

SCIENTIFIC EXPEDITION "LIFE IN ICE"

August 2002 - August 2003

Observations at Kinnvika (80° 3'N, 18° 12'E)

Svalbard, Nordaustlandet

FINAL REPORT

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ABSTRACT

A scientific expedition of the Technical University of Hamburg-Harburg (TUHH) was performed in 2002/03 on Nordaustland, Svalbard. Two humans with two sledge dogs stayed continuously for thirteen months in a little hut at a latitude of 80°N. Using a small, well equipped laboratory, many observations and measurements were performed and documented.

The main purpose of the expedition was the systematical experimental investigation of the growth and melting of sea ice and its microstructure during the course of a whole year. Outgoing from the observations the hypothesis was confirmed about the function of sea ice at the very beginning of Life as a possible matrix to push prebiotic chemistry towards first biological processes. The gained results indeed deliver many arguments that Life may have started in the sea ice of the early Earth, four billion years ago. Sea ice shows a complicated microstructure containing about 10^{14} tiny compartments per cubic metre between which liquid brine drips and mineralic particles, as well as small gas bubbles, are embedded. This environment may support chemical reactions leading finally to primitive life. Outgoing from the investigations of the real sea ice at Nordaustland, a model conception is derived concerning sea ice as a biochemical reactor. The construction of a corresponding technical sea ice reactor is described. With that, future further realistic experimental investigations are possible, which may be performed in the laboratory using artificially produced sea ice.

Sea ice is a favourable environment for the existence of many micro-organisms. Particularly it seems that various bacteria prefer to live in sea ice. During the expedition, in a systematical way, samples of these bacteria were taken each month, which grew in special containers frozen in sea ice. The bacteria samples were sent to the Biotechnological Institute of TUHH where they will be investigated concerning the bacteria's genetic structure. Many kinds of new bacteria were already identified. Some of these may be usable, for example by the food industry, using enzymes under cold environmental conditions.

Nordaustland as an island in the high arctic is, up to now, not very well known. Therefore, on the occasion of this expedition, not only sea ice and its micro-organic inhabitants were investigated, but also, as much as possible, further observations were made and described. Particularly the interest was focused on the weather and vegetation, polar bears and historical artefacts being stranded on the beaches of Nordaustland.

Daily, all available weather data were taken, evaluated and documented. The weather proved to be fairly harsh characterised by cold temperatures and mostly heavy winds. Outgoing from this, the vegetation on Nordaustland is comparatively poor. The growing phase of the plants was documented by hundreds of photos during the course of a whole year.

101 polar bears were noticed and observed, sometimes for many hours and days, close to the expedition hut. Each bear was characterised and its behaviour was described and documented by photo and film. Some conclusions concerning the bears psychological behaviour were drawn. Recommendations about possibilities to count the polar bears on Svalbard and to perform further observations were given.

On the beaches of Nordaustland many historical artefacts were found, for example ribs of old whaling ships, parts of wooden barrels, oars, fragments of a sledge and hunter's equipment. The artefacts deliver a fascinating insight into the various phases of Svalbard's 400 year history. An international scientific programme is proposed to perform a more systematical corresponding investigation.

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1 INTRODUCTION

On the 23rd July 2002 Hauke Trinks and Marie Tièche arrived at Kinnvika to stay on Nordaustland during the expedition “Life in Ice”, together with two sledge dogs, for one year. On the 2nd September 2003 the two humans together with one dog left Kinnvika and were transported by helicopter back to Longyearbyen.

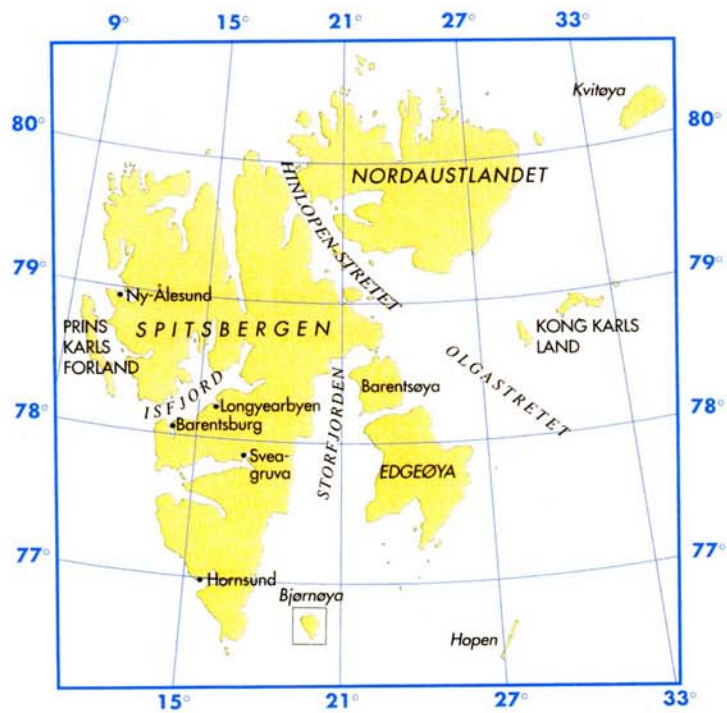
The expedition was financed by the Technical University of Hamburg-Harburg (TUHH) and by private money of Hauke Trinks. The Governor of Svalbard gave permission to live during the expedition in the old houses of the Swedish-Finnish scientific station in Kinnvika. Furthermore, the Governor’s ship *Polarsyssel* transported the two expedition members and all necessary equipment, scientific instrumentation and food from Longyearbyen to Kinnvika. At the end of the expedition in the beginning of September 2003 the governor’s ship *Nordsyssel* transported the equipment back to Longyearbyen.

The President of TUHH and the Governor of Svalbard asked Hauke Trinks to report on the expeditions results and besides this, about observations made in the nature of Nordaustland. The first progress report of the expedition from 18th December 2002 gave an overlook about the scientific activities and the observations concerning weather, microclimate, vegetation and animals living in the vicinity of Kinnvika. The reported results and conclusions in the progress report should be regarded as preliminary.

This more detailed final report was realised shortly after the end of the expedition in autumn 2003 and contains all essential results gained during the expedition.

In the last chapter of this report some recommendations are given. It is proposed to discuss some of these recommendations in the future between the Governor of Svalbard, Norsk Polarinstitut and Norsk Meteorologisk Institutt.

In the attachment “Ice and the Origin of Life” a compiled overlook is given concerning the processes of the ice on the early Earth, which possibly led to the origin of life.



2 PURPOSE OF EXPEDITION

In 1998 Hauke Trinks brought up the hypothesis that in sea ice physical-chemical processes occur which may help to explain the beginning of life four billion years ago on Earth. Besides this, in the bio-technological institute of TUHH, under the leadership of Prof. G. Antranikian, the scientific interest was focused on the investigation of the psychrophilic bacteria which prefer to live in cold environments. Outgoing from these various interests it was decided to execute an expedition into a cold natural area with a lot of sea ice.

In summer 1999 Hauke Trinks sailed with a small but robust sail boat of steel to the laguna of Mushamna on the east coast of Woodfjord on Svalbard. The boat was equipped as a small laboratory to perform during the course of a year, systematical measurements in the ice and to sample bacteria in ice and snow. The boat was frozen into the sea ice and remained in Mushamna a whole year. In autumn 2000 the expedition returned together with the sailboat back to Hamburg with many results and samples of bacteria. The corresponding expedition report of Hauke Trinks "Auf den Spuren des Lebens" was published (2001, Shaker Verlag, Aachen. Germany).

During the following two years the results of the expedition were evaluated, published and discussed with different scientific experts. Outgoing from these discussions it became clear, that the a.m. hypothesis concerning the beginning of life in sea ice opens a new and interesting aspect. Furthermore, the sampled bacteria were investigated and classified. New bacteria could be found being of interest, for applications in the food industry or in the environmental protection industry.

Some questions remained open concerning the structure and behaviour of ice and concerning the life cycle of bacteria living in ice. Therefore it was decided at TUHH to undertake another scientific expedition into the ice of Svalbard with a well defined scientific programme. The main points of this programme were:

Generation of further ideas about the origin of life in sea ice.

Development of a model conception about sea ice as a biochemical reactor.

Investigation of bacteria living in ice.

Particularly that means:

Investigation of the microstructure and the dynamic behaviour of sea ice.

Observation of growth and melting of ice.

Systematical measurement of temperatures, pH-values and salinity in sea ice during the course of a whole year.

Investigation of optical effects in ice leading to polarization effects.

Investigation of the content and the behaviour of CO₂ in ice and snow.

Systematical sampling of bacteria in cold environments in air, soil, ice and snow during one year.

Investigation of bacteria colonies on various surfaces.

3 LOCALITY OF EXPEDITION

During the preparation of this expedition it was decided to use a small house or hut as a simple laboratory situated in northern regions of Svalbard. Besides this, it was desired that sea ice, glacier ice and freshwater ice should be available at the locality of the expedition during the whole year.

Outgoing from some discussions, particularly with experts of the Governor of Svalbard, Kinnvika on Nordaustland was finally selected for the planned expedition.

3.1 Nordaustland

Nordaustland is a nature reserve of about 15,000 Km² on Svalbard. Because of difficult ice conditions the island is not accessible at all points every year. The interior of Nordaustland is covered with several large ice-caps. The north and west coast are deeply indented by many large fjords. Nordaustland is separated from Spitsbergen by the Hinlopen Straight, which is difficult to cross by small boats in summer due to heavy winds and rough sea and in winter due to difficult and unsafe ice conditions.

A large part of Nordaustland is characterised by an arctic desert climate. Huge fields of rocks and stones show nearly no vegetation. Only in minor areas are some poor plants growing. The number of birds and mammals living on Nordaustland is expected to be few.

Up to now only a few people have stayed on Nordaustland during a whole year. In former times a couple of hunters tried to survive on Nordaustland during the winter. Some of them died. In 1957, a scientific station was built and used for two years in Kinnvika on Nordaustland.

The weather, the vegetation and the animals of Nordaustland are up to now, not very well investigated, particularly during the course of a whole year. The animals living on Nordaustland under extreme, hard climatic conditions seem to be of high scientific interest. Only a few observations are available. Therefore it is desirable to gather as much information as possible during the stay of the expedition members on Nordaustland, 2002-2003.

3.2 Kinnvika

Kinnvika is a small bay to the north of Murchisonfjord, Nordaustland. At 80° 3'N, 18° 12'E, the members of the Swedish-Finnish expedition 1957, built an assembly of ten small wooden huts and houses for the performance of the scientific work during the International Geophysical Year 1957-58. In total thirteen people lived and worked in Kinnvika. After 1959, the houses were occasionally used for summer expeditions lasting a few weeks. Later Kinnvika was overtaken by the Governor of Svalbard. Nowadays, Kinnvika is used as an emergency station in the case of a potential rescue action in the area of the Hinlopen Straight.

The huts and houses of Kinnvika are in a fairly good condition, particularly the small Reserve House. It was found to be suitable for the two members of the expedition to live there during a whole year. Since 1973, this expedition is the first one to receive the permission of the Governor of Svalbard to stay for the execution of planned research work on Nordaustland, during 2002-2003.



3.3 Working Conditions

The two expedition members, Hauke Trinks and Marie Tièche, were the only humans staying on Nordaustland during the year 2002-03. Therefore all trips and all activities were undertaken especially carefully to avoid any accidents and dangerous situations. Both expedition members endured the whole expedition period without any problems or disease.

In the old Main Building of Kinnvika, a small laboratory was installed containing various microscopes, laser devices, photographic systems, instrumentation for the measurement of temperatures, pH-values, oxygen content, light, electric air field strengths, magnetic field strengths and others. The necessary electric power was produced by solar panels and an electric generator driven by petrol.

During the experimental work, the filming and the realisation of this report, Hauke Trinks was assisted by Marie Tièche.

The scientific field work in ice and snow sometimes was uncomfortable due to heavy winds, cold temperatures, darkness, the visits of polar bears and the surprising appearance of walrus. Several measurement devices and sensors were destroyed by harsh weather conditions and by the actions of animals. Two data loggers situated on the ice were destroyed by polar bears. One data logger was ruptured by reindeer.

On November 9th measurements were taken in darkness on the fresh ice with a thickness of 15cm close to the beach of Kinnvika. Suddenly a big walrus diving under the ice broke through. Some sensors were lost in the water. The walrus seemed to be aggressive.

The two malamute husky sledge dogs were chained up close to the Reserve House. In winter and spring polar bears attacked a couple of times, both the dogs and humans. One of the sledge dogs was hurt by a bear. The dog finally had to be shot. The second dog became very shy after some bear attacks. He had to be mostly kept inside and was no longer usable as a bear watcher.

Most of the food, fuel and equipment for the duration of the expedition of 12 to 15 months was stored in the Main Building. Driftwood for heating was fetched by sledge from the strand. Besides this, out of date barrels of helicopter fuel, stored at Kinnvika was used for heating. Eight were used. For this, permission was obtained from the helicopter company Airlift.

The communication between Kinnvika and the rest of the world was possible by a short wave transmitter and an IRIDIUM satellite telephone. Besides this, an EPIRB signal system was available for any potential emergency case. For protection against polar bears, a total three rifles, calibre 7.62mm, were used.

Between July 2002 and August 2003 some tours along the coastline were undertaken using a small rubber boat with a 6hp engine. This boat was finally destroyed by polar bears. Besides this, some tours by ski, sledge or on foot were undertaken within an area of approximately 20kms around Kinnvika.



4 WEATHER

4.1 Observations

The weather data are important for the understanding of the growth and melting of ice, which is an essential part of the expedition's purpose. Besides this the complete weather data sampled during a whole year may be of interest for the Meteorological Institute of Norway. The knowledge is poor about the weather on Nordaustland. Up to now only a few complete sets of weather data were gathered on Nordaustland.

The following data sets about the weather in these regions are already or will be available, which could be compared directly with the weather data of this expedition:

- | | |
|----------------|--|
| 1872-73 | Adolf Erik Nordenskiöld spent one year in Mosselbukta in Wijdefjord and observed and published the weather data. |
| 1944-45 | The German weather station "Haudegen" was situated in the south of Rijpfjord on Nordaustland. The corresponding weather data were handed out by Dr. Wilhelm Dege at the end of September 1945 to the Meteorological Institute in Tromsø. |
| 1957-59 | The Swedish-Finnish expedition recorded the weather data in Kinnvika, which were published. |
| 2002-03 | During this expedition weather data were recorded from August 2002 until August 2003 in Kinnvika. |

The weather data, temperature, wind, humidity and pressure were recorded using the German remote weather station METEOMASTER HUGER: (internet: www.huger.de). The corresponding sensors were installed five metres above sea level.

The air electric field strength was measured using the electric probe EFM 251 from KLEINWÄCHTER GmbH., Germany, D79689 Maulburg.

The CO₂ content was measured using the IR system TESTO 535-CO₂ from TESTO GmbH, Germany, D79853 Lenzkirch.

The light flux was measured using a calibrated flux measurement system for photo cameras.

The quantity of rain and snow could be recorded only roughly due to the nearly permanent heavy winds.



The following weather data were taken four times each day at 0800, 1300, 1800 and 2300 local time.

Air Temperature
Daily Maximum and Minimum Temperature
Wind Speed
Maximum Wind Speed
Wind Direction
Air Humidity
Air Pressure
Air Electric Field Strength
Light Flux
Cloud Cover
Visibility
CO₂ Content in Air
CO₂ Content in Snow
Rain and Snow
Sea Water Temperature
Existence of Sea Ice

All data were documented in tabular form and besides this, evaluated as compiled in the following chapter.

4.2 Conclusions

For each month outgoing from August 2002 the most important weather data were evaluated and compiled in the same way. Besides this, the mean values for each day and for each week concerning the following data were shown as graphs:

Air Temperature
Wind Speed
Air Pressure
Cloud Cover
Daylight
Air Electric Field Strength (After February 2003, the instrument was damaged.)

Comparing the observed weather data with those described in reports and diaries of other expeditions from Nordaustland, it seems that the summer of 2002 was comparatively warm without any snow and ice on the fjords. However, the winter of 2003/03 and the summer of 2003 seemed to be unusually cold with a large amount of snow and ice. The strong ice layer on the bay of Kinnvika broke up not before the beginning of August 2003. Consequently, the bird life and the vegetation was poor in summer 2003 in the region of Kinnvika.



WEATHER DATA AUGUST 2002, KINNVIKA

TEMPERATURE

Mean Air Temperature	+3.7°C	
Max. Air Temperature	+9.5°C	on 8.8.02
Min. Air Temperature	-2.0°C	on 30.8.02

WIND

Mean Wind Speed	4.1 m/s	
Max Wind Speed	13.2 m/s	on 16.8.02
Main Wind Direction	Northerly, 30%	Southerly, 55%

AIR PRESSURE

Mean Air Pressure	1014 mb	
Max Air Pressure	1024 mb	on 3.8.02
Min Air Pressure	996 mb	on 26.8.02

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	+1.1 KV/m	
Max Electric Field Strength	+8.0 KV/m	on 13.8.02
Min Electric Field Strength	- 2.0 KV/m	on 27.8.02

DAYLIGHT

Mean Total Daylight	157 K Lux h	
Max Total Daylight	500 K Lux h	on 6.8.02

RAIN and SNOW

Within August during eleven days some drizzle was observed. The amount was small. At the end of August some sleet fell.

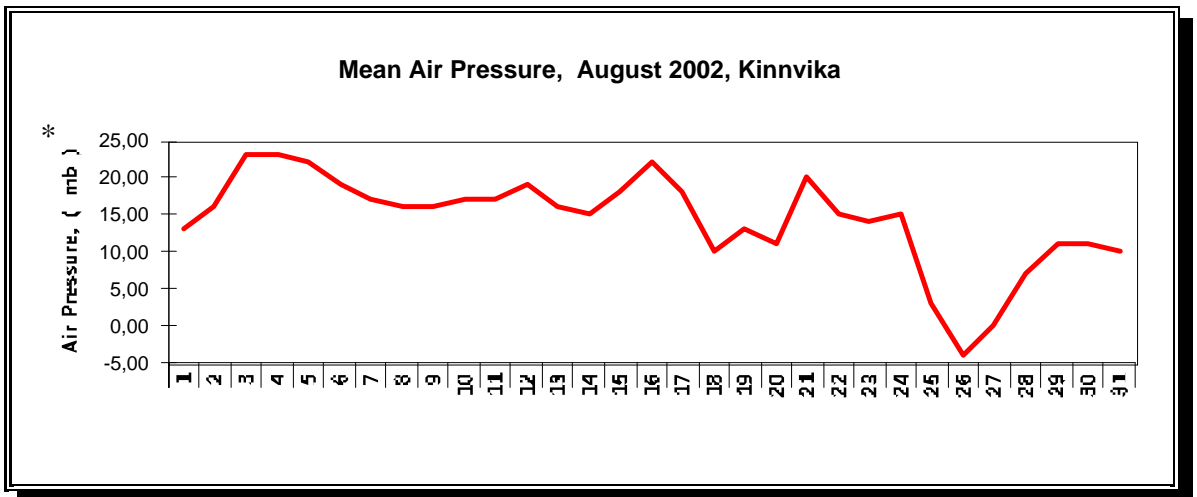
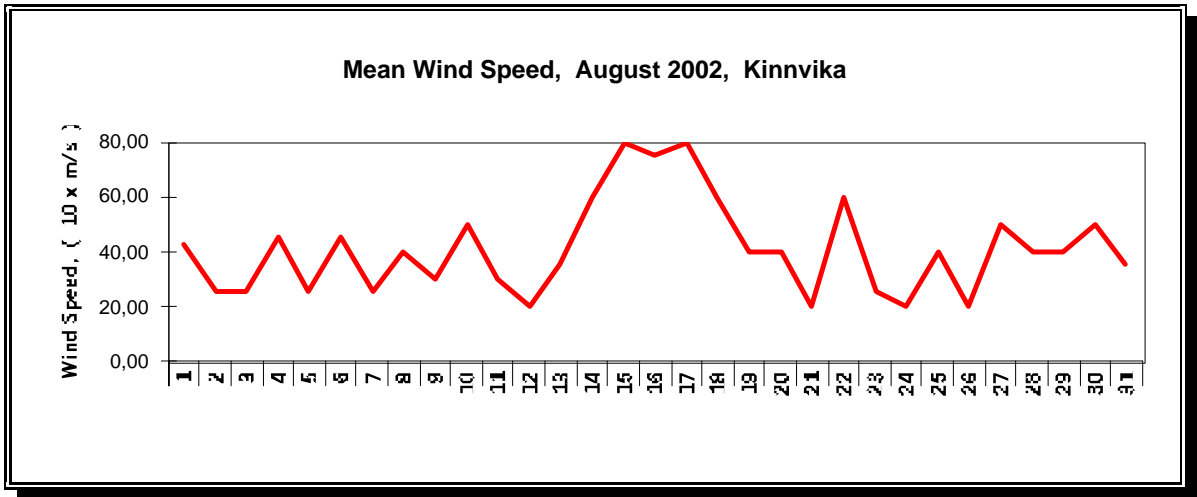
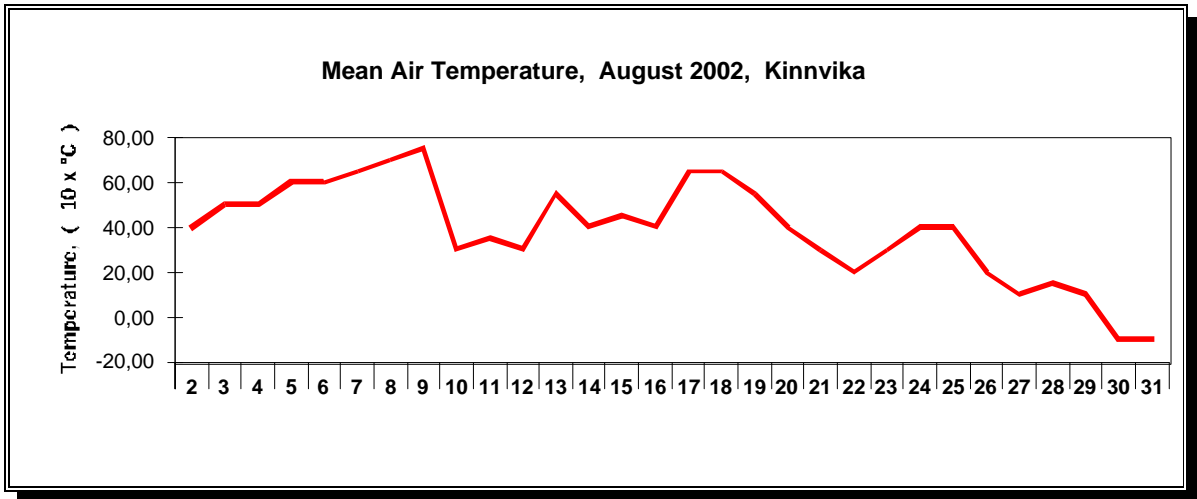
SEA WATER TEMPERATURE

In the beginning of August the temperature was about +4°C. With the arrival of sea ice the temperature dropped down to 0°C. After the ice had gone, the temperature rose to +2°C.

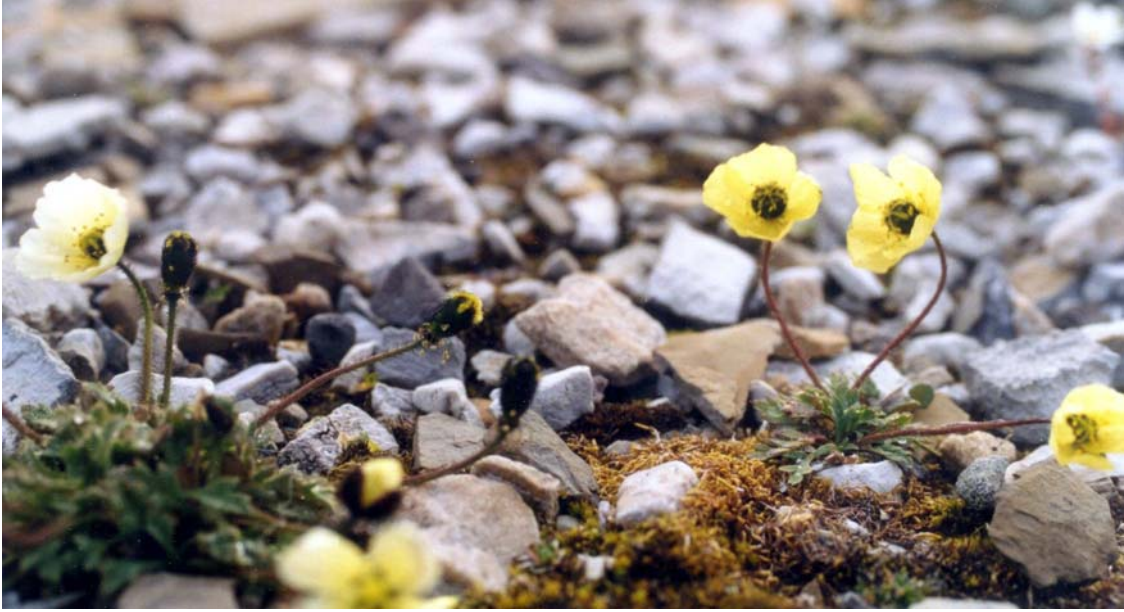
SEA ICE

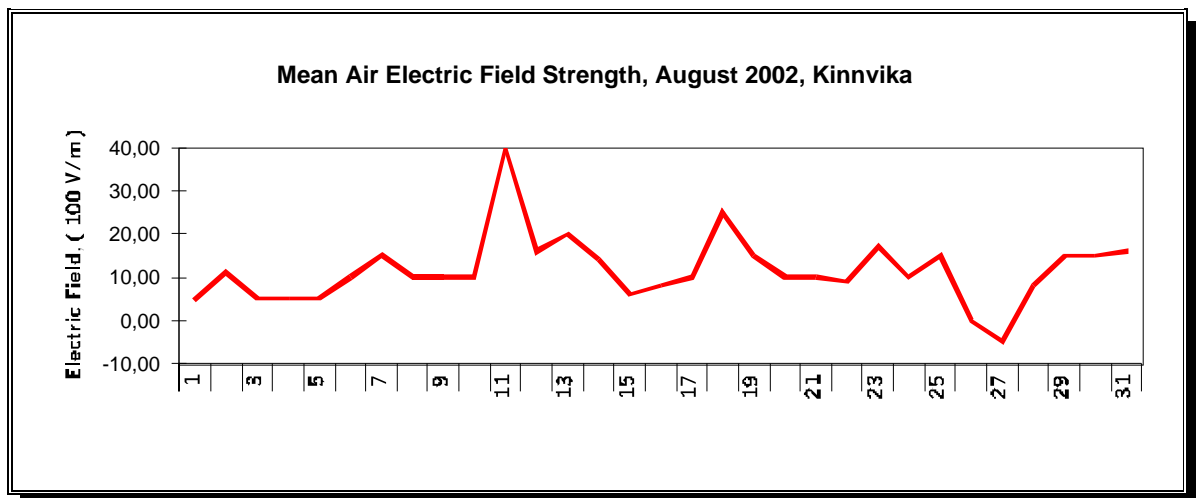
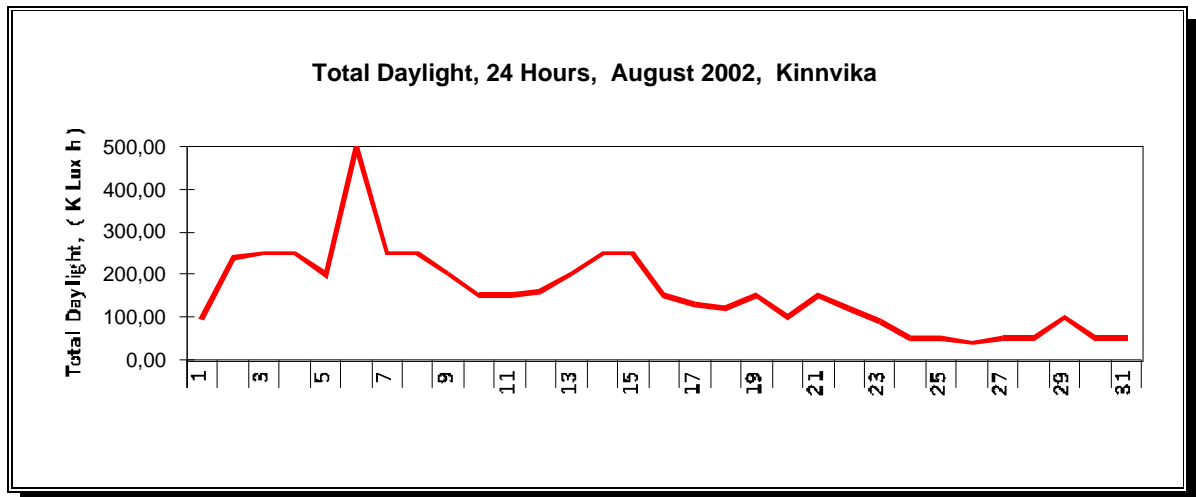
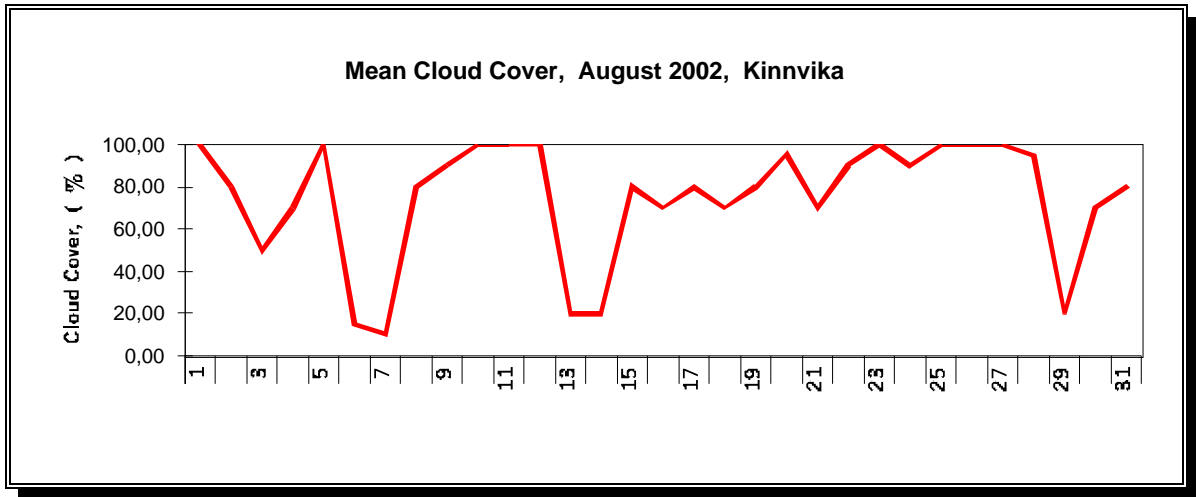
In the beginning of August Murchisonfjord and Hinlopen Strait were completely free of ice. From 13th to 22nd August a strong wind blew from southerly directions. From 19th August sea ice drifted from the south into Murchisonfjord. From 21st until 28th August Kinnvika was blocked by sea ice. Thereafter the ice vanished.





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WEATHER DATA SEPTEMBER 2002, KINNVIKA

TEMPERATURE

Mean Air Temperature	-2.0°C	
Max. Air Temperature	+7.3°C	on 2.9.02
Min. Air Temperature	-8.5°C	on 30.9.02

WIND

Mean Wind Speed	4.6 m/s	
Max Wind Speed	20.2 m/s	on 30.9.02
Main Wind Direction	Northerly, 53%	Southerly, 25%

AIR PRESSURE

Mean Air Pressure	1013 mb	
Max Air Pressure	1027 mb	on 13.9.02
Min Air Pressure	999 mb	on 2.9.02

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	+3.1 KV/m	
Max Electric Field Strength	+20.0 KV/m	on 30.9.02
Min Electric Field Strength	+0.3 KV/m	on 12.9.02

DAYLIGHT

Mean Total Daylight	34 K Lux h	
Max Total Daylight	70 K Lux h	on 3.9.02

RAIN and SNOW

Within September during seven days some drizzle was observed. The amount was small. On one day rain fell.

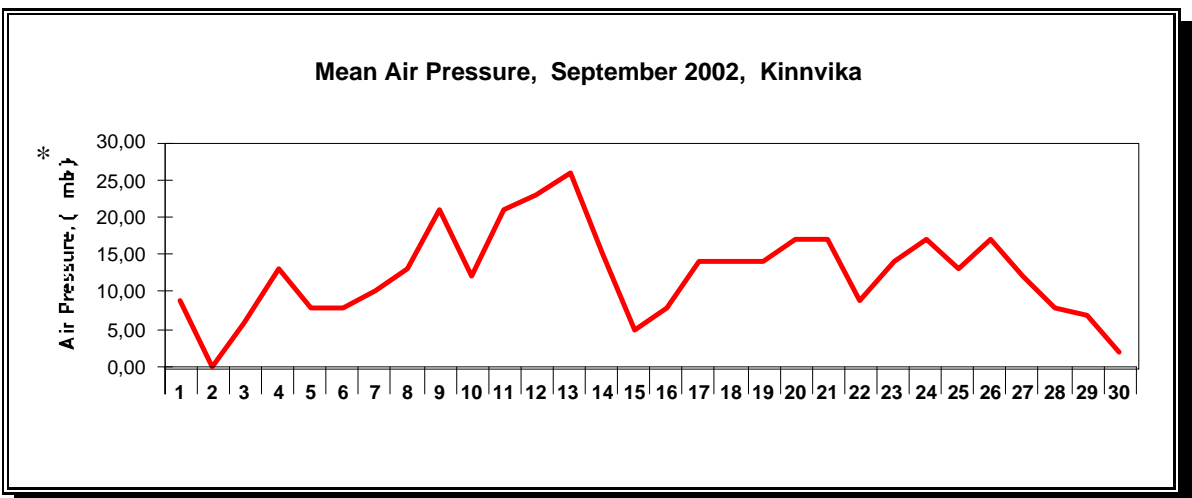
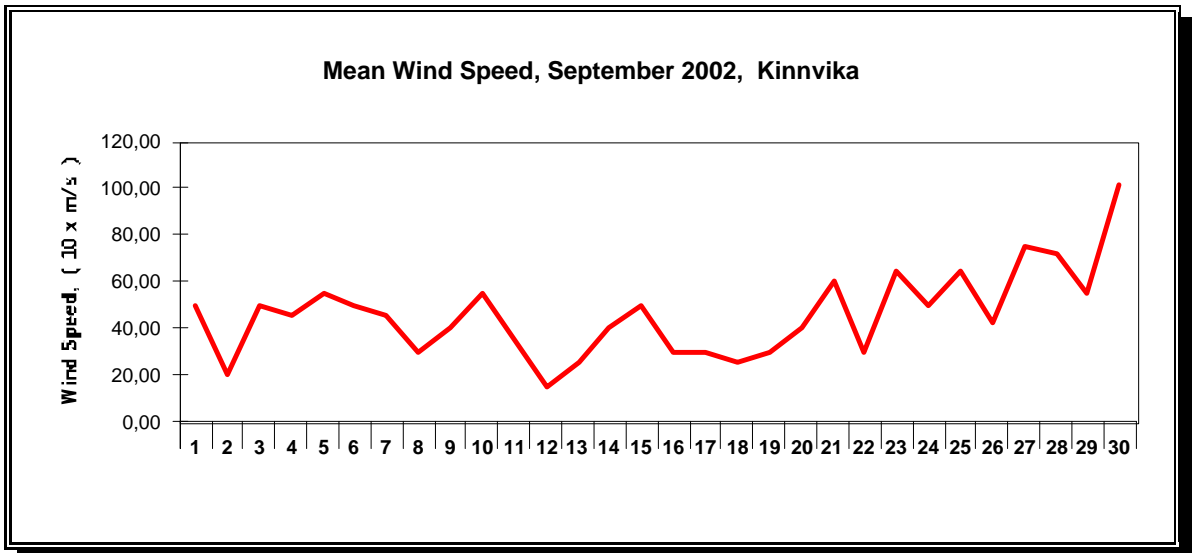
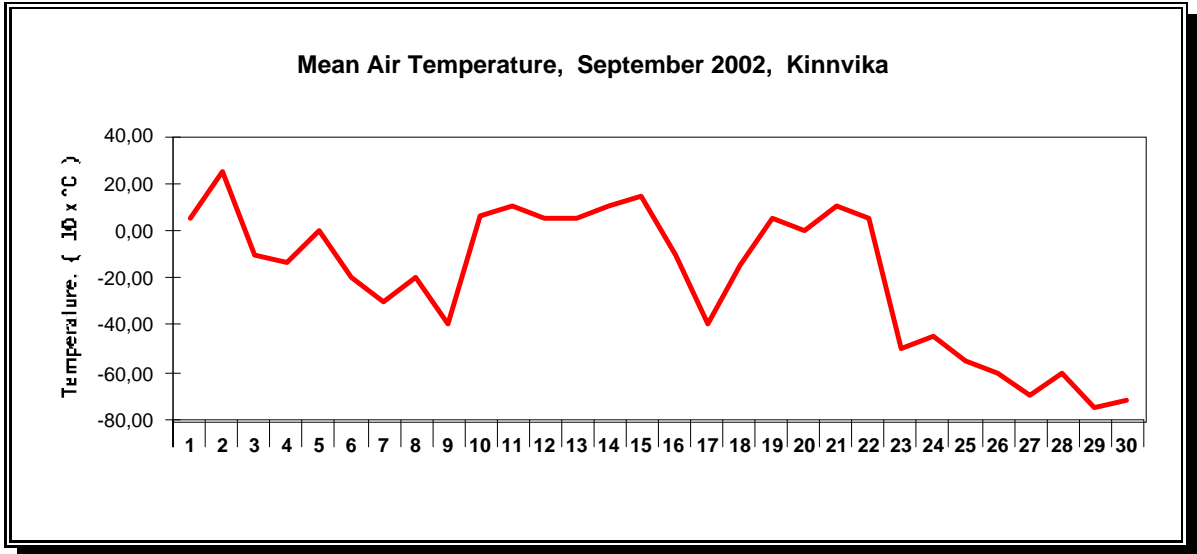
SEA WATER TEMPERATURE

The water temperature went up and down close to +1°C.

SEA ICE

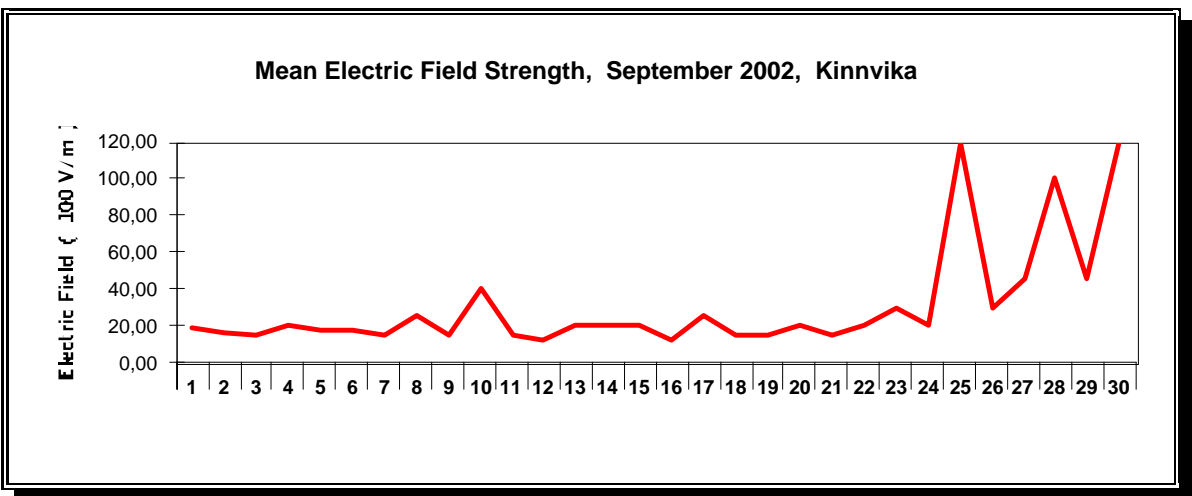
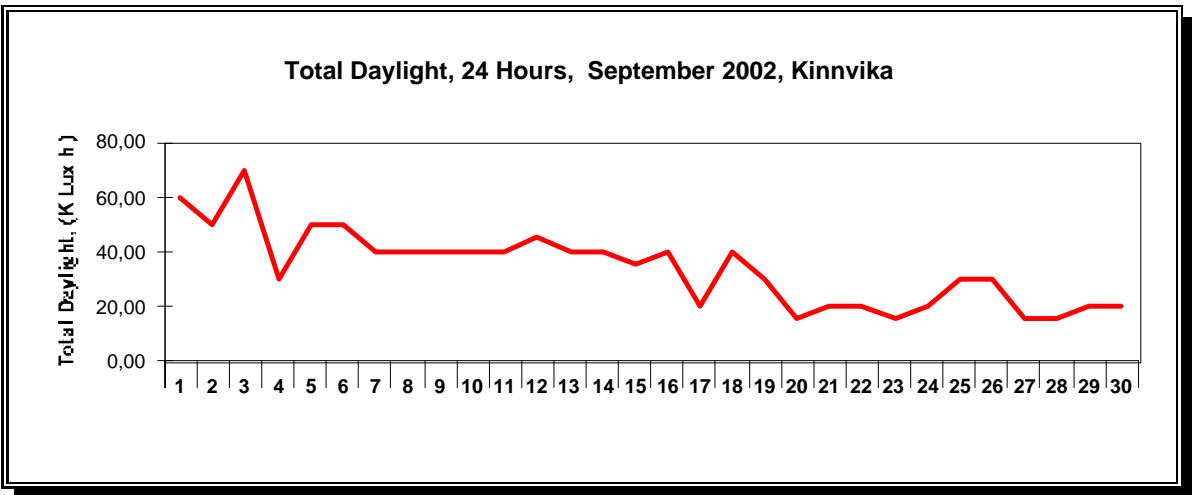
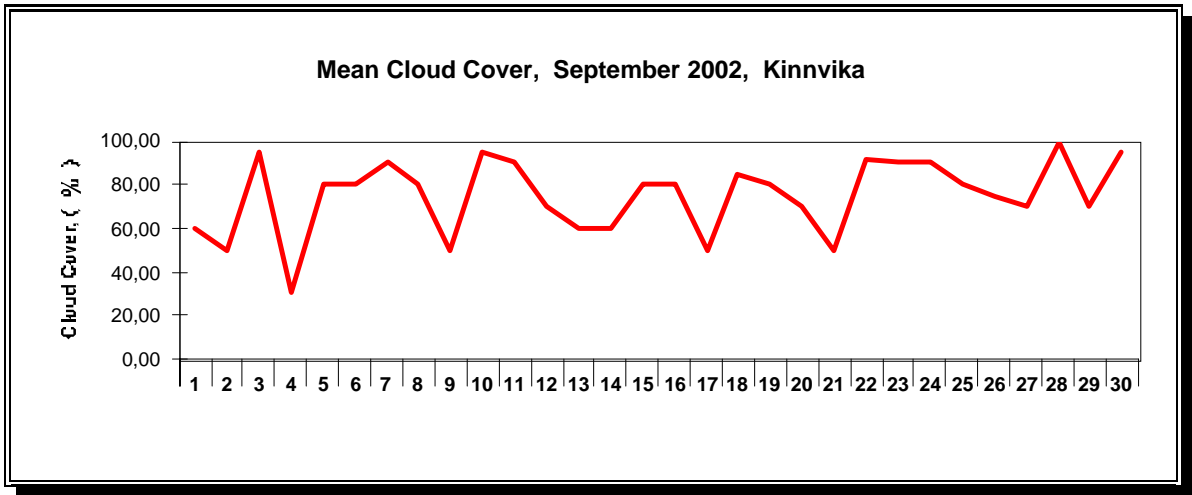
No ice at all was observed neither on Kinnvika Bay and Murchisonfjord nor on Hinlopen Strait.





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WEATHER DATA OCTOBER 2002, KINNVIKA

TEMPERATURE

Mean Air Temperature	-8.1°C	
Max. Air Temperature	+7.3°C	on 11.10.02
Min. Air Temperature	-20.2°C	on 31.10.02

WIND

Mean Wind Speed	5.5 m/s	
Max Wind Speed	14.5 m/s	on 19.10.02
Main Wind Direction	Northerly, 50%	Southerly, 30%

AIR PRESSURE

Mean Air Pressure	1019 mb	
Max Air Pressure	1034 mb	on 21.10.02
Min Air Pressure	1001 mb	on 27.10.02

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	+3.1 KV/m	
Max Electric Field Strength	+30.0 KV/m	on 3.10.02
Min Electric Field Strength	+0.2 KV/m	on 12.10.02

DAYLIGHT

Mean Total Daylight	3.8 K Lux h	
Max Total Daylight	15 K Lux h	on 2.10.02

RAIN and SNOW

Within October during 4 days rain fell, 4 days drizzle was observed, and 14 days snow fell. Due to heavy winds the quantity of snow and rain was not measurable, however it was only small.

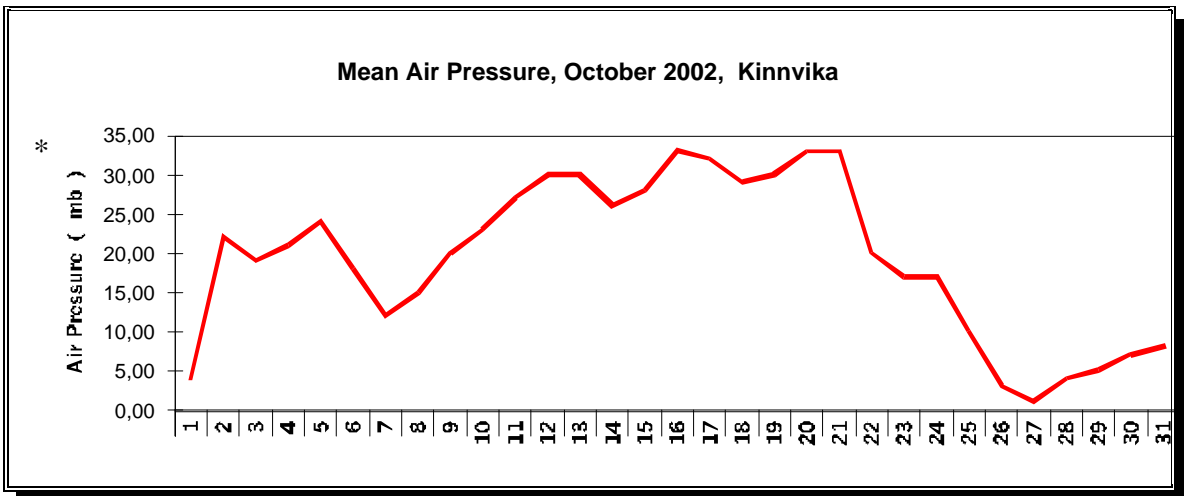
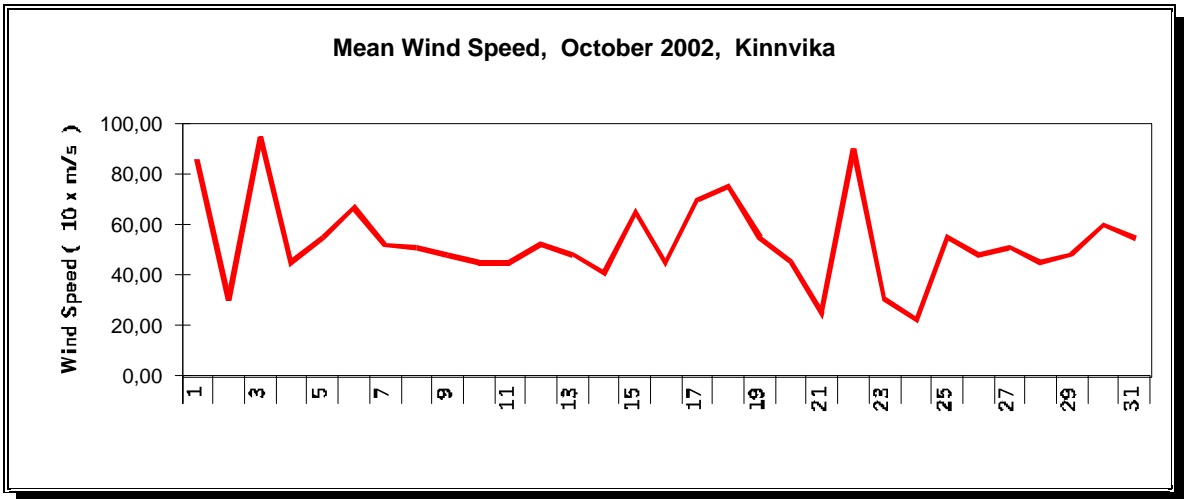
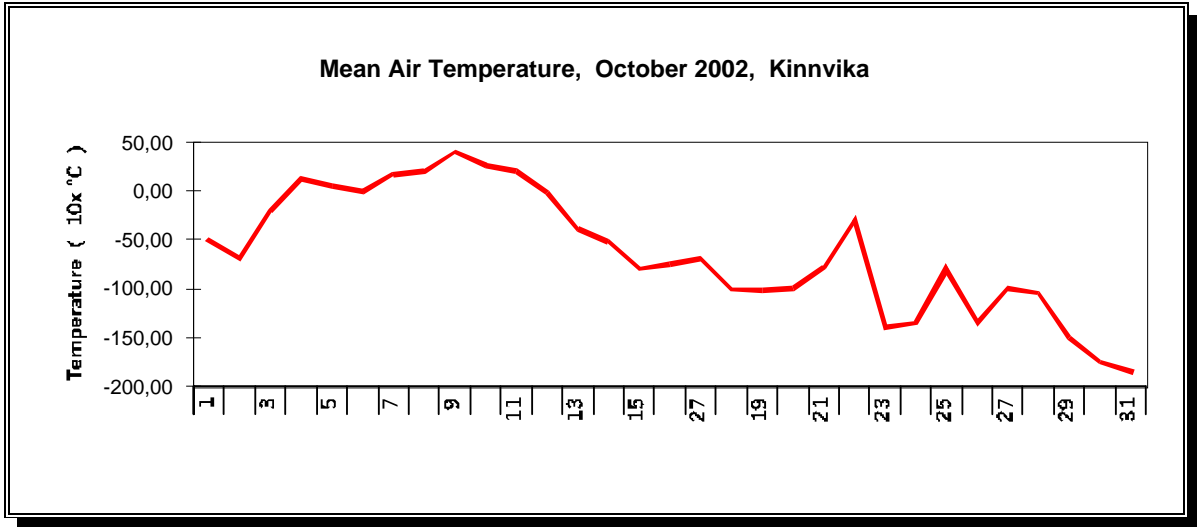
SEA WATER TEMPERATURE

The water temperature went slowly down to about -1.0°C until the end of the month.

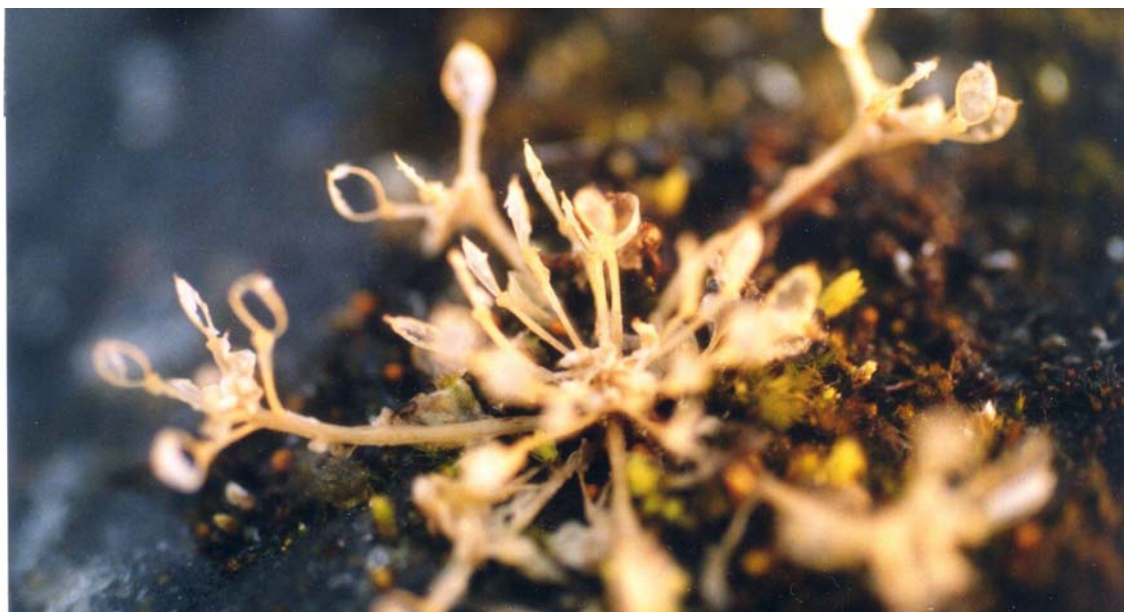
SEA ICE

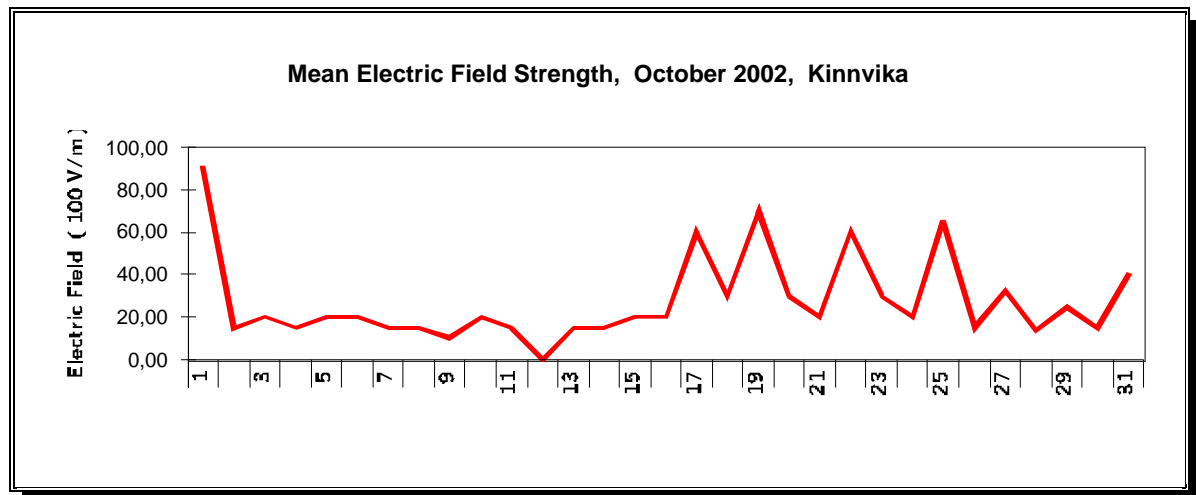
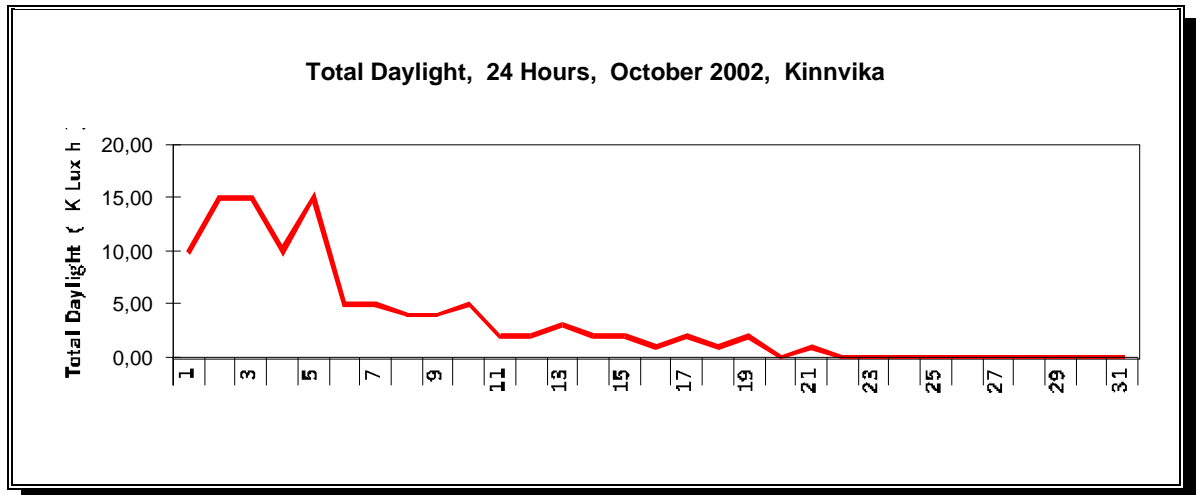
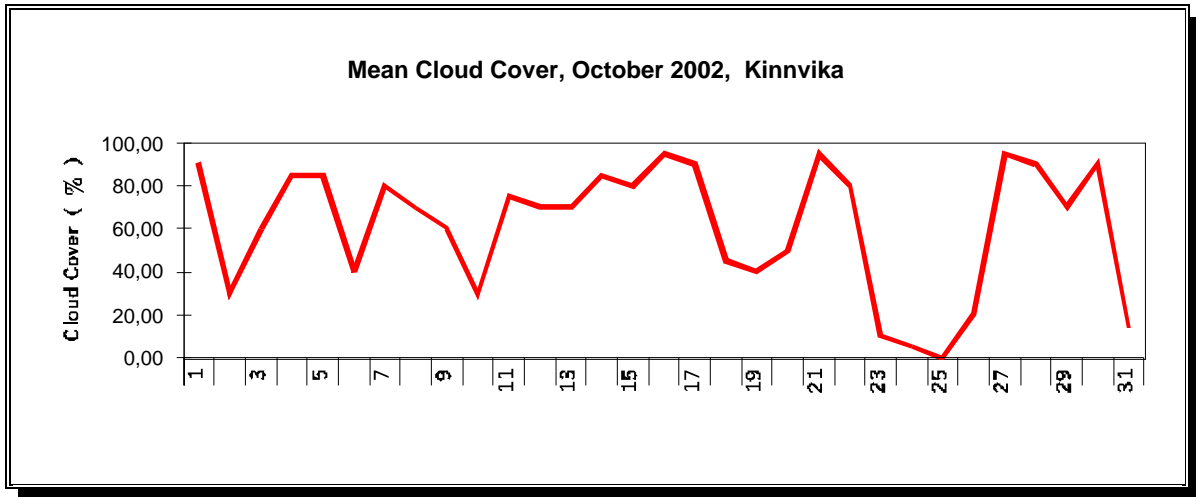
No ice at all was observed neither on Kinnvika Bay and Murchisonfjord nor on Hinlopen Straight. But at the end of the month some ice crystal layers close to the beach of Kinnvika started to grow, (sørpe).





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WEATHER DATA NOVEMBER 2002, KINNVIKA

TEMPERATURE

Mean Air Temperature	-10.6°C	
Max. Air Temperature	+0.5°C	on 28.11.02
Min. Air Temperature	-21.5°C	on 2.11.02

WIND

Mean Wind Speed	5.7 m/s	
Max Wind Speed	16.0 m/s	on 19.11.02
Main Wind Direction	Northerly, 25%	Southerly, 50%

AIR PRESSURE

Mean Air Pressure	1017 mb	
Max Air Pressure	1031 mb	on 27.11.02
Min Air Pressure	1000 mb	on 18.11.02

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	+5.5 KV/m	
Max Electric Field Strength	+25.0 KV/m	on 25.11.02
Min Electric Field Strength	-1.5 KV/m	on 23.11.02

DAYLIGHT

Mean Total Daylight	0.0 K Lux h
Max Total Daylight	0.0 K Lux h

RAIN and SNOW

Within November no rain was observed. On 24 days snow fell. The amount of snow was small. Due to heavy winds, the snow was heaped into snow hills to a height of 1 to 2.5m. The snow layer on the plain ground, was about 10cms.

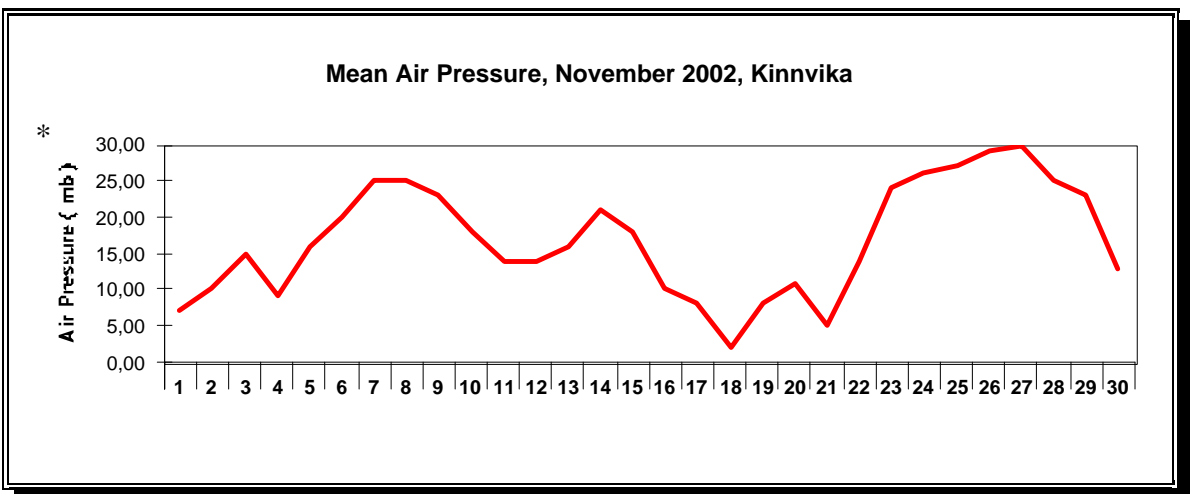
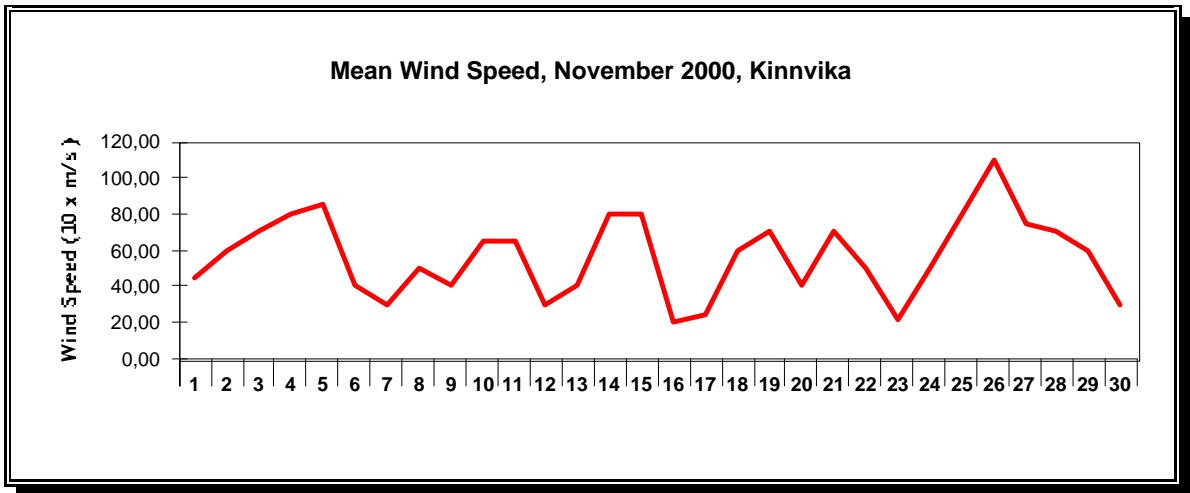
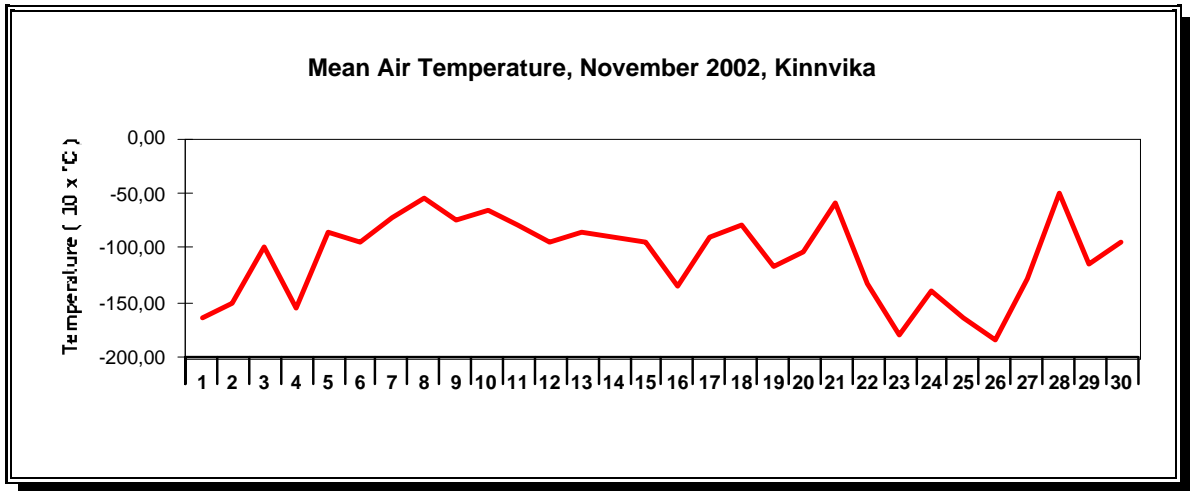
SEA WATER TEMPERATURE

The water temperature was between -1°C and -1.7°C.

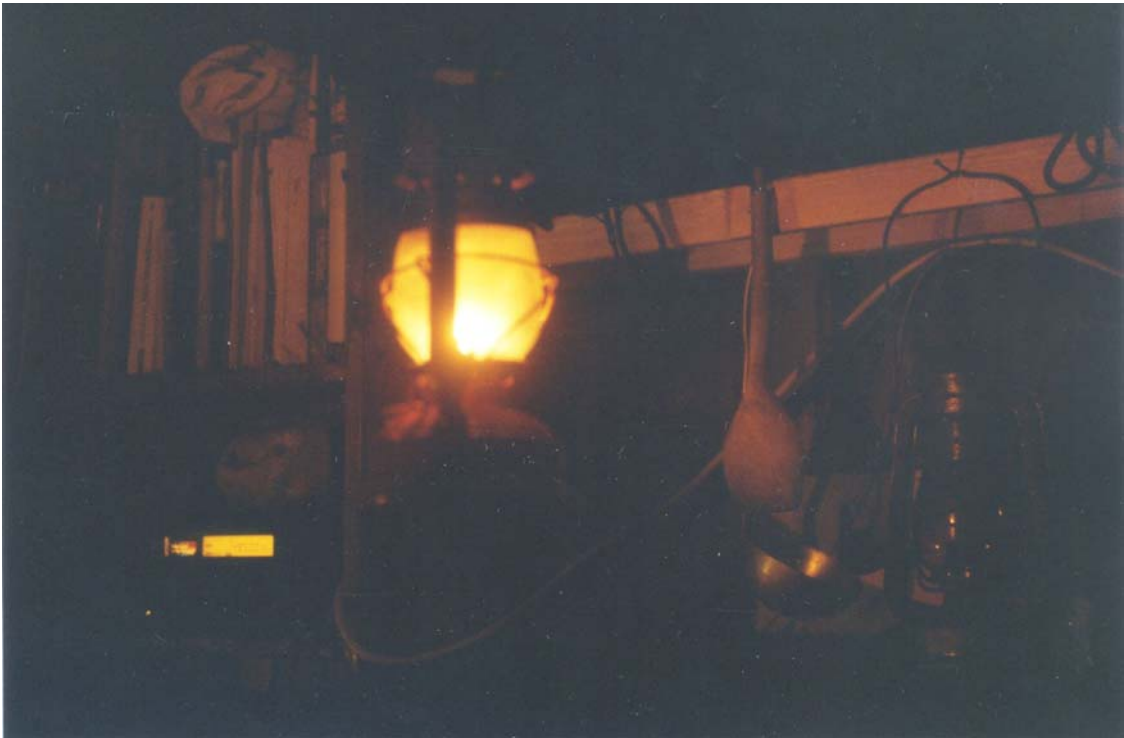
SEA ICE

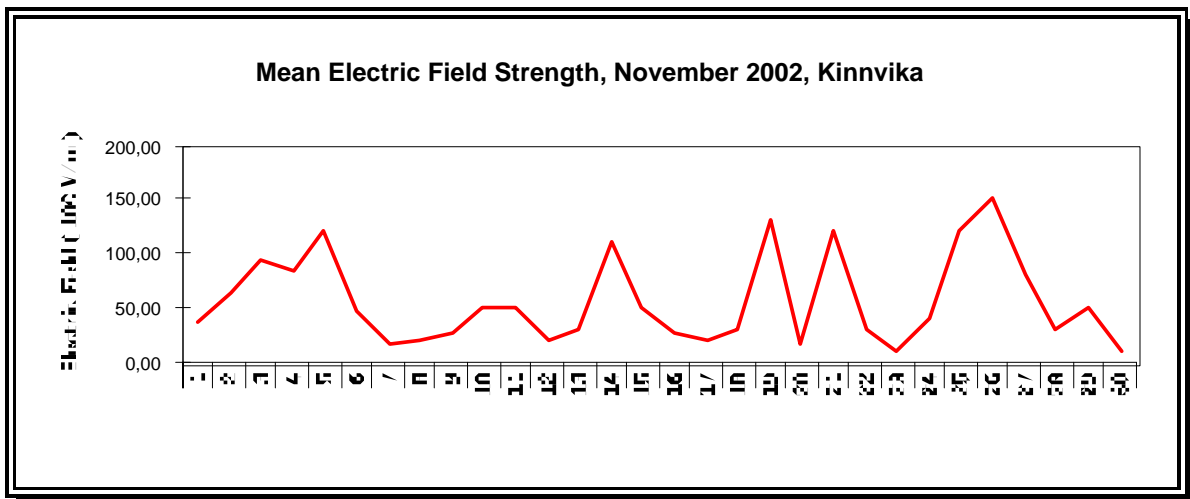
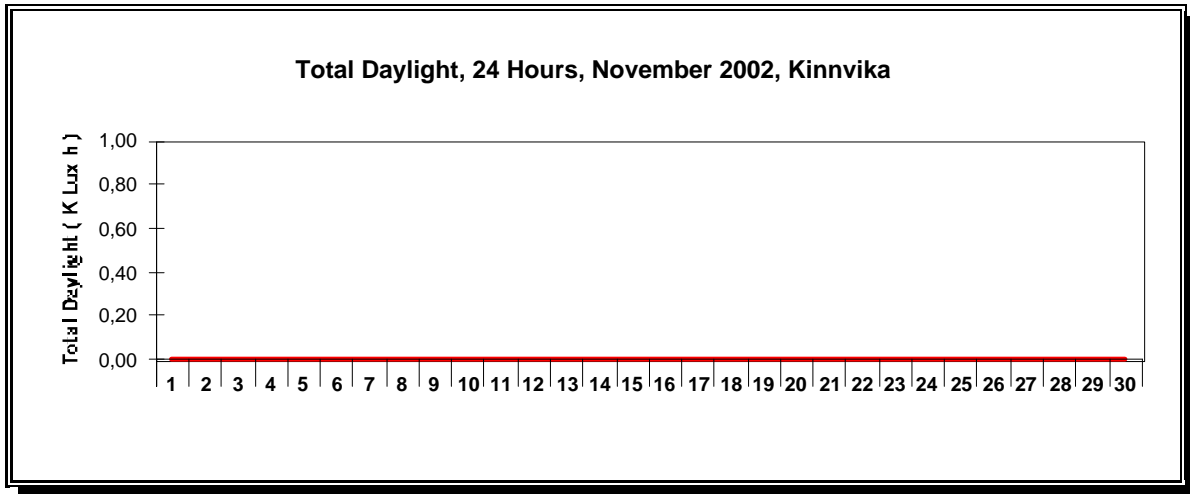
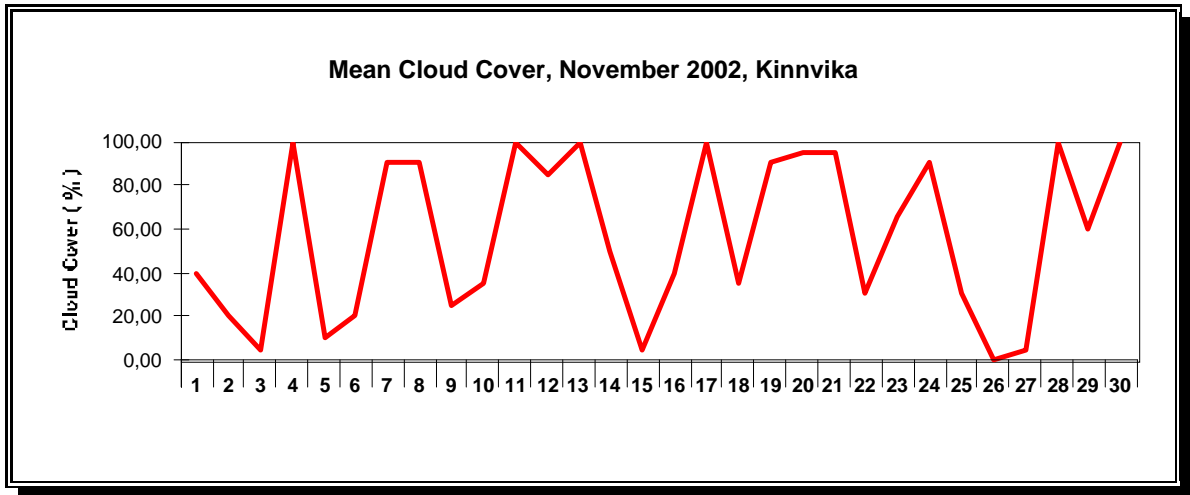
The sea ice on Kinnvika at a distance of about 300m from the beach was growing. At the end of the month the thickness of ice was about 30 to 50 cms. The Hinlopen Straight and the southern part of Murchisonfjord seemed to be free of ice.





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WEATHER DATA DECEMBER 2002, KINNVIKA

TEMPERATURE

Mean Air Temperature	-12.4°C	
Max. Air Temperature	+7.0°C	on 7.12.02
Min. Air Temperature	-30.0°C	on 18.12.02

WIND

Mean Wind Speed	7.1 m/s	
Max Wind Speed	20.8 m/s	on 26.12.02
Main Wind Direction	Easterly, 20%	Southerly, 45%

AIR PRESSURE

Mean Air Pressure	1017 mb	
Max Air Pressure	1032 mb	on 27.12.02
Min Air Pressure	990 mb	on 14.12.02

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	+7.5 KV/m	
Max Electric Field Strength	+30.0 KV/m	on 25.12.02
Min Electric Field Strength	+0.1 KV/m	on 1.12.02

DAYLIGHT

Mean Total Daylight	0.0 K Lux h
Max Total Daylight	0.0 K Lux h

From 5th to 7th December unusual, strong, yellow, reddish light was visible from morning until to midday in the south easterly sky. During this time phase the air temperature was unusually high.

RAIN and SNOW

Within December (6.12.02) one day of rain was observed. On 13 days snow fell. The amount of snow was small. Due to heavy winds, the snow was heaped into snow hills to a height of up to 2.5m. The snow layer on the plain ground, was about 0-20cms.

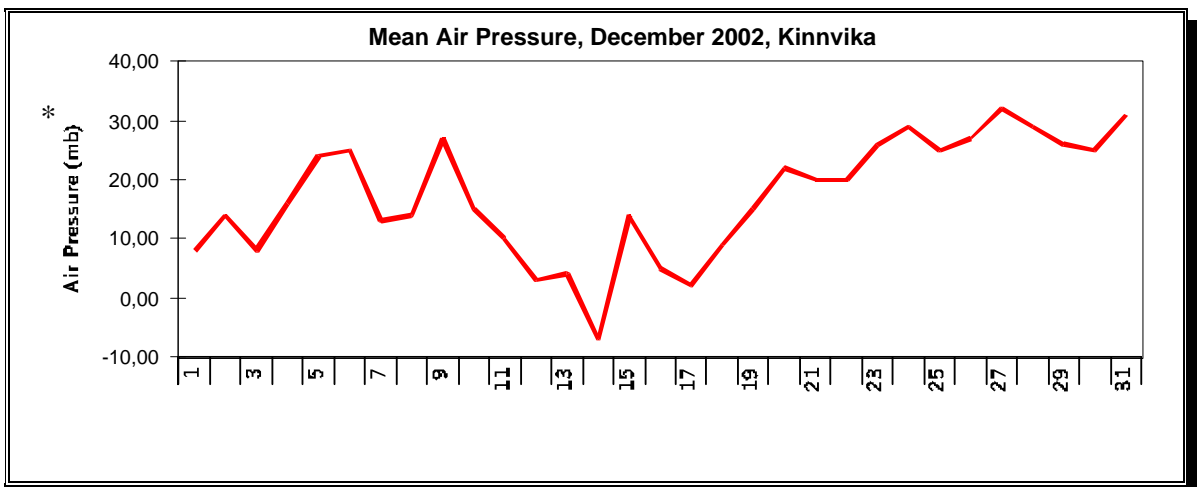
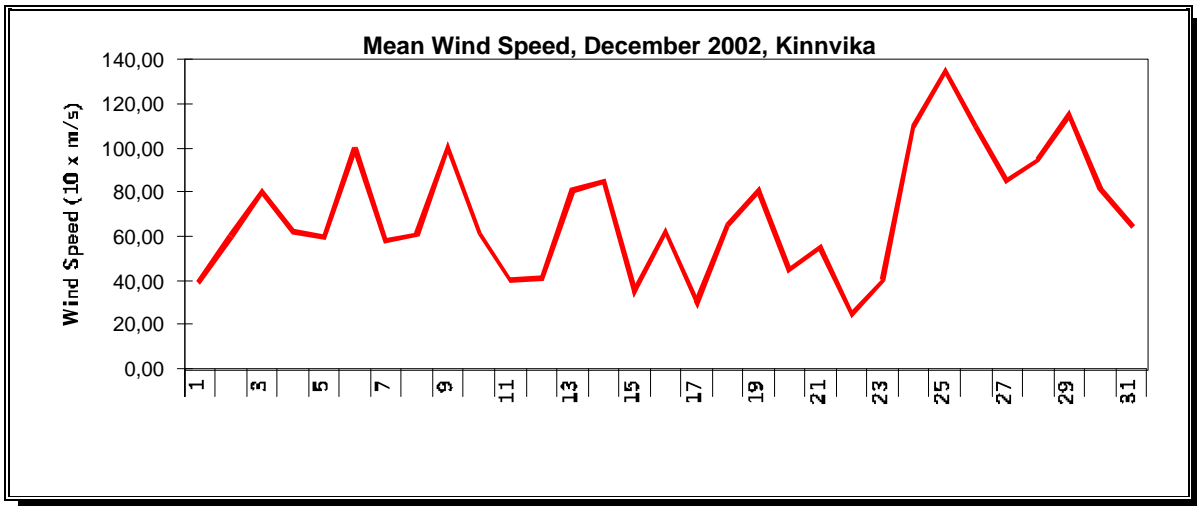
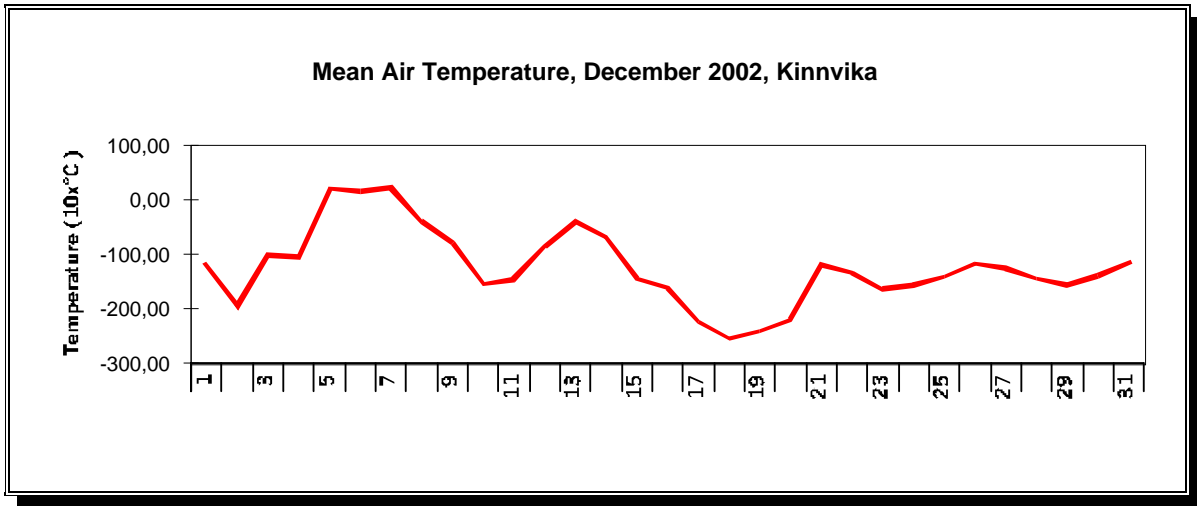
SEA WATER TEMPERATURE

The water temperature was between 0°C and -1.8°C.

SEA ICE

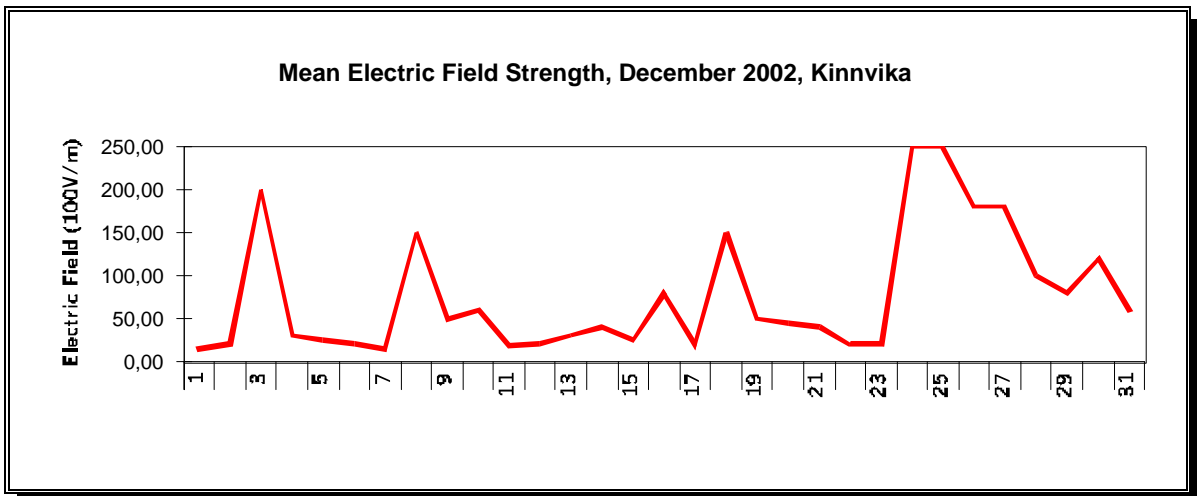
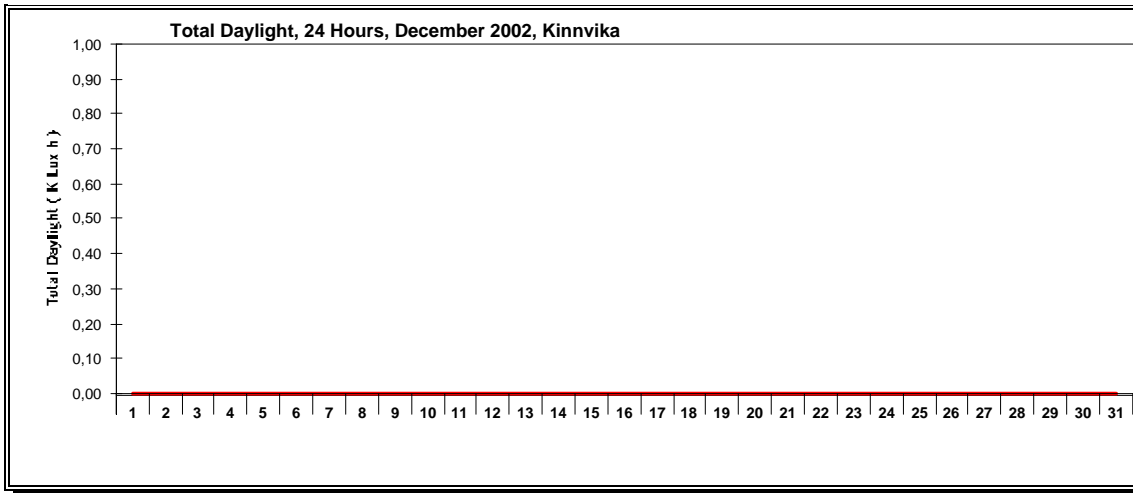
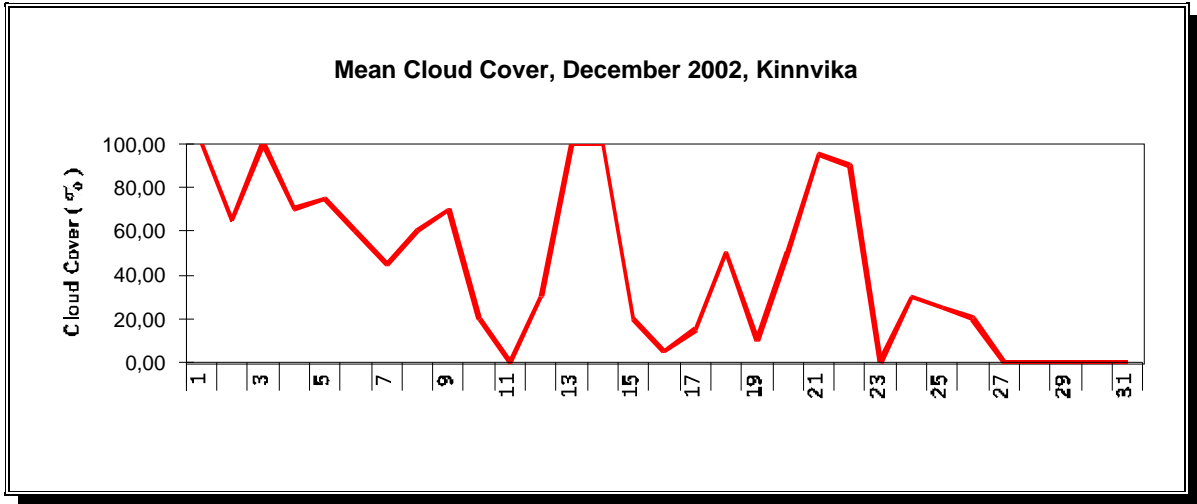
The sea ice in the bay of Kinnvika was very unstable, it came and went from day to day. Only very close to the beach and in narrow inlets some sea ice layers with a thickness of about 30cms remained permanently. However, even this ice seemed to be rotten and showing cracks. The Hinlopen Strait and the main part of Murchisonfjord was free of ice.





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WEATHER DATA JANUARY 2003, KINNVIKA

TEMPERATURE

Mean Air Temperature	-22.1°C	
Max. Air Temperature	-4.0°C	on 7.1.03
Min. Air Temperature	-34.8°C	on 31.1.03

WIND

Mean Wind Speed	5.1 m/s	
Max Wind Speed	17.6 m/s	on 20.1.03
Main Wind Direction	Southerly, 28%	Northerly, 65%

AIR PRESSURE

Mean Air Pressure	1008 mb	
Max Air Pressure	1029 mb	on 1.1.03
Min Air Pressure	990 mb	on 13.1.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	+4.8 KV/m	
Max Electric Field Strength	+40.0 KV/m	on 5.1.03
Min Electric Field Strength	+0.0 KV/m	on 2.1.03

DAYLIGHT

Mean Total Daylight	0.0 K Lux h
Max Total Daylight	0.0 K Lux h

Since 22nd January some twilight was visible at midday.

RAIN and SNOW

Within January no rain was observed. On 14 days snow fell. The amount of snow was sometimes heavy. Due to heavy winds, the snow was heaped into snow hills to a height of up to 2.5m. The snow layer on the plain ground, was about 0-40cms.

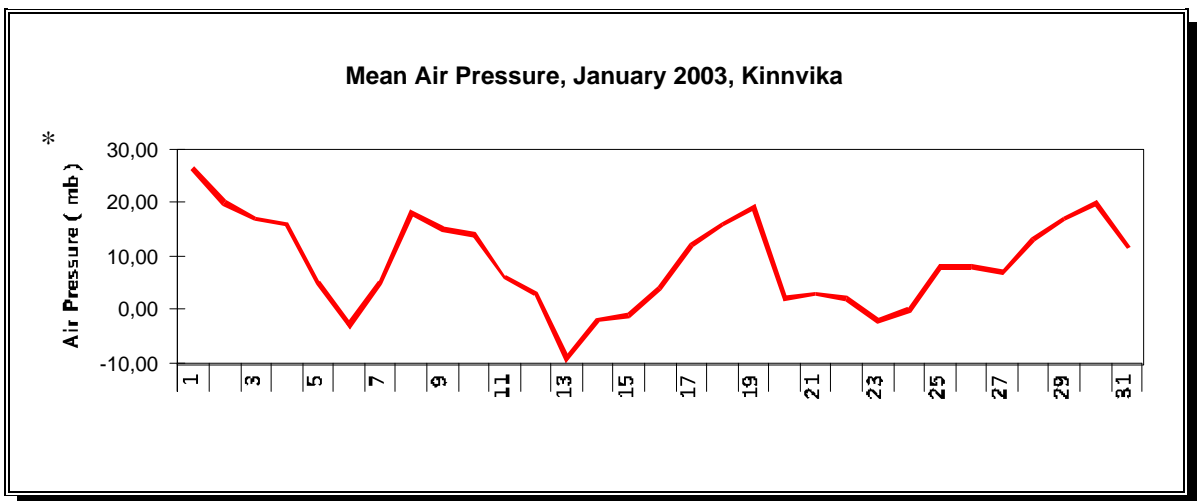
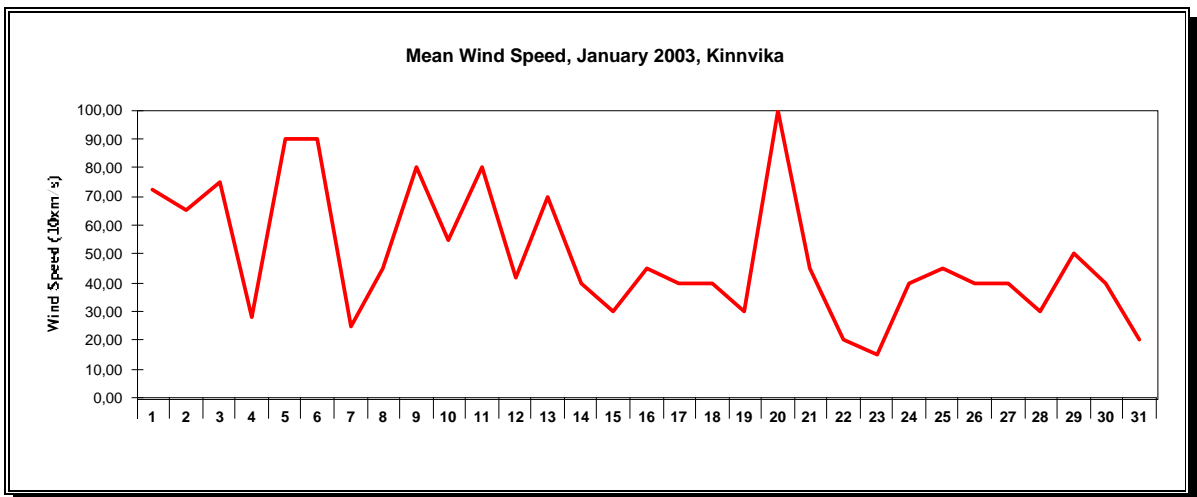
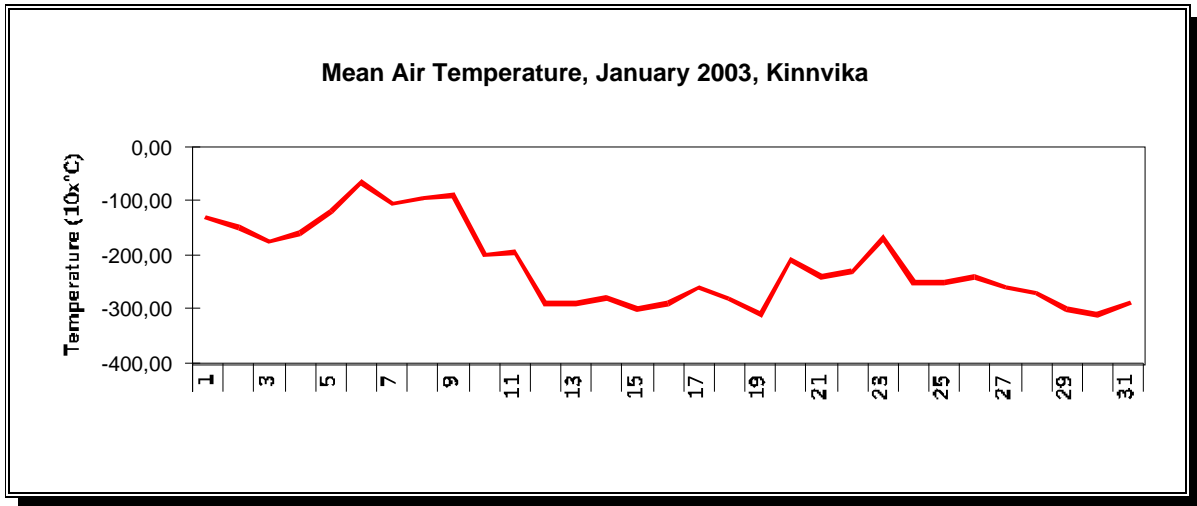
SEA WATER TEMPERATURE

The water temperature was between -1.5°C and -1.8°C.

SEA ICE

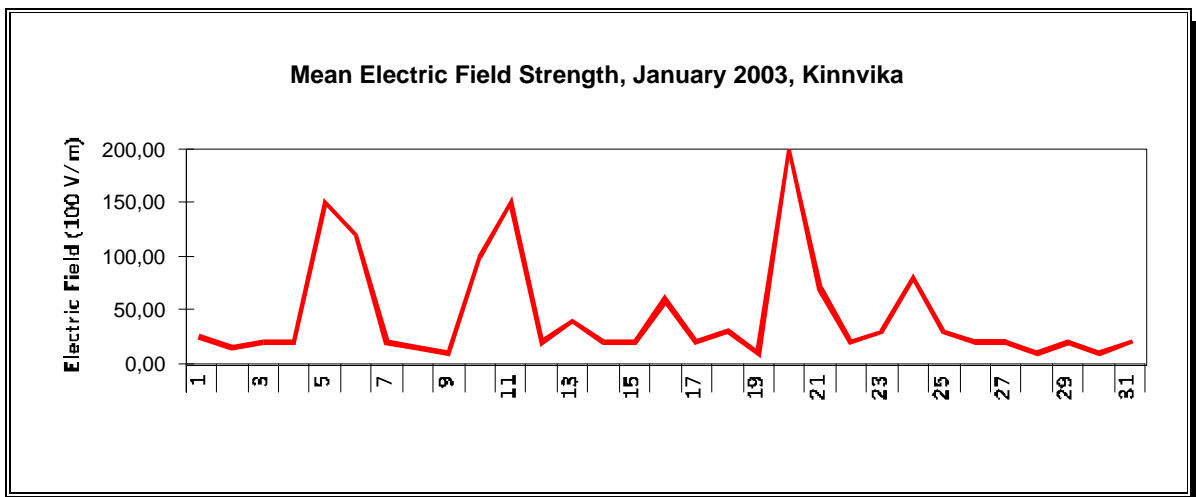
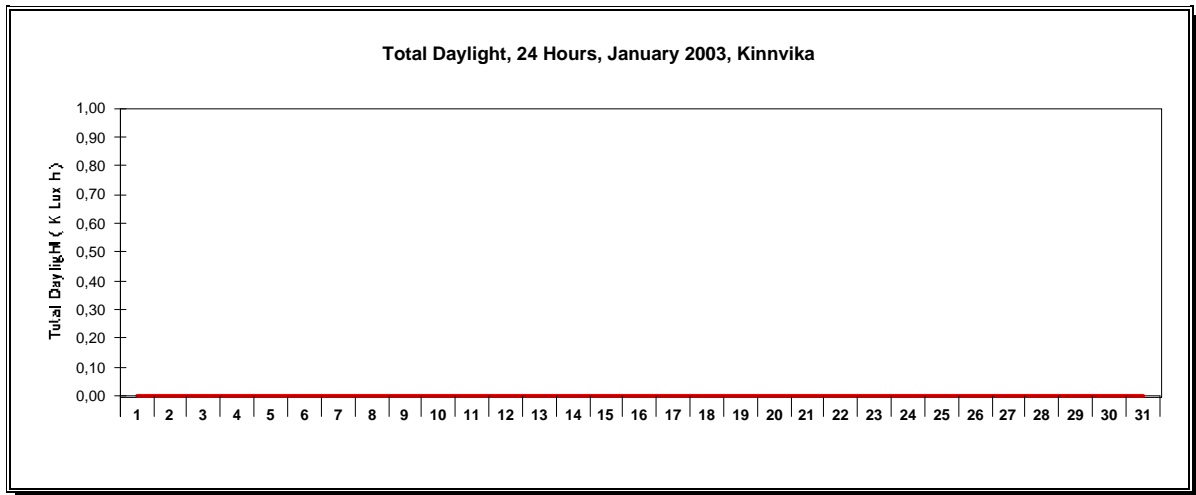
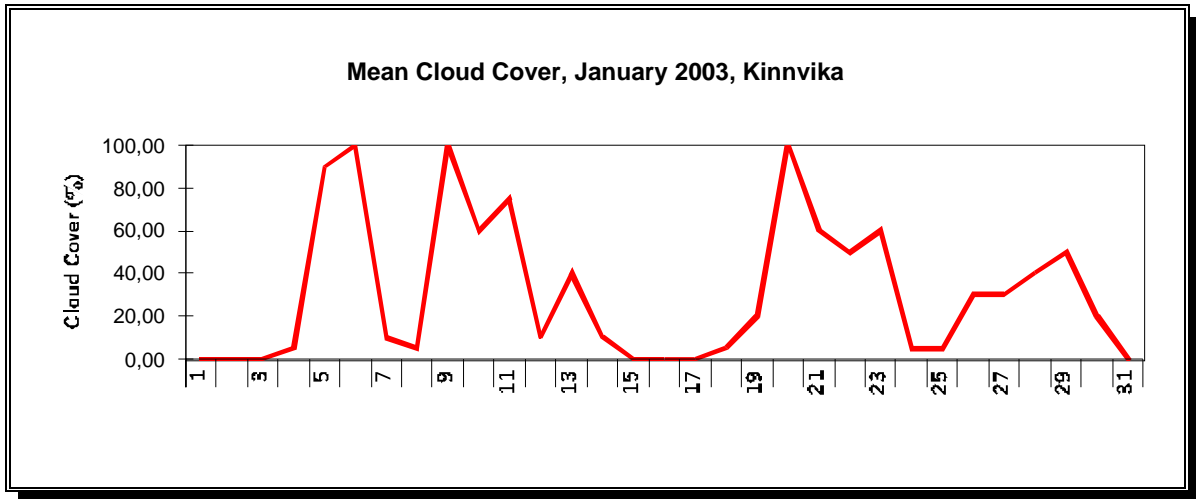
The sea ice in the bay of Kinnvika grew more and more. At the end of January it seemed that the total Murchisonfjord was covered by ice. However the ice was weak and showed sometimes open lanes. The ice thickness close to the beach was about 30-40cms. The Hinlopen Straight seemed to be all the month free of ice.





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WEATHER DATA FEBRUARY 2003, KINNVIKA

TEMPERATURE

Mean Air Temperature	-15.8C	
Max. Air Temperature	+0.9°C	on 15.2.03
Min. Air Temperature	-31.0°C	on 27.2.03

WIND

Mean Wind Speed	7.0 m/s	
Max Wind Speed	29.4 m/s	on 19.2.03
Main Wind Direction	Southerly, 50%	Northerly, 35%

AIR PRESSURE

Mean Air Pressure	1007 mb	
Max Air Pressure	1023 mb	on 28.2.03
Min Air Pressure	990 mb	on 15.2.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	+10.6 KV/m	
Max Electric Field Strength	+30.0 KV/m	on 17.2.03
Min Electric Field Strength	+1.0 KV/m	on 4.2.03

DAYLIGHT

Mean Total Daylight	0.2 K Lux h	
Max Total Daylight	1.0 K Lux h	on 28.2.03

RAIN and SNOW

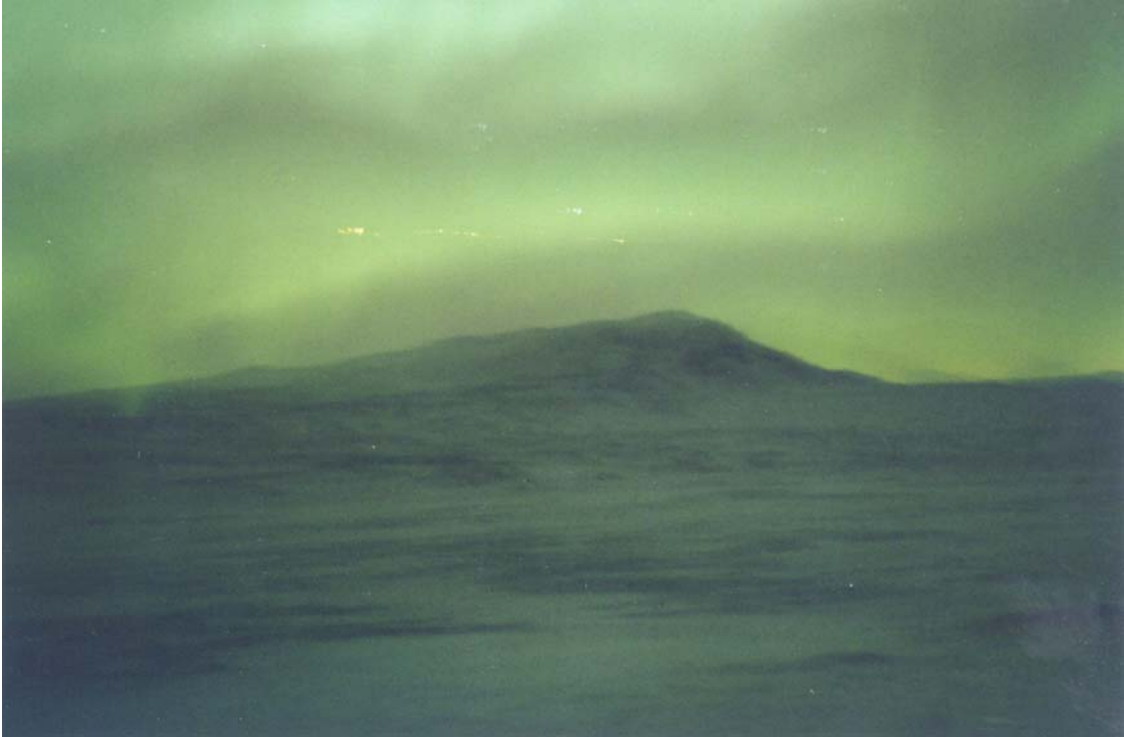
Within February no rain was observed. On 15 days snow fell. The amount of snow was small. Due to heavy winds, the snow was heaped into snow hills to a height of up to 3.0m. The snow layer on the plain ground, was about 0-10cms.

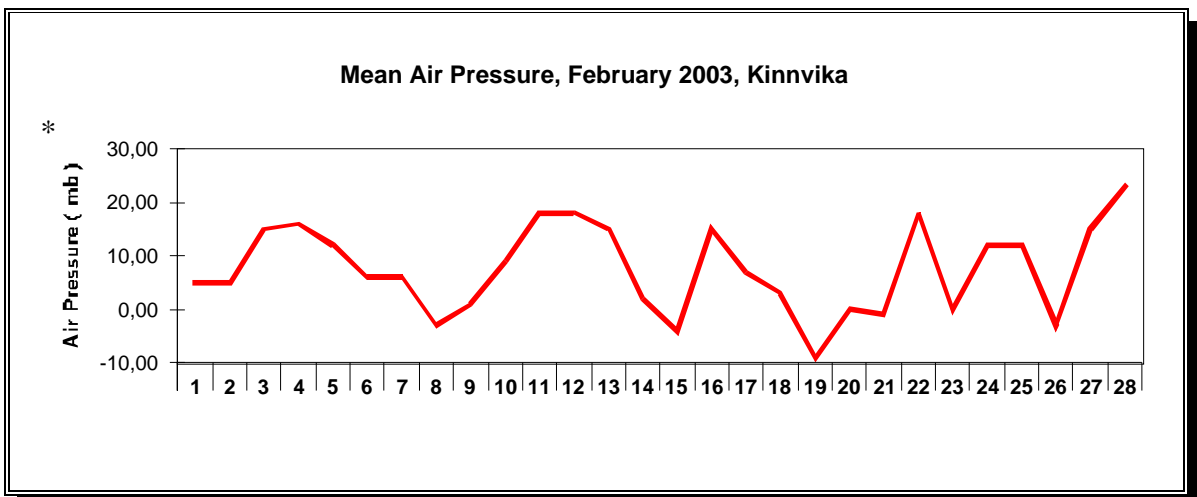
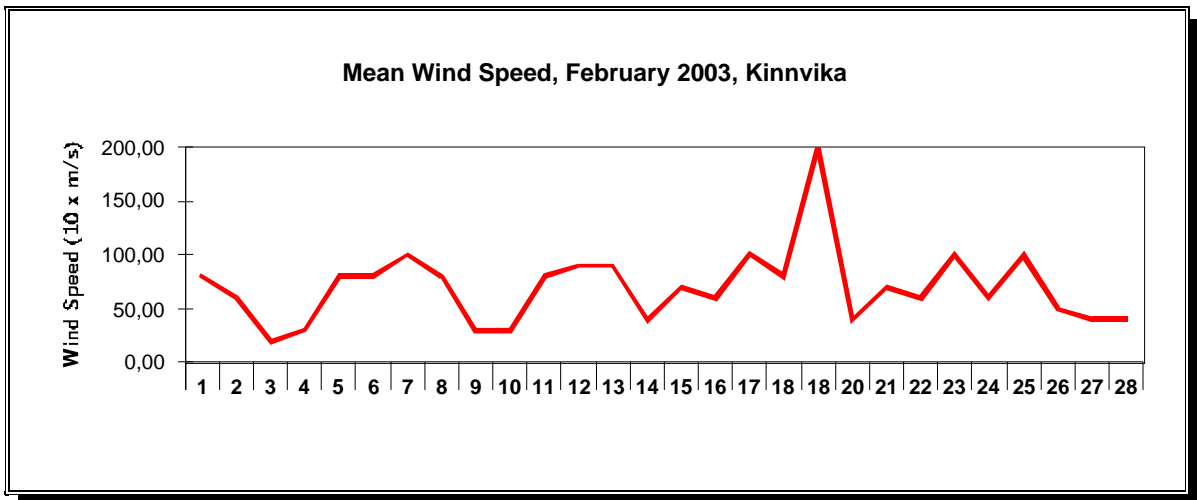
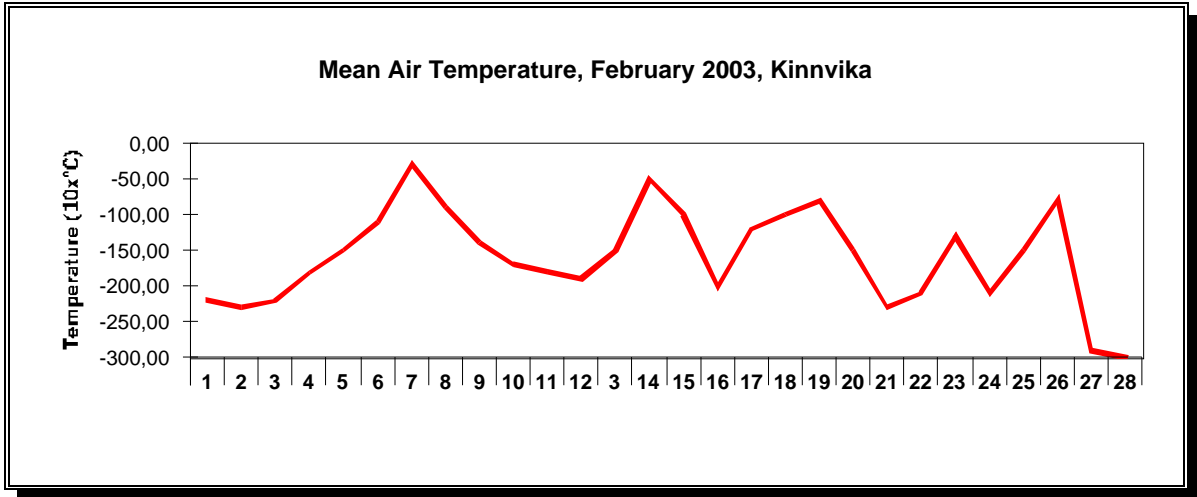
SEA WATER TEMPERATURE

The water temperature was between -1.5°C and -1.8°C.

SEA ICE

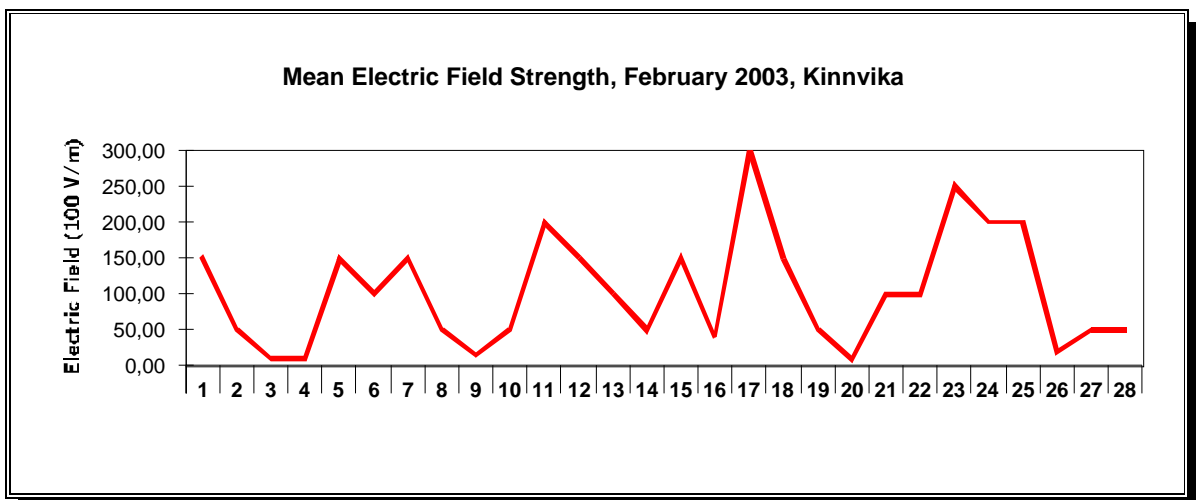
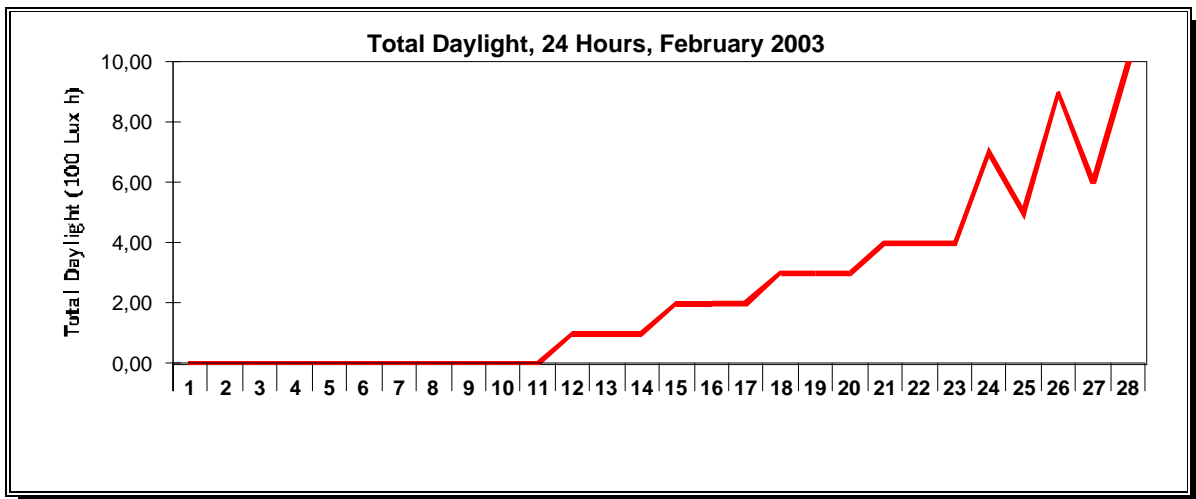
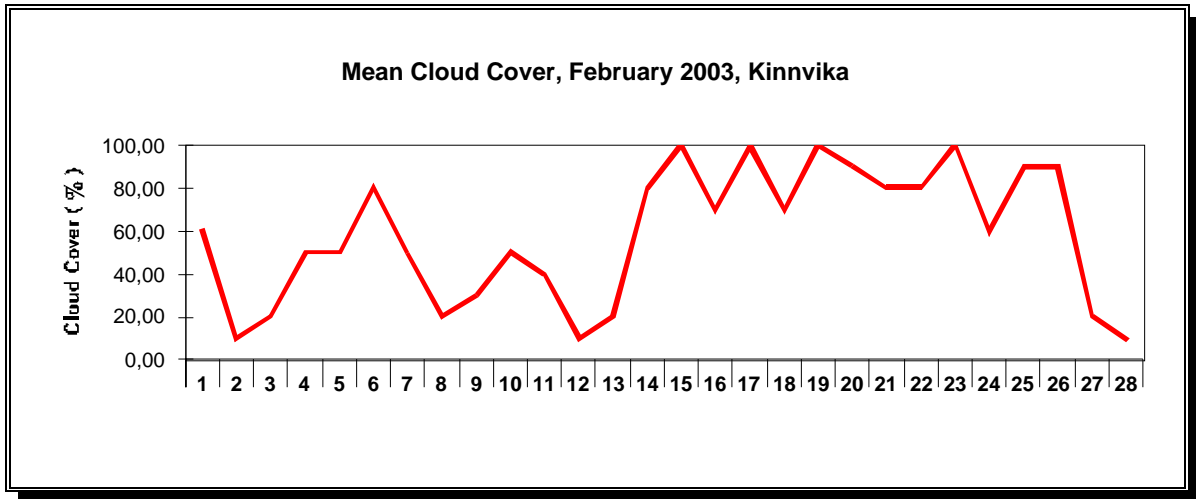
The sea ice in the bay of Kinnvika seemed to be stable and safe, with a thickness of approximately 40cms. The ice layer in Murchisonfjord varied strongly. Sometimes Murchisonfjord was more or less totally covered by ice and sometimes the southern part of the fjord was free of ice. On 18th February due to heavy winds, open water was forced up onto the ice layer in Kinnvika Bay. Hinlopen Strait was free of ice during the first part of the month. Later, it seemed that the northern part of Hinlopen Strait was covered by ice and ice bergs, while the southern part was free of ice.





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WEATHER DATA MARCH 2003, KINNVIKA

TEMPERATURE

Mean Air Temperature	-23.2°C	
Max. Air Temperature	-12.8°C	on 21.3.03
Min. Air Temperature	-35.5°C	on 12.3.03

WIND

Mean Wind Speed	6.0 m/s	
Max Wind Speed	20.0 m/s	on 21.3.03
Main Wind Direction	Southerly, 25%	Northerly, 55%

AIR PRESSURE

Mean Air Pressure	1016 mb	
Max Air Pressure	1026 mb	on 19.3.03
Min Air Pressure	973 mb	on 21.3.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	
Max Electric Field Strength	Instrumentation damaged.
Min Electric Field Strength	

DAYLIGHT

Mean Total Daylight	15.9 K Lux h	
Max Total Daylight	40.0 K Lux h	on 31.3.03

RAIN and SNOW

Within March no rain was observed. On 16 days snow fell. The amount of snow was small. Due to heavy winds, fairly often blizzard conditions stayed for days at a time. The snow was heaped into snow hills to a height of up to 4.0m. The snow became densely packed. The snow layer on the open ground was about 0-20cms.

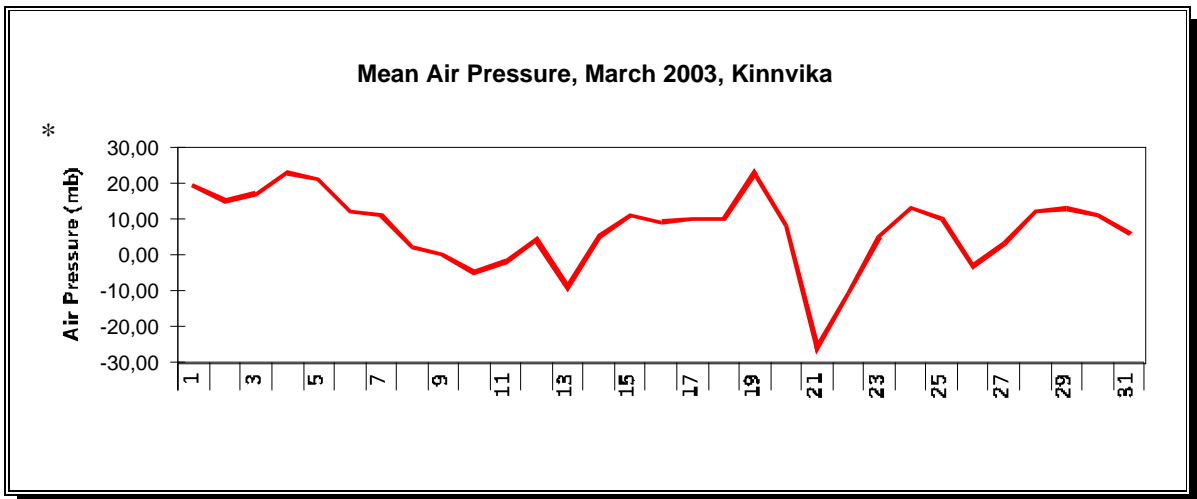
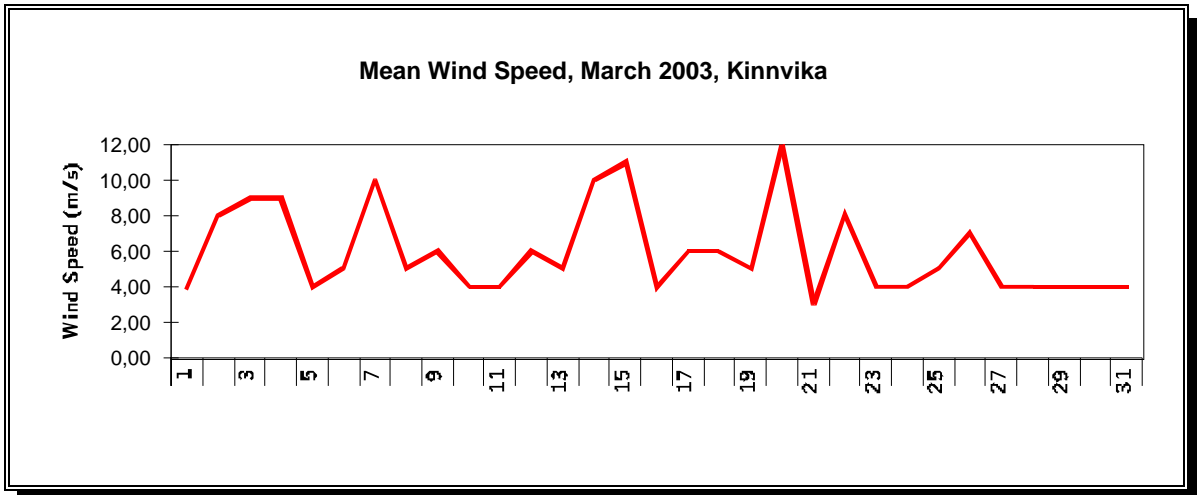
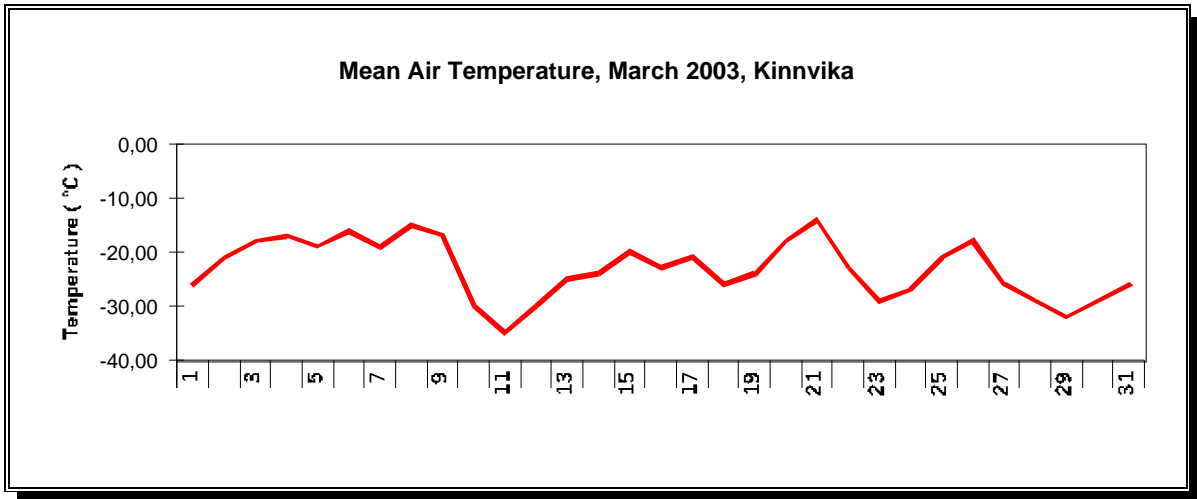
SEA WATER TEMPERATURE

The water temperature was between -1°C and -1.8°C.

SEA ICE

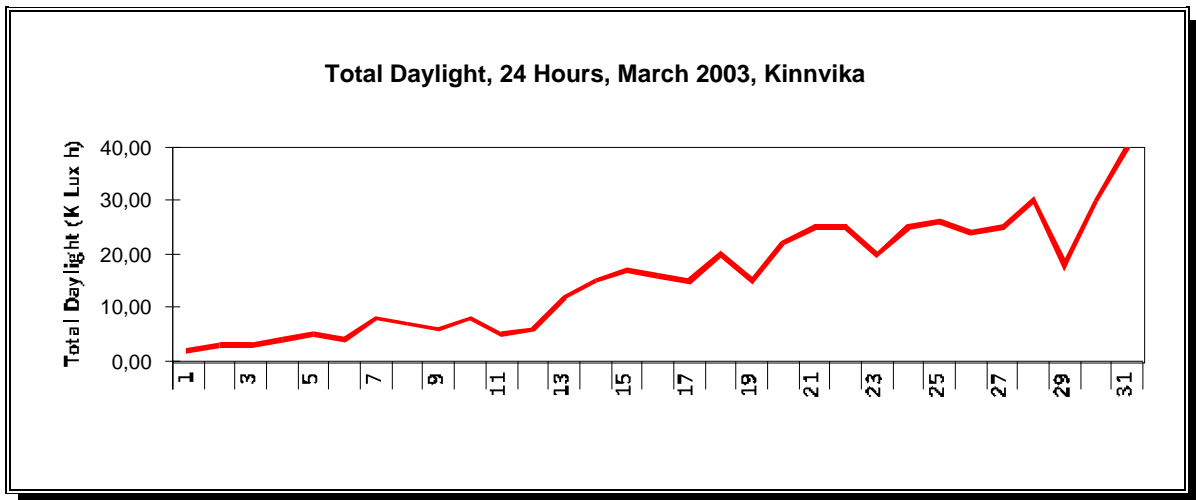
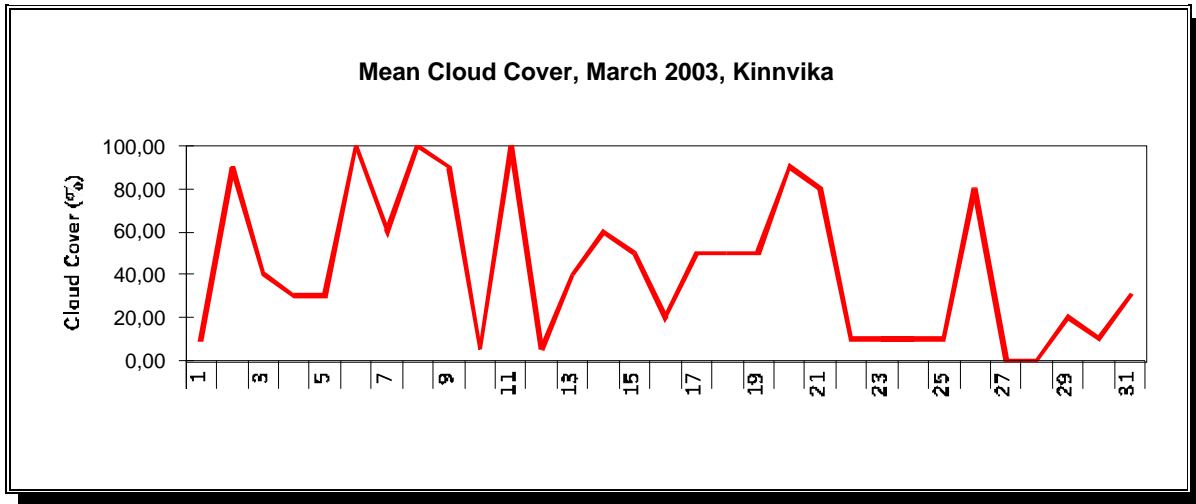
In the Kinnvika bay the sea ice layer was about 60cms in thickness. In the beginning of the month the southern part of Murchisonfjord and Hinlopen Straight were free of ice. On 12th March Hinlopen Straight and the whole of Murchisonfjord was covered by new, fresh ice. On 16th March pack ice came from the north into the north part of Hinlopen Straight. At the end of March, Hinlopen Straight and Murchisonfjord were totally covered by ice. However the ice layer seemed to be, at some locations, very weak. Some small spots and lanes of open water were visible.





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WEATHER DATA APRIL 2003, KINNVIKA

TEMPERATURE

Mean Air Temperature	-13.7°C	
Max. Air Temperature	+1.6°C	on 13.4.03
Min. Air Temperature	-30.1°C	on 5.4.03

WIND

Mean Wind Speed	4.3 m/s	
Max Wind Speed	23.8 m/s	on 9.4.03
Main Wind Direction	Southerly, 20%	Northerly, 53%

AIR PRESSURE

Mean Air Pressure	1017 mb	
Max Air Pressure	1035 mb	on 23.4.03
Min Air Pressure	988 mb	on 8.4.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	
Max Electric Field Strength	Instrumentation damaged.
Min Electric Field Strength	

DAYLIGHT

Mean Total Daylight	111 K Lux h	
Max Total Daylight	220 K Lux h	on 30.4.03

RAIN and SNOW

On 18th April, sleet fell. On 12 days snow fell. The amount of snow was small. Due to heavy winds, fairly often blizzard conditions stayed for days at a time. The snow was heaped into snow hills to a height of up to 3.5m. The snow became densely packed. The snow layer on the open ground was about 0-40cms. During the blizzards and fairly warm temperatures of about -5°C to -10°C, the surface of snow hills became icy. Finally they looked like little glaciers. Even on the ground with very little snow, an ice layer formed on the surface.

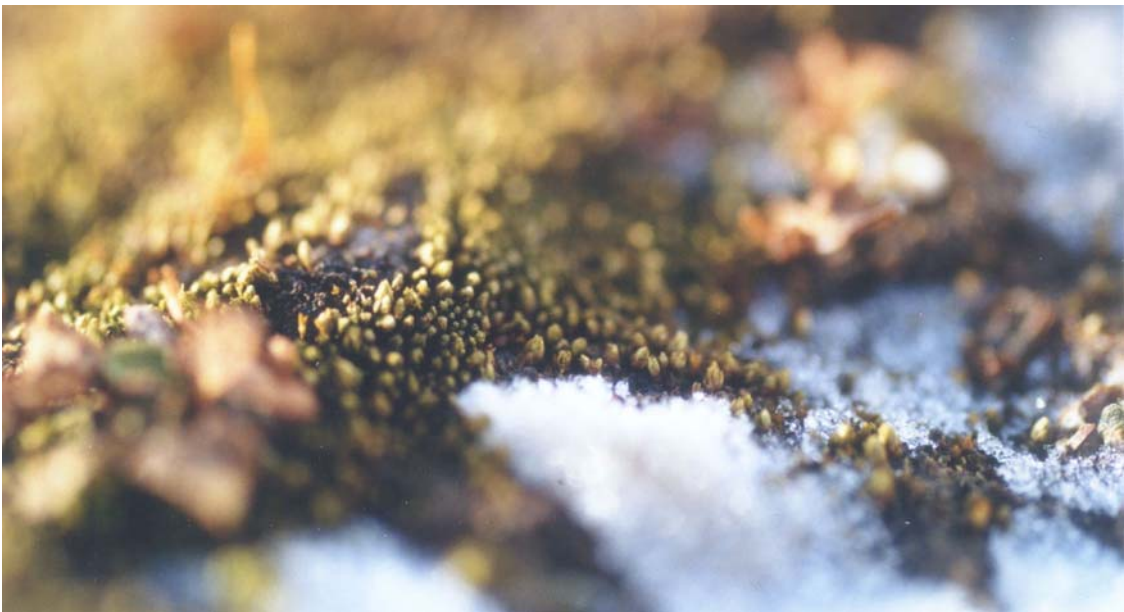
SEA WATER TEMPERATURE

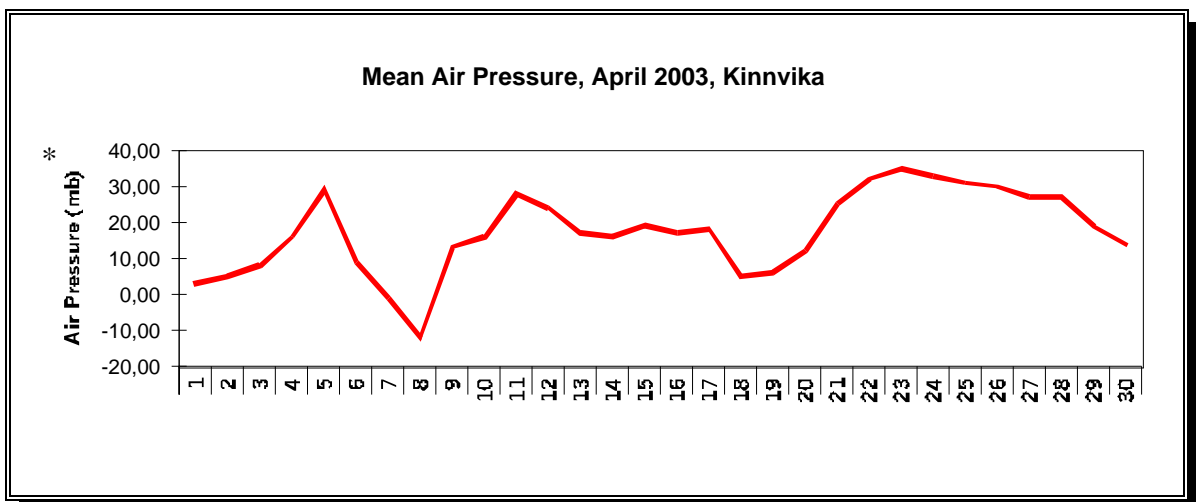
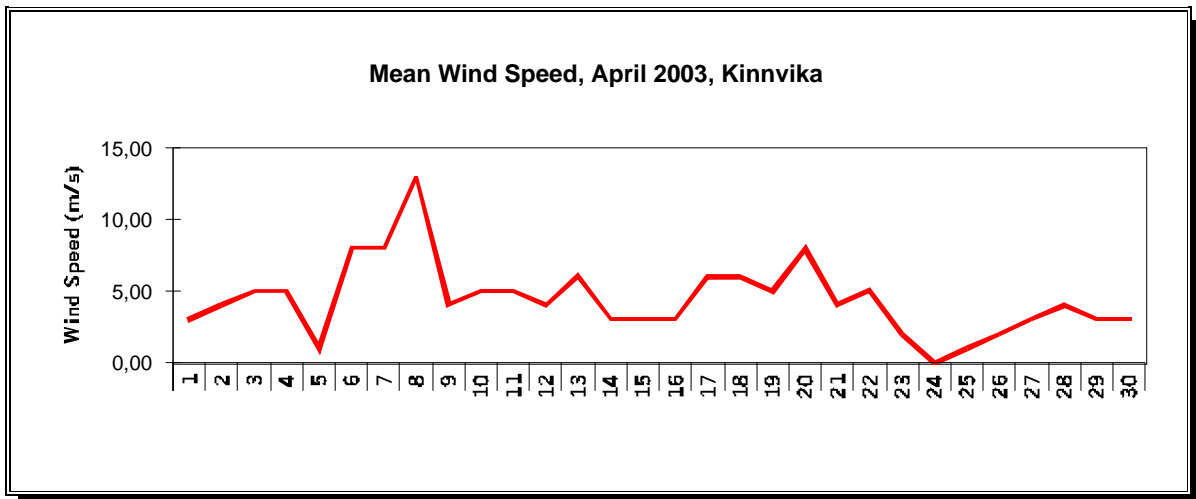
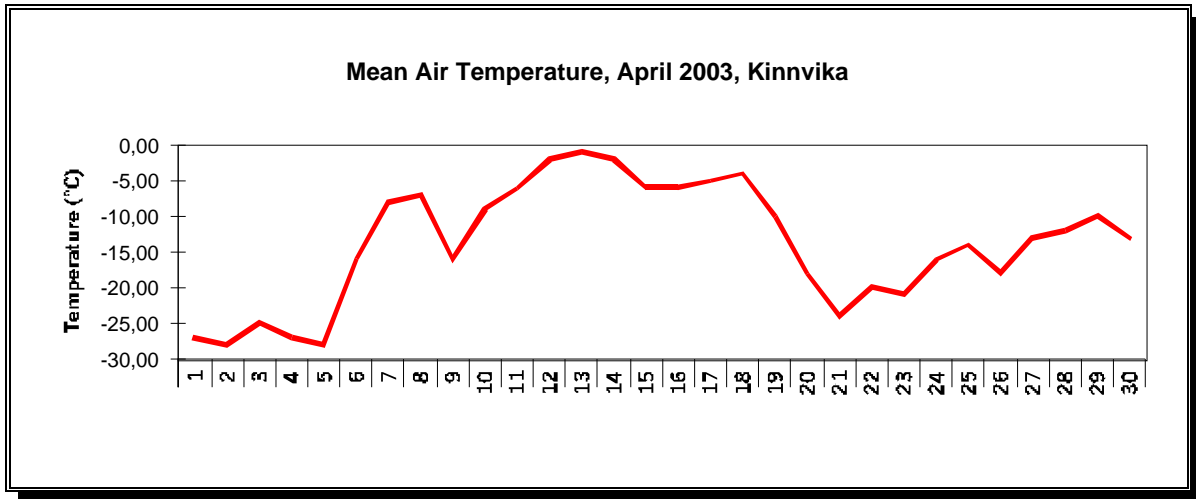
The water temperature was between 0°C and -1.7°C.

SEA ICE

Murchisonfjord and Hinlopen Straight was covered by ice all month. However, in the southern part of Hinlopen Straight, sometimes small spots and lanes of open water were visible. On Hinlopen Straight, particularly in the northern part, big ice bergs with a height of up to 10 metres were frozen into the fairly thin ice layer covering the sea.

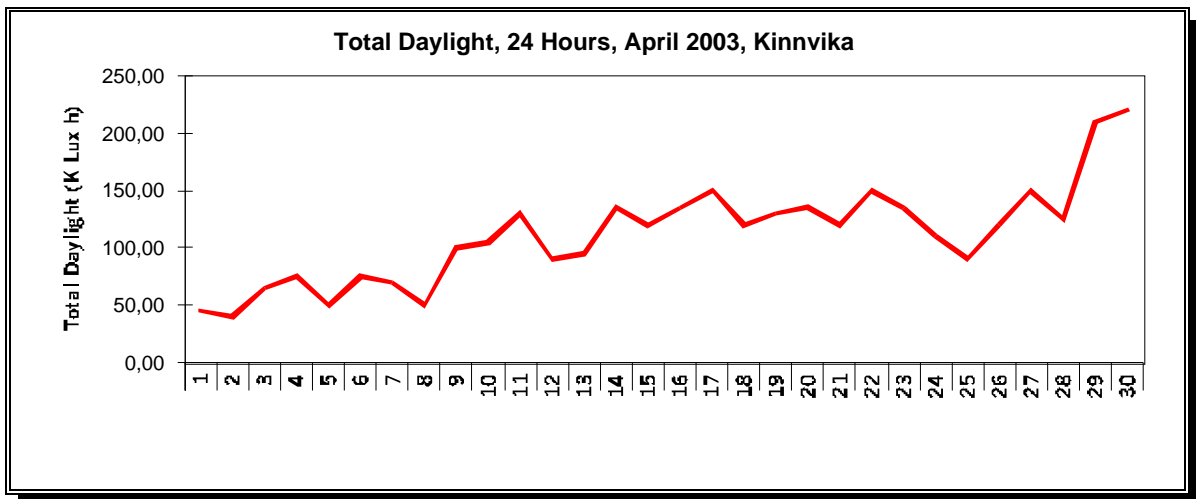
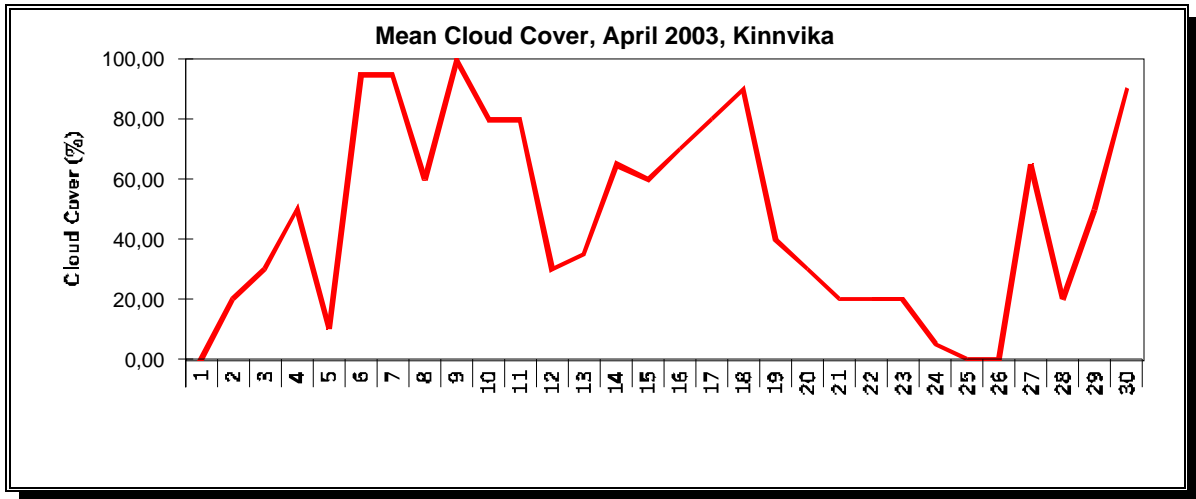
The water temperature under the ice layer close to the beach of Kinnvika seemed to vary, sometimes from day to day. Mostly the water temperature was warmer than -1.7°C. Therefore the ice layer seemed to rot from the underside.





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WEATHER DATA MAY 2003, KINNVIKA

TEMPERATURE

Mean Air Temperature	-5.2°C	
Max. Air Temperature	+3.1°C	on 27.5.03
Min. Air Temperature	-19.7°C	on 3.5.03

WIND

Mean Wind Speed	4.3 m/s	
Max Wind Speed	15.0 m/s	on 25.5.03
Main Wind Direction	Southerly, 30%	Northerly, 50%

AIR PRESSURE

Mean Air Pressure	1013 mb	
Max Air Pressure	1022 mb	on 18.5.03
Min Air Pressure	1001 mb	on 14.5.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	
Max Electric Field Strength	Instrumentation damaged.
Min Electric Field Strength	

DAYLIGHT

Mean Total Daylight	270 K Lux h	
Max Total Daylight	350 K Lux h	on 27.5.03

RAIN and SNOW

Within May snow fell on 18 days. On one day was drizzle observed. During snow fall a huge amount of snow covered the ground and strong winds heaped the snow up to a height of 5m. During warm temperatures and sunshine a little of the snow slowly evaporated but didn't melt. Due to very low values of air humidity, the bare ground beside the snow layers looked very dry. At the end of the month some few snow free regions were visible in the landscape.

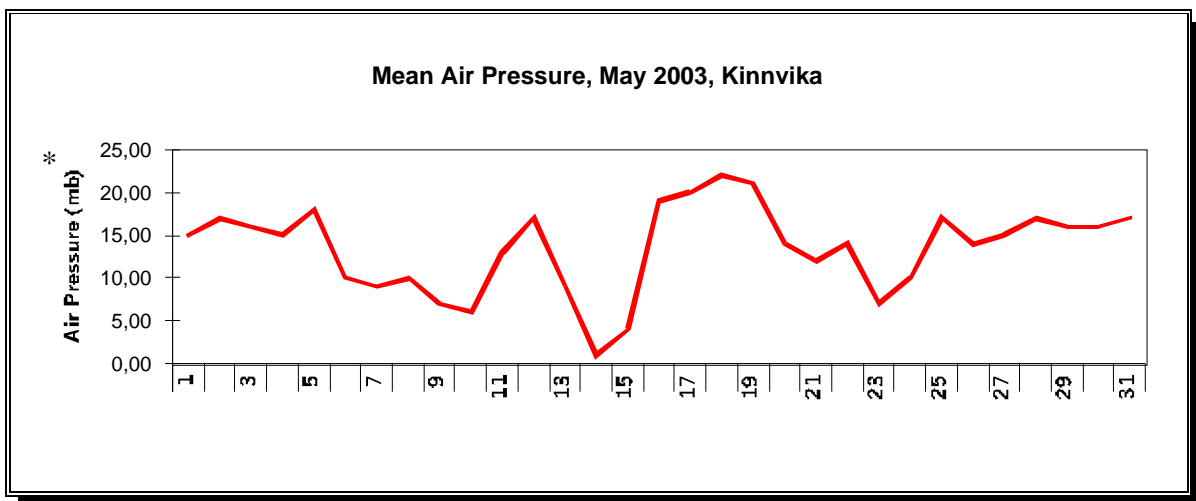
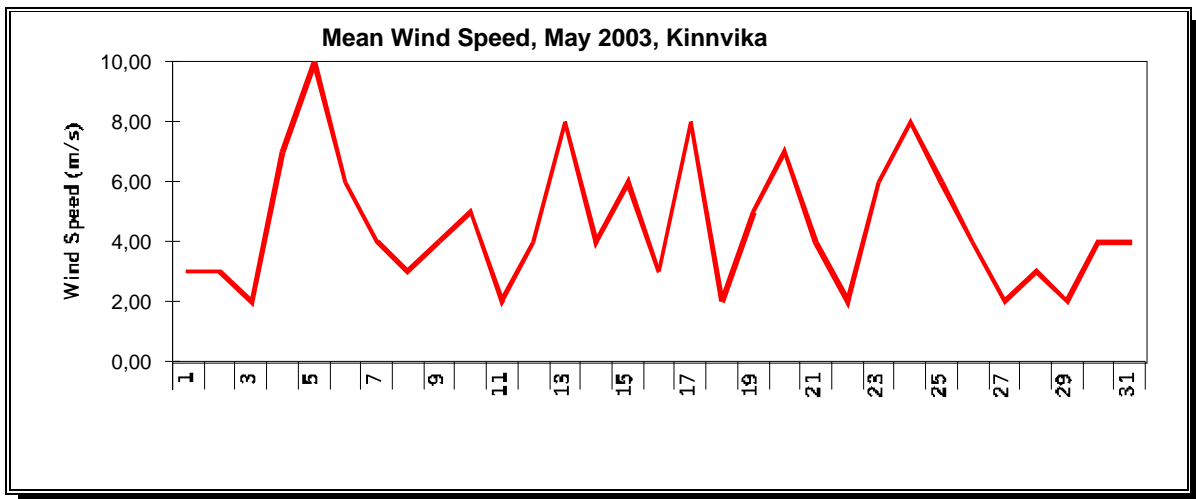
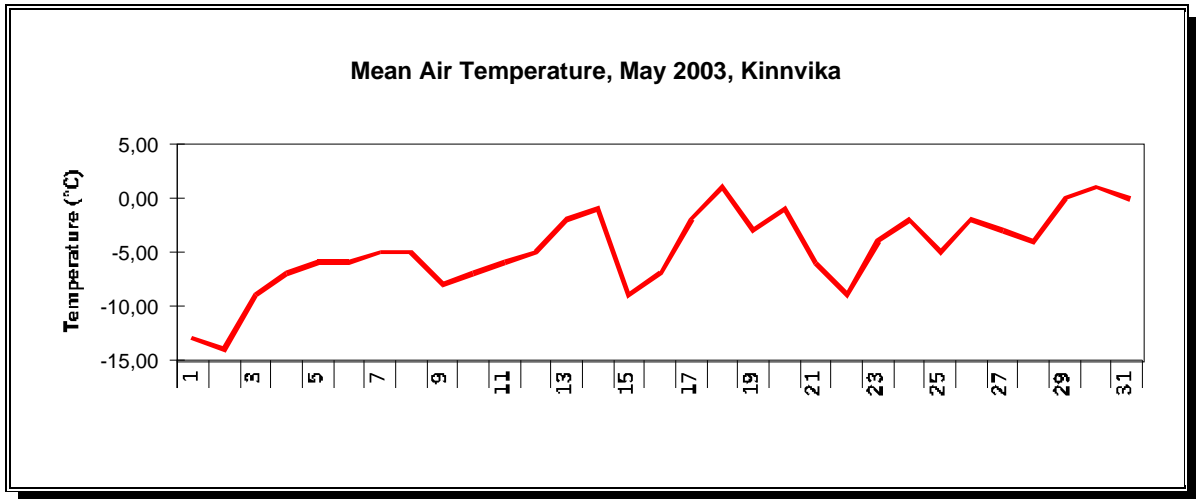
SEA WATER TEMPERATURE

The water temperature was between -1°C and -1.8°C. Occasionally the water temperature was measured as warm as 0°C. It seems that the ice layer starts to rot from the underside.

SEA ICE

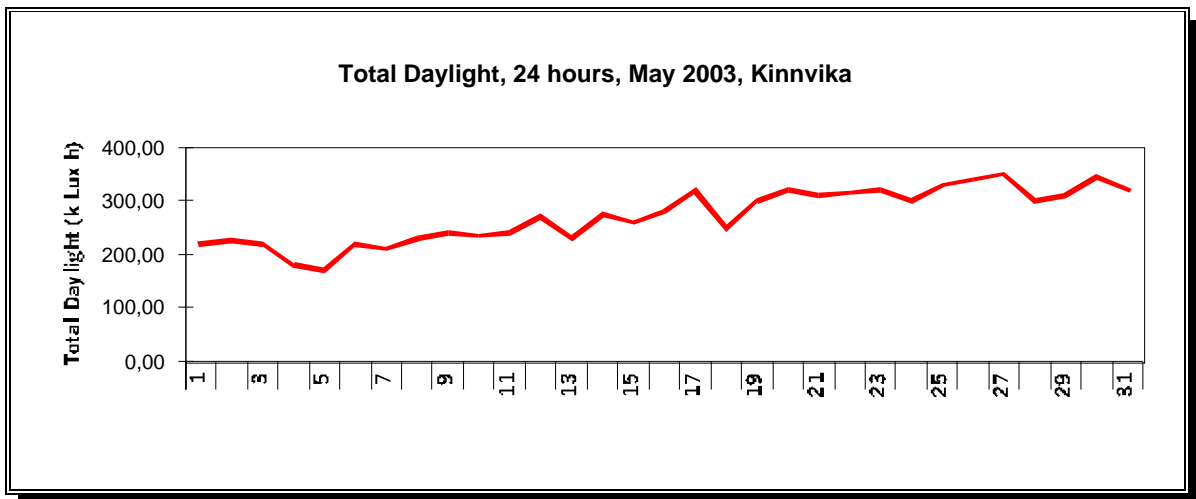
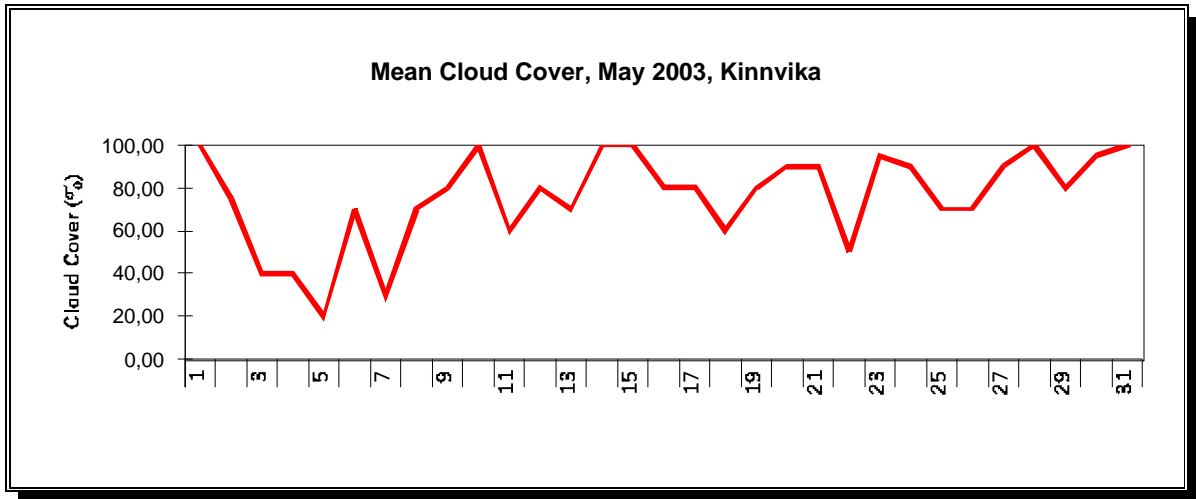
In the Kinnvika bay the sea ice layer was about 60cms in thickness. The ice layer covered the Kinnvika Bay and the whole Murchisonfjord. Some dark areas on the ice under the snow indicated that the ice started to rot. On Hinlopen Straight some open lanes and ice free areas were observed. However, dependent on the wind, huge icebergs and pack ice drifted backwards and forwards changing the situation almost daily.





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WEATHER DATA JUNE 2003, KINNVIKA

TEMPERATURE

Mean Air Temperature	+1.2°C	
Max. Air Temperature	+8.0°C	on 19.6.03
Min. Air Temperature	-6.8°C	on 9.6.03

WIND

Mean Wind Speed	4.1 m/s	
Max Wind Speed	12.0 m/s	on 21.6.03
Main Wind Direction	Southerly, 33%	Northerly, 48%

AIR PRESSURE

Mean Air Pressure	1011 mb	
Max Air Pressure	1021 mb	on 3.6.03
Min Air Pressure	1000 mb	on 28.6.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	
Max Electric Field Strength	Instrumentation damaged.
Min Electric Field Strength	

DAYLIGHT

Mean Total Daylight	375 K Lux h	
Max Total Daylight	440 K Lux h	on 21.6.03

RAIN and SNOW

Within June on two days rain was observed. On twelve days snow fell. the amount of snow was heavy on 12.6.03. The snow layer sublimated strongly in the sun. Since mid June the snow additionally melted and some melt water lay on the ground. At the end of June about 50% of the ground surface was free of snow. However on some locations, snow hills with a height of up to 2m remained.

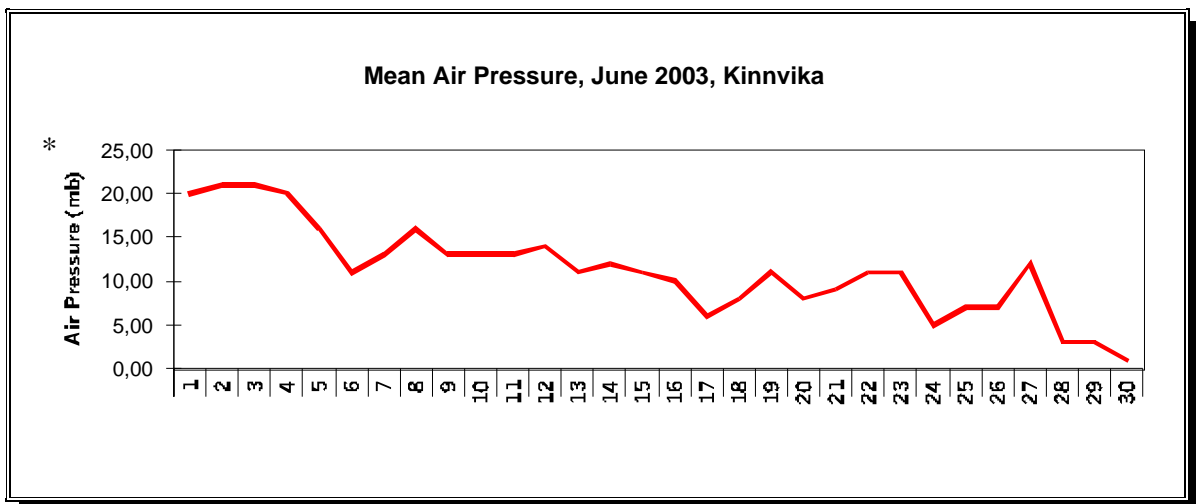
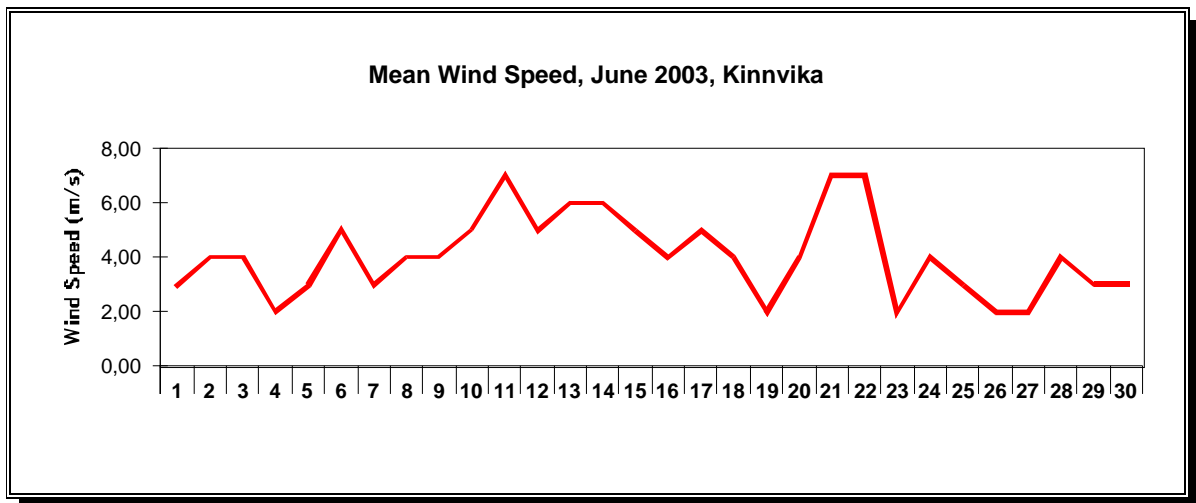
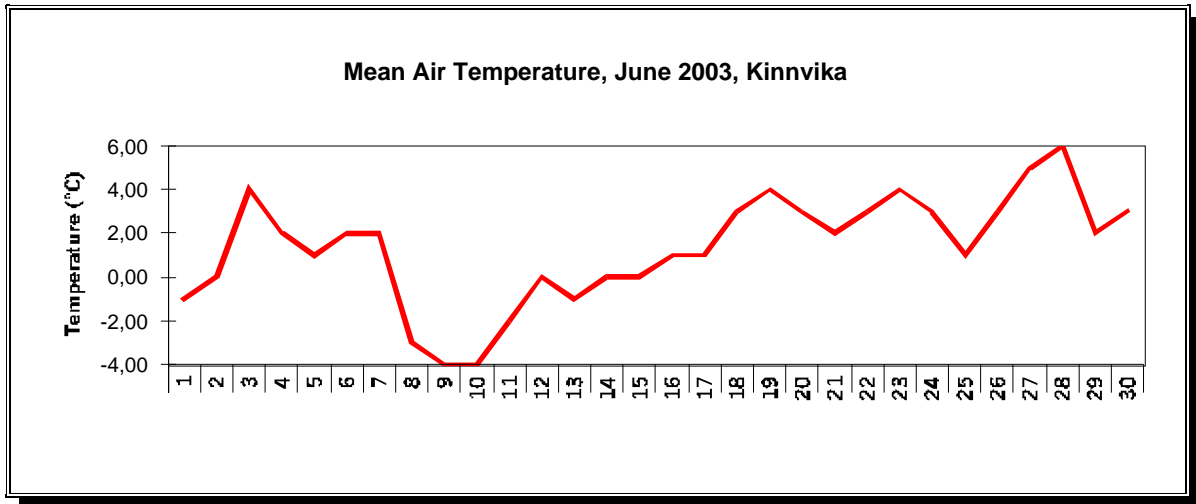
SEA WATER TEMPERATURE

The water temperature rose slowly from -1.7°C at the beginning of June to +0.2°C at the end of June.

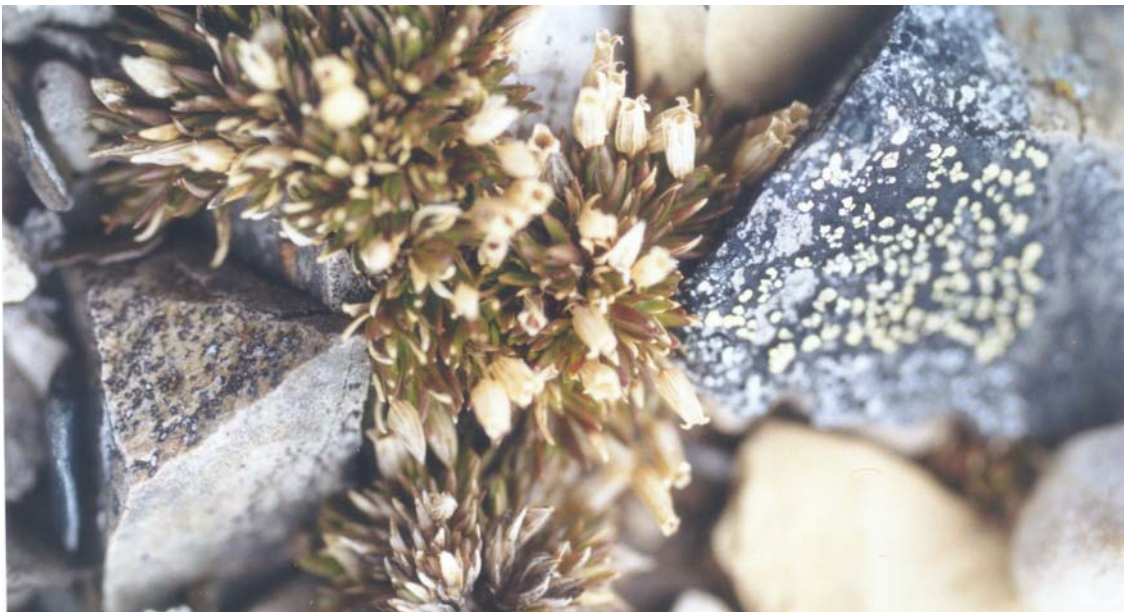
SEA ICE

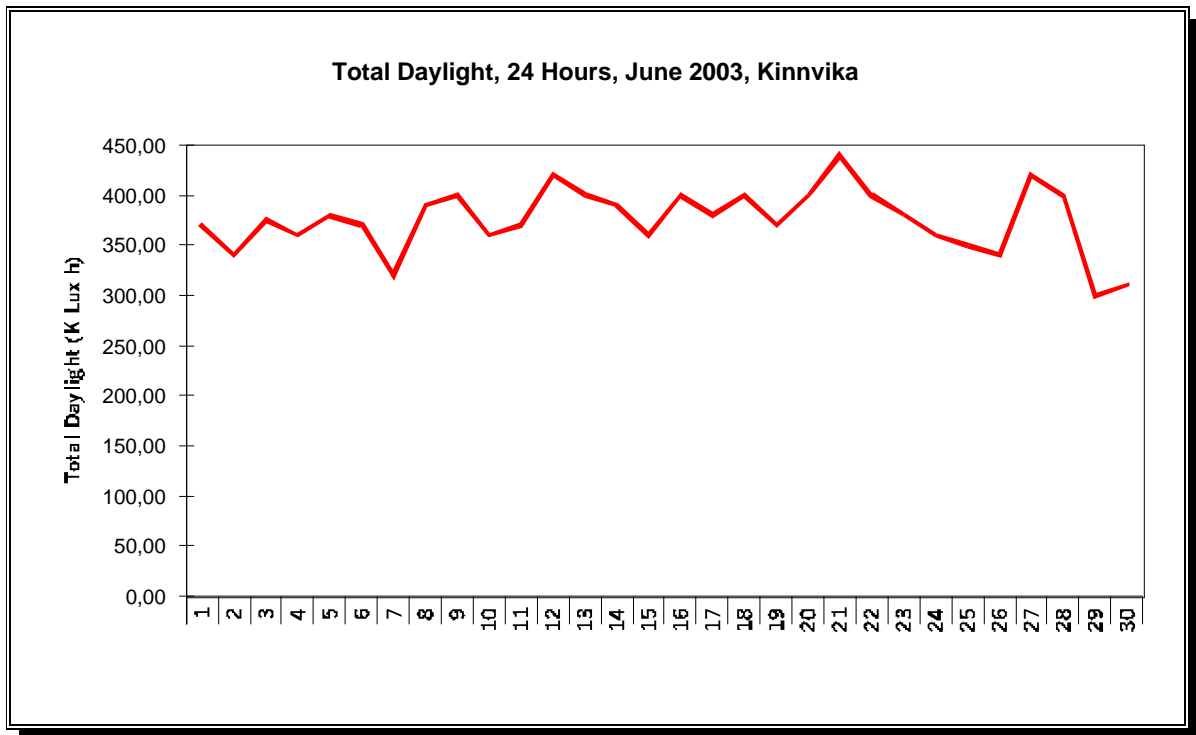
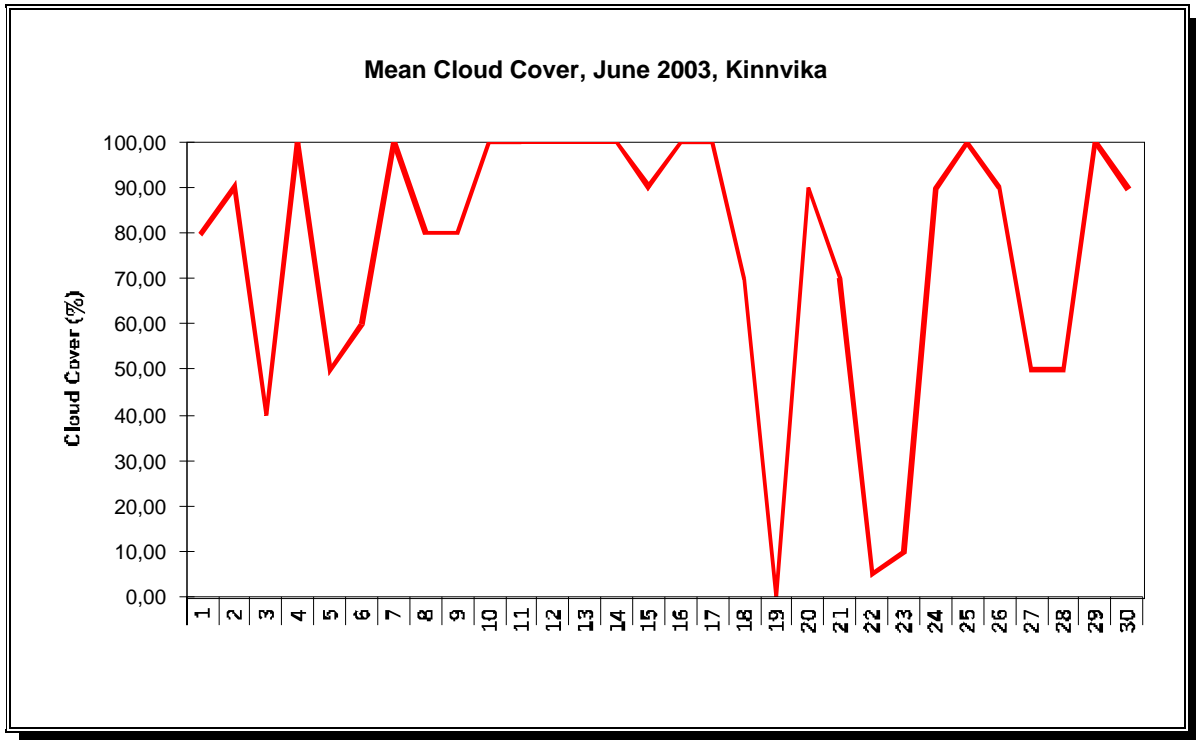
The surface of the sea ice on the Murchisonfjord started to melt at the beginning of June. Some grey areas and some surface water became visible. However the thickness of the ice was, even at the end of June, still strong with a thickness of up to 1m. The sea ice seems to melt not only from the surface in the sunlight, but additionally, to rot from the underside because the temperature of the sea water was above it's freezing point of about -1.8°C. At the end of June the inner Murchisonfjord and Kinnvika Bay was covered by thick, solid ice with some cracks. The Hinlopen Straight was nearly totally covered by heavy drifting icebergs. At the end of June the sweet water lakes were partly open but large ice floes still remained.





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WEATHER DATA JULY 2003, KINNVIKA

TEMPERATURE

Mean Air Temperature	+3.6°C	
Max. Air Temperature	+9.4°C	on 23.7.03
Min. Air Temperature	-1.1°C	on 4.7.03

WIND

Mean Wind Speed	4.1 m/s	
Max Wind Speed	17.0 m/s	on 10.7.03
Main Wind Direction	Southerly, 55%	Northerly, 40%

AIR PRESSURE

Mean Air Pressure	1004 mb	
Max Air Pressure	1013 mb	on 12.7.03
Min Air Pressure	991 mb	on 31.7.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	
Max Electric Field Strength	Instrumentation damaged.
Min Electric Field Strength	

DAYLIGHT

Mean Total Daylight	210 K Lux h	
Max Total Daylight	350 K Lux h	on 6.7.03

The measured daylight is (in all other months too) strongly dependent on the cloud cover and the cloud formation. For example, during thick fog, a higher value of daylight was measured than during clear sky periods.

RAIN and SNOW

Within July, on five days rain and on two days snow fall was observed. The amount, however, was very small. At the end of July the ground was very dry. Small ponds of sweet water were almost all drained away.

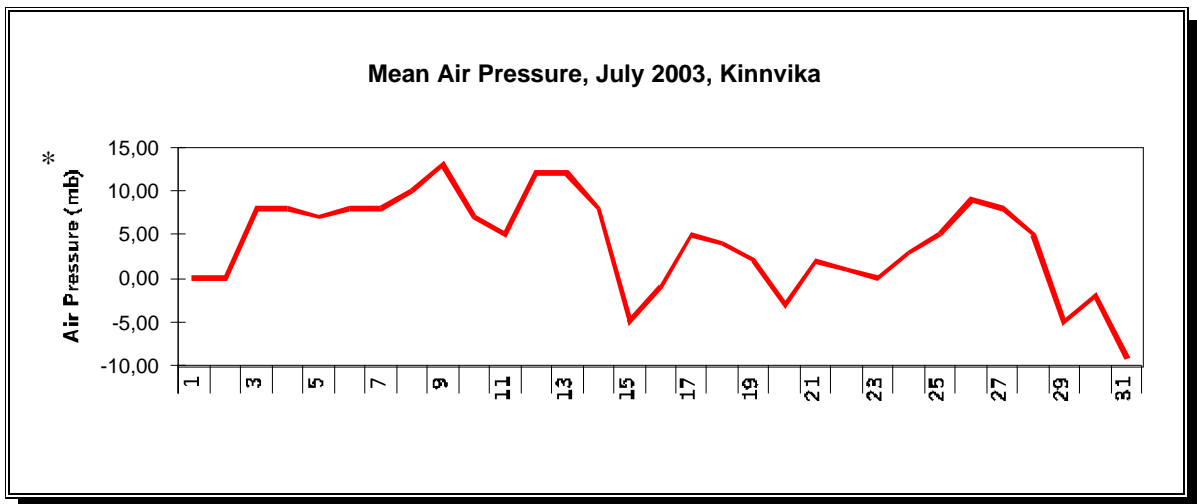
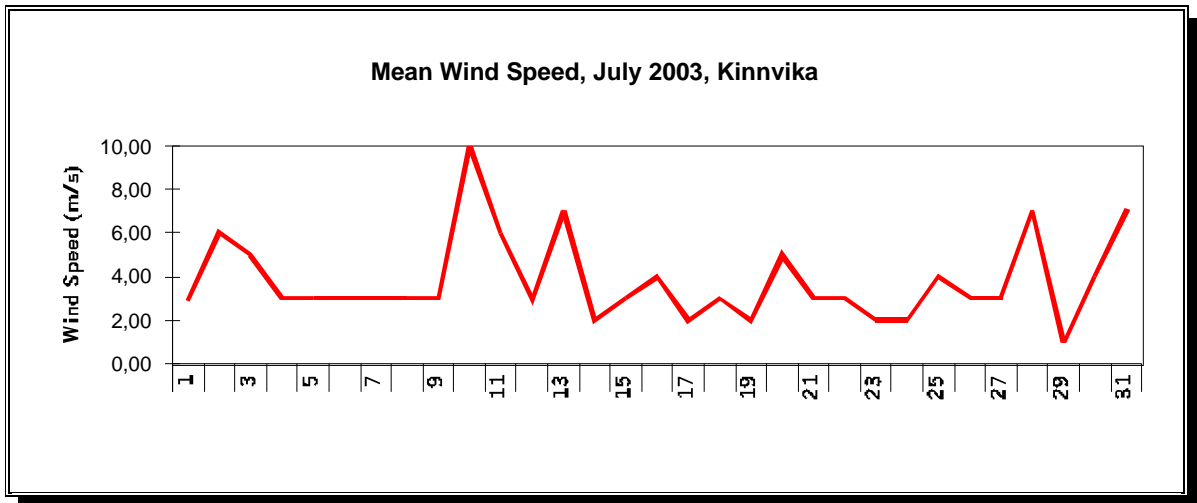
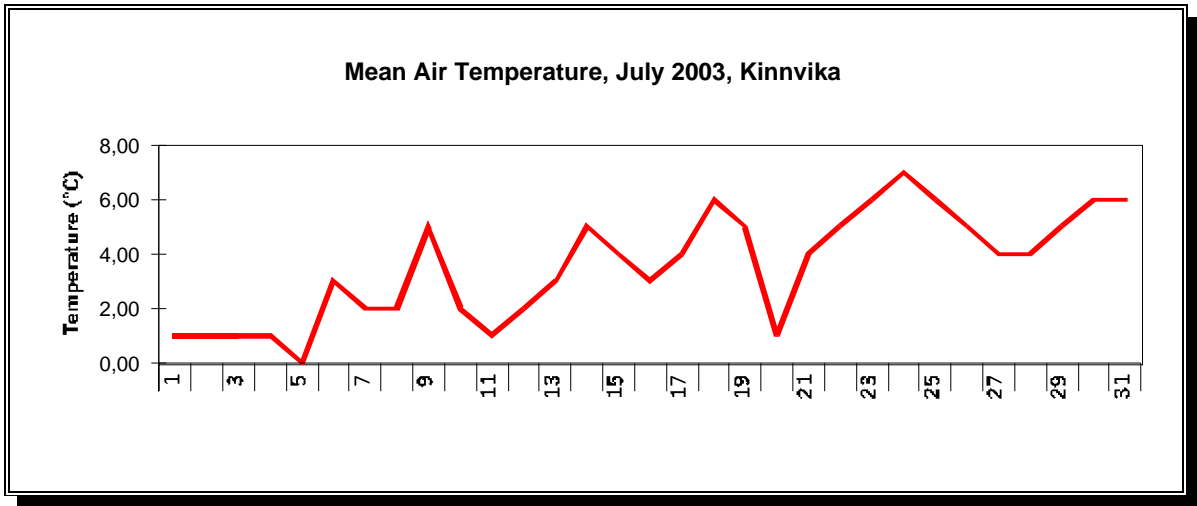
SEA WATER TEMPERATURE

The sea water under the ice layer showed temperatures of between -1°C and -1.5°C.

SEA ICE

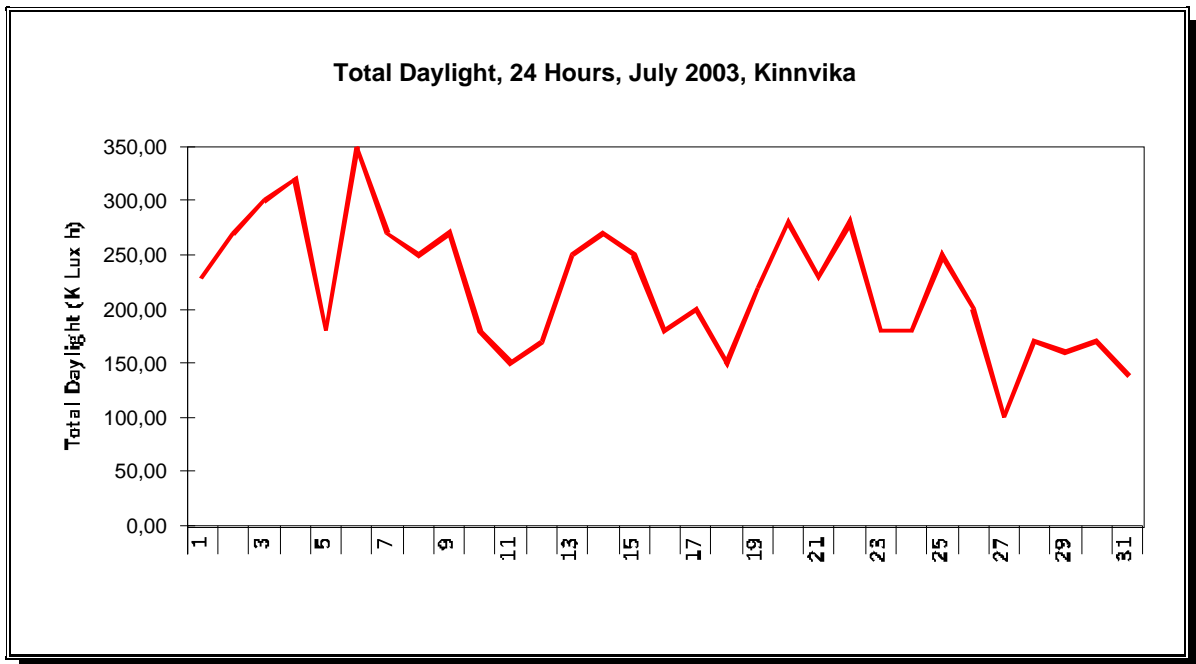
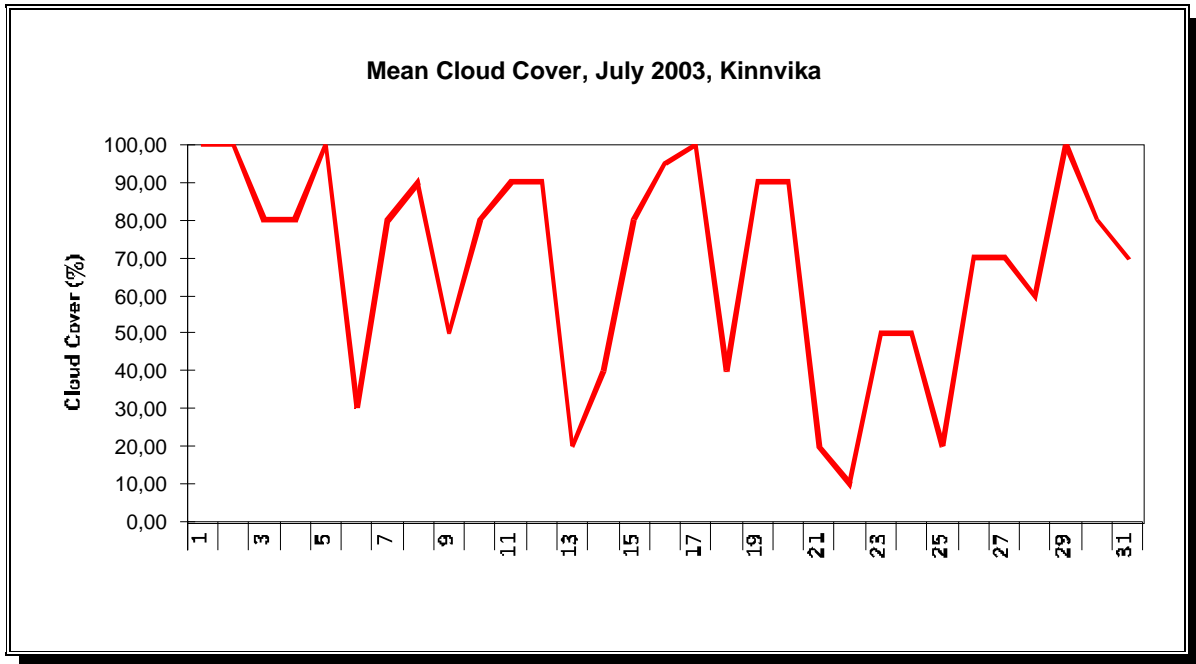
In the beginning of July Murchisonfjord and Hinlopen Strait were almost completely covered by ice. Even at the end of July, huge ice flows, loose pack ice and small icebergs dependent on wind and current, covered more or less the above mentioned areas. All small sweet water lakes were, at the end of July, completely free of ice.





* : +1000







WEATHER DATA AUGUST 2003, KINNVIKA
(1st August 2003 until 20th August 2003)

TEMPERATURE

Mean Air Temperature	+5.1°C	
Max. Air Temperature	+9.5°C	on 15.8.03
Min. Air Temperature	-0.6°C	on 2.8.03

WIND

Mean Wind Speed	4.9 m/s	
Max Wind Speed	15.0 m/s	on 10.8.03
Main Wind Direction	Southerly, 75%	Northerly, 15%

AIR PRESSURE

Mean Air Pressure	1005 mb	
Max Air Pressure	1014 mb	on 9.8.03
Min Air Pressure	989 mb	on 1.8.03

ELECTRIC FIELD STRENGTH

Mean Electric Field Strength	
Max Electric Field Strength	Instrumentation damaged.
Min Electric Field Strength	

DAYLIGHT

Mean Total Daylight	125 K Lux h	
Max Total Daylight	180 K Lux h	on 1.8.03

The measured daylight is (in all other months too) strongly dependent on the cloud cover and the cloud formation. For example, during thick fog, a higher value of daylight was measured than during clear sky periods.

RAIN and SNOW

Within August, on two days rain fell. The amount of rain was small. Snow fall was not observed.

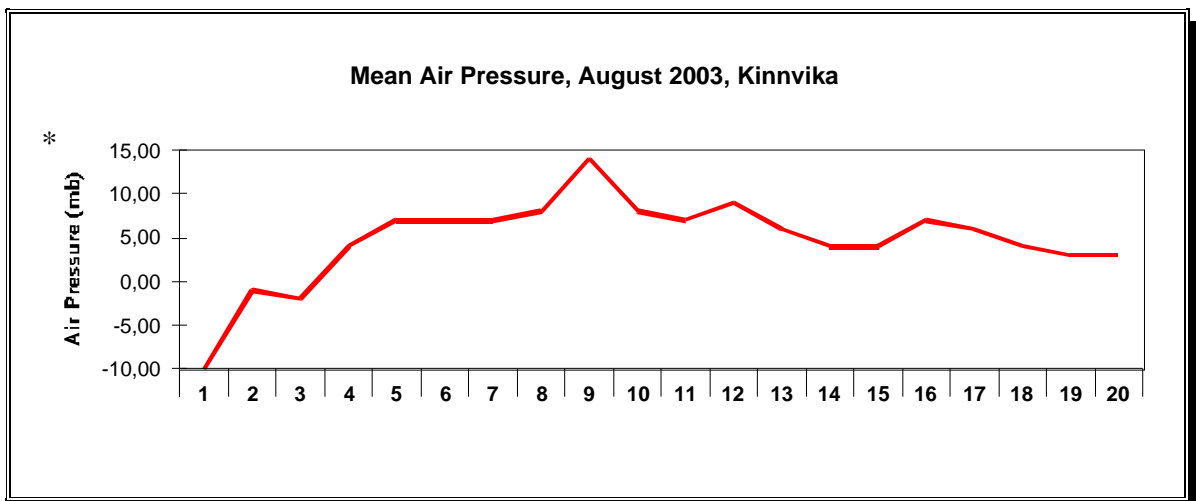
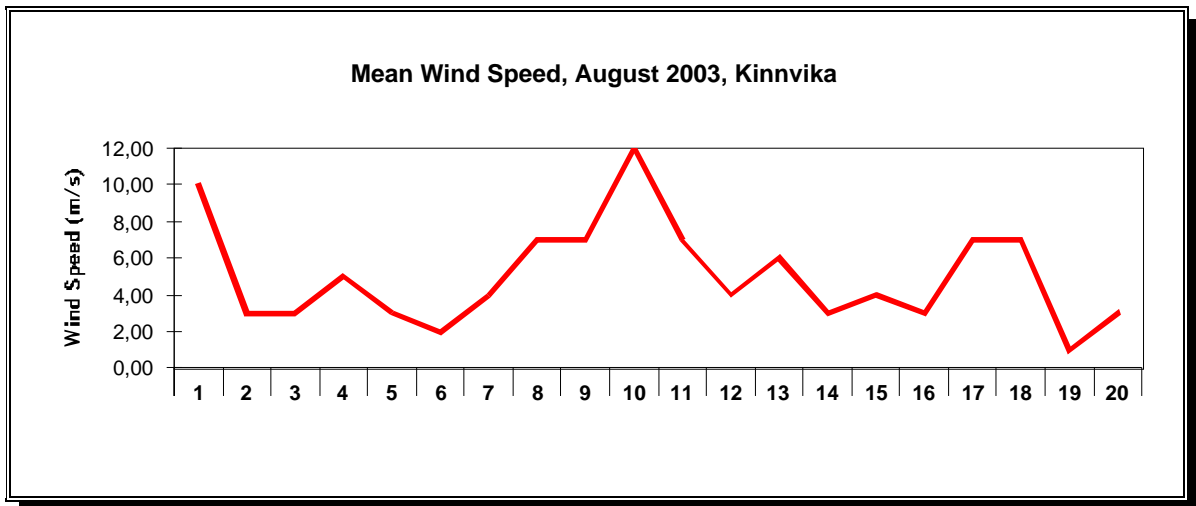
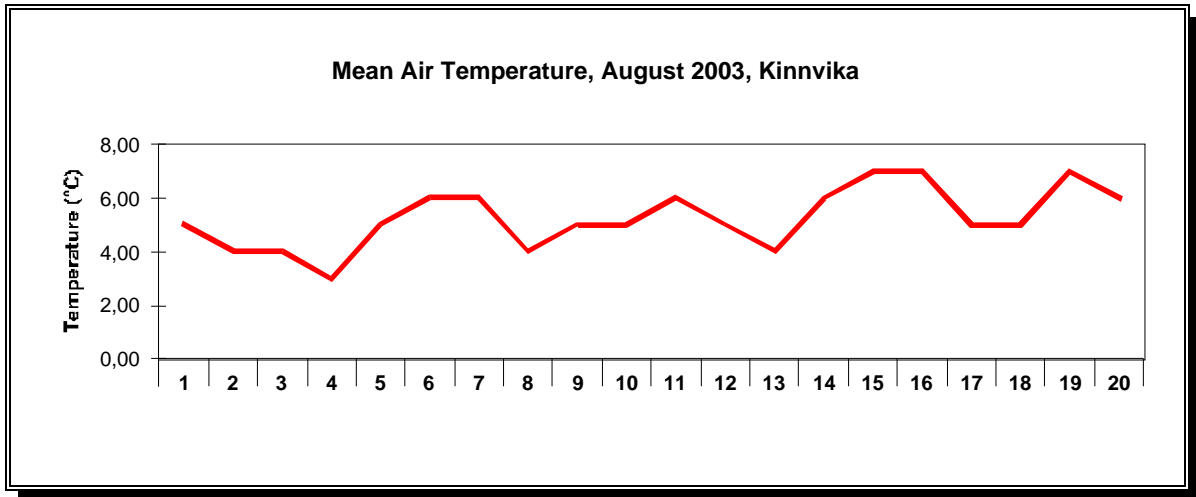
SEA WATER TEMPERATURE

In the beginning of August the temperature was about +1°C. After the ice had gone, the temperature rose to +2°C.

SEA ICE

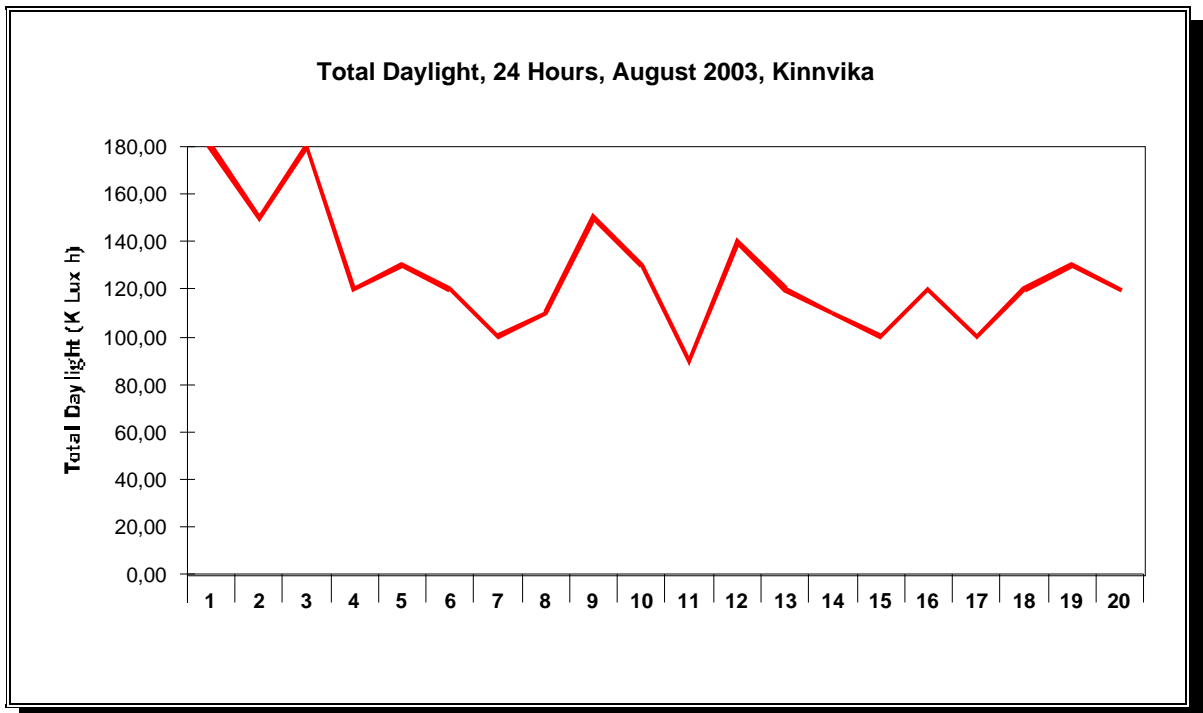
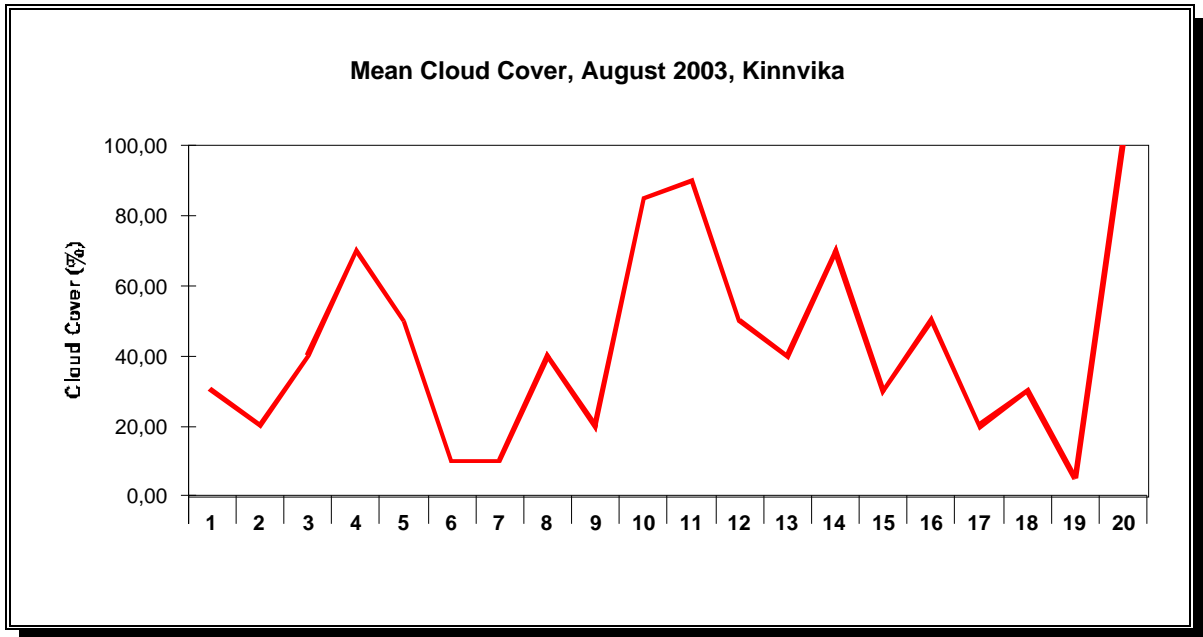
In the beginning of August Murchisonfjord and Hinlopen Strait were more or less still covered by rotten ice. From 5th August the sea ice drifted slowly away. Since 7th August Murchisonfjord as well as Hinlopen Strait were, and stayed, almost free of ice.



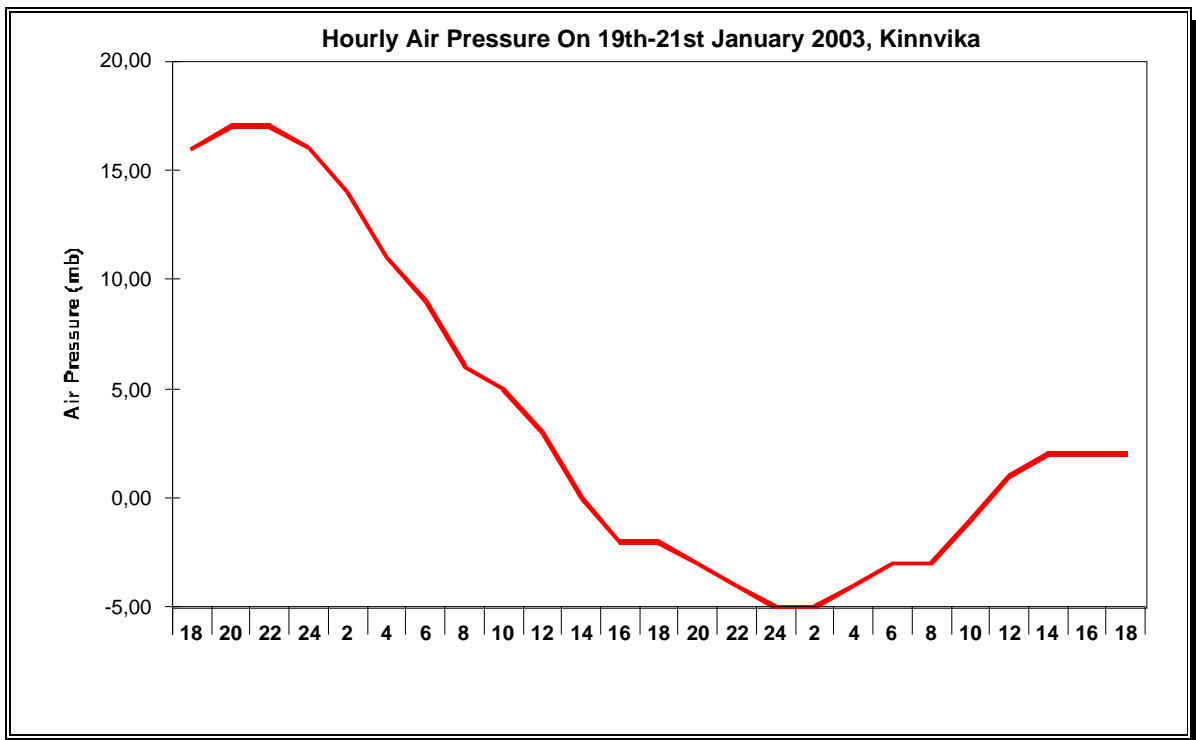
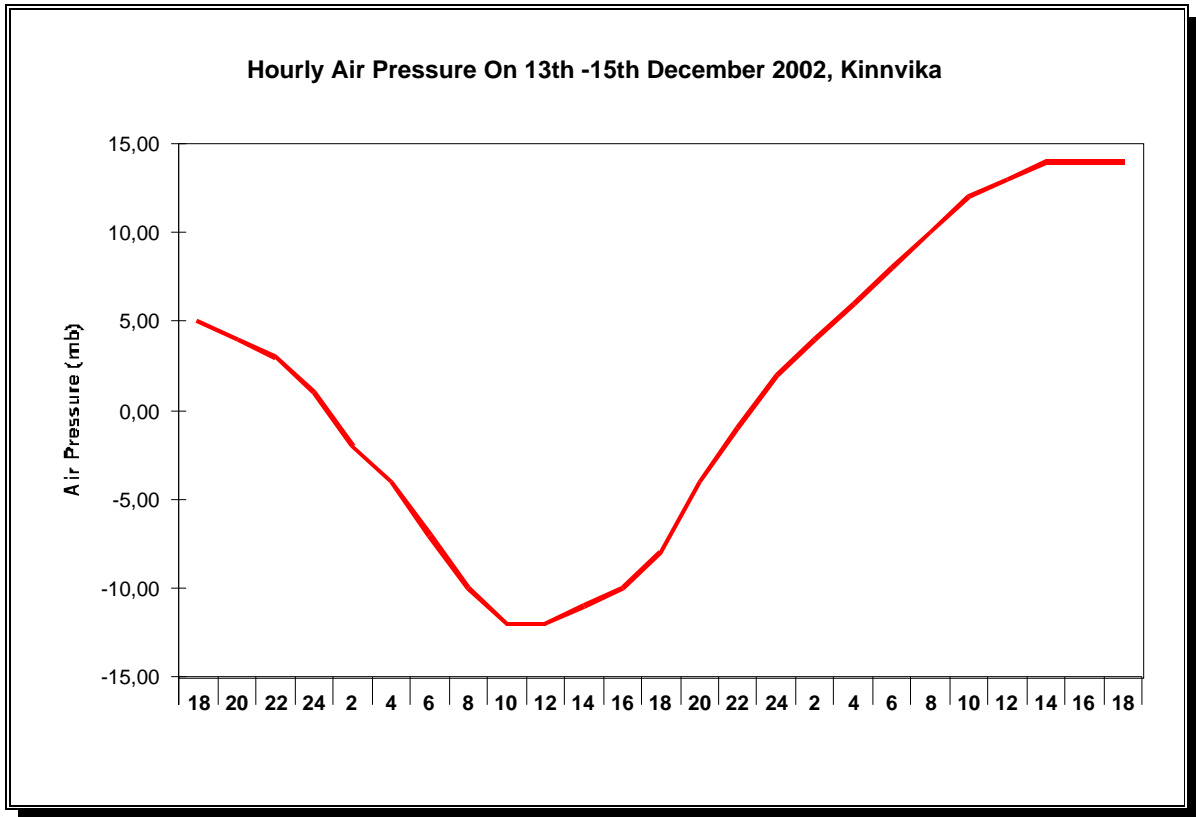


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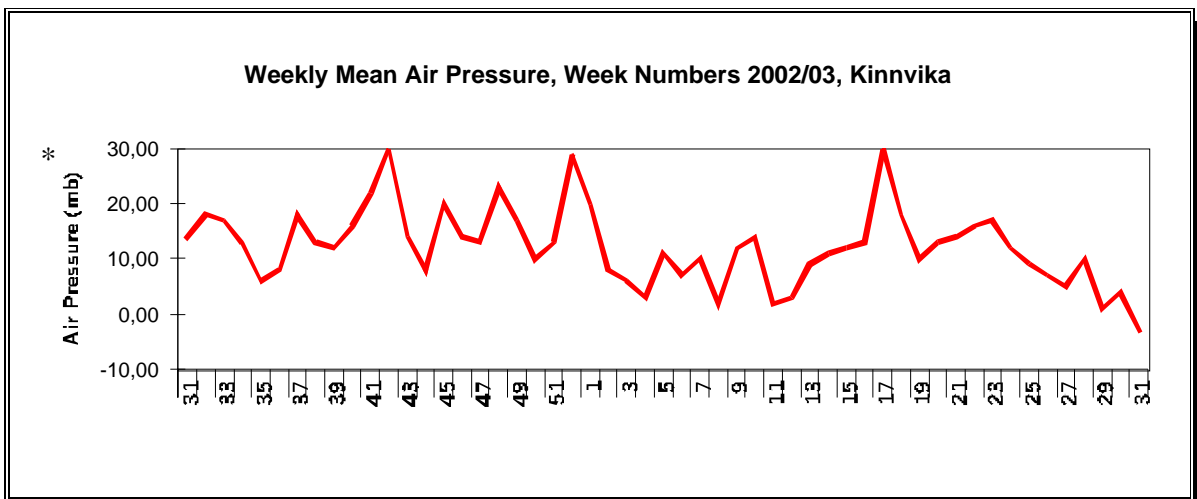
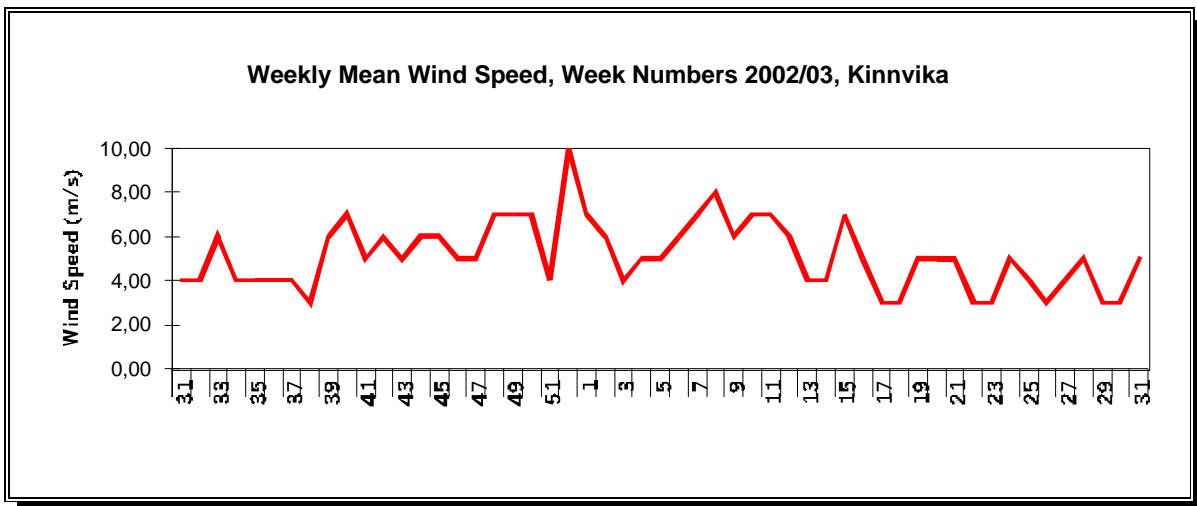
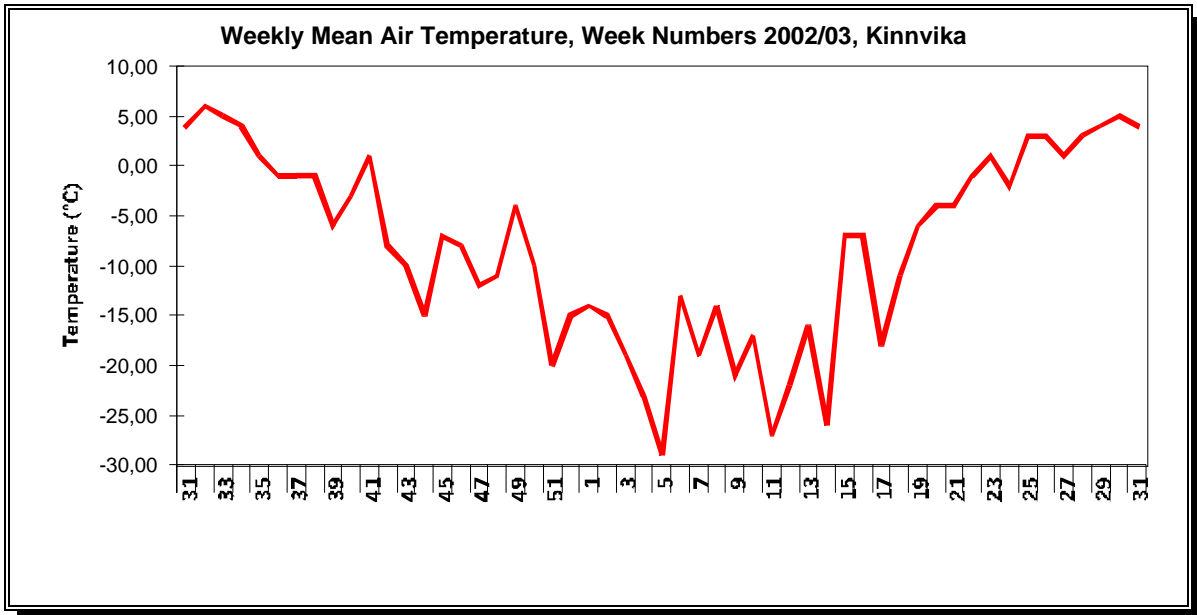




The air pressure on Nordaustland was found to change very quickly. Sometimes within a few hours the pressure values rose or dropped over a range of many mb.

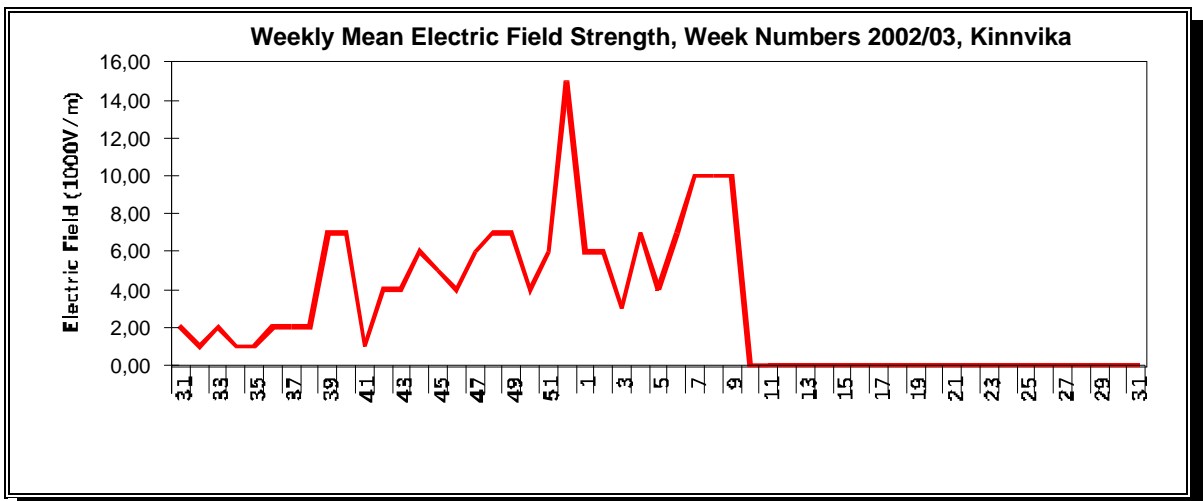
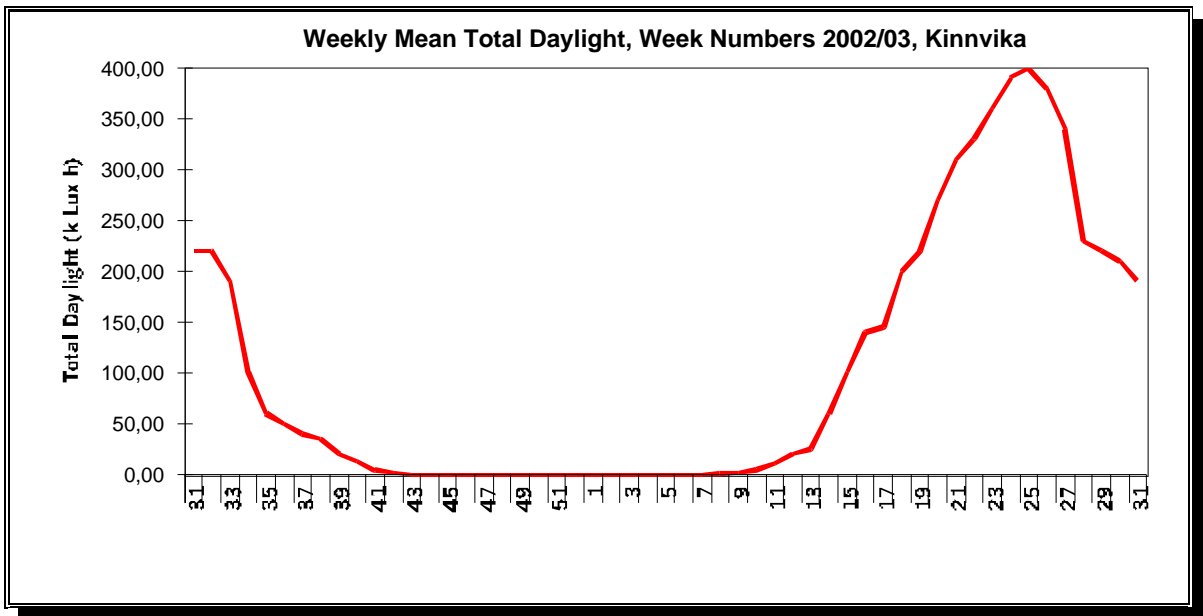
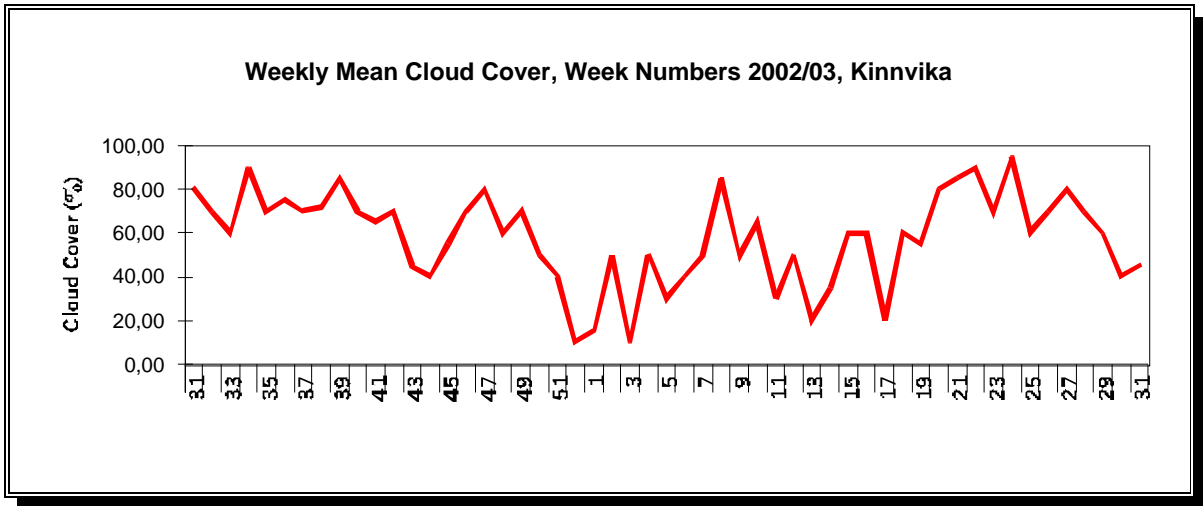
Shown are some typical examples taken in December 2002 and January 2003.





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Comparison of Weather Data from Different Years and Locations

Monthly Mean Air Temperatures (°C)

Year, Location	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1872/73 Mosselbukta	+2.9	-3.9	-12.7	-8.1	-14.4	-9.9	-22.7	-17.6	-18.1	-8.3	+1.1	+4.6
1899/1900 Sorgfjord	+2.1	+0.3	-10.5	-13.9	-11.9	-8.5	-22.6	-27.0	-16.5	-9.6	-1.1	+1.2
1957/58 Kinnvika	+3.7	-0.1	-0.9	-8.0	-14.4	-11.2	-15.8	-18.2	-13.6	-4.3	-0.3	+2.3
1958/59 Kinnvika	+1.1	-3.4	-8.4	-13.2	-18.5	-23.6	-20.5	-22.1	-13.5	-6.0	-0.5	+1.9
2002/03 Kinnvika	+3.7	-2.0	-8.1	-10.6	-12.4	-22.1	-15.8	-23.2	-13.7	-5.2	+1.2	+3.6

Monthly Mean Wind Speed (m/s)

Year, Location	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1957/58 Kinnvika	4.9	5.0	9.1	8.6	6.3	7.4	6.3	5.7	4.1	6.2	4.3	4.3
1958/59 Kinnvika	5.2	4.8	5.9	6.8	5.6	3.4	7.5	4.8	4.3	4.5	4.2	4.1
2002/03 Kinnvika.....	4.1	4.6	5.5	5.7	7.1	5.1	7.0	6.0	4.3	4.3	4.1	3.7

Highest and Lowest Air Temperatures (°C)

Year, Location	Highest Temp.	Date	Lowest Temp.	Date
1872/73 Mosselbukta	+12.8	July 1872	-38.2	February 1873
1899/1900 Sorgfjord	+8.4	September 1899	-40.1	March 1900
1957/58 Kinnvika	+9.1	August 1957	-31.6	March 1958
1958/59 Kinnvika	+8.5	July 1959	-40.3	March 1959
2002/03 Kinnvika	+9.5	August 2002 August 2003	-35.5	March 2003

1872/73	Mosselbukta	Expedition A. E. Nordenskiöld
1899/1900	Sorgfjord	Arc of the Meridian Expedition
1957/58	Kinnvika	Swedish/Finnish Expedition
1958/59	Kinnvika	Swedish/Finnish Expedition
2002/03	Kinnvika	TUHH Expedition



5 MICROCLIMATE

5.1 Observations

Besides the weather data in Kinnvika the microclimate is of importance for the growth and melting of ice as for the development of the vegetation. The local temperature is one of the most important parameters describing microclimate. Therefore various electronic data loggers were prepared to measure automatically the temperature within a whole year.

The data loggers used record automatically the temperature every six hours with an accuracy of 0.1°C. To make possible a direct comparison between the microclimate in different regions of Svalbard, a total of six data loggers were placed at various locations. All data loggers were activated on 1st August 2002. They recorded the temperatures until 1st August 2003 in the air and besides this, 1cm below ground level in soil.

The type of data logger used is: TESTSTOR 175 - Logger from Testo GmbH., Germany.

The various locations were:

1. **Longyearbyen** (Sjøområde, 5m a.s.l.)
2. **Revneset** (Adventfjord, circa 20m a.s.l.)
3. **Ny Ålesund**
4. **Kinnvika** (Air and soil)
5. **Kinnvika** (Air and fresh water lake)
6. **Kinnvika** (Air and sea water fjord)

Some of the data loggers were destroyed during the year by reindeer and polar bears.

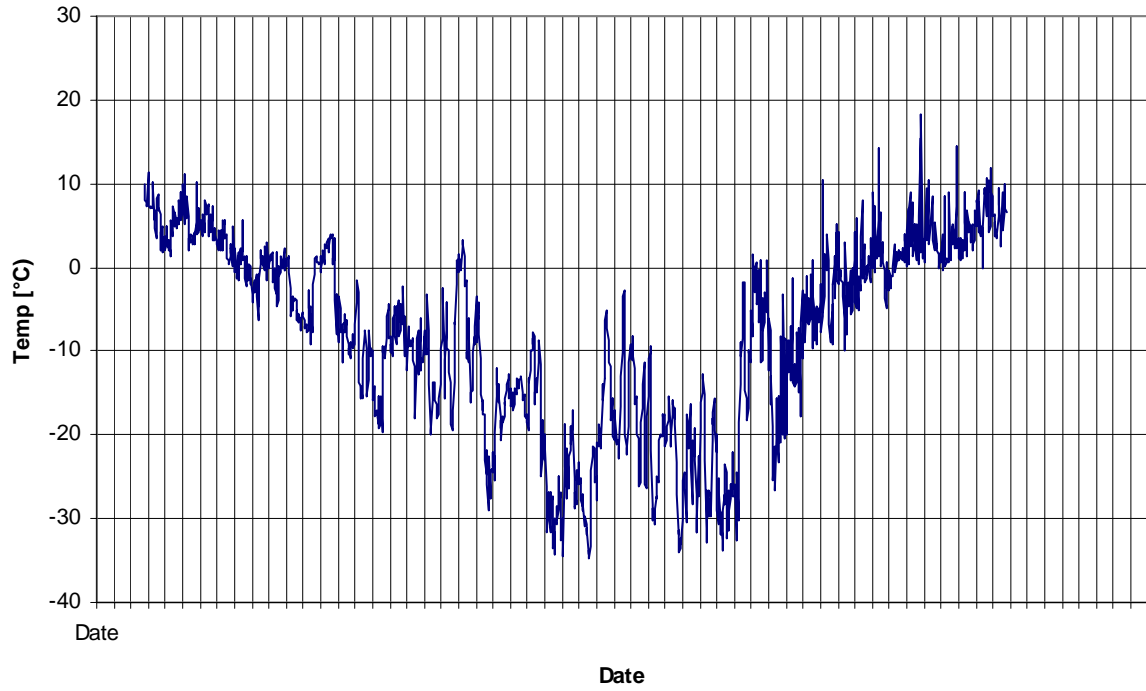
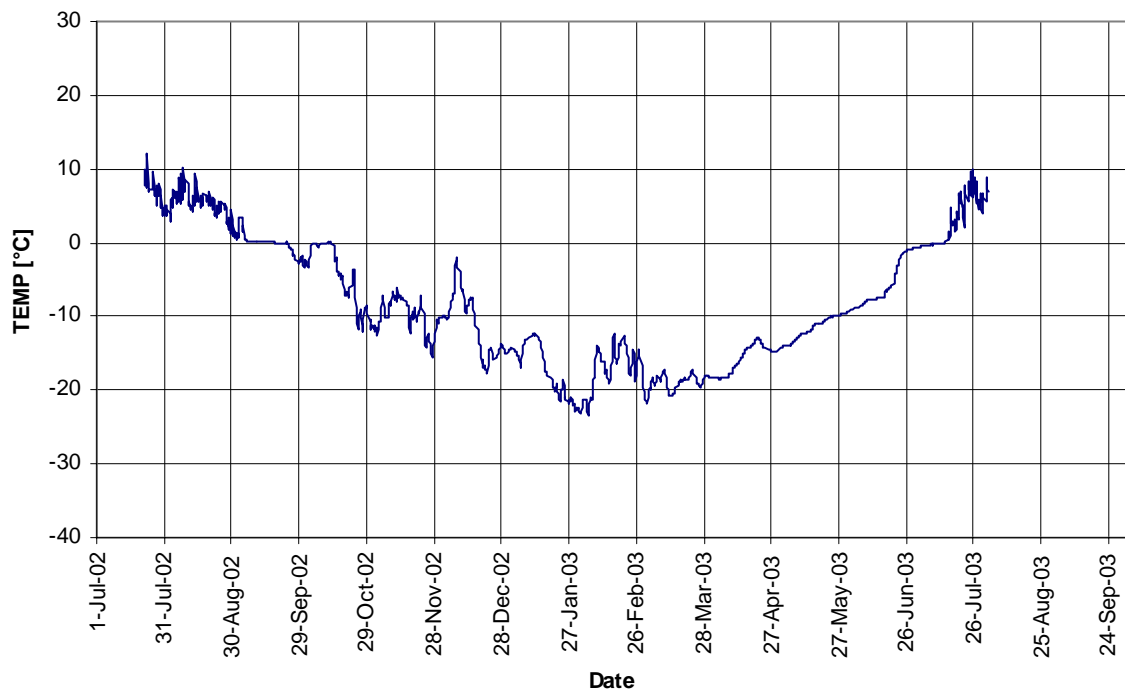
5.2 Conclusions

The temperature values were stored in the various data loggers during the course of a whole year. After the end of the expedition in August/September 2003, all data loggers were evaluated using a corresponding computer. Thereafter for all of the above mentioned locations, the corresponding temperature graphs were available and may be compared with each other.

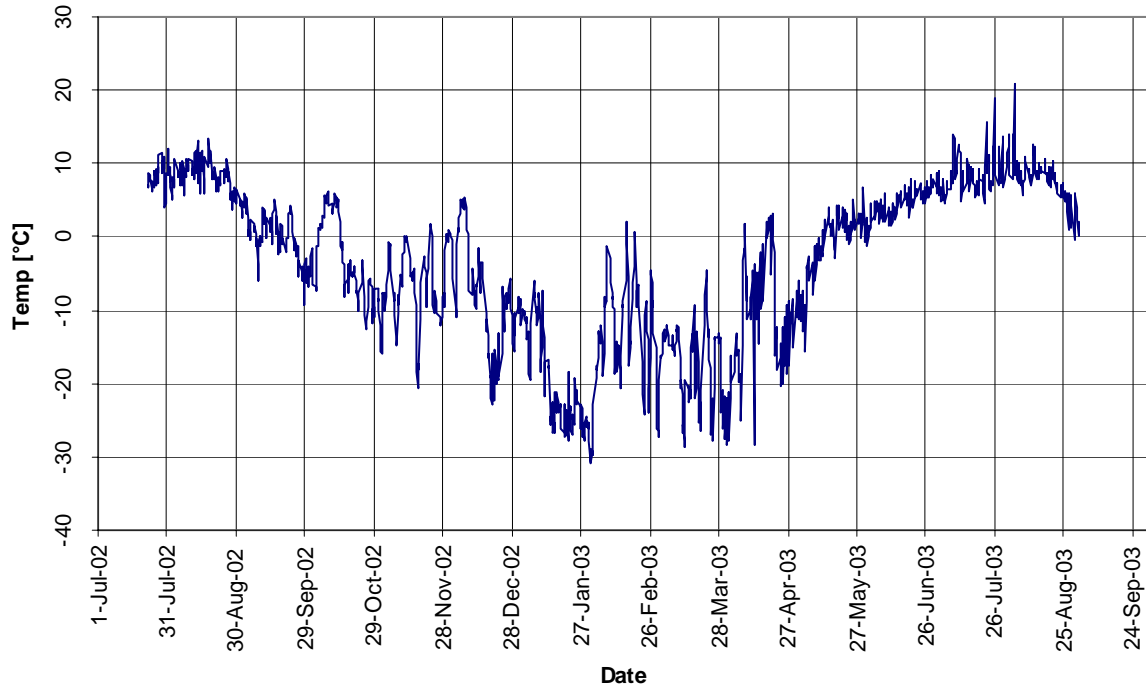
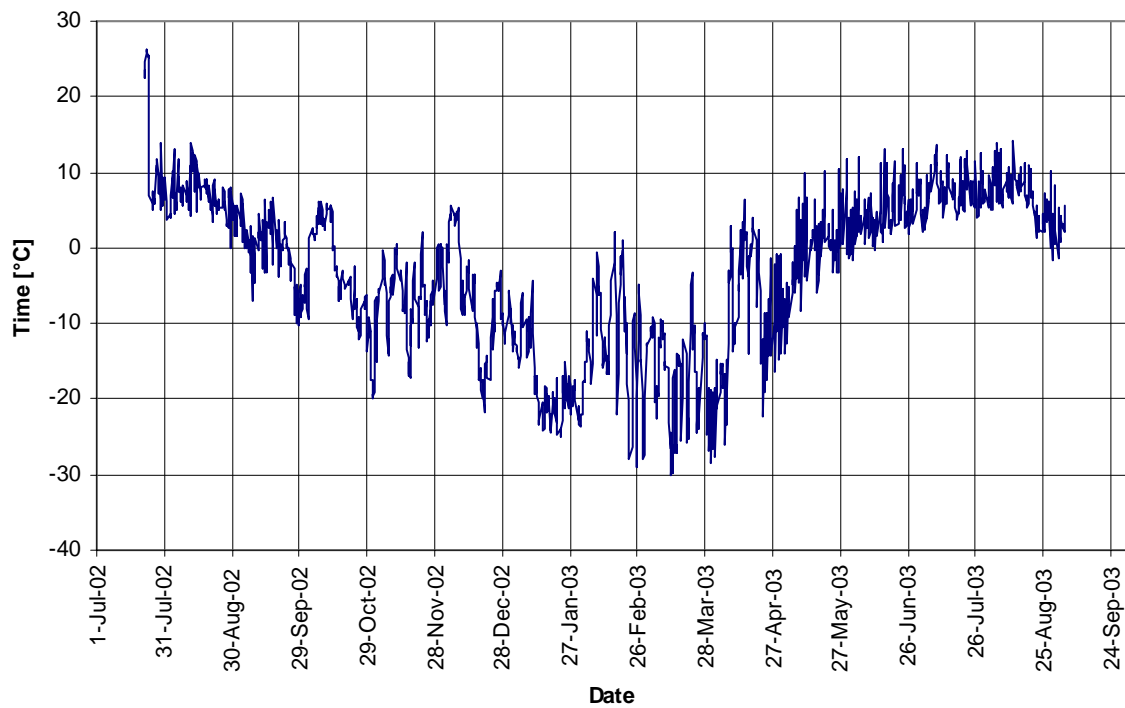
On the following pages some of the resulting graphs are shown.

The measured data of the microclimate may be compared with the status of the vegetation on Nordaustland which was documented regularly by many photos. (see section 10).



Temperature Graphs Recorded by Data Loggers at Kinnvika, 2002/03**Air****Ground**



Temperature Graphs Recorded by Data Loggers at Longyearbyen/Ny Ålesund, 2002/03**-Air-****Longyearbyen****Ny Alesund**



6 ICE

6.1 Observations

The first sea ice on the bay of Kinnvika was observed on 19th August 2002. After a long period of strong southerly winds, sea ice drifted from the south through Hinlopen Straight and reached Kinnvika. Huge pieces of pack ice sometimes blocked the whole Murchisonfjord. After the 28th August 2002, this sea ice was melted or drifted away. Thereafter the whole Murchisonfjord was free of ice until 25th October 2002. In September 2002 the water temperature dropped sometimes for some hours down to about -2°C. Then the surface of the sea water close to the strand of Kinnvika was covered by a layer of ice crystals.

On the narrow side arm of Murchisonfjord, “Tvillingvika” already since 4th October 2002 an ice layer had started to grow. The little fresh water lakes close to Kinnvika had been covered by ice since 17th September 2002. Finally since 4th November 2002 the bay of Kinnvika was frozen. The ice thickness grew and on 30th November 2002 it was about 50cms. In the beginning of December 2002 parts of the total Murchisonfjord seemed to be frozen. Hinlopen Straight seemed to be still open sea water until January 2003. Since the end of February 2003 even on Hinlopen Straight an ice layer existed interrupted by some huge icebergs, open lanes and wakes.

When strong winds and, simultaneously, tidal high water occurred, sometimes the ice layer on the bay of Kinnvika cracked and sea water was forced up onto the ice surface. Since the middle of March 2003, a snow layer of approximately 10-40cms covered the ice surface. By wind and current, some ice floes were piled up into small ice barriers with a height of less than one metre. In the northern part of Hinlopen Straight, such ice barriers seemed to grow much stronger to heights of several metres.

In the end of May 2003, the ice as well as on Murchisonfjord as on Hinlopen Straight looked unsafe. Some large, dark areas visible on the snow layer indicated that there, under the ice, was possibly wet and rotten. On the Hinlopen Straight, sometimes open lanes became visible.

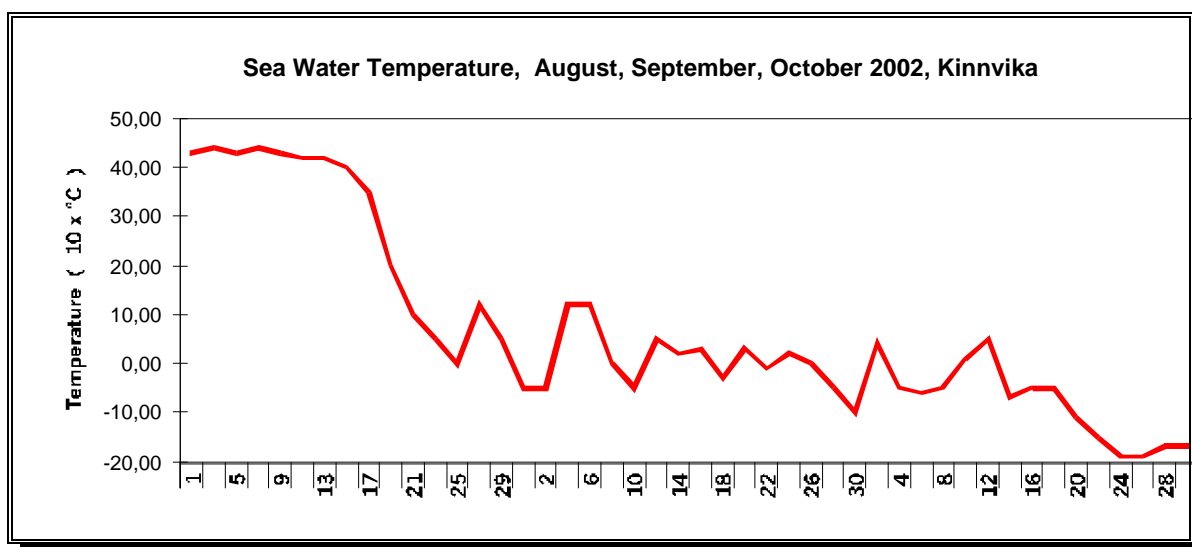
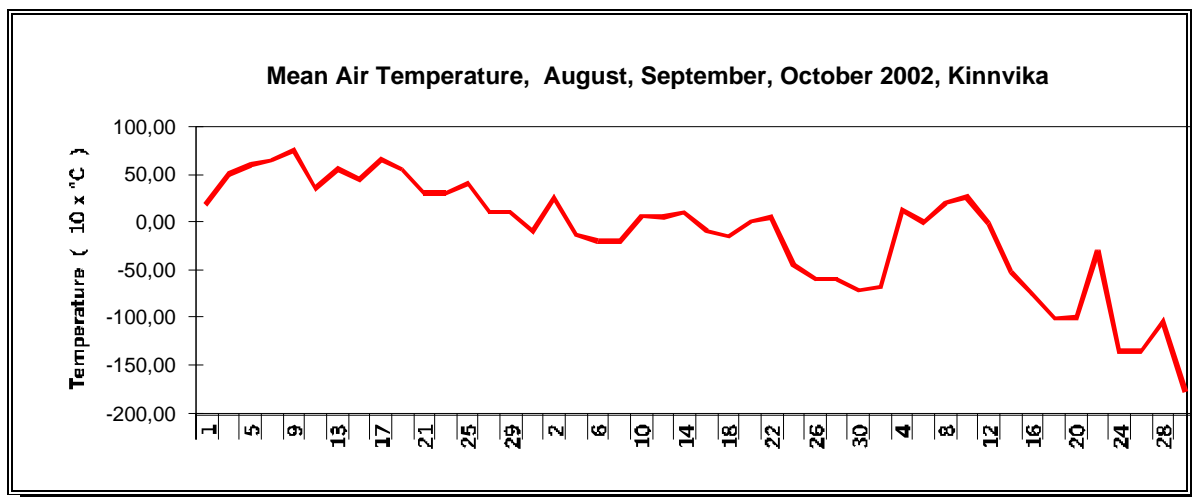
Since the middle of June 2003, due to heavy winds, the ice layer on the outlet of Murchisonfjord started to break up. The inner Murchisonfjord and Kinnvika Bay were covered until mid July with a thick ice layer on whose surface some small ponds of melt water were visible. At the beginning of August, this ice layer fell to pieces and vanished slowly. The Hinlopen Straight was almost completely covered until mid July with densely packed icebergs. Thereafter areas of open water were seen.

Even in August 2003, sometimes single icebergs and ice floes drifted from the Hinlopen Straight into Murchisonfjord.

The ice on the little fresh water lakes close to Kinnvika broke up from 1st July 2003 and melted slowly thereafter.

In the following, some observations are compiled, being essential in connection with the hypothesis of the beginning of life in sea ice, and with the development of a model conception for a biochemical sea ice reactor.





The measured sea water temperature seems not to follow the air temperature.

On the 19th August 2002, after a long period of strong southerly winds, a lot of ice drifted from Hinlopen Strait into Murchison Fjord. Therefore the water temperature at Kinnvika dropped suddenly and remained low even after the ice was gone again.

In September/October, even after many days of cold air temperatures, it took a period of several weeks before the water at Kinnvika started to freeze.

After the 30th October, close to the strand of Kinnvika, the sea water tentatively froze. Finally on 4th November an ice layer of about 5 cms was observed in the bay of Kinnvika.

The water temperature in Kinnvika Bay remained at about -2°C until the end of May 2003. Since the beginning of June 2003 the temperature rose up to -0.5°C at the end of the month. Mid July 2003 the temperature was about +1°C. Sometimes, however, the temperature dropped down to -0.5°C depending on wind and tidal currents.



Growth and Disappearance of Sea Ice (at Nordaustland)

In September 2002, the sea water had a temperature between 0°C and -2°C. In October 2002, the water was cold enough that a large number of small ice crystals containing frozen sweet water started to grow in the sea water. The ice crystals floated due to their relatively low specific weight to the water's surface forming a layer of ice slush, with a thickness of some centimetres. In the slush, small particles and mud was included. Probably, these were gathered by the floating ice crystals which work in some respect like a filter in the sea water.

At cold temperatures of about -10°C, and due to wind and waves, the slush formed round plates, the so-called pancake ice. This ice finally became a solid ice layer with a thickness of 10-20cms, which, within the following months, grew to 50-100cms.

The layer of sea ice seemed, at no time, to be in a firm, steady state. Much more, it's structure and behaviour changed continuously. For example, when the ice layer was loaded by heavy snow, it sank some centimetres into the sea water. Simultaneously liquid brine was forced out of the ice material onto the ice surface, forming a layer of salty liquid between the ice surface and the snow. This layer remained liquid even at cold temperatures down to -20°C.

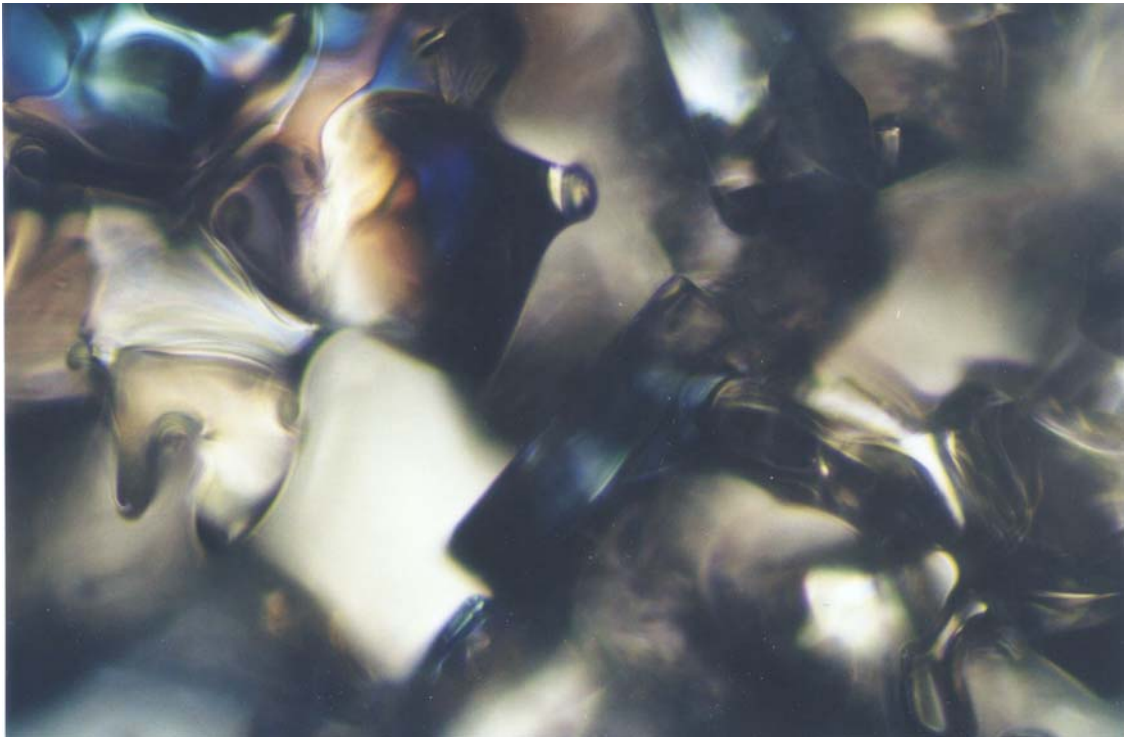
Another situation occurred when, due to heavy storms, the solid ice layer was partially cracked and consequently some sea water was forced onto the ice surface. In this case, small ice bergs were grown and large icy surfaces were generated. It seems that at all times sea ice is in some movement changing it's structure, thickness and strength.

In the early summer, since May and June 2003, the sea water temperature rose slowly, sometimes even beyond the freezing point of -1.8°C. Although the air temperature was still cold, the sea ice started to rot. This process is dissimilar to the melting of sweet water ice.

Sea ice consists of small ice crystals of sweet water between which, liquid brine drips with a high salinity. When the temperature in the sea ice rises, the brine increasingly follows the gravity and drips out of the ice material down into the sea water. By this effect, even in the middle of the cold winter, the uppermost layer of an ice floe is less salty than at the bottom. In early summer, the strength of the ice layer became weak. An increasing number of vertical liquid channels grew in the ice material which finally fell to pieces. The thickness of the ice layer remained, up to this final stage, nearly unchanged at about 100cms.

The growing and subsequent disappearance of sea ice, in some respect, can be compared with the birth, life and finally death of a biological organism, like a tree. For example, the diameter of an old tree doesn't decrease during the dying process, but finally the tree becomes rotten and falls into pieces like old, melting sea ice.

Ice and snow act like a filter sampling dust and small particles carried by the wind. Additionally the current of sea water under the ice transports small particles and organic material which is embedded in the ice structure. When the first daylight appears, plankton and algae are growing in the ice as well as in the snow. Additionally tiny mineralic particles (mostly carbonates) are formed in the ice material under certain temperature conditions. To investigate the quantity and composition of all organic and inorganic particles being embedded or generated in ice and snow at four different locations, snow and ice samples were taken in the beginning of June 2003, before melting. The corresponding sediments were gathered and conserved. Later a chemical analysis of the material will be performed.



Temperature Distribution in Sea Ice

By several sensors, which were frozen at different locations in the ice material, the temperatures in the sea ice were measured continuously during several months. Some of the temperature curves measured by temperature data loggers are shown in chapter 5. Some essential results are compiled in the following:

The temperature at the bottom of the ice layer is close to the water temperature, between 0°C and -2°C. The temperature on the ice surface is strongly dependent on the air temperature and the snow cover. It varies between 0°C and -10°C. The temperature in the middle of the ice layer is between the temperatures at the bottom and on the ice surface.

By the influence of wind, snow fall, changes in the air temperature, and even of tidal currents under the ice layer, the temperature in the ice material sometimes changed quickly with up to 1°C per hour.

By the influence of cracks in the ice and the local variation of the thickness of the snow layers with a corresponding thermal insulating effect, the temperatures in the ice material vary locally with up to 1°C per centimetre.

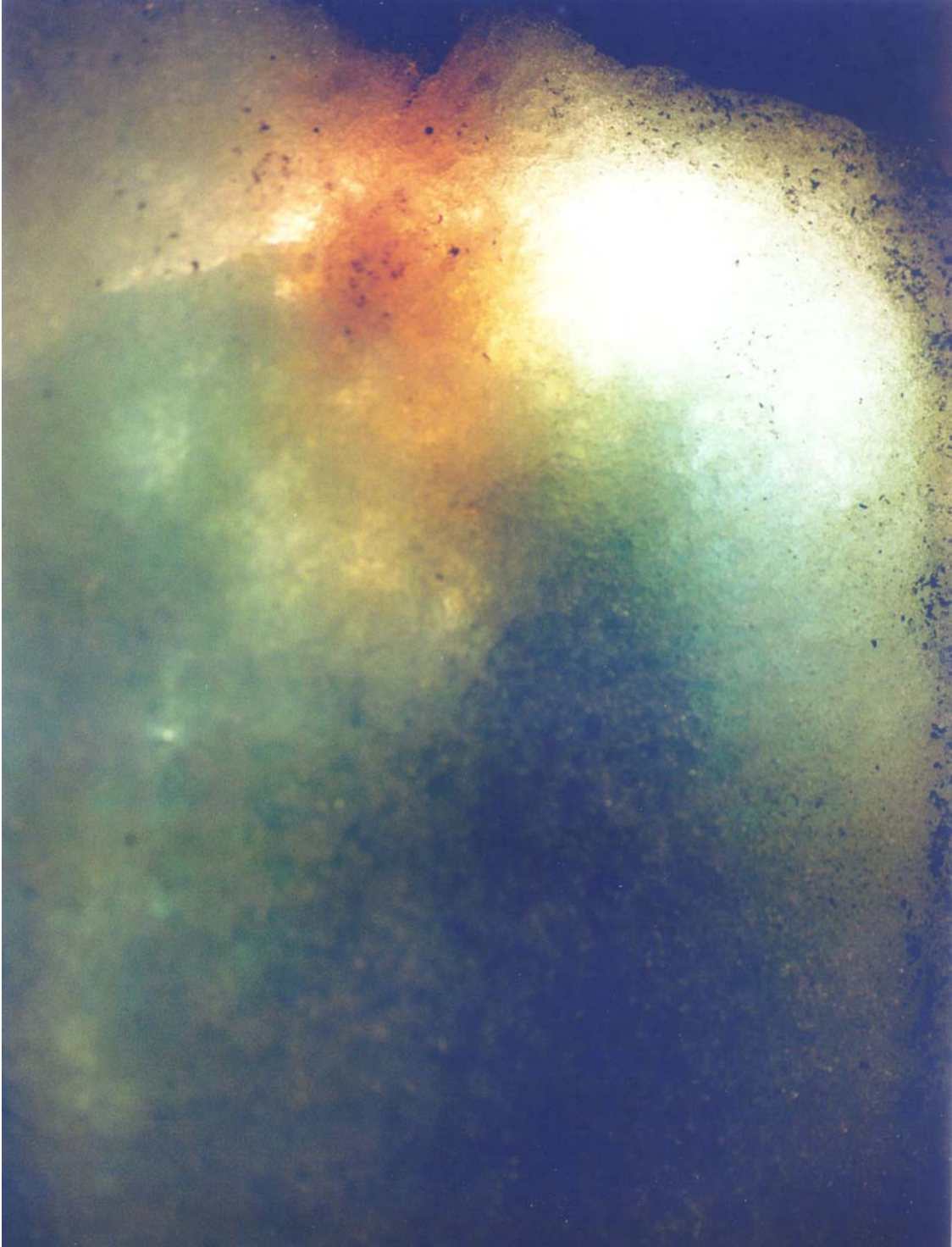
Microstructure of Sea Ice

Hundreds of samples of ice material were taken at different locations in the ice layers under various conditions. The samples were investigated under the microscope. Sometimes the observations were performed outdoors directly on the ice layer. The following observations seemed to be typical for sea ice.

Sea ice material consists of a multi-phase mixture of solid ice crystals of frozen sweet water, more or less wide channels filled with salty brine, manifold crystals like calcium carbonate, and sodium chloride, mineralic particles and finally, small bubbles of gas forming small compartments. The size of the compartments in the ice typically is between 10 and 20 µm. The dimensions of the channels filled with liquid brine is strongly dependent on the temperature. At cold temperatures of less than -10°C, the channels are narrow (some µm), however during the melting process at temperatures of about -1°C, the channels become wider (up to 10mm). The ice crystals and the mineralic particles embedded in the ice material are enclosed by flexible, very thin (less than 1µm) layers, which look under the microscope, similar to biological membranes. These films separate, besides others, tiny cavioles filled with sweet water from the surrounding highly concentrated brine. The film seemed to have semi-permeable properties similar to biological membranes. The cavioles and ice crystals embedded in the salty brine sometimes grew or diminished in size.

When a strong temperature gradient exists in the ice material, for example of 1°C per minute, the microstructure shows fairly dynamic behaviour. For example, then the liquid films change their shape rapidly forming new compartments or unifying different small cavioles to larger ones. Sometimes tiny gas bubbles erupt suddenly from the surface of the ice crystals. Thereafter they may disappear again, being dissolved in the liquid. Probably, these gas bubbles contain carbon dioxide. Using a Testo 535 sensor probe it could be measured that sea ice during it's melting evaporates carbon dioxide. In the liquid channels the brine flows during the dynamic phase with a speed of up to 0.1mm/second, carrying small crystals, mineralic particle and bacteria.

In comparison to the microstructure and the behaviour of sea ice, sweet water ice shows different properties. It looks much cleaner than sea ice and contains no particles, brine channels or crystals. Sweet water ice is a fairly homogenous, optically transparent material without many compartments and liquid inclusions. Only gas bubbles are sometimes visible.



Sorting and Demixing Effects in Sea Ice

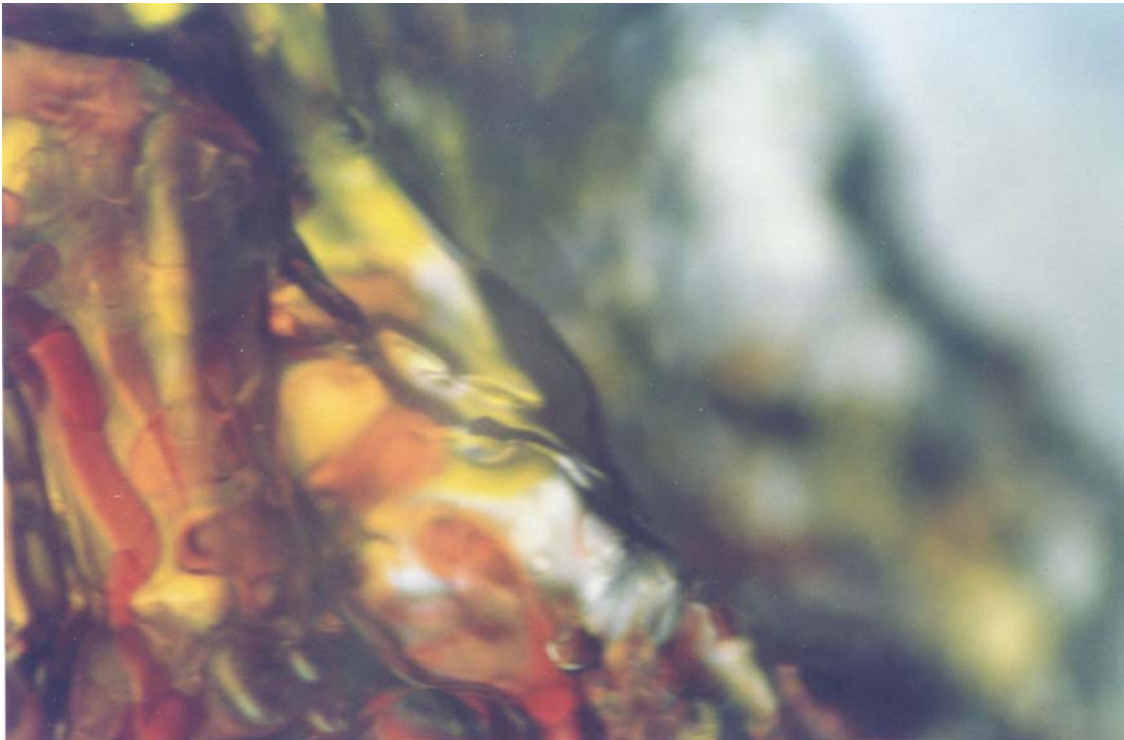
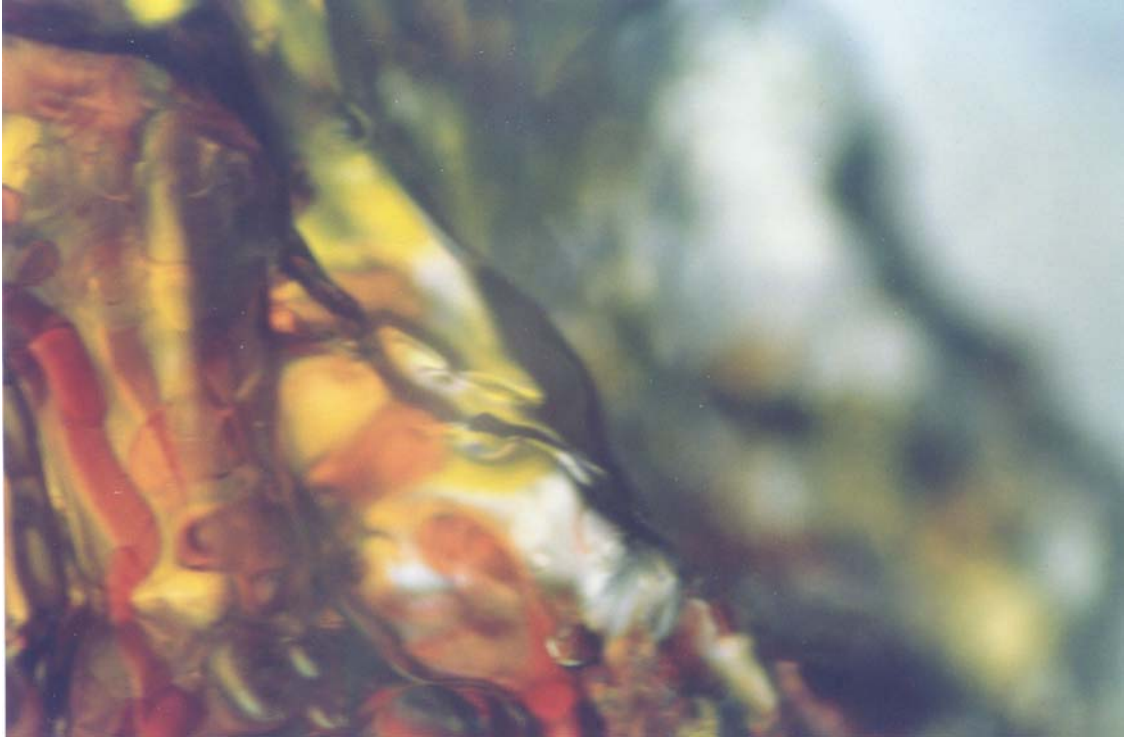
In different layers of sea ice with a thickness of between 50 and 100cms, holes with a diameter of 10cms were drilled, however, not deep enough to reach the sea water under the ice. The hole (for example 50cms deep in a one metre thick layer of ice) filled itself completely with liquid brine within 10-30 minutes after boring. The rising liquid level in the hole was measured dependent on time, at different air temperatures between 0°C and -30°C. The liquid level rises following an exponential law. Even under very cold conditions, finally, the holes were, up to the surface of the ice layer, filled with brine.

The concentration of salt in the brine is up to five times higher than in normal sea water with about 35g salt per litre. This observation is explained by the fact that sea ice is a porous material comparable to a wet sponge with a network of many small compartments and channels through which the liquid brine trickles and drips. Even at -30°C sea ice contains a small amount of liquid with highly concentrated salts. This liquid, following gravity, drips into the bored hole.

When the brine percolates through the network of tiny channels, it passes the surface of ice crystals, mineralic particles, gas bubbles and films. Many complicated processes like temporary absorption, adsorption and dissolution happen to the molecules being present in the dripping liquid. Such processes are similar to those of which advantage is taken in industrial chromatographs used for the separation of mixtures of chemical compounds dissolved in a liquid.

To study this effect in connection with sea ice, a mixture of various coloured powders used in food industry, (azorubin, cochineal red, chinolin yellow, patent blue, amaranth), was dissolved in sea water and thereafter poured on a layer of ice. The colourful liquid dripped within some hours through the network of brine channels. Simultaneously the various compounds were separated from each other due to their different chemical properties. Finally, the various colours were deposited at different areas of the sea ice. The ice material was cut open to make visible the corresponding pattern of colours.

This property of sea ice leading to demixing and sorting of various chemical compounds in the network of ice crystals, brine channels and tiny compartments plays an important role in connection with the hypothesis of the beginning of life in sea ice. (See **Attachment** at the end of this report)



Salinity and pH Values in Sea Ice

Different samples of sea ice were taken under various conditions at different locations in the ice layer. The samples were melted and thereafter analysed concerning its salt concentrations and pH values.

Dependent on the age and temperature, the **concentration of salts** in sea ice varies within a wide range. Fresh, new ice shows a salt concentration similar to sea water of about 35g per litre. In the upper zone of a layer of ice, with an age of one or more years, the salt concentration was measured, sometimes less than 1g per litre. Particularly, the ice of old large icebergs was, in the upper regions, nearly free of salt. However, it was observed that even at temperatures of about -10°C , out of the tips and edges of such icebergs, droplets of brine dripped with a high salt concentration of about 100g per litre.

Obviously, the salt concentration is distributed inhomogenously in the sea ice material. While the solid ice crystals contain frozen, pure sweet water, the liquid brine in the channels show a high concentration far above the normal concentration of sea water. For example, the liquid brine which dripped out of a piece of sea ice, at a temperature of -30°C , a salt concentration of 150g per litre was measured.

The **pH value** of unfrozen sea water lies between 7.6 and 8.5. After the above mentioned different samples of sea ice were melted, the pH values were measured between 7.4 and 8.3. The pH value of old ice floes being stranded at the beach was between 8.0 and 8.3.

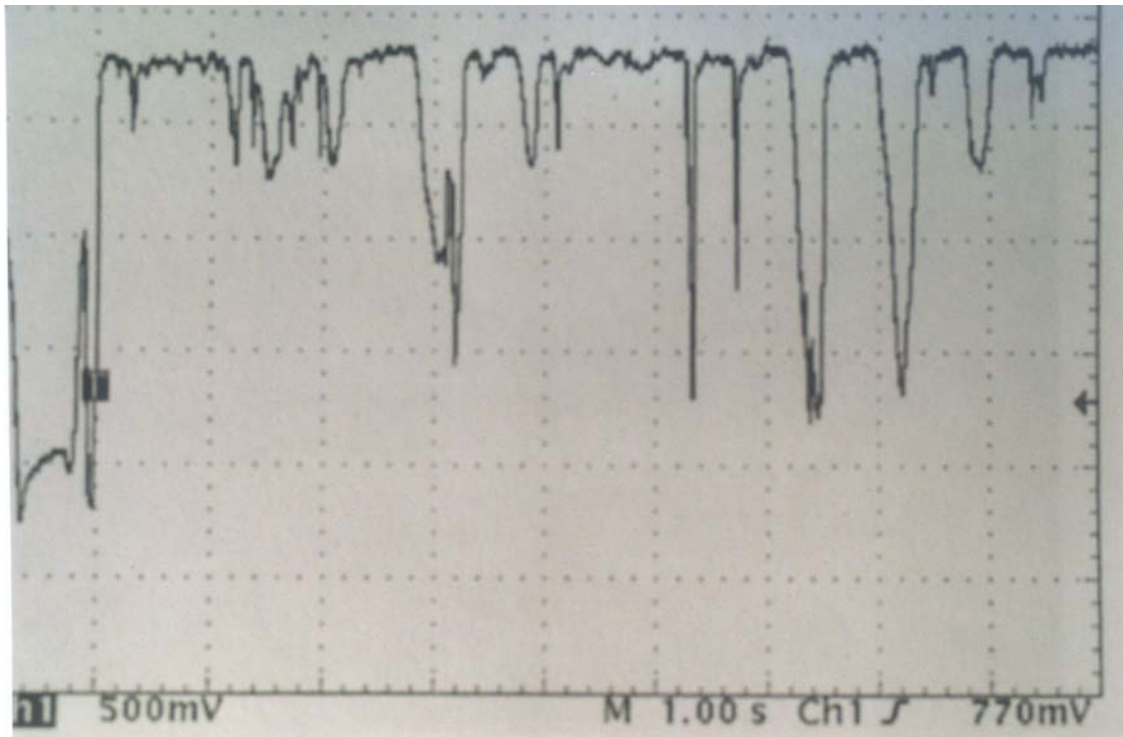
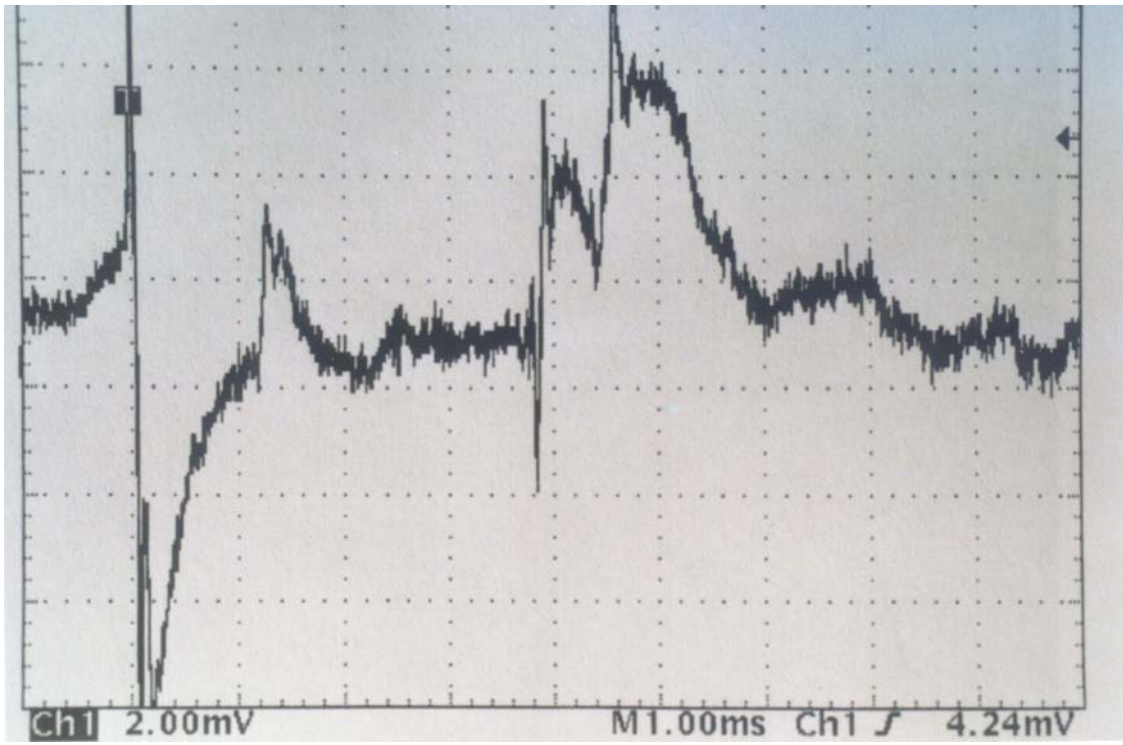
The pH value of fresh snow was measured at 5.8. By this reason sea ice layers covered by snow show pH values that are slightly lower than without snow. The low pH value of snow can be explained by the fact that snow crystals consist of frozen water vapour which is in equilibrium with carbon dioxide in the air. The carbon dioxide dissolved in water produces carbon acid which lowers the pH value.

The pH value of ice slush grown on the surface of cold sea water was measured at 6.4. The small ice crystals growing in sea water during the beginning of the freezing process contain mostly frozen sweet water. These ice crystals in the water seem to be similar to snow flakes concerning their content of carbon dioxide.

To make visible the special distribution of the pH value in the microstructure of sea ice, phenol red was dissolved in the sea water before freezing. The colour of phenol red at pH value 6 is a bright yellow, while at a pH value of 8, the colour becomes violet.

The frozen sea water marked with phenol red was investigated microscopically. The pattern of colour indicated that sometimes the pH values vary from 6 to 8 in the sea ice within short distances of less than $10\mu\text{m}$. Particularly it seems that the frozen ice crystals of sea water show low pH values while the liquid brine has high pH values.

The microstructure of sea ice shows a strong spatial heterogeneity concerning as well the salinity as the pH values. It seems that the flexible films which separate the solid ice particles from the liquid brine, work like a barrier between regions with low salinity and low pH values and regions with corresponding high values.



Pressure Differences in Sea Ice

Due to wind shear forces in the layer of sea ice, an increase of pressure may occur. By pressure sensors (Kistler) frozen in the ice material, some corresponding values were measured with about 0.1-1mbar. Such small pressure values seem not to lead to an essential change of the ice microstructure, however, the resulting macroscopic consequences may lead to strong ice pressure effects between various ice fields. Outgoing from this, sudden huge ice barriers may grow and ice cracks may occur accompanied by loud bangs. During those occasions, strong, but temporarily short pressure spikes in the ice material, up to 1000bar are to be expected.

It is assumed that in a microscopic scale sometimes strong heterogeneities of pressure within the ice microstructure may occur. This is to be expected due to the occasional temperature change and the corresponding expansion of different compartments embedded in the ice material. However, up to now, this predicted local pressure heterogeneities could not be measured because corresponding micro sensors were not available.

Electric Potential Differences in Sea Ice

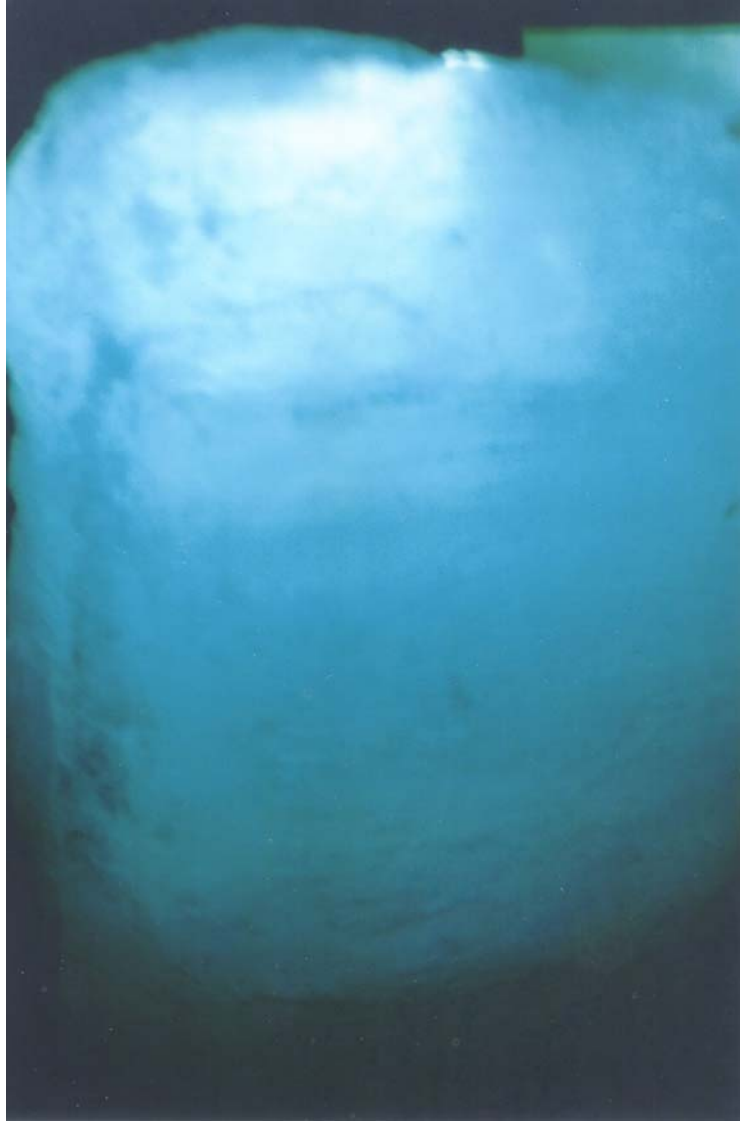
Using medical probes the electrical potential differences in sea ice were measured. Such probes are formed as fine needles. They are originally used in medical applications for the measurement of the electric potential differences in muscles and nerves of humans. When such a probe penetrates a layer of sea ice, electric potential differences of up to 10mV can be recorded.

Outgoing from microscopic observations, it seems that the potential differences were produced when regions with a high ion concentration (for example compartments filled with liquid brine) border upon regions with a low ion concentration, (for example, ice crystals of frozen sweet water). If the sensor needle penetrates the thin film separating the above mentioned different regions, obviously a potential difference occurs.

The electric potential differences, as well as the observations concerning the heterogeneity of the pH values, indicate that in the sea ice material, locally strong energy differences exist. This fact may be important for the understanding of energy consuming chemical reactions leading to macromolecules in sea ice.

Magnetic Fields in Sea Ice

In the interior of sea ice and on the surface of samples of broken sea ice, it was investigated if the magnetic field on Earth is influenced or disturbed by the presence of ice. The measurements were performed using a magnetic probe (Teslameter, FM GEO-X, Projekt Elektronik, Berlin, Germany). It became obvious that the Earth's magnetic field is changed less than 10^{-9} Tesla by the presence of sea ice. In other words, under the given measurement conditions no magnetic field effects could be observed caused by sea ice.



Light Penetration and Polarization Effects in Sea Ice

It was investigated in which way the intensity of sunlight and alternatively of UV light decreases with the depth when it penetrates a layer of sea ice or snow. Sea ice material consists of a huge number of tiny compartments, ice crystals and liquid brine channels. Therefore a light beam is strongly influenced by the effects of scatter, reflection and refraction. In snow, similar effects occur. The consequence is that the light is weakened in an essential manner penetrating even a thin layer of sea ice or snow.

It was measured that the sunlight intensity was weakened by a layer of sea ice with a thickness of **d=500mm** by the factor of **100**. A layer with a thickness of **d=80mm** lowered the original intensity to a half.

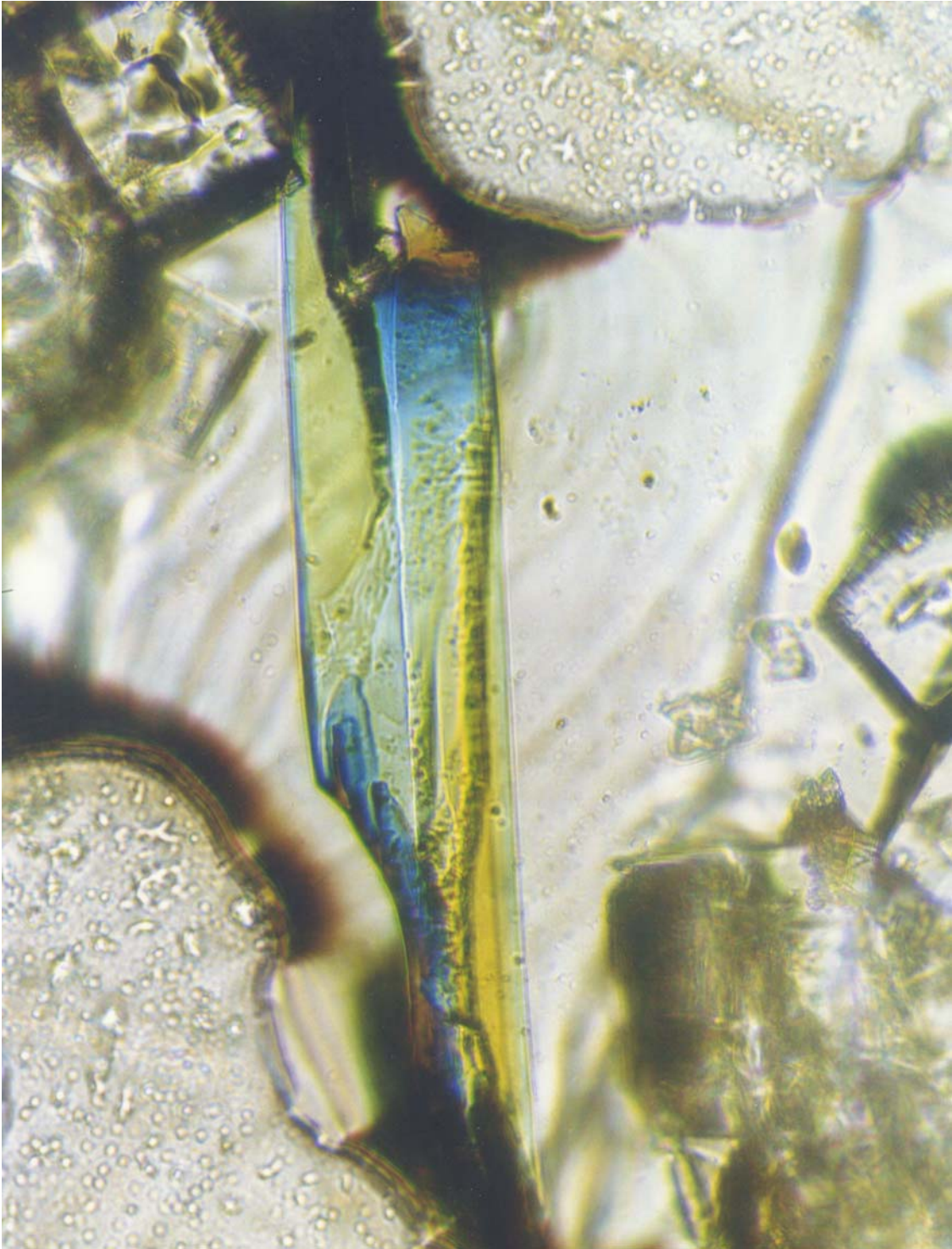
Using an UV light source (wavelength 260nm) it was found that the UV light is weakened much more than sunlight in the ice. The half value of the original UV light intensity was already measured at **d=20mm**. The corresponding value for UV light penetrating a snow layer is much lower with **d=5mm**.

These values describe the real situation very roughly. They vary depending on the different microstructure of the ice and snow. However, it became very clear that sunlight, as well as UV light, by a fairly thin layer of snow or sea ice, was strongly weakened. This fact is important in connection with the discussion in which way the perilous intensity of UV light on the early Earth 4 billion years ago may have been lowered to a harmless level by the effects of sea ice. (see Attachment).

It was investigated if, and in which manner, sunlight may be polarized in sea ice. For this purpose, beams of sunlight which hit layers of ice and snow at various angles were observed. Sometimes by reflection and refraction effects the ice crystals twinkled and sparkled in bright colours. The reflected, scattered and refracted light was photographed and analysed using different optical polarization filters. After many troublesome observations it became obvious that the sea ice, in some cases, operated similarly to optical polarization apparatus, leading to linear as well as circular polarized light. This effect may be explained by "Brewster's Law". That means if a light beam in sea ice is reflected at an ice crystal under a certain angle, the light wave will be completely linear polarized. Furthermore, the linear polarized light will be refracted when it penetrates an adjoining crystal or compartment with liquid brine, being optically double refractive or even optically active.

Under certain circumstances, if the thickness of the brine channel is a certain fraction of the wavelength (for example, a quarter of the wavelength) the light becomes circular polarized. Using a combination of polarization filters it was found that sometimes crystals or structures in the ice structure, indeed, show optical double refractive behaviour.

The effect that sea ice produces from sunlight, under certain conditions, circular polarized light waves in some of its compartments may be important in connection with the separation between left- and right-handed molecules as amino acids being embedded in sea ice. (see Attachment).



Crystals and Minerals in Sea Ice

In the microstructure of sea ice many crystals and mineralic particles are embedded which can be observed by using a microscope. On the one hand, the observed particles were caught from the sea water by the porous sea ice material similar to a filter. On the other hand, the crystals are produced in the ice itself by crystallization effects of the salts dissolved in sea water.

The latter process is dependent on the temperature in the ice. For example, at about -2.5°C Ca CO_3 starts to crystallize in the sea water brine. At about -8.5°C Na_2SO_4 occurs and at -20°C Na Cl becomes visible as solid crystals. Additionally, many further different kinds of crystals grew in the brine with a length of approximately $1\text{-}10\mu\text{m}$.

It is assumed that on the surfaces of some crystals and mineralic particles, possibly catalytic effects take place supporting chemical reactions in the sea ice. (see Attachment).

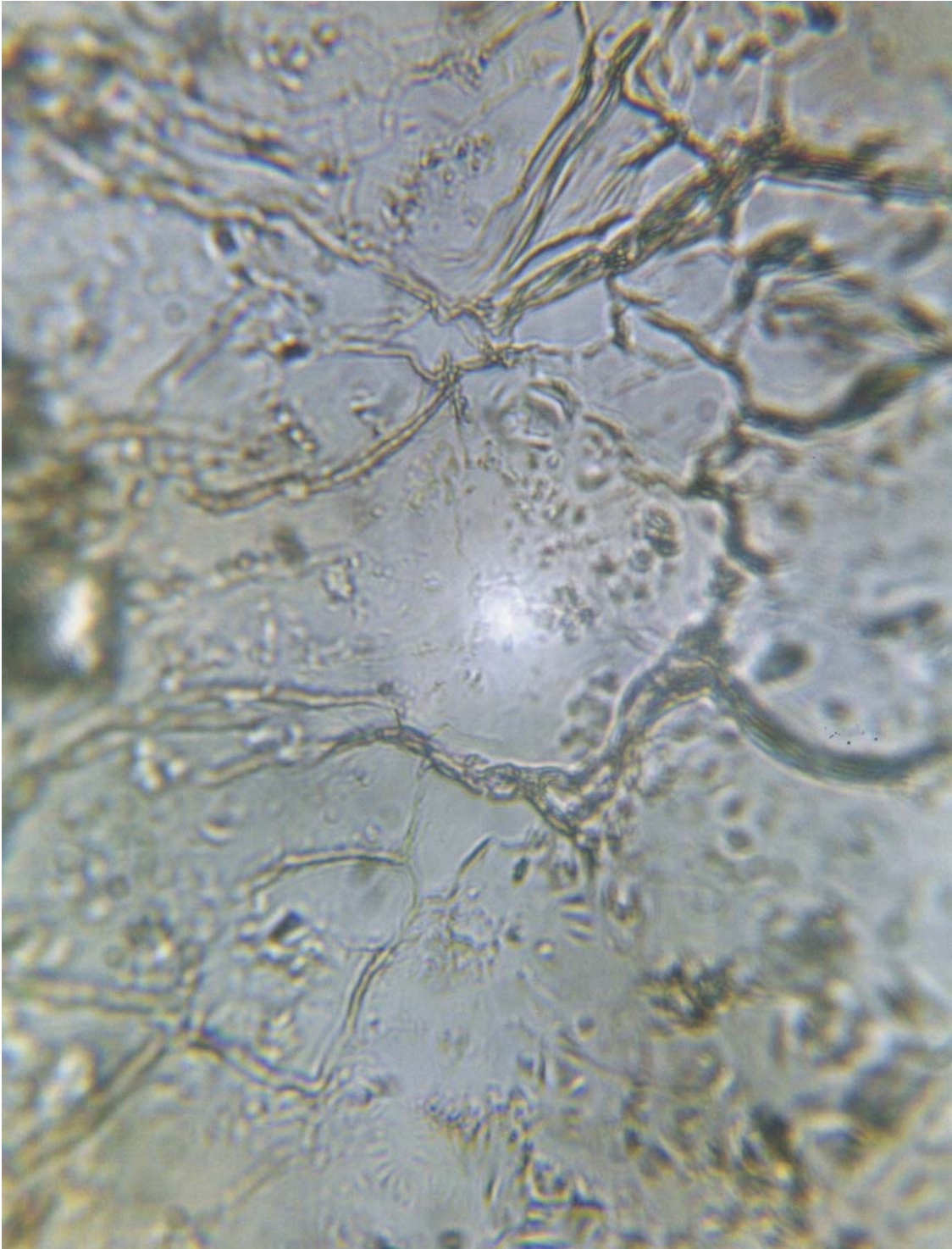
Amino-Acids in Sea Ice

The behaviour of various amino-acids was studied during the freezing process of sea water. Besides others, the amino-acids, glycin, alanin, valin, leucin and phenylalamin were dissolved in sea water. After the sea water was frozen the corresponding ice was observed under the microscope.

It became visible that the amino-acids were strongly concentrated in the narrow channels filled with liquid brine. The solid frozen ice particles seem to be free of the amino-acids. The amino-acids remained in the liquid

When the temperature dropped to fairly low values of about -10°C , the amino-acids formed solid crystals and particles which floated in the brine channels. Sometimes even chains and nets were formed.

It seemed that during the freezing process the various amino-acids were sorted and demixed in the sea ice material similar to the above mentioned mixture of colour powder dissolved in sea water.



RNA Molecules in Sea Ice

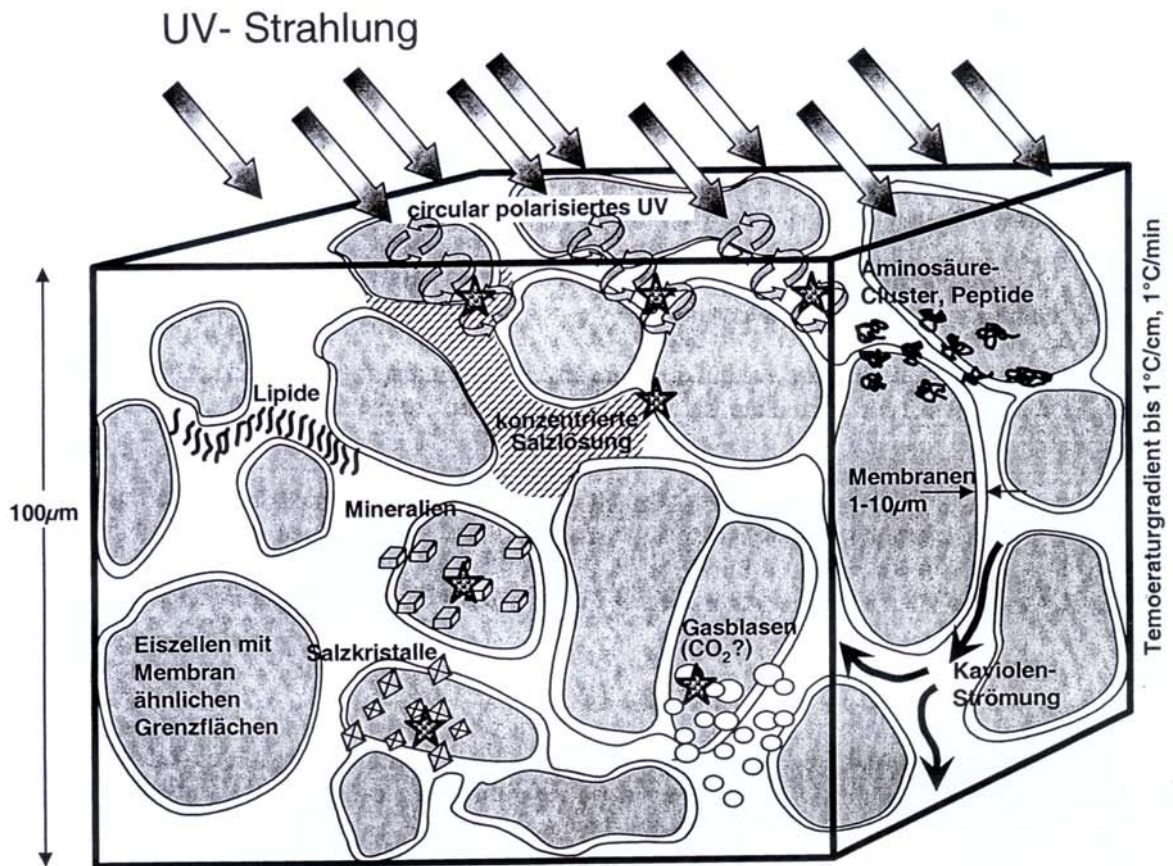
RNA (Ribonucleic acid) of yeast was marked with ethinium bromide by Christof Biebricher from Max Planck Institute in Göttingen. The RNA was thereafter dissolved in sea water. Due to the marker, ethinium bromide, the RNA became visible under the fluorescent microscope.











During the freezing process the observed effects were very similar to the observations made of the amino-acids dissolved in sea water.

The RNA was strongly concentrated in the brine channels forming, finally, small particles and chains. After the ice was melted the RNA structures remained stable for many hours, floating in the sea water.

Alternatively, the sea ice with the embedded RNA structures was irradiated during four hours by UV light (wavelength 260nm). By this procedure the RNA formed chains and nets embedded in the brine channels. Besides this, thin films were generated which enclosed the small gas bubbles in the sea ice. After melting the sea ice the chains, nets and films remained stable.

Possibly these properties of RNA structures in combination with UV light, supported the generation of biological cellular structures in sea ice during the first step of the beginning of Life on the early Earth (see Attachment).



-  Eiszellen mit Membran ähnlichen Grenzflächen (Membran-Dicke 1-10 μm)
-  konzentrierte Salzlösung mit organischen Bestandteilen
-  Salzkristalle
-  Mineralien
-  circular polarisiertes UV-Licht
-  Aminosäure-Cluster, Peptide
-  Lipide
-  möglicher Ort chemischer Reaktionen
-  Kaviolen-Strömung
-  UV-Einstrahlung

**Modell:
Biochemischer
Meereis-Reaktor**

6.2 Sea Ice Reactor

Outgoing from the manifold experimental results gained in the real sea ice close to Nordaustland, a rough model conception was developed concerning sea ice as a biochemical reactor.

Sea ice consists on small cells of frozen pure water between which, a system of narrow channels exists filled with highly concentrated liquid brine. Besides this, many solid crystals and mineral particles supporting catalytic effects, for example, calcium carbonate, chlorides and sulphates are stored between the cells.

The cells are enveloped by thin, flexible films similar to biological membranes. Additionally tiny bubbles of gas (mostly carbon dioxide) jostle in the brine channels, growing or disappearing depending on temperature and pressure.

The small cells or compartments in the ice have a typical size of 10-20 micrometres. Consequently one cubic metre of sea ice contains about 10^{14} compartments, which are connected to each other by a network of brine channels.

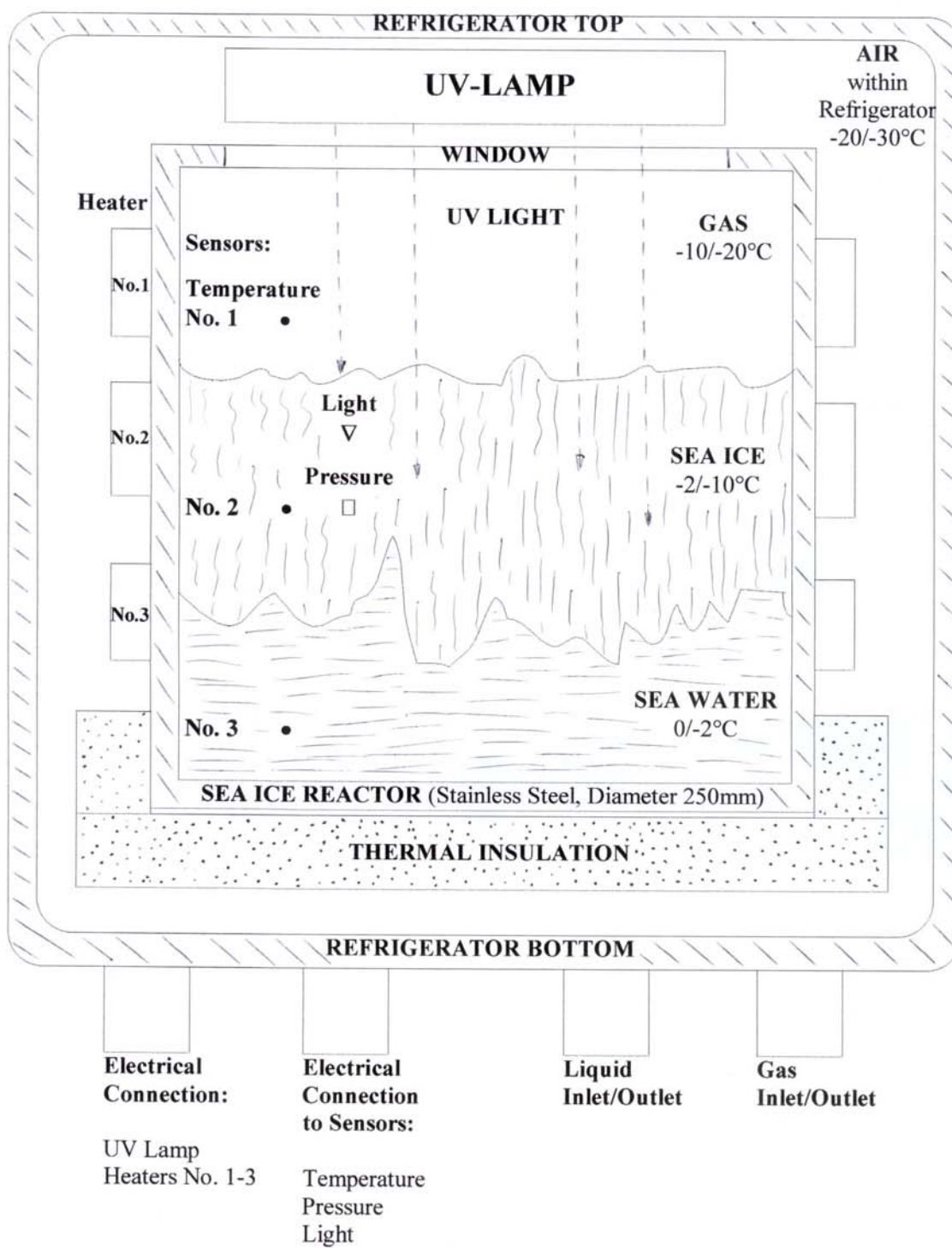
UV light penetrates sea ice only to a depth of 10-20cms until it's intensity is strongly weakened by optical scattering effects. The light waves penetrating the sea ice are scattered, reflected, refracted and polarised. Besides this, circular polarised light could be observed in the ice material.

Due to the high concentration of electrically charged particles and ions in the ice and due to their inhomogeneous special distribution, sometimes strong electrical potential differences are given, particularly between the membranes.

The pH-values vary between 6.0 and 8.5 in different contiguous locations in the sea ice.

By such effects, energy differences exist particularly close to crystal surfaces and the membranes in the ice material.

Taking into account the observations made in connection with real sea ice, the technical realisation of a sea ice reactor is proposed. In this way it would be possible to simulate the growth and disappearance of sea ice in the laboratory in a realistic way.



SEA ICE REACTOR IN REFRIGERATOR

SCHEMATIC DIAGRAM

Technical Realisation of a Sea Ice Reactor

Outgoing from the understanding about the physical chemical processes which take place in real sea ice, it seems to be possible to perform further experiments in the laboratory under more comfortable conditions than in the ice of Svalbard. For this purpose, the realisation of a technical sea ice reactor makes sense being operable in a laboratory.

To simulate the freezing processes of sea ice in a realistic manner, it is necessary that the growing ice material may interact continuously with a sufficient amount of sea water remaining unfrozen all the time.

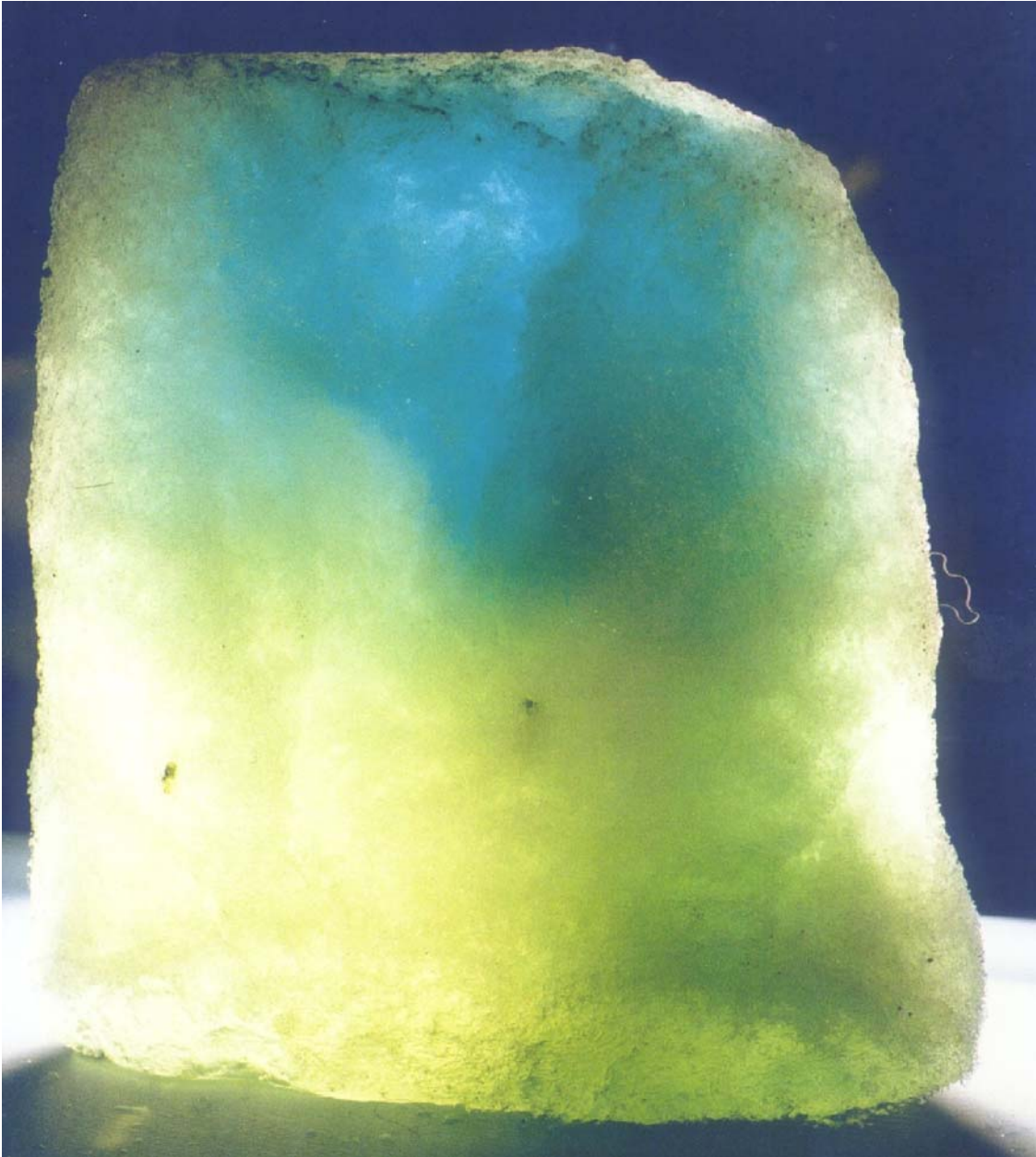
A tube with a diameter of about 250mm and fabricated out of stainless steel, may be filled with well defined artificial sea water.

The tube should be mounted in a refrigerator of a temperature of -20°C . By some heating elements enclosing the outer wall of the tube, a desired temperature profile can be enforced inside the tube.

The essential parameters of the growing piece of sea ice floating on the sea water in the tube may be controlled by different sensors concerning temperature, pressure and light intensity.

The ice surface may be irradiated in the tube from above by UV light to simulate, in some respects, conditions on the early Earth.

The gas and it's pressure above the ice in the tube may be chosen in an appropriate way. Possibly a fairly high concentration of carbon dioxide should be chosen.



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6.3 Conclusions

The main purpose of the expedition “Life In Ice” in 2002/03 at Kinnvika on Nordaustland, Svalbard, was the detailed investigation of sea ice. Simultaneous to the experimental work, a comprehensive study of the available literature concerning the origin of life on Earth was performed and conclusions were drawn. In this connection, more than 1000 corresponding publications were evaluated and compared with experimental results gained in the real ice of Svalbard. Outgoing from these activities and in close co-operation between Christof Biebricher from Max Planck Institute in Göttingen, Wolfgang Schröder from Technical University, Hamburg-Harburg and Hauke Trinks, the following joint publication was realised:

Ice and the Origin of Life, Germany, Shaker Verlag, Aachen 2003

In this publication it is pointed out that the function of sea ice at the very beginning of life as a possible matrix to push prebiotic chemistry towards first biological processes has never been investigated before.

After years of examination in the arctic region and a thorough investigation of literature, we are now convinced that nothing but the environment of sea ice could have better set the spark of life to the early Earth. In comparison to most of the theories about the beginnings of life, our ideas agree with the opinions of other scientists, except the places where everything happened. Some processes proposed to take place on mineral surfaces, in meteorites or under deep sea conditions may even find better support when transferred to sea ice. Our studies of literature show that sea ice seldom has been investigated as a sort of reactor, though it has astonishing properties concerning surface activities, chromatographic effects and phase transfer reactions between liquid, solid and gaseous states. Even the supply of energy to chemical reactions seems to operate more properly in sea ice than in other environments, being much more selective due to the low temperature during compound interaction, linkage and duplication of prebiotic molecules and macromolecular aggregates.

Quite a lot of descriptions concerning the chemical and physical phenomena has been published during the decades of scientific work on arctic materials. But a review putting everything together to describe sea ice as a complex matrix with complex properties has not been published yet. Our treatise seeks to persuade other scientific groups to include the sea ice matrix in their investigation, in finding the way how life managed to emerge from prebiotic molecules.

In the Attachment to this report a possibility is roughly sketched out, in which way the beginning of Life on the early Earth 4 billion years ago could have developed. More details were given in the above mentioned publication.



7 SNOW

7.1 Observations

The first snowfall was observed **27th August 2002** on sea level close to Kinnvika. In **September and October 2002** during 30 days snowfall or sleet and rain was noticed. The snowfall occurred mostly in combination with strong winds from northern directions, while the rain and drizzle was observed during southerly winds. Due to the nearly permanently strong winds the snow did not cover the ground in a thick layer. Most of the snow was blown away shortly after the snowfall. In certain positions hills of densely packed snow were formed with a height of less than 1 meter.

In **November 2002** on 24 days and in **December 2002** on 13 days, snow fell, sometimes in heavy blizzards. In December, rain was observed on one day. From **January to April 2003**, each month on about 15 days, a little amount of snow fell, in combination with blizzards.

The snow layer on the ground and the ice surface grew during these months in a minor way. The snow layer had, at the end of **April 2003**, a thickness of about 30cms. However, between the huts, snow hills were formed with heights up to 3.5m. In **mid-May 2003** large amounts snow fell, probably, in total, more than all months before. Finally the snow layer on the ice was 50cms and between the huts of Kinnvika, huge snow hills were formed with a height of up to 5m.

During **April and May 2003**, with the influence of sunshine, heavy winds and temperatures between -5°C and -10°C it was observed that many snow hills were covered by a 2-5mm thick ice layer, shining in the sun like a glacier.

From **March to May 2003** sometimes it was observed that large, plain ice crystals with a size of up to 20mm grew on certain locations, on the snow surface. These ice crystals sparkled brightly in sunlight and showed, sometimes, various bright colours.

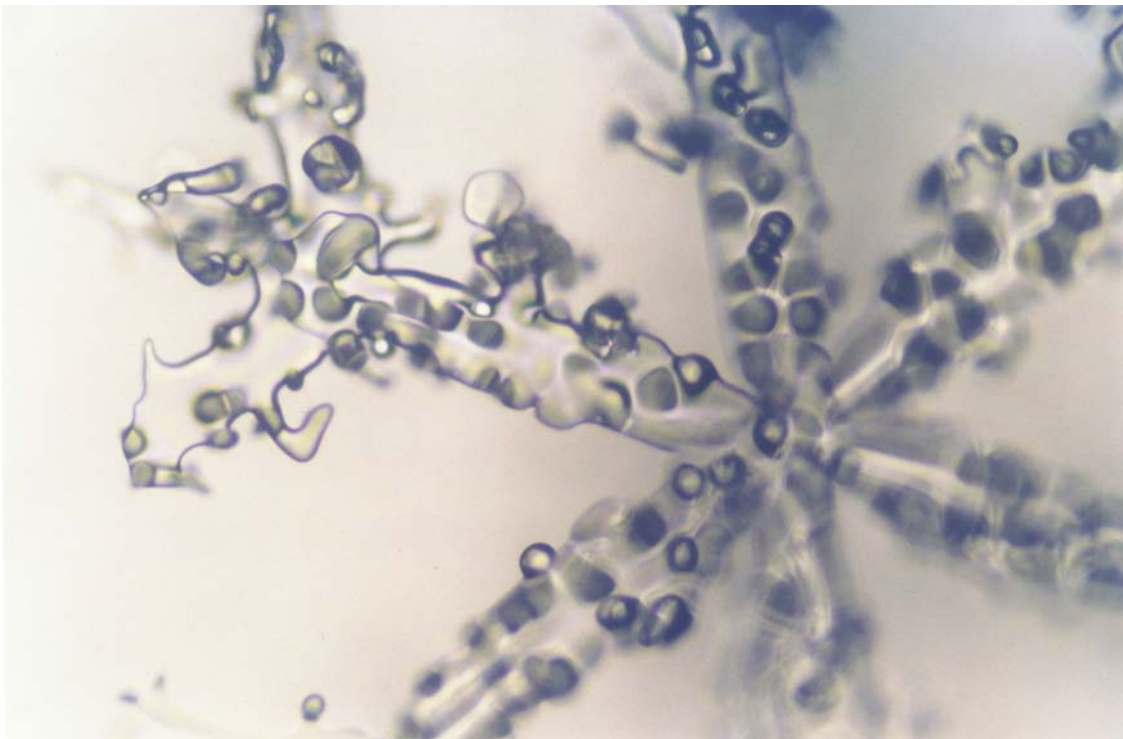
Until the end of **May 2003** even at air temperatures of $+3^{\circ}\text{C}$ the snow didn't really melt. Further, the snow sublimated from its surface, directly into the fairly dry air, being heated by the sun. In this way, at certain areas, the snow slowly disappeared completely from the ground. In the middle of **June 2003** at temperatures of around $+5^{\circ}\text{C}$, the snow really melted, producing a huge amount of water on the surface of the ground. In **mid-July 2003** most of the snow had vanished, only some snow hills remained.

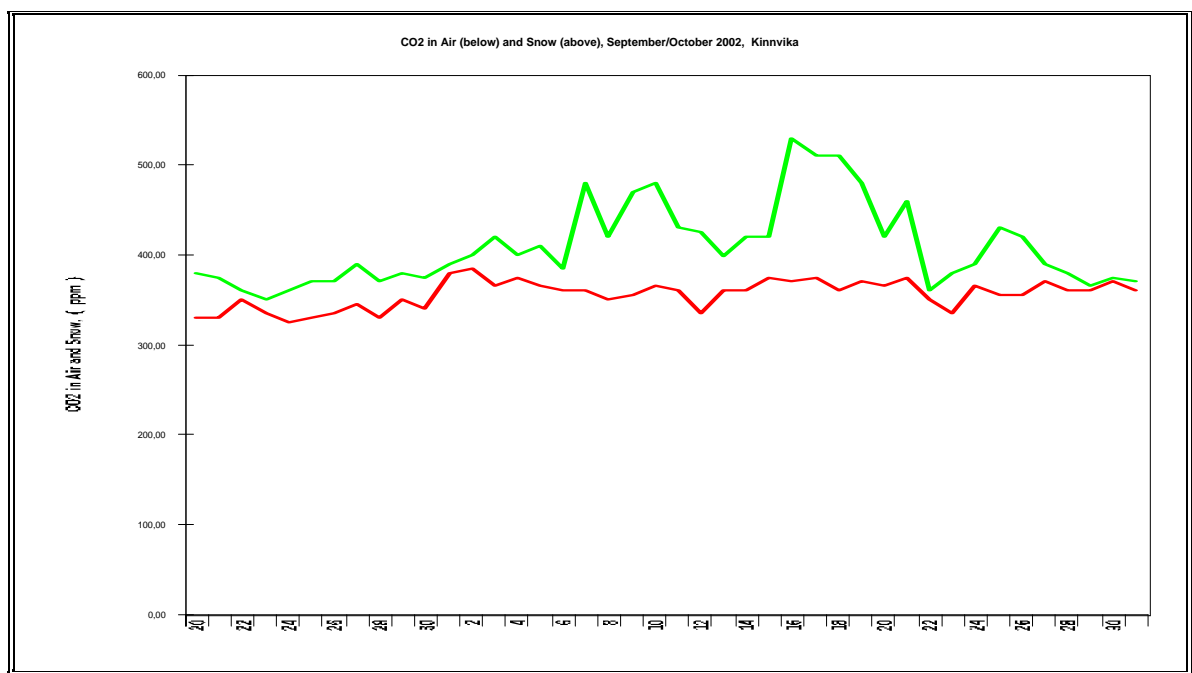
Single snow flakes were caught during snowfall and investigated by microscope. It seems, that in autumn, in combination with northerly winds the snow crystals were covered with frozen micro droplets. This effect was not observable during snowfall with southerly winds.

The CO_2 concentration was measured each day in the air in clear weather as well as during snowfall or rain. Besides this the CO_2 content was recorded in narrow caves which were bored in densely packed snow hills.

In air the CO_2 concentration was between 320 and 380 ppm. It seems, that during rain fairly low values are valid. However during snowfall with northerly winds, the CO_2 content was found to rise up to 380 ppm.

The CO_2 concentration measured in snow in autumn 2002, seemed to differ from those measured in spring 2003. In **September and October 2002** the values recorded in the snow were up to 200 ppm higher than the corresponding values in the air 1 metre above ground. The CO_2 concentration in the snow caves seemed to depend on the temperature in the snow which were between -0.5°C and -10°C . In **spring 2003** similar effects could not be observed.





CO₂ Observation in September and October 2002

The CO₂ content is measured using an IR measuring probe (Testo 535, Germany) in the air as well in small caves (diameter 3 cms.) in the snow layer which was formed by the newly fallen snow.

The values in the air seem to vary depending on the weather situation. Particularly in the case of snow fall in connection with northerly winds the values rise. It seems that the falling snow crystals exhausted some CO₂ gas.

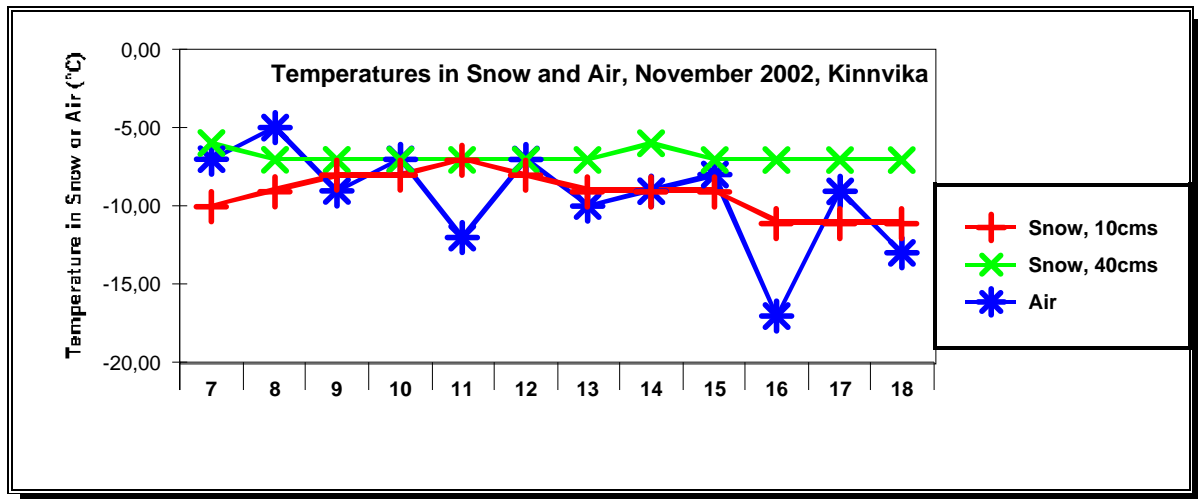
The snow crystals were investigated by microscopy under different conditions. In the case of snow fall in connection with northerly winds, the observed snow crystals were covered with frozen small water droplets. Possibly the water vapour over the open sea water north of Nordaustland, contains a high amount of CO₂.

In the snow the measured CO₂ values seemed to be dependent on the consistency of the snow layer. The highest values were measured in densely packed snow. Within some days these high values of CO₂ decreased to those measured in the air. Besides the consistency of the snow and the time after the snow fall, the temperature in the snow seemed to be important for the CO₂ concentration. It seems that preferable in the temperature range between -1°C and -5°C, the packed snow exhausted CO₂.

When the snow melted in June it became very wet. Consequently the exhausted CO₂ was dissolved in the liquid films and was not measurable in the atmosphere. However when the snow sublimated at cold temperatures during sunshine, instead of melting, the CO₂ bounded by the snow crystals became free and was clearly measurable above the surface of the snow layer.

Snow and ice seem to act in some respect similar to a huge lung. CO₂ gas above the surface of open sea water is transported by the wind and finally bound to snow crystals which are deposited as snow layers on land. During the sublimation of snow this CO₂ gas is expired into the atmosphere over the land. In this way by snow clouds worldwide, a huge amount of CO₂ may be transported out of the sea water and into the atmosphere. Possibly it is worthwhile to investigate this effect by further experiments and theoretical estimations.





Temperature Distribution in Snow Layers

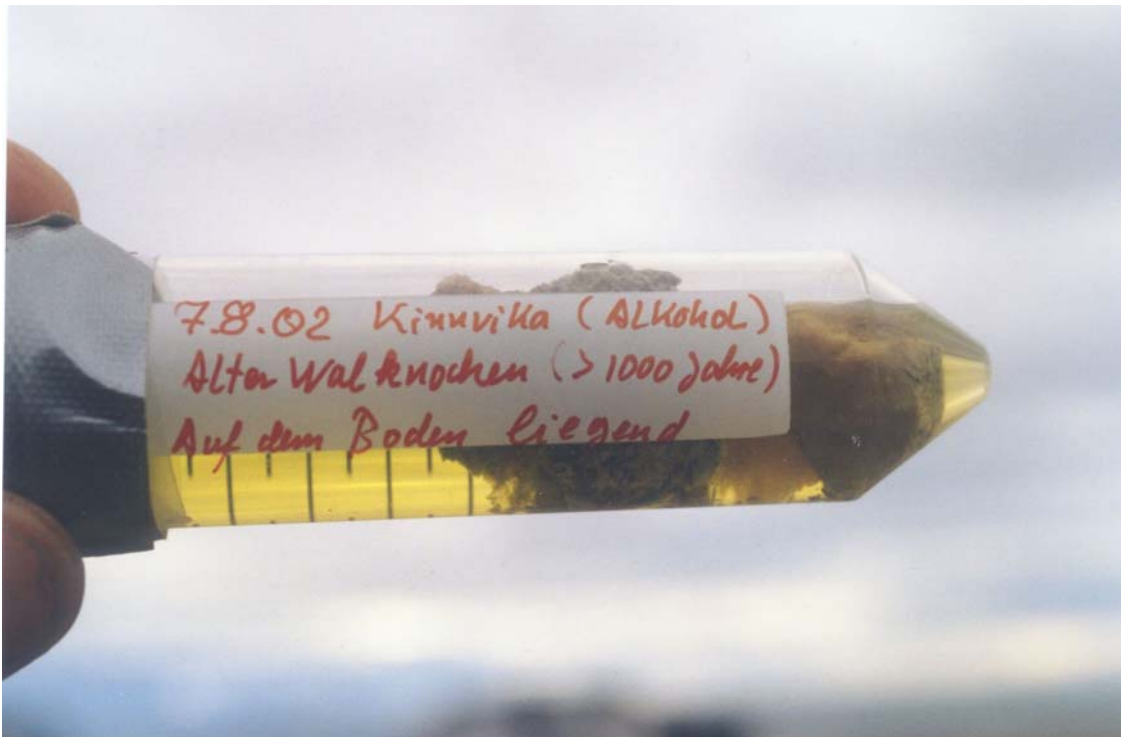
Snow is a very good thermal insulating material. Using sensors, the temperatures were recorded during long time periods in different snow layers. The graph shows an example concerning the temperatures in a snow layer within some days in November 2002. The snow layer had a total thickness of 50cms. The measurements were performed in the air above the snow surface and 10cms and 40cms in the snow, under the surface. It becomes obvious that the temperatures in the snow follow the air temperature, time retarded,. Besides this, the dynamic graph of the air temperature is strongly flattened in the snow graphs.

7.2 Conclusions

It seems that snow, rain and ice have an essential influence on the concentration of CO₂ in the air. This observation corresponds to the CO₂ measurements in ice. Possibly in freezing water vapour forming snow crystals or small ice droplets, the content of dissolved CO₂ gas increases strongly. It seems that this effect is much stronger when the air had the chance to interact directly with the surface of open sea water. This could explain that in early spring, when all open water was covered by ice, the variation of the measured CO₂ concentration was only small. When open water was existing again in late May, the CO₂ values rose up to 380ppm during snow fall.

After the snow flakes fell to the ground, snow layers are formed. The snow flakes were compressed and modified in the snow layers to a densely packed material whose microstructure differs from the original snow flakes. Possibly CO₂ gas will be exhausted from the snow during this process. The CO₂ concentration increases in such regions in the snow layer from e.g. 350 ppm up to 530 ppm.

Kinnvika on Nordaustland is a region far away from any essential sources of man made CO₂ emissions. Therefore it is possible to measure the variation of the CO₂ content in air undisturbed by other sources. The careful investigation and understanding of the observed effects may help to describe the complex transportation processes of CO₂ in the atmosphere. Perhaps a contribution to the discussion will be possible concerning the warming up effects of the Earth due to the rising CO₂ concentration in the atmosphere.



8 BACTERIA

8.1 Observations

Besides the investigation of ice the sampling and identification of bacteria living in cold areas was one of the main purposes of this expedition. At three different locations close to Kinnvika samples of bacteria were taken, where possible, every month. The ice samples with the bacteria were packed in special sterile boxes and alternatively conserved in alcohol. Additionally parts of the samples were stored on AGAR plates, to observe the growing process of the bacteria colonies under cold environmental conditions between 0°C and -10°C.

The three locations were:

Air, 1 metre above ground, covered mostly by snow.

Fresh water and ice.

Sea water and ice.

The sample holders were small quartz plates and additionally quartz spheres of 1mm diameter contained in small boxes of stainless steel mesh. Sometimes it was uncomfortable in darkness and during heavy cold winds to find and retrieve the sample containers from the thick, frozen ice layer. This work was made more difficult due to the presence of walrus or polar bears.

Besides this, photos of bacteria colonies were taken in the sea ice. Particularly, a video film in connection with a microscope was produced showing living bacteria in sea ice.

The observations in the sea ice of Kinnvika seem to prove that during all phases of the whole year many different bacteria live in the ice. The continuous cold temperatures seemed not to prevent the vital life of the bacteria.

8.2 Conclusions

The samples with the bacteria were packed and sent to the Biotechnological Institute (Prof. Garbared Antranikian) of TUHH in Hamburg. The occasions for the corresponding shipping procedures were seldom:

Beginning of September 2002 due to the visit of the *Polarsyssel* to Kinnvika.

End of December 2002 due to the Christmas visit of the Governor of Svalbard's with helicopter.

Beginning of May 2003 due to the visit of a helicopter of the Norwegian Coastguard.

July/August 2003 due to the end of the expedition.

In Hamburg the samples of bacteria were investigated using gene technology methods in a corresponding laboratory of Prof. Garbared Antranikian. The bacteria were identified, classified and possibly will be used for applications in food industry and the environmental protection industry.

Pre-results concerning the bacteria samples indicate that many new bacteria living in cold environments could be identified in the group of Prof. Antranikian. More detailed information will be given in the near future by publications of the Institute of Prof. Antranikian.



9 ALGAE and PLANKTON

9.1 Observations

Besides the bacteria also algae on the glaciers and snow surfaces and plankton in the sea fjord of Kinnvika were observed and sampled.

In August 2002 and August 2003 some snow fields directed towards the south and south west looked reddish and green coloured. The microscopic investigation showed that these colours were produced by algae living and growing under certain conditions on the snow surface. At four different locations at the coastline Murchisonfjord (north) and Junodvåtnet samples of snow and algae were taken and afterwards conserved. These samples were sent to Prof. Günter Fuhr in Fraunhofer Institute Biomedical Technique in Berlin. Between Günter Fuhr and Hauke Trinks a co-operation was agreed concerning the sampling and handling of snow algae on Nordaustland during this expedition.

In the coastal waters close to Kinnvika a large number of shrimps, yellow jellyfish and other small organisms were observed and partly sampled. Particularly *Gammarus Wilkitzkii*, *Parathemisto Libellula*, *Ctenophora* and *Enidoblaster* could be seen close to the strand in flat water regions. When in August 2002 a lot of pack ice drifted to the strand at Kinnvika the ice surfaces even under water were inspected. At certain areas thousands of very small shrimps could be seen grazing, like sheep, the algae from the ice surface under water.

In late **October 2002**, as the sea water started to freeze particularly many *Gammarus Wilkitzkii* and *Parathemisto Libellula* could be observed swimming very actively between the small stone on the bottom of the sea. Many of these copulated. In stormy weather and corresponding waves, the shrimps crept under flat stones close to the strand.

In **November 2002** in some cases a few small shrimps (0.5 to 1mm) were observed on the edge of the ice at the strand glowing, when mechanically disturbed, with a bright bluish light even in temperatures of -10°C.

Some of the different shrimps and *Ctenophora* were photographed, filmed in the sea, caught and preserved in alcohol.

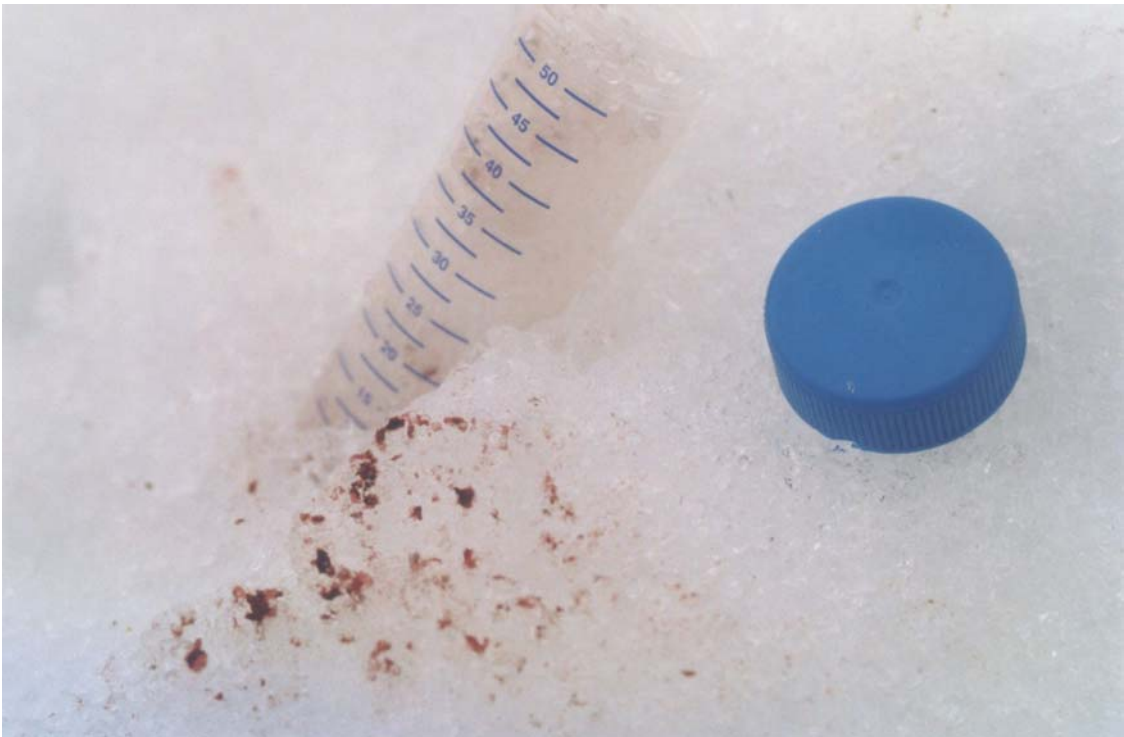
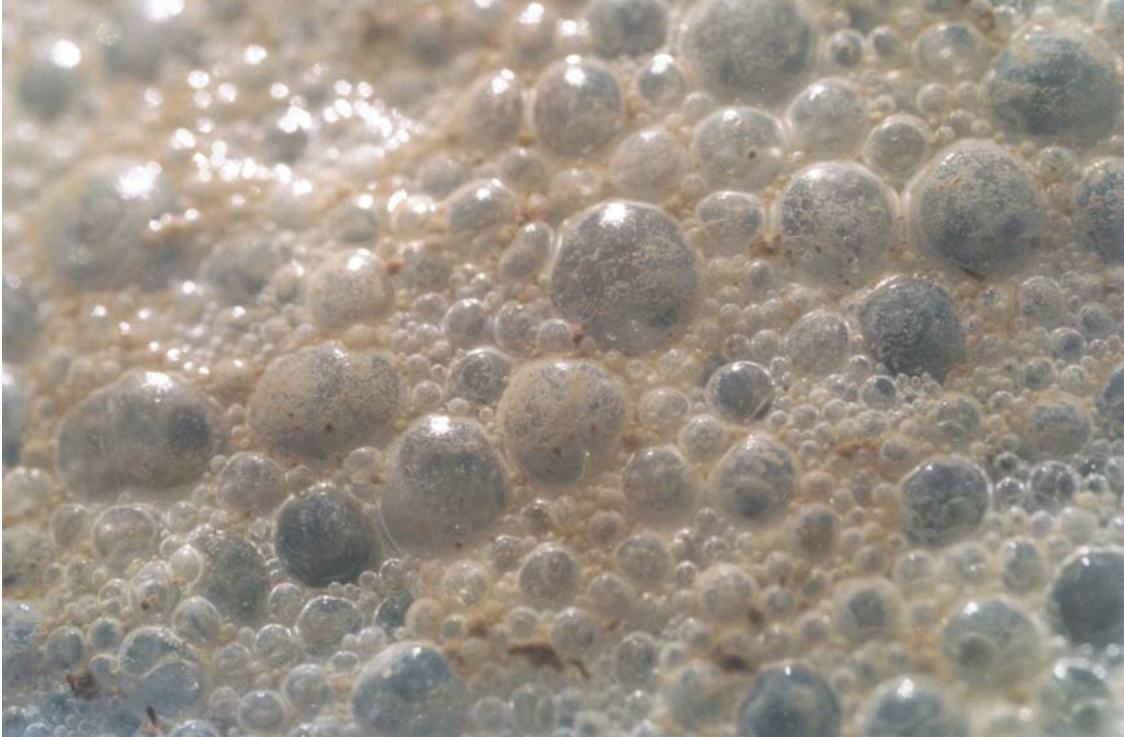
From the beginning of **February 2003**, the first weak daylight appeared. Then, in the ice blocks on the beaches and in the ice layer of small lagunas, the growth of algae was observed.

During **January and February 2003** some frozen jellyfish and *Gammarus Wilkitzkii* were observed in the ice cracks at the strand edge of the Hinlopen Straight. Footprints indicated that a fox sampled and ate some of the frozen shrimps.

During **February 2003** sometimes sea water was forced up through ice cracks onto the snow layer. It happened that *Gammarus Wilkitzkii* were forced onto the ice surface during this process.

In **March 2003**, in some case, *Gammarus Wilkitzkii* (about 2cm long) were transported with the sea water onto the ice surface when a hole was drilled in the ice layer.

Outgoing from such observations it seems that *Gammarus Wilkitzkii* live under the ice or in the ice cracks during all phases of the year, even in the dark time.



In the beginning of **March 2002**, during blizzards, some small droplets (about 3-5mm) containing, probably, snow algae, were blown over the snow fields. The snow algae possibly spawns new colonies at different locations. (Similar observations were made in February and March 2000 in Mushamna, Woodfjord on Svalbard). The red droplets were sampled and sent to Prof. Fuhr.

In March and April 2003, it was tried without success to find under the snow layer some signs of the red algae colonies which were observed in August 2002.

Since the beginning of June 2003 the flowering of algae was observed in the snow, ice and particularly in the little ponds of melt water. The flowering led to various colours in the snow and different structures of scum on the water surfaces. The observed colours were black, like coal dust, yellow, greenish, brown and reddish. It seems that different types of algae flowered during different time phases from June to July at various locations.

Different samples of the algae were taken. The samples were conserved in alcohol and, besides this, investigated under the microscope in a basic manner. Many micro organisms and different types of algae became visible, particularly *Porosira glacialis*, *Nitzschia grunowii*, *Bacterosira fragilis* and *Thalassiosira Antarctica*, were probably identified.

Although insects, of course do not belong to algae and plankton, the following observation are supplied in this chapter.

At the end of May 2003 during snow drift and temperatures below 0°C, locally, between the stones on the beach at Kinnvika, thousands of very small (1mm) black beings jumped around and produced white eggs (less than 0.5mm). Sometimes these beings were observed on water surfaces of little ponds. They seem to live in colonies. Some of them, together with their eggs, were conserved in alcohol and observed under the microscope. Possibly these beings belong to *Tardigrada*.

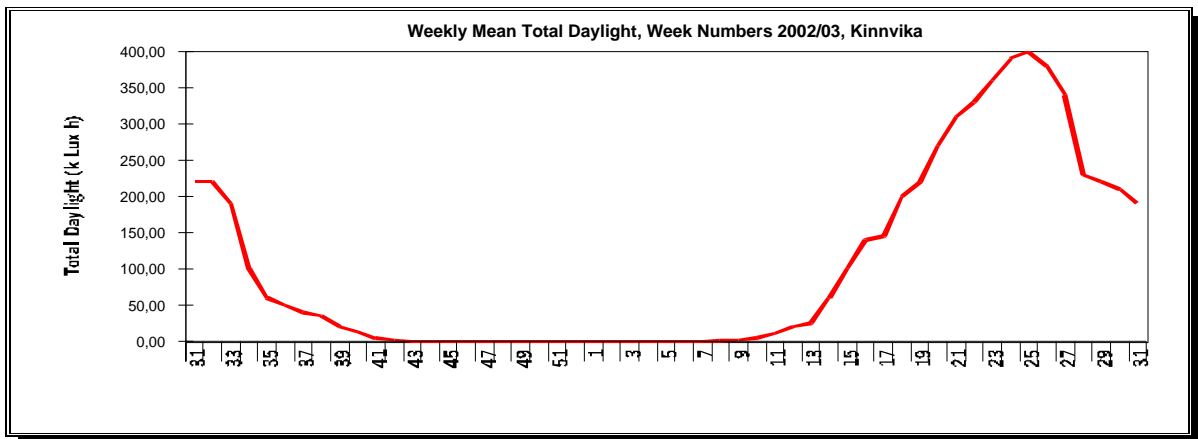
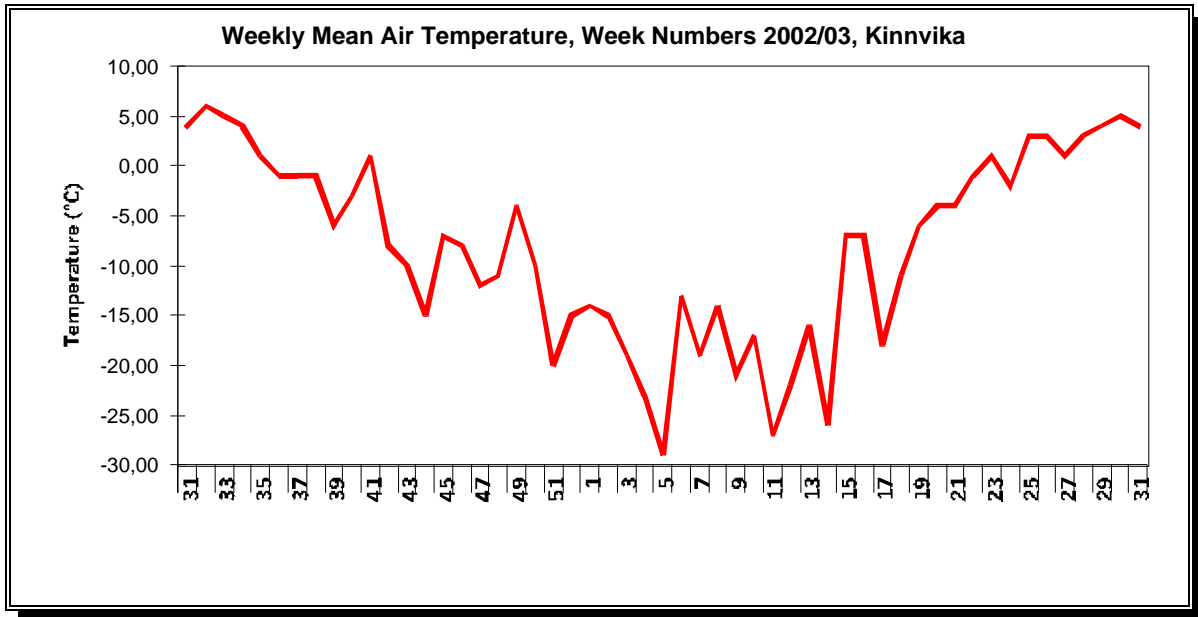
From the beginning of June 2003 at locations free of snow, sometimes various tiny spiders were observed. They seem to be active in temperatures above 0°C.

9.2 Conclusions

Following the observations concerning the micro-organisms living in sea water and sea ice, it seems that during all phases within the year, even in the dark time, vital life exists. *Gammarus Wilkitzkii* particularly showed signs of activity throughout the year.

Already as the first daylight in the beginning of February 2003 appeared, in the ice the growth of algae and plankton could be observed. The flowering of algae seems to take place comparatively late in the year, during June and July. However, many various species could be seen in rich and colourful algae colonies, mostly in the ponds of melted snow.

Although the investigation and identification of algae and plankton were not the main focus of this expedition, it seemed reasonable to perform some observations and to document the results. After the end of the expedition some discussions may be of interest with corresponding experts.



↑↑↑↑↑↑↑↑ ↑
Year 2002

↑ ↑↑↑↑↑↑↑ ↑↑↑↑↑↑↑↑
Year 2003

Shown are the weekly mean air temperature and the weekly mean total daylight during a whole year, 2002/03, at Kinnvika on Nordaustland.

The air temperature and the total daylight are the most important parameters for the growth of the vegetation.

It is indicated with an arrow, ↑ in which weeks the status of some plants was documented by photos.

Some of the photos are shown in chapters 4 and 10.

10 Vegetation

10.1 Observations

Nordautland seems to be, up to now, a not very well investigated area of Svalbard. Therefore during this expedition even the vegetation close to Kinnvika was observed. It became evident that the vegetation was much poorer than in other regions, for example Austfjordneset (Wijdefjord), Mushamna (Woodfjord), Ny Ålesund and Longyearbyen. The ground in most parts of Nordautland close to Kinnvika is covered by sharp stones and gravel. Mostly the area is fairly dry. Only at some minor places the soil is wet, for example in the neighbourhood of melting snow fields or small brooks. Almost continuously, a strong, cold wind is blowing over the flat and unshielded area. The average temperatures on Nordautland seemed to be some degrees Celsius below those measured in the region of Longyearbyen.

It was tried to identify the flowers observed. The following were seen (Norwegian names). For each species the observed start of flowering time is noted (Summer 2003).

Rødsildre	End of May
Tuesildre; Puterublom	Mid June
Svalbardvalmue; Snøarve; Polarvier	Beginning of July
Knoppsildre; Skjørbuksurt; Reinrose; Fjellrapp	Mid July
Trådsildre; Stivsildre; Harerug	End of July
Only in Florabukta:-	
Lappsoleie (?); Setersoleie; Arktisløvetann	Beginning of August

Particularly these flowers were observed systematically during the course of the whole year. Many times during the various seasons of the year, flowers, mosses and lichens were photographed to document the growing phases of the plants.

Besides this, the microclimate at the locations of the flowers was measured continuously using data loggers. By this method, at the end of the expedition some vegetation areas and plants close to Kinnvika were systematically documented over a whole year by photos and corresponding data of the microclimate.

In **August and September 2002** it was observed that even after snowfall and the beginning of very cold weather with temperatures below zero, some plants, particularly Svalbardvalmue and Knoppsildre continued to flower.

In the beginning of **February 2003** some lichens growing on stones and rocks started to show a very bright orange colour shortly after the beginning of the first weak daylight, even at temperatures below -10°C. This effect could be observed at locations which were, due to the heavy wind, mostly free of snow. Some weeks later the bright orange colour faded to a softer shade

In **March/April 2003** it was observed in areas free of snow that tendrils of small plants and moss grew even at cold temperatures. Sometimes even fresh green shoots were seen.

Due to cold temperatures and heavy winds, snow and crusty ice layers covered the soil and the tiny plants repeatedly. However, even when the temperature dropped below -20°C for several days, it seemed that the plants continued to grow slowly.



This situation continued until the end of **May 2003**. Until this time, at some locations, snow hills several metres in height covered the ground. Only in some small areas was the bare soil visible. Sometimes the temperature even at the end of May was below -10°C .

In the middle of **June 2003** it became warmer slowly. The snow started to melt and the soil became very wet. In this period, the observed plants seemed to grow faster and prepared the flowering stage.

In the beginning of **July 2003**, most of the plants had grown and budded and were starting to flower. At the end of July, the leaves became brownish sometimes, and the main phase of flowering came to an end.

In **August 2003**, most of the plants had ceased to flower. The leaves became dry and brown. However, some plants continued to flower, even at temperatures below freezing.

In summer 2003 the vegetation seemed to be poorer than in summer 2002, possibly due to unusually heavy snow and ice conditions.

10.2 Conclusions

Hundreds of photographs form a documentation concerning the observed plants during their various phases of growing in spring, summer, autumn and winter. Together with this documentation the corresponding weather data and microclimate is given. Possibly this documentation could be of interest to some experts.

Outgoing from the observations it seems that the active growing phase of the vegetation is nearly independent of the air temperatures which were, during the whole year, mostly below freezing. However, the existence of light seems to be the most important parameter for growth. It seems particularly, (outgoing from observations made in early spring) that the strong time gradient of the increasing daylight in February stimulates the plants to begin growing, although in February/March, mostly very cold temperatures were measured.

All plants growing under the harsh weather conditions on Nordaustland seem to be well protected against the perilous effects of the plant cells freezing. Besides other effects, the plants seem to be fairly dry giving protection against the freezing conditions. This effect makes the plants fairly immune to the cold temperatures. Consequently, the growth phase for the plants on Nordaustland has the same duration than in warmer climatic zones. However, the speed of the growth of the plants, is, at cold temperatures, much less than that of a warm climate. Consequently the observed plants on Nordaustland show a comparatively small size, even in comparison to the plants close to Longyearbyen.

This phenomenon seems to be similar to the fact that the micro-organisms living in the cold sea water or sea ice have an active life phase within the whole year. Their bodies, by special effects, are protected against perilous freezing effects, similar to the plants on land.



11 Polar Bears

11.1 Observations

During the performance of the expedition, a number of polar bears could be observed which passed and rested close to the huts of Kinnvika, or which hunted seals on the ice. The appearance of each individual bear, its footprints in the snow and the bear's behaviour were carefully observed, described and if possible, documented by photo and film. In some cases the bears staying in the vicinity of the huts could be observed by binoculars during many hours, and even several days. The corresponding documentation of each bear is compiled in a separate **Polar Bear Report** to be found in section 11.3. Some remarks concerning polar bears observed at Kinnvika are given in the following:

Polar bears leave footprints in snow and sometimes on ice. It seems to be possible to characterise and to recognise the bears using these footprints. Outgoing from many observations it was tried to describe the bears footprints during its normal movements by three parameters.

The stride of the walking bear.

The length of his back footprints.

The width of his rear footprint.

It was observed that on certain icy ground covered by a thin snow layer, the signs of the soles of the bears feet became very clearly visible showing characteristic patterns. It seemed to be possible to use these patterns of the soles of the feet to recognise and to identify various individuals. This technique is similar to that used in identifying fingerprints of humans. Some of the observed patterns were documented with photographs and film.

It became obvious that the bears behaviour is quite different in summer and autumn in comparison to winter and spring. Firstly, the observations made in summer and autumn, and thereafter those from winter and spring were compiled. In summer and autumn bears seemed to be very calm and in some respects, friendly.

Summer and autumn bears may be divided concerning their behaviour into four categories:

1. Bears being more or less uninterested in humans, dogs and huts. Those bears ignored us all the time. (about 30%)
2. Bears being fairly shy concerning humans and moving away as soon as they recognised humans or dogs. (about 30%)
3. Bears being curious about humans, dogs and huts. These bears seemed to be interested in contacts without being aggressive. (about 30%)
4. Bears being very hungry or strongly provoked by humans or dogs. Possibly those bears may become aggressive under certain circumstances. (about 10%)

Sometimes bears prefer to stay for several days on the same location doing nothing, only sleeping, resting and observing their environment. These rest places mostly are situated on a higher position allowing a good overlook of the surroundings.



From the observed summer and autumn bears, none of them seemed to be really aggressive. Only in one case, on 25.8.2002, a young female bear with a 6 month old baby made a simulated attack on the dogs close to the huts, however without touching them. In summer the dogs were never attacked by bears. Even in the case when free-running dogs attacked, the bears only tried to defend themselves, refraining from hurting the dogs.

Bears staying close to the huts for several days were not aggressive. It seemed to be possible, without danger, to pass the resting bear at a distance of 50 metres.

To chase away dangerous looking, approaching bears, it proved to be successful to move directly against the bear making noise, for example by banging the metal dog bowls together. The effectiveness of firing single ammunition or warning shots was not good on many occasions. If however warning shots were used, it seemed to be successful to shoot into soil or snow some metres behind or beside the approaching bear. In dark times, it proved to be efficient to chase away bears with strong torch light.

Bears seem to not like to be forced to change the direction of their route or to be forced away. Bears do not seem to like to lose face. This fact should be recognised when meeting a bear or when observing an approaching bear. Try to remain calm, avoid nervous reactions, and don't run away.

The winter and spring bears seemed to be much more active, dynamic and more aggressive than the bears in summer and autumn.

The bears moved fast, they didn't rest for long and they were not shy as in summer. Sometimes they tried to enter the huts.

From February to May, in total three times different bears approached the hut, attacked the lonely, chained dog and tried to kill him. During the corresponding rescue actions of the humans, the bears attacked and seemed to become really dangerous. Mostly they were not reacting fearfully to signal shots.

It became obvious that old, large bears were much more calm and less aggressive than young, adolescent bears.

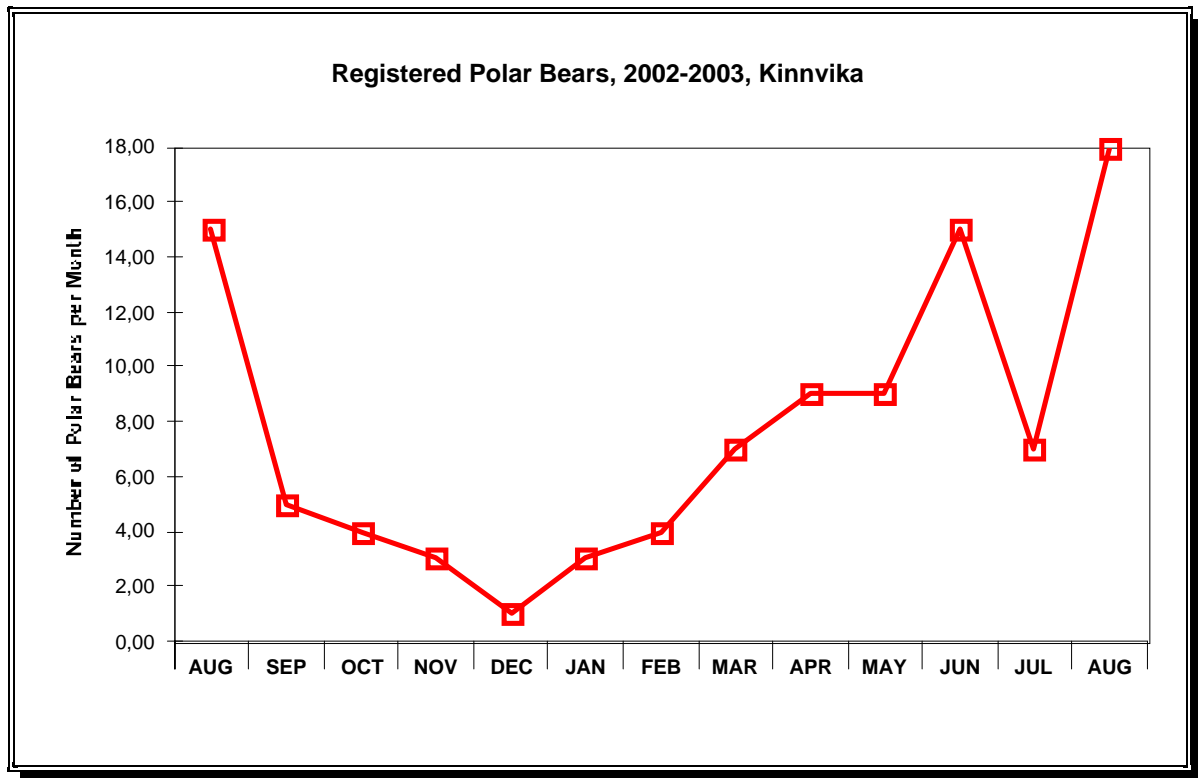
The observed different behaviour of the **summer and winter bears** may be explained by the following reasons:

Polar bears suffer a lot under relatively warm temperatures. Therefore, in summer, they avoid all unnecessary motion and behave calmly.

In the mating season from April to May, bears like to make contact with each other. They follow the footprints of other bears and move fast over long distances.

In summer and autumn 2002, two fairly aggressive dogs stayed close to the huts, barking angrily at each bear that tried to approach the huts. However, from January 2003 only one dog remained who felt sad and shocked by the bears. (The other dog had to be shot due to ill health).





The number of bears which were registered in the vicinity of Kinnvika shows a strong dependence of the year's phases with a minimum in December 2002. Possibly the small number of observed bears may be explained by the darkness. However, most of the registered bears approached close to the huts and would have been remarked even during the dark time.

It seems to be obvious that the bears migrate on tracks following the actual ice conditions. In August 2002, pack ice suddenly arrived in the bay of Kinnvika, together with some seals resting on the ice floes. Consequently, within a few days, a fairly large number of bears arrived and tried to hunt seals.

In the summer of 2003 the ice in Kinnvika Bay remained unbroken until mid July. Sometimes up to 40 seals were visible simultaneously on the ice. That makes understandable the high number of observed bears in the summer of 2003.

The village of Kinnvika from almost all directions, is clearly visible from great distances, of up to 20kms. It seems that most bears visit Kinnvika out of curiosity to inspect the huts. Possibly, therefore, a fairly high number of bears could be registered close to the huts. Besides this, it becomes understandable that most of the close bears were young. The old, adult bears probably know the huts of Kinnvika already, and therefore ignore them.

Most of the registered bears seemed to be different individuals. Obviously they are not local bears staying or living for long time periods in the vicinity of Kinnvika. The bears seem to pass Kinnvika on their tours.

From the registered bears, most animals were single bears. Only six mothers were observed. (Two with one approximately seven month old baby, two with two six month old babies, and two with one and two two year olds). Possibly the living and breeding conditions are not optimal for female bears with young. on Nordaustland.



Further Comments about Polar Bears

In the following, some further comments are given concerning the behaviour of polar bears which were observed on Nordaustland in 2002/03, and besides this, at other locations on Svalbard during the past six years.

Hunting Techniques of Polar Bears

In autumn and spring, bears were observed lying on the smooth ice layers in front of breathing holes of seals, about 10 metres away. The bears lay and waited, similar to a cat in front of a mouse hole, without any motion for many hours, sometimes during a whole night. One of the observed bears stood up in the morning, walked around a little, rolled over in the snow, defecated, and finally went off the ice onto the land where he slept during the day. The following evening he wandered around on the ice from one breathing hole to the next. Finally he decided which of the holes seemed to be most promising. There he spent the next night. After five days he finally killed a big seal looking out of a hole. He dragged the seal about 200m away to a hillock on land and ate it all completely within two days. During this phase, the bear seemed to be restless. He distrusted the glaucous gulls and chased them away angrily again and again. He ate for some hours, thereafter he cleaned his fur and paws carefully in the snow, and rested for a short period close to the carcass. Then the same procedure took place again. After the seal was consumed, the bear appeared to have a fat stomach. Finally, a larger bear arrived, and the first bear fled hastily away. It seems that large bears try to overtake the prey from smaller bears whenever possible. Therefore large bears often look fairly big.

When icebergs and ice floes covered the water, polar bears use to sneak around sniffing carefully, and tried to take, by surprise, a resting seal. The bears hide themselves behind fragments of ice floes. Once, a bear was observed lying on a 5m high iceberg, above a breathing hole in the ice. Suddenly he jumped down in a huge bound and took the seal.

In spring on the bay of Kinnvika, the snow layer was poor. A bear was observed, in the middle of May, following the tidal cracks in the ice, close to the beach. He sniffed into the cracks and sneaked carefully along. Then suddenly he raised himself up onto his back legs and pushed his front paws, two or three times, violently down into the ice crack. Thereafter he forced his head deep into the hole. The bear repeated these actions without success.

When the snow layer on the ice was thick enough, the seal babies were born and hidden under the snow directly on the ice surface. Bears were, in such case, observed sneaking around on the snow field from one flat snow hill to the next and trying to get a seal baby in the above mentioned way, in many cases without success.

In summer bears were observed together with their small babies, swimming to islands, even in rough weather. There they try to get eggs and young birds.

Bears were observed at the strand edge and on the ice suddenly jumping and galloping towards a group of adult ducks, geese or even seals who escaped without problems. Probably the bears tried to test under these circumstances, if possibly one of the birds was unable to fly, or the seal was inattentive or deeply sleeping, which sometimes happens. The bearded seals on the ice seem to be much more inattentive than other seals. The bear has a better chance.

It was observed that reindeer grazed close to a resting bear which took no notice of them.



However it was observed three times that a polar bear tried in March/April to take a sleeping dog, to kill him and obviously to eat him. The bears stood over the dog and bit into the dog's body. It seems that a bear has many more problems to kill a dog than a seal.

Once, in April, a female was observed close to a lane in the ice. The bear dived a couple of times into the sea water and brought up bunches of seaweed from a depth of 3-5 metres. Thereafter the bear and her accompanying baby, ate some of the seaweed. The bear rolled over onto its back in the snow to get dry.

Motion of Polar Bears

It seems that bears move only slowly, however, their speed is fairly high. Even in deep snow they march with an average speed of about 10kms per hour without getting tired. Occasionally the bears trot. A human has, on long distances, no chance to escape a following bear. Under seldom occasions (for example, during hunting activities or being attacked by furious dogs) Bears gallop for short distances. Then the speed is similar to the speed of a running dog. It was observed that a calm moving or even a resting bear began to jump or to gallop within fractions of seconds. The bear's speed running to a sleeping, bearded seal on the ice, once was estimated to be 15m/s.

A bear being on his trek moves over long distances in a straight line without interruption. However, if the bear sees or smells something awaking his interest his motion becomes different:

The bear observed, for example, a hut from a long distance, (1000m) carefully. Then he tried to approach against the wind direction.

While the bear comes closer (100m) he sometimes gapes and sticks out of his mouth his long black tongue many times. In this phase he seems to be curious and undecided what to do. (Twice, however, it was observed that a bear suddenly started to trot at high speed towards the hut or humans, apparently being aggressive).

After a period of some minutes the bear may become more self confident. He approaches much closer (20-50m) and tries to hide himself behind, for example, snow walls. Sometimes he rises up onto his back legs to get a better overlook.

Finally, he is fairly close (1-10m). He inspects, for example, the doors and windows of the hut, tries to climb on to the roof, destroys equipment being stored outside the hut and sometimes shows no fear at all of humans.

Possibly this last phase leads to a simulated or a real attack against the dogs or humans. The bear jumps forward and sometimes stops his motion at the last moment, standing just in front of the dog or human. In such situations he sometimes hisses quietly.

If the bear really attacks, for example a dog trying to kill him, it proved to be extremely difficult and dangerous to chase away the furious, fighting bear.

It was observed that during bad weather, particularly with heavy winds and drifting snow, the bears didn't wander around but preferred to roll up in the snow and rest.



Vocal Sounds of Polar Bears

Bears mostly are silent. Only in a few cases were some vocal sounds heard:

A sleeping bear rolled in the snow was surprised by an approaching dog. The bear jumped up and hissed loudly at the dog who was about three metres away. Thereafter the bear moved away.

A bear rested 50m away beside a hut. A human approached the bear to chase him away. At a distance of 20m the bear started to hiss whilst still lying down. He didn't move away. However as the human started to go retreat backwards, the bear jumped up and made a simulated attack.

A bear approached a human who stood in front of the hut. The bear stopped 5m away and hissed.

Two competing adult bears tried to get seal meat which was stored on a meat rack. Finally they both raised themselves up onto their back legs and fought for some seconds against each other. During this short time phase, they both growled loudly.

A female bear with a little baby was followed, in April, by a huge male bear. The mother fled hastily away with her child, and screamed loudly.

A baby bear (6 months) sat impatiently beside its resting mother. Eventually the baby started to cry loudly, which was audible at a distance of 2km. The mother pushed the baby roughly away and continued to sleep. Thereafter the baby stood about 10m away from the mother and continued whining like a child for many minutes.

Social Life of Polar Bears

Adult male bears and young bears (more than 2 years old) live nearly continuously alone. They normally seem to be disinterested in meeting other bears. Quite the opposite, they avoid approaching less than 50m from each other.

During the mating season in April and May, single bears like to make contact with the opposite sex. However, particularly during this season, mothers with little babies of about 6 months run away, almost in panic, if they notice a large male bear, even at distances of several hundred metres.

Adult female bears are normally accompanied by one or two babies with an age up to 3 years. Once a mother was observed accompanied by two fairly large young bears. The bear group seemed to be very self confident. The group was close knit during their wanderings.

Mother bears suckle their babies several times a day. In May a bear was observed for some days. When she suckled her two young babies (6 months) she sat on her back in the deep snow and held tenderly one in each foreleg, holding them against her breasts. Once in June, another observation was made. A fairly lean bear wandered around with its 18 month old young which looked well fed. Sometimes the mother sat down on her back in the snow and offered to suckle the young bear which appeared almost as big as her. It seemed that the mother loved the close contact to her young.



Two young babies (6 months) were observed together with their mother. The young bears jumped and crawled over the back of the resting mother. The young were not observed play fighting with each other like, for example, young dogs. (Possibly this may be explained by the fact that bears are living solitary lives without the requirement of a group hierarchy. Besides this, the hunting techniques are entirely different).

Grooming Activities of Polar Bears

Polar bears seem to clean their fur carefully nearly all the time. Many times bears were observed rolling over onto their back in the snow during their walks. Having caught a seal, bears clean their paws of blood and fat again and again, particularly the black pads, by rubbing them on the snow surface.

A couple of times it was observed that a adult solitary bear, as well as a baby, climbed onto steep snow hill. Thereafter they slid down on their backs with their paws in the air. This was repeated several times, obviously enjoying themselves at the same time. (It is assumed that the bears tried to clean the fur on their backs The clean fur is important to prevent energy loss).

The bears behave themselves sensitively concerning their heat transfer. At cold temperatures, the bear flops down with the front legs folded under the body, pads facing upwards and tucked into the body. At warm temperatures, bears lie down in the snow on their stomachs and plant their legs wide apart to create sufficient cooling.

Sensitivity to Noise by Polar Bears

Bears react sensitively to noise generated by motor scooters, motor saws or even metal dog bowls being banged together. They seem to hate this noise and mostly move away. On the other hand bears seem to be, in many cases, not impressed with signal shots, shouting of humans or barking of dogs. Sometimes they ignore such noise or become more aggressive. Sometimes it was observed that bears being angry towards barking, chained dogs, jumped towards the dogs and gave them a push with a paw. It seemed that they liked to tell the dogs to be quiet, which warning they obeyed.

To ward off an approaching aggressive bear, it proved to be effective to shoot a rifle bullet into the ground or snow about 1 metre to the side of the bear. To shoot with a rifle into the air seemed generally not to impress the bear.

Humour of Polar Bears

On some occasions it seemed that polar bears like to play with themselves in a humorous way. For example, several times it was observed that a lonely bear held an object between his paws which he had found, such as an empty plastic box, a piece of wood, a flag or even a chair. The bear played with the object, rolling over onto his back and balancing the object on his outstretched legs.

The bears seem to take delight in sliding like a sledge down steep snow banks whilst lying on their backs.



11.2 Conclusions

A large amount of research work concerning polar bears living in the Svalbard area has been, and will be performed in future by the Norsk Polarinstitut. Some of the corresponding results were described in the report No. 160 from the Norsk Polarinstitut, (Tromsø, 2000.) In this report are given some recommendations for further research work.

Outgoing from the observations of polar bears made by Hauke Trinks during his expeditions in Mushamna 1999/2000, (about 70 polar bears) and Kinnvika 2002/2003, (about 100 polar bears) some complimentary recommendations are given.

Counting of polar bears

Additionally to the counting methods described in the above mentioned report of the Norsk Polarinstitut, the following method is proposed.

At certain positions situated close to known migration routes of polar bears automatically operating RADAR traps may be installed similar to the systems used in traffic control. A smell of, for example, seal blubber may entice the polar bear to a certain position. The RADAR trap takes automatically a photo of the bear. The required RADAR systems required already are technically well developed for such application, even in very cold climates. Probably a normal traffic RADAR system with minor technical modifications may be used for the bear counting research work. A restricted number of such RADAR bear traps installed at various locations on Svalbard may help to understand the behaviour and population of polar bears. It is proposed to start a pilot scheme using one or two RADAR traps during a few years to test the effectiveness of this method.

The proposed method is non-intrusive and will not disturb or hurt the polar bears.

Identification of polar bears

The bears footprints and the patterns of the soles may be used for the identification of the bears similar to the corresponding method using fingerprints of humans. It seemed to be possible that the sole prints of the bears may be recorded in combination with the above mentioned RADAR traps. Corresponding pre-experiments could be performed within a pilot scheme.

The proposed method is non-intrusive and will not disturb or hurt the polar bears.

Study of the behavioural psychology of polar bears

Polar bears are fascinating animals, being mostly not at all aggressive towards humans. Up to now numerous scientific efforts were undertaken to understand the population and migration routes of the bears. Comparatively little efforts are known to explore the bears behavioural psychology. The deeper knowledge of this psychology may be helpful to protect bears and to arrange a more harmonic co-existence between bears and humans.

It is proposed to start a corresponding project lasting several years to study the psychological behaviour of the polar bears. For this purpose it seems to be successful that one or two interested humans living in a small hut may observe all bears in their surroundings without disturbing the bears. This hut should preferably be situated close to migration routes of bears or other appropriate sites.

Possibly these three proposed activities may be combined in one single project.



11.3 Polar Bear Report

The following is a complete listing of all polar bears which were noticed at Kinnvika on Nordaustland, Svalbard during the expedition "Life in Ice" from August 2002 until August 2003. Nearly all bears were really observed. Only in a few cases the bears behaviour was derived from their footprints in the snow. It is assumed that probably all of the listed bears were different individuals. The observed bears seemed not to be local inhabitants but animals following their individual treks passing Kinnvika.

No. 1

Date, Time 29.7.02, 16.00-16.30
Size, Age Medium, well fed, 5 years?
Behaviour of bear Arrives from west at beach of Kinnvika. Approaches huts until 50m away and departs to north. Curious and shy.
Reaction of humans None

No. 2

Date, Time 14.8.02, 02.00, until 22.8.02, 0200
Size, Age Medium, thin, unusual light colour, right eye is white, probably very old.
Behaviour of bear Arrived from the beach of Kinnvika, very wet. Close contact with dogs at the hut. Curious, inquisitive, stubborn. Not aggressive and not easily frightened away. The bear liked to stay in close proximity to the huts. Even after aggressive attack by a dog, the bear returned after one day. The bear seemed to be not interested in making attacks. Finally left voluntarily to the north.
Reaction of humans Several fruitless attempts to chase the bear away by the use of signal ammunition, warning shots and noise.

No. 3

Date, Time 21.8.02, 15.00-15.30
Size, Age Small, well fed, young, about 3-4 years old.
Behaviour of bear Arrived from west until 100m from the hut. Curious and shy, he approached. He moved fairly fast to the north after the dogs started barking.
Reaction of humans None.

No. 4

Date, Time 22.8.02, 19.00-20.00
Size, Age Large, well fed, probably male, 8-10 years old.
Behaviour of bear He arrived from the west and passed the huts at a distance of 100m. The bear looks confident and uninterested in huts, dogs or humans. He moved on the ice flakes on Kinnvikafjord
Reaction of humans None



No. 5**Date, Time**

23.8.02, 18.00 until 24.8.02, 10.00

Size, Age

Medium, well fed, probably adult.

Behaviour of bear

He arrived from the west, dug a gravel bed on the beach at Kinnvika, where he slept and rested, observing the ice in the bay. He seemed to be confident and was not intimidated by a human approaching to 50m taking photos. After one day resting, the bear continued his journey to the east following the beach.

Reaction of humans

None.

No. 6 - 13**Date, Time**

24.8.02, 16.00 until 26.8.02

Size, Age

In total 8 different bears were observed on the drift ice in Kinnvikafjord. One huge, fat female bear together with her 6 month old young, could be identified. The other bears were 3 big adults and 3 younger bears.

Behaviour of bear

The bears were hunting seals on the ice. At least 3 seals were caught. The bears maintained a distance between each other of at least 20m. Sometimes the younger bears were running, apparently to get at the remains of the seals. The bigger bears had red, bloody faces from eating the seals. Some bears rested on the ice for many hours, having eaten seals. One large adult with a fat stomach left the ice finally and went halfway up Kinnberget, about 50m above sea level. There he rested 36 hours, and returned to the ice. Afterwards he went back to Kinnberget, about 80m a.s.l. and rested another day. Finally he vanished over the ice.

Reaction of humans

None.

No. 14 and 15**Date, Time**

25.8.02, 15.00 until 26.8.02, 16.00

Size, Age

Small, young female with baby (6 months).

Behaviour of bear

The bear arrived from the drift ice of Kinnvika, approaches the rubber boat at the beach, and destroys the boat with teeth and claws within one minute. Thereafter the baby started to run towards the huts. The mother followed her baby. Finally she passes the baby and hurried towards the huts. The two big dogs fixed on their chains close to the hut, barked very aggressively. The adult bear moved less than one metre close to the dogs, and simulated an attack against the dogs. Finally she hurried away following her baby which returned to the beach at the beginning of the fight. The following day, both bears approached the huts another time, to within 100m. They vanished after a warning shot.

Reaction of humans

Warning shots and noise.



No. 16**Date, Time**

31.8.02, 14.00 until 19.00

Size, Age

Large adult, well fed.

Behaviour of bear

The bear arrived from the west, along the beach and passed the huts at a distance of 100m. Thereafter the bear rested about 200m away, observing the huts. After 4 hours resting, approached, apparently curious, the beach, where two humans were working. The humans were going back to the huts, the bear following slowly. One of the dogs broke his chain and tried to attack the bear. The bear ran away on the ice on the fjord of Kinnvika. The dog tried to follow the bear jumping from ice flake to ice flake but finally gave up. Thereafter the bear moved slowly to the west over the ice.

Reaction of humans

None

No. 17**Date, Time**

8.9.02, 04.00, until 9.9.02, 05.00

Size, Age

Medium adult, not well fed.

Behaviour of bear

The bear arrived from the west and passes the hut at a distance of 50m. Thereafter he moved to the beach. Next night he returned, and approached to within 10m of the hut. He moved away to the west after the dogs started to bark.

Reaction of humans

None

No. 18**Date, Time**

13.9.02, 06.30 until 07.30

Size, Age

Large adult, light coloured. not well fed.

Behaviour of bear

The bear arrived from the east along the beach and passed the huts at a distance of 100m. Following the beach, he went to the west ignoring the huts. He rolled on his back in the snow, thereafter he vanished.

Reaction of humans

None.

No. 19**Date, Time**

14.9.02, 00.30. until 19.9.02

Size, Age

Medium, (young ?), not well fed, grey coloured, very black face.

Behaviour of bear

The bear sneaks round the huts at a close distance, and approached the sleeping dogs against the wind until 2m away. He moved very slowly away being confident and not worried about the barking dogs or the shot of signal ammunition. He seemed to be curious but not aggressive. Finally he moved to a lonely rock 10m above sea level, 300m away from the huts. There he rested, observed the huts, slept and sometimes stood without any movement for hours. He stayed at the rock for 5 days, digging out two snow beds.

Reaction of humans

One signal warning shot in the first night.



- No. 20**
Date, Time 16.9.02, 02.30 until 03.00
Size, Age Large adult, not well fed.
Behaviour of bear The bear arrived from the east and approached the huts until 10m away, fairly fast against the wind direction. He moved on a small circle close to the huts and vanished to the north after the dogs started barking.
Reaction of humans None
- No. 21**
Date, Time 24.9.02, 18.00 until 18.30
Size, Age Very large adult, very well fed. (Looks like an elephant in size!)
Behaviour of bear The bear arrived from the east. He approached the hut until 50m away and lay down confidently observing the hut. A human went slowly against the bear making loud noise with the metal dog bowl. The bear stood up and went away to the east fairly fast.
Reaction of humans Noise.
- No. 22**
Date, Time 9.10.02, 16.00 until 17.00
Size, Age Medium adult, black face, not well fed.
Behaviour of bear The bear arrived from the north and approached the huts. He moved between the huts, very close and curious, finally going away to the west. During this phase, no humans or dogs were at the huts. About 200m away from the huts, the bear met 2 humans with 2 dogs. The bear continued to move in his original direction without any reaction. The humans and the dogs moved to the side, about 50m, and let the bear pass.
Reaction of humans None
- No. 23**
Date, Time 14.10.02, 11.00 until 11.30
Size, Age Medium adult, very well fed.
Behaviour of bear The bear arrived from the east along the beach. At a distance of 300m to the huts, he changed his marching direction to the north and vanished.
Reaction of humans None
- No. 24**
Date, Time 17.10.02, 11.00 until 11.30
Size, Age Medium adult, not well fed.
Behaviour of bear The bear arrived from the east following the beach. He passed the huts at a distance of 100m and vanished to the north.
Reaction of humans None



- No. 25**
Date, Time 23.10.02, 19.30 until 24.10.02, 02.00
Size, Age Medium, young, not well fed.
Behaviour of bear The bear approached very close to the hut, (1m) against the wind and passed the barking dogs, confident at a distance of 2m. The bear moved slowly away after much noise was made by the humans. The following night he approached the hut another time, and moved slowly away to the east, after a signal shot was fired.
Reaction of humans Noise and signal shot.
- No. 26**
Date, Time 2.11.02, 06.00 until 06.30
Size, Age Medium
Behaviour of bear The bear walked from the east following the beach to the west, ignoring the huts.
Reaction of humans None.
- No. 27**
Date, Time 24.11.02, 15.00 until 15.30
Size, Age Large adult, not well fed.
Behaviour of bear The bear approached the huts from north west. He went very close to the silent dogs, and made contact. He seemed to be non-aggressive but curious. After humans made bright light with a powerful torch, the bear moved slowly away to the west.
Reaction of humans Use of powerful torch.
- No. 28**
Date, Time 28.11.02, 02.00 until 02.30
Size, Age Large adult, not well fed. (Possibly the same bear as No. 27)
Behaviour of bear The bear sneaked around the huts several times at close proximity. He made contact to the dogs and attacked them. The bear made no reaction to the powerful torch. Finally; after the use of signal ammunition and warning shots; the bear moved away to the north west.
Reaction of humans Use of signal ammunition and warning shots.
- No. 29**
Date, Time 22.12.02, 0200-0230
Size, Age Medium, adult, not well fed.
Behaviour The bear arrived from the south over the ice of Kinnvika Bay. He destroyed a measurement on the ice and approached the huts. There he damaged a container filled with coal and tried to attack one of the dogs. Thereafter he sneaked around the Reserve House and smashed one of the windows. He hurt himself on one front paw, by the glass fragments. Possibly, therefore, he went away to the west, leaving some blood drops in his footprint.
Reaction of humans None



No. 30	
Date, Time	25.1.03, 0800-1100
Size, Age	Medium adult, well fed
Behaviour	The bear arrived from the south over the ice and approached the huts. He sneaked around very close and inspected, besides others, the damaged but repaired window. Thereafter he dug down into the snow behind another hut and slept. When two humans and one dog approached him, he jumped up and hissed angrily. Finally he disappeared to the west.
Reaction of humans	One signal shot.
No. 31	
Date, Time	27.1.03.
Size, Age	Medium.
Behaviour	The bear passed from south the Kinnvika Bay, ignored the huts, and went over the ice to the west towards Hinlopen Straight. He inspected open lanes and icebergs trapped in the ice. (Bear not observed, footprints only.)
Reaction of humans	None.
No. 32	
Date, Time	30.1.03, 0800
Size, Age	Medium
Behaviour	The bear came from the south over the ice and passed the huts at a distance of 100 metres, moving towards the north. (Bear not observed, footprints only)
Reaction of humans	None
No. 33	
Date, Time	9.2.03, 0600-0630
Size, Age	Medium
Behaviour	The bear approached the huts from the west, sneaking around right up to the reserve house. Finally he went south over the ice.
Reaction of humans	None
No. 34	
Date, Time	20.2.03, 0800-0830
Size, Age	Very large.
Behaviour	The bear approached from the south over the ice, he passed the huts at a distance of 100metres and went to the north.
Reaction of humans	None
No. 35	
Date, Time	27.2.03, 0800-1300
Size, Age	Medium, circa five years, well fed
Behaviour	The bear arrived from Kinnvika Bay and approached the huts until 50 metres away. He seemed to be shy and went back out onto the ice.
Reaction of humans	None



No. 36	
Date, Time	27.2.03, 1000-1800
Size, Age	Large, adult, well fed
Behaviour	The bear tried to hunt seals on the ice. He approached the huts until 100metres away, thereafter he went back to the ice. Later he was observed being red faced; having fed on a seal. The bears, Nos 35 and 36, tried to avoid contact with each other, being on the ice at the same time.
Reaction of humans	None
No. 37	
Date, Time	1.3.03, 1000
Size, Age	Medium, c. five years old, well fed.
Behaviour	The bear was possibly identical with No. 35. The bear wandered over the ice to the south.
Reaction of humans	None
No. 38	
Date, Time	1.3.03, 1000-1800
Size, Age	Large adult, well fed
Behaviour	The bear came from the south over the ice. He inspected the huts closely and approached near to the dog. Later he went to a parked, unmanned helicopter and investigated the instrumentation through he windows, whilst standing on his back legs.
Reaction of humans	None.
No. 39	
Date, Time	6.3.03, 0530-0600
Size, Age	Medium, well fed.
Behaviour	The bear sneaked around close to the huts. He made direct contact with the sitting dog, possibly to prepare an attack. After the humans knocked loudly at the window he went back to the ice.
Reaction of humans	Noise
No. 40	
Date, Time	7.3.03, 0600-1400
Size, Age	Large adult, well fed
Behaviour	The bear arrived from Kinnvika Bay. He inspected the fuel barrels and finally climbed up onto them. He crept close to the huts, approaching the filming humans, as close as 5 metres away, hissing angrily. He left to the south, on the ice.
Reaction of humans	One signal shot.



	No. 41
Date, Time	10.3.03, 1200-1300
Size, Age	Large, adult, not well fed, light coloured.
Behaviour	The bear arrived from the south and sneaked round the huts. He tried to climb onto the roof of the Reserve Hut. He inspected and finally destroyed measurement devices. Finally he wandered off to the west when humans approached the huts after being out on tour.
Reaction of humans	None.
	No. 42
Date, Time	23.03.03.
Size, Age	Small, c 3 years.
Behaviour	The bear wandered over the ice of Claravågen from south to north. (Bear not observed, footprints only)
Reaction of humans	None
	No. 43
Date, Time	29.03.03, 0430-0500
Size, Age	Medium
Behaviour	The bear attacked the sleeping dog, 1 metre from the hut. He tried to kill the dog. The dog (approximately 60 kgs) unsuccessfully defended himself. The humans rushed out hearing the noise, and fired two signal shots. The bear attacked the humans immediately. They fled back into the hut. The bear continued to attack and to bite the shocked dog. Finally Hauke beat a snow spade over the bear's head. Thereafter the bear again attacked Hauke who fled again into the hut. After a couple of similar events, throwing stones and an axe at the furious bear, he finally released the dog reluctantly and moved off a short distance. After warning shots to the side of the bear, the bear vanished. (the dog survived though being hurt, however the dog remained afterwards shocked and refused to watch for bears. Outgoing from this experienced, the dog continued to live mostly inside the hut.)
Reaction of humans	Signal and warning shots.
	No. 44
Date, Time	12.4.03, 0700-0730
Size, Age	Medium, not well fed.
Behaviour	The bear arrived from the west and crept around the huts. When Hauke and the dog came out of the hut, the bear immediately attacked angrily from a distance of about 5 metres. After some dramatic scenes and warning shots, the bear finally vanished to the south.
Reaction of humans	Two warning shots.



No. 45	
Date, Time	12.4.03, 1500-1530
Size, Age	Large adult, well fed
Behaviour	The bear followed the footprints of No. 44, approached the hut, but seemed to be not aggressive. He finally left the hut following No. 44.
Reaction of humans	None
No. 46	
Date, Time	14.4.03, 0800-1400
Size, Age	Very large, old, dirty.
Behaviour	The bear arrived from the north west. He passed over the ice of Kinnvika Bay very slowly and finally rested on the ice. He seemed to be ill, passing liquid motions and vomiting up blood. He eventually moved over the ice to the south, occasionally lying down and rolling backwards and forwards in the snow as he went.
Reaction of humans	None
No. 47	
Date, Time	14.4.03, 2230-2300
Size, Age	Large adult, well fed
Behaviour	The bear suddenly stood in front of the door into the hut. He seemed to be very self confident but not aggressive. He left, finally, to the north.
Reaction of humans	One warning shot.
No. 48	
Date, Time	17.4.03, c 0600
Size, Age	Medium
Behaviour	The bear wandered from the east along the beach at Kinnvika. He inspected the measurement devices and vanished to the west. (Bear not observed, footprints)
Reaction of humans	None
No. 49	
Date, Time	17.4.03, 1200-1230
Size, Age	Very large, adult, well fed
Behaviour	The bear arrived from the west and wandered to the south east over Kinnvika Bay ignoring the huts.
Reaction of humans	None
No. 50	
Date, Time	17.4.03, 1600-1630
Size, Age	Medium, well fed,
Behaviour	The bear came close to the huts and wandered to the south east.
Reaction of humans	None



- No. 51**
Date, Time 21.4.03, 2300-2330
Size, Age Medium, well fed, possibly had 6 instead of 5 toes on front paw.
Behaviour The bear sneaked around the huts. He tried to open the door and looked into the windows of the hut. He seemed to be aggressive and jumped angrily at Hauke who had left the hut to chase away the bear. The bear was not impressed with a signal shot. Finally Hauke started to sing to the listening bear at a distance of 5 metres. The bear became calm and friendly and left finally. (This method was read in an old hunter's diary)
Reaction of humans One signal shot and singing.
- No. 52**
Date, Time 28.4.03, c 0800
Size, Age Medium.
Behaviour The bear meandered along Hinlopen Straight to the north. He inspected Ruud's Hytte on the beach at Hinlopen Straight. (Bear not observed, footprints)
Reaction of humans None
- No. 53**
Date, Time 3.5.03, 1400-1430
Size, Age Medium, well fed, light coloured.
Behaviour The bear wandered from the south over the ice and passed the huts at a distance of 50 metres. He seemed to be shy and left heading north.
Reaction of humans None
- No. 54**
Date, Time 4.5.03, 0600-0630
Size, Age Small, young.
Behaviour The bear sneaked around close to the huts and looked in at the windows, finally vanishing westwards.
Reaction of humans None.
- No. 55**
Date, Time 4.5.03, 1700-1730
Size, Age Large adult, well fed.
Behaviour The bear came from the south over the ice and destroyed a measurement device. He eventually approached the huts and crept sneakily close. He looked into the windows, and then damaged another measurement device. Besides this, he ripped up, with teeth and claws, a Union Jack flag and the upholstery of an outdoor chair. As Hauke moved out of the hut to prevent further destruction, the bear attacked him and seemed very aggressive. Hauke fled into the hut. After 15 minutes, Hauke rushed out again, shooting two signal shots in rapid succession close to the bear who was sitting near to the hut. The bear finally moved away nonchalantly, to the north.
Reaction of humans Signal shots.



No. 56	
Date, Time	6.5.03, 1600-1630
Size, Age	Medium, young.
Behaviour	The bear neared from the south and sneaked around close to the huts. He looked into one window and tried to destroy it. He damaged some measurement equipment and eventually headed off to the west.
Reaction of humans	None
No. 57	
Date, Time	10.5.03, 0800-0815
Size, Age	Large adult, well fed, light coloured.
Behaviour	The bear arrived slowly across the ice from a southerly direction. He passed the huts at a distance of about 200 metres. He ignored the huts and continued his walk to Hinlopen Straight.
Reaction of humans	None.
No. 58	
Date, Time	15.5.03, 2330-2400
Size, Age	Large adult, underfed.
Behaviour	The bear prowled close to the huts during a blizzard. He seemed to look into the windows and finally marched over Kinnvika Bay to the west.
Reaction of humans	None
No. 59	
Date, Time	16.5.03, approx. 0600
Size, Age	Medium
Behaviour	The bear sneaked close to the huts, touching the windows. Possibly he followed bear No. 58. (Unobserved, footprints only).
Reaction of humans	None
No. 60	
Date, Time	17.5.03, approx. 0400
Size, Age	Medium
Behaviour	The bear prowled around the huts, possibly following Nos. 58 and 59. He tried to climb onto the hut roof. (Unobserved, footprints only).
Reaction of humans	None



No. 61	
Date, Time	18.5.03, 1600-2100
Size, Age	Large adult, well fed.
Behaviour	The bear came over Kinnvika Bay following the cracks in the ice close to the strand. He sniffed the ice cracks several times and tried without success to catch seals under the ice. To do this, he rose up onto his back legs and pounced onto the top of the snow covered breathing holes in the ice cracks. Finally he went towards Hinlopen Straight, ignoring the huts. He rested for four hours 400m from the huts, and thereafter vanished to the west.
Reaction of humans	None.
No. 62	
Date, Time	2.6.03, 1700-1900
Size, Age	Large adult, not well fed.
Behaviour	The bear wanders around on the flat ice of Murchisonfjord from one seal to the next. The seals disappeared into their holes when the bear approached up to about 100m away.
Reaction of Humans	None
No. 63	
Date, Time	3.6.03, 1600-1800
Size, Age	Medium adult.
Behaviour	The bear wandered slowly over the ice of Murchisonfjord to the west.
Reaction of Humans	None
No. 64	
Date, Time	4.6.03, 0800-0900
Size, Age	Small, young.
Behaviour	The bear sneaks close to the huts and finally disappears to the west.
Reaction of Humans	None
No. 65-67	
Date, Time	8.6.03
Size, Age	One adult and two two year olds.
Behaviour	A large bear together with two smaller bears move along the ice edge of the inner Murchisonfjord, trying to hunt seals in the ice cracks. Probably a mother with two youngsters. (Unobserved, footprints only).
Reaction of Humans	None



- No. 68**
Date, Time 15.6.03 to 16.6.03, 2200 to 1000
Size, Age Large adult, well fed
Behaviour A very big, adult bear arrived over the ice from the south. He plays with some wood pieces on the ice, rolling over onto his back in the snow. He carefully inspects measurement devices and finally lays down some metres in front of a breathing hole of a seal. After two hours he went towards Hinlopen Straight.
Reaction of Humans None
- No. 69**
Date, Time 20.6.03, 0900-2000
Size, Age Medium adult.
Behaviour The bear wandered around on the ice of Murchisonfjord looking to the seals on the flat ice which disappear one after the other into the water. The bear breaks through the ice and crawls back onto the ice edge.
Reaction of Humans None
- No. 70**
Date, Time 23.6.03, 0900-1100
Size, Age Large adult, white colour
Behaviour The bear moved around very fast on the ice of Murchisonfjord from one seal hole to the next without a chance to catch one of the seals. Finally he disappeared towards Hinlopen Straight.
Reaction of Humans None
- No. 71**
Date, Time 23.6.03, 1300-1400
Size, Age Small, young, (3 years?)
Behaviour The bear arrived from the north, sneaked around the huts and tried to climb on the roof of the dwelling house wherein Hauke was working. The bear seemed not to be impressed with the running electric power generator making noise. The bear sniffed at the door of the reserve house. Finally a signal pen was fired, however the bear showed no fearful reaction. After shooting one warning shot into the snow beside the bear, he moved hesitatingly to the ice of Kinnvika Bay.
Reaction of Humans Signal shots.



	No. 72
Date, Time	23.6.03, 1500-1530
Size, Age	Very big adult, yellow coloured.
Behaviour	The bear arrived from the north passing a grazing reindeer at a distance of about 20m without reactions. Finally he approached the huts without hesitation. At a distance of 30m a warning shot was fired into the snow beside the bear. He turned round and galloped away to the ice of Kinnvika Bay.
Reaction of Humans	Signal shot.
	No. 73-75
Date, Time	28.6.03, 0900-1200
Size, Age	Large adult and two six month old babies.
Behaviour	The mother was observed standing and lying on the ice close to an ice crack where the day before a seal was seen. The mother lay or sometimes stood without any motion for hours, watching the breathing hole. The babies slept close together on the ice at a distance of about 100m from the hunting mother. Finally the babies awoke and moved around on the land close to the ice, sometimes out of the sight of the mother. The mother finally gave up waiting in front of the ice crack and moved slowly away following the ice edge close to the land. She always observed attentively the ice cracks. Only occasionally did she take a short look at her babies. The babies followed their mother at a distance of between 100-200m.
Reaction of Humans	None.
	No. 76
Date, Time	29.6.03, 1500-1600
Size, Age	Very big adult, well fed.
Behaviour	The bear approached the hut from the ice and passed the hut curiously at a distance of about 20m then followed his original trail to the north.
Reaction of Humans	None
	No. 77
Date, Time	3.7.03, 0900-0930
Size, Age	Medium adult, well fed.
Behaviour	The bear came over the Kinnvika ice and approached curiously to the hut. He sneaked around and looked carefully in all windows at a distance of less than 1m. As Hauke went out of the hut the bear fled, frightened, galloping several hundred metres back to the ice. He ignored the next approaching bear, number 78.
Reaction of Humans	None.



Date, Time Size, Age Behaviour	<p>No. 78 3.7.03, 0930-1030 Large adult, old, meagre, white coloured. The bear approached the huts slowly, coming from the ice, where many seals rested. He looked systematically after something to eat in the vicinity of the huts. Besides other things, he dug down deep into the snow close to the hut. He sneaked several times very close to the hut, looking in all the windows and pressing his nose against the glass. Hauke finally went out and filmed the bear at a distance of 10-50m. The bear approached the human ignoring the noise made by banging the metal dog bowls together. Hauke fled and threw his jacket and hat into the snow. The bear stopped for a few seconds at the clothes and damaged them immediately. (This flight method seems to work very well to give further time). Finally a signal pen shot was fired without a fearful reaction from the bear. After the firing of a warning shot beside the bear, into the ground, he fled in a northerly direction.</p>
Reaction of Humans	Signal shots.
No. 79 Date, Time Size, Age Behaviour	<p>9.7.03, 0900-1000 Small, young (3 years?). The bear ran around on the ice of Kinnvika Bay, restless, in heavy fog. Sometimes he trotted long distances from one seal to the next without success. He galloped about 100m to a piece of wood on the ice. Due to the warm temperature of +4°C, the bear obviously suffered under the heat. All the time he had his mouth open like a panting dog. After his hunting actions the bear took a bath in one of the little pools of melt water on the ice surface. Thereafter he rolled over in the snow. Finally he approached the huts directly, becoming faster and faster. At a distance of 50m he started to trot towards the hut looking fairly aggressive towards the humans outside the hut. The bear seemed to prepare an attack. After a signal pen was fired at a distance of 30m against the bear he stopped and then moved slowly away from the hut to the west.</p>
Reaction of Humans	Signal shot.
No. 80 Date, Time Size, Age Behaviour	<p>12.7.03, 2000-2100 Large adult, well fed. The bear moved around on the ice at Kinnvika and tried to hunt seals on the ice. The seals jumped into their holes as soon as the bear was 100m away. Finally he approached a big, sleeping bearded seal. At a distance of 25m he started to suddenly gallop, with a surprisingly high speed of about 15m/s. The seal jumped into the water just ahead of the bear who dived in behind the seal without catching it. Thereafter the bear climbed out of the water and continued his march towards inner Murchisonfjord.</p>
Reaction of Humans	None



- No. 81**
Date, Time 18.7.2003, 1200-1230
Size, Age Medium, well fed, unusually white.
Behaviour The bear arrived from the south over the ice of Kinnvika. He wandered from one seal to the next on the ice, without success. Finally he went towards Hinlopen Straight.
Reaction of Humans None.
- No. 82**
Date, Time 23.7.2003, 1600-1630
Size, Age Medium, not well fed.
Behaviour The bear approached the huts and sneaked around, less than 5m away. He seemed to be very self confident and not reacting to signal shots. The two arctic skuas nesting close to Kinnvika, attacked him without success. Finally, Hauke threw a snow shovel at the bear, hitting him. Thereafter the bear wandered over the Kinnvika ice, heading south.
Reaction of Humans Signal shot and hitting bear with snow shovel.
- No. 83**
Date, Time 26.7.2003, 0900-1000
Size, Age Medium, Not well fed, (possibly identical to No.82).
Behaviour The bear arrived from the south following the beach of Kinnvika. He passed a nesting eider duck at a distance of less than 10m without finding it. Thereafter he passed the young of the arctic skua at a distance of about 10m without reaction. As he approached the huts he was chased away by noise and a signal shot. He went back to the beach and began to dive between the ice floes in the shallow water, approximately 1-2m deep. He dived around 10 times with a duration of 10-30 seconds each time. Thereafter he went towards Hinlopen Straight. (The location of the diving activities was later inspected. It was observed that many small shrimps, 1-3cm long, and additionally small fish lived under and between the flat stones on the sea bed. It is assumed that the bear caught some of these creatures).
Reaction of Humans Signal shot and noise.
- No. 84**
Date, Time 1.8.2003, 1100-1200
Size, Age Large adult, not well fed, calm.
Behaviour The bear followed the beach of Kinnvika. He showed no interest in humans or the huts. Finally he went into the water between the ice floes and swam about 1km across Kinnvika Bay towards Hinlopen Straight.
Reaction of Humans None



	No. 85
Date, Time	6.8.2003, 0800-0900
Size, Age	Large, meagre, old, very slow.
Behaviour	The bear followed the beach at Kinnvika from the south. He went over the tundra in a north westerly direction to Hinlopen Straight, ignoring the huts.
Reaction of Humans	None.
	No. 86
Date, Time	7.8.2003, 0200-0300
Size, Age	Large, not well fed, obviously hungry.
Behaviour	The bear sneaked around close to the huts. He looked into the window and eventually shredded a rug left drying outside. A signal shot made no impression on him. Eventually, after a warning shot into the ground beside the bear, he went hesitantly to the south, following the strand.
Reaction of Humans	Signal pen and warning shot.
	No. 87-89
Date, Time	7.8.2003, 1400, until 9-8-2003, c0200
Size, Age	Mother: Medium, lean. Two babies: 7 months, well fed. One of the babies seemed to have an inflamed eye.
Behaviour	The bears arrived at the huts, from (probably) the north. The mother seemed to be very self confident together with her babies, and crept close around the huts and inspected all doors and shelters carefully. She showed no reactions to humans filming the bears, at a distance of less than 20m. Eventually she started to eat some rotten potatoes near the huts, and then all the bears ate old human excrement for two hours. Hauke tried to chase them away with noise and throwing stones. The bear family showed no reaction. Then Hauke threw a snow shovel at them from a short distance of about 10m and almost hit the mother. She looked at Hauke and hissed. Thereafter the bears went through the rocks and climbed almost to the top of Kinnberget. There on a snow field, the mother dug out a comfortable chair and suckled her babies for 10 minutes at 2300. The mother was sitting like a human, holding a baby to each breast. After feeding, all bears went a few metres further up the snow slope and lay down to sleep for about 4-5 hours. Thereafter the bears descended Kinnberget and returned to the huts to continue eating the human excrement. At 0300 (8.8.2003) the bears finally went behind the main hut to rest again. The two babies often climbed curiously through the open door and into the outside toilet. After 0400, (8.8.2003), the bears No. 90-91 arrived and obviously chased away this family away up into the mountains. At 0900 (8.8.2003), the family returned from the mountains and rested at a distance of about 400m from the huts and No. 90-91. There the mother again fed the babies.



On 8.8.2003 at 2230 the family tried to approach bears No.90-91. They tried to creep around but obviously the mother was too wary to come closer. During these approaching manoeuvres lasting about two hours, the babies mostly kept close to the mother.

Finally the bear family disappeared overnight.

Noise.

Reaction of Humans

No. 90-91

Date, Time

8.8.2002, before 0800, until 10.9.2003, 1000

Size, Age

Mother: Large, lean. One eye inflamed. Baby: 1½ years, well fed.

Behaviour

The bears arrived during the night and obviously chased away the previous bear family, No87-89. Thereafter they went between the huts and eventually started to eat for some hours, the human excrement. The bears seemed to be self confident, however, not aggressive at all. They showed no fear or aggression towards the humans filming at a distance of less than 20m. Finally, about 1000, the two bears went about 100m away from the huts. The mother lay down to rest, changing her sleeping place twice, until 1600. The youngster went alone into the mountains, climbing on sharp rocks, like a goat. It seemed to be interested in making contact with the other bear family resting about 100m away. At 1600 both bears came back to the huts and began eating human excrement again.

On 9th August the family No.90-91 stayed much of the day close to the huts at a distance of about 50-200m resting and eating human excrement. The young bear sometimes moved away on his own for a long walk, and returned after several hours. Hauke tried to chase the bears away by noise. The mother was forced away to a distance of 100m without showing aggression. The young bear stayed watching the approaching human confidently. Finally, at a distance of 20m Hauke stopped approaching the bear and retreated slowly. The bear lay down and slept.

At 1000 (9.8.2003) a large bear No.92 approached from the north walking towards the young bear (No.91). The young bear jumped up and fled, maintaining a distance between the two of them of 100m. During this time the mother No.90 rested and slept, ignoring all, at a distance of 200m. A reindeer approached the bears up to 200m away, then, seeing the bears, the reindeer went up into the mountains. The bears took no notice of it.

After bear No.92 left, the bears continued to rest close to the huts. At 1230 a helicopter flew over the huts. The mother (the young bear was on a tour) jumped up and galloped a short distance. After the helicopter landed, the bear lay down again.

On 10th August at 0800 the bears were resting close to the huts. By 1000 both bears wandered slowly to the north and disappeared.

Noise.

Reaction of Humans



- No. 92**
Date, Time 9.8.2003, 1000-1100
Size, Age Large, well fed adult.
Behaviour The bear approached slowly and confidently from the north, looking at the huts and humans and also bears No90-91. He chased away bear No91. Thereafter he looked curiously around the huts but fairly shy. He seemed to be not aggressive towards the humans who were filming him at a distance of 20m. Eventually the bear wandered towards Hinlopen Straight, following the edge of the beach.
Reaction of humans None.
- No. 93**
Date, Time 11.8.2003, 2200 until 16.8.2003, 1000
Size, Age Small, young male, well fed.
Behaviour The bear behaved all the time curiously and self confident. He showed no respect towards the humans. Shortly after he arrived he started to graze like a sheep at different places close to the huts, eating knoppsildre and lichens for about 30 minutes. This unusual behaviour was documented with film. Thereafter the bear ate human excrement and finally rested 50-75m away from the huts. Several unsuccessful attempts were made to chase him away. He respected a distance of about 20m around the hut where the humans lived.
On 15th August about 50 visitors from the *Polar Pioneer* visited the huts and observed the bear. The bear showed no fear or interest. It was hard to prevent him coming closer with five warning shots.
Each time he was approached by the adult bears, (No.96, 97 and 98), this bear fled to a distance of about 50-100m. He tried to come closer to the huts again when the large bears moved away. Finally he disappeared towards Hinlopen Straight.
Reaction of Humans Five warning shots and noise.
- No. 94**
Date, Time 12.8.2003, 0900-0930
Size, Age Small, young, lean, yellow.
Behaviour The bear curiously investigated the huts. Seeing an approaching human he hissed and ran away in panic towards the west.
Reaction of Humans Warning shot and noise.
- No. 95**
Date, Time 13.8.2003, 0900-0930
Size, Age Large adult, lean.
Behaviour The bear arrived from the north, passed the huts at a distance of 200m and continued his march towards the Hinlopen Straight. He showed no interest in the huts or bear No. 93.
Reaction of Humans None



- No. 96**
Date, Time 13.8.2003, 1100-14.8.2003, 1000
Size, Age Medium adult, medium fed.
Behaviour The bear arrived from the west and sneaked about close to the huts. Eventually he chased away bear No.93 and ate human excrement. The humans chased the bear away with noise. The bear went to the west, 500m from the huts, and rested. On 14th August the bear got up and went to Hinlopen Straight.
Reaction of Humans Noise.
- No. 97**
Date, Time 14.8.2003, 1200-1400
Size, Age Large adult, well fed.
Behaviour The bear arrived from the north and chased away bear No.93. He sneaked close to all the huts and tried to open the doors. He looked into the windows and finally rested close to the hut. Hauke chased him away with noise and warning shots. The bear respected the humans immediately and went away to Murchisonfjord.
Reaction of Humans Noise and warning shots.
- No. 98**
Date, Time 16.8.2003, 0800 until 18.8.2003, 1000
Size, Age Large, very old male, white, meagre. Left eye inflamed red.
Behaviour The bear arrived from the west and chased away No.93. The bear was self confident and took almost no notice of the humans at a distance of 20-50m. He ate some human excrement and lay down and rested 50m from the hut. During the 17th, he rested close to the door of another hut, possibly looking for wind protection. His behaviour and outline reminded us of bear No. 2 which stayed at Kinnvika in August 2002. On the 18th bear No.99 approached the hut. No.98 chased him away, moving very slowly against No.99 who started to run away leaving a distance of 50m between the bears. This demonstration of dominance was repeated a couple of times. However, finally No.99 (younger, smaller and stronger) became more and more confident until he lost his fear of No.98. The story ended on 18th August at 1000, when the old bear fled from the young bear who galloped behind him for a few seconds, about 25m behind. The bears avoided coming closer than 5m to each other. When the confrontation between the bears took place the bears took no notice of the presence of humans. The episode was documented with film.
Reaction of Humans None



No. 99 Date, Time Size, Age Behaviour	<p>16.8.2003, 1200 until 18.8.2003, 1100</p> <p>Medium, very well fed, young, dynamic, self confident.</p> <p>He arrived from the west and approached directly to the huts. He sneaked closely around the huts, curious, and tried to open the doors and windows. He seemed to be fairly aggressive and showed no respect at all to humans or noise. After being chased away by No.98, he returned immediately. He divided his attention between the humans and bear No.98. It seemed to be very clear that he would try to attack the humans as soon as he had an appropriate chance. The humans tried to chase him away with many warning shots, but without success. It was interesting that during these shooting sessions, No.98 took no notice of the noisy action, but continued to rest at a distance of 50m.</p> <p>After No.99 had chased away No.98, on the 18th at 1000, his attention was focused on a tourist ship, the <i>Polar Star</i>, anchored close to the beach of Kinnvika. Hauke tried to contact the ship by radio on diverse channels to warn them of the bear, however was unable to get a reply. The bear hurried to the beach, expecting the arrival of the tourists. Obviously the captain of the <i>Polar Star</i> recognised the situation and they left without landing. The bear departed, swimming strongly in the choppy sea, following the ship.</p>
Reaction of Humans	Warning shots and noise.
No. 100 Date, Time Size, Age Behaviour	<p>18.8.2003, 2100-2115</p> <p>Small, young, well fed, shy.</p> <p>The bear crept close to the huts and looked into the window. As soon as he was observed he was chased away vigorously with warning shots and noise. The bear went to the west and rested 400m from the huts. He had vanished by the next morning.</p>
Reaction of Humans	Warning shots and noise.
No. 101 Date, Time Size, Age Behaviour	<p>19.8.2003, 0800 to 1600</p> <p>Medium adult, average build, yellow.</p> <p>In the morning the bear was seen resting 200m west of the hut. At 1530 the bear stood up and approached the hut with interest. The humans went against the bear making noise by banging two red jerry cans together. At a distance of 50m the bear turned and fled to the beach. He went into the water and swam away across the bay. He was very frightened and hissed nervously.</p>
Reaction of Humans	Noise.



12 REINDEER

12.1 Observations

From the end of **July 2002** until the beginning of the dark time, **November 2002**, a total of 105 reindeer were observed, mostly within a distance of about 2km from Kinnvika. The reindeer mostly formed groups of from 2 to 10 animals. Only twice were single reindeer seen. The small reindeer families normally contained between 2 and 5 animals. They were composed of females with one baby each, and additionally sometimes with one male. In the course of the months, the following groups were identified and sometimes recognised when they arrived another time at Kinnvika. The groups are listed below.

- 1 1 female and 1 baby.
- 2 1 female and 1 baby and 1 male.
- 3 2 females and 2 babies.
- 4 2 females and 2 babies and 1 male (probably groups 1 and 2)
- 5 8 reindeer including 2 babies.
- 6 10 reindeer. No babies.
- 7 1 male
- 8 1 female or male with one antler.

It is estimated that in total about 30 different reindeer were observed close to the area of Kinnvika in summer and autumn 2002. The groups or families of reindeer migrated on certain routes, approaching the huts of Kinnvika after a period of 5 to 10 days, mostly in August 2002. The migration routes seemed to depend on the condition of the vegetation. It was observed that in August and September the reindeer went grazing from one flower to the next, mostly only taking one flower, not eating all flowers in any one area or place. Most of the flowers were *Knoppsildre* and *Svalbardvalmue*. From **September/October 2002** snow and ice covered the vegetation in some places. The reindeer went to areas being free of snow, or they dug in the snow. Due to the nearly permanent heavy winds, large areas of the vegetation were covered by only thin snow layers.

All observed reindeer looked well fed, particularly at the end of **August 2002**, some animals appeared to be really fat. In the middle of September, some babies were observed suckling the mother. The reindeer approaching the huts of Kinnvika were not at all shy of the humans and dogs. Sometimes they were grazing as close as 10m to the dogs, who were fixed to their chains. Once, 5 reindeer were observed grazing at a distance of about 30m to a resting polar bear. The bear didn't try to chase the reindeer.

On **28th September 2002**, one single male reindeer moved to a temperature measurement system attached to a 2m high stick, and tried to rub off the velvet from his antlers. On **1st October 2002**, 5 reindeer approached the hut in Kinnvika. Two of the animals were enmeshed by their antlers by a synthetic fishing net. These reindeer were forced to move very close together, side by side. Sometimes they started to fight against each other. Finally the reindeer vanished behind a hill. On **17th October 2002**, one single reindeer bearing only one antler was observed. This animal seemed to be disturbed and moved around restlessly. On **7th November 2002**, footprints on the snow of 5 reindeer were seen on the beach at Kinnvika. Apparently the reindeer dug for seaweed under the snow on the beach. The same observation was made on **4th December 2002**, however, only one reindeer.



During the dark winter time, neither reindeer nor corresponding footprints could be observed. First, on **10th April 2003**, a single female reindeer was seen. This reindeer stayed for about one week on the bare ground, being free of snow due to the heavy winds. Here the reindeer grazed on the sparse, poorly growing plants and roots. On **16th April** another female reindeer together with its one year old youngster, joined the single reindeer. All reindeer looked well fed.

It is believed that these reindeer were the two little families that were observed during summer and autumn 2002, in the vicinity of Kinnvika. One of the two young reindeer of 2002 seemed to have now vanished.

Outgoing from heavy winds and the variation of temperature, the ground was finally covered by an ice layer. The reindeer couldn't continue to graze and vanished.

On **26th May 2003** a single reindeer, probably a big male was observed moving fairly quickly to the south, close to Hinlopen Straight.

On **8th June 2003** two reindeer with two few-day-old babies were observed at the inner Murchisonfjord near Floraberget. The reindeer, and even the babies, were grazing on the small spots of bare ground. It is assumed that these two reindeer were identical to the two females observed in autumn 2002, close to Kinnvika.

On **18th June 2003** and thereafter during the following days, one single one year old reindeer approached the hut at Kinnvika, very close, without being afraid of the humans or the dog. On **24th June 2003** this reindeer followed the humans and the dog for about one hour during a walk at a distance of between 50-100m. On **20th June 2003** a total of three reindeer were observed probably two males with newly grown antlers, and one young female. On **23rd June 2003** probably the two mothers observed on the 8th June 2003 were seen again near Kinnvika, however this time with only one of the babies.

Thereafter, almost daily, in June and July 2003 one to five reindeer were observed grazing in the vicinity of Kinnvika. It seemed that the animals tried to stay alone, wandering from spot of vegetation to the next. They avoided grazing close to each other. The observed behaviour reminiscent of humans, who for example, pick berries or mushrooms and don't like to be joined by other others.

In **June and July 2003**, sometimes male reindeer with antlers tried to join females without antlers accompanied by babies. The mothers seemed to dislike the approaching males. In **August and September** however, the reindeer formed groups of between three to ten animals, including males.

On **30th June 2003** three reindeer (one male and two young females) came over the ice of the Murchisonfjord from Nordre Russøya or Kvaløya, approaching the strand close to Kinnvika. The animals had some problems to cross the open lanes in the ice. Sometimes they wandered restlessly back and forth to find a suitable way. Finally after about two hours, all of them reached the land.

On **29th July 2003** an old fishing net was found close to the beach at Hinlopen Straight. In the net two small antlers of a reindeer were enmeshed. Possibly the reindeer didn't die but escaped after casting its antlers.



12.2 Conclusions

Outgoing from the observations in the area of Kinnvika, the population of reindeer does not seem to be poor. The observed animals were, in the autumn 2002, early spring and summer 2003, well fed. It is estimated that in total, about 40 reindeer were living in an area of 20 km around Kinnvika.

These observations are in agreement to the remarks made in various diaries and reports of people who stayed on Nordaustland for one year, namely:

1933/34	Torleif Bjertnes in Brennevinfjord.
1944/45	Dr Dege, at the German weather station Haudegen.
1957/59	Swedish/Finnish expedition to Kinnvika.

In all cases, it is reported that reindeer were living on Nordaustland in fairly big numbers and were well fed even in spring. Apparently the poor vegetation on Nordaustland is sufficient for the population of reindeer, particularly in connection with the strong winds blowing away the snow layers.

The reindeer in the area of Kinnvika seemed to be very tame, similar to the reindeer in the town of Longyearbyen. It seemed that the animals know Kinnvika as a friendly location without danger.

The observed reindeer in autumn were very interested to find some spiky obstacles to remove and clean the velvet from their antlers. Because the tundra of Nordaustland is very poor in such obstacles, the animals sometimes seem to prefer old fishing net at the beach. Many such fishing nets were found on several beaches of Nordaustland.

Outgoing from this situation, it seems that the fishing industry in the waters close to Nordaustland, and the corresponding rubbish, may be one of the most important dangers to



reindeer.



13 OTHER MAMMALS

13.1 Observations

Polar Foxes

One fox was seen on **9th May 2003**. He ran fairly fast over the ice of Kinnvika. Footprints of single foxes were observed in the snow on **9th** and **27th September 2002** and on **25th April 2003**. In **February 2003** footprints of a fox were seen following the edge of the beach, and obviously eating small shrimps which were forced through the ice cracks. In mid **May 2003** a couple of times a single fox was heard barking on the ice close to the strand. On **15th July 2003** a fox was observed looking for eggs between Hinlopen Straight and Kinnvika.

Ringed Seals

A few single ringed seals were observed from **July to October 2002** in the fjords close to Kinnvika, in total about 20. Most of them were seen in October. On the newly formed ice of "Tvillingvika" close to Kinnvika on **4th October 2002**, a group of 7 seals were seen once. Thereafter no further seals were observed on the ice until the end of **February 2003**. Thereafter, on calm days without heavy winds, a few single seals were seen on the ice of Murchisonfjord and Hinlopen Straight. Sometimes at the end of **May 2003**, up to nine seals could be observed simultaneously from Kinnvika. In **June 2003** almost daily up to 20 seals, and in **July 2003** up to 40 seals, sometimes in groups of two or three were observed. All seals on the ice were fairly shy. They disappeared down their holes as soon as bears or humans approached them nearer than 100-150m away.

Bearded Seals

Two seals were seen in the open water of Murchisonfjord. One seal was seen on the drift ice in Kinnvikafjord on **21st August 2002**.

Walrus

Twice in mid **August 2002**, a single walrus was seen in the open water of Murchisonfjord. On **26th September 2002**, a single, adult male walrus was observed on the beach at "Vestre Twillingneset" (east coast of Hinlopen Straight). The animal was very big, had two long tusks, and slept, almost without paying attention to humans. This walrus was observed only once. On **9th November 2002**, some measurements were carried in darkness on the thin ice (15cm) close to the beach of Kinnvika. The water depth was 2m. Suddenly a big walrus with 2 long tusks broke through the ice and watched angrily a human and a dog. Some of the measurement devices on the ice surface, was pushed into water by the walrus and was lost. The walrus came up several times at different places, breaking through the ice. It seemed to be curious and aggressive. At the end of **July 2003** twice two or three walruses were observed swimming between the ice floes. On **8th August 2003** three walrus (2 adults, 1 young) and on **15-18th August** two walrus (male and female) were observed on an ice floe close to Kinnvika.

Beluga Whales

On the evenings of **22nd September** and **23rd October 2002**, a group of 3 to 5 beluga whales were observed and heard close to the beach of Kinnvika.

13.2 Conclusions

Outgoing from the observations it seems that the Kinnvika area is fairly poor concerning polar foxes, but comparatively rich concerning polar bears, reindeer and seals.



14 BIRDS

14.1 Observations

The following birds were never seen in the area around Kinnvika:

Svalbard ptarmigan, ivory gull, Brünnich's guillemot, little auk, puffin.

The observed birds are commented on below.

Fulmar

At Kinnvika and on Murchisonfjord, in **August 2002** a few fulmar were observed flying. On **27th April, 4th May** and **26th May**, single birds were observed. In **summer 2003**, only single birds were seldom seen.

Geese

At Kinnvika a group of 7 **Brent** geese was seen twice grazing on the tundra and finally flying away on **18th** and **19th August 2002**. Once, a polar bear tried to catch them on the beach at Kinnvika. On **3rd June 2003**, two flying **Brent** geese were seen close to Kinnvika. On **7th June 2003**, probably a flying **pink footed goose** was observed. On **9th** and **20th June 2003**, five to seven flying **Brent** geese passed Kinnvika. In **July 2003**, almost no geese at all were observed.

Common Eider

At the beach at Kinnvika, in little lagoons, and Claravågen, a small number of common eider was observed during **August 2002**. Mostly the groups contained adult females with fledged young in groups of 5 to 20 birds. On **21st October 2002** 4 male adult eider ducks were seen flying over the beach at Kinnvika. The last time in the year that eider were seen, a group of 5 swimming young were observed on Kinnvikafjord on **22nd October 2002**. On **29th May 2003** seven eider were observed flying close to Kinnvika. Thereafter, almost daily, some eider were seen. On **10th July 2003** about 20 pairs were swimming in a small pond of melted snow. On **11th July 2003** many eider wandered around on the bare ground about 200m away from the beach, possibly to find a suitable nesting place. However, due to the ice layer on the fjord until the end of July, most of the ducks didn't start to breed. From about 30 observed females, only three were breeding, however, without success.

Purple Sandpiper

Twice on the tundra close to Kinnvika, different single purple sandpipers together with 1 and 2 small babies were seen on **24th** and **29th July 2002**. A few purple sandpipers in small groups of 2 to 5 birds were seen on the beach at Kinnvika. The last single sandpiper was observed on the snow and ice covered beach on **14th October 2002**. The first bird of **2003** was seen on **29th May**, although during this time the land and the sea were covered almost completely by snow and ice. In **summer 2003**, it seemed that in total four to six individuals lived in the area near Kinnvika.

Red-throated Diver

On **17th July 2003** a pair was observed close to Hinlopen Strait.



Glaucous Gull

A few single glaucous gulls were observed at Kinnvika. Furthermore, 2 couple with together 5 almost fledged young were observed on the rocks south of the entrance to Claravågen on **8th August 2002**. The last glaucous gulls were seen at Kinnvika on **22nd October**, one adult and one young. The first time in spring 2003, one single bird was observed on **11th April**. Thereafter, roughly every two weeks, one or two birds were seen. In **July 2003** the gulls were observed mostly close to the ducks, probably waiting for hatchlings.

Kittiwake

These birds were seen in big numbers on the colony on Floraberget Murchisonfjord, on **2nd August 2002**. Additionally several kittiwakes were observed at the beach of Kinnvika, mostly in groups of 2 to 7 birds. The last two kittiwakes were seen on the **24th October 2002**. The first time in spring 2003 one single bird was observed on **13th April 2003**. Thereafter, three birds on **17th April**, and 14 birds on **18th April** were seen flying. Thereafter no birds appeared until **mid-May 2003**, when, on some days, one or up to seven birds were observed. Since **June 2003** only single birds were seen apparently from their colony at Floraberget to the Hinlopen Strait. On **8th June** about 100 birds were seen on the bird rock close to Floraberget. Later in **July**, most of the birds had gone, and no breeding could be observed.

Arctic Tern

On the small islands in Murchisonfjord and close to Kinnvika, several arctic terns were observed together with their young. The main group of arctic terns vanished after **12th September 2002** from the area around Kinnvika. Thereafter only a small number of 2 to 7 birds were seen at the beach at Kinnvika. The last 3 birds were observed on **13th October 2002** at Kinnvika. On **13th June 2003** the first four birds were seen flying. Thereafter, almost daily, a few birds were observed. It seemed that only no birds were nesting close to the strand of Kinnvika.

Black Guillemot

A few single birds were observed swimming in the Murchisonfjord at the beginning of **August 2002**. The last single black guillemot was seen flying at the beach at Kinnvika on **22nd October 2002**. The first time in spring, two flying birds were observed on **4th April 2003**. Thereafter only seldom were one or two birds seen close to Kinnvika. On **7th August 2003** over 20 birds were observed in the area close to Florabukta.

Snow Bunting

In **2002**, none were seen or heard. However, on **29th April 2003**, two pairs were observed trying to find food on the bare ground close to Kinnvika. No further birds were seen until **mid-May 2003**. Thereafter, sometimes up to three birds could be seen or heard close to the huts of Kinnvika. It seemed that at least two pairs were breeding close to the huts of Kinnvika.

Arctic Skua

One couple with 2 babies at the end of **July 2002** was seen west of Kinnvika on the tundra. Later this couple with only one young was observed until the middle of September, close to the Kinnvika. In the end of August, about 5 more arctic skua were seen flying in a group or as singles. The last arctic skuas were seen at Kinnvika on **28th September 2002**, one adult and



one young. On **18th April 2003** two birds were observed flying several times over their nesting site of last summer, which was now covered by ice and snow.

Thereafter, about every two weeks, one single bird seemed to inspect the area for a short time. Later in **June 2003** three birds were observed flying to the old nesting site (probably the adult pair from last year together with their young). The old nesting site was covered by snow and water until mid June. Sometimes the arctic skua attacked single passing kittiwakes and forced them to throw up some pieces of food.

From **2nd July 2003** Hauke offered daily to the arctic skuas three chicken's eggs, which were eagerly accepted. After a few days the arctic skuas became very tame towards the humans and the dog. They liked to sit and to fly very close (less than 1m) to Hauke who deposited the chicken's eggs on the ground. One of the birds followed the humans daily even on long walks for example up to the top of Kinnberget. Sometimes one bird was sitting on the back or shoulders of Hauke.

The pair started to nest on a new nest site about 100m from the hut, on **28th June 2003**. The new nest site was about 1000m away from the old one. Hauke continued to feed the arctic skuas with three chicken's eggs. During the feeding one of the birds flew immediately to the egg lying on the ground. Then it took careful aim with its beak two or three times in the direction of the egg. Finally the bird used to peck a hole in the egg and started to eat its content. In this moment, the second bird used to fly from the nest, accompanying the first one. Both birds used to sit peacefully side by side eating the egg. Thereafter they walked or flew to the second egg.

On **5th and 7th July 2003** groups of three to five reindeer approached the nesting site until they were 50-100m away. Both arctic skuas chased away the reindeer in a well planned and systematical action, touching the reindeer softly with their wings. The scenes reminded one of a well trained sheepdog herding a flock of sheep. On **9th July 2003** the arctic skua tried to chase away in a similar manner some eider ducks, however without success. The ducks jumped upwards from the ground, trying to hit the flying skuas with their bills. On **3rd July 2003** a polar bear passed the nesting site at a distance of about 50m. In this case, both arctic skuas only observed the bear without attacking him.

The two arctic skuas were incubating their eggs alternating their jobs after one or two hours. The free bird usually sat about 100m away from the nesting site on the ground, observing the environment continually. It seemed that an area with a diameter of about 100m around the nesting site belonged to the critical territory. Both birds fairly often used to sit in shallow ponds of sweet water cleaning their feathers. It was observed that the behaviour of the two birds differed slightly. The one behaved more brave and active, while the other was more reserved and cautious.

On **25th July 2003** the first, and on the **26th July 2003** the second young bird was observed in the nest. During the first two days of their lives, the young were usually sitting under the warm feathers of one of the parents. Later, the babies walked around, up to 50m away from the nest site, mostly not together. On **31st July 2003** a strong wind of up to 15m/s blew. Thereafter the young birds were seen about 100m away from the nest, downwind. The young became more and more mobile and walked around in an area of about 100 x 100m. The babies grew very fast and had reached, after two weeks, roughly half the size of the parents. Both parents fed the young several times a day.



Later at the beginning of **August 2003**, the young birds went further away, about 1km to the west, close to the old nest site of summer 2002.

The adult birds used at least seven different vocal sounds when communicating:

Approaching the area of the young, from about 200m away from them, the flying birds called quietly a sequence of short sounds, **Kraak, kraak.....** It seems that these calls may inform the young that friendly parents are approaching and not enemies.

When one of the adults reaches the nest or the young, a short soft **Krak** is heard.

When one of the adult birds started to eat an egg on the ground the second bird joined it and ate too. During this procedure, a quiet **Gluck** was emitted.

When the parents observed a friendly human approaching the nesting area, they flew around the human, and a friendly, soft **Kraak** was heard. It seems that a warning was being given not to approach any closer, (50m).

In the case of approaching closer than 50m the birds started to scream very sharply and aggressively, **Kiau!**

When the aggressive behaviour towards an approaching human or polar bear made no impression, one of the adult birds crept along the ground simulating a broken wing. A sequence like a childlike squeaking noise was heard: **Squeak, Squeak.** (Approaching polar bears were not influenced by such diversionary tactics, quite the opposite, the bears became more interested in the nesting area).

Sometimes several (up to five) adult arctic skuas formed flying groups approaching the nesting area. They seemed not to be aggressive to the young. However the parents joined the flying group and tried to chase them away. During the corresponding, sometimes acrobatic, flight manoeuvres, used to shout loudly a long **Eyah.** All birds seemed to be friendly to each other and having fun whilst flying together.

Besides the pair of arctic skuas nesting close to Kinnvika, another pair was observed on **29th July 2003** with two very little babies on the tundra close to the beach at Hinlopen Straight, about 2km away from Kinnvika.

Great Skua

One couple was observed on **19th August 2003** on Nordre Russøya. No young were seen.



14.2 Conclusions

In comparison to other regions of Svalbard, like Adventfjord, Mushamna and Austfjordneset, the population of birds being observed in the area of Kinnvika seemed to be poor. Although the number of shrimps and plankton being observed at the beaches of Murchisonfjord seems to be rich, particularly at the beach at Kinnvika, only a comparatively few numbers of birds seemed to live in this region. Possibly this can be explained by the fact that the area close to Kinnvika is unprotected and not very suitable for nesting, due to the almost permanent heavy winds and cold temperatures. Besides this, snow and ice covered the ground and the sea fjord until mid July.

It seemed to be surprising that many of the observed birds in autumn 2002 stayed for a comparatively long time before leaving. Possibly this can be explained by the unusually warm weather period at the beginning of October 2002, with temperatures up to 7°C. During this time particularly, arctic terns, kittiwakes, glaucous gulls and purple sandpipers could be observed in fairly big numbers at the east coast of the open Hinlopen Straight.

The **summer of 2003** seems to have been unusually late and cold. The ice layer on Murchisonfjord and Hinlopen Straight remained until the end of July or the beginning of August. Probably for this reason, the breeding activities of most of the birds was poor. It seems that no young ducks, kittiwakes or arctic terns at all were grown up during the summer in the area of Kinnvika. Arctic skuas, however, seem to raise their young successfully because they obtained their food, not from the ice covered water, but mostly from the restless, non breeding kittiwakes.



15 STRAND ITEMS

15.1 Observations

In the strand region of Murchisonfjord and particularly at the beach at Kinnvika, many items can be found which were thrown by heavy seas 1 to 2 metres above the high water line. The difference between high and low water levels is 1 to 2 metres. These items contain driftwood, man-made parts of wood, parts of old ship wrecks, equipment of modern shipping, and rubbish such as old shoes, fishing nets, oil containers and fish boxes.

Along a 500m stretch of the beach at Kinnvika, in an exemplary manner, all strand items were carefully registered, counted, photographed and divided into different categories. The following results were found. The very small items, roughly less than 10 to 20cm were not included.

In total 1245 items were found along the 500m stretch of beach.

Category 1	Number of items	100	(8%)	Natural driftwood, apparently not man-made or worked.
Category 2	Number of items	600	(48%)	Driftwood with signs of manmade modifications like drilled holes or cuts.
Category 3	Number of items	150	(12%)	Wooden items manufactured by man, such as boards and planks.
Category 4	Number of items	25	(2%)	Parts of old shipwrecks or old ship equipment, such as pieces of old wooden barrels and oars.
Category 5	Number of items	240	(19%)	Modern rubbish like shoes, oil containers and car wheels.
Category 6	Number of items	130	(11%)	Equipment from modern ships and fishing boats such as nets, fish boxes, floats and bottles.

At some other beach areas like the east beach of Tvillingviken, and on the shore of the eastern part of Hinlopen Straight, similar numbers of items were found.

15.2 Conclusions

By far the most items, more than 90%, were man-made. Only a small amount, less than 10%, seemed to be natural driftwood.

Modern rubbish and the equipment of fishing boats totals more than 30%. Particularly parts of fishing nets produced from synthetic materials, strike the eye with their bright colours. These nets seem to be attractive for reindeer trying to remove velvet from their antlers. The nets are dangerous for reindeer. Future cleaning operations performed on the beaches of Svalbard should be focused on these fishing nets.

About 2% of all items could belong to old ship wrecks or their equipment. A systematical search, registering, and so far as possible, identifying these man-made items on the beach areas of Svalbard, will yield new and interesting fingerprints of the old history of Svalbard concerning the lifestyle and the ships used by humans in historical times.



16 HISTORICAL ARTEFACTS

16.1 Observations

On nearly the whole coastline of Svalbard, historical artefacts can be found, washed up by the sea onto the beach. These items are up to 400 years old and make possible an insight into the various phases of the history of Svalbard.

It was roughly estimated how many old whaling ships wrecked close to Svalbard. It was concluded that many hundreds of fairly big sailing ships were lost, mostly from England, Holland, France, Denmark and Germany, within the last 400 years. Some parts of the wrecks landed on the beaches of Svalbard.

Besides this, many expeditions and hunting activities were undertaken in the region of Svalbard, mostly close to beach areas. By accident or other reasons, parts of the equipment such as sledges or hunter's traps were lost and taken by the sea. Some of these items were finally deposited on the beaches of Svalbard.

Mostly the location of the deposited materials is not related to the area in which it was lost. Due to the cold climate the items were preserved over many hundreds of years. Because most beaches are never, or very seldom visited by humans, the historical witness remains for many hundreds of years.

Many man-made items were found on the beaches of Nordaustland. Some of them could be identified as parts of ship wrecks, old wooden barrels, oars, or even equipment of expeditions and hunting activities. To make possible a systematical identification and documentation of the observed items, the most exciting pieces were carefully taken from the beach and temporarily stored. Before this, the original location on the beach for each piece was documented. By this way it was possible to replace each item after it's careful inspection and documentation and to fulfil the regulations concerning the cultural heritage of Svalbard.

About 120 different items were temporarily taken from the beaches situated close to Kinnvika from August until October 2002 and were brought into the "Cosmic House". There the items were sorted and arranged in a systematical way, taking into account some time phases of the history of Svalbard:

1. **International Whale Fishing (1600 -1750)**
2. **Russian Hunting (1700-1850)**
3. **Norwegian Hunting** including over wintering. **(1795-1970)**
4. **International Expeditions (Since 1775)**
5. **Second World War (1939-1945)**

The 120 items were documented and described with photos. Using historical books, reports and diaries, an attempted was undertaken to identify the different items concerning their historical background, or to obtain information about their original purpose. The documentation and investigation of the 120 items were finalised in spring 2003. Thereafter all items were replaced on the beach where they were originally found. After they were replaced, some of the items will probably be taken by the sea again and lost.

In the following pages, some examples of the different artefacts are shown.



1.1 International Whale Fishing at Svalbard (1600-1750) Ship Wreckage



The picture shows whalers near Spitsbergen from about 1750 (Altonaer Museum, Hamburg)

After Willem Barendsz had discovered Spitsbergen in 1596 and after reports about the huge amount of whales arrived in Europe, a fast growing whaling industry in the region around Spitsbergen began. Since 1600, many large whalers, mostly from England, Denmark, France, Netherlands and Germany sailed each summer to Spitsbergen. The insurance rate for these ships was fairly low (about 3%). Nevertheless, many ships were lost during of hundreds of years close to the coast of Spitsbergen in heavy pack ice, by warlike fights between various competing countries and finally, by fire and other accidents.

More detailed information about these events are given, for example, in the book: *No-Man's Land* by Sir Martin Conway, Norbok a.s., Oslo, Norway.

The ships wreckage mostly were composed of wooden parts floating in the sea. Some fragments were washed up by the waves onto the beach many hundreds of years ago.

The photos show a few artefacts which were found on the beach on Nordaustland:

Rib of an old whaler.

Rigging equipment to space the ratlines of a sailing ship.

Iron nails and wooden parts of wrecked ships.



1.2 International Whale Fishing at Svalbard (1600-1750) Ships Equipment



The picture shows sailors hunting walrus, about 1680 (Altonaer Museum, Hamburg)

The sailors from the whalers hunted not only whales, but also walrus, polar bears and reindeer on Spitsbergen. Some of their equipment was lost during the sometimes dramatic fights. The fragments consisting of wood and cork arrived on the beach at Spitsbergen and can be recorded.

The photos show a few of the artefacts which were found on the beach of Nordaustland:

Various oars, probably from different time phases.

Structures made of cork and fixed together by wooden pins.

(Probably a part of a life belt, and additionally some insulating material against the cold used in the cabin walls of the ships officers.)

Wooden lump with a hole and initials "KK".

(Possibly this item was part of an old log of a sailing ship, for measuring speed)



1.3 International Whale Fishing at Svalbard (1600-1750) Wooden Barrels



The picture shows men stripping off the blubber, 1704, (Altonaer Museum, Hamburg).

In the whalers sailing to and from Spitsbergen, many wooden barrels were stored. These contained supplies for the sailors and oil which was produced from the blubber of whales. On the coastline of Spitsbergen, several cookeries were erected to produce whale oil before sailing home.

The photos show some artefacts which were found on the beach on Nordaustland:

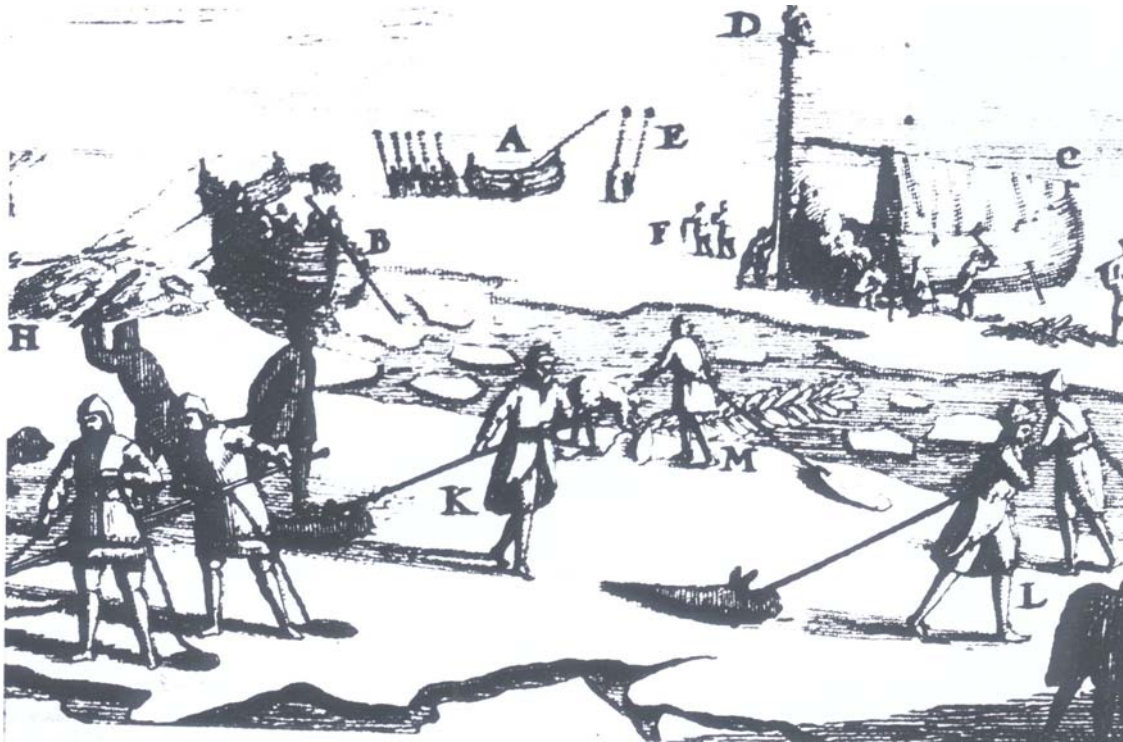
Fragments of wooden barrels of different sizes.

Parts of lids and bases of wooden barrels.

Bung from a big barrel and additionally, a nearly complete small barrel.



2.1 Russian Hunting on Svalbard (1700-1850) Russian “Kochi” Ships.



The picture shows Russian “Kochi” ships, 1785 (Nicolaas Witsen).

In the 17th century the Russian trappers started to use “Kochi” ships (sometimes also called “Lodjes”) along the arctic coast finally reaching even Spitsbergen. “Kochi” ships were constructed fairly small and simply with a curved stem and could be hauled over the ice. Using such ships, parties of Russian trappers were transported to Spitsbergen, where they stayed a whole year, hunting mostly polar bears, walrus, reindeer and foxes. The Russian ships were built more robust and simple than the big European whalers.

Probably, some fragments of “Kochi” ships were found on the beach on Nordaustland:

The photos show some artefacts found on the beach:

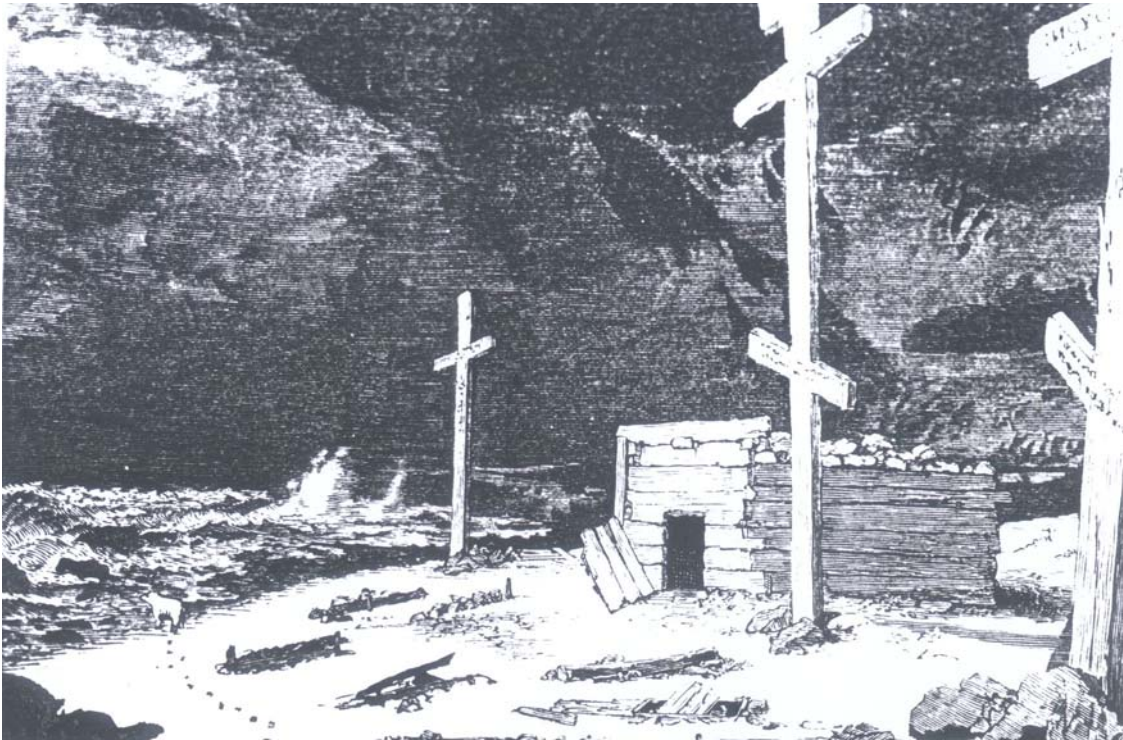
Part of a curved stem.

Pieces of a rudder.

Old wooden fragments.



2.2 Russian Hunting on Svalbard (1700-1850) Russian Trappers' Huts



The picture shows a Russian hut on Spitsbergen, Mathias Keilhau

The Russian trappers built, in preparation for their hunting activities and their planned overwintering, simple huts. The wooden material for the construction was mostly transported by sail ships from Russia to Spitsbergen and taken, after one or two years, to a different hunting location. The Russian hunters sometimes erected wooden crosses close to their huts.

Some of the wooden fragments belonging to the Russian hunting and living activities were washed into the sea over the years.

The photos show some artefacts which were found on the beach on Nordaustland.

Pieces of wooden huts.

Parts of wooden tools.

Old wood fragments.



Norwegian Hunting on Svalbard (1795-1970)

The picture shows a typical hunter's hut (bistasjon), Ruud's Hut, Hinlopen Straight.

After the end of the whale fishery and after the decline of Russian hunting activities, more and more Norwegian trappers came to Svalbard, particularly to hunt polar bears, foxes and reindeer. In many cases, the Norwegian hunters remained on Svalbard even over the winter. Mostly they lived (and sometimes died) in fairly primitive huts with poor equipment.

The photos show some items which were found on the beach on Nordaustland.

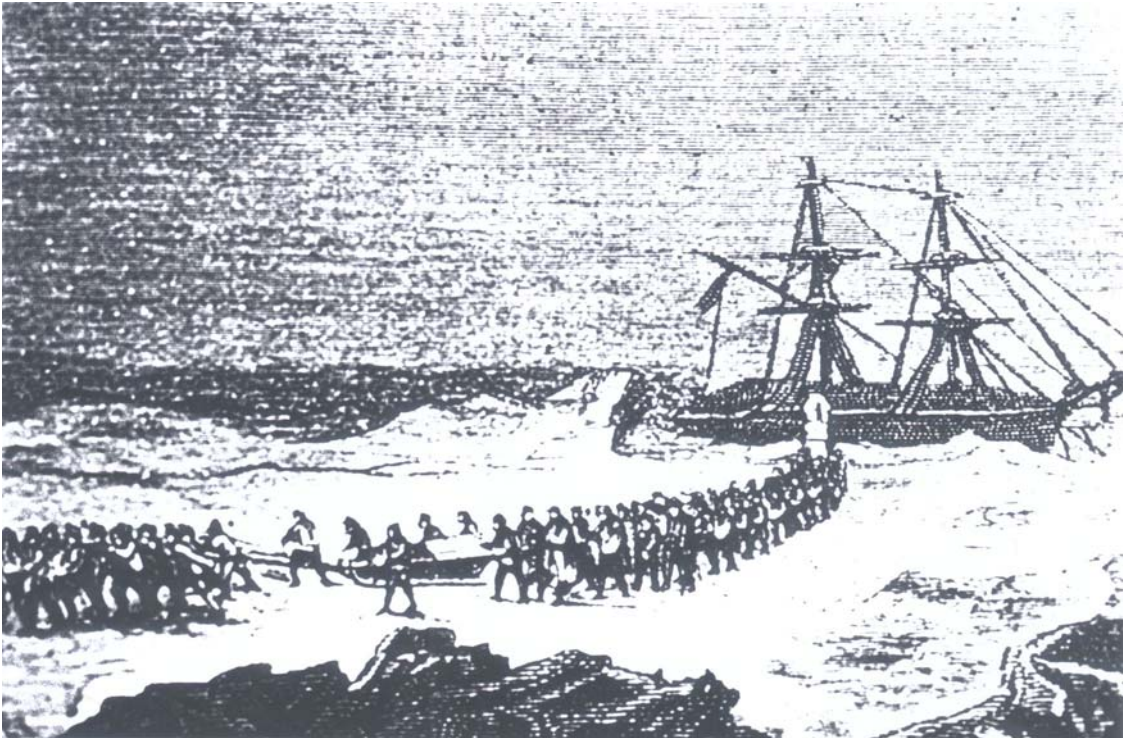
Wooden frame for the installation of a rifle.

(In combination with such tool polar bears were shot automatically, trying to take the bait).

Part of a skeleton of a hunted polar bear.**Some pieces of equipment belonging to a hunter.**



4. International Expeditions on Svalbard (since 1775)



The picture shows a burial ceremony during the Nordenskiöld Expedition, 1872.

Since the 19th century several expeditions, mostly from Great Britain, Sweden and later Norway and Italy, took place in the Svalbard region. The expeditions' goals were manifold. The main purposes seem to have been the preparation of the race to North Pole, and besides this, different scientific questions, for example, to find out more details about the movement of sea ice, the arctic nature and last not least, the occurrence of minerals and coal in the mountains of Spitsbergen.

Some fragments of an old expedition sledge, and additionally a part of a little, lightweight boat, was found on the drifting ice in the bay of Kinnvika. Possibly these items belonged to the expedition of Adolf Erik Nordenskiöld, who marched, in Spring 1873, over Nordaustland. In his expedition report it is mentioned that a sledge and a little boat was left behind on the north easterly beach on Nordaustland.

The photos show some artefacts which were found on the beach on Nordaustland.

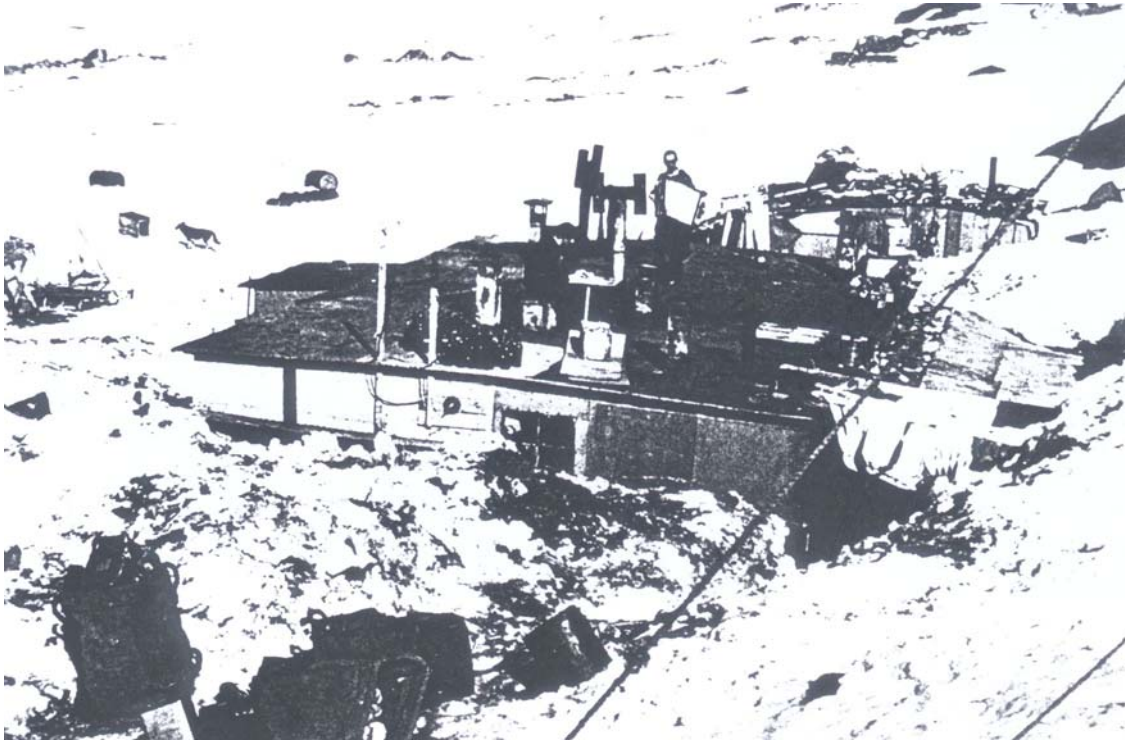
Fragment of a sledge.

Part of a boat.

Some other items.



5. Second World War on Svalbard (1939-1945)



The picture shows the German weather station, Haudegen, on Nordaustland, 1945.

During the Second World War some activities took place on Svalbard, particularly concerning the operation of various weather stations. Besides others, on Nordaustland in Wordiebay, a manned weather station was erected in 1944 by German soldiers. More detailed information in this connection is given in the book:

“Von Nanok bis Eismitte”, Franz Selinger, Convent Verlag, 2001, Hamburg, Germany.

On the beach at Kinnvika were found some items which probably belonged to this weather station.

The photos show:

Fuel barrels of the German army, 1943.

The barrel lid with inscription.

Wooden instrumentation box.



16.2 Conclusions

The number and quality of the items found and investigated up to now is poor. However, outgoing from this temporary collection of items, it may become clear that a systematical investigation of more man-made items from the coast of Svalbard could lead to a future scientific programme. It seems that the man-made strand items can be regarded as the loose pages of a historical book telling the whole history of Svalbard. However, these pages are, up to now, not recognised. They are accidentally deposited on the beaches and possibly taken away again by wind and sea.

Outgoing from the gained preliminary results, it is proposed to encourage historical institutes, particularly in England (for example The Scott Polar Institute) and Germany (for example Hamburg University) to continue the preliminary investigation and to start, possibly, a corresponding scientific project.

The proposed future investigation could become a joint interdisciplinary project of scientists and students from various European research institutes, for example, Denmark, Finland, France, Germany, Great Britain, Italy, Netherlands, Norway, Russia and Sweden, under the sponsorship of the **European Union**.

Some remarks are given on the proposed project: **STRAND ARTEFACTS OF SVALBARD**

Purpose of Project.

Systematical investigation of the historical artefacts deposited on the beaches of Svalbard. Outgoing from this investigation it is expected to gain:

- Better knowledge of the historical development of Svalbard.
- Better understanding of old ship building techniques.
- Better knowledge about the performance of historical expeditions to Svalbard.

Participants.

European research institutes, being competent, besides others, in historical matters, ship building and material sciences.

Activities.

Within an interdisciplinary and international co-operation, besides others, the following activities should be performed:

- Field work by groups of students on the beaches of Svalbard during July and August. (Possibly for two years).
- Evaluation of the inspected items concerning their age, material and historical context.

A close co-operation with Norsk Polar Institutt and the Governor of Svalbard is highly desirable.

Costs.

The costs for the performance of the project are dependent on the number of participants. However, comparing the proposed project with similar other EU projects, it seems that the performance of the first project phase demands only low costs.



17 TRAFFIC

17.1 Visitors

From 27th July 2002 until August 2003 the following visitors arrived with ship or helicopter in the Murchisonfjord and landed at Kinnvika. All visitors stayed for just a few hours.

Date	Name of Vessel/Nationality	Number of people/Actions
23.7.02	Motor ship <i>Polarsyssel</i> , Norway	Landing of expedition members by the Governor of Svalbard.
28.7.02	Sailboat of Hans Lund, Norway	5. NPI.
30.7.02	Sailboat <i>Barca</i> , Norway	4.
1.8.02	Sailboat <i>Morgan's Cloud</i> , Bermuda	3
2.8.02	Tourist ship <i>Prof Moltchacov</i> , Russia	50, circa.
4.8.02	Sailboat <i>Deborah</i> , Holland	2
5.8.02	Tourist ship <i>Nordstern</i> , Norway	80 circa.
6.8.02	Sailboat, ---, France	6
11.8.02	Motorboat <i>Farm</i> , Norway	6, geologists.
12.8.02	Tourist ship, <i>ClipperAdventurer</i> , Nassau	80 circa
13.8.02	Motorboat <i>Tempestet</i> , Norway	8
14.8.02	Tourist ship <i>Polar Star</i> , Norway	50 circa
1.9.02	Motor ship <i>Polarsyssel</i> , Norway	Supplies for expedition.
11.9.02	Sailboat <i>Noorderlicht</i> , Holland	22
28.11.02	Helicopter, super puma, Norway	Training flight, Governor of Svalbard.
18.12.02	Helicopter, super puma, Norway	Christmas visit, Governor of Svalbard.
15.1.03	Helicopter (small), Norway	Technical flight, Airlift.
1.3.03	Helicopter (small), Norway	Film team with Svein Raddum.
7.5.03	Sea King helicopter, Norway	Training flight, Coastguard.
9.8.03	Helicopter, (Airlift) Norway	Didn't stay but dropped off a parcel.
15.8.03	Motor ship <i>Polar Pioneer</i> , Australia	50, visiting the huts at Kinnvika, photographing a polar bear and a walrus
25.8.03	Motor ship <i>Nordsyssel</i> , Norway	Collection of expedition members and equipment by the Governor of Svalbard.



17.2 Fishing Vessels

Occasionally fishing vessels were observed on the Hinlopen Strait from the huts of Kinnvika.

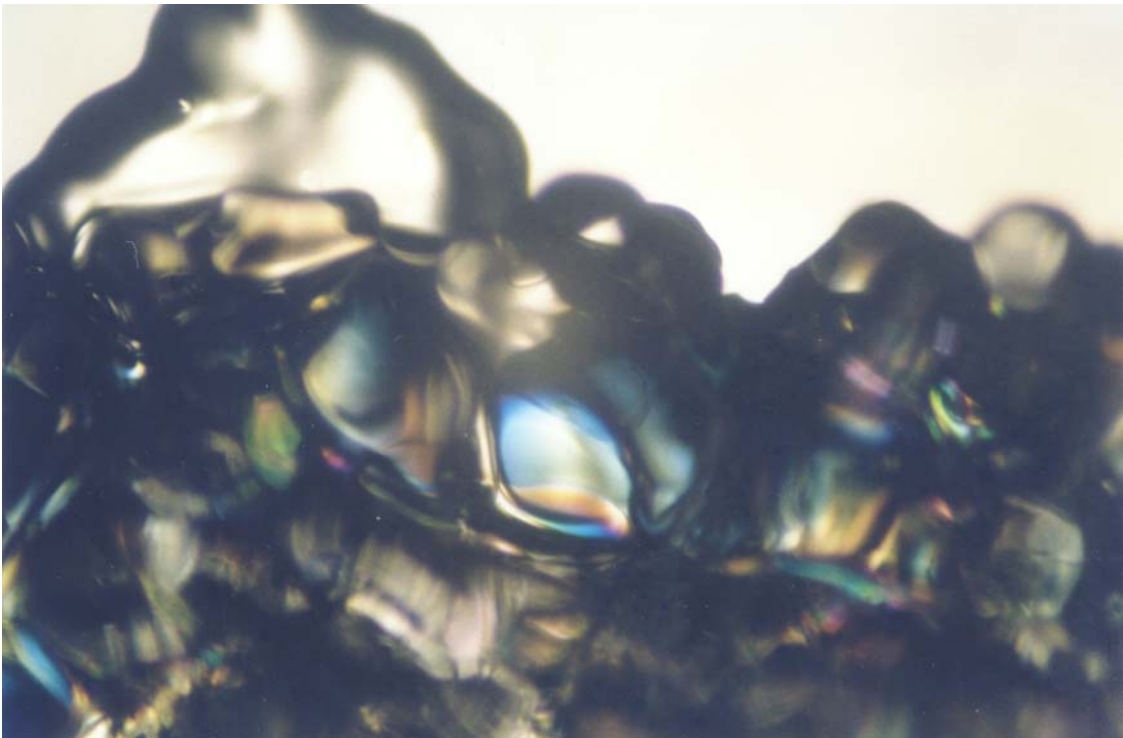
In September 2002, on two different days, each time a single fishing vessel was seen.

On the 6th, 14th and 22nd of November 2002, and then almost daily thereafter in November, the bright working lights of one, or sometimes two, fishing vessels were seen in the northern part of Hinlopen Strait. Sometimes the vessels seemed to fish very close to the east coast of Hinlopen Strait, near Murchisonfjord. All vessels sailed slowly and seemed to fish. Several times it was tried to make contact with the ships, using short wave radio using all common frequencies, without any success.

On 2nd, 6th and 23rd December 2002, a single fishing vessel was seen in the Hinlopen Strait.

From 13th to 16th January 2003, a single fishing vessel was observed near the east coast of Hinlopen Strait.

Thereafter, the Hinlopen Strait was partly covered by ice, and no further fishing vessels



were observed during the winter and summer of 2003.



18 SUMMARY AND RECOMMENDATIONS

18.1 Knowledge of Nordaustland

Nordaustland, its weather, vegetation and animal life is up to now, not well known. Within this expedition some new information on Nordaustland could be gained and documented by reports, photos and film. In this final report, some of the observations were described. The report will be delivered to:

TUHH, Hamburg
Governor of Svalbard, Longyearbyen
Norsk Polarinstitutt, Tromsø
Norsk Meteorologisk Institutt, Tromsø

Recommendations

If the Governor of Svalbard, the Norsk Polarinstitutt or the Norsk Meteorologisk Institutt would be interested in details which were not documented in this report, the expedition members will give, so far as possible, further information.

18.2 Ice and the Origin of Life

Outgoing from the performed investigation of the real sea ice at Nordaustland, it seems that now the main facts are available being necessary for the understanding of physical chemical processes in sea ice. This knowledge of sea ice in connection with literature research undertaken, were of essential importance to justify the hypothesis concerning the origin of life in sea ice. It seems that most of the necessary experimental work in real sea ice is done after the end of this expedition.

Recommendations

It is proposed that outgoing from the acquired experimental result, further theoretical estimates, and additional, well defined experiments in the laboratory, should be performed using the described technical sea ice reactor. Possibly one of the most important future experiments could be the replication of RNA without the use of enzymes in sea ice.

18.3 Ice and Bacteria

During this expedition many different samples of bacteria were gained in sea ice within the course of a complete year. These samples will lead to much laboratory work, which is necessary to analyse the samples to identify the bacteria and to draw the corresponding conclusions

Recommendations

The acquired bacteria samples should be analysed in the Biotechnological Institute of TUHH under the responsibility of Prof. Antranikian. Outgoing from the corresponding results, possibly it may be necessary to take additional samples from the sea ice of Svalbard.



18.4 Bear Observations

About 100 polar bears were observed during the expedition. During many hours, and sometimes many days, individual bears were observed and corresponding photos and film were produced. Outgoing from the observations a special bear report was compiled. Some conclusions were derived concerning counting, identification and investigation of the polar bears behavioural psychology.

Recommendations

It is proposed to discuss further investigations concerning:

Counting of polar bears using traffic RADAR traps, installed near migration routes of bears.

Identification of polar bears using the individual patterns of the bears soles which may be recorded and documented by special devices.

A study of polar bear behavioural psychology by observing individual bears in a systematical way over a long period.

These three different pilot schemes may be combined in one single project under the responsibility of the Governor of Svalbard.

18.5 Historical Artefacts

Numerous manmade historical artefacts were observed on the beaches of Nordaustland. The items were taken temporarily from the beach and investigated in a systematical way. After this procedure, all items were replaced on the beach where they were found. The items deliver a unique possibility to study Svalbard's history over the last 400 years. The temporary collection of historical items showed in which way, during future scientific programmes, the historical items may be found on the beaches of Svalbard, sampled, investigated and thereafter replaced at their original location on the beach. The corresponding results of the ongoing investigation will be delivered to competent institutions in England and Germany.

Recommendations

It is proposed to start a long term research programme to study Svalbard's history outgoing from the historical strand items found on the various beaches. Competent institutions, besides others, from England and Germany were encouraged to discuss and possibly begin a corresponding programme. Possibly, a joint inter-disciplinary European scientific project could be started under the sponsorship of the European Community.



Prof. Dr. Hauke Trinks
Technical University of Hamburg-Harburg

1st October 2003

ATTACHMENT

(To the Final Report of the Scientific Expedition "Life In Ice", 1st October 2003)

ICE AND THE ORIGIN OF LIFE

A1 PREFACE

The main purpose of the expedition "Life In Ice" in 2002/03 at Kinnvika on Nordaustland, Svalbard, was the detailed investigation of sea ice. Simultaneous to the experimental work, a comprehensive study of the available literature concerning the origin of life on Earth was performed and conclusions were drawn. In this connection, more than 1000 corresponding publications were evaluated and compared with experimental results gained in the real ice of Svalbard. Outgoing from these activities and in close co-operation between Christof Biebricher from Max Planck Institute in Göttingen, Wolfgang Schröder from Technical University, Hamburg-Harburg and Hauke Trinks, the following joint publication was realised:

Ice and the Origin of Life, Germany, Shaker Verlag, Aachen 2003

In this publication it is pointed out that the function of sea ice at the very beginning of life as a possible matrix to push prebiotic chemistry towards first biological processes has never been investigated before.

After years of examination in the arctic region and a thorough investigation of literature, we are now convinced that nothing but the environment of sea ice could have better set the spark of life to the early Earth. In comparison to most of the theories about the beginnings of life, our ideas agree with the opinions of other scientists, except the places where everything happened. Some processes proposed to take place on mineral surfaces, in meteorites or under deep sea conditions may even find better support when transferred to sea ice. Our studies of literature show that sea ice seldom has been investigated as a sort of reactor, though it has astonishing properties concerning surface activities, chromatographic effects and phase transfer reactions between liquid, solid and gaseous states. Even the supply of energy to chemical reactions seems to operate more properly in sea ice than in other environments, being much more selective due to the low temperature during compound interaction, linkage and duplication of prebiotic molecules and macromolecular aggregates.

Quite a lot of descriptions concerning the chemical and physical phenomena has been published during the decades of scientific work on arctic materials. But a review putting everything together to describe sea ice as a complex matrix with complex properties has not been published yet. Our treatise seeks to persuade other scientific groups to include the sea ice matrix in their investigation, in finding the way how life managed to emerge from prebiotic molecules.

In principal it is impossible to prove the validity of the hypothesis concerning the origin of life in sea ice. However, outgoing from this hypothesis it seems to be reasonable to describe a realistic way free of contradictions against experimental and theoretical findings, how the primitive life could have been developed in the ice on the early Earth four billion years ago.

In the following chapters, this way is roughly sketched. More details were given in the above mentioned publication and in the expedition's Final Report of 1st October 2003.



A2 CONDITIONS ON EARLY EARTH

How did the scenery look before the very first life began on early Earth?

Four billion years ago on Earth no life or any biologically essential molecules existed. It is assumed that in these times many comets hit the Earth producing strong disturbances. Besides this, strong volcanic activities occurred. Finally the Earth's surface was cooled down and covered by oceans which were produced by heavy rainfall and condensing processes of the water vapour in the atmosphere. The composition of the sea water was probably similar to today, because the minerals in the mountains being washed out by rainfall were more or less always the same. The exact composition of the early Earth's atmosphere is unknown. However the assumption seems to be reasonable that the amount of water vapour, nitrogen and carbon dioxide was fairly high and that no oxygen existed.

The sun radiation reaching the Earth's surface was about 25% weaker than today. The amount of UV radiation was high. The angle of the rotating Earth's pole axis against the ecliptic was nearly the same as today. By this reason, even four billion years ago, Arctic and Antarctic regions on early Earth existed, where during many months in the year, no sun shone. Probably, therefore, in some regions of the Earth similar to today, the oceans were covered by sea ice. Nowadays, about 10% of the Earth's surface shows ice layers.

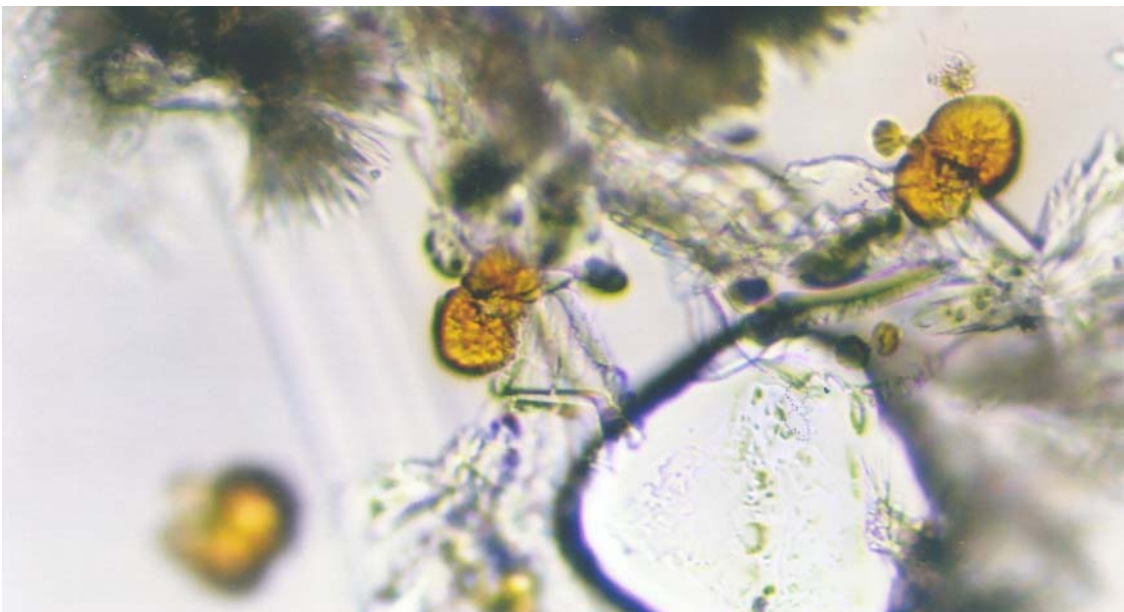
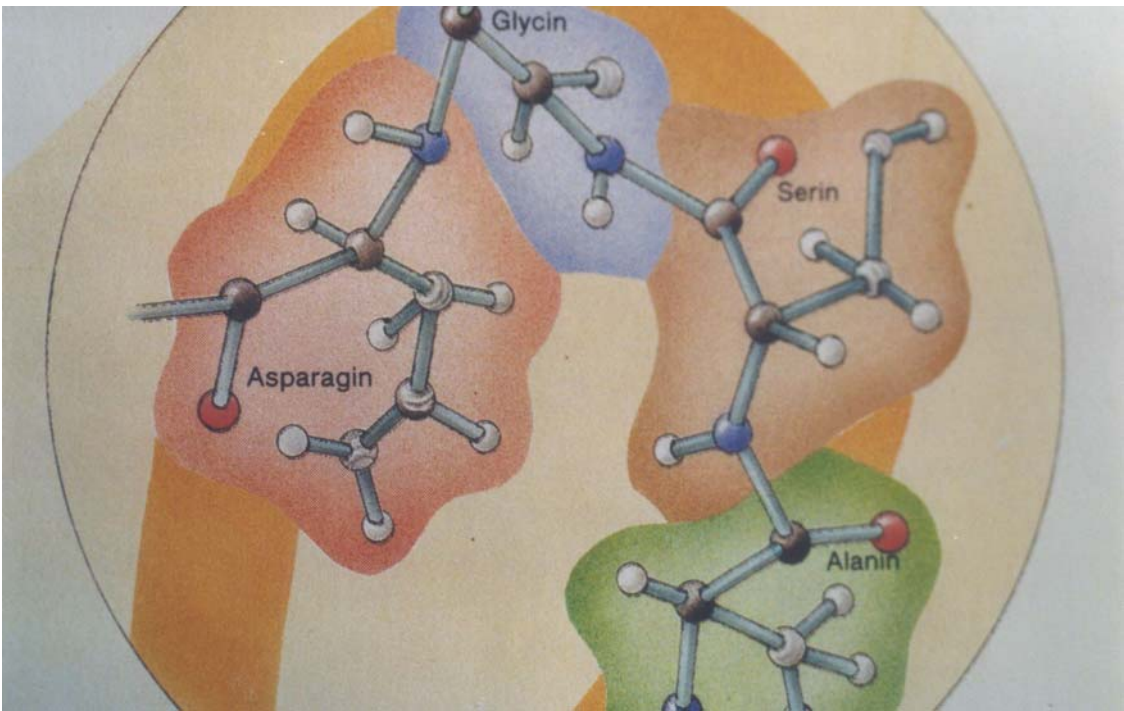
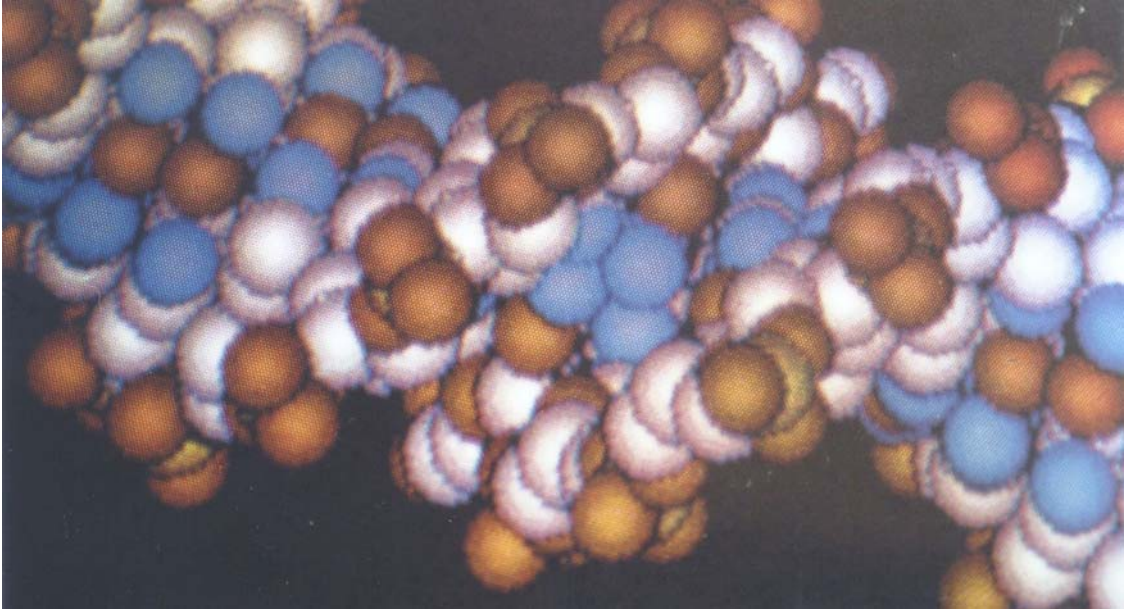
For the following argumentation it is not essential whether 1, 10 or 50% of the Earth's surface was covered by ice during the beginning of life. However the rough assumption seems to be very probable that indeed, during some time phases four billion years ago, a certain amount of ice on Earth existed.

As Stanley Miller demonstrated in 1953 by his famous experiment, it is known that besides other processes, electric lightning in the atmosphere and volcanic activities on the Earth generated simple organic molecules such as amino-acids. Therefore it is assumed, that finally in the Earth's oceans a fairly high concentration of simple organic compounds existed, which were necessary for the further composition of complicated organic molecules leading to primitive life.

Finally within millions of years a soup of amino-acids and other organic compounds was distributed throughout the oceans. Even in the cold regions on Earth covered by sea ice, this soup existed. The simple chemical compounds were gathered and condensed in the ice structure of the early Earth similar to the chemical compounds of environmental poisons nowadays.

In the past it was believed for a long time that the origin of life on Earth took place in a warm little pond filled with a soup of highly concentrated compounds like amino-acids. Chemical reactions leading to macromolecular aggregates are more successful at warm temperatures than in a cold environment. However, macromolecules were destroyed again by the influence of temperature, for example at +40°C within a few short weeks. By this reason, long term processes leading (within thousands or millions of years) to primitive life couldn't take place in a warm, little pond.

Today it is believed that the origin of life had to start in a cold environment. At a temperature of about 0°C the molecules are stable for many thousands of years. (This fact is responsible for the long term dangerous effects of environmental poisons, particularly in cold arctic regions, leading to long term health problems for the members of the arctic food chain).



A3 PROCESSES IN ICE LEADING TO RNA

Successful steps leading to the beginning of life on the early Earth within about 100 million years had to be performed under a number of certain conditions:

Particularly, the simple chemical compounds like amino-acids have to be available in high concentrations.

Besides this, the various compounds must be sorted out spatially concerning their chirality. Organic molecules like proteins or ribonucleic acids (RNA) are composed by left-handed amino-acids without any exception. If right-handed organic compounds are coupled to a growing biological macromolecule aggregate, the growing process will be interrupted and the macromolecule will be damaged.

To promote chemical reactions leading to macromolecules, in most cases, a source of chemical energy must be available.

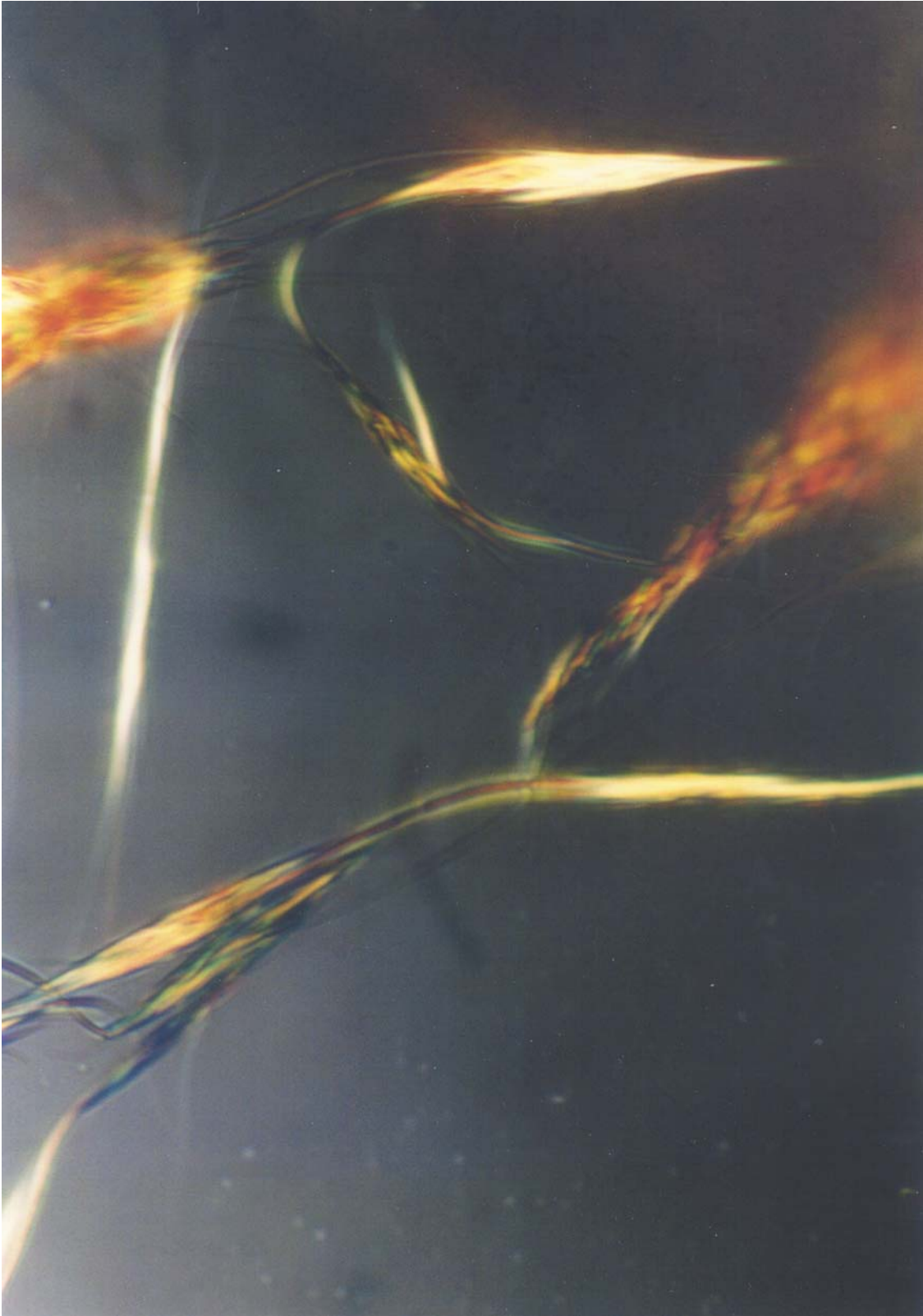
Beside this, the availability of many solid surfaces with catalytic properties would be useful.

Strong, dangerous UV radiation has to be shielded to prevent the rupture of biological macromolecules.

Last not least, the chemical reactions leading to the beginning of life should take place in the huge number of small, separate compartments which offer many various environmental conditions like pH-values, salt concentration, pressure, content of carbon dioxide, and others. By this way it is more likely that finally, successful macromolecule aggregates may be generated by many different chemical reactions running parallel to each other.

Many publications are known describing certain locations on the early Earth referring to one or the other of the above mentioned conditions. Up to now, it was not possible to find a scenario fulfilling all essential conditions together. It seems, however, that sea ice serves this purpose very well.

Sea ice consists on small cells of frozen pure water between which, a system of narrow channels exists filled with highly concentrated liquid brine. Besides this, many solid crystals and mineral particles supporting catalytic effects, for example, calcium carbonate, chlorides and sulphates are stored between the cells. The cells are enveloped by thin, flexible films similar to biological membranes. Additionally tiny bubbles of gas (mostly carbon dioxide) jostle in the brine channels, growing or disappearing depending on temperature and pressure. The small cells or compartments in the ice have a typical size of 10-20 micrometres. Consequently one cubic metre of sea ice contains about 10^{14} compartments, which are connected to each other by a network of brine channels. UV light penetrates sea ice only to a depth of 10-20cms until it's intensity is strongly weakened by optical scattering effects. The light waves penetrating the sea ice are scattered, reflected, refracted and polarised. Besides this, circular polarised light could be observed in the ice material. Due to the high concentration of electrically charged particles and ions in the ice and due to their inhomogeneous special distribution, sometimes strong electrical potential differences are given, particularly between the membranes. The pH-values vary between 6.0 and 8.5 in different contiguous locations in the sea ice. By such effects, energy differences exist particularly close to crystal surfaces and the membranes in the ice material.



In the following, it is roughly sketched under which conditions RNA may be composed in sea ice outgoing from the soup of amino-acids and other simple compounds being trapped in the ice of the early Earth.

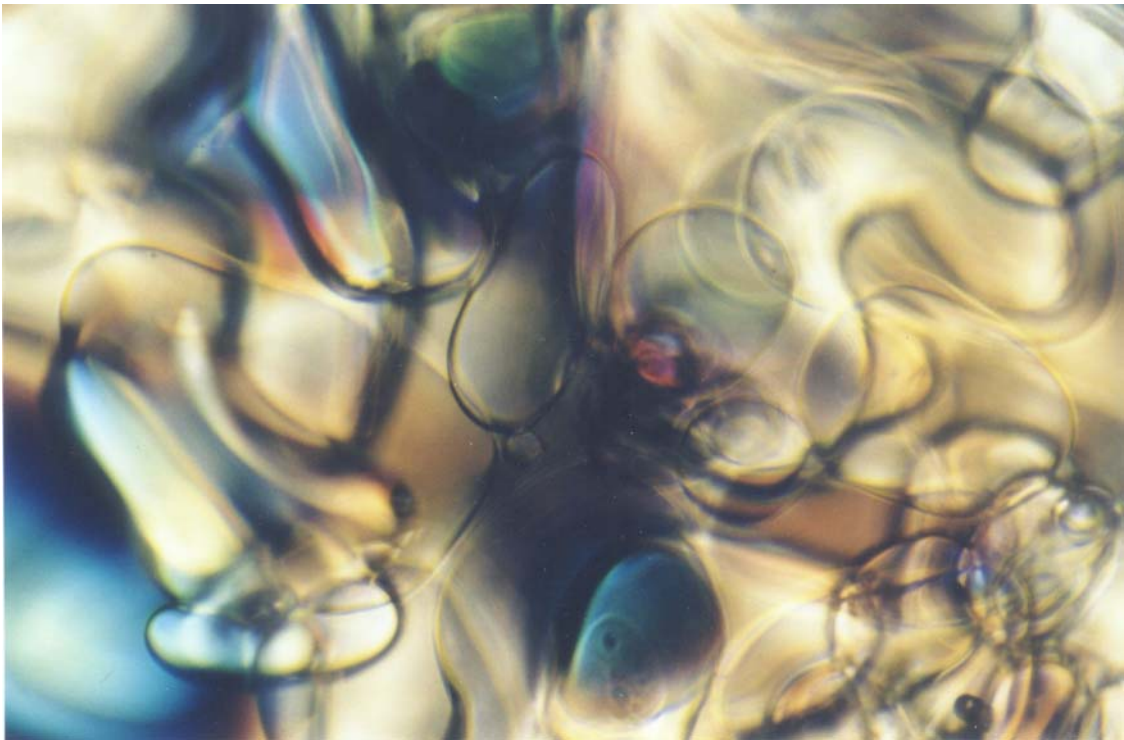
By microscopic and analytical investigations, the behaviour of amino-acids was observed mixed in sea water during the freezing process. The solution of amino-acids was finally highly concentrated in the liquid brine channels, forming clusters and crystals of pure specific amino-acids. Sometimes the growing of long chains and big clusters of amino-acids was observed. By the influence of UV light, the molecules were partly fragmented and energetically excited. The fragments leak through the liquid channels in deeper ice layers where they are finally protected against the strong UV light, and where they could participate in further chemical reactions. Under the various conditions in the numerous different compartments, it seems to be reasonable that complex organic molecules may grow. Such processes will be supported, besides others, by the catalytic effects of the solid mineral particles, the energetic potential differences on the membranes, and finally, the available high concentration of essential chemical compounds. By the effects of circular polarised light the separation could take place between left and right handed amino-acids. The low temperature in the ice material between -2°C and -5°C prevents valuable macromolecular aggregates spontaneously falling to pieces within thousands of years.

Under such conditions RNA molecules could be generated, as it is discussed in the above mentioned publication.

The given large number of compartments is essential in which the various generation processes of organic molecules may take place. Nowadays, about 10^{13} m² of sea ice with a thickness of more than 1m covers the Earth's surface. Taking into account 10^{14} compartments in one cubic metre of sea ice. consequently approximately 10^{27} single, tiny compartments exists on Earth. The number of compartments was probably similar on the early Earth. In these compartments within a time phase of, for example, 100 million years, an incredibly large number of different chemical reactions could have taken place, under various conditions, leading finally to a structure similar to RNA.

RNA molecules contain genetic information. Some pre-experiments indicate that RNA may be able to replicate itself in sea ice without support of enzymes. This would be one of the most important steps towards life.

The primitive RNA structures existing hypothetically in sea ice may be regarded as a kind of **virus**, containing more or less pure RNA. Nowadays, viruses exist in similar ways to parasites in living cells generating various diseases. The primitive RNA structures in sea ice met with similar conditions to the virus of today in biological cells. Possibly this fact could serve as another argument for the credibility of the hypothesis concerning the origin of life in sea.



A4 DEVELOPMENT OF CELLS IN ICE

After the generation of primitive RNA structures in sea ice on the early Earth, the development of biological cells would have been the next important step to life. It is hard to understand in which way such complicatedly composed structures may have been generated as biological cells containing, besides other things, membranes, vacuoles and inlets and outlets. Particularly the spontaneous generation of a biological cell seems to be impossible in a liquid soup free from any mechanical structures.

Sea ice may be regarded as a kind of organic organism showing structures similar to those in biological cells. Under the microscope it is possible to observe in sea ice tiny compartments embedded in flexible films similar to biological membranes. In the narrow channels, liquid brine drips, small gas bubbles are embedded and the solid ice crystals build up a mechanical structure. The flexible films in sea ice separate tiny droplets of pure water and ice crystals from the highly concentrated liquid brine. It seems that the observed films in the sea ice show some properties similar to biological membranes. Outgoing from these facts, the microstructure of sea ice could have served as a mechanical matrix for the generation of primitive biological cells embedded in the ice.

Experiments were conducted using yeast RNA which was dissolved in sea water before freezing. During the production of ice, it could be observed that the RNA molecules formed long chains and nets which were placed in the narrow brine channels. Particularly under the influence of UV radiation, these RNA structures remained mechanically stable even after the ice melted. It seems that RNA, but also other macromolecules, like to form continual structures with the support of sea ice. Possibly, this behaviour led, step by step, to the generation of primitive biological cells which were embedded in sea ice during the early development stage.

Even today it is possible to find in nature slime structures generated by **myxomycetes** in snow and ice or by the very early bacteria **myxococcus**. Besides this, snow algae live in a symbiotic way together with some primitive creatures, forming in the snow, slimy threads.

The very first life on Earth seems to be represented by the **Stromatolithes** which nowadays can be found in shallow waters of some oceans, for example, close to Australia. Stromatolithes go back 3.5-3,8 billion years. They are essentially composed of mineralic particles containing carbon dioxide caught from the sea water. In the porous material various colonies of primitive bacteria exist forming different layers and living together in a symbiotic way. It seems to be obvious that the composition, microstructure and organic function of Stromatolithes resemble, in some respect, those of layers of sea ice. This fact could be regarded as a hint, that sea ice plays, indeed, the role of a supporter for the first life on Earth.

Outgoing from the hypothesis that sea ice helped to promote life on Earth, it is understandable that life was not started by a single miraculous event. The conditions on early Earth, outgoing from the special properties of sea ice, led in an automatic way to the generation of primitive life. During approximately 100 million years, in 10^{27} different compartments in sea ice, all the essential chemical reactions took place. The compartments were well equipped with all necessary chemical compounds, energy sources, catalytic systems, films and mechanical structures. Additionally, all compartments were connected to each other by a network of channels. By this way, at different times, and at various locations, early life structures could be generated and possibly destroyed again. But finally the various sparks of life succeeded to ignite a vital and widespread fire, leading to the development of continuous life.