godt synkronisert for de fleste reirene, men tidspunktet varierer med lokale snø- og isforhold. Hunnen ruger alene i 25-26 døgn. Hannene forlater som regel hekkeplassen før eggene klekkes og samles i myteflokker. Ungene følger mora på sjøen kort etter klekking. De blir selvstendige etter 7-8 uker, men flyr først etter ca. 10 uker.

Status i Gipsdalen / Templet

Løvenskiold (1964) oppgir Gåsøyane som hekkeområde (koloni). Lokaliteten ble i 1973 vernet som fuglereservat med ferdselsforbud om sommeren (Prestrud 1989).

Endel fugl hadde sommeren 1989 alltid tilhold langs strendene i Gipsvika, innunder Templet og ved utløpet av Gipsdalselva, men ingen store konsentrasjoner ble observert. Eksempelvis ca. 70 individer (hvorav rundt 2/3 hanner) 8.7. Arten ble også ofte sett i ferskvannsdammene på strandvollene i Gipsvika, hvor opptil 50-60 individer kunne ha tilhold. En gang observert så langt inn i dalen som til ferskvannet nedenfor Dalkallen, hvor tre hunner ble sett sammen med en praktærfugl hunn 10.7.

De eneste reirfunnene var to forlatte reir ved ferskvannsdammer (trolig plyndret av fjellrev): på elveterrassene ved Gipsdalselva ca. 3 km ovenfor elveoset 10.7, og innerst i Gipsvika 20.7 (Fig. 5). Noen få ungekull ble observert i Gipsvika: 2 dununger i en flokk med 14 hunner 20.7; to kull à 2 dununger 31.7; minst fem kull 7.-8.8 med 2-4 dununger i hvert, tilsammen 12 unger.

Sårbarhet

Forstyrrelse av ærfugl på hekkeplass kan påvirke hekkesuksessen gjennom avbrudt hekking og økt predasjon (Gabrielsen 1987, Mehlum 1989). Hunnene bruker minst mulig energi til annet enn rugingen. De spiser omtrent ikke gjennom rugeperioden og reduserer derfor sin kroppsvekt med inntil 40 %. Stress som følge av forstyrrelser fra mennesker eller predatorer og gjentatt varming av eggene etter avbrudt ruging medfører ekstra energikostnader. Over tid kan vekttapet resultere i at hunnene må oppgi rugingen for å berge seg selv (Gabrielsen 1987). Når fuglene skremmes av reiret vil dessuten eggene lett bli utsatt for predasjon.

Ærfuglen har trolig en naturlig lav produksjon av unger. Rekruttering til bestanden balanseres med lav voksendødelighet (Åhlund & Gutmark 1989). På Svalbard er polarmåke og fjellrev ofte årsak til betydelige tap av egg og unger (Løvenskiold 1964, Norderhaug 1982, Mehlum 1989). Åhlund & Gutmark (1989) fant på den svenske vestkysten økt risiko for stormåkepredasjon på unger av ærfugl når kullene på forhånd var blitt forstyrret av båter.

Gabrielsen (1987) registrerte større varhet hos ærfuglhunner som hekket i koloni på holmer enn hos enslige rugende hunner på "fastlandet". De siste hadde svært kort fluktavstand overfor mennesker og forlot ikke reiret før forstyrreren var under en meter unna. Holmehekkende ærfugler reagerte med uro allerede når mennesker i åpen båt var 100-200 m fra holmen, og forlot reirene ved 15-30 m avstand. Sammen med ikke-hekkende ærfugler oppholdt de seg likevel i nærheten av reirene, og ruget på ny noen få minutter etter at holmen igjen var fri for mennesker. Polarmåkene lot derfor til å ha relativt små sjanser til å forsyne seg av eggene (Gabrielsen 1987).

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

Ærfuglen er i likhet med andre marine dykkender (f.eks. praktærfugl 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 gjennom forringelse av næringsgrunnlaget, ved at olje som synker skader bunnfaunaen (Anker-Nilssen 1988).

De relativt nyetablerte og ekspanderende bestandene 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

En høyarktisk art med cirkumpolar utbredelse fra Svalbard, Novaja Semlja og kystene av Nord-ishavet fra Kaninhalvøya øst til Beringstredet, og i arktisk Nord-Amerika fra Alaska til Øst-Grønland. Om vinteren lever den i europeiske farvann fra Kvitsjøen til norskekysten (spesielt i Troms og Finnmark) og på Island.

Forekomst og status på Svalbard

Størrelsen på Svalbards hekkebestand er ikke kjent, men praktærfuglen er betraktelig mindre tallrik enn ærfuglen. Viktige hekkeplasser fins på flate og ferskvannsrike tundraområder langs vestkysten av Spitsbergen, særlig fra Prins Karls Forland sør til Bellsund, men den fins også på de sørøstre delene av øygruppa (ikke Bjørnøya). Myteflokker er kjent i grunne farvann utenfor vest- og sørkysten av Spitsbergen. I hekketida opptrer den mest parvis, men samles i flokker ellers i året, ofte sammen med ærfugl. Når praktærfuglen ankommer og forlater øygruppa er ikke kjent.

Biologi og levevis

Praktærfuglens biologi er lite studert. I likhet med ærfuglen spiser den særlig muslinger, krepsdyr og pigghuder. Insektlarver kan være viktig næring på hekkeplassene. Dykker ofte til større dyp enn ærfuglen.

Praktærfuglen er trolig monogam. Paret etableres som regel på våren, og den blir kjønnsmoden som treåring. Reirene plasseres enkeltvis på tundraen, vanligvis åpent eksponert og gjerne nær ferskvann. Reiret er svært rikt på dun. Eggleggingen finner trolig sted fra midten av juni. De 4-6 eggene ruges av hunnen i 22-24 døgn. Hannen forlater hekkeplassen noen dager etter at rugingen tar til. Hunnen og ungene tilbringer den første tida ved ferskvann. Det er ikke kjent når ungene blir flydyktige og selvstendige.

Status i Gipsdalen / Templet

Praktærfugl er tidligere funnet hekkende i Gipsdalen (Løvenskiold 1964). Ett hekkefunn i 1989: En hunn med 3 dununger i en liten myrdam på elveterrassene innerst i Gipsvika 20.7 (Fig. 5). Også enkelte andre observasjoner kan indikere hekking i Gipsdalen: En hunn i ferskvannet nedenfor Dalkallen 10.7, og seinere samme dag en hunn (den samme?) i flukt over dalbunnen et lite stykke lenger inne; en hunn i Gipsdalselva ved sørenden av Leirflata 13.8.

Øvrige observasjoner i Gipsdalsområdet sommeren 1989: En hunn i flokk med 5 ærfugl-hunner ved Gipsvika på morgenen 18.7, og flokk på 5 hunner som fløy inn dalen samme ettermiddag; 4 hunner 20.7, 2-3 hunner 31.7 og en hunn 7.8, alle i ferskvannet innerst i Gipsvika og som regel i flokk med ærfuglhunner; dessuten en voksen hann i Gipsvika 8.7 og 20.7, og en hann i eklipsdrakt ved Gipshukodden 20.7.

Sårbarhet

Rugende praktærfugler er trolig sårbare overfor forstyrrelser på samme måte som enslig hekkende ærfugler, men konkrete undersøkelser over dette foreligger ikke. I likhet med ærfugl er også praktærfuglen sterkt utsatt for oljeforurensninger til havs (Anker-Nilssen 1988).

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 fåtallig i isfrie farvann sør til Nordsjøen, i vår del av verden i store antall i Østersjøen og langs kysten av Nord-Norge.

Forekomst og status på Svalbard

Utbredt over store deler av øygruppa, men er mest tallrik i de vestlige kyststrøkene og på Bjørnøya, hvor den hekker på holmer langs kysten eller ved ferskvann på tundraen. Noen haveller ses langs iskanten svært tidlig på våren, og arten kan trolig overvintre i isfrie farvann rundt Svalbard. Hovedmengden ankommer imidlertid i mai, og de fleste forlater trolig øygruppa igjen i oktober - november.

Biologi og levevis

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

Monogam, men sterk tendens til flokkdannelse utenom hekkesesongen. Ny paretablering 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 bakken og er en grunn grop fôret med litt plantemateriale og dun. De 5-9 eggene legges på Svalbard som regel i siste halvdel av juni, og ruges av hunnen i ca. 26 døgn. Hun avbryter rugingen i korte perioder flere ganger om dagen. Hannene forlater hekkeplassene 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 / Templet

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

Svalbardrype er en underart av fjellrype, som er cirkumpolart utbredt i arktiske og nordlige/ alpine tempererte strøk. Underarten hyperboreus er begrenset til Svalbard med Bjørnøya, og Frans Josefs land.

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 høyarktiske bestander som de i det nordlige Grønland trekker til områder sør for hekkeplassene om vinteren. Tilsvarende 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 oppe 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 øygruppa 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).

Territoriell. Steggene etablerer territorier i mars - april, mens tundraen ennå er snødekket. Reiret er en grunn grop, fôret med plantedeler. Det plasseres på tørr mark, som regel høyt i terrenget og gjerne i sørvendte skråninger. Egglegging en foregår i mai eller juni, men forsinkes ved sein snøsmelting eller omlegging. Kullstørrelsen er vanligvis 10-11 egg, og høna ruger i 21-24 døgn. Ungene er flydyktige etter 10-12 døgn, men de holder seg sammen med mora i 10-12 uker før de blir selvstendige. Hekkesuksessen er knyttet til hønenes kroppsvekter. Høner med høye kroppsvekter danner par og hekker tidligere enn andre, de legger et større antall egg og deres kyllinger er større når vinteren kommer enn høner med lavere kroppsvekter (Unander 1987).

Fjærskiftet er komplisert og varierer mellom kjønn og alderskategorier (Unander 1987). Hønene begynner 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 / Templet

Løvenskiold (1964) nevner observasjoner (men ikke hekkefunn) fra Templet 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 høyere 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

Svalbardrypene er lite redde mennesker (Unander 1987). Ville rugende høners reaksjon på forstyrrelser er studert av Gabrielsen (1987). Hønene trykket når en polarmåke eller havhest fløy over reirområdet. Ved provokasjon av mennesker viste svalbardrypehønene svakere adferdsmessige og fysiologiske reaksjoner enn lirypehøner *Lagopus lagopus* i fastlands-Norge. I motsetning til disse hadde de ingen fluktavstand eller forberedelser til flukt fra reiret. Svalbardrypehønene ble liggende rolig inntil de ble fanget eller dyttet av reiret. Når de måtte forlate reiret fløy de ikke vekk og spilte ikke skadd, men ble rolig gående på bakken. De oppholdt seg nær reiret, laget "hvese"-lyder, og returnerte straks til eggene når inntrengeren forlot reirområdet (Gabrielsen 1987).

Diverse

Det er tillatt å jakte svalbardrype i tidsrommet 1. september - 31. mars. På Bjørnøya er den totalfredet (Prestrud 1989).

SANDLO *Charadrius hiaticula*

Utbredelse og vandringer

Utbredt i arktiske og nordlige tempererte strøk av Europa og Asia, i de nordøstre deler av arktisk Canada og på Grønland. Hekker i Europa fra Svalbard, Novaja Semlja og Island sør til Frankrike (Bretagne), Nordsjøkystene, Østersjøen og Polen. De fleste sandloer er trekkfugler, men sørlige bestander er delvis standfugler. Vinterkvarterene strekker seg via Middelhavsområdet og kystene av Midt-Østen sør til Sør-Afrika og Madagaskar. Vinterkvarterene for Svalbards sandloer er ukjente, men nordlige bestander trekker generelt lengst sør (Cramp & Simmons 1983).

Forekomst og status på Svalbard

Hekker spredt på øygruppa, for det meste på vestsida av Spitsbergen, men er funnet hekkende nord til Sjuøyane. Bestanden ble anslått til å telle 300-600 par i 1979 (Kålås & Byrkjedal 1981). Som tilholdssted velger sandloen helst vegetasjonsfattige sletter med sand eller grus nær salt- eller ferskvann. Arten ankommer Svalbard i begynnelsen av juni, og trekker bort igjen fra slutten av juli til slutten av august.

Biologi og levevis

Livnærer seg på hekkeplassene hovedsakelig av insekter, små krepsdyr og andre virvelløse dyr den finner på land og i fjæra. Byttet lokaliseres med synet og plukkes vanligvis fra overflaten ved hjelp av det forholdsvis korte og rette nebbet.

Sandloene blir kjønnsmodne og hekker ett år gamle. Reiret plasseres på tørr sand eller grus. De fire eggene legges direkte på underlaget i en grunn grop uten annen fôring enn noen tilfeldig sammenraskete skjellbiter eller strå. Egglegginggingen foregår hovedsakelig i juni, og eggene ruges av begge kjønn i 23-25 døgn. Ungene forlater som hos andre vaderarter reiret straks etter klekking. De blir passet av begge foreldrene til de blir flydyktige etter ca. 24 døgn. Voksne sandloer spiller "skadd" når de forstyrres på hekkeplassene. Hensikten er å lede predatorer bort fra egg og unger.

Status i Gipsdalen / Templet

Løvenskiold (1964) oppgir at arten er funnet ved Gipshuken og i Gipsdalen. M.A. Ogilvie (upubl.)

fant minst tre par hekkende på nordsida av Gipsvika i 1983.

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 Norströmfjellet, hvor enkeltindivider ble registrert 27.7 (varslende) og 30.7, og to individer 13.8 (varslende).

Enkeltindivider ble observert i den østlige delen av Gipsvika ved et par anledninger 8.-16.7, og på elveterrassene 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 vadefugl kan imidlertid egg eller unger bli kraftig avkjølt, og slike forstyrrelser øker også predasjonsfaren. Dersom fuglene hekker kolonipreget, slik tilfellet er i Gipsvika, kan følgene for lokale bestander bli store. De viktigste predatorene på Svalbard er fjellrev, polarmåke og tyvjo.

Vadefugler regnes generelt ikke som spesielt utsatt for oljeforurensninger (Anker-Nilssen 1988). Ved tilgrising av strender og steiner i fjæra kan de likevel rammes, både direkte og gjennom forringet næringsgrunnlag.

SANDLØPER *Calidris alba*

Utbredelse og vandringer

En høyarktisk art som foruten på Svalbard hekker i det nordligste Sibir, på Severnaja Semlja, Nysibirøyene, Nord- og Nordøst-Grønland, og i arktisk Canada. Trekkfugl, som i stor grad er knyttet til kyster under trekket og om vinteren. Vinterutbredelsen strekker seg helt sør til det sørligste Sør-Amerika, Sør-Afrika og Australia.

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 &

Byrkjedal (1981) anslo bestanden til 5-15 par i 1979, men estimatet er utvilsomt lavt. Ankommer øygruppa i begynnelsen av juni, og kan opptre i mindre flokker langs kysten før de sprer seg til hekkeplassene på tundraen. Høsttrekket foregår hovedsakelig i august.

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, vegetasjonsfattige og helst tørre tundraområder. Reiret er en grunn grop i vegetasjonen eller på bar mark, ofte fôret 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 ruges av 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 (iherdig 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 høsttrekk: opptil fem 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 fåtallig på Svalbard, og kunnskap om hekkeplassene er derfor viktig for den nasjonale forvaltning av arten.

FJÆREPLYTT *Calidris maritima*

Utbredelse og vandringer

Holarktisk utbredelse. Hekker i de nordøstre deler av arktisk Canada, på Grønland, Island, Jan Mayen (van Franeker et al. 1986), Færøyane og Svalbard, i Nord-Skandinavia og på Kolahalvøya, og ellers i sovjetisk Arktis fra Frans Josefs land og Novaja Semlja øst til Taymyr og Severnaja Semlja. Trekkfugl, som om vinteren har tilhold langs isfrie klippekyster, i Europa fra Murmansk til Biskaya (hovedsaklig norskekysten og Island). Artens vandringer er imidlertid dårlig kjent.

Forekomst og status på Svalbard

Den mest tallrike vaderarten på Svalbard. Hekker på tundraen over det meste av øygruppa. Tettheten av hekkende fjæreplytter på Svalbard er funnet å være omtrent ett par pr. km^2 (Mehlum 1989). Kålås & Byrkjedal (1981) anslo bestanden i 1979 til 2.000-4.000 par på Spitsbergen og 45 par på Bjørnøya. Fjæreplyttene ankommer Svalbard allerede i første halvdel av mai, og holder seg gjerne flokkevis på mudderstrender og i fjæra en stund før de parvis sprer seg utover på hekkeplassene. På ettersommeren samles de igjen i flokker langs kysten før de forlater øyene i løpet av september.

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).

Fjæreplyttene hekker parvis, men selv i hekketida kan de samles i grupper under næringssøk i fjæra. Som reirplass velges forholdsvis tørre tundraområder, både ved kysten og inne i landet. Reiret plasseres ofte i mose- eller lavvegetasjon. Arten er svært uredd mennesker når den ruger, og den kamuflasjefargede fjærdrakten gjør den nesten umulig å oppdage der den ligger i ro. Eggleggingen kan foregå til forskjellige tider, avhengig av snøsmeltingen, men de fleste kull legges fra midten av juni til begynnelsen av juli. Eggene ruges av begge kjønn i 21-22 døgn, mest av hannen. Ungene finner maten selv, men passes av hannen inntil de blir flydyktige etter ca. 3 uker.

Status i Gipsdalen / Templet

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

Påtruffet og påvist hekkende over så godt som hele undersøkelsesområdet i 1989 (Fig. 2). Bestandsstørrelse vanskelig å anslå, men antas å ligge på minst 30-40 par og kan være høyere. Konkrete hekkefunn: Reir m/4 egg Gipsvika 19.7 (fortsatt ruging 22.7, men klekket ved ny kontroll 31.7); reir m/4 egg innunder Grahamkammen 21.7; fem kull observert i Gipsvika 16.7-6.8; 2 dununger (ulike kull) ved Leirflata 21.7; 2 dununger (ulike kull) innunder Meakinsfjellet 29.7; 2 dununger ved Gipsdalselva innunder Usherfjellet 8.8. Det ble ringmerket 14 unger fra 8 kull.

Flokkdannelse under næringssøk i fjæra og på strandvoller første gang registrert 19.7. Flokkene forekom hyppigst i august da også størst antall i flokk ble observert (15 individer 8.8).

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 Nordishavets 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 utenom hekketida nesten utelukkende er å treffe langs kyster, gjerne på stein- eller klippestrand. Vinterutbredelsen omfatter alle kontinenter bortsett fra Antarktis. Vandringsveiene for Svalbardbestanden er ikke kjent.

Forekomst og status på Svalbard

Hekker spredt i fjordområdene på vestsida av Spitsbergen; hekket på Bjørnøya i 1977 (Cramp & Simmons 1983). Som tilholdssted velges helst steinet mark med glissen lavvegetasjon i umiddelbar nærhet av saltvann. Bestanden er anslått til 10-40 par i 1979 (Kålås & Byrkjedal 1981), men dette er uten tvil for lavt. Fuglene ankommer i første halvdel av juni, og trekker bort igjen i løpet av august.

Biologi og levevis

Lever vesentlig av virvelløse dyr, på tundraen hovedsakelig insekter. Steinvenderne benytter flere ulike matsøkteknikker. En del av maten finner de ved å velte små steiner o. lign. for å komme til byttedyr på undersida, men de plukker også dyr fra overflater, ved boring i mudder og sand, og fra oppskyllet tang og tare m.m.

En sosial art som ofte går i grupper under matsøk også om sommeren. Hekker parvis eller i løse kolonier. Kjønnsmoden to år gammel. Steinvenderne er monogame, og paret kan holde sammen mer enn en sesong. Reiret er en grunn grop i marken, fôret med småblader og andre plantedeler. De fire eggene legges i siste halvdel av juni eller begynnelsen av juli, og ruges av begge foreldrene i ca. 22 døgn. Hunnen ruger mer enn hannen, særlig mot slutten av rugetiden. 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.

Status i Gipsdalen / Templet

Løvenskiold (1964) opplyser at steinvenderen er funnet ved Gipshuken. Malcolm A. Ogilvie (upubl.) fant arten hekkende på nordsida av Gipsvika, men opplyser ikke om hvor mange par. Det framgår likevel at det var mer enn ett par.

Hekking påvist i Gipsvika i 1989, fra Gipsdalselva vest til strand-vollene midtveis mellom Gipsvikas innerste del og Gipshukodden; trolig ett par også i Gipsvikas østre del (Fig. 7). Bestanden anslås til 3-5 par. Unger fra 3-4 kull ble observert, med stor spredning i klekketidspunkt: flydyktige unger allerede 20.7 og dununger ennå 10.8. En unge ble ringmerket.

Sårbarhet

Se sandlo (s. 96) for en generell framstilling om vadefugler. Steinvenderen er mer vàr på hekkeplassen enn de andre vaderne på Svalbard. Ved forstyrrelser fjerner den seg fra reiret og holder seg et stykke unna. Resultatet kan lett bli tap av egg eller unger på grunn av predasjon eller avkjøling (Mehlum 1989).

TYVJO *Stercorarius parasiticus*

Utbredelse og vandringer

Cirkumpolar utbredelse i arktiske og nordlige tempererte strøk. I Europa hekker tyvjoen fra Island, Jan Mayen, Svalbard og Kong Karls land sør til Østersjøen, Skagerak, Færøyane og Skottland. Knyttet til kyster i den sørlige delen av utbredelsesområdet; i Arktis kan den hekke på tundraen langt fra sjøen. Pelagisk utbredelse utenom hekketida strekker seg over meget store havområder, og omfatter både Atlanterhavet, Stillehavet og de nordvestre deler av Indiahavet. Vinteren tilbringer de fleste tyvjoer sør for ekvator, europeiske fugler trolig vesentlig utenfor

Afrikas vestkyst, men artens vandringer er
relativt dårlig kartlagt.

Forekomst og status på Svalbard

Hekker spredt langs kysten over mesteparten av
øygruppa, minst tallrik i nordøst. Opptrer 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

Livnærer seg ofte ved hjelp av kleptoparasittisme,
dvs. ved å forfølge andre sjøfuglarter mens de er
på vingene og tvinge dem til å oppgi sitt bytte.
På Svalbard er det særlig krykkje og rødnebb-
terne det går utover, men også alkefugler
(Mehlum 1989). Byttet er som regel fisk, som
tyvjoen fanger opp i lufta. Fisk er dominerende
kost for kysthekkende par og ikke-hekkende
individer. Tyvjoen tar imidlertid annen type føde
også, som insekter, egg og fugleunger, og den
kan også selv fange og drepe voksne fugler
(småvadere, små spurvefugler), foruten at den
spiser åtsler. I områder hvor det fins tar den
også småpattedyr.

Monogam og territoriell. Parbindingen er vanlig-
vis livsvarig etter to til tre hekkinger, og paret
er tro mot territoriet. Første hekking finner sted
i en alder av 3-5 år, tidligst hos nordlige be-
stander. Reiret plasseres på tørr mark, gjerne på
en tue, og som regel i nærheten av sjøen eller
ferskvann. Den grunne reirgropa fôres med
plantedeler; reirtuer får en frodig plantevekst på
grunn av den rike gjødslingen. Eggleggingen
foregår i juni, og eggene ruges av begge kjønn i
25-28 døgn. Kullet består vanligvis av to egg,
iblant bare ett. Ungene forlater reiret kort tid
etter klekking, men fôres og passes av foreldrene
inntil de blir flydyktige etter ca. 5 uker. Selv-
stendige blir de først minst to uker seinere.

Status i Gipsdalen / Templet

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

Fem territorier ble lokalisert 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 om-
stendigheter som tydet på hekking eller stasjo-
nære 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.

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

Territorium 2: Gipsdalen øst for Gipsdalselva, på
dalbunnen mellom Dalkallen og Aitkendalen.
Paret forsvarte territorium ovenfor kortnebbgjess
10.7 og fjellrev 11.7. Reir eller unger ble ikke
aktivt søkt etter. Paret ble også observert på
lokaliteten 18.7, men ikke 30.7; en voksen tyvjo
tilstede 8.8 uten tegn til hekking.

Territorium 3: Gipsdalen øst for Gipsdalselva, på
dalbunnen ved sørenden av Leirflata. Reir m/1
egg funnet 11.7. Ruging pågikk fortsatt 26.7, og
egget ble bedømt som ubefruktet. En voksen var
fremdeles tilstede 13.8; fuglen var like opphisset
som ved tidligere besøk og spilte skadd, men vi
lette ikke opp reiret igjen denne dagen og søkte
ikke etter unger.

Territorium 4: Gipsdalen vest for Gipsdalselva,
innunder Gipshuken rett vest for Tverråas
elvevifte. Paret forsvarte territorium ovenfor en
reinbukk 20.7, og var sterkt opphisset og spilte
skadd ved vårt besøk samme dag. Tross aktivt
søk fant vi imidlertid verken reir eller unger, og
ved en ny kontroll i området 31.7 ble arten ikke
observert.

Territorium 5: Myrdam på platået ovenfor Gips-
hukodden. Sterkt opphisset par 20.7; ved søk fant
vi en dununge, som ble ringmerket. En voksen et
lite stykke nærmere Gipshuksletta 9.8, og en
nylig flydyktig unge uten ring ble observert i
nærhet av lokaliteten 14.8. Det er derfor mulig
at paret hadde to unger.

Sårbarhet

Joer er sårbare overfor oljeforurensninger, spesi-
elt de mer pelagiske artene polarjo *Stercorarius
pomarinus* og fjelljo *Stercorarius longicaudus*
(Anker-Nilssen 1988). På hekkeplass vil tyvjoen
spille skadd eller opptre aggressivt overfor inn-
trengere, og ofte er dette tilstrekkelig beskyttelse
for egg og unger. Overfor mer langvarige for-
styrrelser er den imidlertid sårbar, fordi den har
lengre fluktavstand enn andre arter som hekker
enkeltvis på tundraen, f.eks. fjæreplytt.

POLARMÅKE *Larus hyperboreus*

Utbredelse og vandringer

Arktisk cirkumpolar utbredelse. I Europa hekker
arten på Island, Jan Mayen, Svalbard, Frans
Josefs land, Novaja Semlja, Vaigach og Kolgujev,
og langs Nordishavets kyster østover fra Kanin-
halvøya. Delvis trekkfugl, som vinterstid for det
meste påtreffes langs isfrie kyster og åpne hav-
områder, i Europa så langt sør som til Kattegat,

Den engelske kanal, Sør-Irland og Sør-England (Cornwall).

Forekomst og status på Svalbard

Utbredt langs kysten over hele øygruppa, oftest i eller i nærheten av fuglefjell eller holmer med hekkende gjess og ærfugl. Hekker som regel parvis, men kolonier på opptil flere hundre par forekommer, f.eks. på Bjørnøya og langs Spitsbergens vestkyst. Kan ses i Svalbards farvann hele året, men mange trekker sørover til norskekysten, Færøyane, Island eller det sørlige Grønland.

Biologi og levevis

Polarmåka er alteter, med hovedvekt på animalsk føde. Ernærer seg både ved aktiv predasjon, åtseleting og kleptoparasittisme (se tyvjo). I hekketida tas mye egg og unger av andre sjøfuglarter, gjess og ærfugl. Voksne alkekonger har den ingen problemer med å sluke hele i lufta. Polarmåka fyller samme økologiske funksjon som rovfugl gjør lenger sør, men betydningen av predasjonen for bestandsstørrelsene av dens byttearter er ukjent. Polarmåka tar også mange marine organismer i fjæra og fra havoverflaten, og den utnytter gjerne søppelfyllinger. Den gode næringstilgangen på slike steder bidrar til redusert vinterdødelighet, og dermed økt bestand av polarmåke.

Polarmåka er monogam, men artens biologi er lite studert på de europeiske hekkeplassene. Kjønnsmoden alder ikke kjent, men hos andre europeiske stormåkearter finner første hekking normalt sted i fjerde til sjette leveår. Reiret plasseres som regel på toppen av rauker eller høyt oppe i klipper langs kysten, eller på andre forhøyninger i terrenget. Ved fuglefjell vil den ofte holde til ovenfor de andre sjøfuglene. Reiret er stort, opptil 40 cm i diameter, og består av gress, mose og tang. De 2-3 eggene legges på Svalbard trolig rundt månedsskiftet mai/juni, og ruges av begge kjønn i 27-28 døgn. Ungene forlater reiret etter noen få dager, men holder seg likevel i reirområdet. De vernes og fôres av foreldrene inntil de blir flydyktige og selvstendige etter ca. 7 uker.

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 koloniopptreden i området. De første flydyktige ungene ble observert i Gipsvika 5.8, noe som betyr egglegging 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

Måkefugler er generelt sårbare overfor oljeforurensninger i nærheten av hekkeområdene (Anker-Nilssen 1988). Ved matleting blir de lett tilgriset, og deres næringsgrunnlag kan også forringes, selv om polarmåka i likhet med de fleste andre stormåker er en opportunist i matveien. Forstyrrelser i hekkeområdene kan også være en negativ faktor av betydning (Anker-Nilssen 1988). Polarmåka later imidlertid ikke til å være spesifikt studert i disse henseender. Eneste art som er jaktbar hele året på Svalbard (Prestrud 1989).

KRYKKJE *Rissa tridactyla*

Utbredelse og vandringer

Krykkja har vidt atskilte bestander i de nordlige deler av både Atlanterhavet 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 arktisk 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 øst for Sicilia. Opptrer ofte svært tallrik langs kyster etter kraftig vind, og forekommer også i innlandet. Europeiske krykkjer overvintrer på begge sider av Atlanterhavet.

Forekomst og status på Svalbard

Svalbards vanligste måkeart. Hekker i fuglefjell over det meste av øygruppa, enten alene eller i blandingskolonier med andre sjøfuglarter, særlig polarlomvi. Kolonier fins fra Bjørnøya i sør til Sjuøyane 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 næring fra overflaten eller øvre vannlag i sjøen. De spiser småfisk og pelagiske virvelløse dyr, i Svalbard-området mest polartorsk *Boreogadus saida*, lodde *Mallotus villosus*, krill og amfipoder (Mehlum & Giertz 1984). De opptrer ofte i flokk og følger gjerne fiskefartøyer.

En monogam art. Paret gjenforenes hver vår, men nye parbindinger er heller ikke uvanlig. Hekker første gang 4-5 år gammel, og kan oppnå en alder av minst 25 år. En utpreget fugle-fjellsart, som bebor tette kolonier på smale hyller i loddrette fjellvegger. Benytter ofte hyllene ved foten av fjellveggen som reirplass. Eggleggingen finner på Svalbard sted i første halvdel av juni. Krykkja legger vanligvis to egg, iblant bare ett, som ruges av begge kjønn i ca. 27 døgn. 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.

Status i Gipsdalen / Templet

Løvenskiold (1964) oppgir at det er en stor koloni i Templet, 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 Templet 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 koloniene 11.8 ble det oppdaget at deler av kolonien tidligere hadde vært skjult for oss. Disse partiene omfattet minst 200-300 par. Et forsiktig estimat for de to krykkjekoloniene i Templet i 1989 lyder derfor på minst 1.500 par. Det ble ringmerket tre årsunger og sju voksne fugler. Vi fant ikke andre hekkeforekomster i studie-området.

Krykkjeflokker på opptil 20-30 individer badet ofte i ferskvannsdammer i Gipsvika og i de nederste delene av Gipsdalselva.

Sårbarhet

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

Våpenskudd (avstand fra kolonien ikke oppgitt) fikk mange krykkjer (men langt fra alle) til å fly av reirene. Provokasjon av flere personer som ankom stranda nedenfor kolonien eller av en person rett under den resulterte ikke i noen synbar endring av fuglenes adferd, men tele-metriske EKG-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 vingene. Det er uklart om reak-sjonen skyldtes lyden eller synet av helikopteret. Når krykkjer flyr av reirene fordi de skremmes av et overflyende helikopter oppstår det risiko for at egg eller unger kan rives med og gå tapt i panikken som oppstår. Provokasjoner med heli-kopter 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 fartøyer i sjøen, men det er ikke påvist samme tendens til å forsyne seg av fremmed-elementer fra forsøpling. Se også polarmåke (s. 99) for generell beskrivelse av måkerfugls sårbarhet overfor oljeforurensninger.

ISMÅKE *Pagophila eburnea*

Utbredelse og vandringer

En høyarktisk art som bare er kjent som hekke-fugl i arktisk 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 utvilsomt også forflytninger til om-råder sør for driviskanten, og er en regelmessig vintergjest i lite antall til Island. Vandringene er imidlertid dårlig kjent.

Forekomst og status på Svalbard

Et lite antall små kolonier er kjent, de fleste i de 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 selkadav-re og andre åtsler er også viktige. Ekskrementer fra sel og isbjørn inngår også i kostholdet, for-uten 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 plante-
deler og fjær, og bygges av begge foreldrene.
Kullet har vanligvis av to egg, som ruges i ca. 25
døgn. Ungene fôres av foreldrene inntil de blir
flydyktige etter ca. 7 uker.

Status i Gipsdalen / Templet

Eneste kjente koloni i Isfjordområdet ligger ifølge
Løvenskiold (1964) ved Ebbabreen innerst i Bille-
fjorden. Vi observerte voksne ismåker i Gipsvika
ved tre anledninger i 1989: to individer 21.7, og
enkeltindivider 5.8 og 11.8. Utenom studie-
området så vi minst 30 individer under et besøk
i Pyramiden 12.8.

Sårbarhet

Ingen informasjoner. Arten opptrer ofte nær
bebyggelse og fysiske installasjoner under matsøk,
og vil således lett kunne komme i kontakt med
lokale forurensningskilder. Se også polarmåke
(s. 99) for generell beskrivelse av måkefuglers
sårbarhet overfor oljeforurensninger. Observa-
sjoner på Svalbard i seinere år tyder ellers på et
visst konkurranseforhold mellom krykkje og
ismåke om reirhyller (Mehlum 1989), og en bedre
oversikt over ismåkas status på øygruppa er
påkrevet.

RØDNEBBTERNE *Sterna paradisaea*

Utbredelse og vandringer

Holarktisk utbredelse i arktiske og nordlige
tempererte strøk. I Europa hekker arten på
Island, Færøyane, Jan Mayen, Svalbard og Frans
Josefs land, og langs kystene fra Sibir sør til De
britiske øyer, Nederland og Østersjøen. På Island,
i Fennoskandia og øst for Kvitsjøen fins den
dessuten mange steder langt inne i landet,
hovedsakelig på tundra og i høyfjellet. Er delvis
i tilbakegang i de sørlige delene av utbredelses-
området, og har forsvunnet som hekkefugl i
Frankrike (Cramp 1985). Rødnebbterna utfører
det lengste av alle fugletrekk: fra hekkeplassene
på inntil ca. 83°N til vinterkvarterene som
hovedsakelig ligger i den antarktiske drivissonen.
Under trekket kan den ses overalt langs Vest-
Europas kyster og i de åpne havfarvannene.

Forekomst og status på Svalbard

Vanlig hekkefugl på strand og tundra nær sjøen
og på holmer og skjær langs kysten over hele
øygruppa. Hekker parvis eller i kolonier på opptil
flere hundre par. Ankommer Svalbard i slutten
av mai eller begynnelsen av juni, og forlater
øyene igjen fra slutten av august til midten av
september.

Biologi og levevis

Føden består hovedsakelig av småfisk og pelag-
iske krepsdyr, som fanges under stup på grunt
vann. Rødnebbterner kan bli meget gamle; årlig
gjennomsnittlig dødelighet for voksne er beregnet
til 10-15 % (Cramp 1985). En ringmerket fugl ble
nærmere 34 år, en annen merket som unge på
Svalbard ble gjenfanget i live etter 21 år.

Monogam, med tendens til fast parbinding.
Hekker første gang to til fem år gammel, som
regel som fireåring. Etablerer territorium allerede
før reirplassene blir snøbare. Reiret plasseres
åpent på bakken, og er lite annet enn en grunn
grop med noen få sammenraskede strå eller
skjellrester. Eggleggingstidspunktet varierer, men
er vanligvis fra slutten av juni. Som regel 1-2
egg, som legges med et intervall på opptil fem
dager. Eggene klekkes likevel omtrent samtidig,
etter drøyt 20 døgns ruging av begge foreldrene.
Ungene holder seg i reiret til de er et par dager
gamle, og forflytter seg deretter rundt i reir-
området inntil de blir flydyktige ca. 3 uker
gamle.

Status i Gipsdalen / Templet

Hekkeforekomst på Gåsøyane nevnes kort av
Løvenskiold (1964). Lokaliteten ble i 1973 vernet
som fuglereservat med ferdselsforbud om som-
meren (Prestrud 1989). Gåsøyane ble ikke besøkt
i 1989, og antall ternepar der er ikke kjent.

Hekking ble i 1989 påvist på strandvollene ca. 2
km øst for Gipshukodden hvor en dununge ble
funnet 9.8, og i Gipsvika øst for Gipsdalselva
hvor en nesten flydyktig unge ble sett 10.8 (Fig.
8). På begge lokalitetene opptrådte fire voksne
terner aggressivt. Paret (eller parene) øst for
Gipsdalselva har trolig ruget på elvevifta neden-
for Dalkallen, da rødnebbterner ble jevnlig sett i
dette partiet av elva fra de første dagene vi var
i området. Høyst sannsynlig hekket det dessuten
to eller tre par på Gipshuksletta, etter fuglenes
adferd der 20.7 å dømme.

Rødnebbterner ble ellers ofte sett i Gipsvika og
langs stranda innunder Templet, som regel i
svært små antall.

Sårbarhet

De indirekte konsekvenser av oljeforurensninger
er generelt vurdert som svært betydelige for
terner, selv om fuglene normalt ikke kommer
direkte i kontakt med oljen (Anker-Nilssen 1988).
Deres fisketeknikk gjør at selv en tynn oljehinne
på sjøen vanskeliggjør matsøk.

Rødnebbternene er også sårbare overfor forstyr-
relser på hekkeplassene (Anker-Nilssen 1988). De
hekker ofte i kolonier og er svært aggressive mot
inntrengere som derfor normalt holdes effektivt

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 *Uria lomvia*

Utbredelse og vandringer

Holarktisk utbredelse langs arktiske og sub-arktiske kyster. I Europa hekker polarlomvien på Novaja Semlja, Frans Josefs land, Svalbard, Jan Mayen og Island, og fåtallig langs Barent-shavkysten fra Kolahalvøya til Vest-Finnmark og på Røst i Lofoten. Pelagisk utbredelse for disse bestandene ligger i Barentshavet og det nordlige Atlanterhavet sør til New England (USA), Fær-øyane og Midt-Norge, hovedsakelig over konti-nentalsoklene.

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 Spits-bergen, og i Storfjorden- og Hinlopenområdet. Polarlomviene ankommer hekkeplassene på Sval-bard i april, og forlater dem igjen i løpet av august. Resten av året tilbringer de trolig i farvannene sørvest for Grønland og i Barents-havet.

Biologi og levevis

Ernærer seg hovedsakelig på fisk, men tar også endel virvelløse dyr. Fisk er dominerende i kost-holdet 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 stu-dium). 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*) er en alder av 32 år påvist (Cramp 1985).

Lever i monogame parforhold gjennom hekke-sesongen. Alder for første hekking er ikke kjent. Parene hekker tett på smale fjellhyller, i rene polarlomvikolonier eller i blanding med andre sjøfuglarter. Tilstede på hekkeplassene allerede tidlig på våren, men eggleggingen finner ikke sted før i månedsskiftet mai/juni. Det enslige egget er pæreformet, og ruller derfor ikke så lett

utfor hyllekanten når foreldrene flyr av. Eggene legges på omtrent samme tid av alle hunnene i en koloni, og klekkingen er derfor noenlunde synkron for hele kolonien. Egget klekkes etter 30-35 døgns ruging av begge kjønn. Ungen passes og fôres av begge foreldrene. Ved ca. 20-21 døgns alder hopper ungen fra reirhylla uten ennå å kunne fly, og følges av hannen til havet. Enkelte kolonier ligger så langt fra sjøen at ungene ikke når fram direkte; under vandringen ned til sjøen er de da sterkt utsatt for predasjon fra fjellrev og polarmåke. Det er ikke kjent når de blir flydyk-tige. Ungene passes av foreldrene flere uker etter at de har forlatt kolonien.

Status i Gipsdalen / Templet

Polarlomvien var svært tallrik ("immense num-bers") 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.-23.7.89. Polarlomviene hekket 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 enkeltkolonien alene. I sum ble Templets 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. Templets total-bestand av polarlomvier i 1989 var følgelig klart i overkant av 3.000 individer.

Tabell 1 Kolonier av polarlomvi *Uria lomvia* i Templet 15.-25.7.89 (antall voksne individer).

Koloni	Minimum	Maksimum
1	322	358
2	164	200
3	60	90
4	69	69
5	198	199
6	366	379
7	1.506	1.657
SUM	2.685	2.952

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

Sårbarhet

Fjeld et al. (1988) studerte effekten av helikopter-trafikk og simulert helikopterstøy på hekke-suksess og fuglenes adferd i en mindre polar-lomvikoloni ved Ny-Ålesund. De kunne ikke

påvise tap av egg eller unger som direkte følge av utførte eksperimenter, og fant ingen effekter på hekkesuksessen. Både hekkende og ikke-hekkende fugler reagerte likevel på provokasjonene, og visuelle såvel som auditive signaler var av betydning. Det ble funnet en klar sammenheng mellom støynivå (desibelstyrke) og fluktreaksjon. Betydningen av lavfrekvent infralyd ble også framhevet, men endelige analyseresultater er ikke presentert. I ekstreme tilfeller kunne polarlomvier forlate hyllene allerede mens støykilden var på 6 km avstand. Reaksjonene var sterkest i de tilfellene hvor helikopteret hadde kurs rett mot kolonien og lyd- og synsinntrykk ble gradvis forsterket. Helikoptre som beveget seg parallelt med fjellveggen i 500 m avstand avstedkom nesten ingen reaksjon.

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 og/eller store kolonier bør helikoptertrafikk dirigeres til spesielle traseer i minst 6 km avstand fra koloniene (Fjeld et al. 1988).

Alkefugler er generelt svært sårbare for oljeforurensninger i sjøen. Mytende bestander (alle arter) og flyveudyktige unger av polarlomvi, lomvi og alke *Alca torda* på svømmetrekk tidlig på høsten er ekstra utsatt. Både de direkte effekter for bestand og reproduksjon, og mer indirekte følger som f.eks. forringet næringsgrunnlag vurderes som svært betydelige (Anker-Nilssen 1988).

Diverse

Ifølge Malcolm A. Ogilvie (upubl.) skal både lomvi og polarlomvi hekke i Templet. I juli 1983 observerte han lomvi ved to anledninger i Isfjorden: seks individer ved Adventfjorden 12.7 og et enkeltindivid nær Templet 26.7. Arten ble imidlertid ikke sett ved et besøk i Templet 13.7 (Malcolm A. Ogilvie upubl.).

Polarlomvien er på Svalbard jaktbar i perioden 11. august - 31. oktober (Prestrud 1989).

TEIST *Cepphus grylle*

Utbredelse og vandringer

Holarktisk utbredelse langs arktiske og nordlige tempererte kyster, hovedsakelig i Atlanterhavet. I Europa hekker teisten fra Island, Jan Mayen, Svalbard, Frans Josefs land og Novaja Semlja sør til Østersjøen, Kattegat, Færøyane og De britiske øyer. Arten er mindre pelagisk enn andre alkefugler. I hekkesesongen er den mest å finne i fjæreregionen, og den oppviser ikke like klare vandringer som andre arter. Sørlige bestander overvintrer relativt nær hekkeplassene og i kystnære farvann. Fugler fra arktiske bestander har trolig tilhold så langt nord de finner åpent

vann. I hvor stor grad de trekker lenger sør er ikke kjent.

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 næring etter tilgjengelighet. På Svalbard tar den i stor grad bunnfisk som ulker, i drivisen mest polartorsk og krepsdyr (Mehlum 1989). Fisker ved dykk fra overflaten, for det meste ned til 10 m dyp, og nesten alltid alene.

Teisten er 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, steinurer, eller andre naturlige eller menneskeskapte hulrom, parvis eller i løse kolonier. Hekker som regel nær sjøen, men iblant opptil 2-3 km inne i landet. De to eggene legges direkte på underlaget, på Svalbard trolig fra slutten av mai, og ruges av begge kjønn i 28-31 døgn. Ungene fôres 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 hekker bortgjemt i hulrom, og løper derfor ikke den samme risiko for tap av egg og unger som polarlomviene når de flyr opp fra sine smale åpne hyller i stupbratte fjellvegger. De tre artenes adferdsmessige reaksjoner ved forstyrrelser på hekkeplassene later imidlertid ikke 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 oljesøl for alkefugl er gitt under polarlomvi.

Teist, alkekonge og lunde kan jaktes på Svalbard i perioden 1. september - 31. oktober (Prestrud 1989).

ALKEKONGE *Alle alle*

Utbredelse og vandringer

En arktisk art som hekker på Grønland (hovedsakelig vestkysten), Grimsey nord for Island (fåtallig), Jan Mayen, Svalbard, Frans Josefs land, Novaja Semlja (fåtallig) og Severnaja Semlja; muligens noen få par også i Vest-Finnmark (Lorentsen 1982, Cramp 1985). Cramp (1985) inkluderer også det nordlige Stillehavet i hekkeutbredelsen, men gir ingen nærmere opplysninger. Pelagisk utbredelse omfatter Barentshavet og det nordlige Atlanterhavet sør til Nordsjøen og havområdene utenfor det nordøstligste USA.

Forekomst og status på Svalbard

Øygruppas tallrikeste fugl, men bestandens størrelse er ikke kjent. Vidt utbredt, men er mest tallrik i Hornsundområdet og på Nordvest-Spitsbergen. Hekker som regel i talusurer i fjell med prekambriske og siluriske bergarter, iblant på flatmark. Ankommer gjerne hekkeplassene i begynnelsen av april, og forlater kystområdene igjen i august - september. Alkekonger kan ses i farvannene rundt Svalbard mesteparten av året, og mange overvintrer trolig langs iskanten mellom Grønland og Svalbard og i Barentshavet, men eksakt viten om vandringene mangler.

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 i urer, mellom steinblokker eller i fjellsprekker. Alkekongen legger bare ett egg, på Svalbard i annen halvdel av juni eller i begynnelsen av juli, som ruges av begge kjønn i 29 døgn. Ungen fôres 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 opptelling 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 Sindballefjellet 6.8 (Fig. 10).

Det ble ikke funnet hekkeplasser i fjellene rundt selve Gipsdalen. Ved foten av Storholen, mellom Sandbreen og Macleanbreen, var det tilsynelatende egnede hekkeplasser i en talusur, men arten ble ikke observert her under et besøk 9.7.89. På dalbunnen nær sørenden av Leirflata spiste et tyvjopar 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

Hekker langs arktiske og nordlige tempererte kyster i det nordlige Atlanterhavet, i Europa fra Spitsbergen og Novaja Semlja sør til Frankrike (Bretagne). De største europeiske koloniene fins på Island, Færøyane, De britiske øyer og i Nord-Norge. Pelagisk utbredelse dekker store deler av det nordlige Atlanterhavet sør til ca. 55°N. Europeiske lunder tilbringer trolig vinteren først og fremst fra Nordsjøområdet sørover til det vestlige Middelhavet og havområdene utenfor Nordvest-Afrika.

Forekomst og status på Svalbard

Mindre tallrik på Svalbard enn andre hekkende alkefugler bortsett fra alke. Hekker spredt langs klippekyster, spesielt på vestkysten av Spitsbergen og nord til Sjuøyane, og på Bjørnøya. Bestandens størrelse og når lundene ankommer og forlater hekkeplassene på Svalbard er ikke kjent.

Biologi og levevis

Lever hovedsakelig av fisk, men de voksne spiser også en del virvelløse dyr, særlig krepsdyr og vingesnegl. Fisker i 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 i nebbet 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 gresskledte 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 fôres 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 / Templet

Løvenskiold (1964) oppgir hekkeforekomster i Templet og på Gåsøyane. Gåsøyane ble ikke besøkt i 1989.

De forbehold som er gitt for alkekongen gjelder også lunden. I alt ble det registrert 893 voksne lunder i Templet 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 Templets vestre hjørne og rett øst for Skiltvakten, eller i Bjonadalen; noen flere lunder hadde tilhold i dalen nord for Skiltvakten og omtrent midt på fjellets fasade mot sjøen; mens 477 lunder (46 % av totalen) ble opptalt i fjellets sørøstre hjørne ved Bjonapynten. Lunder ble også observert i Sindballefjellet 6.8.89, og i den sørøstre eggen av Dalkallen i september 1989 (R. Hansson pers. med.; Fig. 10).

En mindre lundeflokk 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 oljeforurensning og alkefugl er gitt under polarlomvi. Se også teist (s. 104).

SNØSPURV *Plectrophenax nivalis*

Utbredelse og vandringer

Holarktisk utbredelse i arktisk og nordlige tempererte strøk. I Europa hekker snøspurven fra Island, Jan Mayen, Svalbard og sovjetisk Arktis sør til Fennoskandias og Skottlands fjellområder. Trekkfugl som overvintrer i tempererte strøk, f.eks. Mellom-Europa.

Forekomst og status på Svalbard

Den eneste spurvefugl som har vid hekkeutbredelse på Svalbard, og fins over så godt som hele øygruppa. Ankommer tidlig på våren, mange allerede i april, og forlater øygruppa igjen seint på høsten. Hannene kan ankomme flere uker før hunnene. Opptrer ofte flokkevis i åpent terreng og i fjæra utenom hekkesesongen. Ringmerkingsgjenfunn tyder på at snøspurvene på Svalbard trekker i sørøstlig retning over Kola-halvøya om høsten.

Biologi og levevis

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

Territoriell. Hekker parvis, på Svalbard i steinet tundraterreng, i fjellsider, og ved fuglefjell og bebyggelse. Reiret plasseres godt skjult i fjellsprekker, under steinheller, i urer eller bygninger. Det er godt 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. Eggene 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 / Templet

Løvenskiold (1964) nevner forekomster i Templet 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 Templet. 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; fåtallig 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 rein-distrikter i sentrale deler av Spitsbergen og på Edgeøya/Barentsøya.

Biologi og levevis

Fjellreven er en utpreget opportunist og generalist som spiser det som byr seg, og den er både toppredator og åtseleter. På Svalbard utgjør sjøfugl og ærfugl/gjess den viktigste nærings-kilden om sommeren. Utover høsten avtar til-gangen på byttedyr, og om vinteren fanger den ryper og lever på reinkadavre og isbjørnens etterlatenskaper etter selslakt. På våren er unger av ringsel et viktig byttedyr. Denne ekstreme variasjonen i næringstilgang møter fjellreven på Svalbard med hamstring og fettlagring, og trolig også redusert aktivitet og metabolisme i vinter-halvåret (Hansson et al. 1989). Matavfall fra menneskelige bosetninger har også blitt en viktig næringskilde om vinteren.

Fjellreven hevder et territorium som i gjennomsnitt er 10-20 km² stort (Mehlum 1989). Hannen kan ha flere tisper innenfor territoriet, men normalt er det bare en som pares. På Svalbard legges hiene gjerne i steinurer nær fuglefjell eller oppe i dalsidene, iblant også utgravd i løsmasser (Hansson et al. 1989). Paringen finner sted i mars, og ungene fødes i mai. Kullet består av 8-10 valper, som overlates til seg selv og forlater hiet i juli - august. Når det er dårlig med mat overlever få valper hiperioden, mens næringstilgangen vinterstid er avgjørende for bestandsstørrelse og -tetthet neste ynglesesong. Fjellreven har et svært høyt reproduksjonspotensiale, og den kan derfor raskt øke bestanden når de bestandsregulerende faktorene er gunstige (Hansson et al. 1989).

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 "moreneter-rasser" godt hevet over strandflaten. Avstanden mellom hiene var ca. 5 km.

Hi 1: Ved Skiltvakten i Templets vestende, funnet 15.7. Hiet ble lokalisert på grunn av byttedyrrester i terrenget. En voksen rev ble observert i området uten å vise tegn til aggres-sivitet eller nervøsitet. Yngling ble ikke konstatert før 11.8 da en valp dukket opp ved hytta i Gipsvika og (formodentlig den samme) seinere på dagen søkte tilflukt i hiet.

Hi 2: Ovenfor Bjonasletta, ved Templets østlige hjørne. Funnet 24.7, da det inneholdt minst to valper; en voksen rev varslet intenst. Følgende byttedyr ble registrert i hiområdet: 1 havhest-unge, 4-5 voksne havhester, 1 polarmåke, 1 kryk-kjeunge, 4-5 voksne krykkjer, og 4 voksne polarlomvier.

Sjøfuglrester ble også funnet i Dalkallens øst-vendte fjellside, men hi kunne ikke lokaliseres. En fjellrev i sommerpels ble i juli og august 1989 flere ganger sett på dalbunnen mellom Dalkallen/ Usherfjell og Leirflata, og eventuell yngling i dette området kan ikke utelukkes.

Voksne fjellrever ble iakttatt ved ytterligere tretten anledninger i Gipsvika og Gipsdalen nedenfor Leirflata sommeren 1989, men spor og sportegn ble funnet nesten helt inn til dal-bunnen. Sju av observasjonene dreier seg om rev som fremdeles helt eller delvis bar vinterpels. Etter pelstegningene å dømme omfattet observa-sjonene 3-6 voksne individer (hiene ikke medregnet). Den blå fargevarianten ble ikke observert.

Sårbarhet

Fjellreven på Svalbard kan jaktes og fanges i perioden 1. november - 15. mars (Prestrud 1989). Fangsten er viktig for fangstmennene på Sval-bard (Hansson et al. 1989), og utgjør øyensynlig ingen fare for bestanden. Det er imidlertid sann-synlig at arten kan bli skadelidende ved oljeforu-rensninger i sjøen, fordi sjøfugl utgjør en så viktig del av kostholdet. Rev kan også bli for-giftet ved å spise oljeskadd fugl eller sel, eller selv bli tilgriset og dermed utsatt for redusert isolasjon, hudirritasjoner og økt energiforbruk. Effekten kan i alle tilfeller bli økt dødelighet lokalt (Hansson et al. 1989).

Diverse

Fjellreven på Svalbard utnytter ofte forsøplings-avfall fra ferdsel og bosetting. Det er derfor sannsynlig at økt turisme og industriell aktivitet lokalt vil medføre økt innvandring, reproduksjon og forekomst av rev (Hansson et al. 1989). Dette kan igjen få konsekvenser for lokale bestander av gjess og ærfugl, og kanskje for sjøfugl og ringsel. Videre er det påvist rabiesvirus i fjellrev-bestanden på Svalbard, og det ser ut til å være en sammenheng mellom antall rabiestilfeller hos rev og bestandens størrelse. Økt forekomst av rev, spesielt i og nær bebyggelse, vil derfor øke risikoen for overføring av rabiesvirus (Hansson et al. 1989).

En fjellrev i sommerdrakt ble 26.7.89 observert

mens den utvungent la på svøm over Gipsdals-
elva nedenfor Usherfjellet. For observasjoner av
predasjon på gjess, se kortnebbgås (s. 88).

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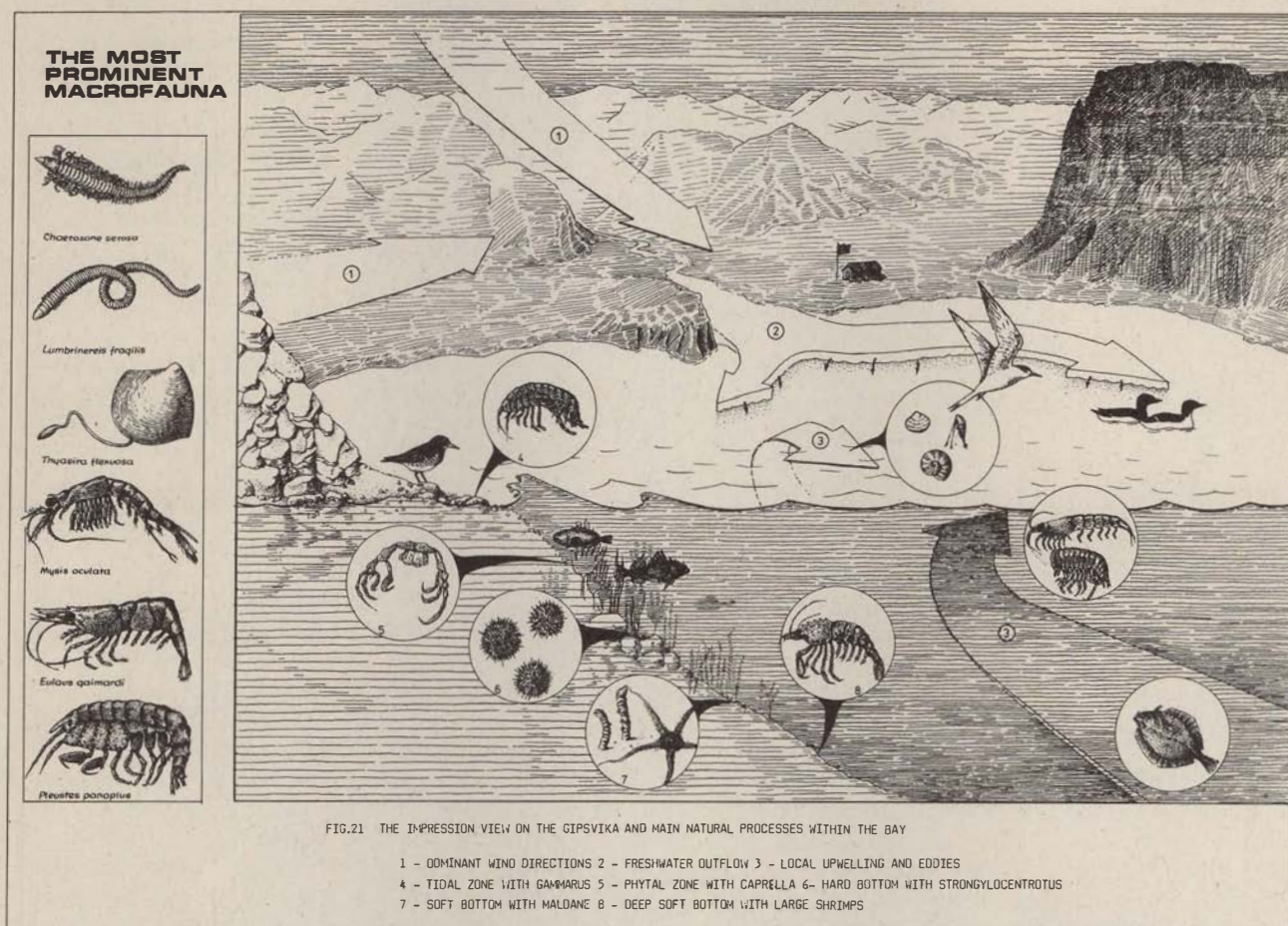
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SUMMER ENVIRONMENTAL SURVEY OF GIPSVIKA, SVALBARD

THE MOST PROMINENT MACROFAUNA

Chaetozone serosa

Lumbrinereis fragilis

Thyasira flexuosa

Mysis oculata

Eualus gaimardi

Pleustes panoplus

FIG.21   THE IMPRESSION VIEW ON THE GIPSVIKA AND MAIN NATURAL PROCESSES WITHIN THE BAY

1 - DOMINANT WIND DIRECTIONS 2 - FRESHWATER OUTFLOW 3 - LOCAL UPWELLING AND EDDIES
4 - TIDAL ZONE WITH GAMMARUS 5 - PHYTAL ZONE WITH CAPRELLA 6- HARD BOTTOM WITH STRONGYLOCENTROTUS
7 - SOFT BOTTOM WITH MALDANE 8 - DEEP SOFT BOTTOM WITH LARGE SHRIMPS

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 6×10^7 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-Wienner diversity coefficients were exceptionally high ranging from 2 to 8. Phytobenthos 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., Weslawski 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 Sechchi disc.

Bottom fauna was sampled quantatively 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-
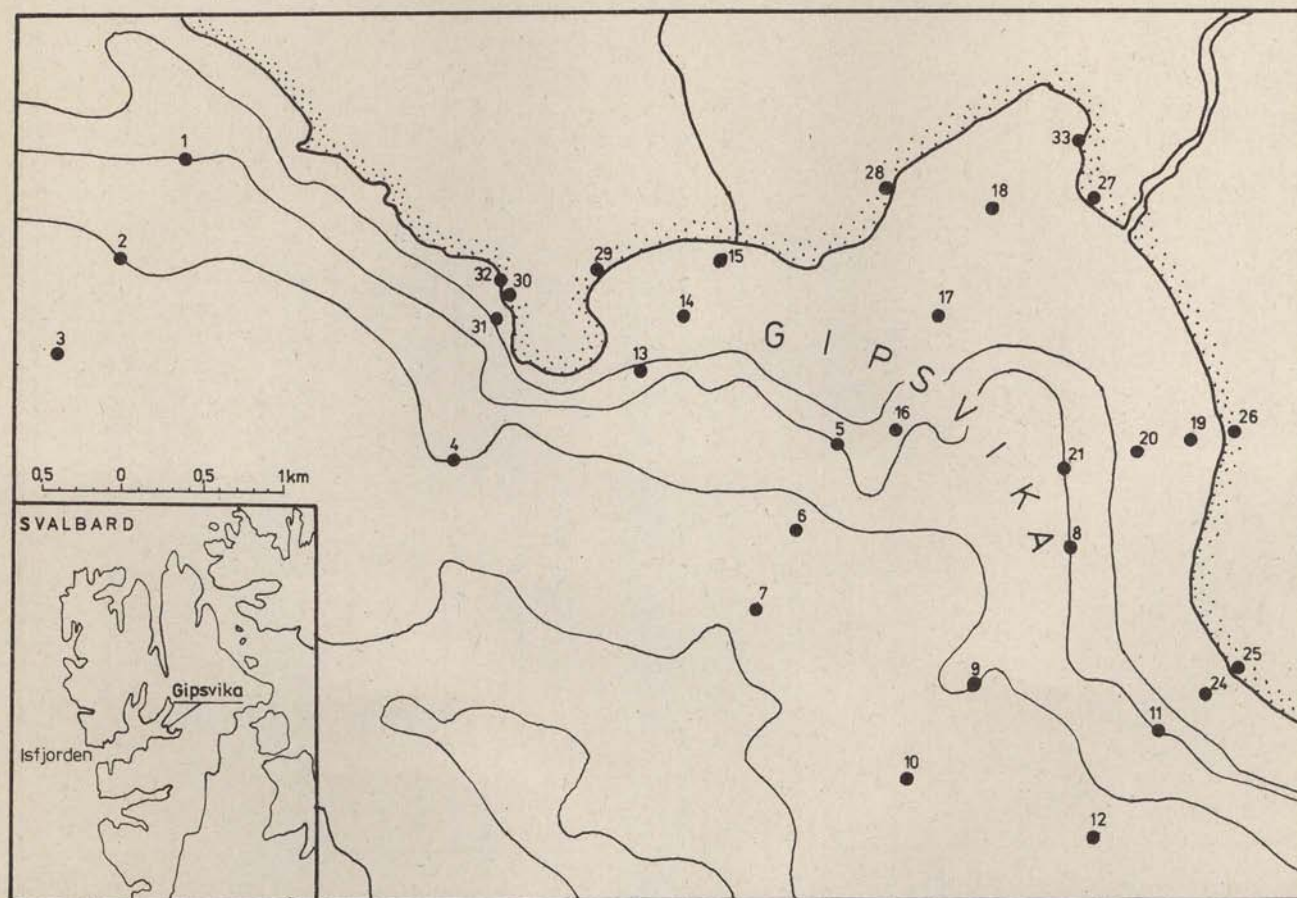

Figure 1 The geographical position of Gipsvika, samplingstations and bathymetry.

vika 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 6×10^7 m³, 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).
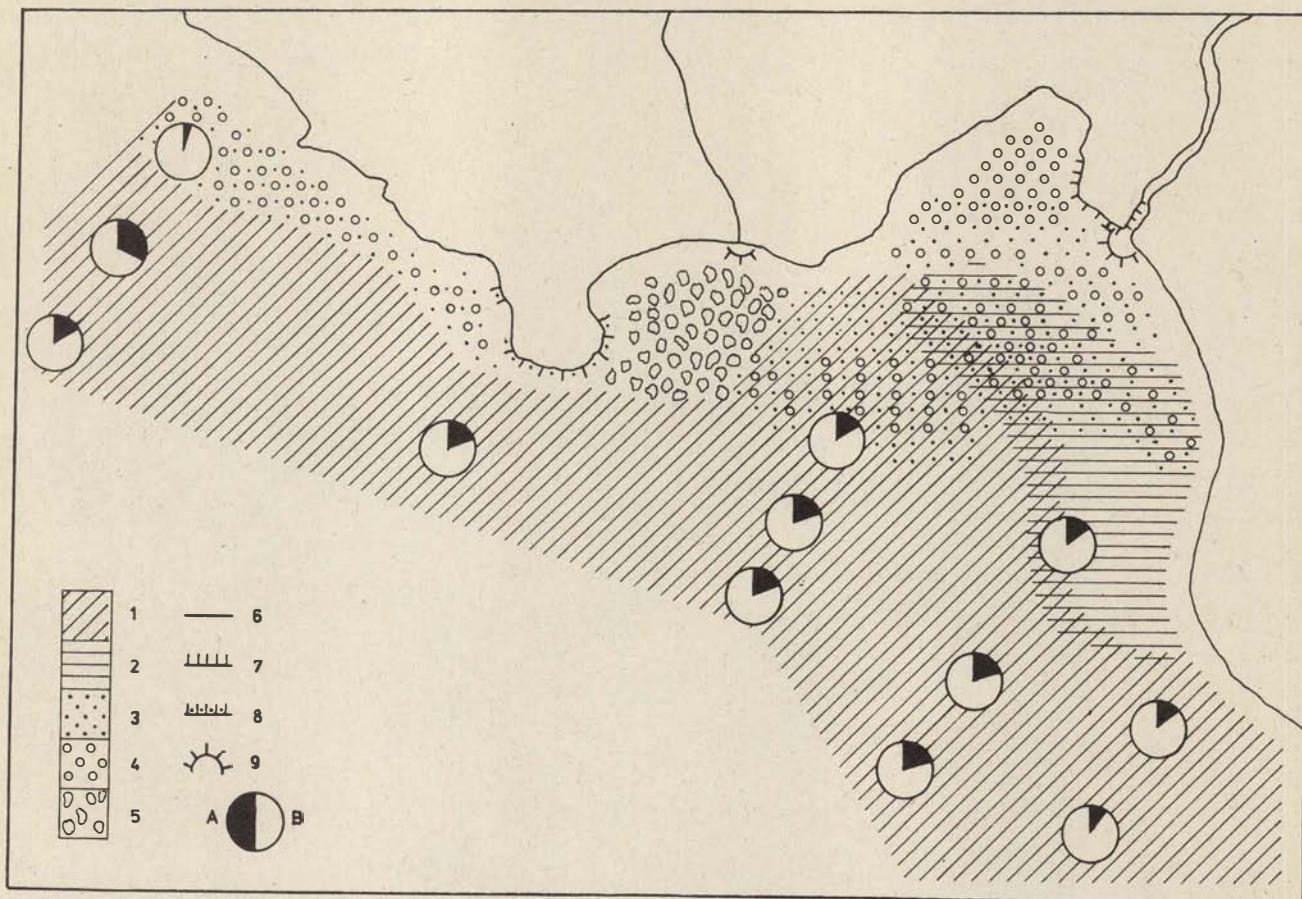
Coasts

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

Figure 2 Coast types and bottom sediments in Gipsvika.

1 slit	4 gravel	7 abrassive cliff	A organic
2 mud	5 stones	8 cliff, rock slide	B mineral matter
3 sand	6 low beach	9 river mouth	

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.
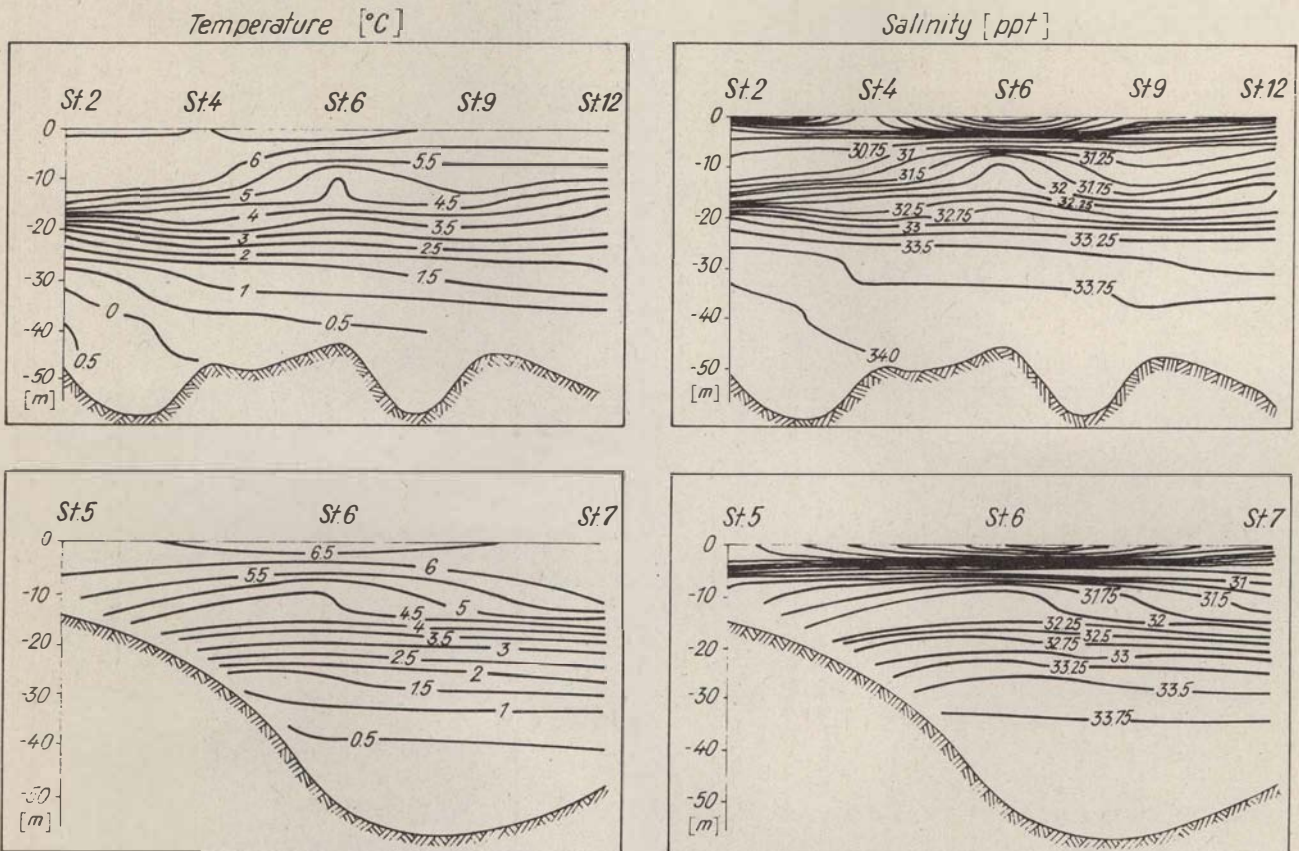
The bottom distribution of temperature and salinity were typical for Spitsbergen fjords. Isolines were almost parallel to isobathes. Temperature increased and salinity decreased towards the coasts. The bottom effect gave some perturbations in T and S distributions - in the eastern part of the bay high 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 firds. 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, Tsecotskaya & Zlobin 1977). For Isfjorden the following para-

Table 1 Values of T and S parameters in Gipsvika during fieldwork in August 1989.

	West st. 1	Center st. 5	East st. 11
Depth (m)	17	16	25
Surface temp. (°C)	7.13	6.45	6.06
Surface salin. (ppt)	26.61	29.10	30.15
Depth (°C) Max. salin. (ppt)	bottom 33.38	bottom 31.87	bottom 33.13
Depth (m) Min. depth (°C)	bottom 2.52	bottom 4.79	bottom 2.64
Subsurface depth (m)	14-15	5-6	---

Figure 3 Temperature and salinitysections in Gipsvika, August 3-4 1989.

meters can be determinated 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.
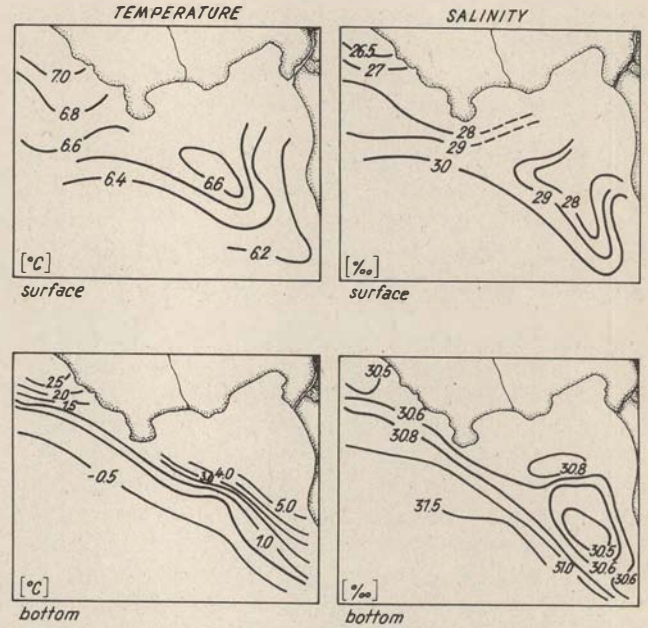
Figure 4 Temperature and salinity distributions on the surface and near the bottom in Gipsvika, August 3-4 1989.
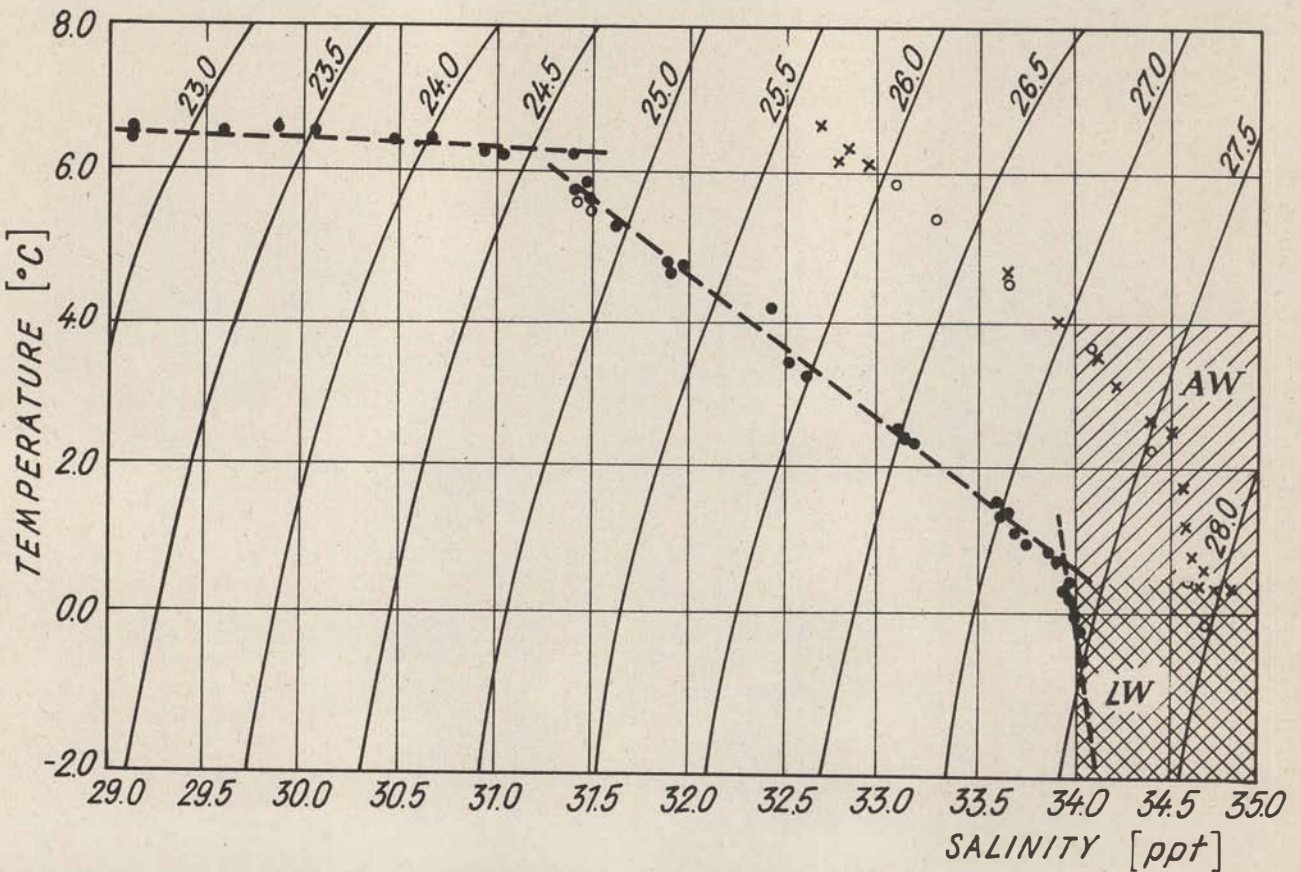
Figure 5 Temperature and salinity diagram of waters in the Sassenfjorden area.

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:

$$FWF = (So - S)/So \quad or$$

$FI = FWFx100\%$ 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 extend 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 rivermouth. 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 picnocline 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 picnocline 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/dm^3, usually 10 mg/dm^3. The sechchi 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/m^2 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
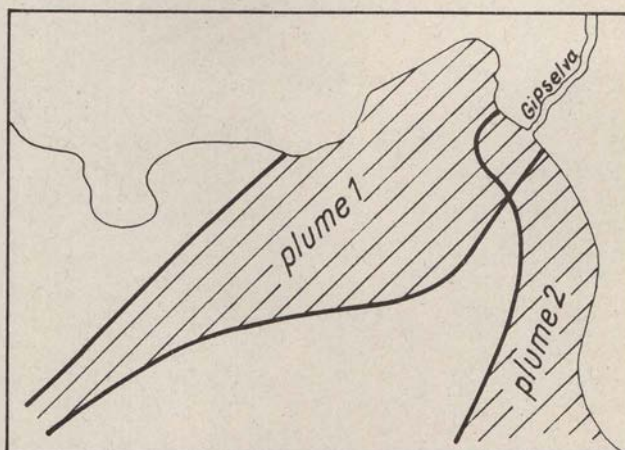
Figure 6 The approximate location of the plume in Gipsvika.
  1 - August 4-5 1989, 04:06 GMT
  2 - August 3-4 1989, 13:18 GMT

Table 2 Suspensions amount in Gipsvika's surface waters, August-September 1989.

St. no.	3. Aug. mg/dm³	31. Aug. mg/dm³
1	8.3	
2	15.0	
3	13.1	
4	14.1	
5	11.0	
6	11.7	
7	14.3	
8	48.3	
9	13.2	
10	10.5	
11	41.0	
12	14.7	
14	12.4	
15		14.4
16		12.7
17		16.0
18		16.3
19		8.4
20		17.0
21		0.4
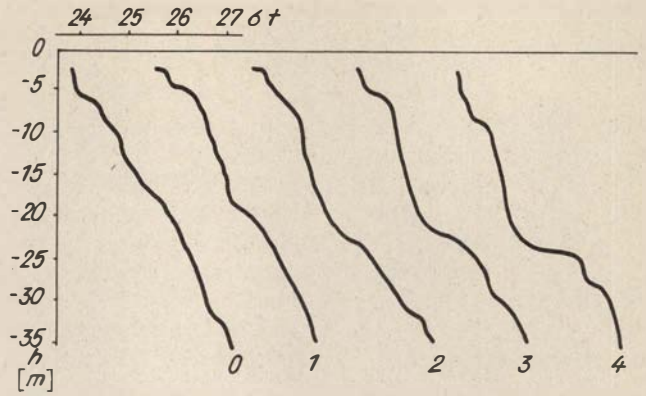
Figure 8 Density plots of water from stations 5 and 6 from Gipsvika, August 4-5 1989.

0 - 23:17 GMT	3 - 03:11 GMT
1 - 00:39 GMT	4 - 04:19 GMT
2 - 02:20 GMT	
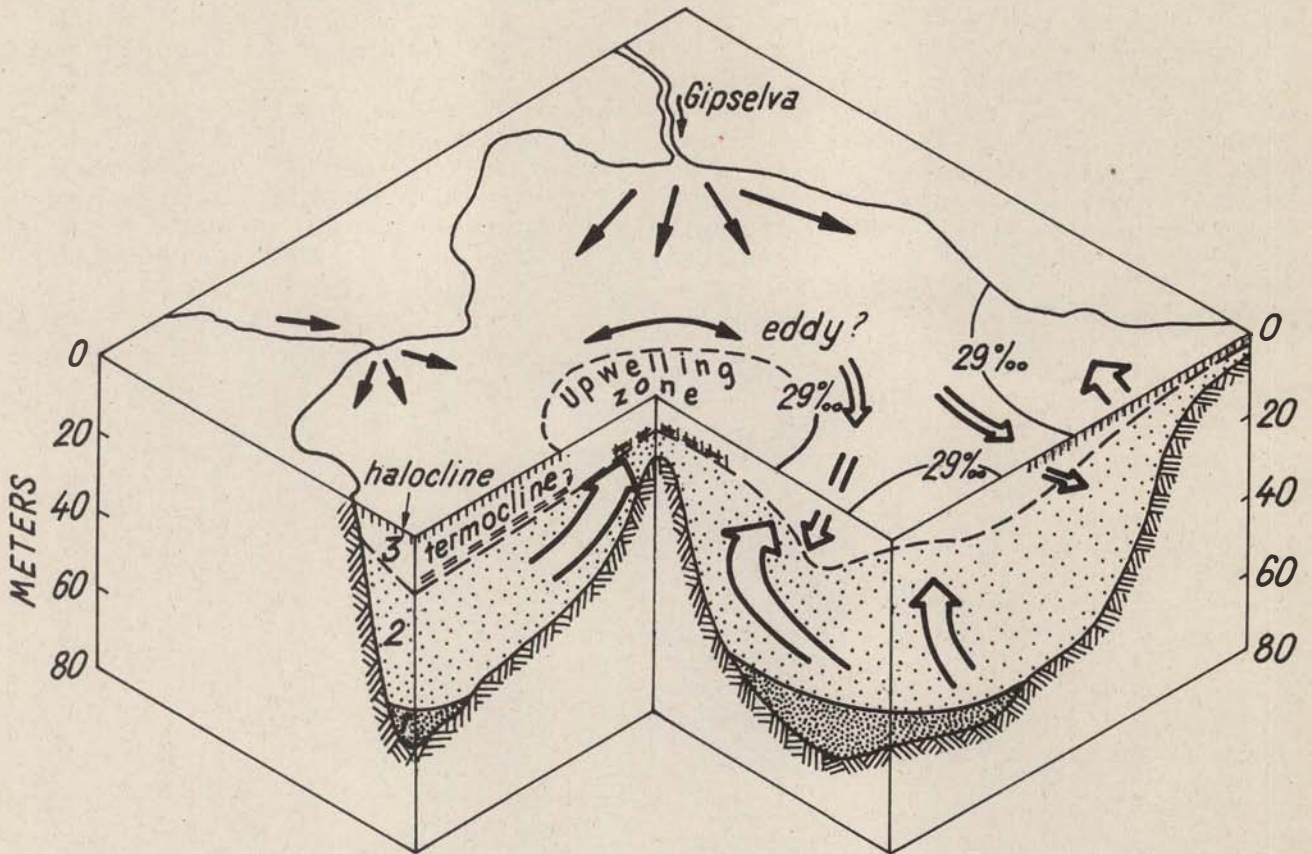
Figure 7 Isometric perspective of the waters in Gipsvika, and a general scheme of water layers and circulation.

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.
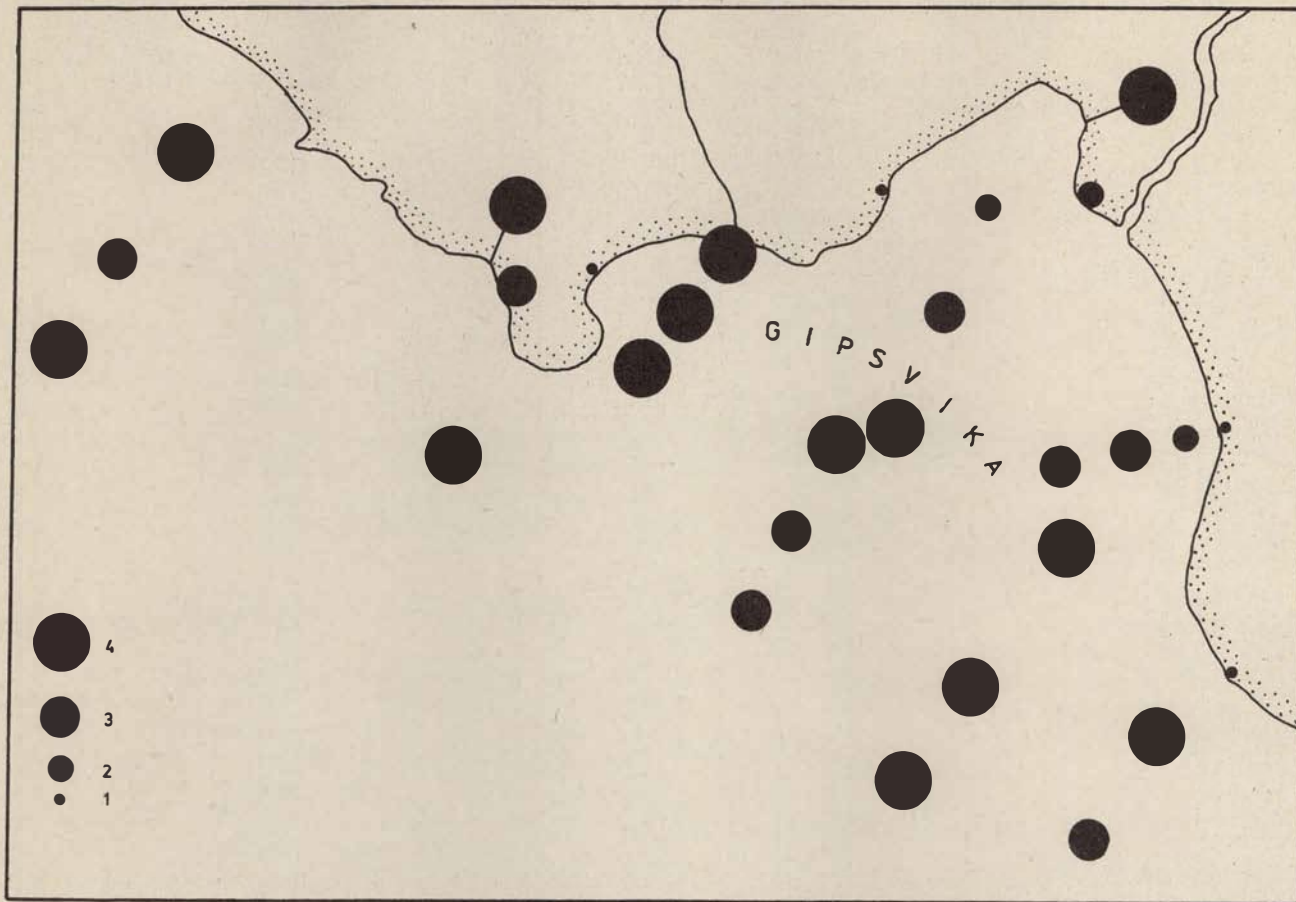
Figure 9 The biomass of bentic fauna from Gipsvika. Data from triplicate Petersen grab samples, August 1989.
1   < 1 g/m²
2   1.1 - 10 g/m²
3   10.1 - 100 g/m²
4   > 100.1 g/m²
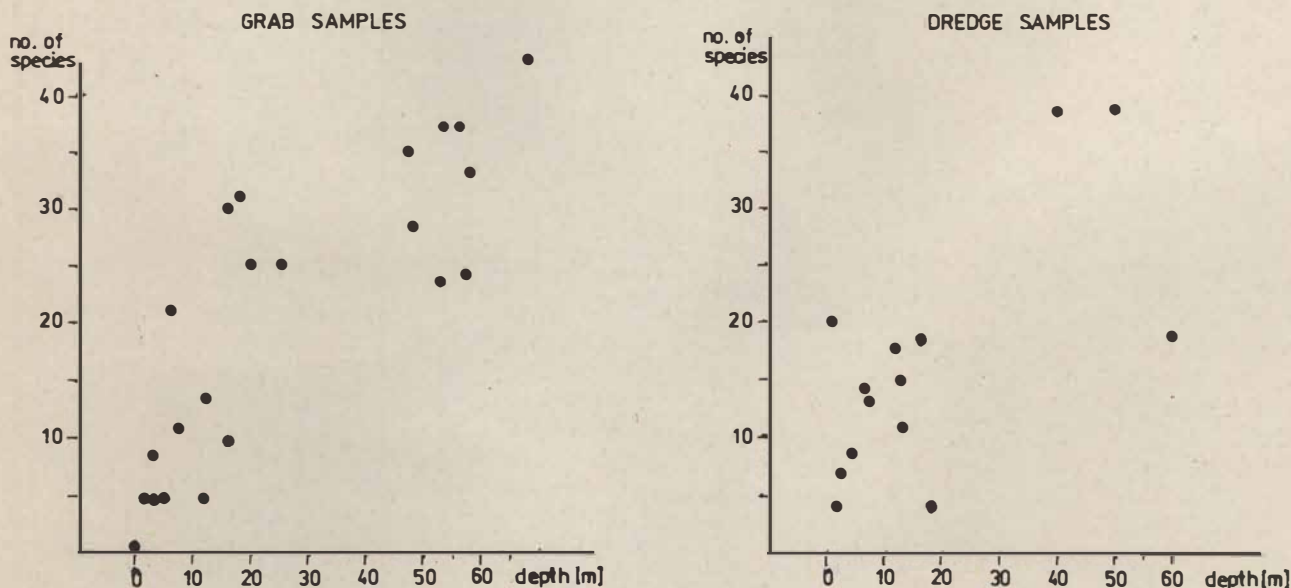
Figure 10 The relation between depth and number of species in benthos in Gipsvika.

Table 3 Characteristic of benthic stations sampled in Gipsvika in August 1989.

St. no.	S-W coeff.	Biomass g/m^2	Depth m	Substrate	Density ind/m^2	St. no.	S-W coeff.	Biomass g/m^2	Depth m	Substrate	density ind/m^2
1	3.8	542.0	20	sand	238	14	4.8	1.5	5	stones	22
2	3.8	51.0	53	silt	165	15	4.4	200	3.5	stones	215
3	4.3	107.3	68	silt	508	16	6.3	200	17	rock	66
4	4.1	156.0	58	silt+stones	228	17	5.2	26.1	6	mud+stones	719
5	4.1	401.0	16	silt+sand	400	18	2.3	10	1.5	gravel+mud	135
6	7.5	56.5	48	silt	350	19	3.6	10	3.5	gravel+mud	63
7	8.3	88.2	54	silt	508	20	6.2	50	6.5	gravel+mud	231
8	6.8	155.0	18	mud	670	21	6.9	50	12	stones	162
9	6.8	112.0	47	silt	587	27	0	20	0	stones	2800
10	6	168.7	57	silt	660	28	0	1.5	0	stones	50
11	6.5	226.7	25	silt+stones	710	29	1.5	0		stones	100
12	8.2	33.8	56	silt	429	30	0	20	0	rock	1850
13	4.8	200	11.5	stones	26						

Table 4 The most prominent species of Gipsvika.

GRAB SAMPLES:

Taxon	Freq. %	Density ind/m^2
Polychaeta		
Chaetozone setosa	50	55
Lumbrinereis fragilis	50	54
Terebellides stroemi	50	30
Maldane sarsi	35	40
Nepthys cilliata	35	16
Bivalvia		
Thyasira flexuosa	42	11
Astarte montagui	27	37

DREDGE SAMPLES:

Taxon	Freq. %	Density ind/100m^2
Decapoda		
Eualus gaimardi	71	40
Sclerocrangon ferox	57	9
Amphipoda		
Halirages fulvocinctus	35	48
Pleustes panoplus	57	20
Caprella septentrionalis	50	32
Mysidae		
Mysis oculata	86	500
Pisces		
Myoxocephalus scorpius	64	14

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 boreo-arctic 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 macrophytes was represented both with *Caprella septentrionalis* and *Margarites groenlandica*. Soft bottom communities were distinguished on low sedimentation areas with Foraminiferans 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	Ca	carnivore	1	high importance
AB	arctic-boreal	Fi	filter feeder	2	medium importance
BA	boreo-arctic	De	deposit feeder	3	low importance
B	boreal	Om	omnivore		
Ko	cosmopolitic	He	herbivore		

No.	Species	Zoo./ geogr. status	Fee- ding type	Impor- tantce class	No.	Species	Zoo/ geogr. status	Fee- ding type	Impor- tance class
	AMPHIPODA				54	*Nuculoma tenuis*		Fi	2
1	*Acanthonotozoma serratum*	AB	Om	3	55	*Portlandia arctica*	A	Fi	3
2	*Acanthostepheia malmgreni*	A	Ca	3	56	*Serripes groenlandicus*	AB	Fi	3
3	*Ampelisca eschrihti*	AB	De	3	57	*Thyasira ferruginea*	AB	Fi	3
4	*Anonyx nugax*	AB	Ne	3	58	*Thyasira flexuosa*	Ko	Fi	3
5	*Anonyx sarsi*	AB	Ne	3	59	*Yoldia hyperborea*	A	Fi	3
6	*Apherusa sarsi*	A	Om	3	60	*Yoldiella fraterna*	A	Fi	3
7	*Arrhis phyllonyx*	A	Fi	3	61	*Yoldiella lenticula*	A	Fi	3
8	*Byblis gaimardi*	AB	De	3					
9	*Caprella septentrionalis*	BA	Ca	2		**BRYOZOA**			
10	*Corophium crassicorne*	B	De	3	62	*Bryozoa not determined (A)*		Fi	3
11	*Gamarellus homarii*	AB	Om	3	63	*Bryozoa not determined (B)*		Fi	3
12	*Gammarus oceanicus*	BA	Om	3	64	*Cellepora ssp.*	AB	Fi	3
13	*Gammarus setosus*	AB	Om	1	65	*Leieschara coarctata*	A	Fi	3
14	*Goessia depressa*	AB	De	3	66	*Membranipora sp.*		Fi	3
15	*Halirages fulvocinctus*	AB	Om	2					
16	*Haploops tubicola*	AB	De	3		**CIRRIPEDIA**			
17	*Ischyrocerus spp.*	He		3	67	*Balanus balanoides*	AB	Fi	3
18	*Lepidepecrenum umbo*	A	De	3					
19	*Melita dentata*	AB	De	3		**CUMACEA**			
20	*Melita formosa*	AB	De	3	68	*Campylaspis rubicunda*	AB	De	3
21	*Melita palmata*	AB	De	3	69	*Diastylis goodsiri*	AB	De	3
22	*Monoculodes borealis*	AB	De	3	70	*Diastylis scorpionides*	AB	De	3
23	*Monoculodes longirostris*	A	De	3	72	*Eudorella emarginata*	AB	De	3
24	*Monoculodes sp.*		De	3	71	*Diastylis spp.*	AB	De	3
25	*Odius carinatus*	AB	Om	3					
26	*Onisimus caricus*	A	Ne	3		**DECAPODA**			
27	*Onisimus edwardsi*	A	Ca	3	73	*Enalus gaimardi*	AB	Ca	1
28	*Orchomene minuta*	AB	Ca	3	74	*Eupagurus pubescens*	AB	Ca	3
29	*Parapleustes biscupis*	BA	He	3	75	*Hyas araneus*	AB	Ca	3
30	*Paroediceros lynceus*	AB	De	3	76	*Lebbeus polaris*	AB	Ca	3
31	*Pleustes panoplus*	BA	Om	2	77	*Sabinea septemcarinata*	AB	Ca	3
32	*Pleusymptes glabroides*	BA	He	3	78	*Sclerocrangon boreas*	AB	Ca	2
33	*Pontoporeia femorata*	AB	De	3	79	*Sclerocrangon ferox*	A	Ca	2
34	*Syrrhoe crenulata*	AB	Om	3	80	*Spirontocaris turgida*	AB	Ca	3
35	*Themisto libellula*	AB	Ca	3					
36	*Unciola leucopis*	AB	De	3		**ECHINODERMATA**			
37	*Weyprechtia pinguins*	A	Om	3	81	*Strongylocentrotus droeb*	AB	He	3
					82	*Thysanoessa inermis*	BA	Ca	3
	BIVALVIA								
38	*Arctinula groenlandica*	A	Fi	3		**FORAMINIFERA**			
39	*Astarte borealis*	AB	Fi	3	83	*Dentalina obligua*	AB	Fi	3
40	*Astarte crenata*	A	Fi	3	84	*Hyperamina spp.*	AB	Fi	3
41	*Astarte montagui*	A	Fi	1					
42	*Ciliatocardium ciliatum*	A	Fi	3		**GASTROPODA**			
43	*Cuspidaria subtorta*		Fi	3	85	*Acmaea rubella*	A	He	3
44	*Dacrydium vitreum*	BA	Fi	3	86	*Admeta viridula*		He	3
45	*Hiatella arctica*	Ko	Fi	3	87	*Cylichna alba*	AB	He	3
46	*Hiatella striata*	A	Fi	3	88	*Cylichna occulta*	AB	He	3
47	*Macoma calcarea*	AB	Fi	2	89	*Lacuna pallidula*	B	He	3
48	*Macoma moesta*	A	Fi	3	90	*Lepeta caeca*	AB	He	3
49	*Macoma torelli*	A	Fi	3	91	*Lunatia pallida*	AB	He	3
50	*Musculus corrugatus*	A	Fi	3	92	*Margarites groenlandica*	AB	He	3
51	*Mya pseudoarenaria*	AB	Fi	3					
52	*Mya truncata*	AB	Fi	3					
53	*Nuculana pernula*	AB	Fi	1					

Table 5 (cont.)

No.	Species	Zoo./geogr. status	Feeding type	Importance class	No.	Species	Zoo/geogr status	Feeding type	Importance class
	HOLOTHURIOIDEA				128	*Gattyana amondseni*	AB	Ca	3
93	*Myriotrochus rinckii*	AB	De	3	129	*Gattyana cirrosa*	AB	Ca	3
					130	*Glycera capitata*	AB	De	3
	HYDROZOA				131	*Goniadidae sp.*			3
94	*Actinia sp.*		Ca	3	132	*Harmathoe sp.*	AB	Ca	3
95	*Cerianthus lloydi*		Ca	3	133	*Harmatoe imbricata*		Ca	3
96	*Hydropolipae nd.*			3	134	*Laena ebranchiata*	AB	Fi	3
					135	*Lanice conchylega*	AB	Fi	3
	ISOPODA				136	*Laonice cirrata*	AB	De	3
97	*Isopoda parasitica*		Pa	3	138	*Leichone polaris*	A	De	3
					139	*Lumbrineris fragilis*	BA	Ca	1
	MYSIDEA				140	*Lysippe labiata*	AB	Fi	3
98	*Mysis oculata*	AB	Om	1	141	*Maldane sarsi*	Ko	De	1
					142	*Myriohele heeri*	AB	De	3
	OPHIUROIDEA				143	*Nemertini sp.*	AB	Ca	3
99	*Ophiocten sericeum*	AB	De	3	144	*Neoamphitrite affinis*	AB	De	3
100	*Ophiura robusta*	AB	De	3	145	*Neoamphitrite figulus*	AB	Fi	3
					146	*Neoamphitrite groenlandica*	AB	Fi	3
	PISCES				147	*Nephtys ciliata*	AB	De	1
101	*Anisarchus medius*	AB	Ca	3	148	*Nereimyra punctata*	B	De	3
102	*Eumicrotremus spinosus*	A	Ca	3	149	*Nereis succinea*	AB	Ca	3
103	*Liparis liparis*	AB	Ca	3	150	*Nereis zonata*	AB	Ca	3
104	*Lycodes sp.*		Ca	3	151	*Ophelina accuminata*	AB	De	3
105	*Myxocephalus scorpius*	AB	Ca	2	152	*Orbinia norvegica*	AB	De	3
					153	*Pectinaria belgica*	AB	De	3
	POLYPLACOPHORA				154	*Pherusa pulmosa*	AB	De	3
106	*Tonicella marmorea*	AB	He	3	155	*Polycirrus arcticua*	A	Fi	2
107	*Tonicella rubra*	AB	He	3	156	*Polycirrus medusa*	AB	Fi	3
					157	*Polyphyssia crassa*	AB	Fi	3
	POLYCHAETA				158	*Potamille veniformis*	AB	Fi	3
108	*Aglaophamus malmgreni*	AB	De	3	159	*Praxiella gracilis*	AB	De	3
109	*Ampharete finmarhica*	AB	De	3	160	*Priapulus caudatus*	AB	De	3
110	*Ampharetinae nd.*			3	161	*Rhodine gracilior*	AB	De	3
111	*Amphitrite cirrata*	AB	Ca	3	162	*Samytha sexcirrata*	B	Fi	3
112	*Anaitides groenlandica*	AB	Ca	3	163	*Scalibregma inflatum*	AB	De	3
113	*Anaitides maculata*	Ko	Ca	3	164	*Scoloplos armiger*	Ko	De	2
114	*Anaitides mucosa*	AB	Om	3	165	*Spiochaetopterus tipicus*	AB	De	3
115	*Arcidea jeffreysi*	AB	Fi	3	166	*Spirobis spiryllum*	BA	De	3
116	*Artacama proboscidea*	AB	Fi	3	167	*Terebelldomorpha n.d.*		Fi	3
117	*Axiothela catenata*	A	De	3	168	*Terebellides stroemi*	Ko	Fi	1
118	*Axonice flexuosa*	A	Fi	3	169	*Travissia forbesi*	AB	De	3
119	*Brada inhabilis*	AB	De	3	170	*Trichobranchus glacialis*	AB	De	3
120	*Brada villosa*	AB	De	3	171	*Typosyllis armillaris*	AB	De	3
121	*Chaetozone setosa*	Ko	De	1					
122	*Chone duneri*	AB	Fi	3		**PRIPULIDA**			
123	*Chone infundibuliformis*	AB	Fi	3	172	*Priapulus caudatus*	AB	De	3
124	*Cirratulus cirratus*	AB	De	3					
125	*Enipo torelli*	AB	Ca	3		**SIPUNCULIDA**			
126	*Etone longa*	AB	Ca	3	173	*Phascolosoma sp.*	AB	De	3
127	*Euchone papillosa*	AB	Fi	3					

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 (Polysyphonia, Pylayella). Since the SW winds create heavy

Table 6 Inhabitants of laminarian ryzoids sampled in 0-5 m depth range in Gipsvika, stations 13 and 14.

	Epifitic taxon	Freq.(%) N=20
1	Lithothamnium sp.	15
2	Periphiton red algae	25
3	Periphiton brown algae	10
4	Bryozoa n.d. 1	30
5	Bryozoa n.d. 2	20
6	Bryozoa n.d. 3	5
7	Hydroidea	5
8	Foraminifera	5
9	Gastropoda eggs	10
10	*Spirobis spiryllum*	25
11	*Anaites groenlandica*	10
12	*Margarites groenlandica*	30
13	*Hiatella striata*	25
14	*Thyasira flexuosa*	5
15	*Mya pseudoarenaria*	5
16	*Caprella septentrionalis*	5
17	Diastylis sp.	5
18	Onisimus sp.	5
19	Strongylocentrotus sp.	5
20	Empty	50

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 litoralis
Sphacellaria arctica

Rhodophyta
Phycodrys plumosa
Polysyfonia nigrescens
Ceramium sp.
Ptilota plumosa
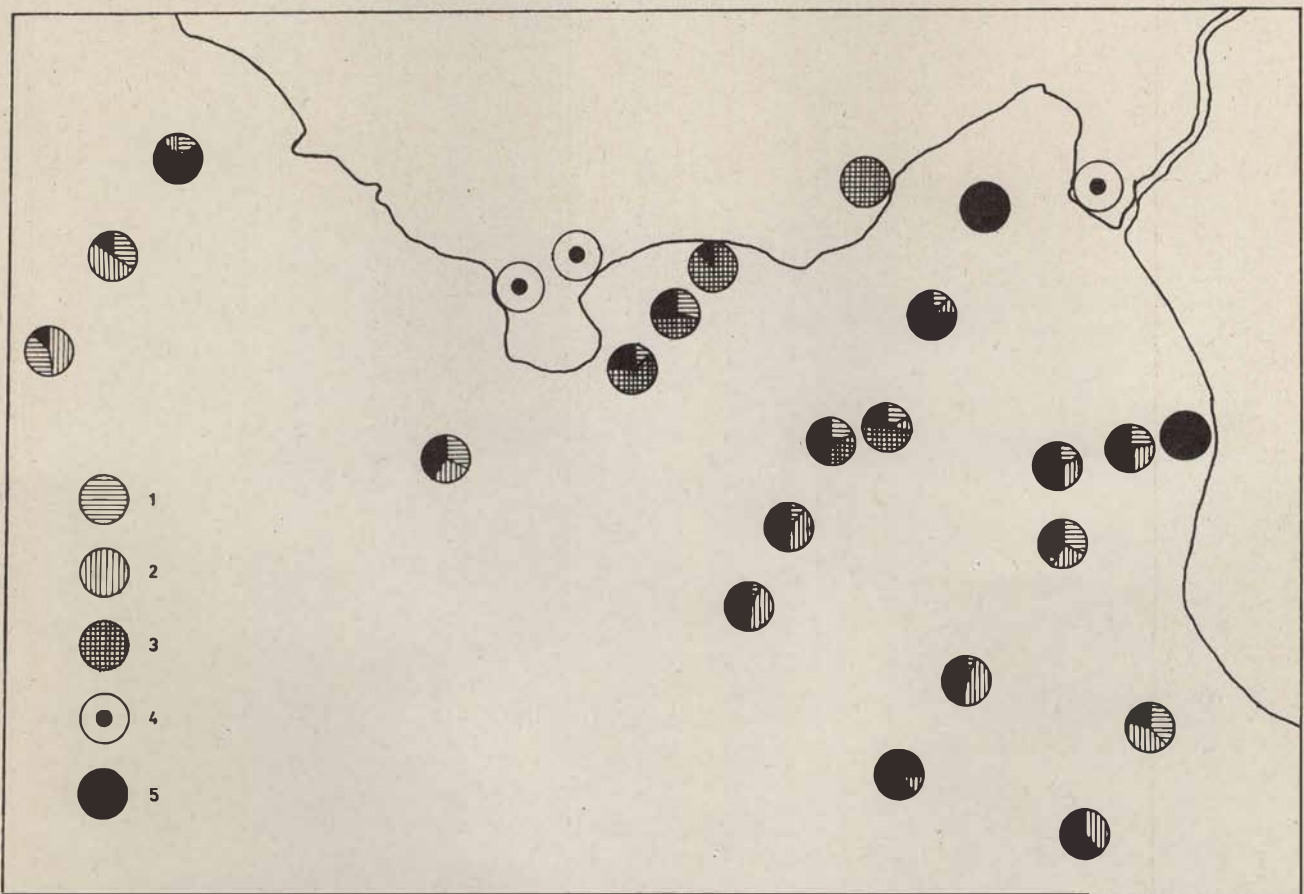
Figure 11 The distribution of feeding types among benthos in Gipsvika. Expressed as % of density (individuals/m²).
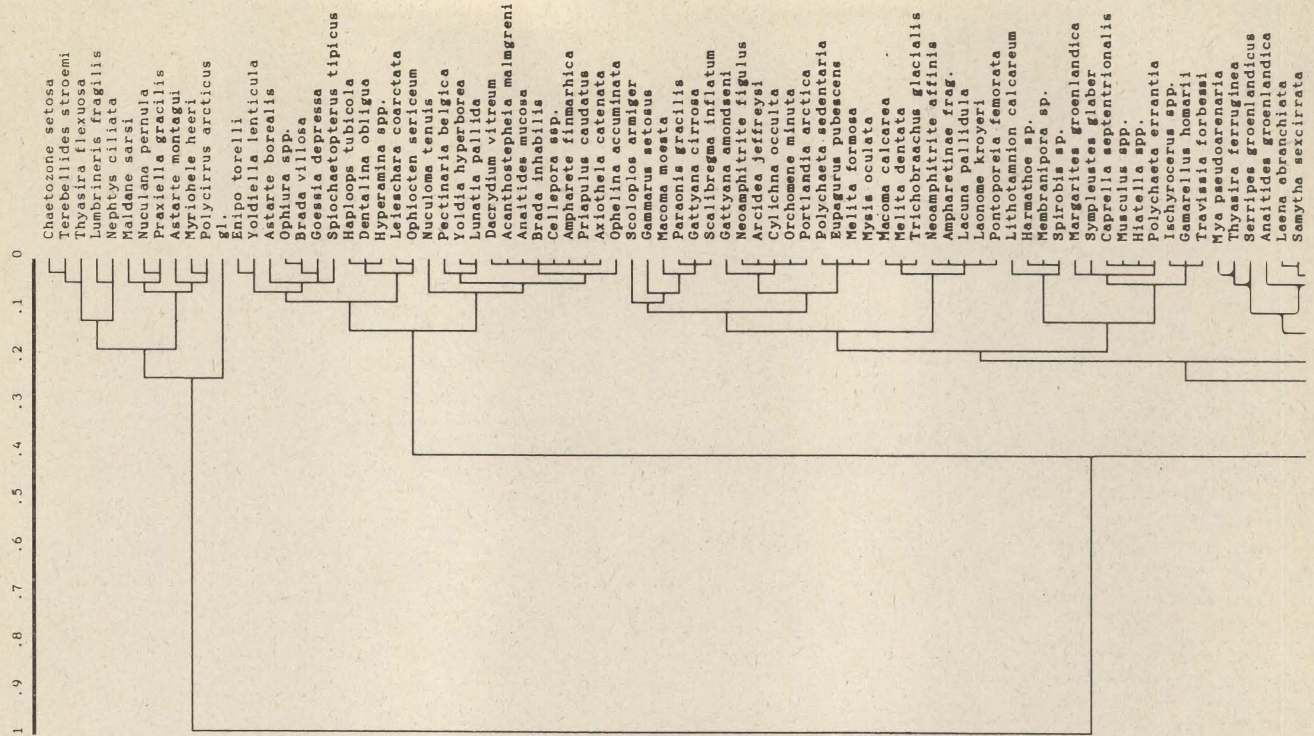
Figure 12 Macrobenthos coocurrence calculated according to Camberra distance. Grab samples only.
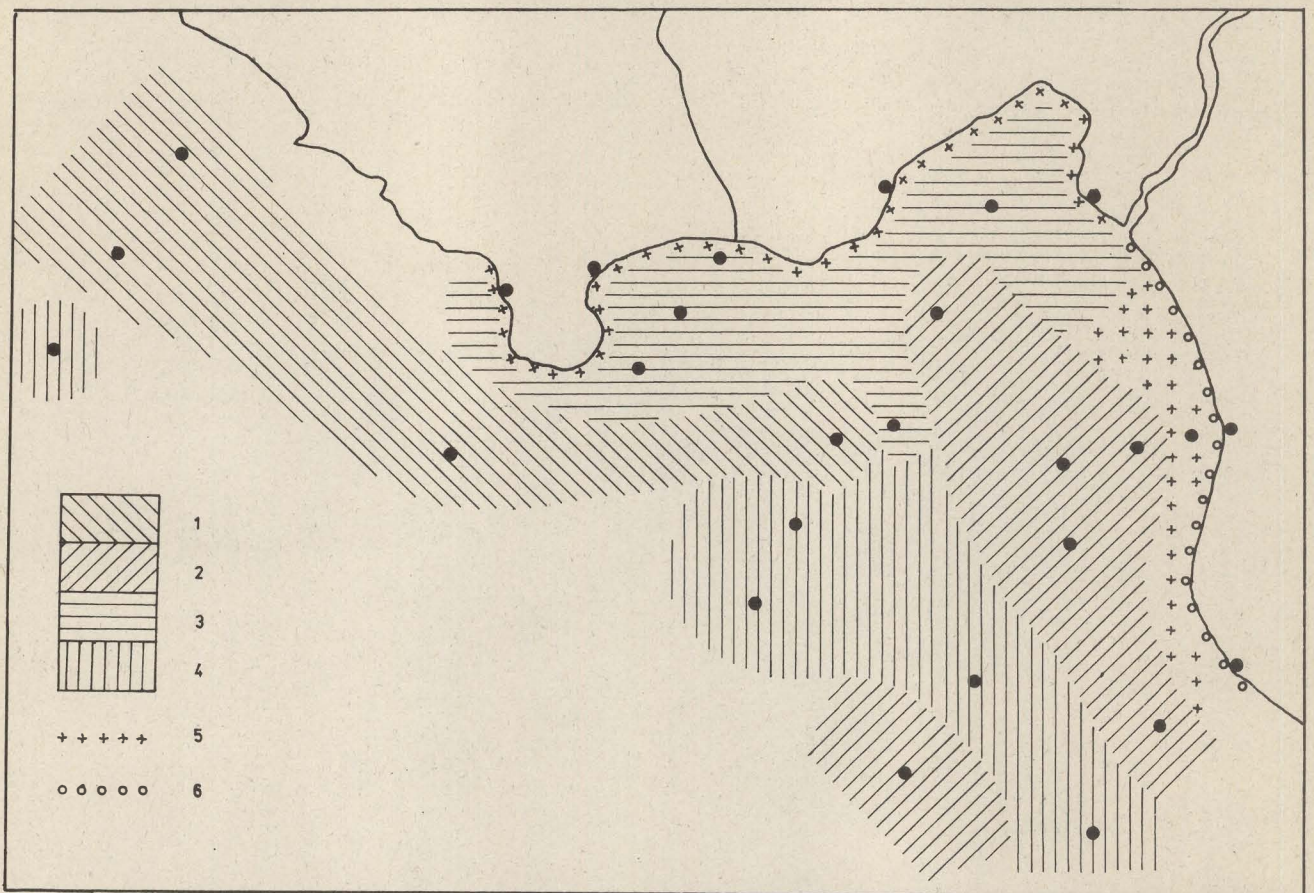

Figure 13 Bentic fauna assemblies according to the cluster grouping of stations in Gipsvika (see Fig. 13).

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 stones in tidal and subtidal zones with *Gammarus spp.*

6 oligotrophic gravel beaches without macrofauna.
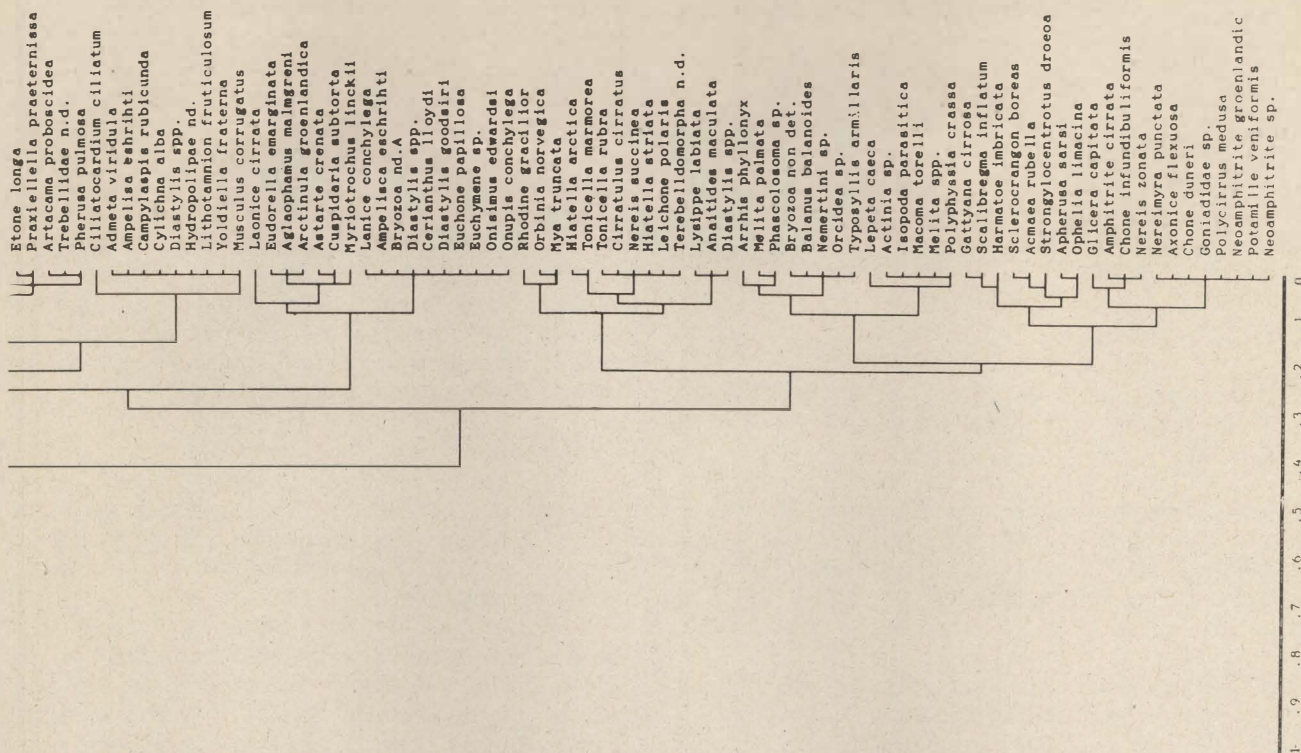
Figure 12 (cont.)
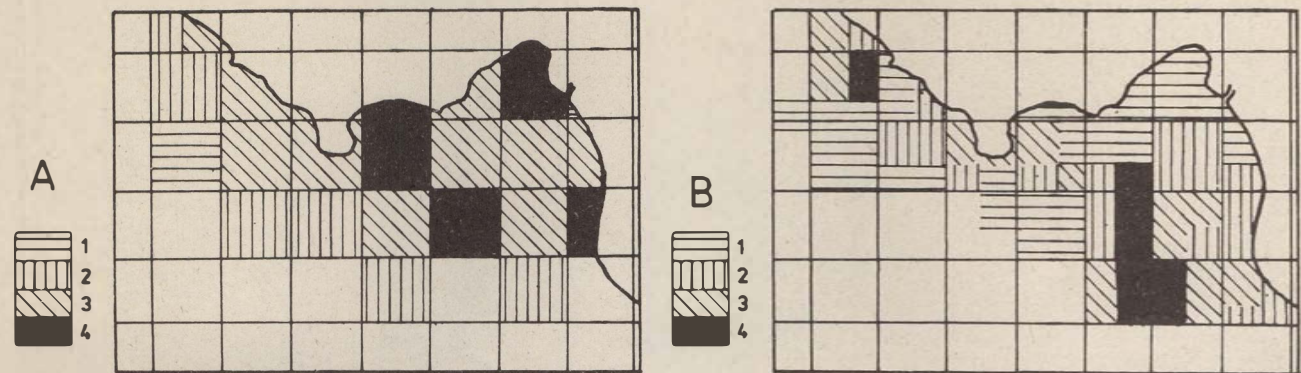
Figure 14 Gipsvika as a feeding ground for vertebrates, estimation of prey item density.

A 1 < 10 ind/100 m^2
   2 11 - 100
   3 101 - 1000
   4 > 1000

B 1 < 1 tonn/km^2
   2 1.1 - 10
   3 10.1 - 50
   4 > 50

C 1 < 10 kg/km^2
   2 10.1 - 100
   3 100.1 - 1000
   4 > 1000
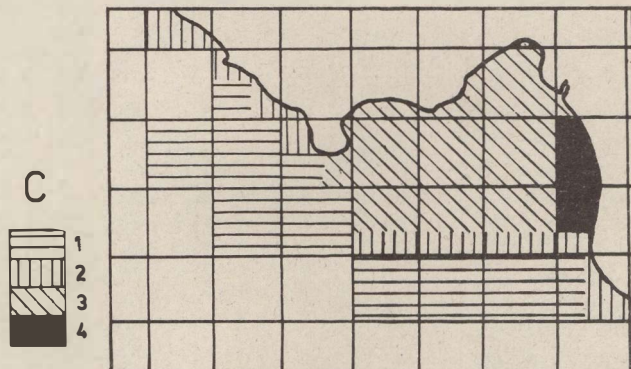
waving, no rich macrophytes were found on the windward side of the bay, and algae deposits on the shore were scarce compared to sheltered coasts off West Spitsbergen (Weslawski et al. 1988b).

The species given in Table 6. are among the most common and abundant algae of Svalbards 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/m^3 in st. 10, to 1000 mln cells/m^3 in st. 3.

The density and taxonomic set of species are similar tophytoplankton assemblages observed near the mouth of Hornsund (Wiktor and Baun-

cer 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.
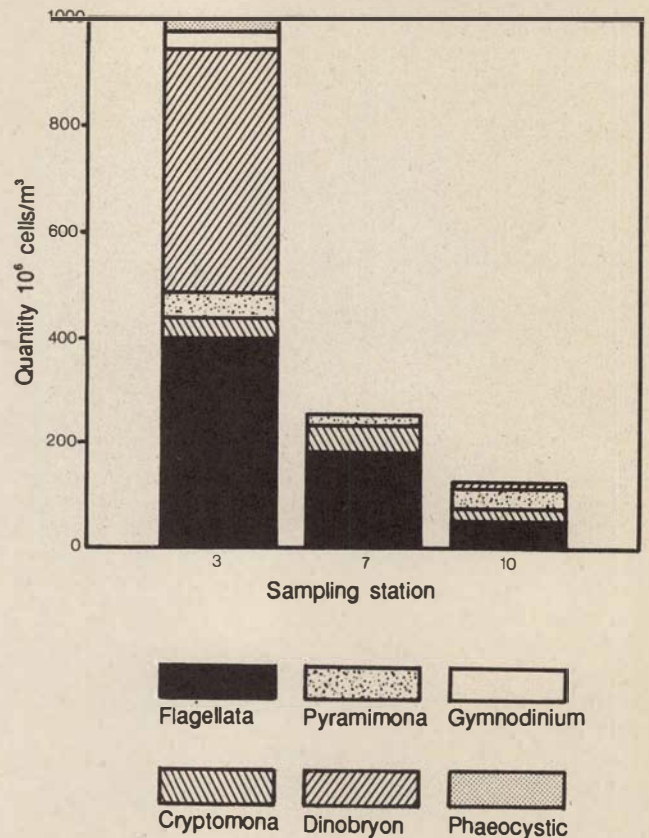
The high amount of *Phaecystis pouchetti, Dinobryon baltica* and minor flagellates resemble the post bloom phytoplankton assemble observed in Sassenfjorden in late May 1987 (Wiktor and Bancer in prep.). St. 3 is situated at the border between Sassenfjorden and Billefjorden. This may cause a "frontal 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 thetaxon, 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 introductionary 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./m^3.

Station/Taxon	St.3	St.7	St.10
1 Flagellatae non det.3um	135.9	182.9	47.0
2 Cryptomonas sp.small	40.8	53.8	5.9
3 Pyramimonas sp.	54.4	10.8	17.6
4 *Phaeocystis pouchetti*	27.2		5.9
5 *Nitzchia delicatissima*	1.6		2.2
6 Tintinide	0.4		0.1
7 *Dinobryon baltica*	462.1		
8 Flagellatae non det.3-7	258.3		
9 *Gymnodinium simplex*	27.2		
10 *Cryptomonas pelagica*			5.9
11 Navicula sp.	1.2		
12 *Nitzchia longissima*			0.4
13 Gyrodinium sp.			0.1
14 *Dinophysis rotundatum*			0.1
TOTAL	**1009.1**	**247.5**	**85.2**

Table 9 The characteristic of taxa composition of meiofauna from Gipsvika's tidal zone.

Taxon	Freq. ind/10cm^2	Min.	Max.	Avg.	SD
Foraminifera	16.67	3	10	6.33	2.87
Nematoda	72.22	3	579	104.08	193.05
Turbellaria	77.78	3	107	31.50	31.52
Oligochaeta	55.56	3	1487	171.30	439.94
Harpacticoida	16.67	3	8	5.33	2.05
Ostracoda	16.67	3	3	3.00	
Acarina	50.00	3	22	7.78	7.25
Rotatoria	27.78	3	8	4.00	2.00
Tardigrada	5.56	3	3	3.00	
Bivalvia veliger	27.78	3	37	14.00	12.62

Figure 15 The phytoplancton abundance on three stations in Gipsvika, August 1989.

(Radziejewska & Stankowska-Radziun 1979, Radziejewska & Stankowska-Radziun 1985, Kwasniewski 1988) and Port Valdez, Alaska (Feder & Paul 1980).

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 holoplanctonic 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 copepoda 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/m^3 (st. 3, BL) to 19981 ind/m^3 (st.
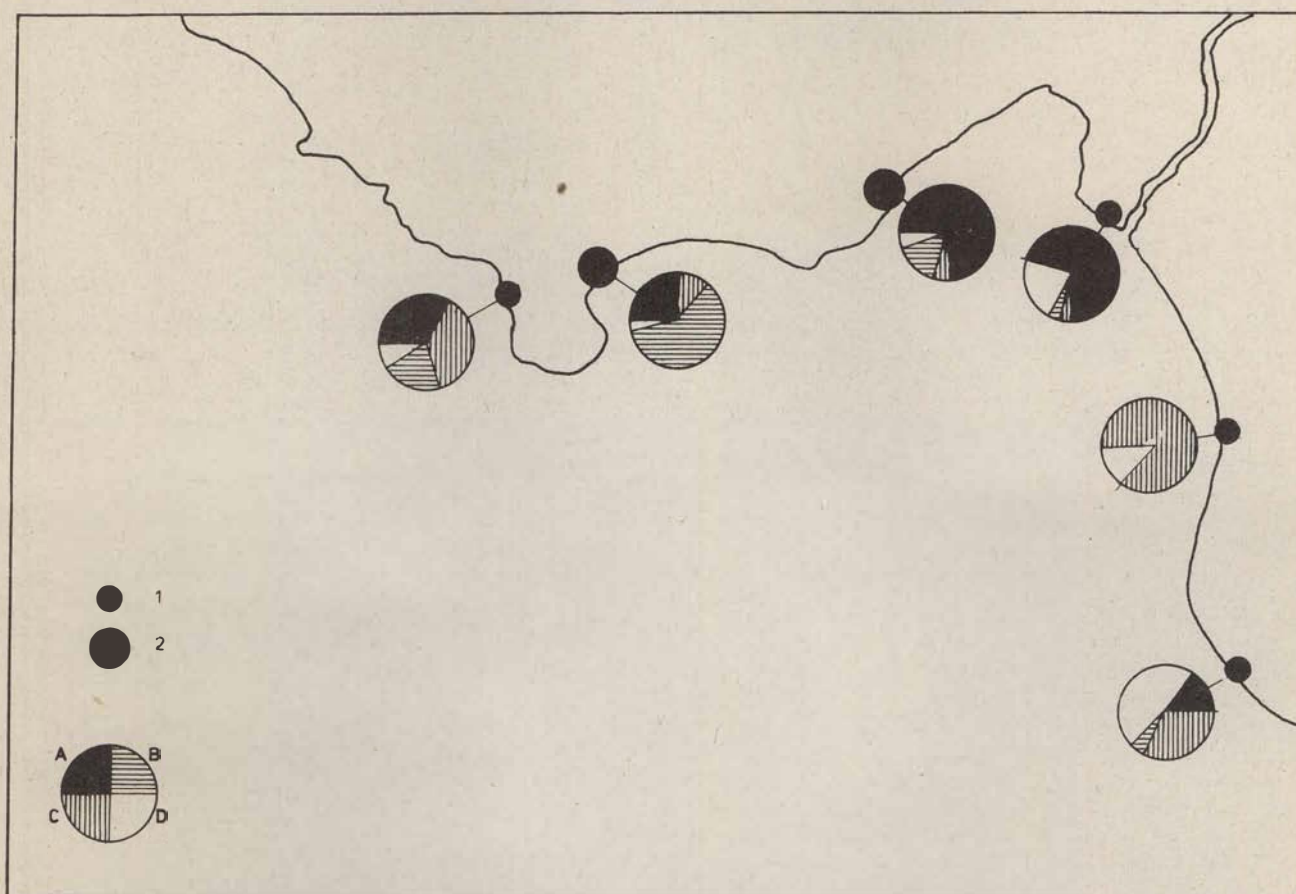
Figure 16 The distribution of meiofauna and its abundance within the tidal zone of Gipsvika, August 1989.

1 10 - 100 ind/10 cm^2 **A** Nematoda   **C** Turbellaria
2 101 - 1000 ind/10 cm^2 **B** Oligochaeta   **D** others

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 indivision into two groups. The values of proportion taken as a feature, distinguished three groups, at the 75 % level of similarity among the
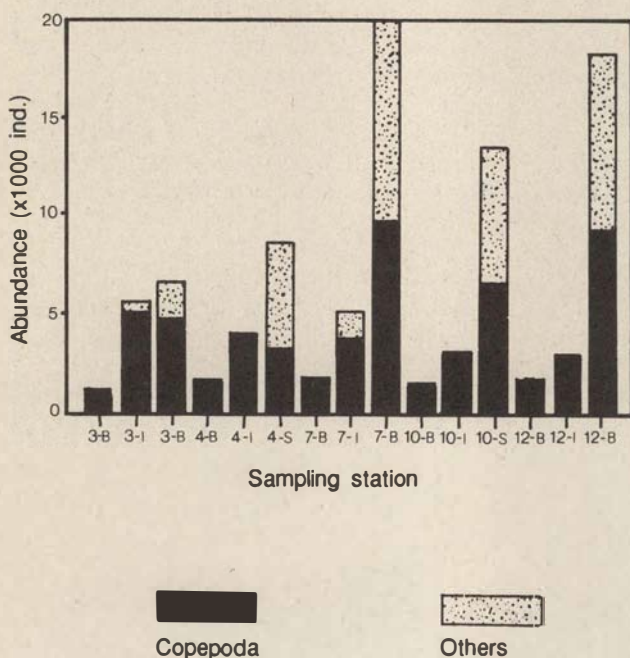
samples. The group of samples from all surface layers and intermediate layers at st. 7, separated in both clustering is characterized by 1) high abundance values of mesozooplankton, amounting for the four major taxa, i.e. *Calanus finmarchicus/glacialis, Pseudocalanus minutus, Oithona similis* and Bivalvia 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-
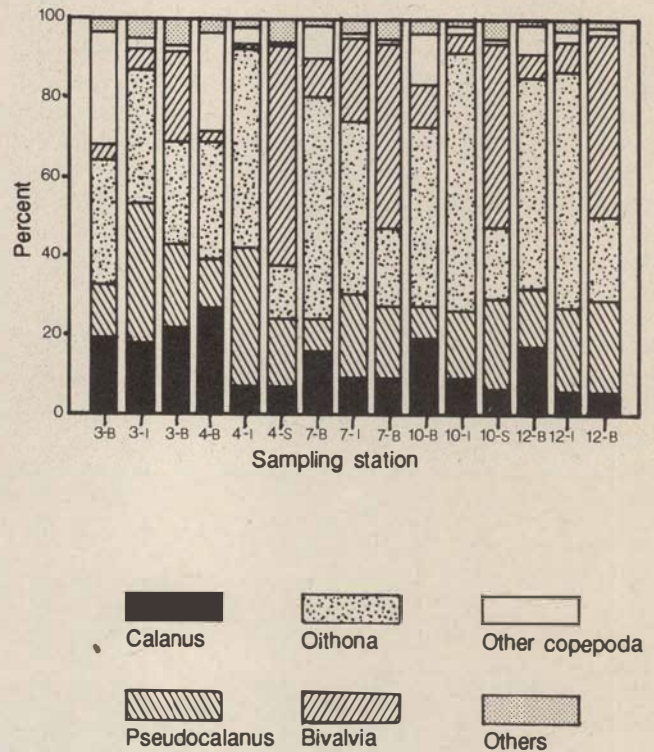

Figure 17 The abundance of mesozooplancton in Gipsvika, August 1989.

Figure 18 The proportion of mesozooplankton taxa in Gipsvika, August 1989.

Table 10 Charakteristic of Mesozooplankton sampled in Gipsvika.

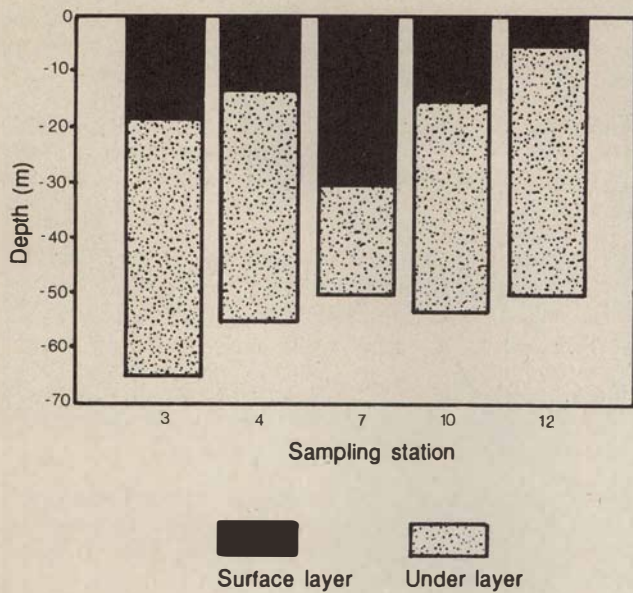| Taxon	Abundance of taxa					Proportion of taxa			
	Freq.	Min.	Max.	Avg.	Std.	Min.	Max.	Avg.	Std.
Calanus finm./glac. tot.	100.00	159	1901	674.27	496.50	5.67	32.27	58	8.11
Calanus hyperboreus	53.33	1	34	17.38	11.27	0.00	2.59	0.51	0.75
Pseudocalanus min. tot.	100.00	131	4360	1394.00	1346.55	8.33	35.78	19.75	7.82
Microcalanus spp.	60.00	8	103	45.67	26.42	0.00	8.88	1.68	2.41
Metridia longa	33.33	12	20	16.40	2.94	0.00	1.28	0.31	0.46
Acartia longiremis	100.00	18	279	91.20	71.69	0.36	17.64	3.53	5.19
Oithona similis	100.00	355	3780	1701.67	1023.37	12.74	65.04	36.57	15.76
Oncaea borealis	53.33	9	16	11.25	2.38	0.00	1.03	0.30	0.35
Harpacticoida	6.67	12	12	12.00	0.00	0.00	0.18	0.01	0.04
Copepoda nauplii	46.67	6	40	16.43	10.29	0.00	0.52	0.16	0.19
Isopoda juv.	6.67	9	9	9.00	0.00	0.00	0.50	0.03	0.12
Bivalvia veliger	100.00	38	9340	2164.80	3189.04	0.94	56.13	19.18	18.98
Limacina helicina juv.	100.00	6	260	82.07	70.24	0.46	2.60	1.32	0.61
Polychaeta larvae	46.67	6	40	15.29	10.48	0.00	0.88	0.20	0.28
Echinodermata larvae	93.33	10	740	174.29	216.49	0.00	4.33	1.88	1.41

Surface layer   Under layer

Figure 19 The result of cluster analysis for the abundance of mesozooplankton taxa in Gipsvika, August 1989.

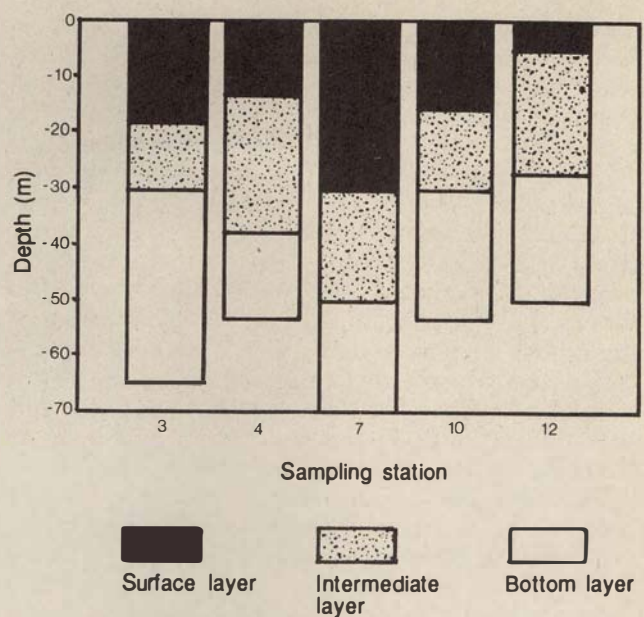Surface layer   Intermediate layer   Bottom layer

Figure 20 The result of cluster analysis for the proportion of taxa; Gipsvika, August 1989.

tant role. The samples from the intermediate layers grouped together with those from the bottom layers for clustering with abundance values as a characterizing feature, but separated for clustering, with proportion values, differ with higher proportions of *Pseudocalanus minutus* (27.73 %, in average), *Oithona similis* (51.64 %, in average) and lower proportions of *Acartia longiremis* (1.87 %, in average) and *Microcalanus pygmaeus* (0.57 %, in average). Additionally, the samples from bottom layers were distinguished by a high proportion of *Calanus finmarchicus/ glacialis* (20.10 %, in average), with 8.35 % *Acartia longiremis* and 4.68 % *Microcalanus pygmaeus* (in average). The values of abundance of the mesozooplankton taxa which gathered the intermediate and bottom layers samples into one group, are distinctly lower than those for surface layer and amount, in average, 367 ind/m^3 for *Calanus finmarchicus/glacialis*, 1181 ind/m^3 for *Oithona similis* and 125 ind/m^3 for *Bivalvia veliger*.

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, Koszteyn & 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/ glaci-alis*) 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 proportio-nally high percentage of Oithona similis (in all cases in intermediate layers) seems typical for this cosmopolitic 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 showe 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 lokal area. The intermediate layers are linked to the hydrologically described thermo- and haloclyne 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 importance to the neighbouring marine ecosystem, because it might be a breeding ground of larvas of bottom organisms, and a feeding ground for sea birds, especially in the eddy area.

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