File Name: 898.pdf **UNESCO Region:** EUROPE AND THE NORTH AMERICA

SITE NAME: **The High Coast**

DATE OF INSCRIPTION: 2nd December 2000

STATE PARTY: SWEDEN

CRITERIA: N (i)

DECISION OF THE WORLD HERITAGE COMMITTEE:
Excerpt from the Report of the 24th Session of the World Heritage Committee

Criterion (i): The site is one of the places in the world that is experiencing isostatic uplift as a result of deglaciation. Isostatic rebound is well-illustrated and the distinctiveness of the site is the extent of the total isostatic uplift which, at 294m, exceeds others. The site is the "type area" for research on isostacy, the phenomenon having been first recognised and studied there.

A number of Committee members supported the nomination. The Committee, however, discussed a number of issues relating to the integrity of the site. In light of the evolving management regime, the Committee requested a review of the effectiveness of the management of this site in two year's time.

The Delegate of Finland informed the Committee that the evaluation of the site was beneficial for the preparation of the proposed Kvarken World Heritage nomination.

In supporting the enlistment, the Delegate of Morocco highlighted the fact that The High Coast was very significant because, apart from Hudson Bay in Canada, it was the most important example of glacio-isostatic uplift and the only icecap and geological feature in the north.

The Observer of Sweden informed the Committee that the designation of this property is of great importance and thanked the Committee for the constructive review process requiring the production of additional studies. This material will be beneficial for the management of the area.

BRIEF DESCRIPTIONS

The High Coast is located on the west shore of the southern Gulf of Bothnia, a northern extension of the Baltic Sea. The size of the area is 142,500 ha including a marine component of 80,000 ha, which includes a number of off-shore islands. The irregular topography of the region, a series of lakes, inlets and flat hills rising to 350m, is largely shaped by the combined processes of glaciation, glacial retreat and the emergence of new land from the sea which continues today at a rate of 0.9m/century. Since the final retreat of the ice from the High Coast 9,600 years ago, the uplift has been in the order of 285-294m which is the highest evident ”rebound” known.

1.b State, Province or Region: Gulf of Bothnia

1.d Exact location: 56° 20' N, 16° 0' E

THE HIGH COAST

NOMINATED BY SWEDEN
FOR INCLUSION AS
A NATURAL PROPERTY
IN THE UNESCO
WORLD HERITAGE LIST

1. Identification of the property

a. Country

Sweden

b. State, Province or Region

Province: Västernorrland County
Municipalities, rural districts, Kramfors and Örnsköldsvik

c. Name of property

The High Coast ("Höga Kusten")

d. Exact location on map and indication of geographical co-ordinates

The High Coast is situated between latitude 62°45′–63°13′N. and longitude 17°55′–18°10′E

See also Maps 1, 2, 3, and Appendix maps at scale 1:100,000

e. Maps and/or plans showing boundary of area

1. Europe & Asia, Map 1
2. Scandinavia, Map 2
3. Historical maps, Map 3, 5-8
4. Administrative maps, Map 11-12
5. Appendix I: Topographic maps at scale 1:100,000

f. Area of property

1425 km², including 625 km² land (mainland plus islands) and 800 km² sea surface

2 Justification for inscription

a. Statement of significance

There have been three known ice ages on the Scandinavian peninsula— the Elster, Saale and Weichsel periods— separated by warmer periods when the glaciers retreated and the land surface was exposed. The entire Scandinavian landscape has been profoundly affected by glaciation, as well as the shifting of soils by surrounding seas associated with the land elevation that has been in progress since the retreat of the most recent ice-age glacier. Those processes have to a large extent established the basic conditions for the area's variety and distribution of plants, and thus for human settlement.

The greatest measurable land elevation has occurred along the High Coast on the northern Baltic. It is by far the most distinctive geological evidence of the elevation process in Scandinavia. With its powerful upward thrust, calculated as 800 metres during the past 18,000 years, the area is unique on earth.

The High Coast provides a concentrated display of the geological forces that have formed and still influence Scandinavia during the current inter-glacial period. This applies especially to the layers of soil and gravel. The area has also been of great importance in calculating the pace of glacial retreat and changes in the rate of land elevation. During the past 9600 years, the High Coast has risen 285 metres above the present sea level. The current rate of elevation is eight millimetres per year.

The landscape is very beautiful, with high rounded hills, plunging faults, narrow cultivated valleys, an archipelago, and inlets of the Baltic Sea that penetrate far inland between steep cliffs. Deep fissures and different types of rock provide the basic conditions of a varied landscape.

The history of plant succession following the glacier's retreat has been fairly well documented. Still present today are relicts of the last ice age and more southerly plant species that were able to spread to these latitudes during warmer climatic periods. The land rising from the sea is constantly being colonised by plants and animals. This can result in various kinds of transformation, as when inlets of the sea are enclosed and salt water is gradually replaced with fresh, or when beaches are colonised by forest or become marshes. Changes in the landscape proceed so rapidly along the High Coast that they may be experienced within the space of a single lifetime.

The effects of land elevation are also reflected in the human history of the area, from the Stone Age to the present. The most ancient settlements are always situated at the highest elevations, near the shoreline of the period in which they were established. Dwelling sites from subsequent eras are usually separated from each other in a pattern that follows geological history down to the current shoreline. In terms of both placement and style, the buildings of today are similar to those of the past few centuries. Remains from all

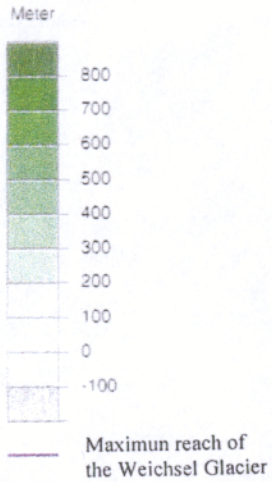
Map 1

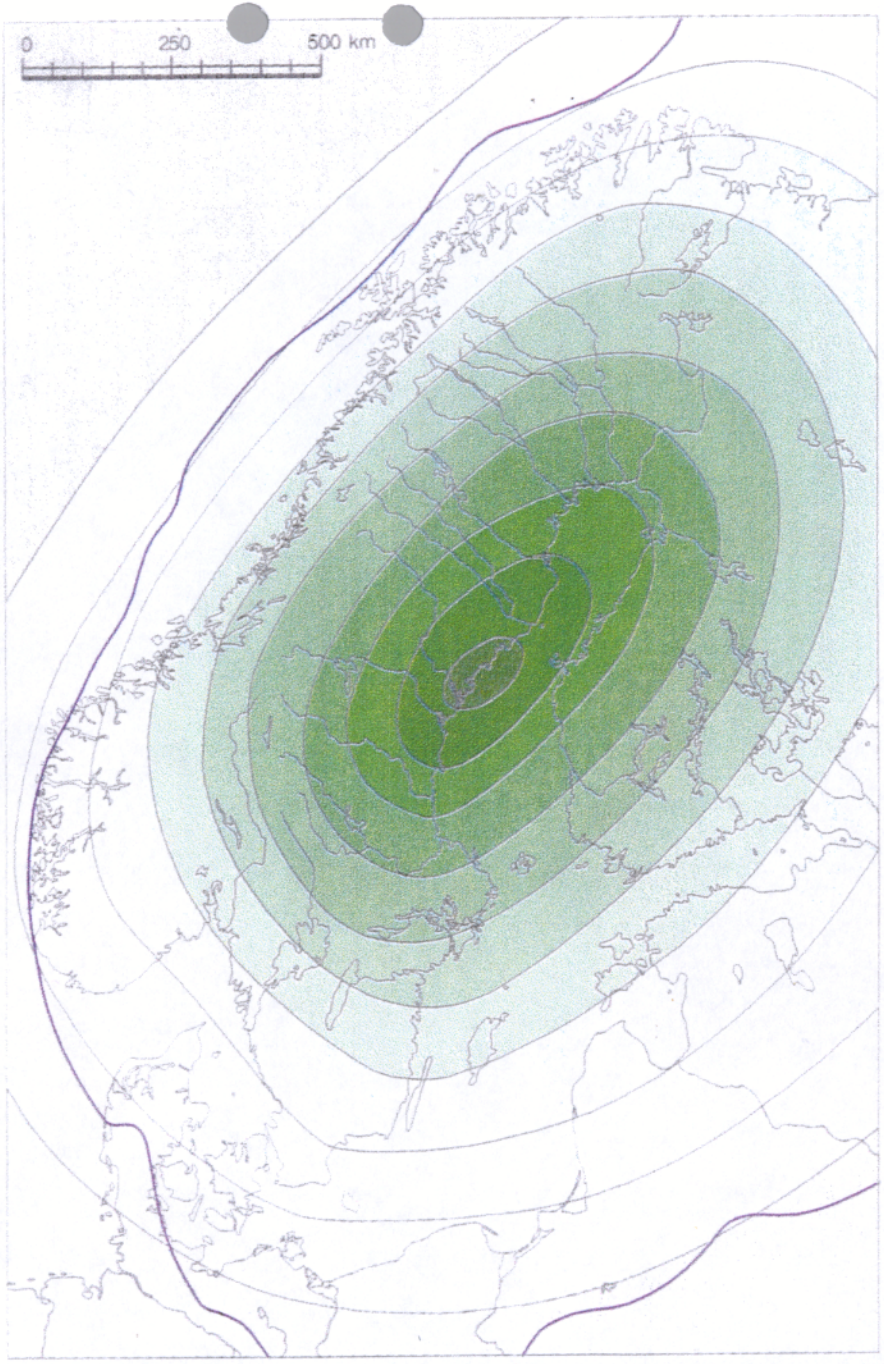
ALEUTERNA
BERINGS HAV
ISHAVET
GRÖNLAND
SVALBARD
NORSKA
HAVET
ISLAND
BRITTISKA ÖARNA
NORD-SJÖN
EUROPA
ASIEN
AFRIKA
Sahara
Arabiska halvön
Volga
KAUKASUS
Indiska Oceanen

Map 2
J 8° K 12° L 16° M 20° N 24° P 28° Q 32° R 36° S 40° T
Nordkapp
Vardö
Söröya
Hammerfest
Varanger-fjorden
Kildin
Pechenga
Polyarnyy
Murmansk
Murmanskusten
Kola
Tromsö
Senja
Vesterålen
Lofoten
Vestfjorden
Hinnöy
Narvik
Inari
LAPPLAND
Kola
Imandra
Kirovsk
Kandalaksha
Jukkasjärvi
Kiruna
Stora Lulevatten
Gällivare
Salla
Alakurtti
Kandalakshskaya
Bodö
Sulitjelma
Saltdal
Harsprånget
Kemijärvi
Pyaozero
Rovaniemi
Kemijoki
Top Ozero
Ukhta
Jokkmokk
Torneå
Haparanda
Kem
Hornavan
Boden
Luleå
Kuyto Ozero
Belomorsk
Sorsele
Oulu
Oulu järvi
Umeå älv
Nappes
Iisalmi
Umeå
Jakobstad
Pielinen
Seyozero
Levanger
Kallsjön
Vasa
Kuopio
Kondopoga
Trondheim
Storsjön
Östersund
Härnösand
Sundsvall
Orivesi
Sortavala
Petrozavodsk
Hedemarken
Hedemarken
Bräcke
Mikkeli
Snöhetta
Hudiksvall
Ljusdal
Tampere
Saimaa
Ladoga
Sarna
Björneborg
Lahtis
Hämeenlinna
Drva
Falun
Gävle
Åbo
HELSINKI
Kotka
Leningrad
Hamar
Åland
Kronstadt
Pushkin
Finska viken
Narva
Hangö
Paldiski
TALLINN
Uppsala
Mälaren
STOCKHOLM
Dagö
Peipus
Novgorod
OSLO
Drammen
Karlstad
Örebro
Skien
Fredrikstad
Larvik
Vänern
Nyköping
Norrköping
Ösel
ESTLAND
Tartu
Pärnu
Pskov
Vänersborg
Riga-bukten
Valga
Skagen
Göteborg
Borås
Jönköping
Vättern
Västervik
Visby
Gotland
Ventspils
RIGA
Frederikshavn
Växjö
Jelgava
Daugava
LETTLAND
Aalborg
Kattegatt
Halmstad
Öland
Liepaja
Daugavpils
(Dvinsk)
Polotsk
Kalmar
Siauliai
Jylland
Aarhus
Helsingborg
Karlskrona
Klaipeda
(Memel)
LITAUEN
Helsingør
DANMARK
KØBENHAVN
Malmö
ÖSTERSJÖN
Kaunas (Kovno)
Odense
Sjælland
Fyn
Bornholm
Kaliningrad (Königsberg)
Vilnius
(VILNA)
Borisov
Minsk
Suwałki
Falster
Bothniska viken

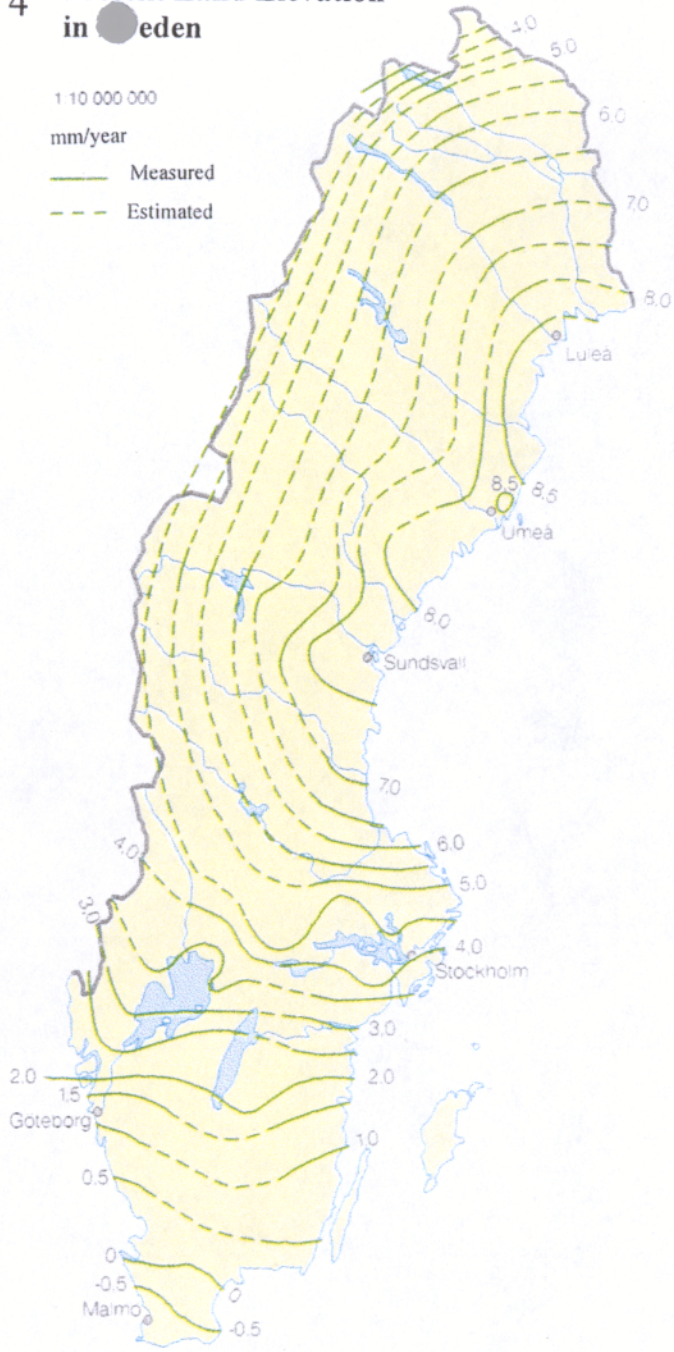
Map 4

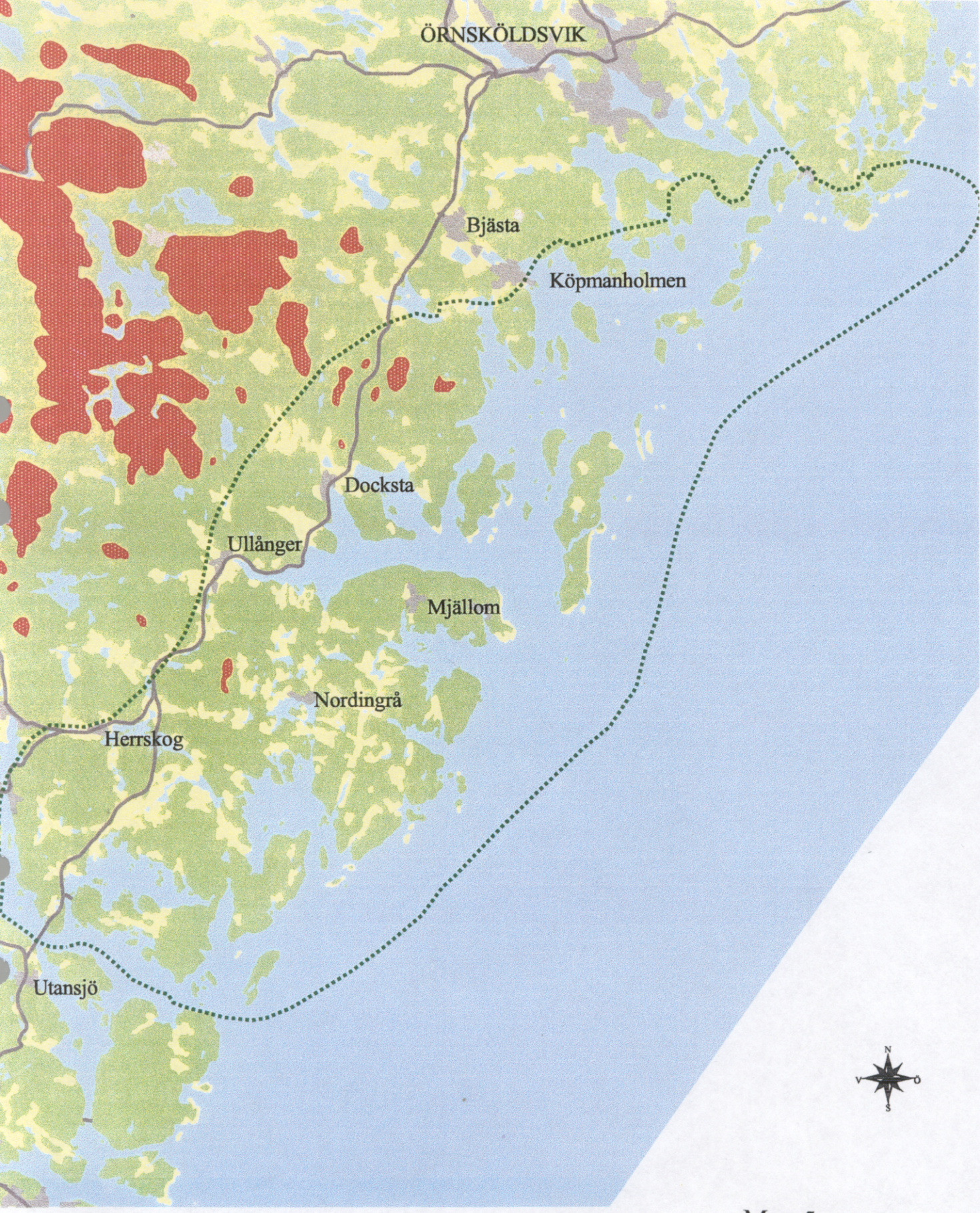
Land elevation in Northen Europe





Present Land Elevation in Sweden





Map 5

Land area over the shoreline 9000 years ago. 275 m over the present shoreline.

The High Coast

20 0 20 kilometer

Map 6

Land area over the shoreline 7000 years ago. 100 m over the present shoreline.

The High Coast

20 0 20 kilometer

Map 7

Land area over the shoreline 4500 years ago. 50 m over the present shoreline.

The High Coast

20 0 20 kilometer

Map 8

Land area over the shoreline 2500 years ago. 25 m over the present shoreline.

The High Coast

20 0 20 kilometer

historical periods of human settlement are found in the area, to an extent that is unique in Scandinavia, and are located in close proximity to one another. They are also well-preserved and, since they do not lie directly over each other in layers, they are easy to detect.

b. Comparative analysis

The raised coastline of the area displays a complete series of quaternary formations which clearly reflect the ongoing geological process known as "isostatic land elevation". The height of the elevation is the greatest in Scandinavia, and has no counterpart in the rest of Europe. Its concentration and distinctive form is unique on earth. The rising land mass has also formed an archipelago in one of the world's largest brackish seas, which itself has an interesting history.

c. Authenticity/Integrity

The nominated area is a section of landscape that includes elements of mainland, sea and archipelago. Most of the geological formations that are important for an understanding of the landscape's geological processes and development are well-represented. The majority of the most important formations are protected by law, in the form of one national park and eighteen nature reserves, or by other means in accordance with Swedish conservation and natural resources legislation.

Together with the affected local governments, the national government exercises effective control over any activity that might damage the landscape and its valuable natural features. Building construction (except for agricultural purposes), gravel pits, mining, aerial power lines, roads, etc., require special permits. The High Coast is specifically designated in Sweden's Natural Resources Act as an area of national interest. Its values for natural and human history, tourism and outdoor recreation must be taken into account in the evaluation of any proposed development. Pulp and paper mills, wind farms, or any other facility that may result in a significant environmental impact may not be constructed without the national government's permission.

Small-scale farming and logging are conducted in the area; both are well-suited to the landscape, and help to keep older traditions alive. The siting and appearance of buildings have for the most part retained a traditional character. With the exception of Motorway E4, there are no large-scale facilities for tourism, electric power, industry or communications to disturb the environment. The few scars that remain in the landscape from past mining and quarrying activities have not damaged key geological features. An EU-financed experiment with the ecological adaptation of tourist facilities is currently in progress. The area has the capacity for an increase in visitors without being damaged.

The High Coast is a mosaic of landscapes, including both natural areas and those altered by human activity. The boundaries of the proposed World Heritage site have been drawn

on the basis of extensive research and planning. Consideration has been taken both to the entirety and to important components, including those that provide a complete picture of ongoing geological processes. An important aspect is the visual harmony that results from the mosaic of farmland and hilly natural landscape.

d. Criteria under which inscription is proposed

According to the criteria of Article 44(a), the proposed area has exceptional universal value due to the:

1. Well-developed topographical formations, which demonstrate the effects of the ice-age glacier on the landscape, as well as the gradual shifting of the shoreline resulting from the dramatic land elevation which has continued since the glacier´s retreat. Examples of such formations include till-capped hills, vertical zones of wave-washed rocks, areas of stone rubble, shoreline grottoes, shoreline banks, mounds of shell gravel, sand dunes, rounded outcrops, fissure networks and steep faults. The character of the entire landscape has been shaped by the sea´s continous wave action and sifting of soils

   The land mass has risen 285 metres during the past 9600 years. The rate of elevation has declined; but at eight millimetres per year, it is still substantial. There are remains of shoreline formations from the three earlier phases of the northern Baltic— the Yoldia Sea, Lake Ancylus and the Littorina Sea.

   Clear evidence of the ongoing land elevation is provided by the enclosure of sea inlets and the joining of offshore islands with the mainland. In addition to such indications of present activity, there are traces of the geological process that has gone on for 9600 years.

2. Establishment of new vegetation zones along the shoreline, as new land area is exposed as a result of the continuing elevation. The formation of fens on new land. The transition from brackish-water plant species to freshwater species following the enclosure of sea inlets. The forestation of beaches. Changes in the composition of the shorebird population as a result of changes in the offshore islands. The presence among the local flora of relicts from both ice ages and warmer periods. Of the area‘s fish species, the four-horned sculpin *(Myoxocephalus quadricornis)* is one example of an ice-age relict.

3. Historical and natural landscapes of great beauty, including extremely valuable historical features. The High Coast is one of three stretches of uninterrupted Swedish coastline that have been identified by both national and international authorities as of exceptional value for outdoor recreational purposes.

3. Description

a. Description of property

Topographical formations

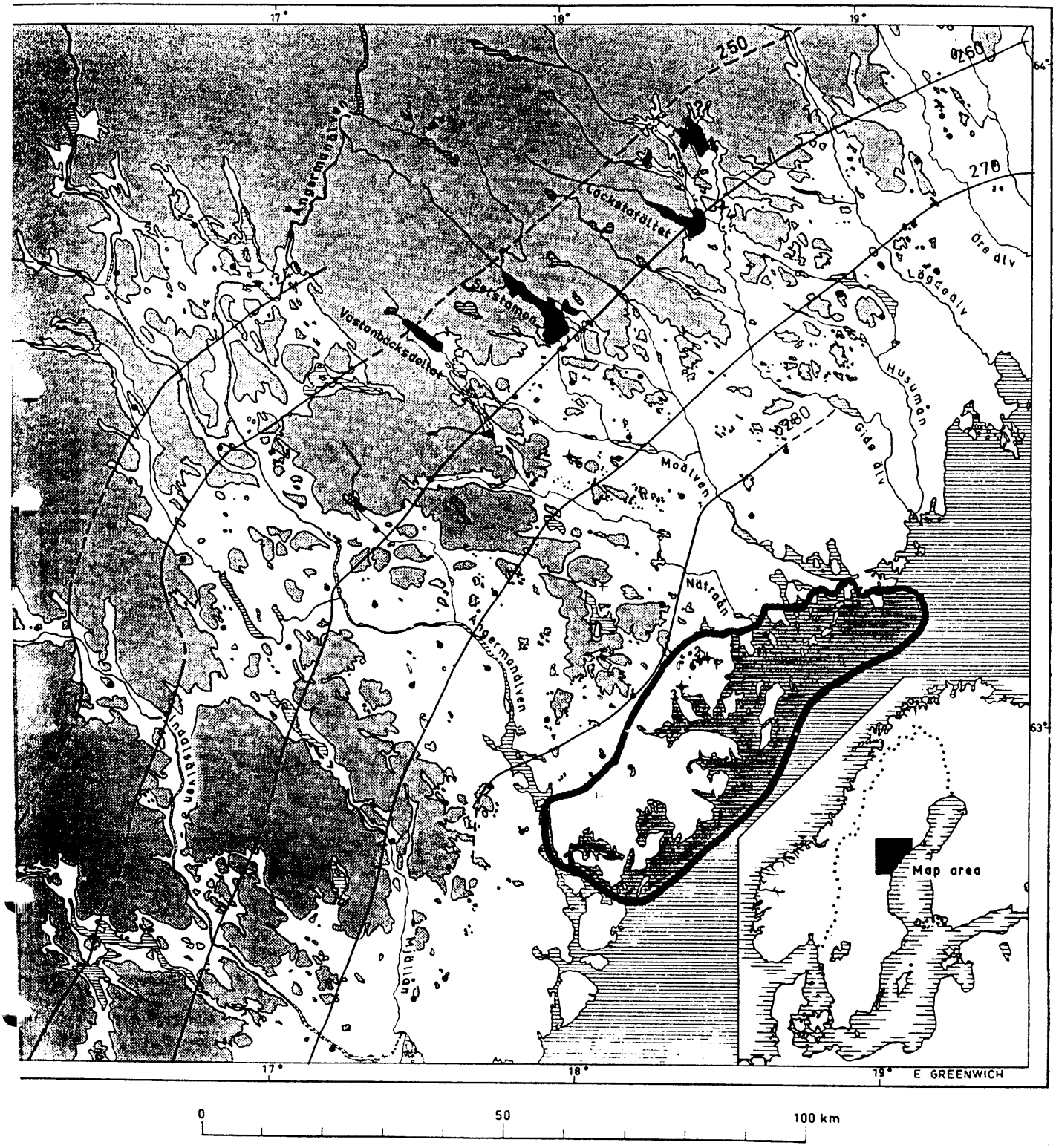
The High Coast lies on the coast of the northern Baltic near the mid-point of the Scandinavian Peninsula, between the towns of Kramfors, Härnösand and Örnsköldsvik. It is here that the raised topography of Sweden's inland stretches all the way to the Baltic coast, where it forms a landscape of lofty hills, narrow valleys, deep inlets and an archipelago. Viewed from the adjacent sea, the landscape appears rocky, barren and desolate. But in the valleys between the hills, there is fertile soil, farmland and forest. Located in the area are five small rural communities and, in sheltered inlets, five small fishing camps. The highest hills are 350 metres above sea level. Also located in the area is Mjältö Island, at 236 metres above sea level the highest in Sweden. The High Coast is an area of steep hills, with a maze of fissures and valleys. There are also plunging faults that extend under the sea, forming shoreline cliffs and deep sea canyons. The greatest depth of the northern Baltic, 293 metres, is located near the nominated site.

The landscape has been powerfully influenced by earlier periods of glaciation, land elevation and the sifting of soil and gravel along the various coastlines. The hills have a distinctly asymmetrical pattern. The northwest sides have experienced the greatest wear, as the glacier advanced from that direction. The southeast sides of the hills are usually steep, with local climates that are warmer than the surroundings. Grooves worn into the hard surfaces of granite and gneiss indicate the direction of the glacier's movement. When the glacier retreated, it left behind a layer of mixed soil and gravel, a moraine.

After the glacier withdraw from the area some 9600 years ago, the current land surface was covered almost completely by the sea. An important geological boundary in Scandinavia is the highest coastline ("HC"), which is the level of the ancient shoreline before the process of land elevation commenced (Map 3). Now high above the current sea level, it usually marks the point below which most farmland is to be found, and above which forest and marshland are located. Along the High Coast, the HC can be clearly seen as a boundary line between the undisturbed moraine above, and the rocks below that have been washed clean by the sea. In the central part of the High Coast region, the HC is all of 285 metres above sea level. There are nine till-capped hills in the area on which the HC can be seen; the three highest of these are protected within nature reserves and the national park.

Soils and quaternary formations

The moraines washed from the hills by the waves of the sea have been gradually sifted and transported down the slopes. Level areas of stone rubble spread out toward the sea. In more sheltered locations, large quantities of gravel have been deposited. Silt, sandy soil and clay have been deposited in layers in the valley bottoms, which is clearly



Map 3

The isobases of the highest shoreline of the Bothnian Sea. The grey areas represent land above the highest shoreline.

Boundary of the High Coast

reflected in the location of farmland. The coarser soils below the hillsides' bare-rock zones are forested.

The low-lying areas of stone rubble are still expanding, as in the Norrfällsviken Nature Reserve. The stone rubble area on Högklinten is a special case, as its large boulders have been shaped by the waters of Lake Ancylus and both the Yoldia and Littorina seas. The patches of stone rubble and the grottoes at various elevations provide very clear evidence of the land elevation process. Such areas are protected in several nature reserves. The area also contains many stable shoreline banks, some including shell gravel.

Land elevation

The most recent ice-age glacier, the Weichsel, was centred on the High Coast region. It was at its greatest volume about 18,000 years ago, and the total land elevation since then has been calculated as 800 metres (Map 4 - 8). Immediately following the glacier's retreat, the rate of elevation was 100-150 millimetres per year, but is currently eight mm per year. Patterns of human settlement have been greatly influenced by such phenomena as the enclosure of sea inlets which then become lakes, the joining of islands with other islands and the mainland, decreasing depths of sea routes, and the lifting of docks and boat-houses above the water line. In the course of a human lifetime, the depth of the local sea decreases by nearly a metre.

Bedrock

The bedrock in the southwest section of the High Coast region consists of granite and gneiss. In the eastern and northern sections are magmatic rocks between 1.5–1.6 milliard years old, including reddish rapakivi granite and two dark grey varieties of deep bedrock, gabbro and anorthosite. Running through the entire area are seams of diabase 1.2 milliard years old, and there are also giant slabs of diabase which shield the ancient sandstone that lies above the deep bedrock. On the floor of the northern Baltic, the sandstone has been covered by younger rocks, including Ordovician limestone. The different types of rock are easy to study, given the large bare surfaces of cliffs and hills. In several of the nature reserves, including Trysunda, there can be seen many fine examples of contact zones where layers of different rocks lie atop on another.

Also running through the High Coast region are numerous faults and fissures. The steep hills were formed when shattered rock was transported from these clefts in the bedrock by running water and the ice-age glacier, leaving behind deep valleys gouged out of the landscape in nearly straight lines.

Characteristics of the vegetation

The geological conditions of the High Coast are also clearly reflected in its vegetation, especially in the distribution of various forest types. On the wave-washed hillsides there are isolated patches of dry sandy soil which support a sparse growth of pine. The moist sediments of the valley bottoms are dominated by spruce, and by mixed forest of evergreen and broad-leaved species. The boundaries between the different forest types are unusually sharp, and there is an exceptionally large variation between different forest types.

The site quality of many stands of spruce is very high— comparable to the fertile soils of southern Sweden. This results from a combination of moving ground water and the large quantities of nutrients contained in particles eroded from the gabbro, anorthosite and diabase rocks. Several of these spruce woods have a very wide variety of flowering plants, including many southerly species which are otherwise rare in the region. The Halsvik Ravine Nature Reserve offers a good example. A completely different type of spruce forest grows in the unwashed moraine on those hilltops that have always remained above the highest coastline.

The steep slopes of the landscape contribute to a favourable local climate, with long growing periods and good soil conditions at the base of the south-facing cliffs. Closely linked to this habitat are more than half of the roughly forty plant species for which the High Coast region is the northern limit. Some of them are relicts of warmer periods, for example hazel (Corylus avellana), linden (Tilia cordata) and maple (Acer platanoides). Exceptionally good examples of such plant habitats are provided by the Omneberg and Skulleberg nature reserves.

On the north-facing cliffs of the highest hills grow isolated patches of such alpine plants as purple saxifrage (Saxifraga oppositifolia), tufted saxifrage (Saxifraga caespitosa), the fern Polystichum lonchitis and three-leaved rush (Juncus trifidus). The plant that is especially characteristic of the High Coast is the mountain rock-cress (Cardaminopsis petraea); it is the only plant in Sweden that is limited to this area, alone. All of these plants are considered to be relicts of the last ice age.

Shorebirds

In the archipelago and surrounding waters, birds nest only on flat, treeless islands. There is also a distinct pattern in the distribution of species between the sheltered islands of the inner archipelago and the exposed outer islands. A survey conducted in 1987 found 6000 pairs of shorebirds, representing 24 species, nesting on 133 islands in the High Coast region. Many large colonies were noted. Eight islands of the archipelago are bird sanctuaries which are off limits for human visitors during the nesting season. Gnäggen Nature Reserve is an especially valuable bird island, with its nesting guillemots (Uria aalge) and razorbills (Alca torda), two species that nest at only a few locations in the Baltic. As a result of land elevation and associated forestation, birds gradually move to newly-formed islands.

Exploitation of natural resources

The High Coast is a mosaic of natural and altered landscapes. In drawing the boundaries of the nominated World Heritage site, consideration has been given both to the entire entity and to key components. The altered landscape can only be maintained within the context of a living rural community, and with the application of good farming practices. Small-scale logging is conducted with methods that are well-suited to the landscape as a whole, and to the requirements of endangered species and habitats. The number of farmers has steadily decreased during recent decades, and commercial fishing has nearly come to a halt. The land is for the most part privately owned, primarily in the form of mixed farm and forest. The population of the entire High Coast region is in decline.

Parts of the landscape and environment have been affected by Motorway E4, local roads, a few older gravel pits, some radio towers and aerial power lines. But taken as a whole, such encroachments have not destroyed key geological features or significantly altered the landscape profile. Located within the region are five small towns whose economies are based on retail trade, services, tourism and smaller industries, including many connected with the lumber trade, product assembly, electronics, baked goods, fish-canning, and boat-building. Of the previously dominant forest industry, only a small segment remains. No large, environmentally intrusive industries have been established in the High Coast region.

b. History

9500-9600 years ago

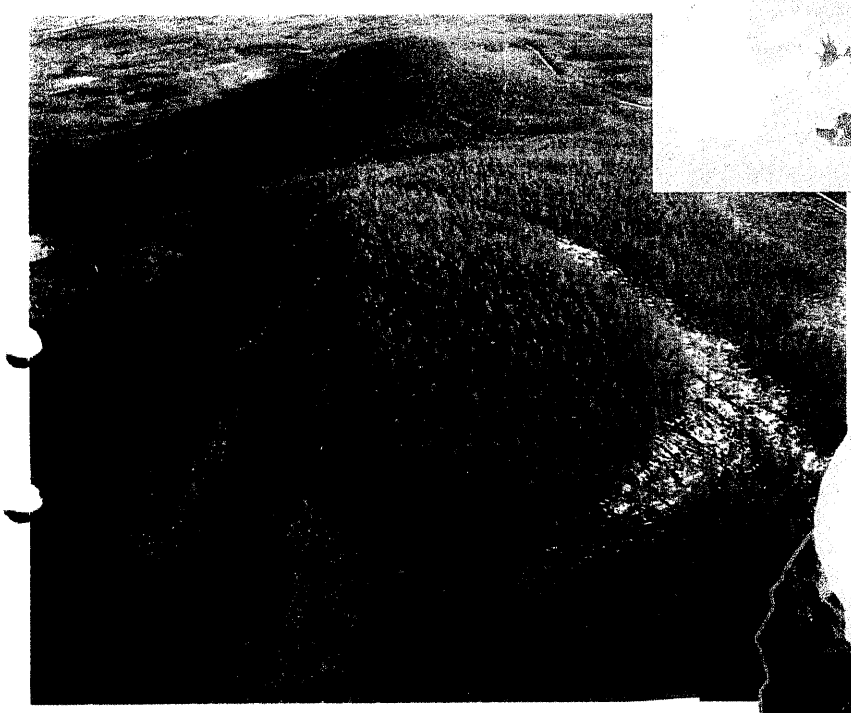
During this period, the ice-age glacier retreated from the High Coast, and the resulting land elevation during that time has been estimated as ca. 150 millimetres per year. The first offshore islands, now the highest hills on the mainland. began to emerge from the sea. The sea of that time, the Yoldia, was salty. The climate was probably at least as warm as today's.

8000-9500 years ago

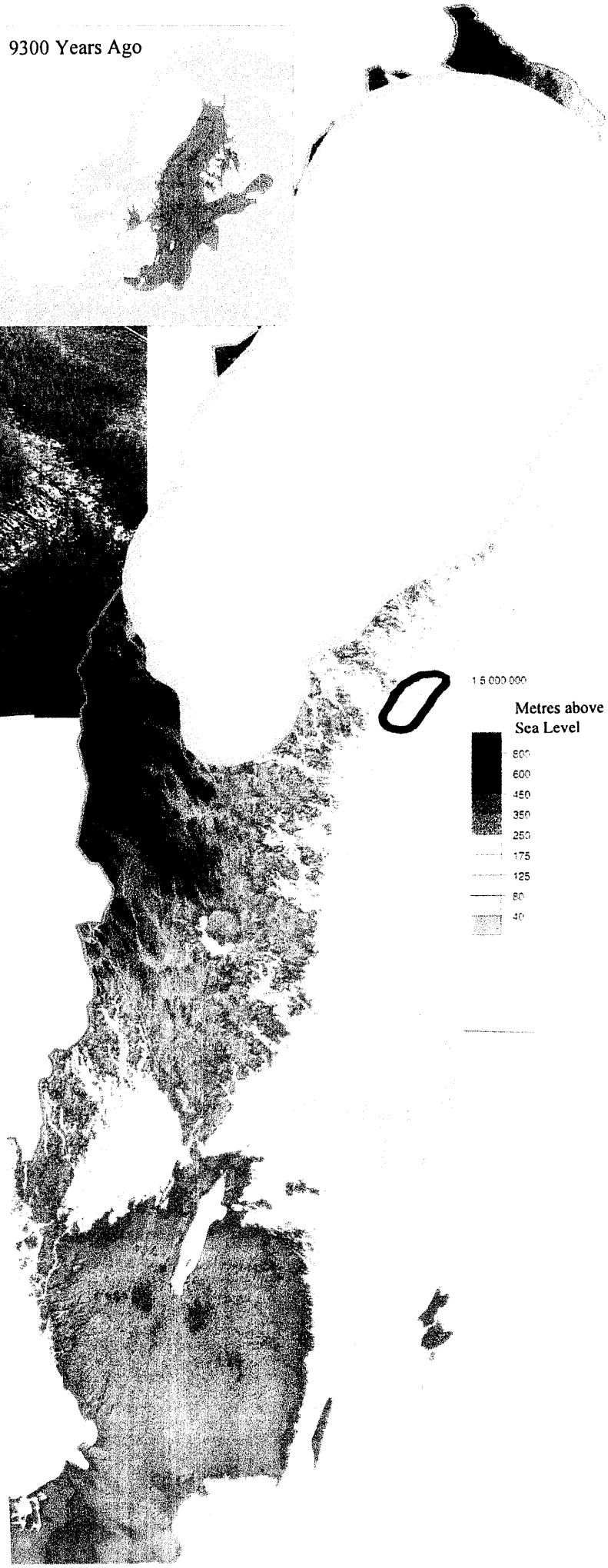
Half of the total land elevation to date took place during this period, and large areas of new land were lifted out of the sea within a fairly short time. The climate is warmer and drier than at present. The initial alpine vegetation is quickly replaced by birch (Betula), aspen (Populus tremula) and pine (Pinus sylvestris). The first human visitors arrive. The Yoldia Sea is cut off from the North Sea and is transformed into a great freshwater lake, named Ancylus (Map 9).

Map 9

9300 Years Ago



Typical till-capped hill with forested moraine above a wave-washed zone that marks the highest coastline.

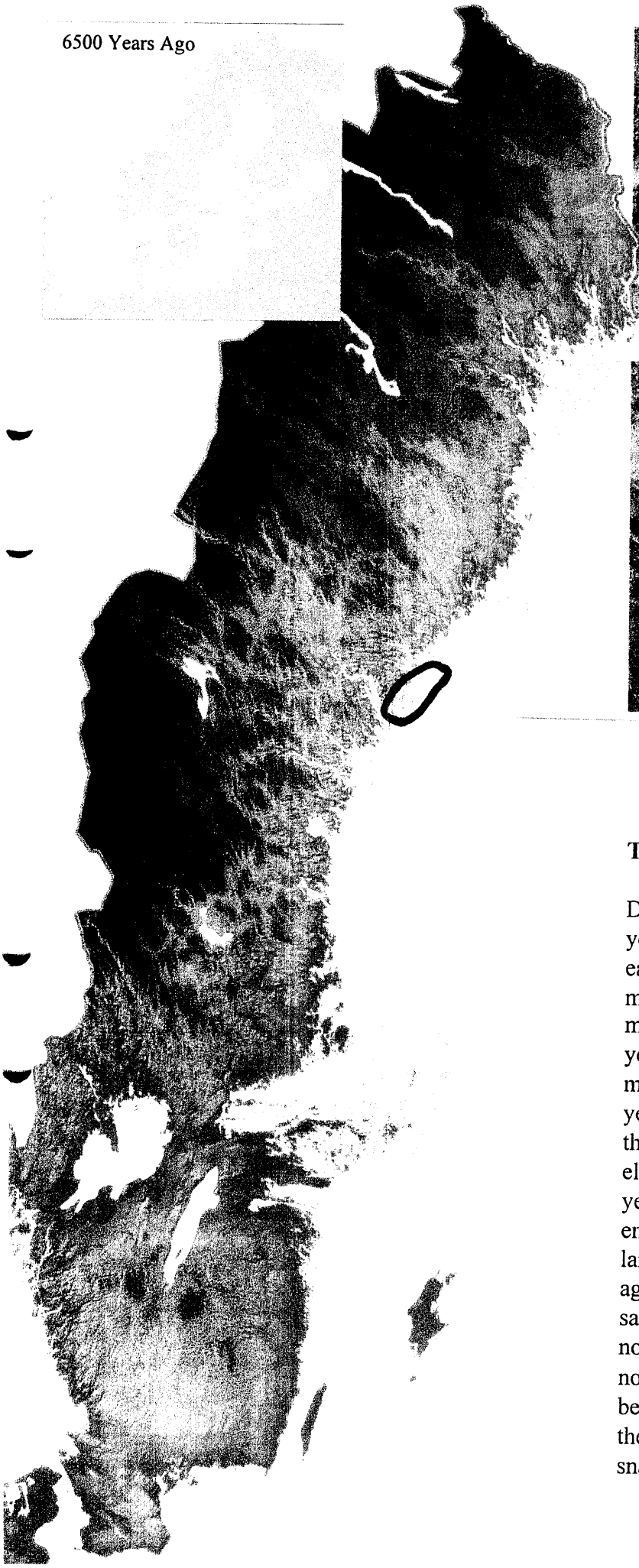


8000-9500 years ago

The second stage in the Baltic's history was the freshwater Lake Ancylus, which is named after the freshwater snail, Ancylus fluviatilis. The lake emptied into both the Göta River and Otteid Sound, the latter of which no longer exists. When both outlets became increasingly narrow and shallow as a result of land elevation, the surface of the lake was forced upward. Since the rate of elevation was greater in the north than in the south, the mass of water shifted southward, leading eventually to what is known as the "Ancylus Transgression".

Map 10

6500 Years Ago



The last 8000 years

During the period from 9000–5000 years ago, the average level of the earth's oceans rose by roughly 35 metres. The increase was twelve metres during the first thousand years of that period, and five metres during the final thousand years. The increase was greater than that of southern Sweden's land elevation. The result was a 4000-year-long period of steady encroachment by the sea onto the land. Starting about 8000 years ago, the Baltic became increasingly salty, and brackish water spread northward. It gradually reached the northern Baltic, marking the beginning of its next phase, that of the Littorina Sea, named after the snail Littorina littorea.

4000-8000 years ago

It was during this period that a warmer period reached its culmination, with temperatures 2–3 degrees centigrade higher than today. Broad-leaved forest of alder (Alnus glutinosa), hazel (Corylus avellana), elm (Ulmus glabra), linden (Tilia cordata) and maple (Acer platanoides) spread rapidly throughout the High Coast region. This was toward the end of the Stone Age, and many contemporary dwelling sites have been discovered, most of them along the shoreline of that time. Farming was practised during the latter part of this interlude. Wheat (Triticum aestivum) and barley (Hordeum) were being grown 4000 years ago. Salt water began to penetrate Lake Ancylus, and the water became increasingly salty during the transition to the Littorina Sea (Map 10).

4000 years to the present

Beginning 4000 years ago, the climate started to become colder and more continental in character. The broad-leaved tree species of hazel, elm, linden and maple began to disappear; but there remained patches on climatically favourable sites such as south-facing slopes. Some 3000 years ago, a new species began to dominate the landscape—the spruce (Picea abies), which migrated from the north. Around the same time, Stone Age humans began to bury their dead in stone cairns. There is a heavy concentration of such cairns along the High Coast at thirty metres above sea level.

Permanent settlements developed during the Iron Age, and the area of cultivated land increased. Gene prehistoric village near the northern boundary of the High Coast, the well-preserved remains of a settlement from the years 1-600 A.D., has been excavated and restored. The resident population lived in large families in permanent longhouses. Pollen analyses indicate that cultivation of the landscape expanded rapidly 1000–1200 years ago, during the Viking Era.

The area's fishing camps date from the 16th century. Some were used by local farmers, others by seasonal fishermen from the south. By this time, typical housing had changed from large longhouses to smaller log cabins. From the end of the 1800s to the beginning of the 1900s, in response to a heavy increase in population, there was a major expansion of land placed under cultivation and large numbers of trees were cut down for sale to nearby sawmills.

Historic sites

The High Coast region contains many historic remains which display a pattern of continuity from the Stone Age to the present. Dwelling sites and harbours have been moved upward in response to land elevation, but there are also buildings today located near Stone Age dwellings sites at higher elevations. (Fig 1) The historical sites are typically separated from each other in a vertical direction from the current shoreline. All periods of local human history are represented and are clustered closely together.

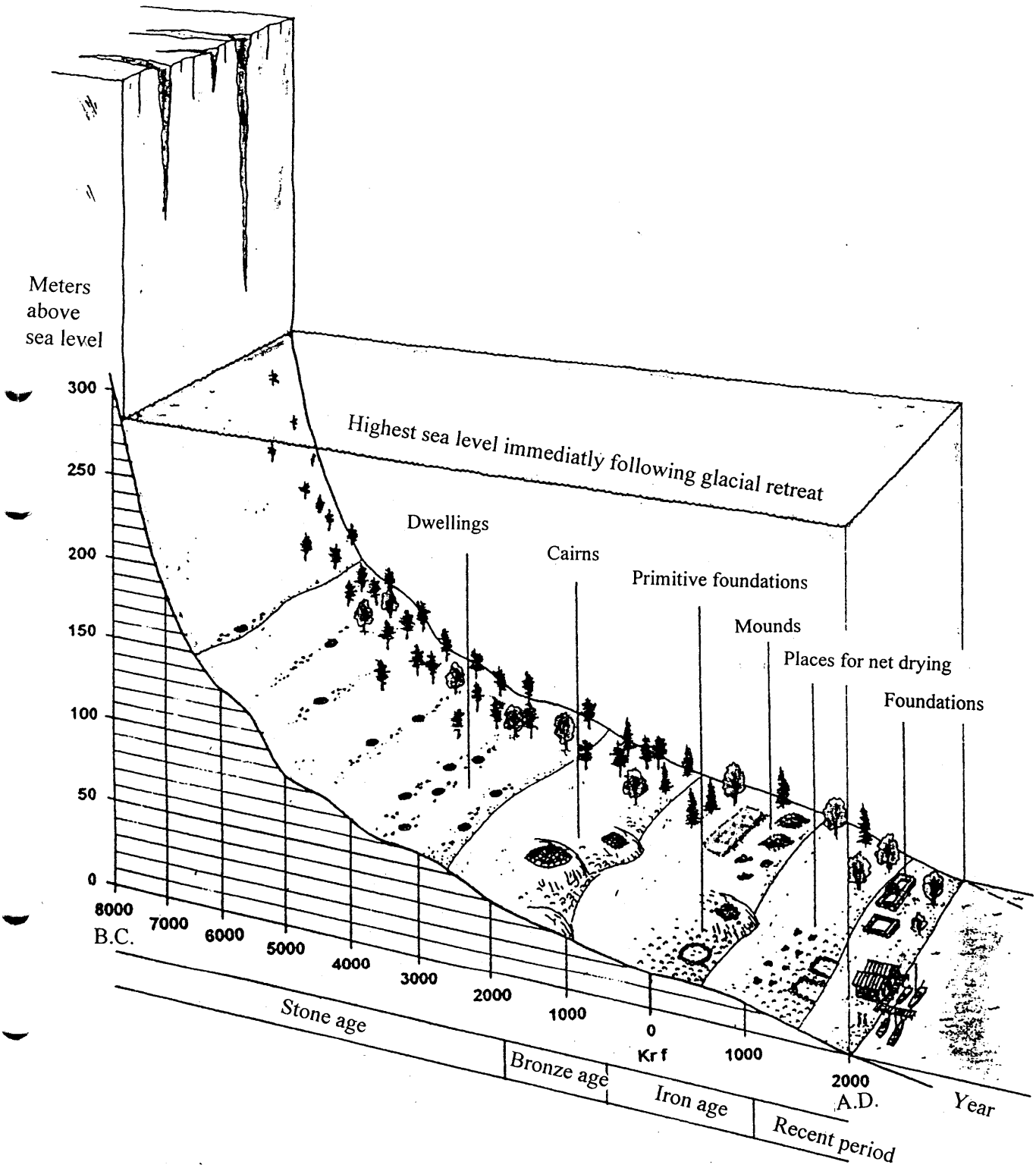


Fig 1

Schematic diagram of land elevation process and the development of human settlement in the High Coast region, illustrated by some typical remains at relevant elevations

Ancient remains are easy to discover, since they are covered only by a thin layer of soil. Areas of historical interest are indicated on map. . . .

The High Coast's ancient remains and other traces of human history are of significant national interest, and contribute as well to an understanding of the landscape's geological development. According to the responsible Swedish agencies, however, the area's human history is not in itself sufficient to motivate its nomination as a cultural World Heritage site.

c. Form and year of recent records

The bedrock has been charted and described in various studies dating from the close of the 19th century and onward. Lundbom published a highly detailed bedrock survey in 1899, and the results of additional studies were published by Högbom in 1909, Sobral in 1913, and T. Lundqvist and Samulesson in 1973. A detailed description of the area's bedrock was published by T. Lundqvist in 1990.

Many researchers have studied land elevation, glacial retreat and quaternary sediments within the High Coast region and surrounding river valleys, partly with the help of varved clays from the bordering valley of the Ångerman River and the highest coastline. Basic research in this regard has been carried out by Lidén (1911, 1913 and 1938), Hörnsten (1964) and others. In connection with a later soil survey (1987), Lundqvist provides a detailed description of glaciation, land elevation, soil types, as well as pollen analyse that shed light on plant succession in the area.

Extensive surveys of the local flora have been carried out during the past thirty years by Västernorrland County and a special project of the Ångermanland region. There is a large body of accumulated knowledge, much of it reviewed by Mascher (1990) and a series of reports by the Västernorrland County Administrative Board. Detailed studies of plant succession along the Baltic shoreline have been carried out by Ericson (1980, 1981). The vegetation of Skuleskogen National Park has also been surveyed.

Studies of the flora and fauna in seven of the region's lakes are in the process of being published. Algae populations in the Baltic are monitored frequently in a joint regional and national programme (cf. Kautsky).

Birdlife along the entire coast was surveyed in 1973 and 1987 (cf. Ångermanland's Ornithological Society, 1974; also, Grenymyr & Holmkvist, 1994).

Archaeological digs at important dwelling sites have been carried out by the county museum and Umeå University at Lappnäset (cf. Forsberg, 1997), Gene (Ramqvist, 1983) and Överveda (Baudou, 1977).

A large body of knowledge concerning the High Coast region has been assembled in the Västernorrland County Administrative Board's data base, "DaNi", including information on 108 sites. The boundaries of these and other protected natural areas have been recorded by Geographical Digital Information System (GIS).

The values of the area according to natural and cultural heritage have been evaluated by an interdiciplinary group of scientific experts in an investigation of potential World Heritage sites in the Nordic countries. The group worked on behalf of the permanent Nature Conservation Working Group under the Steering Committee for Environmental Conservation of the Nordic Council. The result of the work has been published in the report; Nordic World Heritage, proposals for new areas for the UNESCO World Heritage List (1996). The High Coast is one of the areas in the report proposed for nomination as World Heritage site, natural property.

d. Present state of conservation

The nominated area is protected by three types of legislation:

1. Areas protected according to Sweden's Nature Conservation Act, including: national parks (§4 and 5), nature reserves (§7-10), nature conservation areas (§18), landscape protection areas (§19), and bird sanctuaries (§14).

2. Other protected status according to general provisions of the Nature Conservation Act, including: protection of beaches (§15), prohibition against open-pit mining (§18), and compulsory consultation (§20).

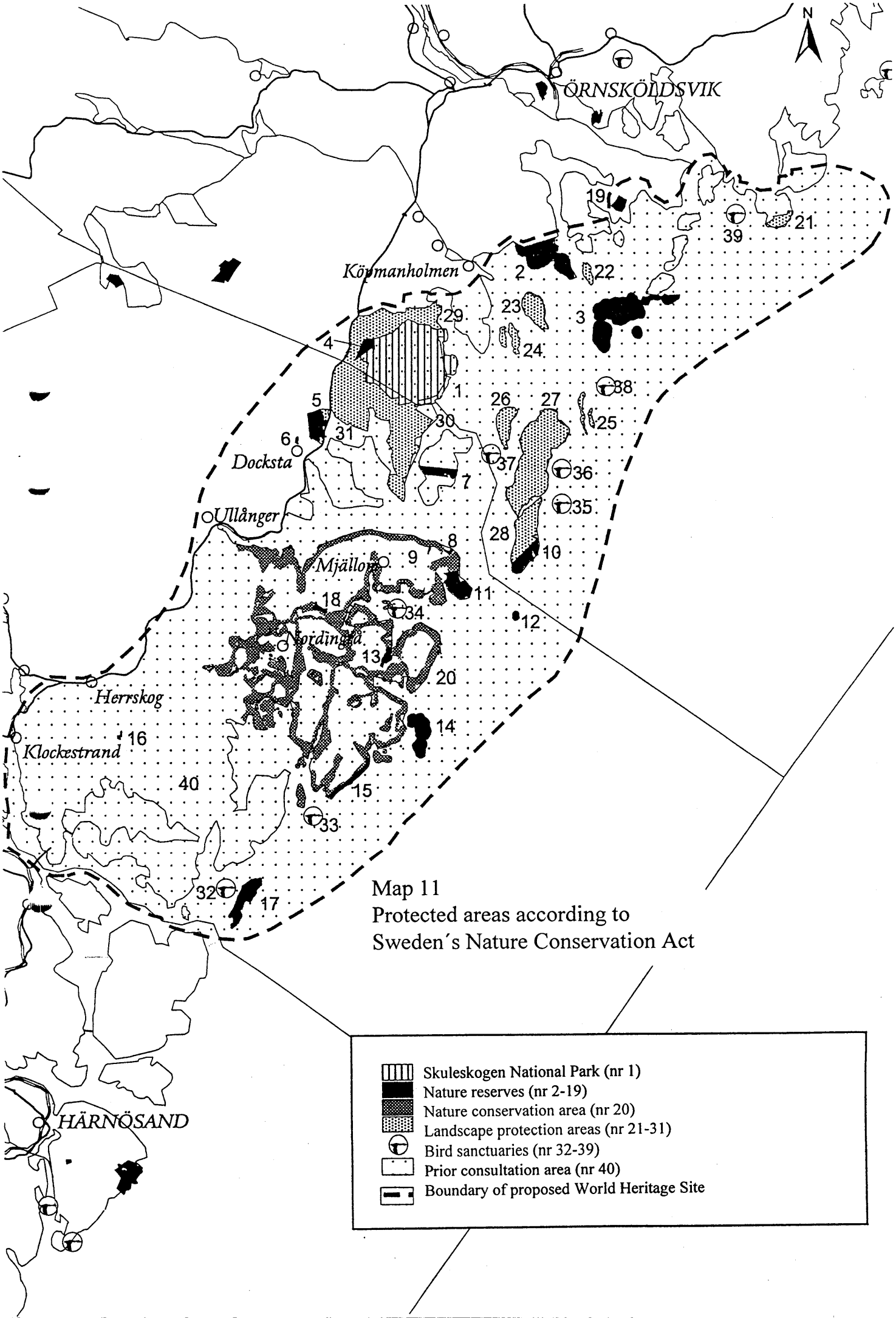
3. In addition, there are special provisions in the Natural Resources Act and in municipal development plans.

1. Protected areas (Map 11)

National park

The High Coast region includes one national park, Skuleskogen, which was established in 1984 and contains 2950 hectares (ca. 7290 acres), of which 2650 hectares are land surface. The land is owned by the state, and the government has proposed that the national park be designated a "Natura 2000" area of the European Union.

Skuleskogen National Park lies in an area where the lofty terrain of Norrland's interior meets the Baltic coast. The park is a hilly, roadless wilderness area with rocky outlets, tracts of ancient forest, tree-clad valleys, expanses of stone rubble, small lakes and streams. The bedrock consists largely of reddish rapakivi granite. Running through the park is a maze of fissures, with associated canyons and grottoes. The greatest elevation of the highest coastline is located here, and the park lies at a geographical boundary of significant botanical interest. The fauna is characteristic of evergreen forests, including



Map 11
Protected areas according to
Sweden´s Nature Conservation Act

several species which depend on mature natural forest and relatively pristine habitats.

Nature reserves

Located within the nominated area are eighteen sites of particular geological and biological value which have been protected as nature reserves. They contain a total area of 3711 hectares (ca. 9170 acres), of which 2566 hectares are land surface. Any activity that might damage the land or its basic form is prohibited; this includes, for example, the construction of buildings or masts, excavating and ditching. Nature reserve ordinances provide permanent protection for topographical features, soils, plant and animal life. Decisions regarding the establishment and management of nature reserves are made by county administrative boards. Of the eighteen reserves, nine have been proposed as EU Natura 2000 areas.

Area	Name	Total hectares	Established
2	Balesudden	934	1985-06-14
3	Trysunda	932	1987-05-22
4	Skuleskogen	97	1990-06-03
5	Skuleberget	226	1974-12-20
6	Herrestaberget	9	1971-09-24
7	Mjältön	147	1974-09-18
8	Storsand	12	1969-02-10
9	Vilmyran	5	1974-03-29
10	Södra Ulvön	200	1971-09-20
11	Norrfällsviken	227	1969-02-10
12	Gnäggen	2	1970-04-08
13	Halsviksravinen	63	1974-03-29
14	Högbonden	335	1987-05-22
15	Rotsidan	112	1974-05-31 (exp. 1977-11-25)
16	Storholmen	9	1975-06-09
17	Storön	302	1970-03-31
18	Omneberget	27	1992-06-16
19	Ögeltjärn	72	1994-06-07

Nature Conservation Area

Nature conservation areas are similar to nature reserves, but restrictions on various uses of the land are less stringent. For the Nordingrå Nature Conservation Area, special building regulations apply. Among other things, no repainting or new construction is allowed without special permission of the Västernorrland County Administrative Board.

20	Nordingrå	6000	1983-03-03

Landscape protection areas

In these protected areas, special permission of the relevant county administrative board is required for the construction of new buildings, transmission lines, roads, etc. This applies to the following areas:

Area	Name	Established
21	Skeppsmalen	1983-03-03
22	Järvön	1968-09-17
23	Älgön	1968-09-17
24	Strängöarna (2 islands)	1968-09-17
25	Värnsingöarna (2 islands)	1968-09-17
26	Ronön	1968-09-17
27	Norra Ulvön	1968-09-17
28	Södra Ulvön	1968-09-17
29	Area south of Lake Skulesjö	1968-10-21
30	Within and beside Skuleskogen	1974-12-20
31	Mount Skuleberget (2 areas)	1969-02-26

Bird sanctuaries

The purpose of bird sanctuaries is to protect nesting birds from unnecessary disturbance. For the eight areas listed below, that protection applies from April 15–August 15, during which time humans are not allowed to enter the sanctuaries or to conduct themselves in any way that might disturb the birdlife.

32	Grönviksflasen	1976-03-22
33	Långskärsklubben	1976-03-22
34	Skorpan and Gåsen	1976-03-22
35	Flasan	1976-03-22
36	Gråbuten	1976-03-22
37	Ratan	1976-03-22
38	Värnsingsklubbarna	1976-03-22
39	Västerskär-Mellanskär	1976-03-22

2. General legislation (Map 11)

Prior consultation

In addition to protections for the areas noted above, no work that might cause significant damage to the natural environment may be commenced without prior consultation with the Västernorrland County Administrative Board. This applies to essentially all land

between the coastline and Motorway E4. By a special decree of the Board from 1975, consultation is required for any project within the High Coast region involving the construction of roads or of aerial power lines with a capacity of 10 kV or greater. The County Administrative Board may, at its own discretion, require those responsible for such projects to take measures for the protection of the environment. It also has the power to prohibit proposed projects. It may not, however, make any decision that poses a significant obstacle to existing uses of the land, such as forestry.

40 High Coast between Baltic coast and E4 1976-03-22

Shoreline protection

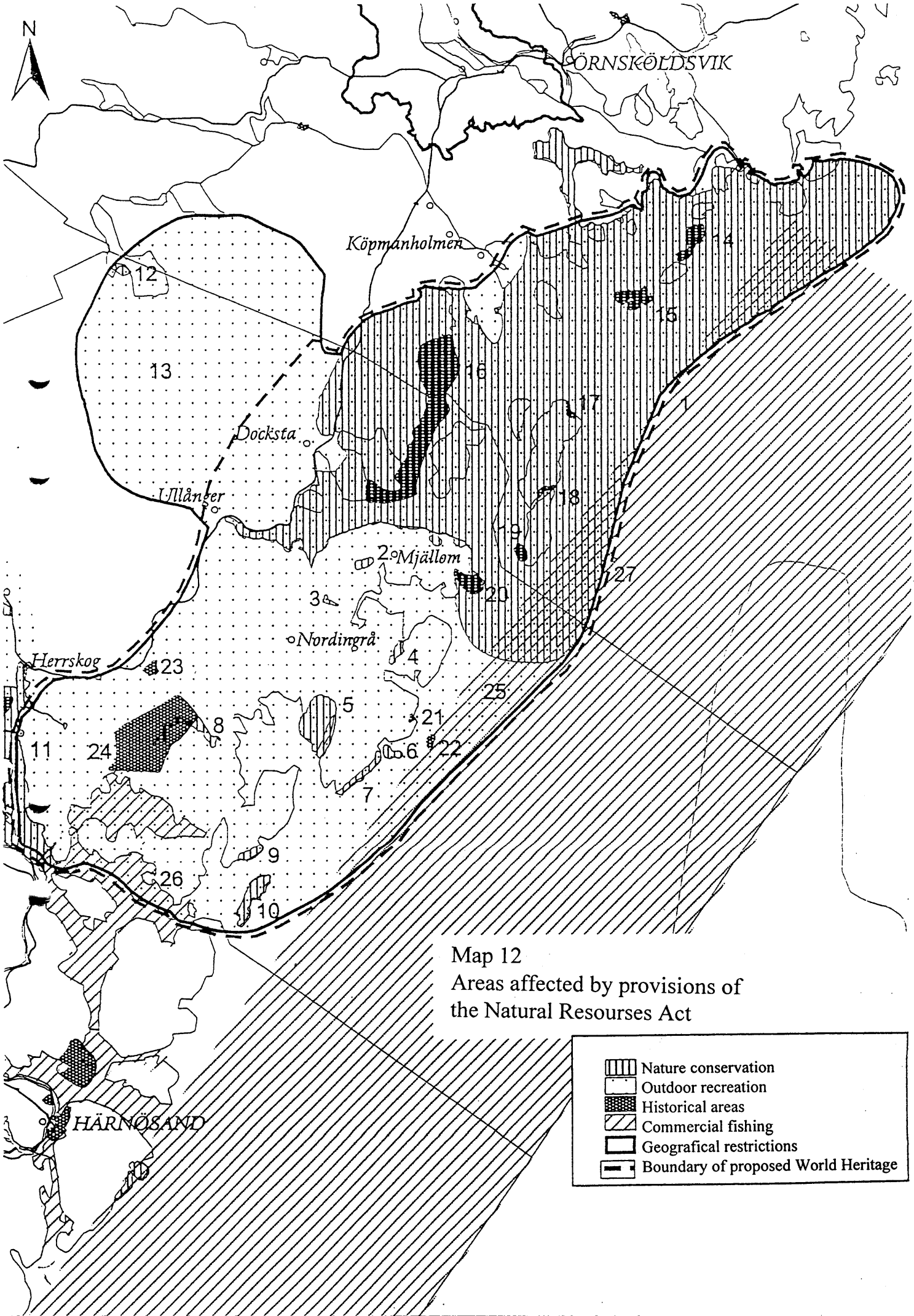
All shorelines along lakes, watercourses and the sea are protected, unless otherwise specified. This protection applies to all land and water for 100 metres on either side of the water line at normal mid-tide. The range in the seaward direction is extended to 200 metres from sea islands and over half of the mainland coast. In these areas, special permission is required for the construction of buildings, docks and any other facility. The purpose of shoreline protection is to secure the general public's access to suitable areas for bathing and other forms of outdoor recreation. Recent amendments to the law stipulate that consideration must also be given to the preservation of favourable living conditions for plants and animals.

Mining and excavating

The removal of stone, gravel, sand, clay, soil, peat or any other surface material, for purposes other than the landowner's personal requirements, is not allowed without special permission of the county administrative board. In cases where such permission is granted, environmental protection specifications are included. The state is not liable for compensation of any sort if an application for special permission is rejected. Those who receive permits are required to demonstrate how the land is to be restored after the surface materials have been removed. The county administrative board has adopted an especially restrictive policy regarding naturally occurring gravel, a finite resource. As the result of a very restrictive policy, few permits for the removal of surface materials have been granted in the High Coast region.

3. Special provisions of the Natural Resources Act, et al. (Map 12)

The Natural Resources Act is intended to promote the long-term conservation of land and water. The Act states that certain uses of land and water resources are of *national interest,* including those relating to nature conservation, the preservation of historical remains and artefacts, and outdoor recreation. The national interest may also allow room for certain kinds of exploitation, especially if the nation's resource requirements cannot



Map 12
Areas affected by provisions of the Natural Resourses Act

otherwise be fulfilled. However, no activity may be permitted if there is a risk that it might seriously damage some national interest. It is up to the relevant central authorities to specify which land and water resources are of national interest within their areas of responsibility.

Some geographical areas, including the High Coast, have been specified by law as of national interest in their entirety, due to the value of their natural and historical features. In addition to natural and historic values, tourism and the more active forms of outdoor recreation are to be given special consideration in the evaluation of proposed developments within the High Coast region. Certain kinds of facilities may not be built without special permission of the national government; these include pulp and paper mills, wind farms with a combined generation of greater than 10 megawatts, and any other facility that may be expected to have a significant and/or intrusive impact on the area in question.

Local municipalities are required to maintain an up-to-date development plan that provides guidelines for decisions affecting the use of land and water resources, as well as the development and preservation of the built environment. The development plan is also expected to provide for the satisfaction of national interests for areas within the municipality. Evaluation of proposed new projects must consider potential damage to the valuable features which form the basis of the area's national interest.

Development plans are meant to function as agreements between the state and the municipality. The state is empowered to intervene if a municipality fails to satisfy national interests. In reviewing applications for encroachments on affected areas, all legislation which is linked to the Natural Resources Act shall also be taken into consideration, including laws relating to roads, railroads, water resources, planning, construction, and environmental protection. The degree of agreement between such laws and municipal development plans shall be clearly stipulated.

The High Coast region includes two Västernorrland municipalities, Örnsköldsvik and Kramfors, both of which adopted development plans in 1990. Örnsköldsvik is currently in the process of revising its plan, which includes an especially detailed treatment of valuable features in the shoreline area lying within the municipality's boundaries. The county administrative board, representing the state, has determined that, with some minor exceptions, the plans of the two municipalities make adequate provision for known items of national interest within the High Coast region.

The following areas are affected by various provisions of the Natural Resources Act ("NRL"):

<u>Nature conservation (NRL 2:6)</u>

Area	Name
1.	Ullångersfjärden–Skuleskogen–Örnsköldsvik archipelago
2.	Högklinten

3. Omneberget
4. Halsviksravinen
5. Ringkalleberget–Sörleviken
6. Barstaö Island and surrounding islands
7. Rotsidan
8. Norasund
9. Bråtan
10. Storö Island
11. Ångerman River downstream from Sollefteå
12. Svarnäsudden

Outdoor recreation (NRL 2:6)

13. High Coast region

Historical areas (NRL 2:6)

14. Grissland
15. Trysunda
16. Värns, Sund, Fanö Island
17. Sandviken
18. Ulvöhamn
19. Marviksgrunnan
20. Norrfällsviken
21. Bönhamn
22. Högbonden
23. Gallsäter
24. Rossvik

Commercial fishing (NRL 2:5)

25. Trolling area near Ulvödjupet
26. Ångerman River outlet and surroundings

Geographical restrictions (NRL, Chapter 3)

27. High Coast region, including shoreline and archipelago

e. Policies and programmes related to the presentation and promotion of the property

The 1990 development plan for the Municipality of Örnsköldsvik, and the more detailed plan for the coastal area.

The 1990 development plan for the Municipality of Kramfors.
An environmental strategy for Västernorrland County. Action plan with regional objectives adopted 1997. Historical sites programme for Västernorrland County, Part 1: Strategies for 1997-2001.

4. Management

a. Ownership

Most of the land is owned by a large number of private persons. The rest is owned by a few companies, the local municipalities and the state. The state owns ca. 5000 hectares that are protected in the form of a national park, nature reserves and bird sanctuaries, or have been set aside to become nature reserves.

b. Legal status

See section 3.d.

c. Protective measures and means of implementing them

The geological formations need to be protected from exploitation, as described in section 3.d. In order for the landscape to retain its characteristic mosaic of essentially undisturbed natural areas and humanly altered sites, there is a need for effective planning by national, regional and municipal authorities, legislated protection against harmful exploitation, and support for small-scale farming. All of these factors are present in the High Coast region. Increased awareness among the general public would improve chances for preserving the area's valuable features.

d. Agencies with management authority

The regional and local authorities responsible for preserving the High Coast for future generations are the Västernorrland County Administrative Board, the municipalities of Örnsköldsvik and Kramfors, and the Västernorrland County Forestry Board. Various non-governmental organizations and interest groups also work toward the same goal.

e. Levels at which management is exercised

Management of the area occurs at both the local and regional level.

f. Agreed plans related to property

The recommendations of the 1974 High Coast Commission have provided guidelines for the development of tourism and conservation measures. The relevant municipal development plans were adopted in 1990. The Västernorrland County Administrative Board has carried out a programme of nature conservation on a continuous basis. An environmental strategy for Västernorrland County was adopted by the county's administrative board in 1997.

g. Sources and level of finance

The state provides funding for the management of the national park, the nature reserves and historical sites. Support to agriculture is provided by the state and the EU. The county administrative board and the EU support various development projects for public information, the promotion of tourism and other purposes. The area is eligible for funding from the EU structural funds, Objectives 2 and 5b (archipelago).

h. Sources of expertise and training in conservation and management techniques

The personnel involved in planning and management of the area are well-qualified and experienced.

i. Visitor facilities and statistics

There is a Nature Centre (Skule Naturum) with information on the natural history of the High Coast, tourist attractions and Skuleskogen National Park. During the summer season, six additional tourist centres are in operation.

There are substantial museums in Härnösand and Örnsköldsvik. Mannaminne and Gene stone age village are outdoor museums within and near the High Coast. There are information displays on various subjects at several locations.

Sleeping facilities include smaller hotels, cabins, hostels and camping grounds. There are also cabins for hikers along some trails and, thanks to Sweden's right of public access, all visitors are entitled to camp at any suitable site for 24 hours.

The High Coast Trail is a hiking trail that runs for 100 kilometres through the area between the Ångerman River and Örnsköldsvik. Shorter trails, parking areas, toilet facilities and information displays are provided in the national park and most of the nature reserves. In the archipelago, there are many fine natural harbours and marinas.

The comparatively short tourist period is divided into a summer season from June-August, and a week or two of winter sports in March. The total number of visitors in 1993 was 3,056,900, a figure that has increased slightly in subsequent years. Tourist statistics for the High Coast region include the towns of Kramfors and Örnsköldsvik. The visitors, of which roughly 95 percent are Swedish, can be sorted into the following categories:

174,000 business travellers in hotels and hostels
458,600 overnight visitors in cabins, private rooms,
free campsites and recreational boats
2,424,600 in summer homes and on visits to friends and relatives.

j. Management plans

There are management plans for the national park and all the nature reserves. Other properties are subject to the logging policies of the county forestry board, the provisions of the municipal development plans, and management plans for historical sites.

5. Factors affecting the nominated property

a. Development pressure

There is some development pressure on the area with regard to the dredging of shallow bays, and the construction of masts and power generating windmills. A new section of Highway E4, including one of the world's longest suspension bridges, has been built through the southern section of the area.

Depopulation of rural areas is a growing problem. There are very few farmers, and commercial fishing has nearly ceased. Maintenance of the rural landscape is crucial for the future of the High Coast region. There is a need for a development plan aimed at creating opportunities for the population to remain in the area and preserve it for future generations.

b. Environmental pressures

Data from an extensive environmental monitoring programme indicate that acid rain and the discharge of pollutants into the sea have declined sharply during the past ten years, and are returning to acceptable levels. The sea waters are now so clean that a national reference station has been placed in an inlet of the High Coast. There is no significant deterioration of natural features due to tourism.

c. Natural disasters

There are none.

d. Pressures from tourists and other visitors

Negligible.

e. Number of inhabitants within property

Approximately 4500.

f. Monitoring

Methods and techniques for the monitoring of a complete landscape such as the High Coast are currently under development. The entire area has been photographed from the air with infra-red film in order to provide a baseline for the monitoring of changes in land use and alterations of the landscape. The water quality of lakes and watercourses, and of environmental conditions in the sea, is monitored on a continual basis. The population of shorebirds is systematically surveyed every 10–15 years.

The Västerbotten County Administrative Board has adopted a programme for monitoring of the national park and the nature reserves.

7. Documentation

Photographs and slides

Enclosed

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Abbrevations:
GFF: Geologiska Föreningen i Stockholm Föhandlingar
SGU: Sveriges Geologiska Undersökningar
SNV: Statens naturvårdsverk (Naturvårdsverket)
STF: Svenska Turistföreningen

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Addresses where inventories, records and archieves are held

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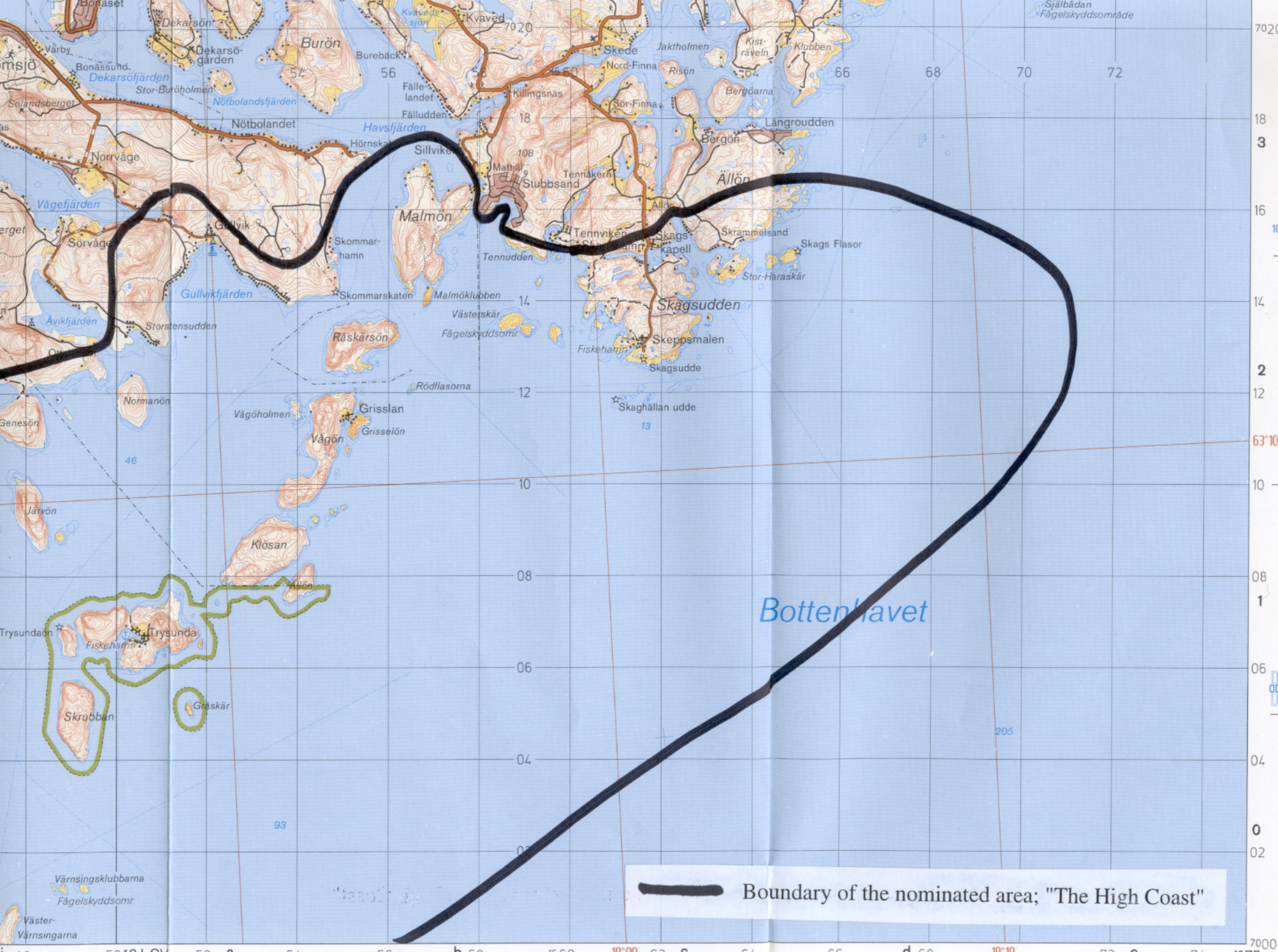
S-751 28 Uppsala

Riksantikvarieämbetet
Box 5405
S-114 84 Stockholm


Bottenhavet
Boundary of the nominated area; "The High Coast"
Dekarsöfjärden
Nötbolandsfjärden
Havsfjärden
Gullvikfjärden
Avikfjärden
Vågefjärden
Burön
Nötbolandet
Norrvåge
Sillvik
Malmön
Stubbsand
Skagsudden
Skeppsmalen
Skagsudde
Skagshällan udde
Skags Flasor
Skrammelsand
Skagskapell
Tennviken
Tennäkern
Tennudden
Skommarhamn
Skommarskaten
Malmöklubben
Västerskär
Fågelskyddsomr.
Råskärsön
Rödflasorna
Grisslan
Grisselön
Vågön
Vågöholmen
Normanön
Genesön
Järvön
Klösan
Allön
Trysundaön
Trysunda
Fiskehamn
Skrubban
Gräskär
Värnsingsklubbarna
Fågelskyddsomr.
Väster-Värnsingarna
Bergön
Bergöarna
Risön
Jaktholmen
Skede
Nord-Finna
Sör-Finna
Killingsnäs
Fälleländet
Fälludden
Burebäck
Dekarsön
Dekarsögården
Bonäset
Bonässund
Stor-Burön
Solandsberget
Kvaved
Kvaveds sjön
Klubben
Kisträvelen
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Fågelskyddsområde
Stor-Haraskär
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Gullvik
Genesön
Trysunda
Trysundaön
Klösan
Älgön
Strängöarna
Hummelvik
Hummelviksbodarna
Näskebodarna
Höggrundet
Ronögrunden
Hälsingen
Högholmen
Röholmen
Tärnättholmarna
Skatauddan
Stråsundviken
Svartholmen
Näskeberget
Tjockriset
Tjärtunnberget
Slättdalsberget
Mossaberget
Magdbäcken
Storruten
Skultjärnberget
Sörgällstasjön
Dalsjön
Ytterböle
Nyjund
Skule
Åsen
Malberget
Björkåbäckssjön
Björkåbäck
Långraberget
Trollberget
Odsbodarna
Snödberget
Nylandsbodarna
Pikberget
Pålsjön
Verdal
Dal
Gärden
Bölen
Järvvik
Svärtdalen
Alviken
Bredänger
Spjute
Norum
Bräcke
Sand
Långnäs
Fjällåkern
Tvivlet
Jämtsborg
Bjällsta
Kornsjö
Kornsjösjön
Näs
Sunnanjö
Orrvik
Eden
Vik
Västanå
Västanåmarken
Bläsvik
Västersel
Österset
Mjäla
Fors
Norrtjärn
Sörtjärn
Ovalsjön
Hälle
Finnborg
Frostdal
Frostdalssjön
Skrike
Alby
Björsby
Oden
Utby
Utbysundet
Sörgård
Stensnäs
Sågtorpet
Fågelberget
Buhalsberget
Middagsberget
Vårsudden
Bäck
Vågön
Genesön
Sandlågan
Faxnäset
Storstensudden
Avikfjärden
Normanön
Vågöholmen
Halviken
Köpmanholmen
Nässjöbäcken
Kuba
Prästberget
Vårdhemsberget
Ramstoberget
Sunnanbergshöjden
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Bonäset
Bonässund
Solandsberget
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Hambjärnen
Gårdsjärnen
Toberget
Skärberget
Stoarsberget
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Stor-Buröholmen
Höga Kustenleden
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Ullängersfjärden
Mjällomslandet
Östervaltobodarna
Sjubröberget
Mjällom
Högklinten
281
Hamnslätten
Norrfällsviken
Fiskehamn
Måviken
Östervalto
Bred-
viken
Trollarviken
Ytternäsan
Björnån
Öjsand
Örarna
Fågelskyddsområden
Omnefjärden
Gnäggen
Omne
Ön
Skataudden
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Läskären
Ulvviksbodarna
Ulvvik
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Lidböle
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Rävsön
Klubben
Örsta
Edsätter
Rävsön
Gåsnäs
Själand
Rödv.
Hummelv.
Bäckland
Björnäs
Gärde
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68
Edsätterfjärden
Älgsjö
Kåsta
Insjöbacken
Näsänget
Bönhamn
Fiskehamn
Höglosmen
Stormyran
Mjösjö
Sörle
Näsviken
Adalsberget
Högbonden
Barsta
Barstaön
Ådal
Fällsvik
Grisselskäret
Skatan
Rotsidans
naturreservat
Fågelskäret
Fällvikshamnen
Rotskäret
Fågelskyddsområde
Bottenhavet
S. Ulvön
Rödudden
Grunnans kapell
Marviksgrunnan
Långskäret
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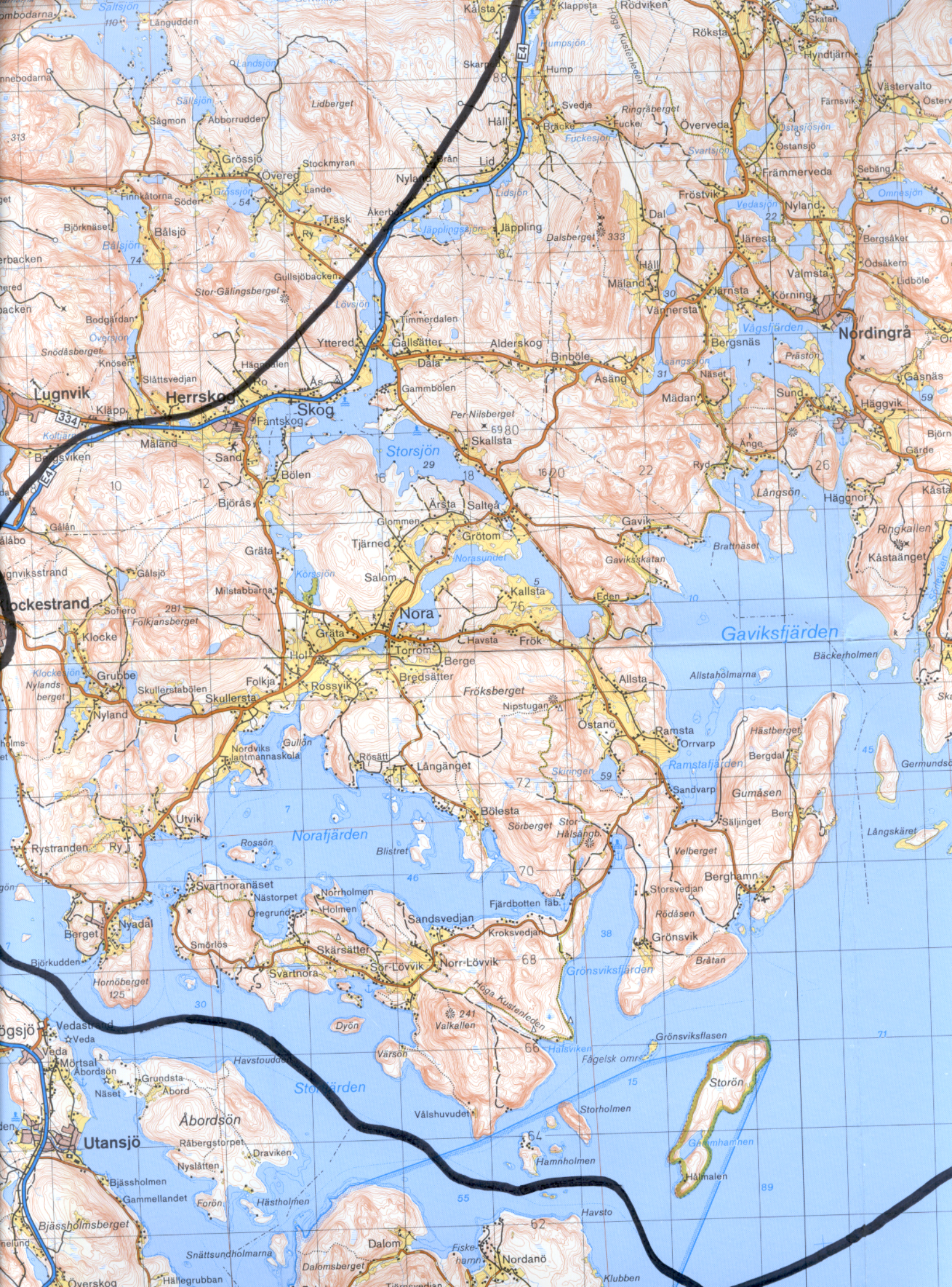
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Fucker
Fuckesjön
Bräcke
Hall
Överveda
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Färnsvik
Grössjö
Stockmyran
Övered
Lande
Brån
Lid
Nyland
Lidsjön
Fröstvik
Vedasjön
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Omnesjön
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Söder
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Bålsjön
Ry
Gullsjöbacken
Stor-Gälingsberget
Löksjön
Hall
Mäland
Järnsta
Körning
Valmsta
Ödsåkern
Lidböle
Bodgärdan
Timmerdalen
Vännersta
Vägsfjärden
Nordingrå
Snödåsberget
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Gällsätter
Alderskog
Binböle
Bergsnäs
Prästö
Knösen
Hägnadalen
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Åsäng
Näset
Gäsnäs
Slättsvedjan
Gammbölen
Mädan
Sund
Häggvik
Lugnvik
Herrskog
Skog
Kläpp
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Fantskog
Per-Nilsberget
Skallsta
Ange
Gärde
Koltjärn
Måland
Storsjön
Ryd
Sand
Bölen
Björås
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Norasundet
Gavikskatan
Kåstaänget
Gålsjö
Körssjön
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Eden
Sofiero
Nora
Folkjansberget
Klocke
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Havsta
Frök
Gaviksfjärden
Torrom
Berge
Bäckerholmen
Klockesjön
Grubbe
Bredsätter
Allsta
Allstaholmarna
Nylands-berget
Skullerstabölen
Folkja
Rossvik
Fröksberget
Skullersta
Nipstugan
Nyland
Östanö
Ramsta
Orrvarp
Hästberget
Nordviks lantmannaskola
Gullön
Rösätt
Långänget
Skimmen
Ramstafjärden
Bergdal
Germundsö
Sandvarp
Gumåsen
Utvik
Bölesta
Sörberget
Stor Hälsängb.
Säljinget
Berg
Norafjärden
Rossön
Blistret
Rystranden
Ry
Velberget
Långskäret
Svartnoranäset
Nästorpet
Norrholmen
Bergtjamn
Storsvedjan
Oregrund
Holmen
Fjärdbotten fäb.
Rödåsen
Nyadal
Sandsvedjan
Berget
Kroksvedjan
Grönsvik
Smörlös
Skärsätter
Björkudden
Sör-Lövvik
Norr-Lövvik
Bråtan
Svartnora
Grönsviksfjärden
Hornöberget
Hoga Kustenleden
Vedastrand
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241
Valkallen
Grönsviksflasen
Mörtsal
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Värsön
Halsviken
Fågelsk omr.
Åbordsön
Grundsta
Näset
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Storfjärden
Storholmen
Åbordsön
Utansjö
Räbergstorpet
Draviken
Hamnholmen
Nyslätten
Hälmalen
Bjässholmen
Gammellandet
Forön
Hästholmen
Havsto
Bjässholmsberget
Dalom
Snättsundholmarna
Fiske-hamn
Nordanö
Dalomsberget
Klubben
Hällegrubban
Tjärnsvedjan

PERMANENT DELEGATION
OF SWEDEN
TO UNESCO

Paris, 12 April 2000

M. Georges Zouain
Director a.i.
World Heritage Center
UNESCO

Ambassadör Ingemar Lindahl

Nomination for the World Heritage List

Dear Georges,

Enclosed I have the honour to send you some complementary information on the High Coast in the Province of Västernorrland, Sweden, which has been proposed by my Government to be included in the World Heritage List. I hope that this substantial additional information shall help to create a solid basis for the inclusion in the List.

Sincerely yours,

Ingemar Lindahl
Ambassador
Permanent Delegate

Address
1, rue Miollis
F-75732 Paris Cedex 15

Telephone
33-(0)1-45 68 34 50/51

Fax
33-(0)1-47 34 10 03

Email:
unesco-delegationen.paris@foreign.ministry.se

REGERINGSKANSLIET

11 April 2000 Ku2000/1222/Ka

Ministry of Culture
Stockholm, Sweden

Division for Cultural Heritage
Mr. Lars Amréus, Head of Section
Telephone +46 8 405 19 62

UNESCO World Heritage Centre
7, place de Fontenoy
753 52 Paris 07 SP
France

Re: Nomination of The High Coast, Sweden, for inclusion on the World Heritage List

Dear Madam/Sir,

In June 1998 the Swedish Government decided to nominate the High Coast in the province of Västernorrland for inclusion on the World Heritage List. At its 23d ordinary session in Marrakech in December 1999, the World Heritage Committee set up under the Convention concerning the Protection of the World Cultural and Natural Heritage decided to defer the nomination.

Enclosed, please find an extensive complementary addition to the nomination, worked out by the Swedish Environmental Protection Agency, the County Administrative Board of Västernorrland, the National Heritage Board and the Geological Survey of Sweden.

Sincerely yours,

Per-Magnus Nilsson
Director

Postal address
SE-103 33 STOCKHOLM
SWEDEN

Visitors' address
Drottninggatan 16

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+ 46 8 405 10 00

Fax
+ 46 8 21 68 13

E-mail: registrator@culture.ministry.se
X.400: S=Registrator; O=Culture; P=Ministry; A=SIL; C=SE

Telex
114 61 LOENDEP S

Cc:
Permanent Delegation of Sweden to Unesco
Ministry of Education (Svenska Unescorådet)
National Heritage Board
Swedish Environmental Protection Agency
County Administrative Board of Västernorrland

2000-04-11 Reg. no. 319-2222-98

Name: Rolf Löfgren
Section: Terrestrial Environment Section
Tel: +46-8-698 1392

Fax: +46-8-6981662
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Supplementary documents for the nomination of the High Coast as a World Heritage Site

The Swedish Government decided in June 1998 to nominate the High Coast in the county of Västernorrland for inclusion on the World Heritage List. At the World Heritage Committee meeting in Marrakech in December 1999 the committee, following the recommendations of IUCN, decided to defer the nomination. The grounds for IUCN's recommendation are provided in detail in the technical evaluation of the area. In brief, the recommendation was that the nomination be deferred in order to allow the Swedish authorities to (i) more fully document the assets of the marine portion of the area; (ii) provide a more complete comparative analysis including its relation to the proposed Quark World Heritage nomination; and (iii) address the various issues relating to integrity. It was also recommended that the state Party consider the prospect of nominating the site under cultural criteria.

The Swedish Environmental Protection Agency, the Västernorrland County Administrative Board, the Central Board of National Antiquities and the Geological Survey of Sweden have jointly reviewed the grounds for deferment. The consensus reached was that the material for evaluation of the above-mentioned issues must be improved and also that other factual circumstances concerning the area's biological value etc. should be described in greater depth. Guided by IUCN's technical evaluation a number of studies and compilations of factual material have been produced with respect to the following issues.

- Global comparative study of other prominent land uplift areas.
- Comparison between the High Coast and the Quark area
- The area's geological history and distinctive character
- Management plan focusing on issues concerning the area's integrity and long-term administration
- Biological assets in the marine segment of the nominated area

- The High Coast's value as a cultural landscape
- The area's distinctive culture-historical character associated with the land uplift
- The landscape's aesthetic values and superlative natural phenomena
- Biological assets within the land section of the nominated area
- The on-going project to eco-label tourism in the High Coast.

The studies performed and the factual compilations are presented in 9 enclosures. A summary of the results of these undertakings follows below.

Comparative analysis

In the Committee's decision an analysis of the High Coast's characteristics as an area of land uplift in comparison with other similar areas of the world and a comparison with the Quark area was requested. A brief summary of the global comparative study conducted (***Enclosure 1***) shows the following.

Summary

- The High Coast has the highest isostatic land uplift in the world after the latest glaciation. The relative land uplift is 285 metres above the present sea level. A comparison with all land uplift areas in the world after the latest glaciation shows that the only comparable area is at Hudson Bay in Canada where the equivalent uplift is 272 metres. The other areas with isostatic land uplift reach substantially lower levels. Furthermore, within many of these areas the isostatic land uplift can be difficult to distinguish from tectonic uplift.

- Due to the undulating terrain the distance between the highest shoreline in the High Coast and its present shoreline is only approximately 2 km whereas at Hudson Bay the distance is roughly 50 km. The land uplift's geological and biological impact is therefore exceptionally evident and concentrated in the High Coast while they are scattered and diffuse at Hudson Bay. The rate of land uplift in the High Coast is presently 8 mm per annum.

- The High Coast is the finest site for the study and understanding of the important processes that formed the glaciated and land uplift areas of the earth's surface and which have decisive significance in the explanation of:
  - the distribution of various vegetation types above and below the highest shoreline
  – the current division of cultivated land and forestland in the countryside.

  The High Coast is situated in a climatic area that permits a considerably wider

spectrum of these conditions than Hudson Bay that is located in a permafrost region.

- The long-standing scientific studies of the High Coast mean that it is, to a greater extent than Hudson Bay, an area of global significance with respect to the interpretation of the geological as well as biological and culture-historical effects of the great inland ice sheets and land uplift.

Two information documents have been produced to further illuminate the fundamental importance that land uplift has had for the landscape's geological and culture-historical development and which is uniquely reflected in the High Coast (***Enclosures 2 and 5***).

The High Coast in relation to the Quark area

The Quark designates the narrowest segment of the Baltic Sea between Sweden and Finland. The Quark consists of archipelagos near the mainland of both countries and a bottom sill that is, at most, 25 metres below the water surface. The most southerly part of the Quark is on the Swedish side about 30 km north of the High Coast.

The Quark's surface form is entirely dominated by till formations spread across a flat landscape. The geological formations are described in ***Enclosure 1***. In summary, the differences between the High Coast and the Quark can be described as follows.

Summary

- The High Coast shows post glacial geological history on land covering approximately 9,600 years while the corresponding period of time in the Quark is about 2,000 years.

- The Quark's low lying till archipelagos, open sea and shallows represent an entirely different landscape type than the High Coast's hilly mainland, high islands, deep bays and straits.

- The geological history and geological phenomenon are the High Coast's most important assets while the Quark's most important assets are presumably linked to the Baltic Sea as a unique brackish sea and the development of the eco-system in connection with the land uplift. The latter aspects are also represented in the High Coast.

In this context is should be noted that the proposal to nominate the Quark for inclusion on the World Heritage List is based on a regional initiative from the

Quark Council which is a border zone co-operation organisation of the Finnish counties in Österbotten plus the county of Västerbotten and the municipality of Örnsköldsvik in Sweden. The central public authorities in Sweden have not participated in this undertaking. The starting point for the Swedish Environmental Protection Agency's work has been the proposals presented in the **Nordic World Heritage** report (Nord 1966:30). This study includes the Vasa Archipelago in Finland as one of the most distinguished archipelagos in the Nordic countries but not the Quark in its entirety.

Integrity, Management Plan

On the basis of IUCN's stated opinion it is evident that the efficient application of Swedish legislation is sufficient to maintain the area's integrity alongside the existing national park and other specially protected areas. A difficulty that remains is that natural sites on World Heritage List require guarantees with management and administration in a special management plan. Work has commenced to produce a *management plan* to resolve this problem. The plan describes how the area is to be managed in the long-term. Furthermore, a *management committee* is being formed for the High Coast area with representatives of the County Administrative Board, the municipalities of Örnsköldsvik and Kramfors as well as the County Forestry Board.

The management plan is currently a draft document that is to gain the support of the authorities that are to be represented on the administration council. The plan focuses foremost on the management of the special assets that form the basis for the nomination for inclusion on the World Heritage List. These are:

- Geological and biological phenomena related to land uplift
- The marine environment
- The landscape's natural beauty

Moreover, the role of legislation in the preservation of the area's assets will be addressed in greater detail compared with the original nomination, in part due to new and more powerful environmental legislation enacted in Sweden during 1999.

The area's dominating natural feature is the forests. Guidelines for the management of forestland will be included in the management plan. The timetable for the completion of the management plan is presented below under "Conclusions".

Eco-labelling of the High Coast

One aspect of care of the High Coast's environment concerns preparations for an anticipated influx of tourists. With this in mind, a project is underway to eco-label the entire area and the enterprises operating in there. The project commenced in 1999 and is partially funded by the European Union. The objective is to:

- strengthen tourism and the area as a whole by highlighting and preserving environmental and natural assets associated with tourism.
- certify companies that participate in environmental training, produce an environmental strategy and satisfy demanding environmental requirements.

A more detailed description of the project is presented in ***Enclosure 8.***

The marine part

The IUCN inquired about the motive for the delineation of the High Coast's marine area that encompasses 56 % of the total area nominated. The grounds stated in the original nomination for the inclusion of the water area are that the High Coast's hilly landscape and the special geological phenomena continue out into the Gulf of Bothnia. The shoreline areas become increasingly shallow, new islands are born and other islands are transformed into peninsulas as they are united with the mainland. The water area therefore constitutes an important part of the High Coast as an entity and is an element essential to an understanding of the historical and on-going geological processes. The sea area's approximately 70 islands also contribute to natural beauty and distinctive character of the entire landscape.

Inclusion of the greater portion of the marine environment can also be justified on biological grounds as presented in the enclosed compilation (***Enclosure 3***). The following can be summarised from the description entitled LIFE IN THE SEA.

Summary

- As part of the world's only brackish sea, the Baltic Sea, the High Coast's marine section displays unique biological conditions. No similar marine environments are present in areas currently on the World Heritage List.
- The Baltic Sea has undergone dramatic changes since the latest glaciation, going from marine over freshwater to brackish water systems. During the last 7,000 years the environmental conditions have been more stable in this ecosystem. The biota established is composed of a very special and scientifically interesting mixture of marine, brackish and fresh water species.
- A considerable number of Baltic Sea species are marine relics from earlier periods when the Baltic sea was linked with the Atlantic. Some of these relics are also found in lakes formed as the land uplift isolated them from the sea. The

impact of the land uplift is therefore also reflected in the marine life and lake system of the High Coast.

- The particular topography of the High Coast means that, within a limited area, there are several different types of sea areas, from shallow inlets to open bays and great depths. The water is also relatively clean. Seen from a global perspective, the combination of natural geographic features characteristic of the Baltic Sea and the High Coast constitute a unique set of conditions for marine life.

It should be noted that the marine part of the High Coast is highlighted as one of 15 Swedish marine sites in a project regarding evaluation of valuable marine areas in the Nordic countries. The project was conducted by the Environmental Protection Group under the Nordic Committee of Senior Officials for Environmental Affairs. A final report was published in 1996 (Tema Nord 1996:546). The area is also included on HELCOM's list of valuable marine areas in the Baltic Sea. The Västernorrland County Administrative Board is currently investigating the need for special protective measures to supplement the protection afforded by general legislation.

Cultural Assets

The High Coast's culture-historical value and the possibility of nominating the area as a cultural landscape were assessed in connection with the area's nomination. The responsible authorities deemed that the area certainly had extremely great values associated with the culture-historical development but that these were foremost of national significance. This question has been subjected to further study as evidenced by the appended compilation (***Enclosure 4***).

Summary

- Cultural landscapes with prehistoric remains in situ exist generally in Scandinavia. The combination of the world's highest isostatic land uplift and the cultural landscape that reflects the effects of the land uplift makes the High Coast's cultural landscape particularly interesting. The fact that the highest shoreline is only 2-3 km from the present shoreline contributes to the existence of well-preserved shore bound remains from continuous human activity during 7,000 years are represented within a limited area. Within the area the frequency of prehistoric remains is remarkably high.

- Knowledge of the traces of human activity in comparable area is exceedingly fragmentary. An analysis and assessment of the present level of knowledge of the High Coast is therefore that the area does not satisfy the criteria for cultural landscapes in the World Heritage Convention. Future research can result in a change in this status.

- The cultural landscape illuminates the land uplift's effects and the description of the cultural landscape thereby serves as an important complement to the geological and biological descriptions. These conditions are presented in greater depth in ***Enclosure 4 and 5***.

Biological assets on land

The High Coast exhibits a host of remarkable and interesting phenomena in its vegetation which, in whole or in part, can be linked to land uplift. A detailed description of the area's distinctive vegetation is presented in ***Enclosure 7***.

Summary

- The assortment and distribution of soil types in the landscape resulting from the land's emergence from the sea is extremely perceptible in the High Coast. Thus, the full range of forest types, from the most poor to the richest, is concentrated in a limited area. Of the richer types there are similar stands only in the southernmost part of Sweden and on the Continent. The reasons for this are, in part, the favourable local climate and, in part, the assortment of soil types and deposits of shell resulting from the land uplift process.

- Just as noteworthy is the occurrence of forest types on till above the highest shoreline. Forests of these types, which otherwise exist to a considerable extent above the highest shoreline far inland, are found in isolated pockets near the shore in the High Coast.

- The High Coast area also contains a diversity of flora that is remarkable and which is directly related to the land uplift process. Examples of this are species bound to shell deposits, rocky land uplift shores, relic species at lakes and marches cut off from the sea as well as shoreline forests with age zones affected by the land uplift.

- For topographical, geological and climatological reasons the High Coast is a vegetation boundary area with a rare blend of southern species together with northern Boreal, western oceanic and eastern species.

- The High Coast is also a notable meeting place for southern and alpine relic species from warmer and colder periods respectively. The southern species grow on the southern slopes of the hills and the alpine ones on the shaded northern slopes.

Beauty of the landscape, extraordinary natural phenomena

The High Coast is the only hilly area around the Baltic Sea. The islands and coastal area are wild and largely unsettled. Even the inner parts are unsettled with the exception of some valleys where agriculture is possible. The area's aesthetic values are well-known and attract both Swedish and international visitors. The unequalled geological phenomena contribute to the area's attraction. Samples of the landscapes views and phenomena are presented photographically (***Enclosure 6***). The landscape's external forms and how they are perceived by visitors are described in ***Enclosure 9***.

CONCLUSIONS

The High Coast is nominated for inclusion on the World Heritage List in accordance with criteria i, ii and iii. As support for, and supplementary information to, the original nomination we wish to bring attention to the facts presented above and in the enclosed documents, 1-9. The material can be linked to the criteria as follows below.

i) Primarily Enclosures 1 and 2. Secondarily Enclosures 5 and 7 which provide examples of the culture-historical and vegetation developments closely linked with the geological development.

ii) Primarily Enclosures 3 and 7.

iii) Primarily Enclosures 6 and 9. Secondarily Enclosure 2 which provides examples of exceptional geological natural phenomena in the area.

The summary above and the enclosed documents serve to support the assertion that the area is an outstanding global asset and its exceptional position in relation to comparable areas including the Quark.

Regarding matters related to the area's integrity please, as mentioned above, refer to the management plan that is in process and that the management committee is being constituted for the High Coast area. Responsibility for the production of the management plan rests primarily with the Västernorrland County Administrative Board. The Swedish Environmental Protection Agency along with concerned regional and local authorities will participate in this work. The plan will be finalised and forwarded to the World Heritage Centre and IUCN before 1 October 2000.

The eco-labelling work presented in Enclosure 8 indicates that both businesses and the population of the area express general interest in and concern for the area's natural environment.

The area's culture-historical value is of substantial national importance as indicated in Enclosures 4 and 5. The studies undertaken do not however give rise to any amendments to the assessments in the original nomination with respect to nomination of the area in accordance with the criteria for Cultural World Heritage status.

ENCLOSURES

1 GLACIO-ISOSTATIC UPLIFT, A GLOBAL VIEW

2 THE HIGH COAST, RAISING FROM THE SEA FOR 10,000 YEARS

3 LIFE IN THE SEA

4 CULTURAL LANDSCAPE AND HISTORY

5 THE HIGH COAST, 5,000 YEARS OF HUMAN HISTORY

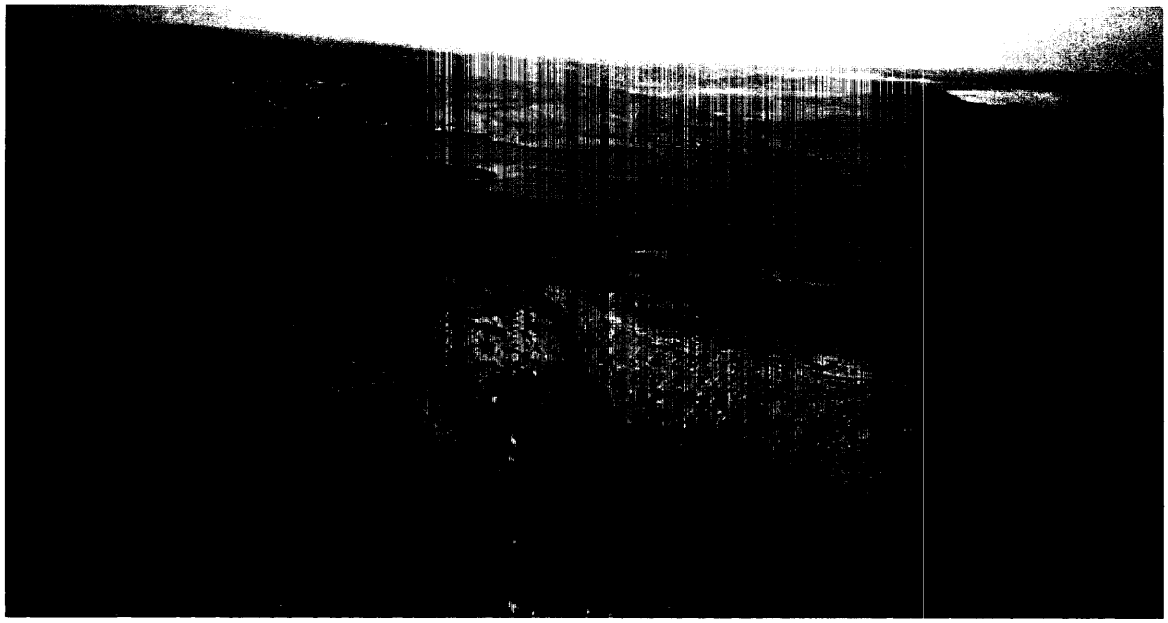
6 PICTURES OF THE HIGH COAST

7 VEGETATION AND LAND UPLIFT IN THE HIGH COAST

8 ECO-LABELLING OF THE HIGH COAST

9 DESCRIPTION OF THE HIGH COAST LANDSCAPE

THE HIGH COAST



ENCLOSURE 1

GLACIO-ISOSTATIC UPLIFT
A GLOBAL VIEW

April 2000

The County Adminstration of Västernorrland

Cover photo: The Skuleberget National Park,
View of the Slåttdalsberget (John Chang McCurdy)

MILJÖMÄRKT TRYCKSAK
341.206
Color Tryck, Härnösand

Glacio-isostatic uplift
A global view

Curt Fredén, Geological Survey of Sweden

Great Ice Sheets

During cold periods glaciers expanded in the mountains. These glaciers gradually merged and extended beyond the mountains, leading to large ice-covered areas, *inland ice sheets.*

The latest great ice sheets existed at their fullest extent about 17,000 to 22,000 years ago and subsequently collapsed to remnants in Antarctica and Greenland as the Earth came out of the latest ice age. The great ice sheets of the Northern Hemisphere in particular developed a characteristic cycle of slow build-up to full glaciation, followed by rapid melting and deglaciation.

Submergence and Land Uplift

The largest of the Quaternary ice sheets were up to 4 km thick. As the ice sheets slowly grew to their maximum thickness, the underlying bedrock was progressively depressed by the weight of accumulating ice. The highly viscous and malleable mantle below, in turn, supports the crust. As the ice melted the crust slowly rose to regain its pre-glacial level. These *isostatic readjustments* to the waxing and waning of the great Quaternary ice sheets caused changes in the relative levels of land and sea. The changing ice mass borne by the continents resulted in *isostatic uplift* and hence the evidence of old shorelines and other coastal markers has inevitably shifted, especially near glaciated areas. This is particularly pertinent to the study of Quaternary sea-level changes, which were caused by the growth and melting of inland ice.

The highest situated traces of the highest marine shoreline are at different altitudes depending on how deeply the crust had been depressed, how much the local sea surface had risen, and the time at which the area had become ice-free.

The present coastline lies in a position that should be regarded as a hinge zone separating the ocean water surface and the rising land, freed of the Quaternary ice load.

Latest Great Ice Sheets

The largest ice sheets in the history of the world were found in the Northern Hemisphere where they covered extensive areas. As far as it has been established the chronology of the latest glacial stage in the Southern Hemisphere is very similar to that of the Northern Hemisphere and the ice growth in the south reflected the same global climate instability.

Northern Hemisphere

The great ice sheets covered large areas of the Northern Hemisphere. The ice sheet in North America consisted of three parts, the Cordilleran, the Laurentide and the Greenland.

The largest in Europe is known as the Scandinavian ice sheet.

Southern Hemisphere
The largest area of ice growth in South America developed in the far south of the Andes. In the northerly parts of this zone, the ice mostly took the form of valley glaciers. In the southern part, ice accumulated to form the Patagonian ice sheet that reached a thickness of about 1.2 km.

The largest ice-covered area in the south-west Pacific region was to be found in the Southern Alps of the South Island of New Zealand. The ice was however relatively thin, possibly no more than 100–200 m on average.

Laurentide Ice Sheet

The Laurentide ice sheet covered North America between the Cordilleran in the west and the Atlantic in the east. In Illinois it stretched as far south as latitude 37°N.
At its maximum there were several ice domes in the Hudson Bay area. One of them was situated east of Hudson Bay, and is estimated to have been 3–3.5 km thick.

Shorelines in Canada were once associated exclusively with the latest deglaciation. However, in several areas of eastern and northern Canada the highest shorelines or sediments are older. The final deglaciation is marked by a prominent low-level shoreline that is eroded into older marine sediments. The relative sea level record is still poorly dated in the areas of major regional centres of the ice sheet, e.g. Hudson Bay. Apparently, each of these centres of the ice sheet has a corresponding uplift centre. The highest marine limit is to be found in the south-eastern part of Hudson Bay. The inland limit of marine submergence shows a belt of glaciofluvial delta deposits and raised beaches.

Deglaciation and Land Uplift at South-eastern Hudson Bay
The highest isostatic response to the ice load is to be found along the south-eastern coast of Hudson Bay. The area was deglaciated ca. 8,000 years ago, contemporary with the inundation of the Tyrell Sea, a glacial isostatic marine water body that occupied Hudson Bay Lowlands at the close of, and following, deglaciation. The highest elevation of the shoreline in Canada, 272 m, is situated in a hilly area about 50 km east of James Bay. Present rate of land uplift, as determined by tide gauge and historical records, is ca. 11 mm/year.

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Scandinavian Ice Sheet

Northern Europe was affected by the latest glaciation. At the maximum of glaciation, the boundary was in Russia, northern Poland and Germany as well as central Jutland in Denmark. In the west, the ice sheet calved at the edge of the continental shelf. There are divided opinions as to its extent into the North Sea and the Arctic Ocean. The heavy inland ice, with a maximum thickness of ca. 3 km, pressed the crust down at least 800 m beneath its main ice dome in the High Coast area.
The glaciation and deglaciation conditions are well described by Scandinavian geologists.

Deglaciation

The margin of the most recent ice sheet was still at its outermost position about 18,000 years ago. This was followed by a marked improvement in climate and the ice started to melt, a process that concluded after about 10,000 years. The recession of the ice margin can be dated in different ways. In submerged areas, the Swedish geo-chronological time scale (glacial clay with annual layers) has been extended to the present time by means of post-glacial layered clay-silt sediments in the river valley of the Ångermanälven at the south part of the High Coast area.

Glacio-isotatic Uplift

Through an extraordinary piece of fieldwork, Gerard De Geer (1858–1943) completed a map of the "uppermost marine limit" in 1888. De Geer had very carefully chosen the areas destined to show the highest sea level. On the map, the isobases for 60, 120 and 180 m showed a concentric pattern with an elliptical central area between Oslofjorden and the northern part of the Gulf of Bothnia. The isostatic effect, after deglaciation, was thus elucidated and a long-standing, controversial issue was settled.

Later studies show that the centre of the land uplift is situated in the High Coast area and the highest shoreline is at 285 m above sea level. The highest shoreline in Norway is 220 m above sea level in the Oslo area.

The maximum area of the present land uplift has shifted northwards and today is situated in the northern part of Gulf of Bothnia.

The Quaternary History of the Baltic

It has long been known that the sea once reached high-lying areas far away from the present coast. In Swedish literature on Quaternary geology, shoreline displacement and the late Quaternary development of the Baltic Sea and the Gulf of Bothnia is comprehensively described and analysed.

In the old days, the scientific authority of the Bible was very strong and the doctrine of evolution was not questioned. All observations and interpretations were adjusted to the stories of the Creation and the Flood. The history of "sea decrease" research in the 17th, 18th and 19th centuries is well documented.

When the ice margin receded from the south Swedish highlands, marine water intruded the Baltic basin. This stage of brackish water (very low salinity), called the *Yoldia Sea*, existed 10,300–9,500 years ago.

The next Baltic Sea stage, the *Ancylus Lake*, 9,500–8,000, is characterised by fresh water. About 8,000 years ago the Baltic Sea started to become characterised by brackish water, the *Littorina Sea*, that gradually spread northwards to the Gulf of Bothnia. It is possible to view the Baltic Sea and the *Gulf of Bothnia*, from a modern perspective, from about 2,500 years ago onwards, but no distinct stratigraphical limit exists to distinguish this stage from the Littorina Sea.

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The High Coast

The magnificent bedrock landscape has been formed during millions of years of weathering, glaciations and littoral processes. The morphology in many places clearly reflects the underlying lithologies. The area has attracted great attention in connection with geological congresses and symposia, and during national as well as international excursions. The High Coast is a key area for the understanding of glacio-isostatic isostasy.

Bedrock Geology

The bedrock forms the hilly region of the High Coast with its narrow valleys, deep inlets and archipelago. The peaks of the highest hills are about 350 m above sea level and the island of Mjältön, the highest island in Sweden, reaches 236 m above sea level. The greatest known sea depth in the High Coast area is 120 m.

The high topographic relief and the well-exposed wave-washed shores offer good opportunities for studies of the rocks and their structures. The area has long had great scientific value with its rich variety of well-exposed examples of e.g. various intrusive rocks, their contact zones, metamorphism, sheeting, igneous layering and lamination plus faulting.
Five rock types form the major constituents of the High Coast bedrock: amphibolites, mica schists and slates and their migmatic equivalents are found in the western part, and are ca. 1870–1950 Ma old. The main part of the coastal area is dominated by a rapakivi complex of granite, gabbro and anorthosite. These rocks were formed about 1580 Ma ago. The post-rapakivi development of the Nordingrå area involved uplift, weathering and erosion, faulting and dolerite intrusions. In situ weathering breccias and arkosic sandstone formed a blanket on top of the rapakivi rocks. The sandstone formation is capped by a dolerite which intruded 1200–1250 Ma ago. In this dolerite, the mineral ulvite (ulvöspinell) was first discovered in 1946. Large areas of the same sandstone are found in the Bothnian Sea, where they have an average thickness of 1000 m.

One spectacular site is a pegmatitic rock with up to 0.5 m. long crystals of pyroxene.
Another spectacular bedrock site is the 40 m. deep, ca 200 m long and 7 m wide Slåttdalsskrevan, an erosion cleft cutting through the granite, originally filled, at least partly, by dolerite. The site is situated close to the till-capped hill, which forms the highest shoreline.

The chemical composition of the different rocks is essential for the flora. The Stone Age people used slate and quartz for tools. The vast shingle fields are linked with the rapakivi granite.

Quaternary Geology

The area was deglaciated about 9,600 years ago according to the Swedish geo-chronological time scale. The ice margin receded westwards. The ice-free parts of

the High Coast were exposed the waves of the Yoldia Sea. The highest shoreline in the High Coast area reaches the highest position in Scandinavia, 285 m above sea level. From there it falls in all directions. The total uplift, ca. 800 m, reaches its maximum in approximately same region as the highest shoreline actually reaches its maximum level.

The highest shoreline is marked by till-capped hills with a forested top above the wave-washed zone. Below this, wave-washed sediments, shingle, gravel and sand, form a more or less continuous cover on many slopes and are often concentrated in pronounced beach ridges. These deposits may be exceptionally thick, up to 20 m. Large shingle fields occur in the massif of the easily weathered rapakivi granite.

During the Littorina stage the salinity and temperature of the sea water was higher than today and hence there was a partly different type of marine fauna. Several present day species had a more northerly distribution. Shells and shell fragments of at least five species of molluscs are to be found in wave-washed sand. The shell-bearing deposits are found 75–25 m above sea level. The faunal composition, frequency and altitude of the shell-bearing sediments indicate changes in temperature and salinity as well as the marine development of the Gulf of Bothnia. Moreover, the calcareous sand is essential for special flora.

Archaeological Evidence – Coastal Dwelling Sites
It is relatively easy to place archaeological finds in chronological order based on the relation the sites have to shoreline displacement at the locality in question. In the same manner that archaeological finds are thus related to the Baltic the same archaeological material has come to serve as a valuable tool in studying the history of the Baltic.

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Comparative Analysis

The highest glacio-isostatic land uplift in the world is found in North America at south-eastern Hudson Bay in Canada and, in Europe, at the High Coast in Sweden.

The High Coast
The High Coast of Sweden is a hilly coastal region with well-documented traces of relative land uplift of 285 m during a time span of ca. 9,600 years. The highest shoreline is marked by till-capped hills (forested till-top above wave-washed zone). Impressive raised shores, mainly on shingle fields, have been documented and dated since the beginning of the century. The distance between the evidence of the highest shore and the current sea level is 2–3 km.

The main character of the High Coast is a scenic bedrock coast of hilly peninsulas, islands, narrow valleys and inlets, deep bays and straits as well as ongoing processes due to the land uplift such as isolated lakes in the inlets. Wave-washed sediments are very common on the valley slopes and fine-grained sediments are cultivated on the valley floors. Large shingle fields are found from ca. 250 m. to the present sea level. The geological features are well-documented and dated.
The present rate of land uplift is ca. 8 mm/yr.
The traces of land uplift and the development during a time span of 9,600 years are impressive, easy to find and easy to grasp in a limited area.

Hudson Bay
The south-eastern coastland of Hudson Bay is characterised by marine sediments, outcrops and till. The area around the highest glacio-isostatic rebound was deglaciated ca. 8,000 years ago, the highest marine limit 272 m above sea level, is found in a hilly area about 50 km east of the present shore, and the current rate of land uplift is ca. 11 mm/year.

The Quark area
The Quark area in Finland and Sweden is characterized by low hilly terrain below 20 m above sea level, covering the last 2,000 years of land uplift. The landscape is largely influenced by the latest glaciation and to a lesser degree by post-glacial processes. The Quaternary deposits are dominated by till. Pronounced north-south bedrock structure with superficial deposits of till and drumlins, gives the western coastal area its characteristic appearance with a system of shallow inlets with widths from 100 m to 1,000 m. Irregular ridges of till, so-called Rogen moraine, and clusters of small till ridges, so-called De Geer moraines, are typical features of the Vasa archipelago.
Wave-washed sediments such as shingle, gravel and sand are found in relatively small areas due to the flat and low topography.
The area of the present maximum uplift has shifted a somewhat northwards. The present rate of land uplift in the Quark area is 8–9 mm/year.
The sea bottom of the Quark forms a sill at a depth of about 30 m.

References
(In Swedish only)
Eklund, A., 1991: Beskrivning till kvartärgeologiska kartorna 19J/20J Husum/ Vännäs, 20K/20L Umeå/Holmön. – SGU (Geological Survey of Sweden) ser. Ak no. 5 och 6. Kartor i skala 1:100 000.

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Manuskript.

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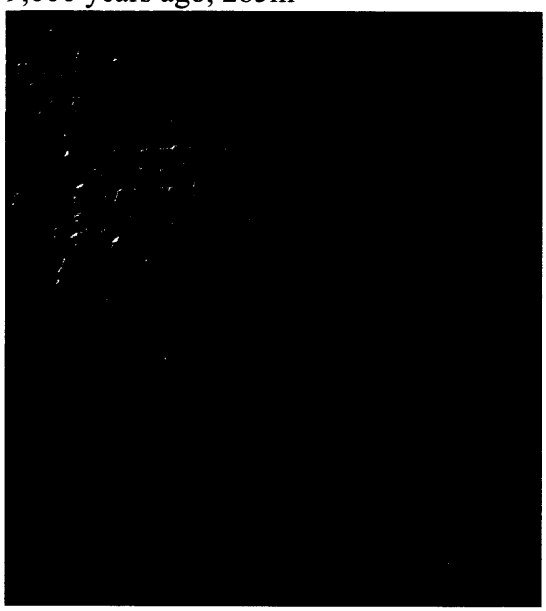
Summary

The High Coast with its well-documented and dated geology, its record of shoreline displacement, 285 m, over the course of 9,600 years, is outstanding in comparison with Hudson Bay's 272 m during 8,000 years. The distance, between the highest and the present shore, is approximately 50 km in the Hudson Bay area and only 2–3 km at the High Coast.
There is no other area of glacio-isostatic rebound comparable to the High Coast to be found anywhere in the world.
Processes of land uplift in the High Coast area are recorded over a time span of 9,600 years compared with the time span of 2,000 years for the Quark.
Ongoing processes, due to the land uplift such as isolated lakes in the inlets, are intensive in the High Coast area, and extensive in the Vasa archipelago due to shallow water.

The geological conditions of the High Coast are unique.

Maps over the High Coast area

9,600 years ago, 285m



Palaeographical maps of the High Coast area from deglaciation about 9,600 years ago to present times. Current coastline is shown and approximate year and level of relative land uplift in meter above sea level is given for each map.

9,000 years ago, 200m

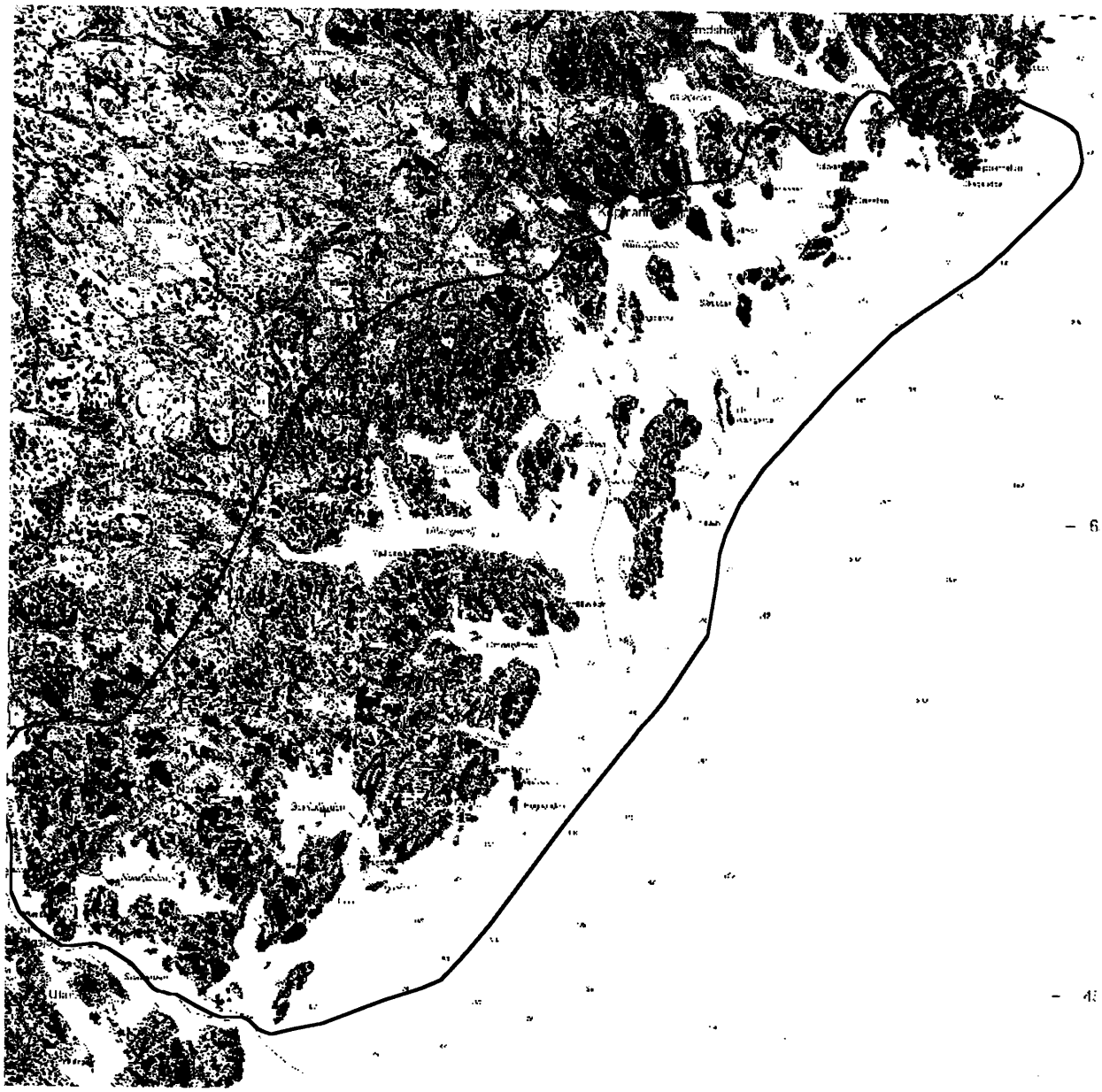
8,500 years ago, 150m

7,000 years ago, 100 m

4,500 years ago, 50 m

2,000 years ago, 20 m

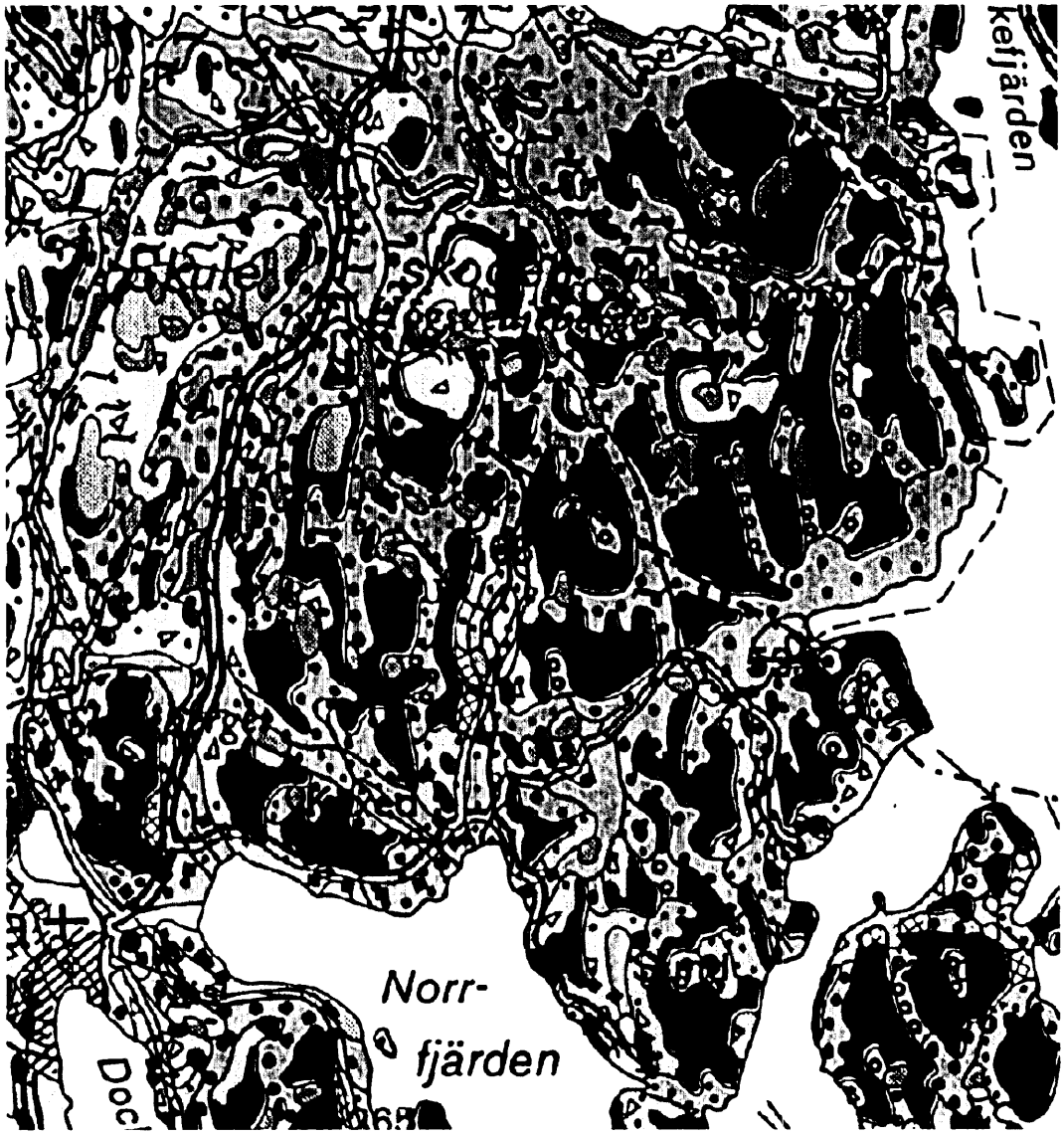
Present-day



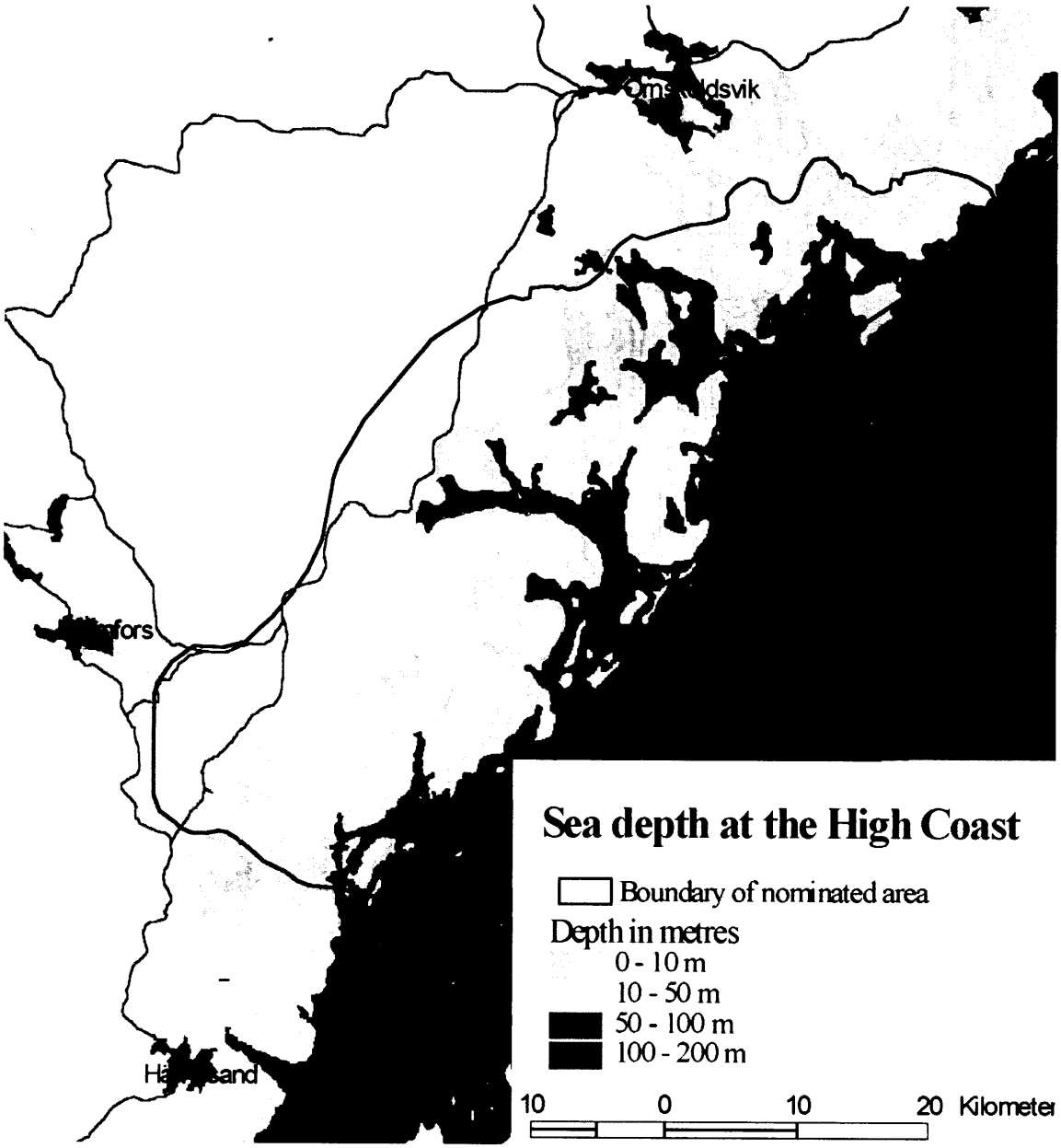
Quaternary deposits in the High Coast

The occurrence and distribution of the Quaternary deposits in the High Coast region evidently reflect an area characterised by land uplift. The glacial deposit till (blue colours) is widely spread in areas which are uneffected by waves, i.e. above the highest shoreline. Inexposed places, the till is heavily wave-washed and areas below the highest shoreline are dominated by outcrop (red), wave-washed sediments, shingle, gravel and sand (orange), and clay (yellow). Excerpt from the Map of Quaternary deposits of the county of Västernorrland in scale 1:200,000 (J.Lundqvist 1987).
The scale here is ca. 1:400,000.

▬ = Boundary of nominated area



The Skuleskogen National Park, Qaternary deposits (detail)


Sea depth at the High Coast
Boundary of nominated area
Depth in metres
0 - 10 m
10 - 50 m
50 - 100 m
100 - 200 m
10
0
10
20 Kilometer

The High Coast

Rising from the sea for 10,000 years

ENCLOSURE 2

County Administration
of Västernorrland

Publication 2000:1

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The companion volume, *The High Coast. 5000 years of Human History*,
may also be ordered from this source.

The cover photo shows the sheer eastern cliff face of Skuleberget.
There is a glimpse of the forested till cap at the summit.
It is 285 m above sea level and one of the hill caps in the High Coast
that denote the world's highest shoreline. The elevation of
the former shoreline is a consequence of the depression of the area
during the latest Ice Age and subsequent land uplift.
In the background are the hills at Nordingrå and Ullångersfjärden.

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COLOR TRYCK, Härnösand, 2000

Foreword

This review of the post-glacial geological history of Sweden's High Coast region was commissioned by the Västernorrland County Administrative Board, in connection with the area's nomination as a UNESCO World Heritage site. To be included on the World Heritage List, a natural or historical setting must be regarded as especially worth preserving for future generations, and possess unique or outstanding features within a global perspective.

The natural landscape of Sweden is rich and varied, and its cultural heritage is well-preserved. At present, there are nine World Heritage sites in Sweden, one due to its exceptional natural values and eight of special cultural-historical significance.

The distinctive character of the High Coast region is due to its post-glacial geological history, which is unique on earth. That history began when the last ice-age glacier receded, thereby removing its enormous weight from the land mass that it had pressed down. At that point, the land began to rise again, and the dramatic consequences are now visible along the High Coast.

That process of land elevation is still in progress. It is the steady rising of the land mass and the resulting sharply-contoured landscape which form the basis of the High Coast's unique character. The ongoing land elevation also provides unusually favourable conditions for the study of geological and historical processes. One consequence of the area's unique geological history is that it is also fairly easy to detect traces of its human history. Concentrated along the coast are the remains of successive human settlements from the Stone, Bronze and Iron ages to the present.

The purpose of this review is to describe the post-glacial history of the High Coast in a way that is both interesting and easy to understand. For that reason, some aspects have been simplified, and strict scientific usage has not always been followed. The booklet has been produced in co-operation with the Geological Survey of Sweden and the Swedish Environmental Protection Agency.

Börje Hörnlund, Governor
Västernorrland County

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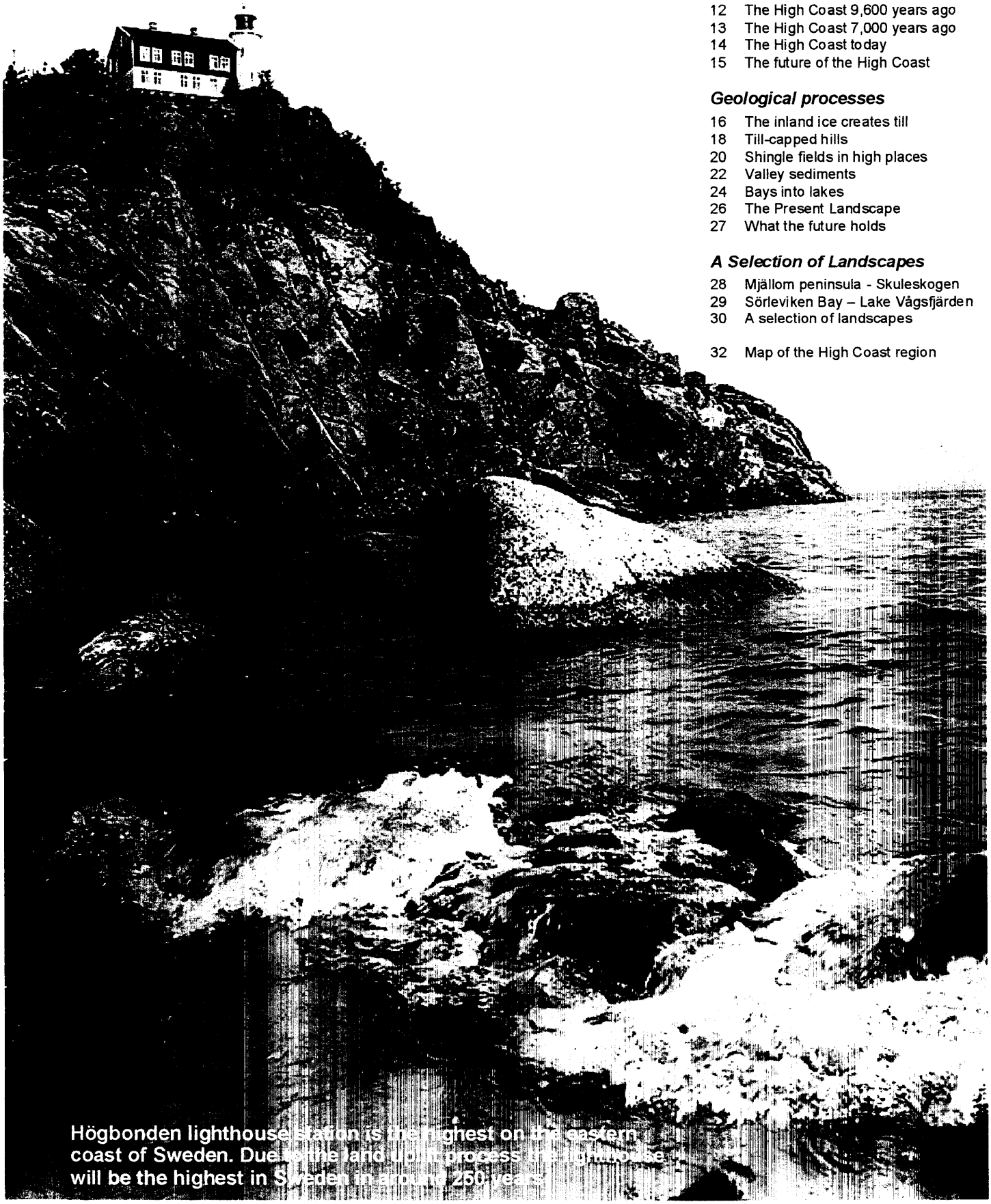
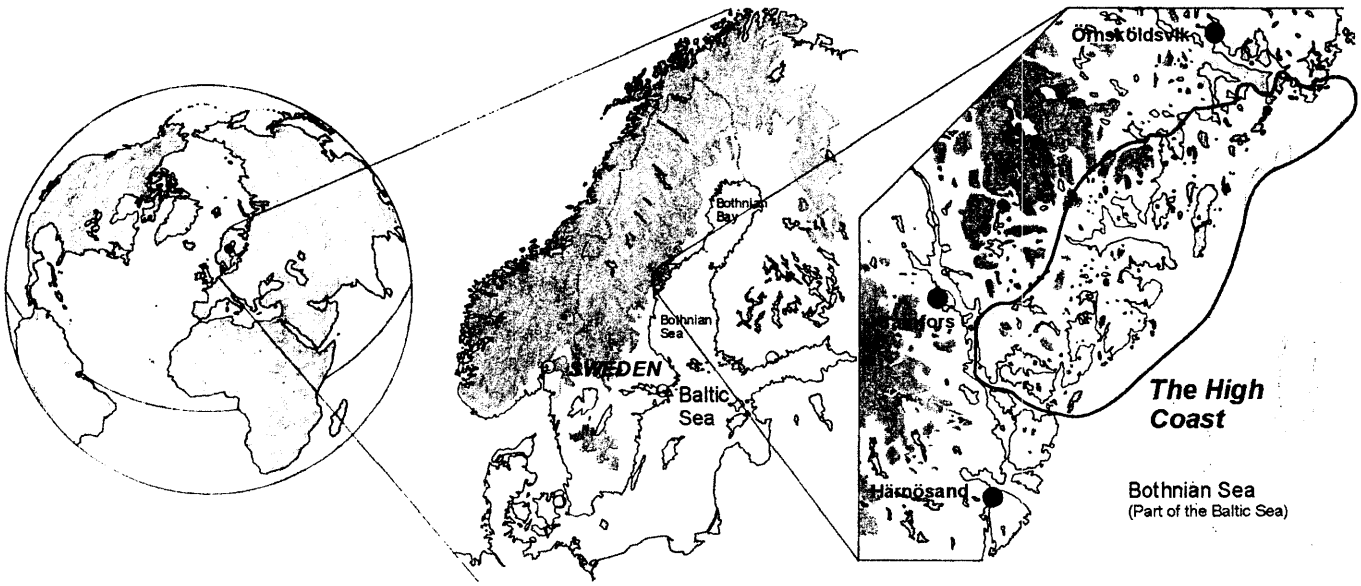


Högbonden lighthouse station is the highest on the eastern coast of Sweden. Due to the land uplift process the lighthouse will be the highest in Sweden in around 250 years.



The High Coast

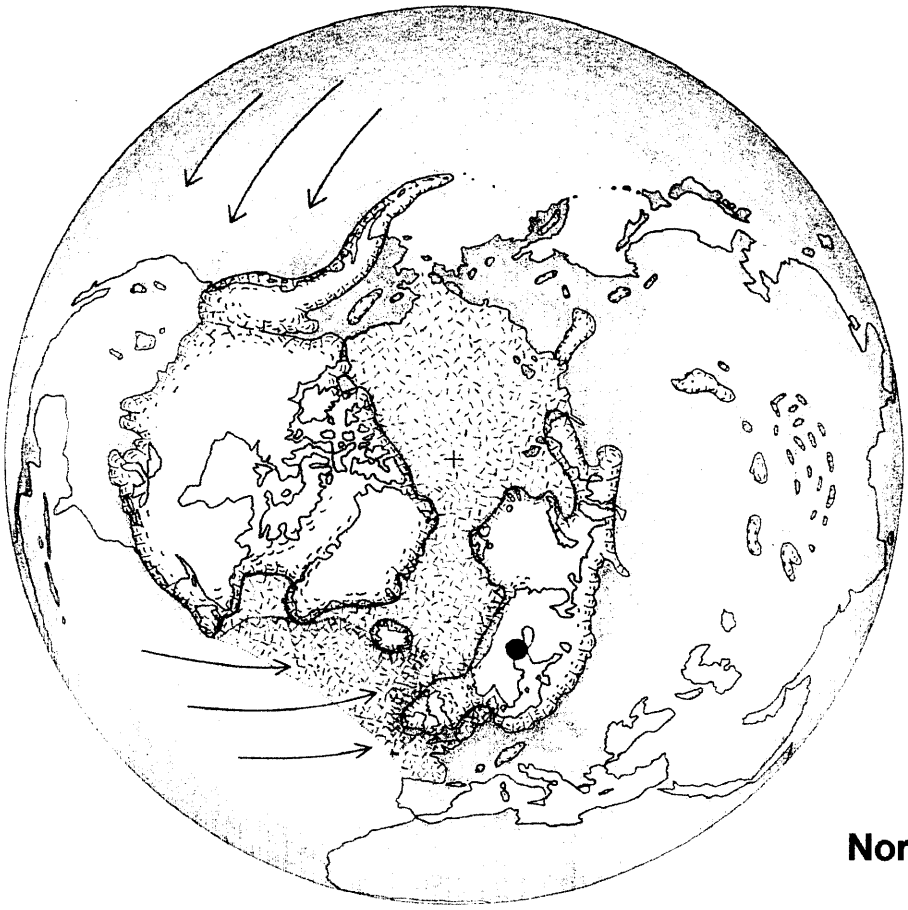
A geologically unique region

"High Coast" is the name given to the area between the cities of Härnösand, Kramfors and Örnsköldsvik, a region where the hilly landscape of Ångermanland meets the Bothnian Sea. Due to the varied terrain, the coastline is quite uneven - steep and lofty hillsides alternating with deeply gouged bays and inlets. The deepest sections of the Bothnian Sea are located off the High Coast.

The bedrock of the High Coast region consists of such varieties as greywacke, Härnö granite, amphibolite, gabbro, anorthosite, Nordingrå granite, sandstone and dolerite. The oldest rocks are slightly less than 1.9 billion years old, while the younger were formed about 1.2 billion years ago. This diversity of bedrocks provides the geological basis of the High Coast's distinctive landscape.
The landscape as a whole is greatly influenced by the comparatively rapid rate of land uplift, currently eight mm/yr. During the last Ice Age, Scandinavia was depressed by an ice sheet with a thickness of up to three km. The centre of depression, ca. 800 m deep, was located in the High Coast area. The highest shore marks are situated at 285 m above current sea level, which is outstanding in the world. Due to the area's topography, with steep hills abutting the sea, the historical process of land uplift has left its traces at various levels along the current and ancient shorelines. These include such phenomena as till-capped hills, wave-washed hills, shingle fields, caves and grottoes, valley floors covered in sediment, lakes formed from inlets cut off from the sea, and newly-formed skerries and islands. All these traces of land uplift are concentrated within a limited area.

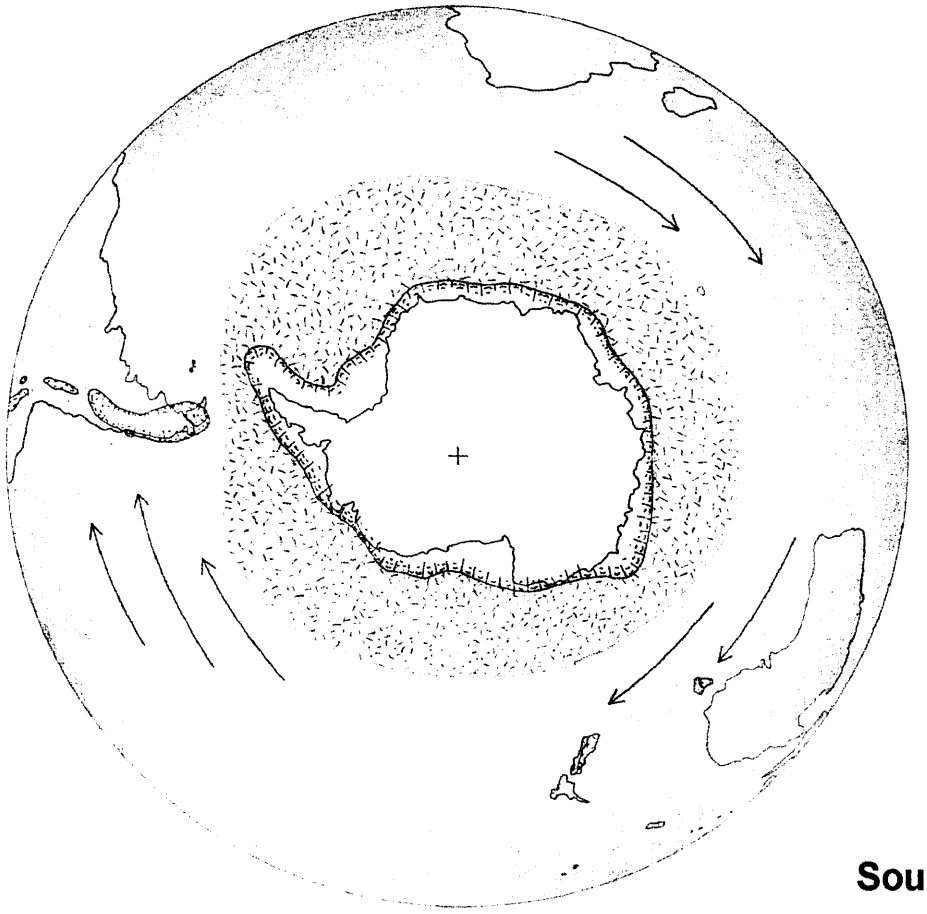
The area's human history has also been influenced by the process of land uplift. Since the Stone Age, humans have continually colonised the new land rising from the sea. Thus, land uplift has provided suitable conditions for settlers to live, hunt and grow crops in the region. The coastal area has always been especially important for fishing and seal-hunting. But due to land uplift, the coastlines from various periods have gradually shifted upward. As a result, the remains of ancient settlements can now be found at corresponding heights above the present sea level.

Additional details on historical-cultural developments in the region are provided in the companion volume, *The High Coast: 5000 Years of Human History* ; see inside-front cover for ordering information.

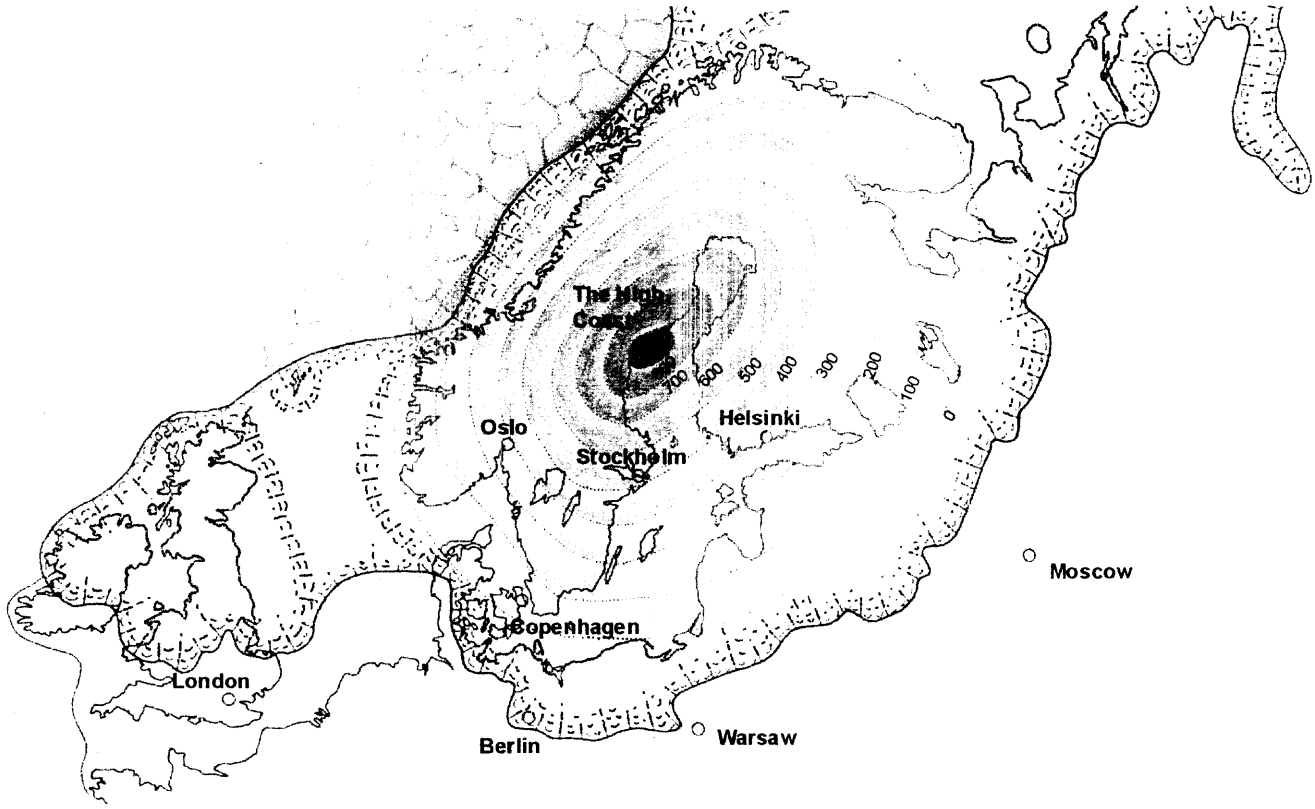


Northern Hemisphere

Maximum cover of inland ice sheets and sea ice during the latest Ice Age (Weicsel).
The coverage in the North Sea, the Arctic Ocean, Siberia and northern Canada is debated.
The arrows indicate the prevailing winds.



Southern Hemisphere



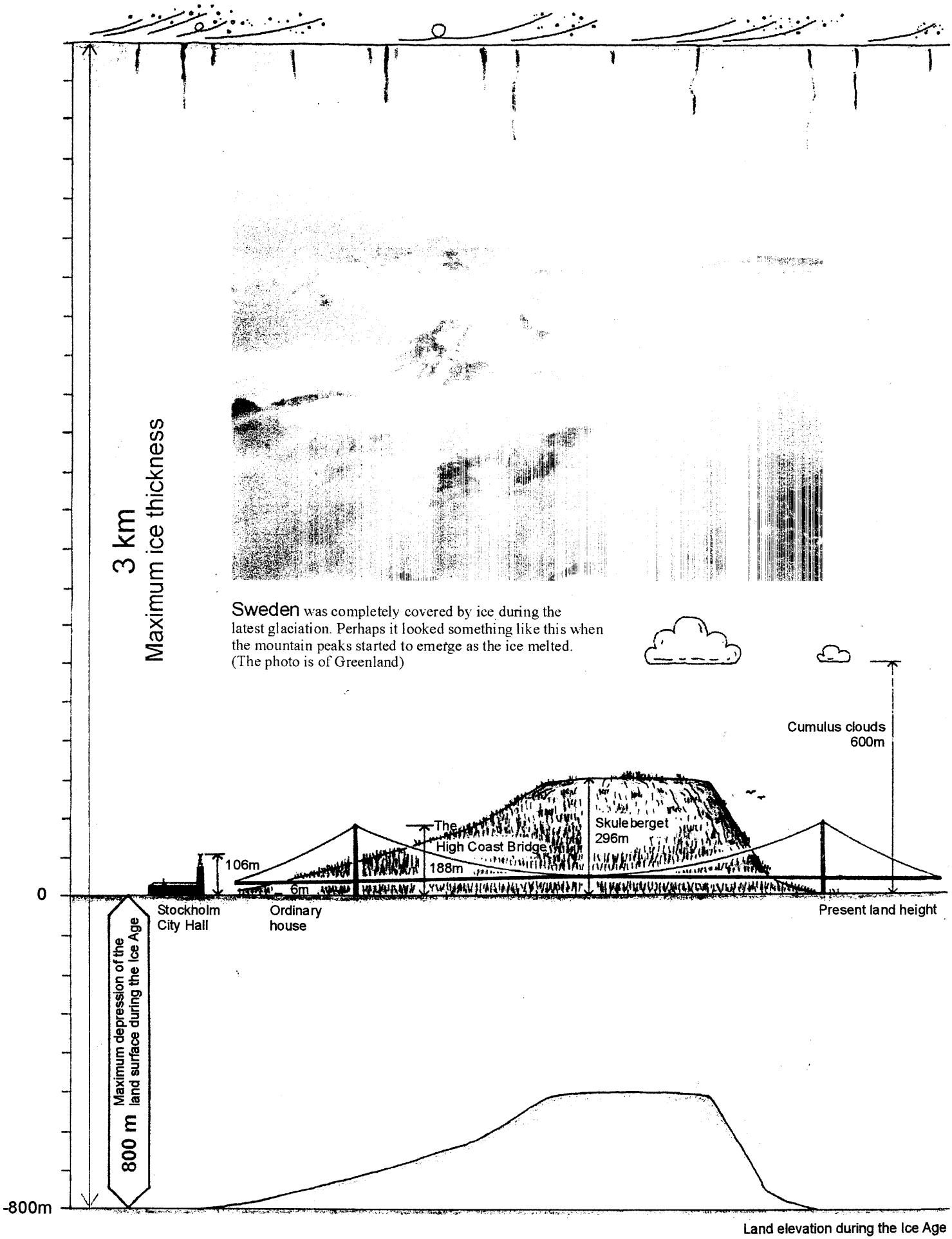
The maximum cover of inland ice sheets in Europe, 20,000 years ago.
The greatest depression of land under the weight of the ice sheet was in the High Coast area, more than 800 m. This corresponds to an equivalent uplift after the Ice Age.

Covered in ice

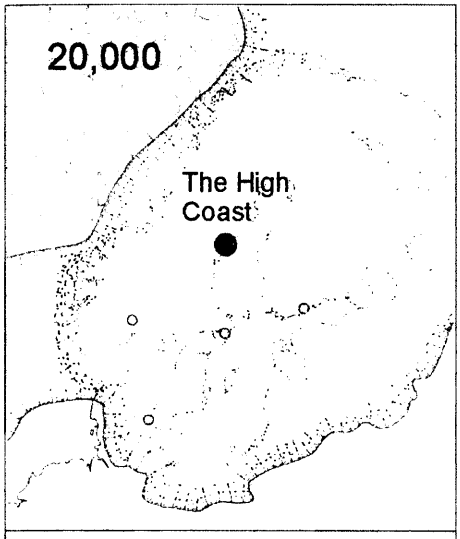
Ice ages with massive ice sheets have occurred at regular intervals throughout the earth's history, beginning for example 700, 450 and 280 million years ago. The past 2.5 million years have been characterised by fluctuations between lengthy ice ages and warmer intervals of shorter duration. For Europe and Scandinavia during that time, four distinct ice ages have been documented and it is likely that more have occurred.

The great ice sheets had their origins in mountainous areas with heavy precipitation, during periods of increasingly colder temperatures. The most recent ice age, in Northern Europe called the Weichsel, lasted ca. 100,000 years and came to an end about 10,000 years ago. During the glacial maximum, which occurred about 20,000 years ago, both Canada and Northern Europe were covered by ice of up to three km thickness. Other areas entirely or partially glaciated at that time were Greenland, the Antarctic, the southern tip of South America and New Zealand. Even the high mountains of the Alps and Himalayas were covered by ice. The maximum range of the great ice sheets is indicated on the accompanying maps. Today, we are living in a warm period whose eventual length is not known. In the past, warmer intervals between ice ages have lasted 10,000 - 20,000 years.

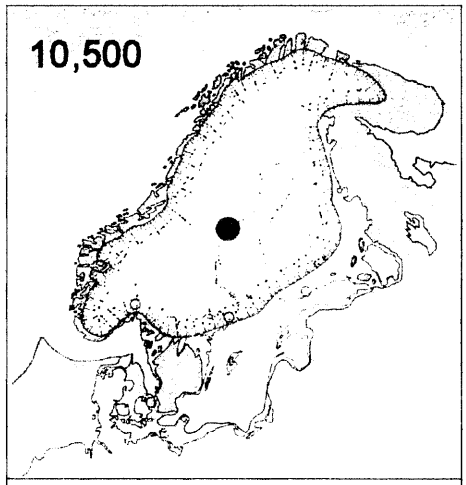
With its three-km thickness and its massive weight, the inland ice sheet pressed the outer layer of the earth downward. The maximum depression caused by the Scandinavian ice sheet was over 800 m, at the High Coast. The process can be likened to a giant hand pressing against a soft rubber ball: When the hand is withdrawn and the pressure is released, the ball returns to its original form. This is what has been and is still occurring at the High Coast, which today is rising at the rate of about eight mm/yr.



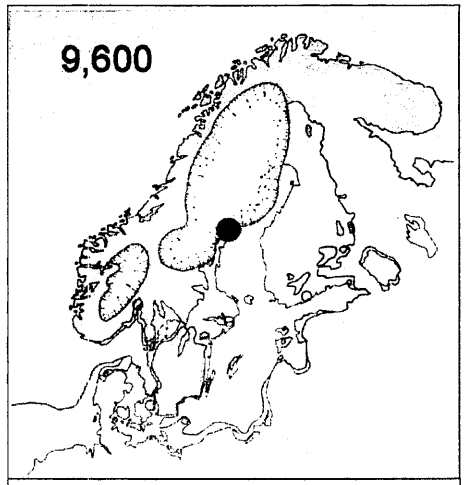
The diagram illustrates the elevation relations during the maximum ice cover at the High Coast.
The ice-sheet´s enormity and the maximum depression of the land surface compared with several landmarks.



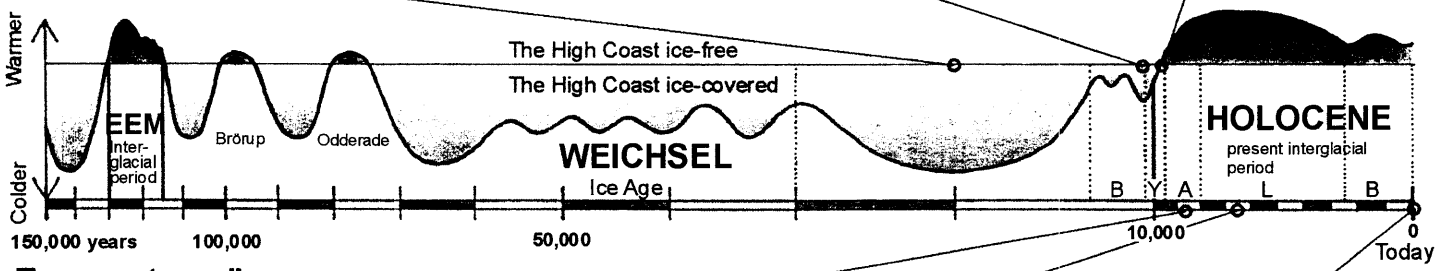
The Ice Age´s latest main phase
(30,000 - 13,000 years ago)



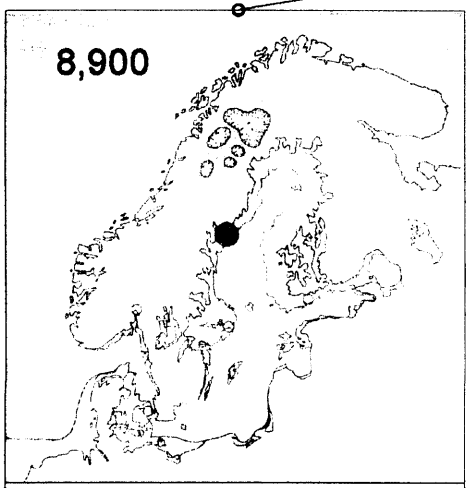
Baltic Ice Lake (13,000 - 10,300 years ago)
Lake with cold, fresh water.



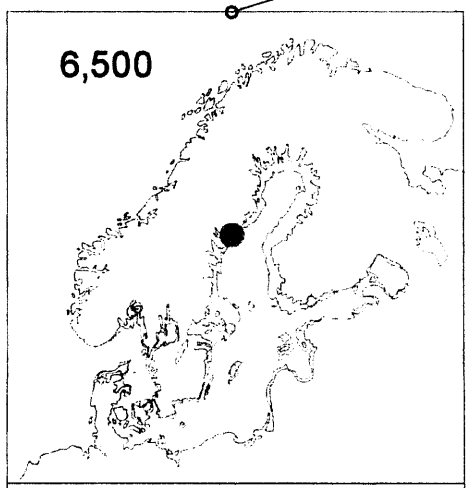
Yoldia Sea (10,300 - 9,500 years ago)
Inland sea with cold, brackish water.



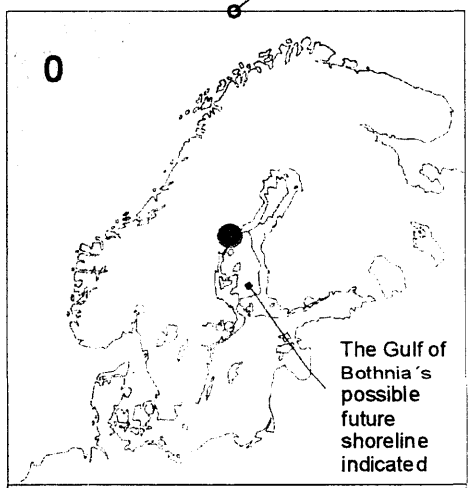
Temperature diagram of the latest Ice Age
(Logarithmic time scale)



Ancylus Lake (9,500 - 8,000 years ago)
Lake with cool, fresh water.



Littorina Sea (8,000 - 2,500 years ago)
Inland sea with warm, brackish water.

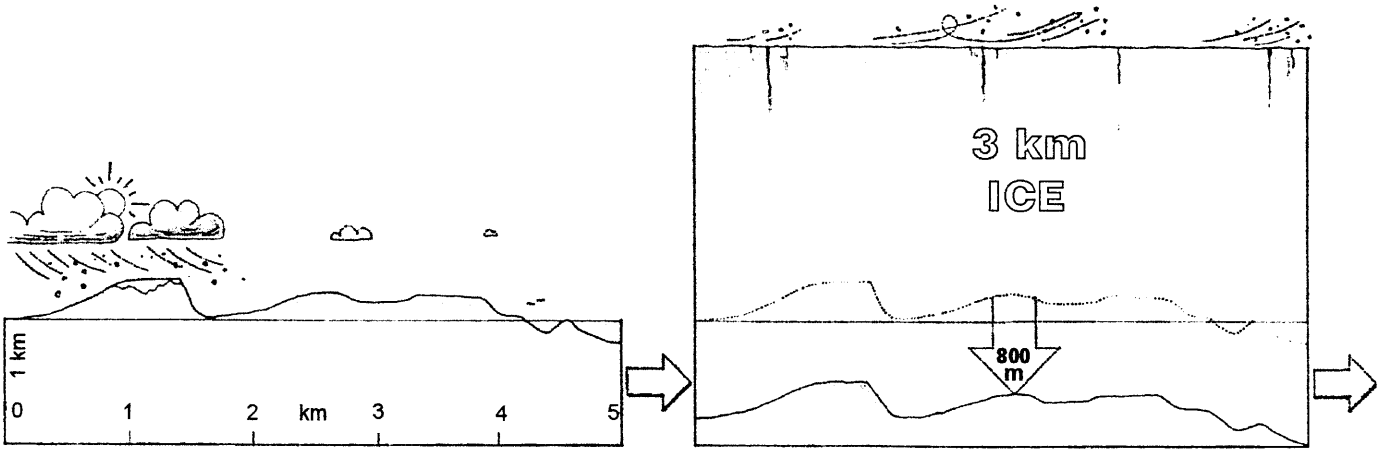


Baltic Sea (2,500 years ago - today)
Inland sea with cooler, less brackish water.

The ice retreats

After the farthest advance of the last inland ice some 20,000 years ago, the climate became warmer and the ice began to melt. Its thickness decreased, and the ice margin retreated towards the interior of northern Sweden. The end of the ice age is generally placed at about 10,000 years ago. Most of northern Sweden was still covered in ice. It was not until 9,600 years ago that the margin of the retreating ice sheet reached the High Coast. By somewhat less than 9,000 years ago, the ice sheet had completely melted away.

During the deglaciation, the Baltic Sea alternated between stages of fresh and brackish water, as the link to the ocean to the west was cut off and re-established. In past-to-present sequence, the different stages have been named as follows: Baltic Ice Lake, Yoldia Sea, Ancylus Lake, Littorina Sea and today's Baltic Sea, which is the largest body of brackish water on earth. With a mixture of fresh- and brackish-water species, the Baltic's flora and fauna are also unique. As the process of land uplift continues, the Bothnian Sea will become less saline and, furthermore, the Bothnian Bay will be cut off to become a freshwater lake.



115,000 years ago
Eem interglacial period
The landscape is close to today´s level.

20,000 years ago
Ice Age maximum Weichsel III
The landscape is depressed 800 m.

A journey in time and elevation with a typical High Coast landscape through the Ice Age and the subsequent land uplift.

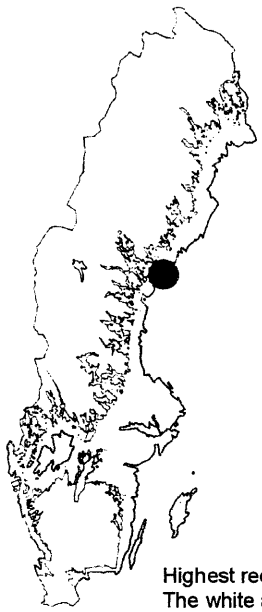
The land rises from the sea

The process of land uplift actually began some 20,000 years ago, following the beginning of the deglaciation. The land rose at an increasing rate, reaching a maximum at the High Coast about 10,000 years ago when it is calculated to have exceeded 10 cm per year (equivalent to 10 m every hundred years). The rate of uplift was fastest where the depression of the land had been greatest. When the margin of the ice sheet had retreated west of the High Coast about 9,600 years ago, the area had already risen nearly 500 m from its lowest level. Since then, the land has risen approximately an additional 300 m, for a total of ca. 800 m from its lowest to its current level.

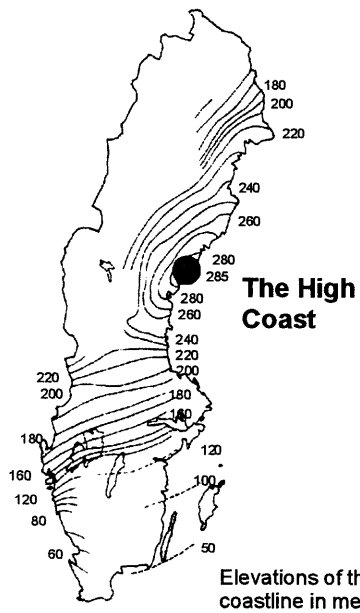
When the ice sheet retreated from the High Coast 9,600 years ago, only the highest bits of land penetrated the surface of the Yoldia Sea. These islands and skerries have since become the tallest hills of the area, with elevations of ca. 300 m and more, and their summits are covered by till that was not washed away by the ancient sea. The highest ancient shore marks now lies at the level of 285 m above current sea level, and can be observed on several hilltops within Skuleskogen National Park. Those coastal remnants also constitute the greatest relative land uplift in the world.

Since that time, the present-day hills of the High Coast region have been washed by the waves of the Yoldia Sea, the Ancylus Lake, the Littorina Sea and the Baltic Sea. Traces from all these stages of alternating fresh and brackish water can be seen along the High Coast. The large shingle fields on the hill, Högklinten, were formed during the first three of those stages.

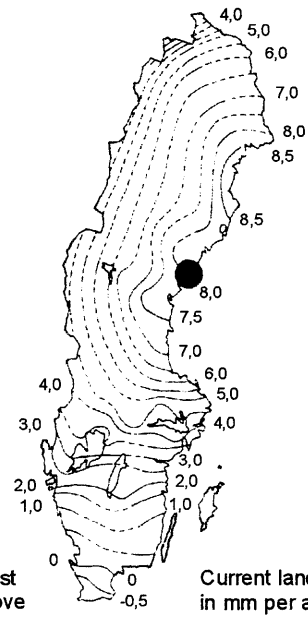
The land continues to rise today, at the rate of 8 mm annually. It is possible that the land uplift can continue a further 50 m.



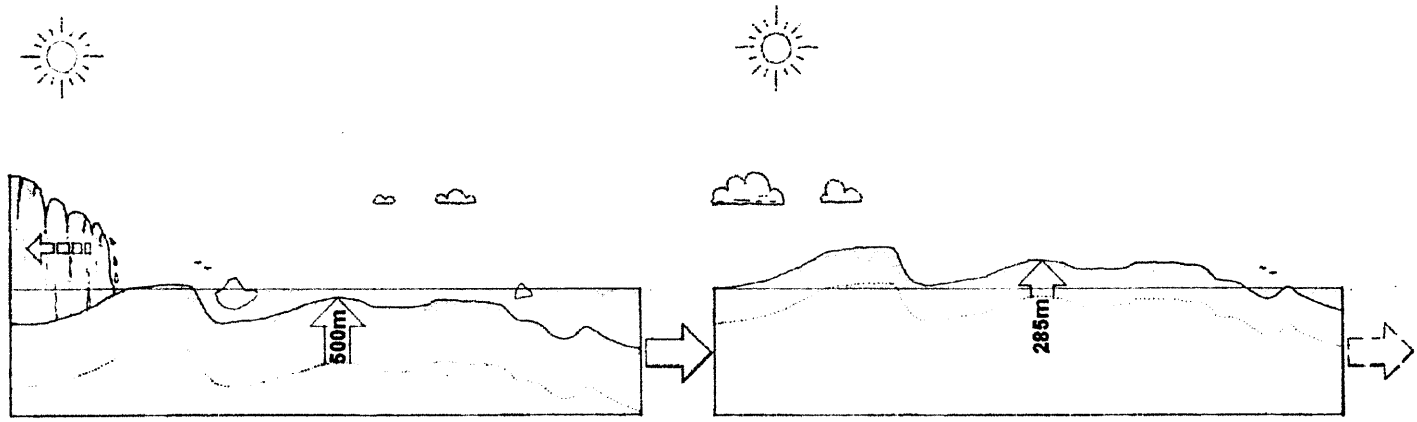
Highest recorded coastline. The white area has at some time been submerged.



Elevations of the highest coastline in metres above present sea level.

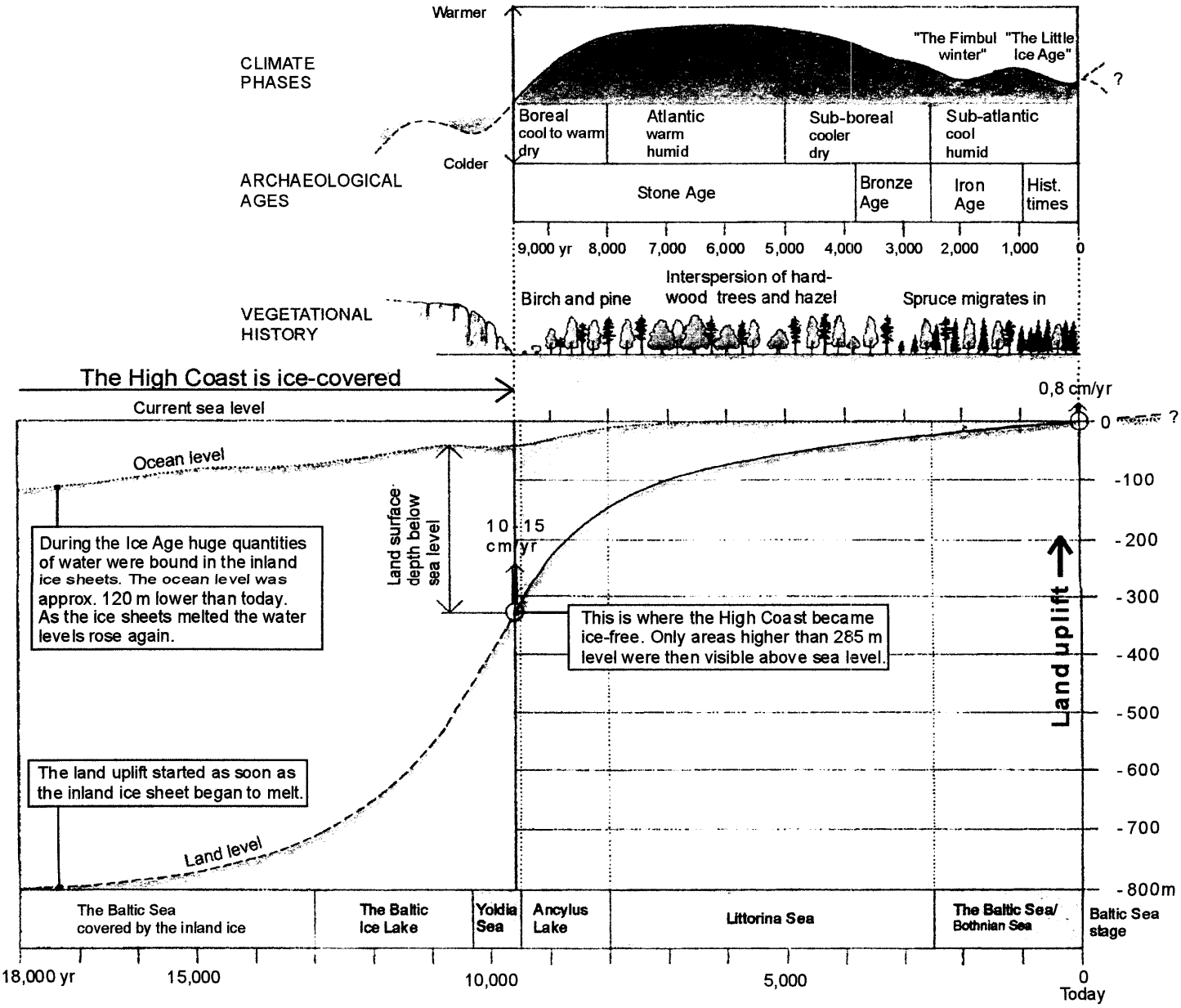


Current land uplift in mm per annum



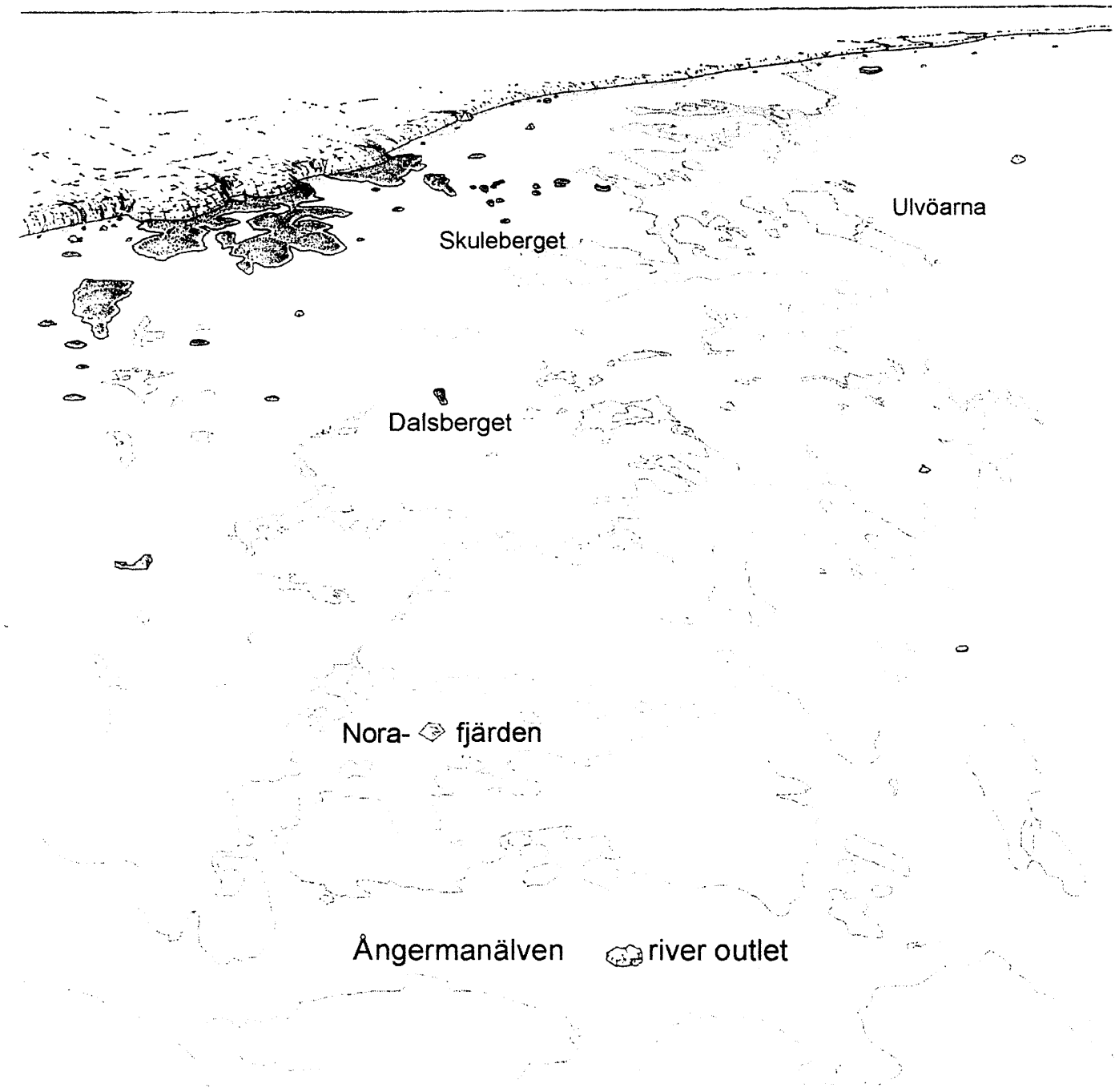
9,600 years ago
Deglaciation
The landscape has risen close to 500 m.
The highest parts break the surface of the water.

0
Today
The landscape has risen a further 285 m in relation to sea level.
The land uplift continues at a rate of 8 mm per year.
It is possible that the land will rise a further 50 m.



Land uplift diagram for the High Coast showing the rate of the land uplift combined with a diagram of Baltic Sea stages, plus climatic, vegetation and cultural development. Note that a considerable portion of the land uplift occured while the area was still ice-covered and that the ocean level has risen too.

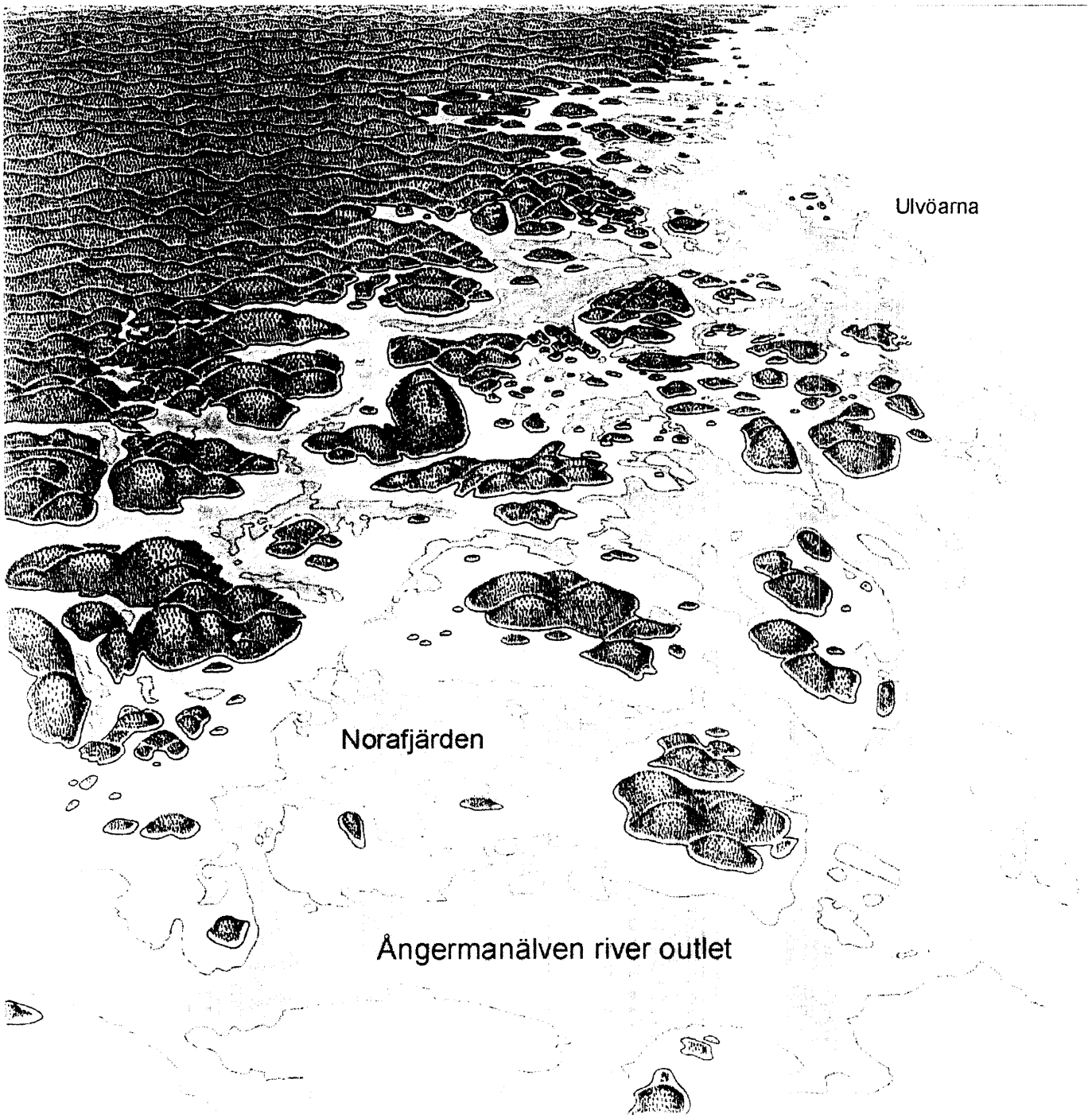
7,600 years BC



The High Coast 9,600 years ago

The ice sheet has retreated from the area and left behind an open sea, the Yoldia Sea, which is full of icebergs and floes. The highest areas of the High Coast penetrate the surface to form islands and skerries. The visible remains of this stage can be seen today on the region's till-capped hills, with their crowns of till above the zone of wave-washed bedrock. The landmass has risen nearly 500 m from its lowest level some 20,000 years ago. From the time of this illustration, it will rise another 285 m to form the landscape of today, whose outline is indicated here with the lighter colour beneath the surface of the Yoldia Sea.

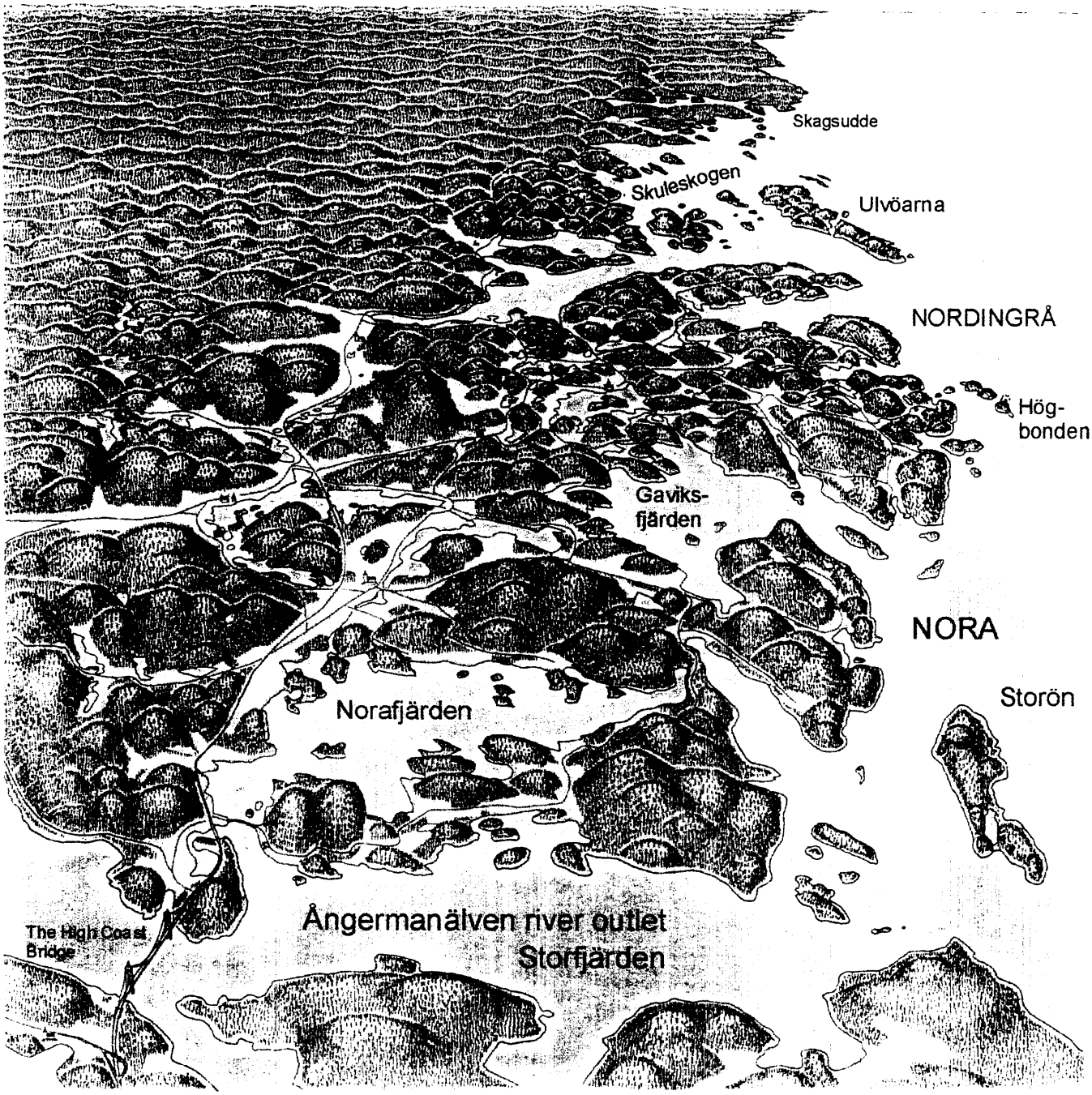
5,000 years BC



The High Coast 7,000 years ago

The land has risen nearly an additional 200 m. The former islands have grown together and merged with the mainland. New islands have emerged from the water and formed an archipelago. The sea is eroding the shoreline, leaving behind numerous strips of shingle fields which today lie high up on the hillsides. From the time of this illustration, the land will continue to rise approximately 100 m to the present level.

Today



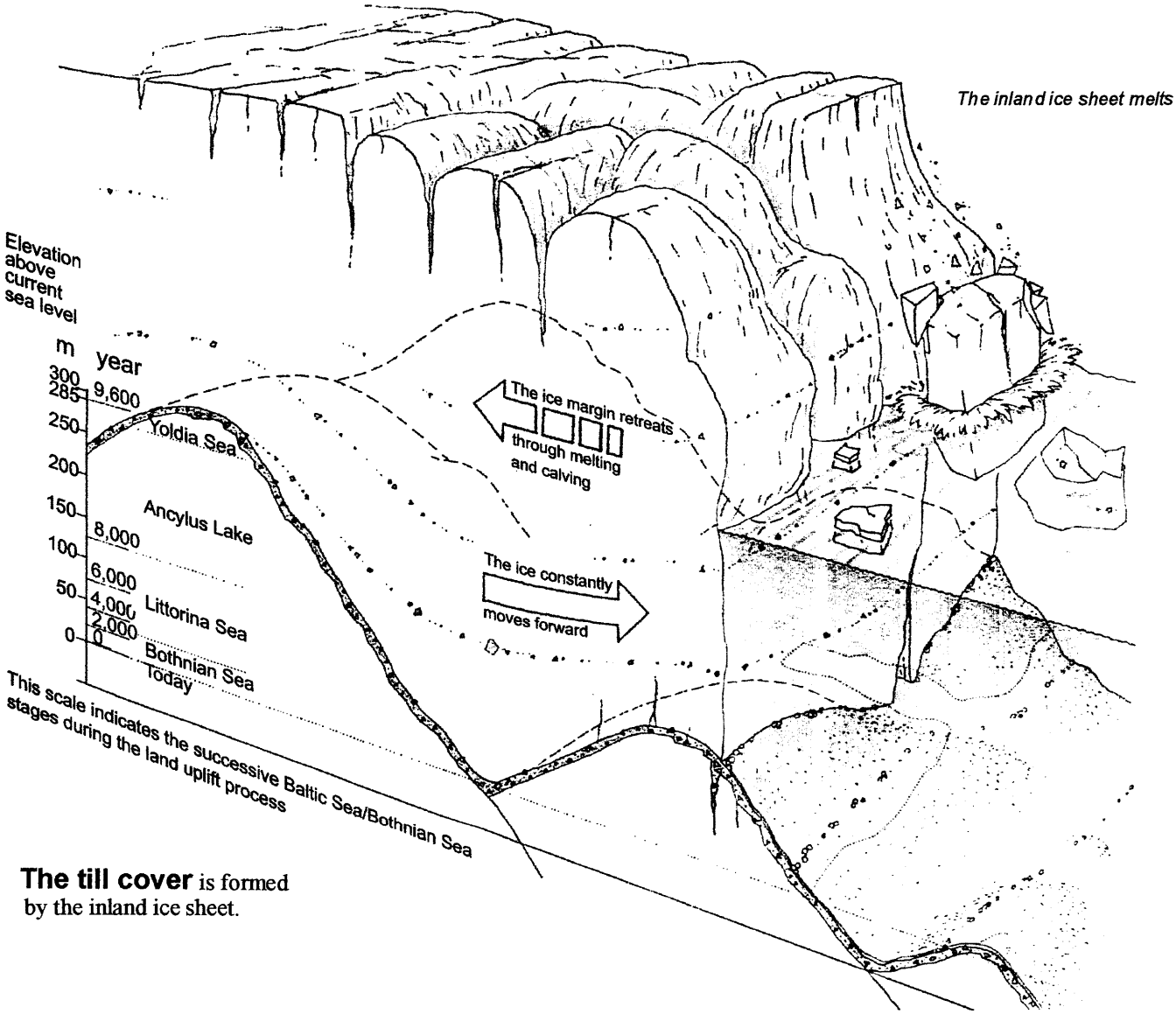
The High Coast today

The land has risen another 100 m. The islands and skerries of the ancient archipelago have grown together to form today's landscape of steep hills and narrow valleys, deep bays, and an archipelago with high, steep-walled islands. The valleys are former sea inlets that have risen to become dry land, and the sediments deposited in them make good farmland. The process of land uplift continues at the rate of eight mm annually.

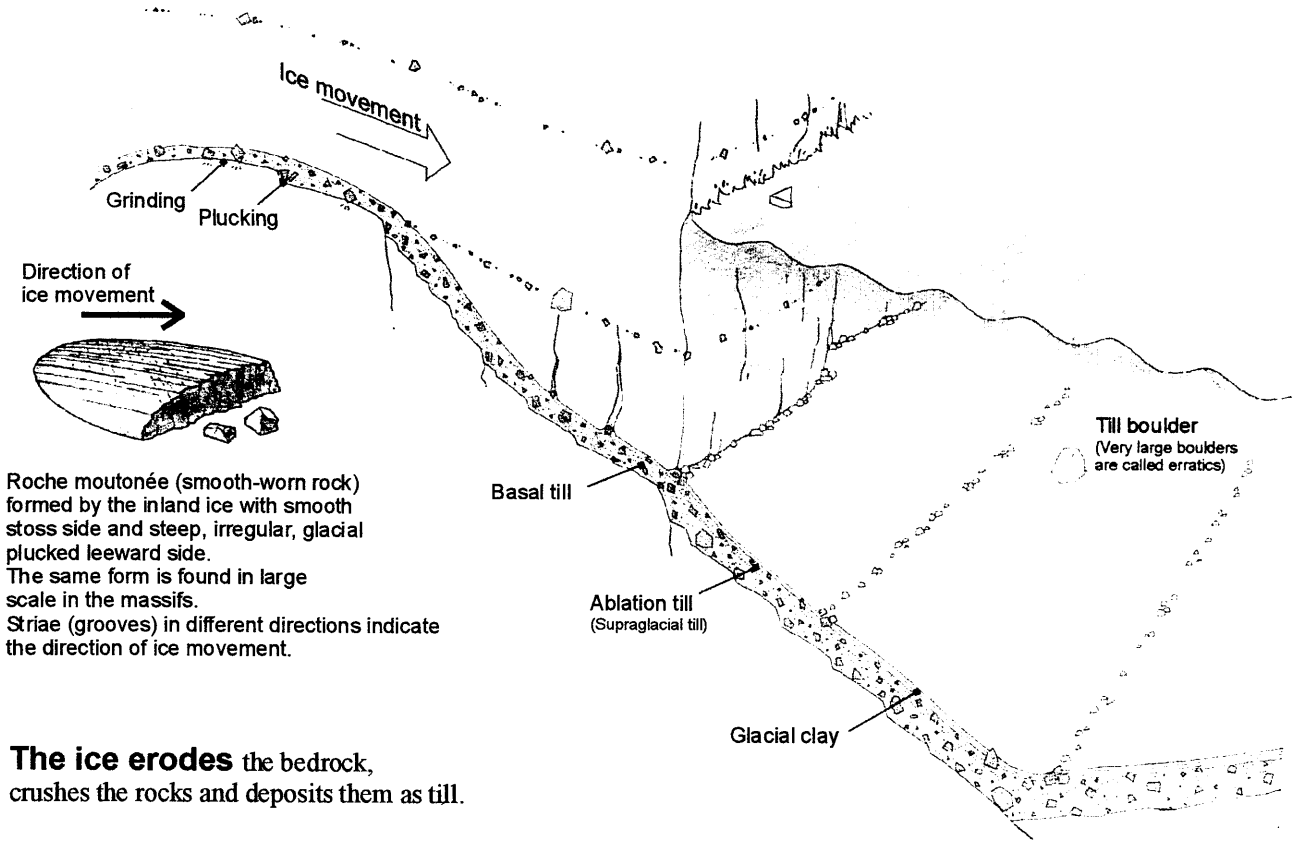
The Future

The future of the High Coast

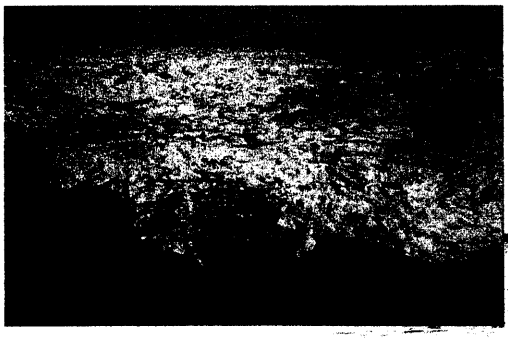
In the scenario illustrated here, the land has risen nearly an additional 50 m during a period of perhaps 10,000 years. The Bothnian Bay has undergone dramatic change, becoming so shallow that Sweden and Finland are now joined by a landbridge at the Northern Quark. The shoreline of the High Coast has not changed to the same degree, due to the great depth of the Baltic waters off the coast. But there have been major changes at sea level. Islands have merged with the mainland, and inlets have been cut off to form lakes. The area of many lakes has decreased due to sedimentation and overgrowth. The mouth of the Ångermanälven River has moved eastward, and now consists of a narrow channel between the Nora area to the north and Hemsö Island to the south. By this time, however, the next glaciation may be on the way. . . .



The till cover is formed by the inland ice sheet.



The ice erodes the bedrock, crushes the rocks and deposits them as till.



Rocks emerge from melting ice in Greenland. This is how it may have looked when the ice sheet retreated from the High Coast.

Roche moutonée (smooth-worn rocks) with grooves ("striae") gouged by the inland ice sheet.

Till is a mixture of usually sharp-edged particles of various sizes.

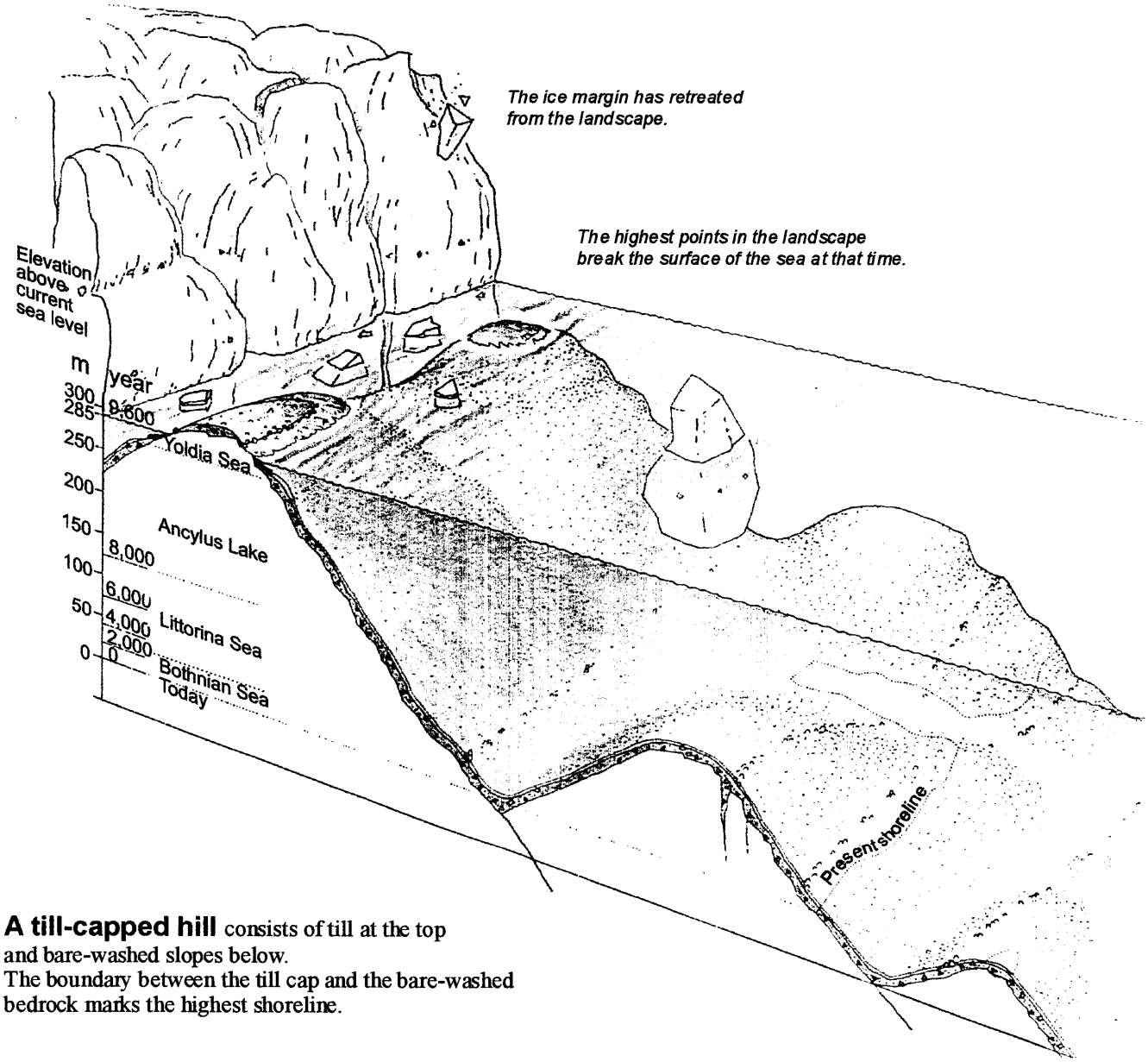
The drawings on page 16-27 illustrate how glacial and littoral processes have shaped the High Coast during the past 9,600 years of land uplift. The diagrams show a cross-section of the High Coast landscape and details of geological processes.

The inland ices creates till

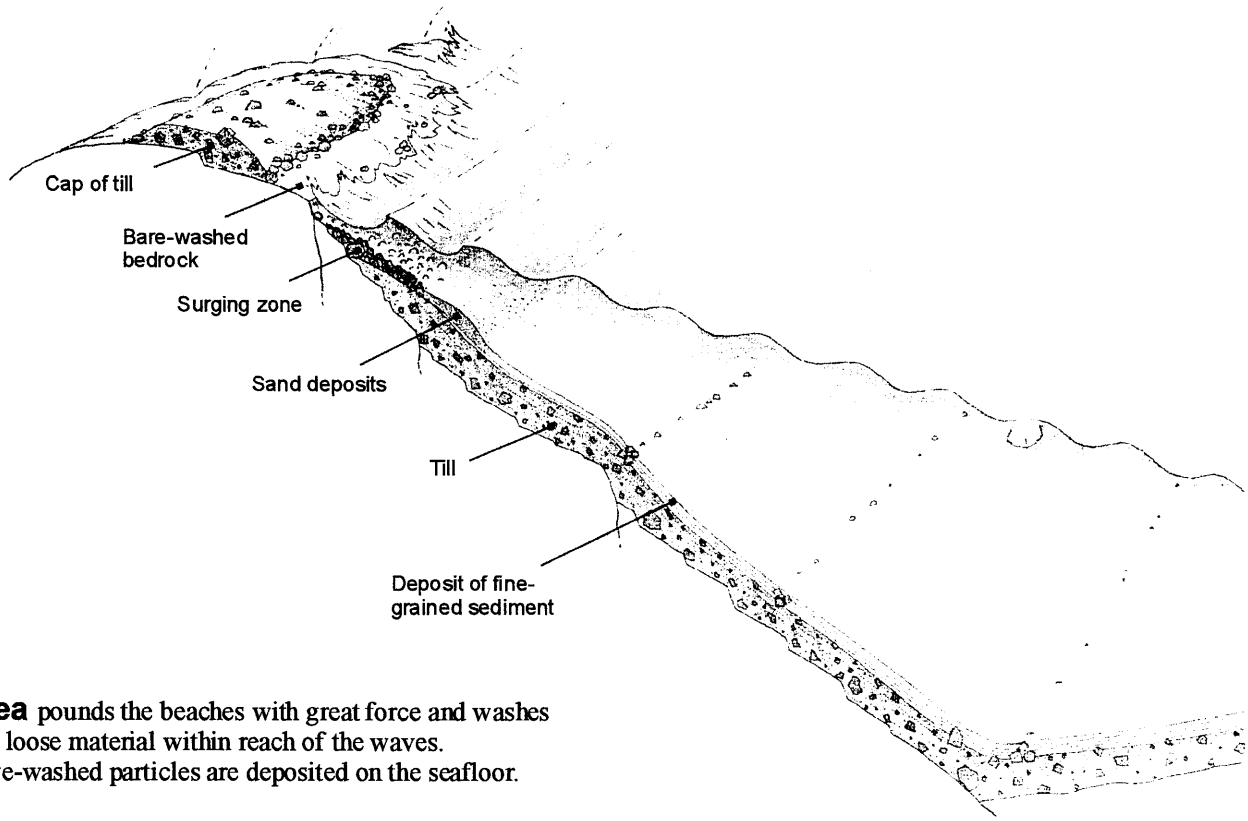
During its advance, the inland ice eroded and transported older deposits. It also crushed and broke down irregularities in the bedrock. Through internal movements, rocks, boulders and gravel could also be transported upward and accumulate in higher layers of ice. Even when the ice sheet was melting and retreating, the major body of ice kept moving toward the margin. But the melting process was much faster than the slow movement of ice toward the front, and the net result was the retreat of the ice margin.

The ice sheet moved over the landscape like a gigantic sheet of sandpaper. Stones and boulders at the base of the ice gouged grooves in the rock underneath; the orientation of these "striae" indicate the direction of the ice sheet's movement.

Till is a mixture of particles that can range in size from tiny clay particles to massive boulders. As a rule, these materials are rather sharp-edged. After the retreat ot the ice sheet from the High Coast, much of the area was covered by till of varying depth. However, most of the till in the region have been wave-washed.



A till-capped hill consists of till at the top and bare-washed slopes below.
The boundary between the till cap and the bare-washed bedrock marks the highest shoreline.



The sea pounds the beaches with great force and washes away all loose material within reach of the waves.
The wave-washed particles are deposited on the seafloor.

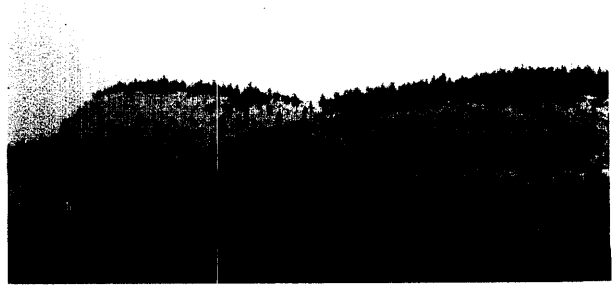
Till-capped hill in Skuleskogen. The crown bears a "cap" of till which is densely wooded. The wave-washed rocks below are bare.

Till-capped hills

When the ice sheet retreated from the High Coast 9,600 years ago, the land was still pressed down to a depth of 285 m below current sea level. Then, the tops of the highest hills in today's landscape were but small islands and skerries in the Yoldia Sea of that time. Most of the bedrock was covered by till. When the waves of the sea beat the till-covered shores, fine-grained particles were washed away and deposited on the seafloor offshore. All that remained were stones and boulders. In areas of especially powerful wave action, all till down to the bedrock was removed. Along the High Coast, entire hillsides have been washed bare in this way.

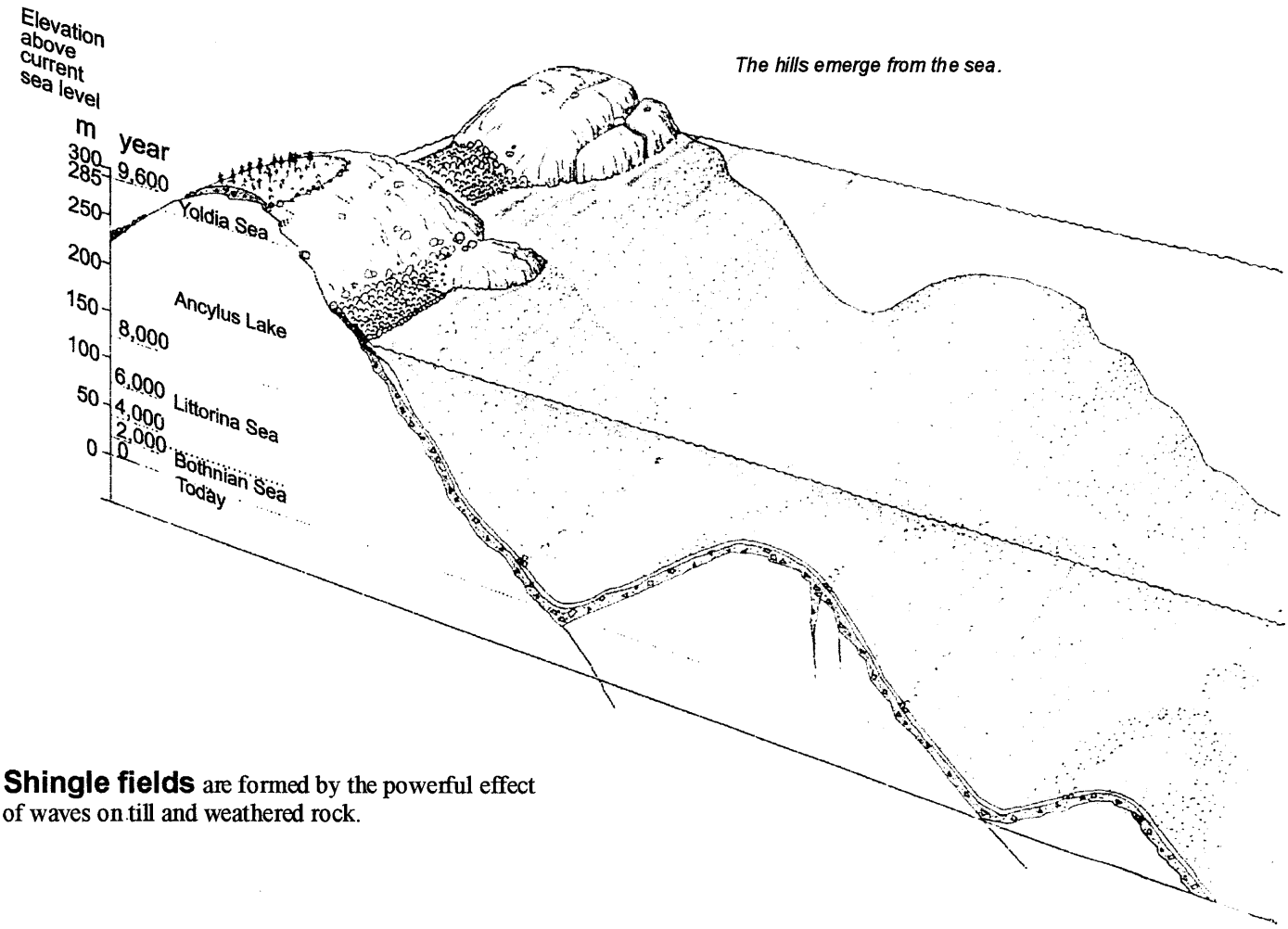
Some of the islands were so high that the waves did not wash over them. The till thus remained in place to form a so-called "cap" of till. These former islands have now become the highest hills in the High Coast region and their till caps, which are densely wooded, are a distinct feature of the landscape. They are especially visible where till caps contrast with the hillsides below that have been washed completely bare.

The highest coastline in the world, at an elevation of 285 m, has been measured on several till-capped hills in the Skuleskogen area of the High Coast.

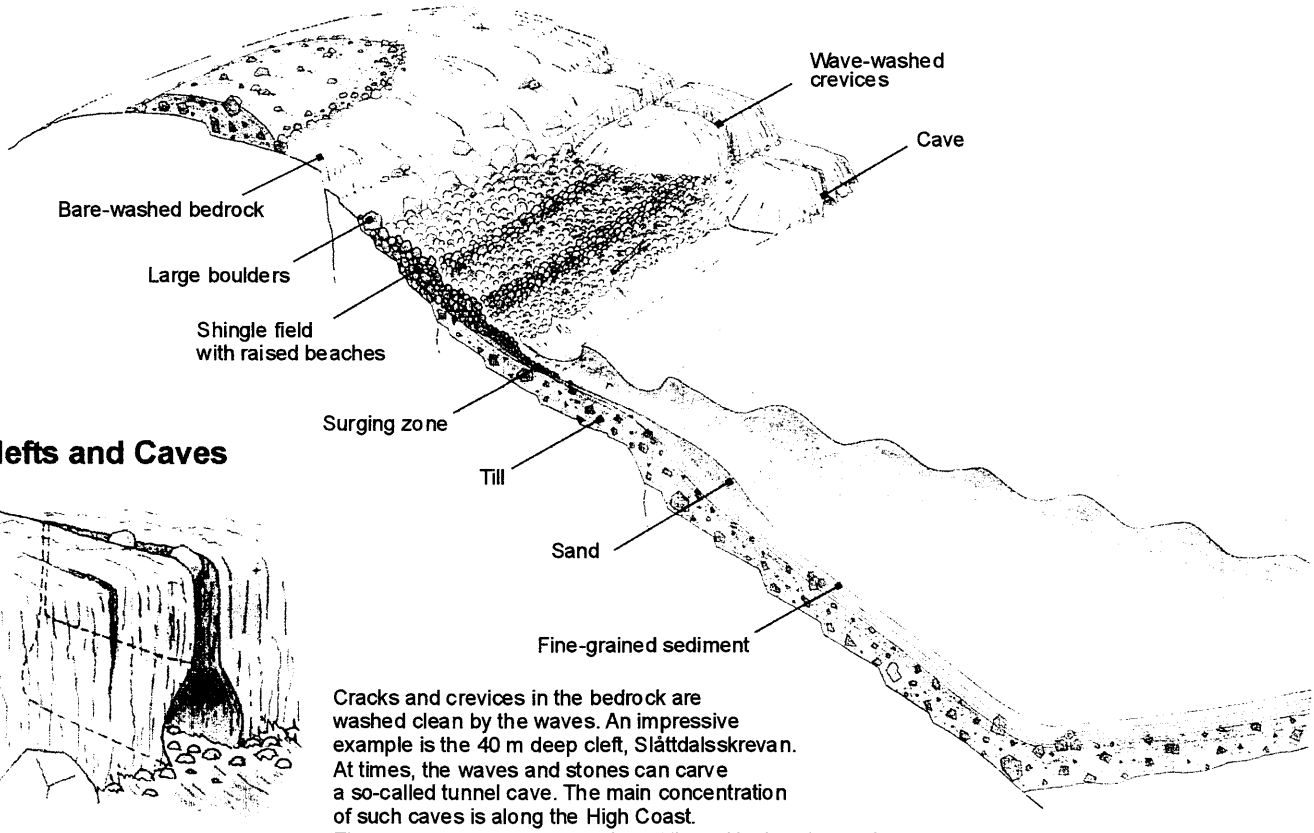


Till-capped hills in Skuleskogen. The caps on the crowns allow the observer to sense the highest shoreline, 285 m above sea level.

Skuleberget. Those parts of the hill below the highest shoreline have been washed bare. Only on the highest crown has a small cap of till been left behind.



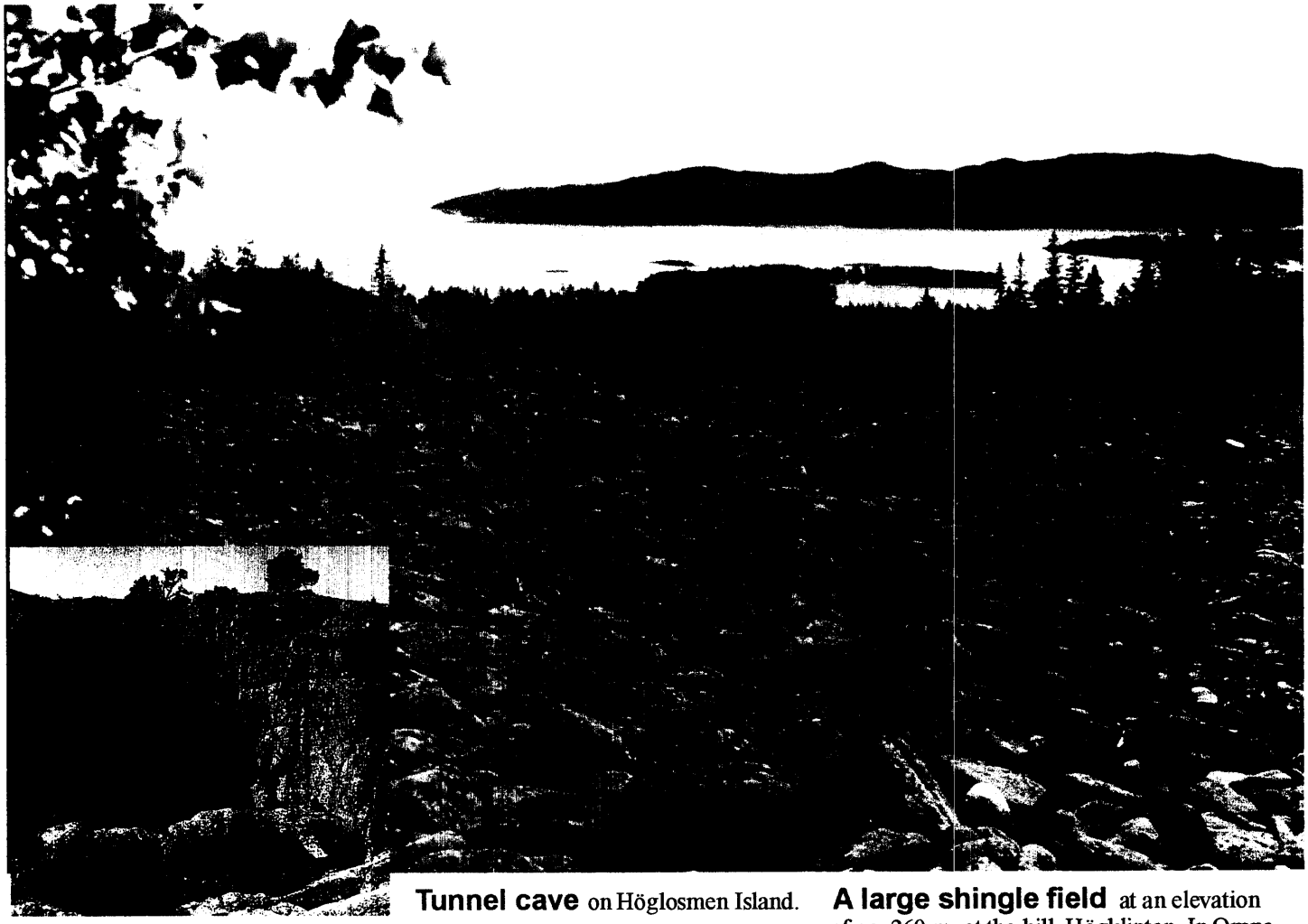
Shingle fields are formed by the powerful effect of waves on till and weathered rock.



Clefts and Caves

Cracks and crevices in the bedrock are washed clean by the waves. An impressive example is the 40 m deep cleft, Slåttdalsskrevan. At times, the waves and stones can carve a so-called tunnel cave. The main concentration of such caves is along the High Coast. There are fine examples on Norra Ulvön, Högbonden and at an elevation of 105 m on Mjältön.

The till is worked by the surf. The fine-grained particles are eroded and deposited on the seafloor. The remaining rocks are reworked into shingle.



Tunnel cave on Höglosmen Island.

A large shingle field at an elevation of ca. 260 m, at the hill, Högklinten. In Omnefjärden Bay below, the Örarna and Skorporna islands continue to rise from the sea. In the background is Rävsön, once an island but now a peninsula.

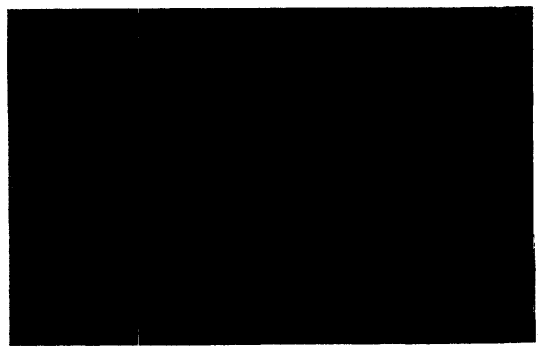
Shingle fields in high places

As the land rose from the sea, the skerries developed into larger islands. Their shorelines were exposed to heavy seas, and the most exposed shores were partly or entirely washed clean. The finest particles were transported by sea currents, and eventually settled out to form sediments in deep waters. Larger and heavier particles were transported by coastal currents over shorter distances.

But in some places, there remained patches of stones and boulders that have been rounded by the action of ice and waves. This shingle usually consists of local rocks, but may also include stones transported by the inland ice. Many different types of rock, displaying a wide variety of colours, may be represented in the same shingle field. They are often covered with a deep green lichen which provides an element of colourful variation.

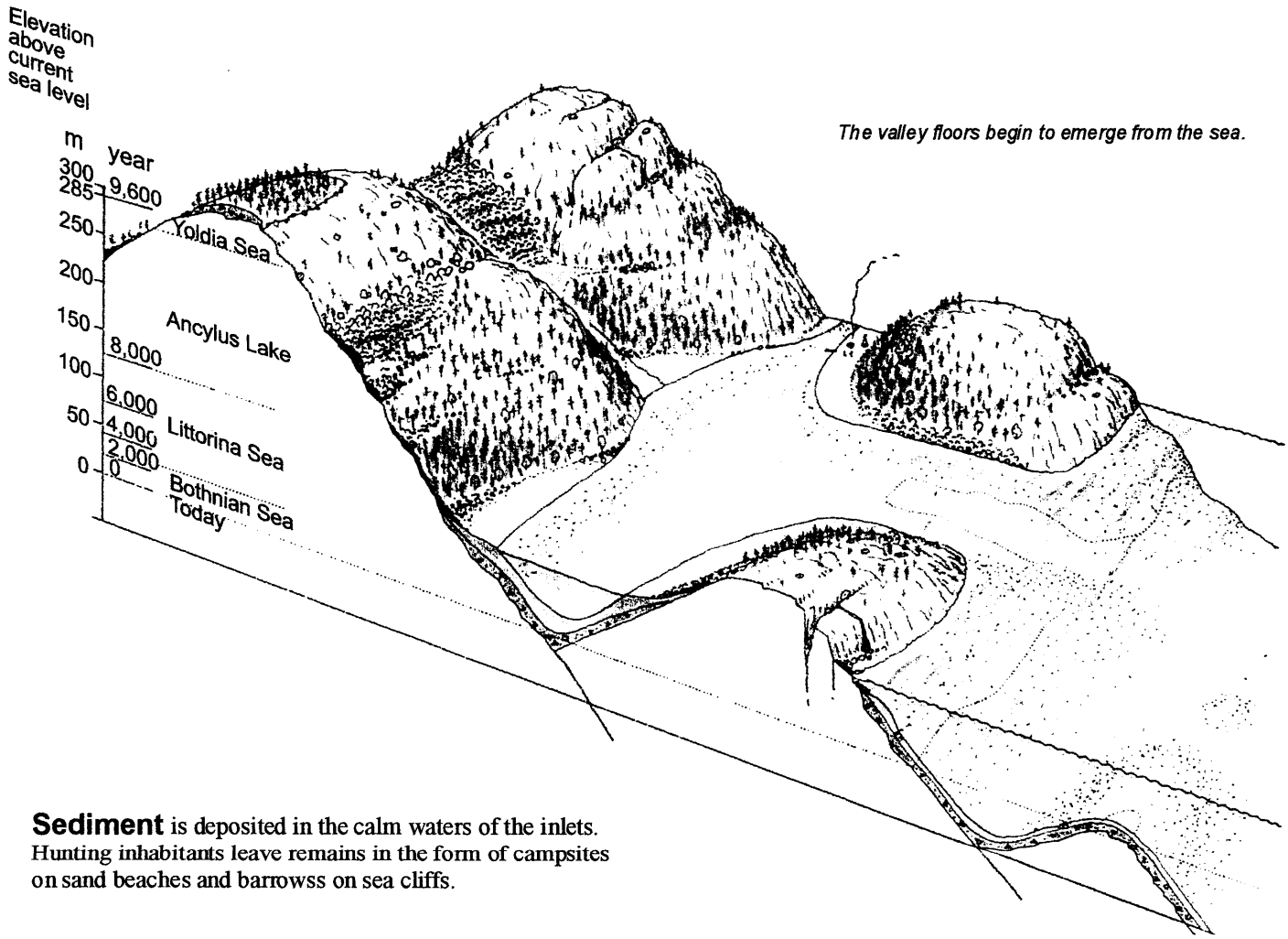
There are many such shingle fields along the High Coast. On the hill Högklinten, there is a huge lengthy strip of shingle fields with raised beaches that have been formed by powerful storms and the shifting of winter ice. They were formed during three stages of the Baltic Sea's development, beginning when the inland ice retreated from the area. At an elevation of ca. 260 m, it is the highest shingle field in the world.

Perhaps the most beautiful example of a shingle field with raised beaches is located near Norrfällsviken Bay, where shingle formation is still in progress. At the higher levels of this field, there are several barrows that were constructed at the ancient shoreline some 2000 years ago.



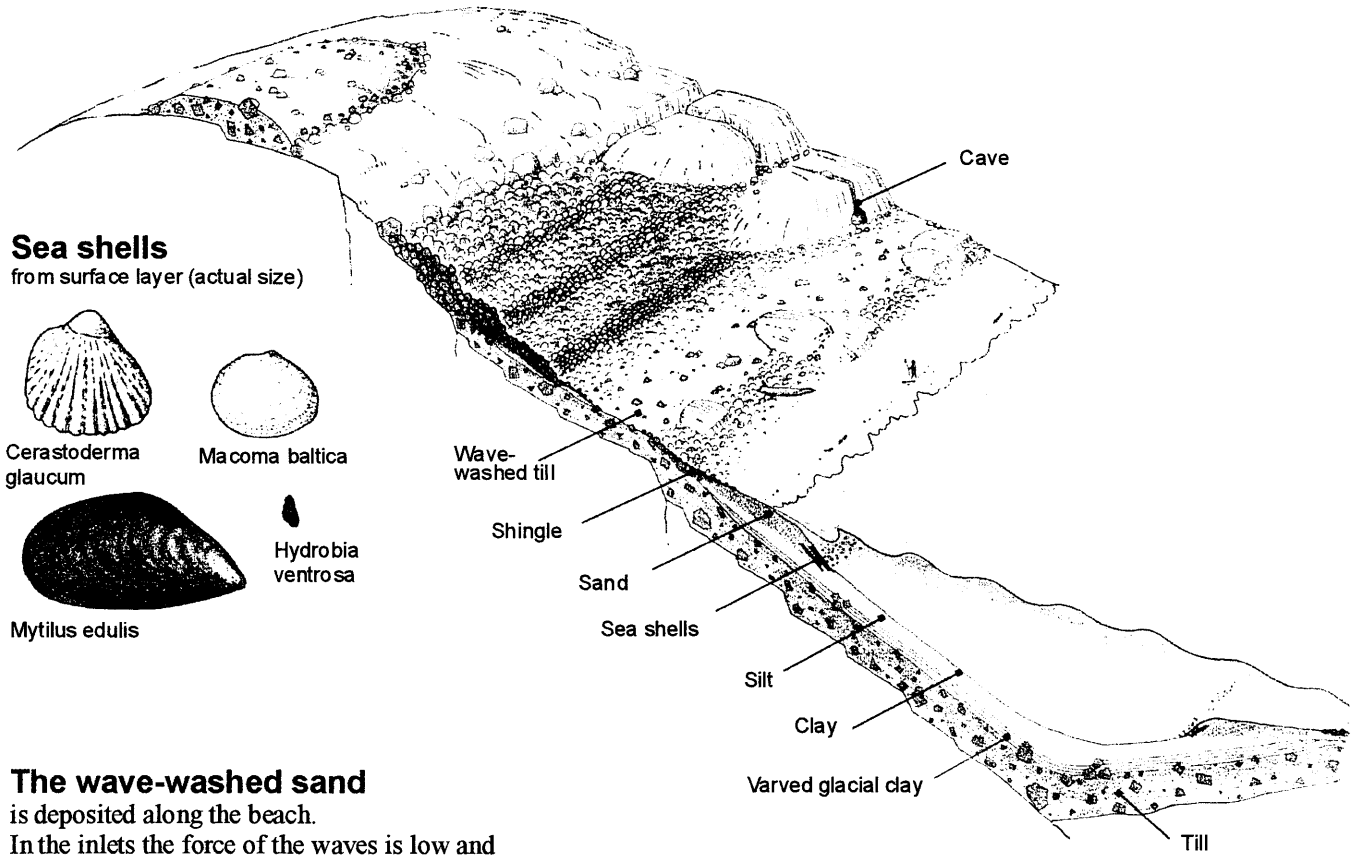
Shingle overgrown with lichen, at Norrfällsviken.

A barrow in Skuleskogen, constructed close to the ancient coastline.



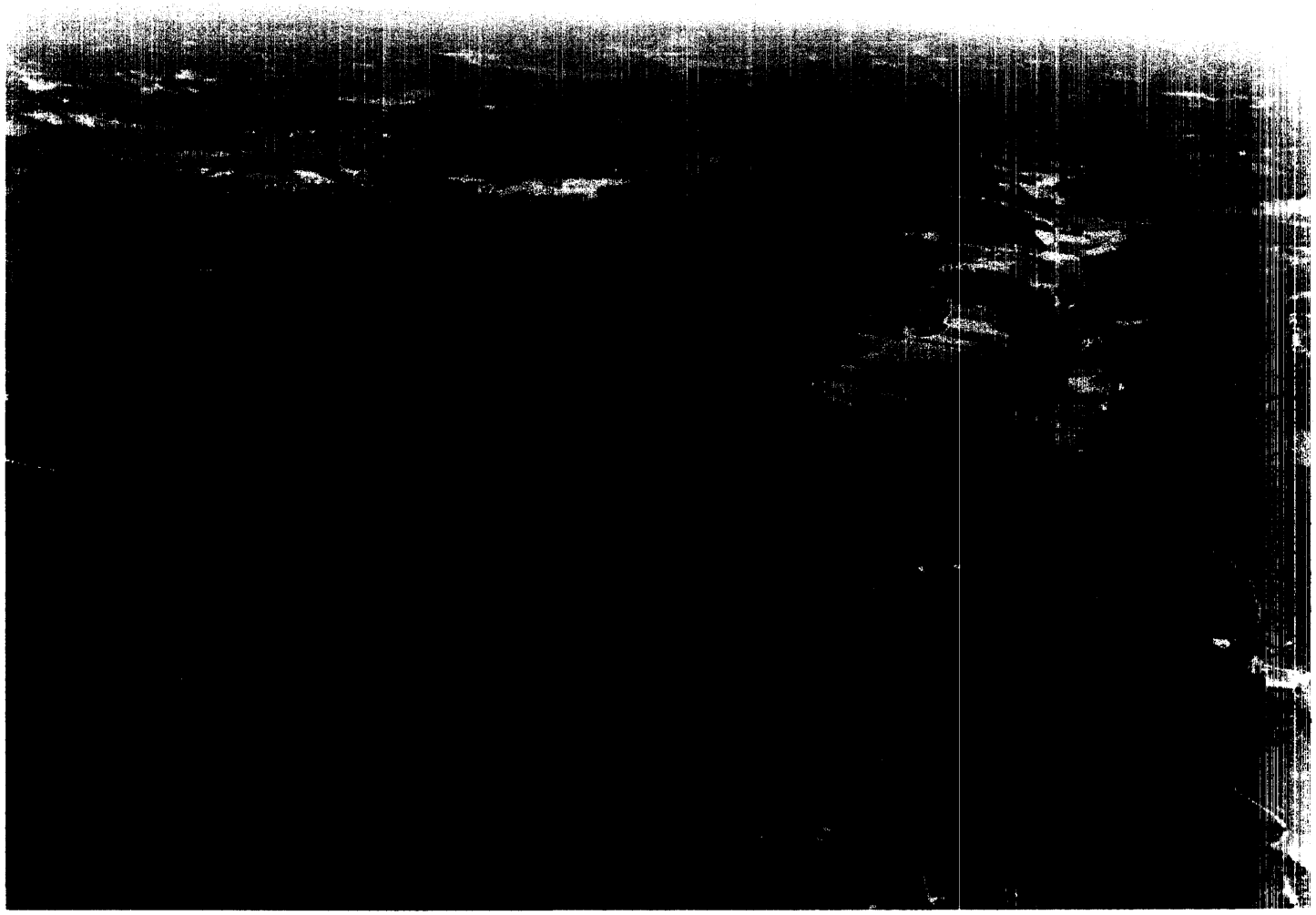
The valley floors begin to emerge from the sea.

Sediment is deposited in the calm waters of the inlets.
Hunting inhabitants leave remains in the form of campsites on sand beaches and barrowss on sea cliffs.



Sea shells
from surface layer (actual size)

The wave-washed sand
is deposited along the beach.
In the inlets the force of the waves is low and only the top layer of the sand is affected.
Sea shells and shell fragments are deposited with the sand.
Sand, silt and clay are deposited at the bottom of the valley, on top of till and glacial clay.



Fine-grained sediments have been deposited in the long and narrow valleys, as clearly reflected in the narrow farming settlements between the rocky hills. One thousand years ago, the entire valley at Sörleviken was an inlet of the sea.

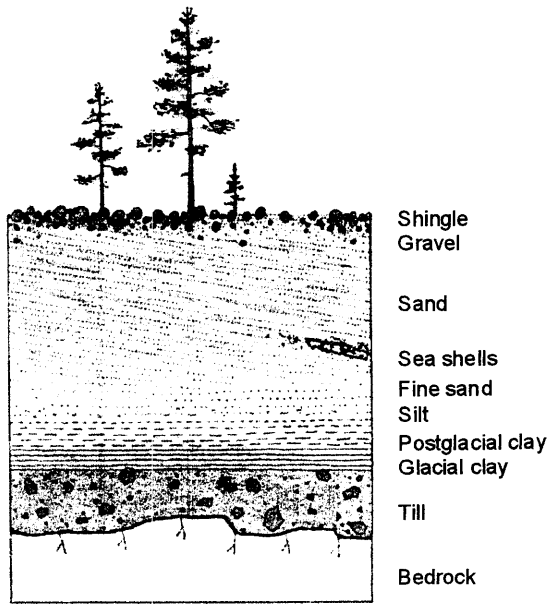
Valley sediments

Another consequence of land uplift was that bays and straits shrank to narrow inlets. In the bays and at other sheltered locations, the fine-grained particles had formed sediments. In some locations, the action of waves and currents resulted in accumulations of sand and gravel along the sides of valleys, so called wave-washed gravel. In the sheltered lower areas of the valleys were deposited the finest-grained particles such as fine sand, silt and clay.

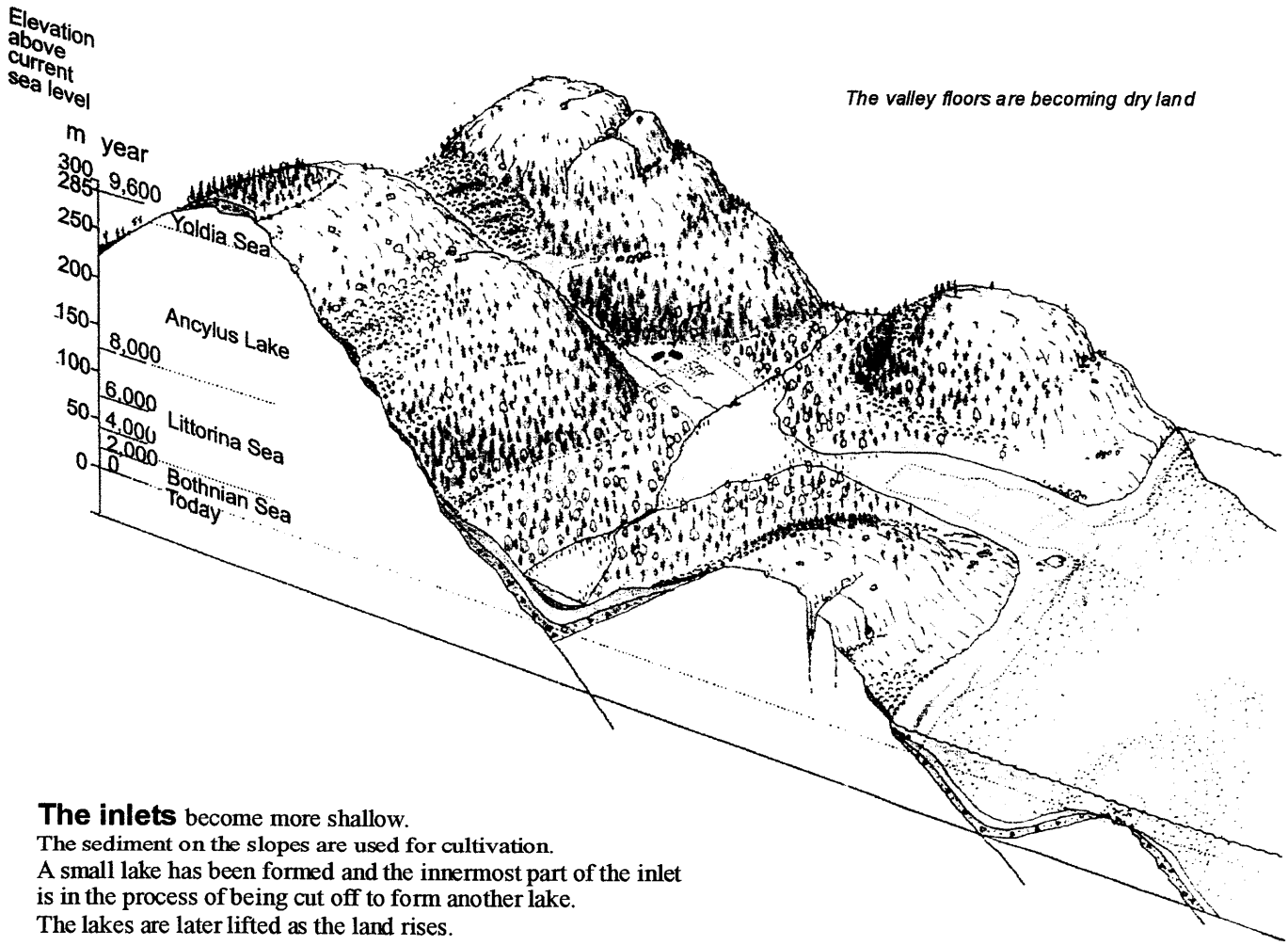
During the Littorina Sea stage, there were many molluscs on the sea-floor and along the shoreline. Their shells were removed by waves and currents, and eventually embedded in layers of sand. These deposits of shell fragments can now be seen as bright white and violet layers in sandpits and road cuts. The ongoing dissolution of the shells benefits the flora of the High Coast, which includes many sites for plants that require large amounts of calcium. Among these are many species of orchids.

The sorting and distribution of wave-washed particles made it possible for humans to settle in the region at an early stage. The earliest traces of the human presence can be found at camps used for seal-hunting and fishing located on ancient sand beaches. The oldest dwelling sites may date from the Ancylus Lake stage some 8000 years ago. Today, those sites lie high up on the valley slopes.

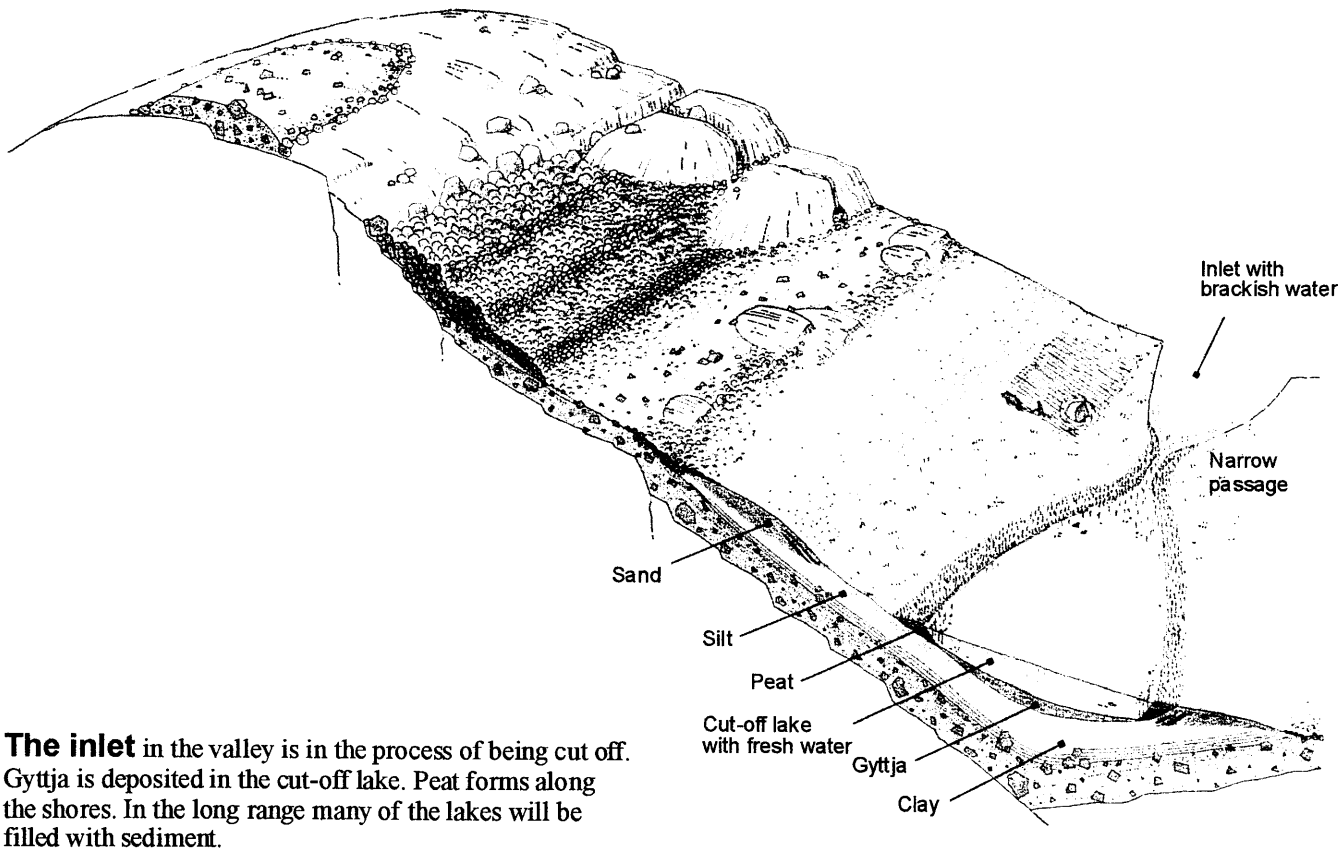
As the land continued to rise, the former inlets of the sea became completely dry, retaining their fine-grained sediments of silt and clay.



The different layers visible in gravel pits often reveal the characteristics of the High Coast, which has been strongly influenced by the waves and currents of the sea. The coarsest material is at the top, the finest at the bottom.



The inlets become more shallow.
The sediment on the slopes are used for cultivation.
A small lake has been formed and the innermost part of the inlet is in the process of being cut off to form another lake.
The lakes are later lifted as the land rises.



The inlet in the valley is in the process of being cut off. Gyttja is deposited in the cut-off lake. Peat forms along the shores. In the long range many of the lakes will be filled with sediment.

The surface of the lake known as Vågsfjärden Bay in the foreground is nearly two metres above sea level. As the name implies, it was an inlet of the sea a few hundred years ago, but was then cut off from the bay that can be seen in the background. Now, that bay is in the process of being cut off at the narrow passage, Trångsundet. The settlement is part of the village Häggvik in the Nordingrå area.

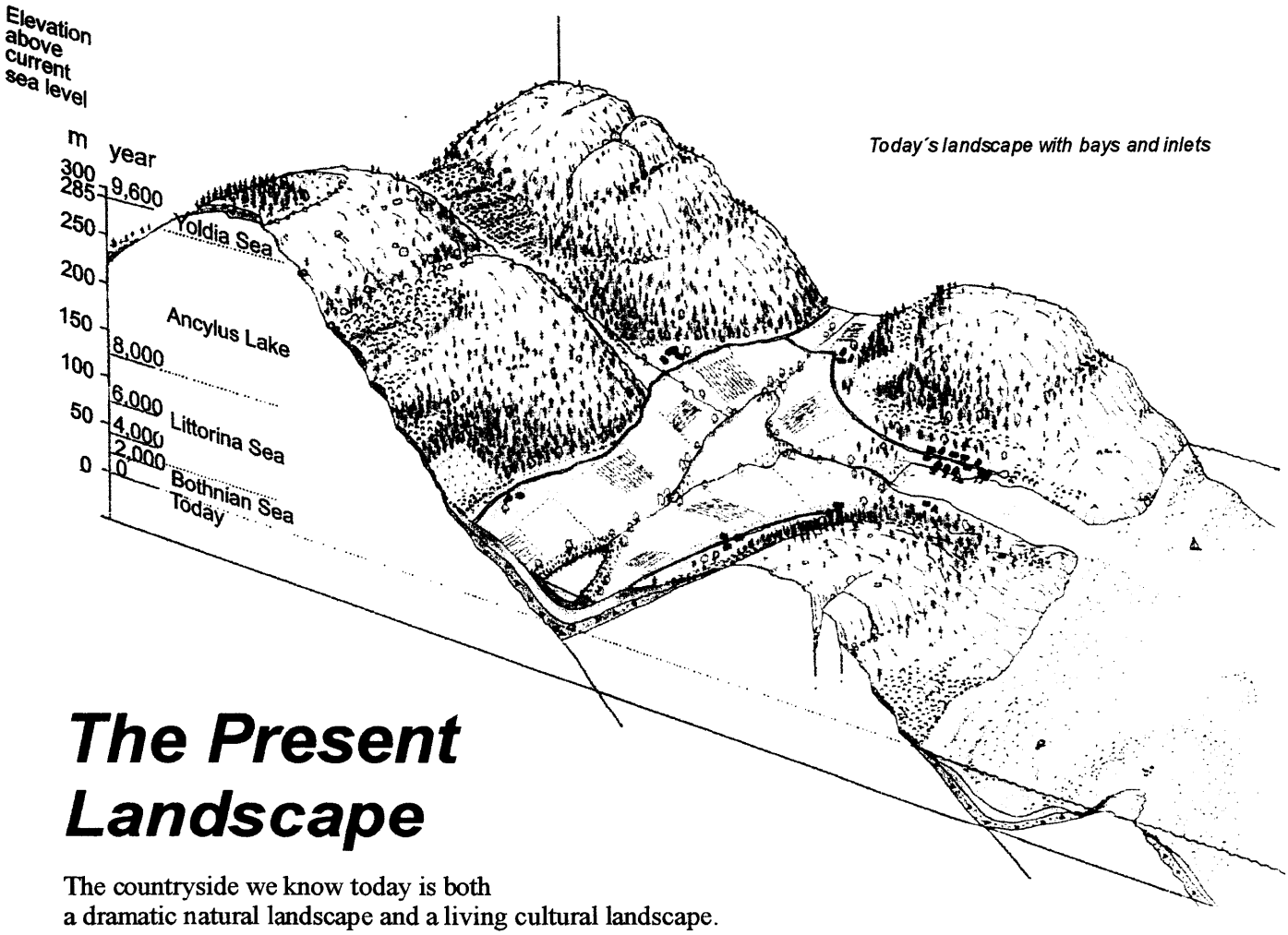
Bays into lakes

One consequence of land uplift is that inlets of the sea become increasingly shallow, and may even dry out. This usually occurs at narrow, shallow passages and inlets. Gradually they are transformed into freshwater lakes. After that, the surface of the lake maintains a fairly constant level in relation to the surrounding landscape. This process results in dramatic changes in associated flora and fauna, and is still going on today. In time, many of the lakes formed in this way will be overgrown and eventually turn into marshland.

Along the High Coast are many examples of inlets at various stages of development. Just a few hundred years ago, Lake Vågsfjärden near Nordingrå was a brackish-water bay. To the east, the entrance to Sörleviken Bay is currently in the process of being cut off. At a high elevation in Skuleskogen National Park, south of the monumental cleft, Slåttdalsskrevan, is the remnant of a sea inlet that was cut off ca. 9,000 years ago; today, it is a peat bog.

The sediments on the valley floors make for good cropland, and nearly all of the narrow valleys have been cultivated. The first agricultural settlements in the region were established around the time of Christ. They were located on coarse grained dry ground, high up on the valley slopes; the crops were grown in the fine sand and silt soils below. Hay was grown in the clay and silt soils on the valley floor, and this has left its mark on the local area to the present day. The distinct variations in land use have their origins in the distribution of different kinds of deposits during the process of land uplift.

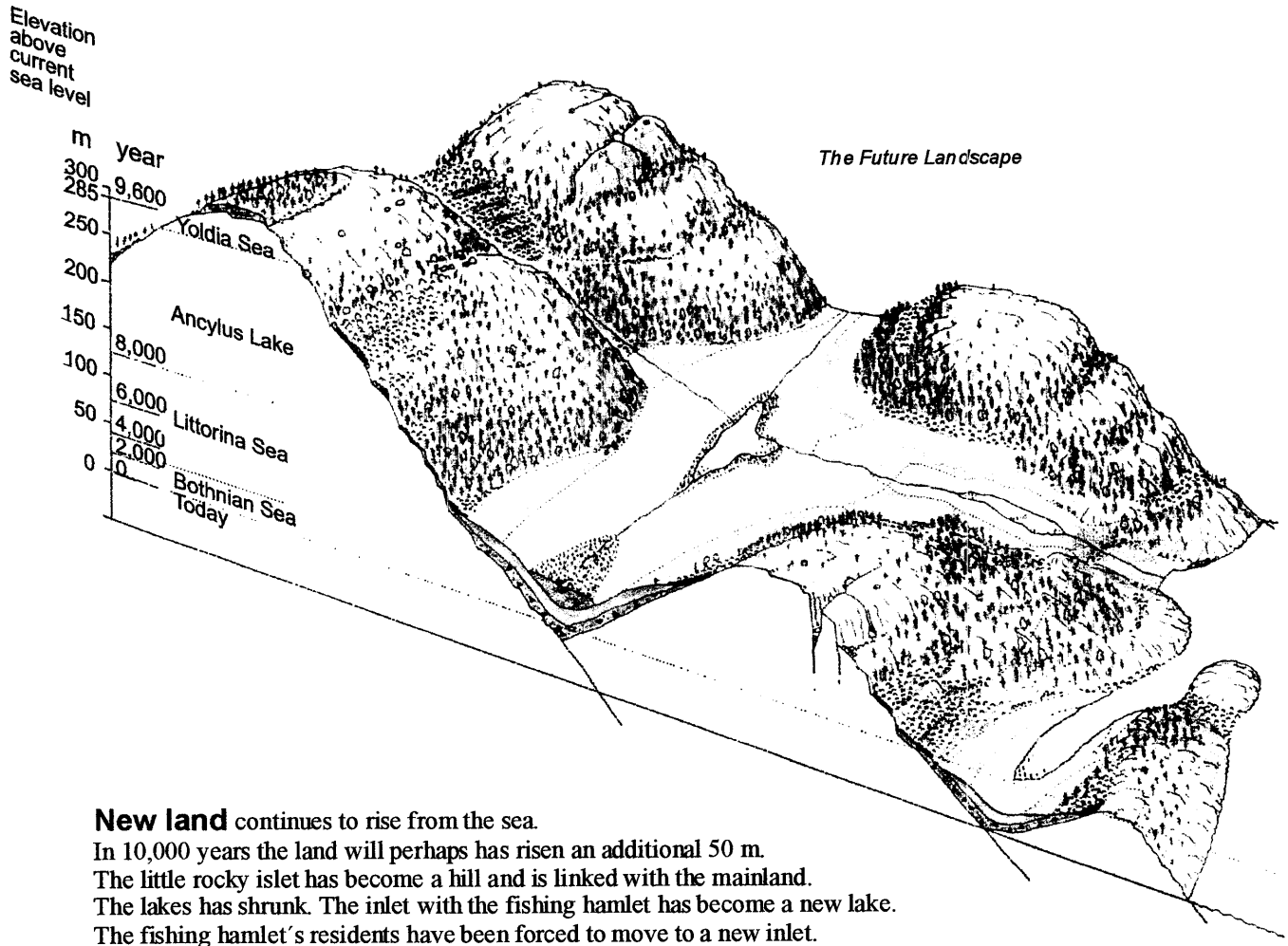
Lake Norasundet was cut off from the sea between 500 - 1000 years ago. This lake is fairly shallow and is being filled in and sub-divided into smaller lakes by eutrophication. Farms in the relatively open Nora district are concentrated along the forest border, with fields sloping down to the lake.
Nora church can be seen in the foreground.



The Present Landscape

The countryside we know today is both
a dramatic natural landscape and a living cultural landscape.

Bönhamn fishing camp is typical for the High Coast - a dense cluster of buildings in a small, sheltered bay. It now provides anchorage for visiting sail- and motorboats. The southern entrance to the bay is now only a narrow passage.



New land continues to rise from the sea.
In 10,000 years the land will perhaps has risen an additional 50 m.
The little rocky islet has become a hill and is linked with the mainland.
The lakes has shrunk. The inlet with the fishing hamlet has become a new lake.
The fishing hamlet's residents have been forced to move to a new inlet.
Let us leave the appearance of future settlements to the imagination.

What the future holds

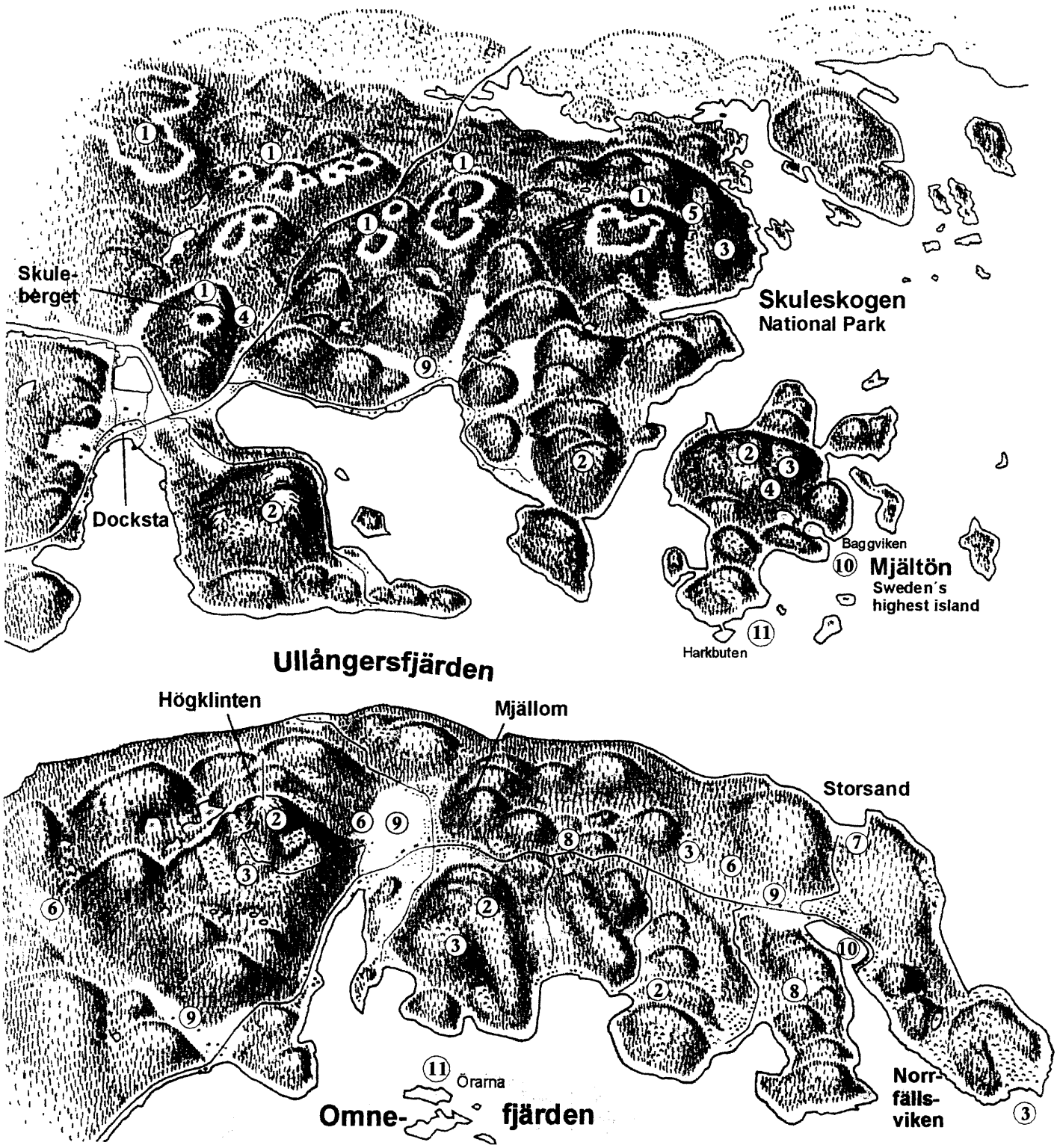
The process of land uplift continues to unfold before our eyes. Residents of the High Coast region live amidst visible evidence of rising land and changing shorelines. The depth of the waters around boat-houses, wharves and jetties is decreasing. Older boat-houses are now situated far from shore. Submerged rocks have become skerries, as other submerged rocks move toward the surface. Bays and channels are becoming shallower. Old maps and nautical charts are no longer valid.

The changes that occur in the shoreline zone when the former seafloor becomes new land, or when a sea inlet with brackish water becomes a freshwater lake, are of great interest from the standpoint of botany and limnology.

In a broader perspective it is fascinating to imagine that the shingle field stretching along the shoreline of today will one day in the future be situated high up on a hillside - just as the tiny skerries of the archipelago, which at times may be drenched in waves, will become bare hilltops high above the surface of the sea.

It is equally fascinating to move backward in time via the imagination - to consider, for example, that the shingle field that now lies 260 m above sea level near the crown of Högklinten once lay at the water's edge. Perhaps some Stone Age beachcomber walked along that very strip of shingle some 9,500 years ago. . . .

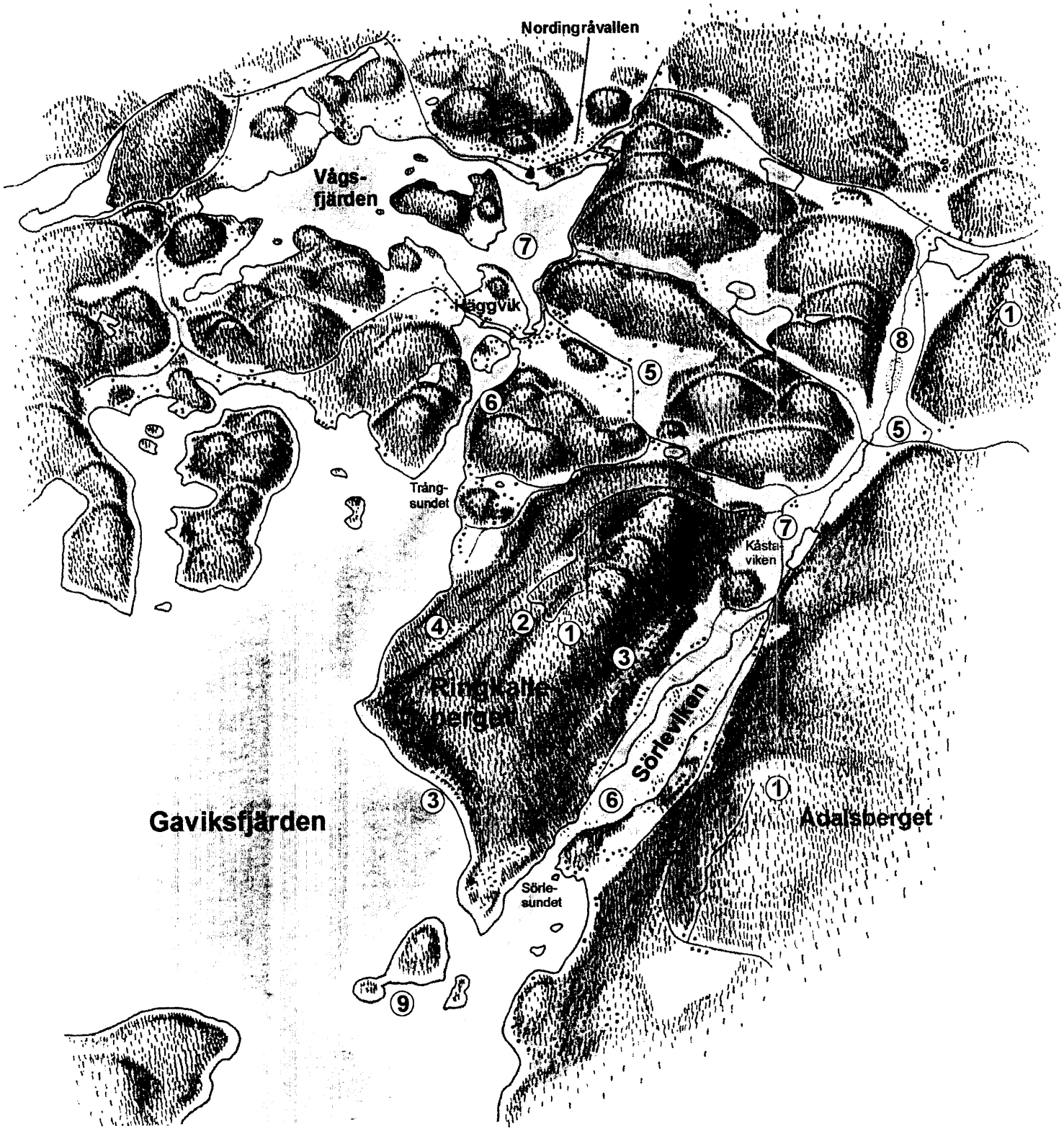
Such thoughts come readily to mind when visiting the High Coast, where the traces of the past 10,000 years' land uplift are concentrated within a very limited geographical area. The highest hills offer many beautiful views, as well as an aerial perspective on the entire historical process of land elevation - from the highest coastline, to submerged rocks that are just about to break the surface of the sea.



Mjällom peninsula - Skuleskogen

The effects of the sea have left many traces during 10,000 years of land uplift.

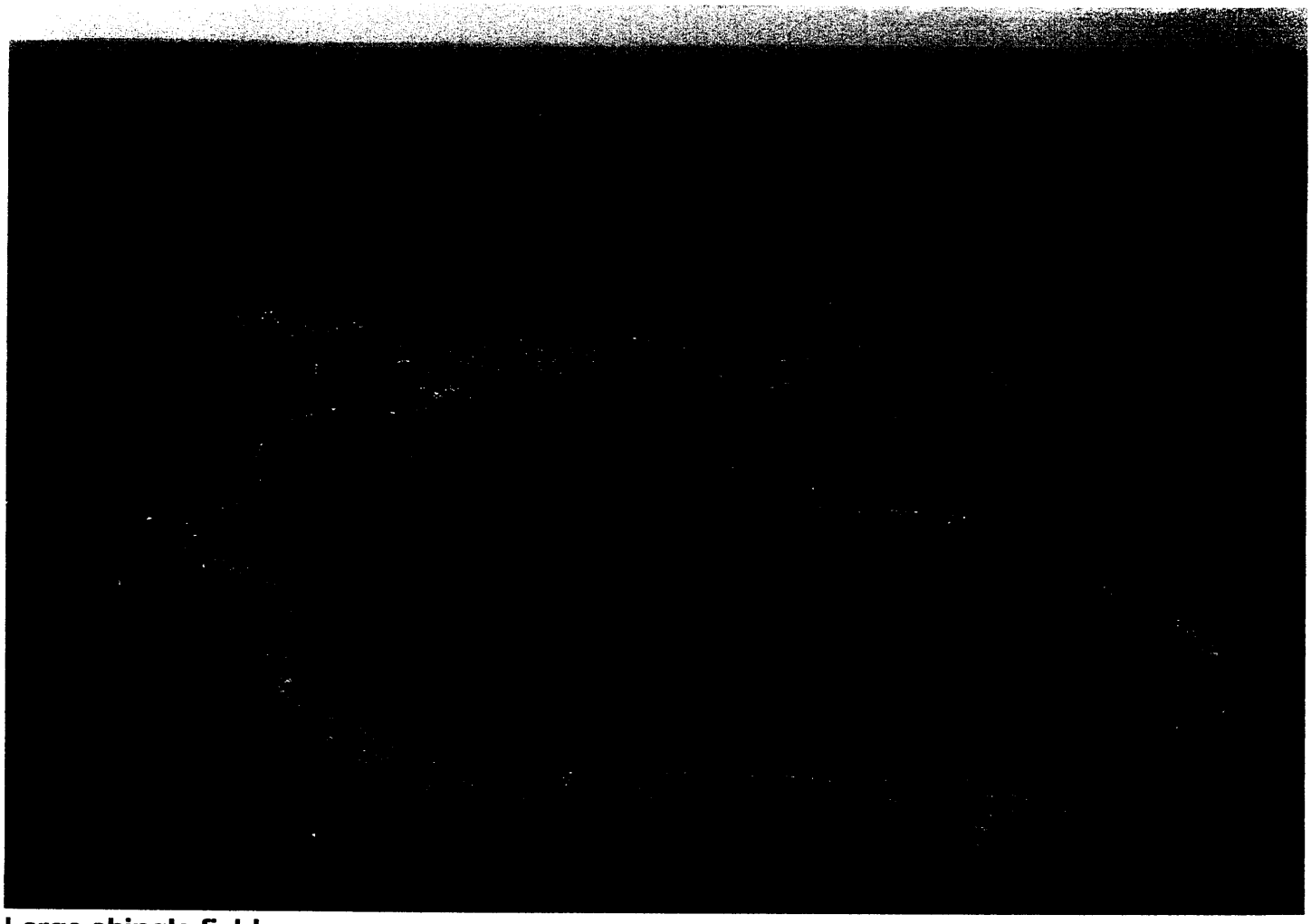
1. **Till-capped hill** with remnant of till indicating the highest coastline at 285 m above sea level.
2. **Wave-washed hilltop.**
3. **Strips of shingle** at various levels.
4. **Caves and grottoes.**
5. **Slåttdalsskrevan,** a large cleft in the bedrock.
6. **Sand and gravel.**
7. **Sand dunes.**
8. **Layers of shell fragments** in sand.
9. **Fine-grained sediments** on valley floors make good cropland.
10. **Sea inlet** that will be cut off to form a lake.
11. **New land** emerging from the sea.



Sörleviken Bay - Lake Vågsfjärden

An area with several features, including cut-off inlets, lakes and valley sediments.

1. **Wave-washed hilltop** of weathered dolerite, fine outlook.
2. **Wave-washed till** on lee side of hilltop.
3. **Talus slope** with large boulders.
4. **Small shingle field,** including shale and sandstone.
5. **Fine-grained sediments** on valley floors make good cropland.
6. **Inlet** in the process of being cut off from the sea.
7. **Lake** that was a sea inlet a few hundred years ago.
8. **Wetland** that most likely was previously a lake.
9. **New land** rising from the sea.

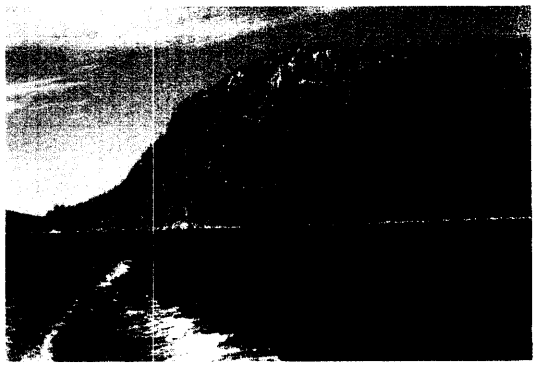


Large shingle fields at Norrfällsviken, situated between rocky hillocks. The largest field is ca. 250 m wide and 500 m long, and contains numerous raised beaches. At some places there are barrows erected along the ancient coastline of around 2000 years ago. Norrfällsviken fishing camp is located in the sheltered bay in the background. In the distance can be seen the island Mjältön and Skuleskogen National Park.

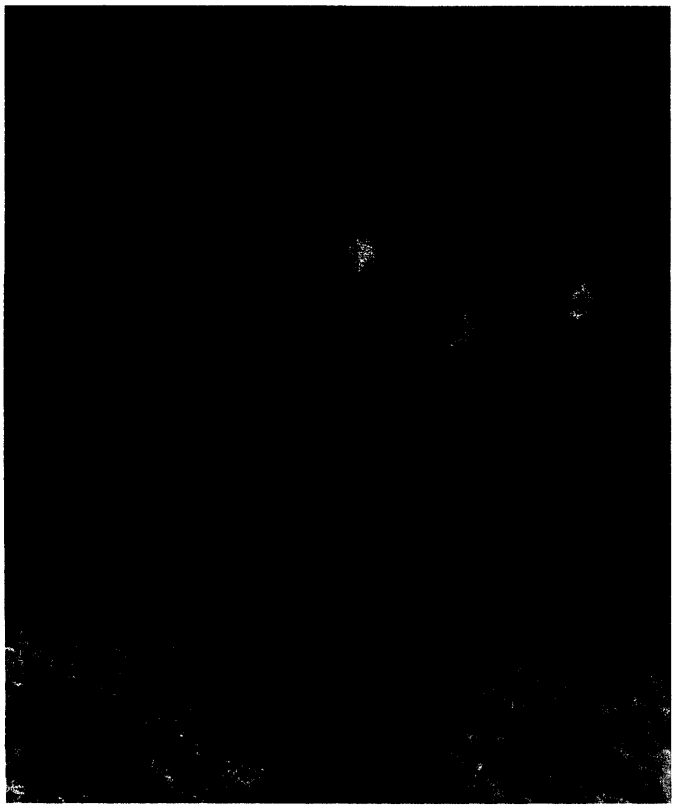
Högbonden is a 75-m high island which has the highest lighthouse station on Sweden´s east coast. Lying between the wave-washed rock ledges is a shingle field. Some of the rocks lying just beneath the surface are about to emerge from the sea. In the distant future, this island will become the crown of a large hill.

The cleft, Slåttdalsskrevan in Skuleskogen National Park was formed when a large vein of dolerite eroded and was washed away by the sea. It is 40 m deep and 200 m long.

From the wave-washed crown of the hill, Slåttdalsberget, there are exquisite views of the Tärnättvattnen lakes and the archipelago near Skuleskogen. Among the islands visible here are Trysunda and Skrubban.

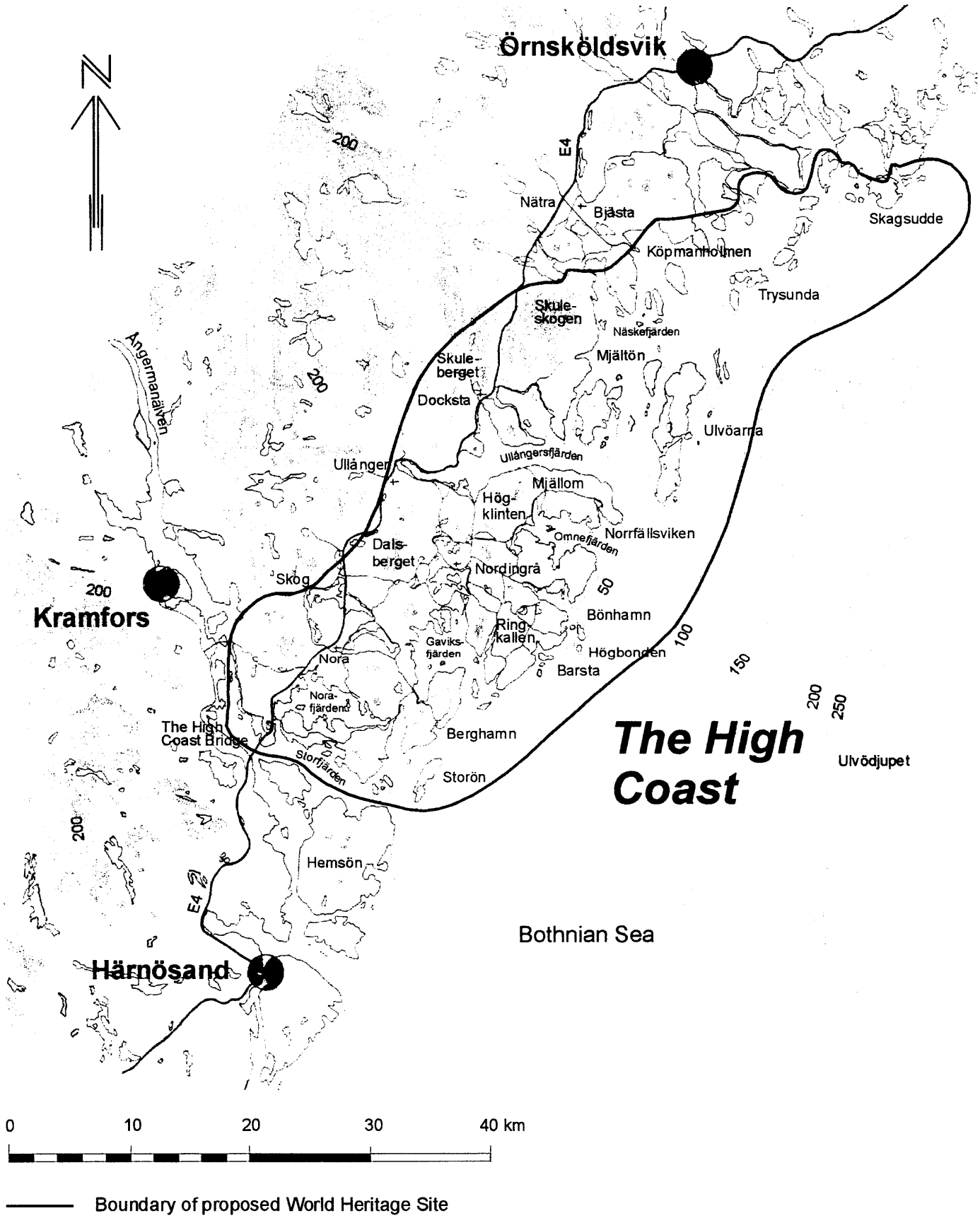


Valaberget is a typical example of a high, wave-washed hill that plunges into the deep waters off the High Coast. The steep slope rises 150 m above the water.



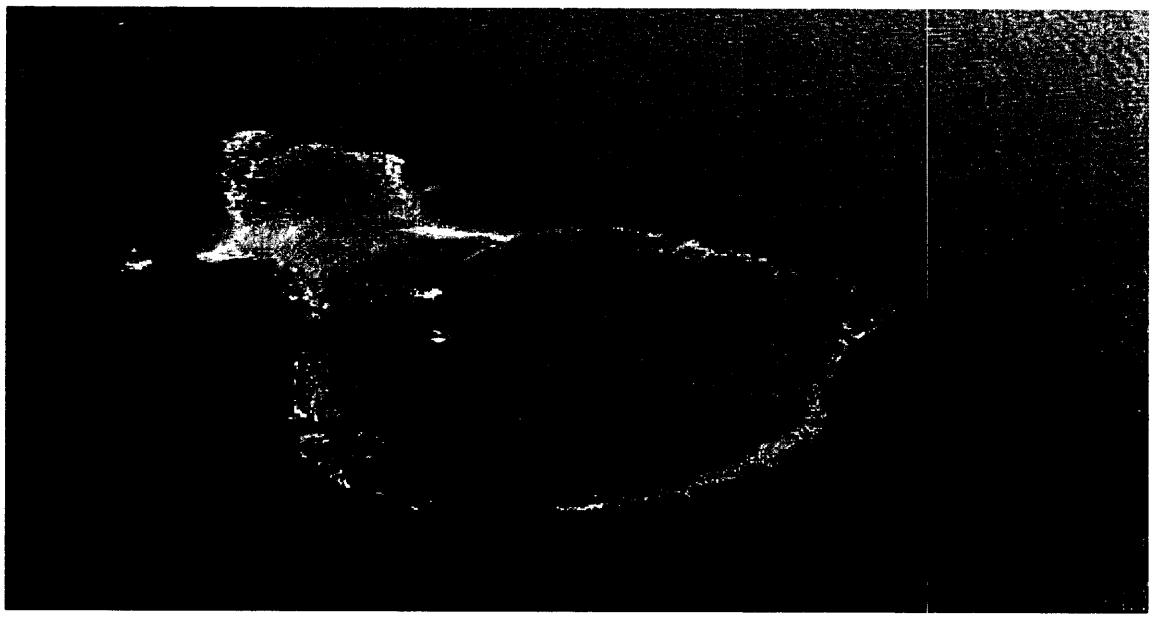
Calypso bulbosa is a rare orchid that grows in the High Coast region, in moist depressions deep in the woods where fragments of sea shells have made the soil rich in lime.

The former fishing camp on Sandviken Bay at the island of Norra Ulvön is now far from shore, due to the land uplift.



The High Coast comprises the coastal area between the mouth of Ångermanälven and Skagsudde. Here the undulating northern Swedish terrain reaches all the way to the coast and several hilltops rise above 300 m. It is also here that the Bothnian Sea is deepest, Ulvödjupet with a depth of 293 m.

THE HIGH COAST



ENCLOSURE 3

LIFE IN THE SEA

April 2000

The County Administration of Västernorrland

Life in the Sea

– Enclosure 3 to the Swedish nomination for inclusion as a natural property in the UNESCO World Heritage List.

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The Baltic Sea – a unique body of water

During the last ice age, the current area of the Baltic Sea was covered by glacial ice. The glacier was up to three kilometres deep, and its southern limit extended across present-day northern Germany. Since the glacier began its retreat over 10,000 years ago, the Baltic has been alternately connected to and cut off from the North Sea, with corresponding fluctuations between fresh and salt water as a result (see appendix 1 and 2).

Today, the Baltic Sea is the world largest body of brackish water, and is regarded as an estuarine system. In contrast to most of the world's estuaries, the salinity of the Baltic is stable within its various sectors. The shallow channels to the east and west of Denmark, Store Bælt and Öresund, restrict the flow of salt water into the Baltic, while fresh water from the many rivers that empty into the sea influence the salinity of their immediate areas. It takes roughly thirty years for all the water in the Baltic proper to be replaced, and about ten years in the Sea of Bothnia (see figure 3). This gives rise to stable environmental conditions for communities of plants and animals.

The flora and fauna comprise a unique mixture of fresh- and saltwater species (Kautsky 1989, 1995), all of which are affected by the extremely harsh environment associated with the Baltic's salinity, which ranges from 8 to 2 psu (see figure 1 & 2). One consequence is that the number of species present is quite limited. Their populations can be extremely large, however, due primarily to the limited diversity of competitors and predators, in combination with the stable environmental systems (Kautsky & Kautsky 1995). This particular set of conditions is unique to the Baltic Sea.

The number of marine species declines sharply at the entrance to the Baltic in the south, and continues to decrease by degrees to the north (figure 2). The decline in number of species is more abrupt in the transitional zone between the Baltic proper and the Sea of Bothnia (i.e. the Sea of Åland) and that between the Sea of Bothnia and the Bay of Bothnia

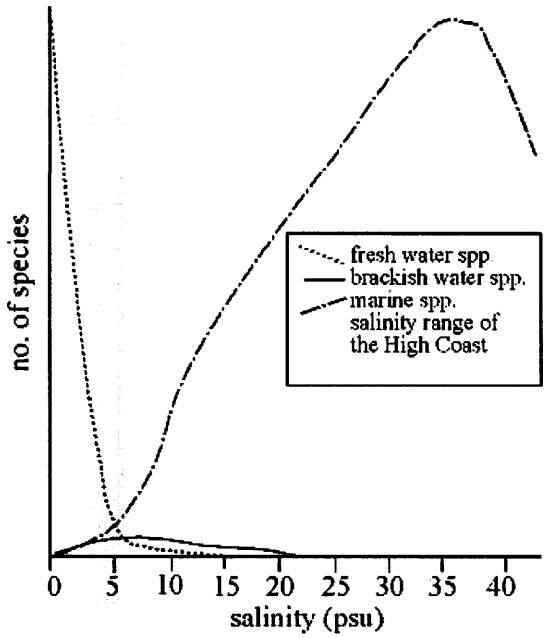


Figure 1. *Total number of marine, brackish water and fresh water species in relation to salinity. Shaded area shows the salinity range at the High Coast. From Remane (1940).*

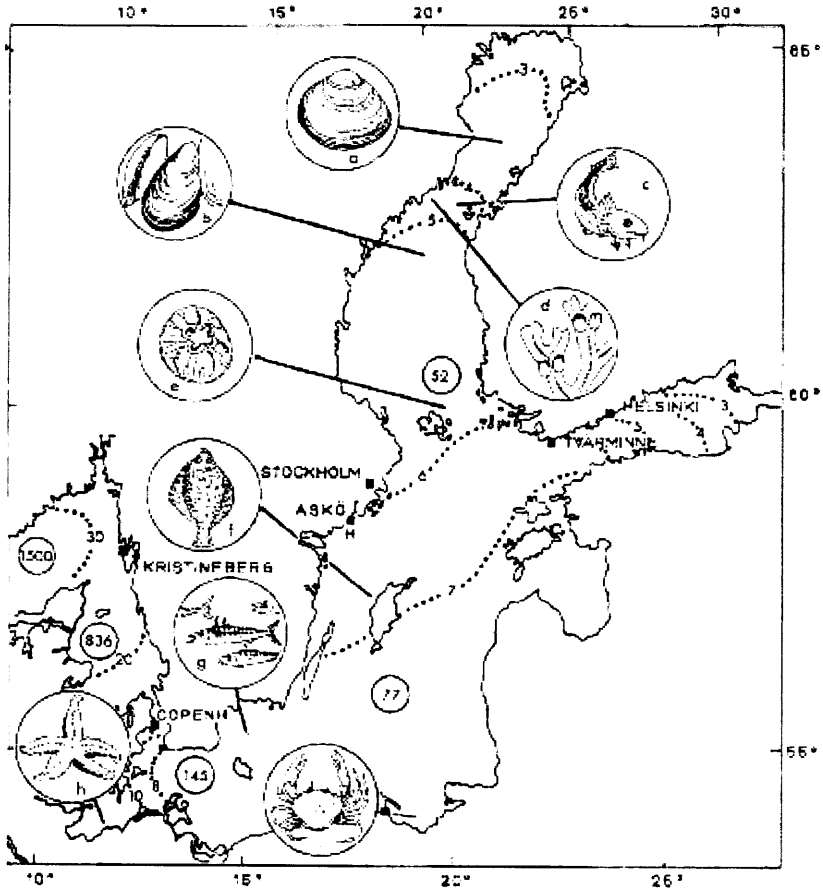


Figure 2. *The semi-enclosed Baltic Sea. Dotted lines are surface salinity isohalines (psu) and the numbers within circles are the number of marine macrofauna species found in the area. Some common marine species northern limits in the Baltic are indicated; a)* Macoma balthica *b)* Mytilus edulis *c) cod* Gadus morhua *d) bladder wrack* Fucus vesiculosus *e)* Aurelia aurita *f) plaice* Pleuronectes platessa *g) mackerel* Scomber scombrus *h)* Asteria rubens *i)* Carcinus maenas. *From Jansson (1972).*

(i.e. the Northern Quark, figure 3). There are still several marine species present at the level of the High Coast (figure 4); but the northern sector of the area is near the northern limit for most of them. As salinity declines, the number of fresh water species increases. This is particularly evident in the innermost, least saline waters near the High Coast, e.g. Norafjärden Bay and shallow bays which are in the process of being cut off due to land elevation (Kautsky 1988).

In contrast to Scandinavia's west coast, there are no significant tidal variations in the Baltic Sea; the difference between "high" and "low" tide amounts to only a few centimetres. However, there can be substantial occasional changes in the water level, which are caused by changes in air pressure and wind conditions. The greatest variations occur at the extremities of the Baltic. In the northern tip of the Bay of Bothnia, the difference between low- and high-water can be two–three metres (normally about one metre). These fluctuations in water level have significant consequences for the flora and fauna, and a decisive impact on shoreline plant communities (Ericson & Wallentinus 1979).

Another unusual feature of the brackish Baltic Sea is that it is partially covered by ice during winter. This applies primarily to the Bay of Bothnia, which is completely ice-covered during normal winters. The ice scrapes and moves material, and greatly affects the vegetation of shorelines and shallow bottoms. During late winter, the ice serves as breeding grounds for seals.

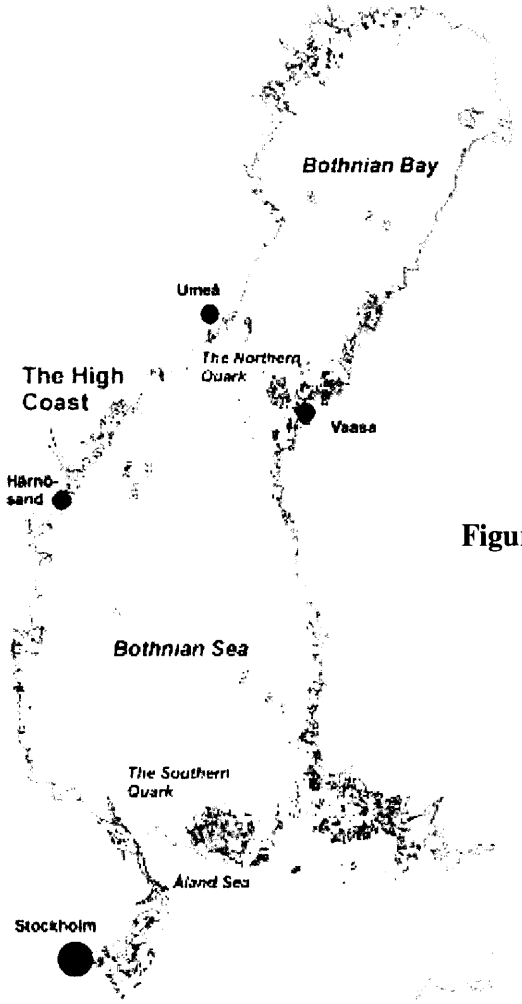
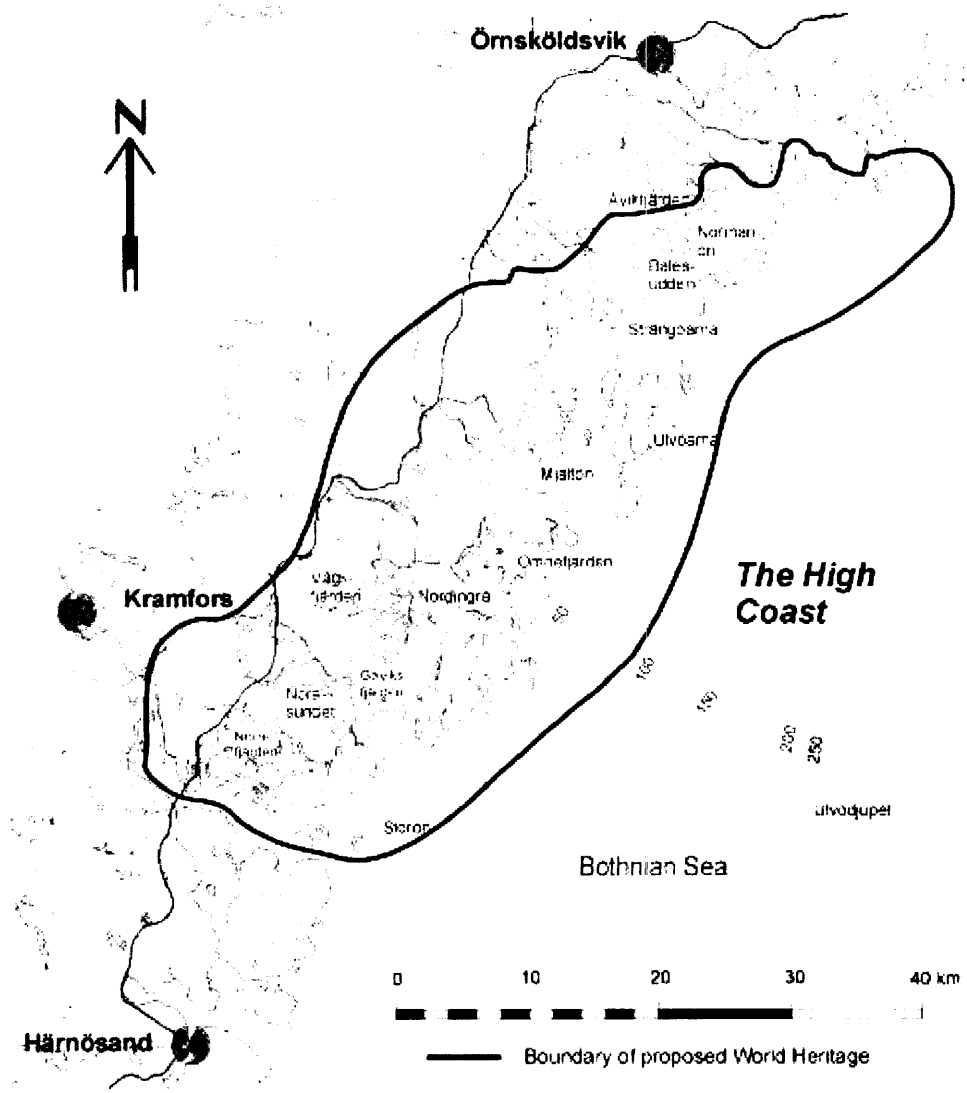


Figure 3. *The Gulf of Bothnia.*

Figure 4. *The High Coast region.*



Relicts and colonisation of the Baltic

Brackish water conditions are usually temporary due, for example, to the salinity variations of tidal action. Furthermore, the stable salinity of 4–6 psu in the High Coast area has only existed for the past 7000 years. For these reasons, very few distinctly brackish-water species have evolved in the Baltic Sea or anywhere else. However, the marine and freshwater species in the Baltic usually have an above-normal tolerance to extreme salinity conditions (in comparison to their original populations), which suggests that new brackish-water species may be in the process of evolving.

At present and at various times in the past, the Baltic has been linked to the Atlantic, and it is believed that it was once linked to the White Sea, as well. These channels have functioned as colonisation routes for, above all, the benthic (bottom-dwelling) organisms of the Baltic. Some marine species have migrated from the west, for example the common mussel *Mytilus edulis* and the Baltic mussel *Macoma balthica* (see Ekman 1953, Segerstråle 1959, Rudstam & Hansson 1990, Söderlund & Pedersen 1993; and on the Internet, http://www.ku.lt/nemo/mainnemo.htm).

Several of the characteristic species of the Baltic's benthic fauna have eastern origins, however. They are believed to have reached the Baltic's prehistoric predecessor, the Yoldia Sea, via the above-mentioned link with the White Sea. There need not have been a direct link: It is more likely that the organisms have been transported, in water trapped along the leading edge of the ice age glacier, to lake Ladoga, and eventually to the Gulf of Finland. Due to the effects of land elevation, these organisms became isolated relicts in the Baltic Sea, cut off from their original populations along the Siberian coast where they are found primarily in estuaries (Ekman 1953, Segerstråle 1959). Examples of such relict animal species are listed in table 1.

Table 1. *Examples of ice-age relict fauna with easterly origins, i.e. the coast of Siberia. (From Rinkineva & Bader 1998).*

Amphipoda
Monoporeia affinis
Pallasea quadrispinosa

Isopoda
Saduria entomon

Mycidacea
Mysis relicta

Ostracoda
Heterocyprideis sorbyana
Paracyprideis fennica

Copepoda
Limnocalanus macrurus

Pisces
Coregonus albula, vendace
Triglopsis quadricornis, four-horned sculpin

Mammalia
Phoca hispida, ringed seal

Among these relicts are the amphipod *Monoporeia affinis* and the isopod *Saduria entomon* (figure 5). These species and the Baltic mussel *Macoma balthica,* which occurs to depths of ca. fifty metres, completely dominate the benthic fauna of the deeper waters throughout the Gulf of Bothnia (see Leonardsson 1991). All three species also occur, together with other organisms, in slightly shallower waters (see *The High Coast's archipelago and bays*). *Monoporeia affinis* is the principal food source for *Saduria entomon,* which in turn is eaten by fish such as the four-horned sculpin *(Triglopsis quadricornis),* a benthic fish that is also an ice-age relict. Other relicts in the open sea are the opossum shrimp *Mysis relicta* and the copepod *Limnocalanus macrurus.* The brown algae *Sphacelaria arctica* is also regarded as a relict. The Baltic's vascular plants also include a number of Arctic relicts, the so-called *Primula sibirica* group, which are more common north of the High Coast (Ericson & Wallentinus 1979).

Typical for many of these relict species is that they are also found in lakes, due to the effects of land elevation. This applies to the relict animals noted above, and to the four-spined amphipod *Pallasea quadrispinosa,* which occurs primarily in fresh water, but also in sparse amounts on shallow bottoms in the Gulf of Bothnia (Sevola 1987, Foberg 1994).

Figure 5. *The isopod* Saduria entomon *and two amphipods* Monoporeia affinis, *ice-age relicts which dominate the deeper bottoms in the Gulf of Bothnia. Drawing: Görel Marklund.*

Land elevation and cut-off inlets along the High Coast

At some time in the future, the Gulf of Bothnia will be cut off at the Southern Quark and the Northern Quark due to land elevation (figure 3). As a result, the total area of the seafloor will decrease, and the habitats of the affected marine organisms will shrink.

Another consequence will be a downward shift of the vegetation zone, so that the vertical distribution of species remains unchanged. Species composition will remain the same at deeper levels; but at the surface, there will be a transition to dry-land species. It will be possible to observe the succession of species throughout the entire area within the space of a human lifetime. Naturally, the changes will be more striking and pronounced along level shorelines and in shallow bays.

These phenomena have been studied and described primarily in connection with southern Finland, the Northern Quark, the Stockholm archipelago, and the Swedish side of the Sea of Bothnia's southern sector (see for example Willén 1962, Lundegårdh-Ericson 1972, Ingmar & Willén 1980, Munsterhjelm 1987a, 1987b, 1997, Lindholm m fl 1989, Hästbacka 1991, Rinkineva & Molander 1997, Wallström & Persson 1997).

The following general description of phenomena associated with cut-off bodies of water is based on Munsterhjelm's studies in southern Finland (Munsterhjelm 1987a, 1987b, 1997). When an inlet is cut off from the sea, several successive stages can be distinguished: *sea inlet, flad, glo-flad, glo and glo-lake* (Munsterhjelm 1997). A "flad" has a narrow, shallow opening to the sea. "Glo" refers to an inlet whose previous outlet has risen above sea level, but continues to receive sea water during storms and high-water periods. A "glo-lake" is a glo that has been completely cut off, with no additions of sea water under any conditions. "Glo-flad" refers the transitional stage between flad and glo (see figure 6).

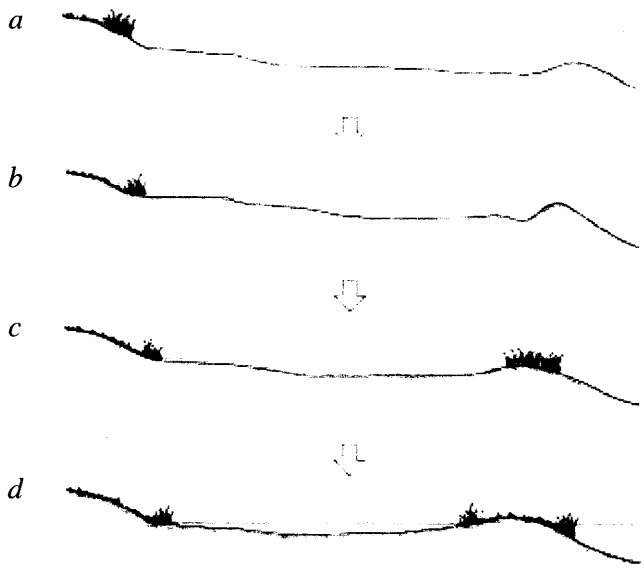


Figure 6. *Morphological development of a flad. Stages: a) juvenile flad b) flad c) glo-flad d) glo. From Munsterhjelm (1997).*

When a sea inlet is cut off in this way, it undergoes a number of changes that have great significance for the associated flora and fauna. Although the salinity gradually drops, this has no significant affect on the vegetation during the early stages. It is usually later in the entire process that the transition to a freshwater environment becomes important, especially along the High Coast.

There are factors other than salinity which may affect flora and fauna, and cause certain species to decline long before the transition to fresh water is completed. For instance, the inlet acquires an increasingly sheltered character. The water becomes warmer and shallower, with more light reaching the bottom. Currents become weaker, and sediments are gradually covered over with an ooze that is rich in nutrients. Together, all these changes provide favourable conditions for the dense and productive benthic vegetation which is characteristic of many flads.

Among the possible effects of the winter ice-cover are oxygen depletion, increased acidity, and the formation of hydrogen sulphide (H_2S). Shifting ice may also result in erosion, which is intensified by variations in water level. When the water's oxygen is depleted, nutrients such as phosphorous are released from the bottom, and this process may be accelerated by nutrients entering the water from nearby farms and settlements. Useful index species in this connection are algae of the Characeae family. These stoneworts are common in these waters, and are vulnerable to acidification and eutrophication (Blindow 1994, Alexandersson 1995).

The plant communities of a flad may keep the same appearance for several decades, and then undergo drastic change within the span of a few years. Plant succession may occur in sudden jumps, or sometimes "go backwards", due to such factors as variations in water level, exceptionally icy winters and the length of time within each stage.

Of fundamental significance is the water depth at the time that the inlet starts to become a flad. Typically, the vegetation of a flad consists of a dense growth of a few species within a limited area. There is usually a benthic community and, near the surface, beds of vegetation that forms parallel with the shoreline. Along the coast of southern Finland, the most typical species noted in studies of flads (as well as at later stages) are coral stonewort *(Chara tomentosa)* and greater naiad *(Najas marina),* which grow together with several other plants. Of these two, only coral stonewort occurs along the High Coast (Kautsky *et al.* 1997, Mascher 1990).

Reed beds in flads are usually well-developed and, in some areas, effectively displace most other plant species. The number of plant species is greatest at the beginning of the flad stage, when the inlet retains some of its marine characteristics and includes several different types of habitat. Thereafter, no new species establish themselves and biological diversity declines. These trends are reversed as the proportion of fresh water increases and a new plant succession takes place. The length of time that a glo-lake remains open varies; shallow areas can become overgrown so rapidly that no sediments are formed.

Due to the topography of the High Coast, there are few small, shallow inlets in the region. They tend, instead, to be broad, deep and open to the sea. The presence of the bird's nest stonewort (*Tolypella nidifica*), which thrives in brackish water, indicates good water circulation in Norafjärden Bay (figure 4, 11) through its narrow but deep outlet, even though it appears to be cut off from the sea. This conforms with the findings of Munsterhjelm (1997), who observed this species in circulating waters near the mouths of flads.

Even though Norafjärden Bay has not yet been entirely cut from the sea, it is likely that some of the smaller inlets have become flads; the same applies to other small inlets in the region. Thus, there are large bays and smaller, shallower inlets (figure 7) side-by-side along the High Coast. Two examples of the latter are Åvikfjärden and Bäckfjärden in the northern part of the High Coast region, both with shallow outlets. The beaches of Åvikfjärden are long and flat, and at several places there are shoreline meadows of great botanical diversity; It is an area that is very suitable for the study of plant succession in connection with land elevation (Kautsky et al 1997).

The High Coast region also contains examples of lakes that previously were inlets of the sea, i.e. glo-lakes. The surface of lake Vågsfjärden near Nordingrå is 1.5–2 metres above sea level, which means that it was probably cut off from the sea at the beginning of the 19th century. Another example is lake Norasundet north of Norafjärden, whose surface is five metres above sea level. There are also glo-lakes on some of the offshore islands, for example Lake Gammhamnen on Storön at 2 metres above sea level and Lake Bysjön on Norra Ulvön at 28 metres.

Figure 7. *Salsviken, formerly an inlet of the sea, now separated from the sea as a result of land elevation. Photo: Rolf Löfgren.*

An interesting phenomenon is that the amphipod *Monoporeia affinis* – the ice-age relict and brackish-water species which dominates the benthic fauna of the Gulf of Bothnia and the northern sector of the Baltic proper – is also found in lake Vågsfjärden. Two other ice-age relicts, the four-spined amphipod *Pallasea quadrispinosa* and the opossum shrimp *Mysis relicta,* occur in both lakes Vågsfjärden and Norasundet.

Present in Lake Bysjön on the island of Norra Ulvön is the snail *Theodoxus fluviatilis,* a freshwater species which is otherwise absent or very unusual in lakes and watercourses of the High Coast region. This is also the case with the snail *Bithynia tentaculata,* which is found in some coastal lakes, including Gammhamnen and Vågsfjärden (Anon 2000). These species are examples of organisms that have probably remained behind in former sea inlets that have become lakes due to land elevation.

In general, new land area is formed at a comparatively slow rate along the High Coast. As a result, there are no broad zones or strips displaying various periods of succession. There are also comparatively few small shallow inlets that are in various stages of being cut off from the sea. The major changes take place, instead, in broad and deep bays with narrow but deep outlets. These retain a dwindling proportion of salt water over a lengthy period of time, before they are finally cut off and become relatively large lakes.

But due to the High Coast's mosaic of landscapes, it is possible for visitors to experience a wide variety of coastlines that are located within a few kilometres of each other, from sheltered flads to shoreline cliffs beaten by the waves of the sea.

Marine life along the High Coast

The High Coast has the most sharply contoured topography along the Sea of Bothnia coast. Not far from the coastal area, with its sheltered bays and inlets, is the open sea with depths of 100–200 metres; the greatest depth of 294 metres is in the Ulvö Trench.

The following text describes the marine life of the High Coast region, in particular the macroscopic benthic flora and fauna. There is also a discussion of fish fauna; plankton organisms are not dealt with here (see instead Sandström 1982, Andersson *et al.* 1996, Kuparinen *et al.* 1996). A brief description of bird life is found in appendix 7.

Two seal species are present in the waters of the High Coast – the ringed seal *(Phoca hispida)* and, in much larger numbers, the grey seal *(Halichoerus grypus).* There are, however, no suitable haul-out grounds for large gatherings of grey seals (letter from B. Helander of the National Museum of Natural History in Stockholm). The major haul-out grounds are located in the Northern Quark and south of the High Coast. But seals move over large areas and, as noted, the grey seal is common along the High Coast.

The seafloor of the deeper waters

As in the Sea of Bothnia generally, the benthic fauna of the deeper waters near the High Coast are dominated by a small number of species. These include the isopod *Saduria entomon*, the amphipod *Monoporeia affinis*, the Baltic mussel *Macoma balthica,* and a few semi-pelagic opossum shrimp species (Mysidae) (Leonardsson *et al.* 1999). In addition to these species, the polychaete *Marenzelleria viridis* has been observed in these waters; it is believed to have been transported in the ballast tanks of freighters from North America's Atlantic coast to the waters of continental Europe and the Baltic. This species is more common north of the High Coast, and is believed to have spread to Swedish waters via the Northern Quark from the Finnish side of the Sea of Bothnia (Leonardsson 1995, 1999).

The fish on the deeper bottoms are species that are usually present only during the summer, such as the four-horned sculpin *(Triglopsis quadricornis),* white fish *(Coregonus lavaretus)* and the common sea snail *(Liparis liparis).* The principle food of the four-horned sculpin is the isopod *Saduria entomon,* whereas the diet of the other fish noted consists primarily of the amphipod *Monoporeia affinis* and the Baltic mussel *Macoma balthica* (Leskelä *et al.* 1991, Rinkineva & Bader 1998).

The High Coast's archipelago and bays

At the initiative of Västernorrland County Administrative Board, a survey of vegetation on the shoreline and shallow bottoms of the High Coast region was conducted during 1996–98 (Kautsky & Foberg 1996 & 1998, Kautsky *et al.* 1997). A survey of soft-bottom fauna was also carried out during the same period (Leonardsson *et al.* 1999).

The plant survey was conducted by divers who inspected vegetated bottoms to depths of ca. 15 metres. The soft-bottom fauna survey was conducted from the surface with sampling equipment, on vegetated bottoms from depths of 1.5 metres and downwards and in the

open sea to depths of 200 metres. Both types of survey were carried out in three types of environment: inner archipelago, mid-archipelago, and the edge of the open sea. These surveys provide the basis for the following description of marine life.

Edge of the open sea

On the shallow bottoms of the outer archipelago, from the surface to depths of about a metre, there are usually few or no larger plants. Most of the vegetation consists of fast-growing microscopic diatoms. At the next-lower level grow various species of green algae, especially *Cladophora* spp. This pattern of vegetation is due in part to the irregular fluctuations in water level, as a result of which the uppermost areas are often exposed. This exposure is aggravated by erosion, caused primarily by shifting ice. These are the main reasons that perennial species can not survive in the zone from the high-water mark to a depth of about one–two metres.

Immediately below the green algae zone grows bladder wrack *(Fucus vesiculosus)*. This is a brown algae which plays an important ecological role as substrate, food as well as reproduction and hiding place for many fish, invertebrates and other algae (Kautsky *et al.* 1992). In the outer archipelago of the High Coast, bladder wrack grows at depths from three metres to slightly over ten metres. The latter is a comparatively great depth for bladder wrack in the Baltic Sea, indicating that the sea water near the High Coast is very clean, with relatively few particles to impede light penetration.

Growing within the same zone as bladder wrack are the red algae *Ceramium tenuicorne* and *Furcellaria lumbricalis,* and the brown alga *Pilayella litoralis.* The last of these grows at depths below the bladder wrack zone, together with the brown alga *Sphacelaria arctica* (figure 8). Other algae are: the red algae *Polysiphonia nigrescens*, *Rhodocorthon purpurea* and *Phyllophora truncata*; the brown algae *Chorda filum* and several *Stictyosiphon* species; and the green algae *Cladophora aegagrophila* and several *Enteromorpha* species. Some mosses may also be present, including the fresh water bryophyte *Fontinalis dalecarlica.*

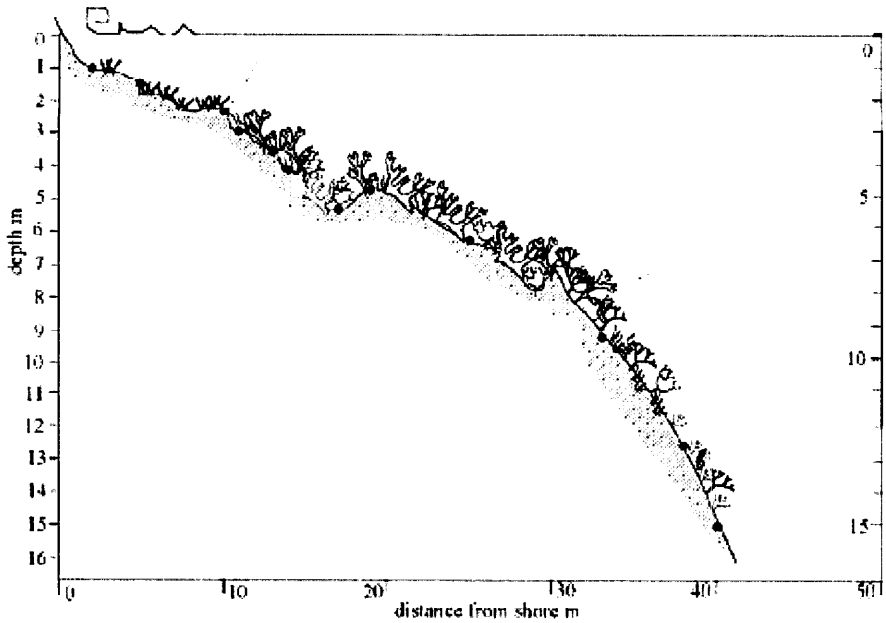


Figure 8. *Profile of a steep and exposed bottom in the outer archipelago. For legend, see figure 9. From Kautsky & Foberg (1998).*

Living amidst these algae are a number of macroscopic animals, for example the common mussel *(Mytilus edulis)*, the acorn barnacle *(Balanus improvisus)*, the coralline *Electra crustulenta* (Bryozoa), the Baltic mussel *Macoma balthica* and the freshwater snail *Theodoxus fluviatilis.* Compared with similar habitats closer to shore, there are fewer animals in the outer archipelago, probably as a result of exposure to waves. The typical species of the deeper waters of the open sea, *Saduria entomon* and *Monoporeia affinis*, are also found in shallow waters of the outer archipelago.

Mid-archipelago

The vegetation is very different in the mid-archipelago, as exemplified by the area around Balesudden and the islands Mjältön, Strängöarna and Normanön. Since this area is more sheltered than the outer archipelago, the vegetation reaches higher, often the surface. A similarity with the outer archipelago is that *Cladophora* green algae often grow just beneath the surface. There are also beds of bladder wrack at lower levels, and these are often denser in more exposed locations. The bladder wrack may even occur near the surface, at depths of half a metre, if it is sheltered from scraping ice. This underscores the significant effects of ice on shoreline ecosystems. Also occurring on the bottoms of this area are the red and other brown algae present in the outer archipelago, including *Ceramium tenuicorne*, *Furcellaria lumbricalis* and especially *Pilayella litoralis*. In short, the same algae which occur in the outer archipelago are also found in the mid-archipelago, although usually in smaller numbers.

The major difference between the outer and inner sectors of the archipelago is the presence of vascular plants and stoneworts in the latter. For example, perfolliate (*Potamogeton perfoliatus*) and fennel-like pondweed (*P. pectinatus*), water mil-foils (*Myriophyllum* spp) and horned pondweed (*Zannichellia palustris*) grow at depths of 4–5 metres and upward. Beaked tassel pondweed *(Ruppia maritima)* also occurs in the mid-archipelago, the northern limit of its range in Sweden (Kautsky *et al.* 1997).

Various stoneworts comprise a prominent feature, and even predominate on some bottoms, among these are coral stonewort (*Chara tomentosa*) and bird's nest stonewort (*Tolypella nidifica*). In the outer archipelago, the action of ice and waves results in deposits of sand and other sediments in deeper waters, with poor light conditions which hinder the growth of vascular plants. In sandy areas, waves leave distinct traces in the form of ripple marks on the bottoms. In shallow waters of the archipelago's inner regions, fine material can accumulate in which vegetation can establish itself. Near the High Coast, there are sheltered areas dominated by vascular plants not far from the open sea. Any of the large outer islands may have exposed bottoms with bladder wrack on the eastern shore, and sheltered bottoms dominated by vascular plants on the west (figure 9).

There are obvious differences between the benthic fauna in the deep waters of the open sea and that of more shallow waters. Shallower and more protected settings provide denser vegetation with favourable conditions for insect larvae and sediment-dwelling crustaceans. All the species found on the bottoms of the open sea are also present in the mid-archipelago; this includes the most characterisic species, *Saduria entomon* and *Monoporeia affinis*. However, the Baltic mussel *Macoma balthica* and worms of the Oligochaeta order are more frequent in the mid-archipelago.

Also present are many benthic fauna species, including such crustaceans as the amphipods *Gammarus zaddachi*, *G. oceanicus* (whose northern limit is the High Coast), *G. salinus*, *Pallasea quadrispinosa* and *Corophium volutator*. The last of these is typical of sandy and muddy soft bottoms. *Pallasea quadrispinosa* is a relict that is found primarily in fresh water. The freshwater isopod *Asellus aquaticus* also occurs in the mid-archipelago. Other species that are more common in areas which are even better protected than the shallow waters of the outer archipelago are the snails *Paludestrina jenkinsi*, *Theodoxus fluviatilis*, *Lymnaea peregra* and *Bithynia tentaculata*. The coralline *Electra crustulenta* is a brackish-water species that forms colonies on rocks and the fronds of bladder wrack, among other places.

A large group of species represented in the inner archipelago is that of the Chironomidae family, or midges, whose larvae are bottom-dwelling. The soft-bottom fauna off the High Coast include over thirty species that have not been observed anywhere else in the Gulf of Bothnia. Many of these are freshwater species and more than half of them are midges. Among these distinctively High Coast species is a brackish-water organism, a flatworm of the genus *Procerodes* (Leonardsson *et al.* 1999, table 2).

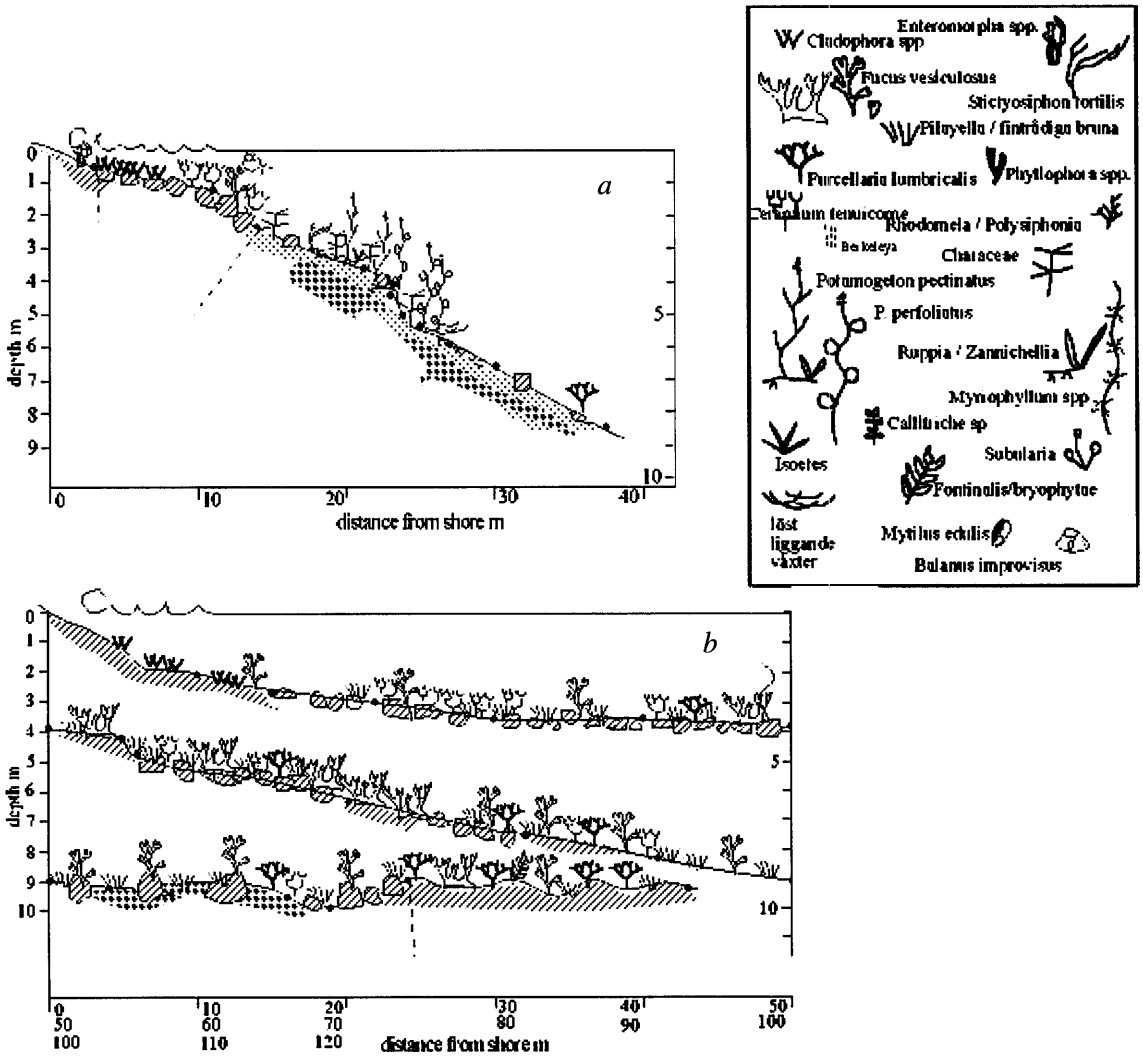


Figure 9. *A more sheltered bottom (a) and an exposed bottom (b) at the Ulvö Islands. From Kautsky & Foberg (1998).*

Table 2. *Presence of soft-bottom fauna in different parts of the Gulf of Bothnia. Symbols: SHC = south of the High Coast, HC = High Coast, NBS = northern Sea of Bothnia, BB = Bay of Bothnia. From Leonardsson et al. (1999), which also includes a list of comparable surveys.*

Scientific name	SHC	HC	NSB	BB
Alderia modesta	■			
Anisus contortus	■			
Balanus improvisus	■			
Dendrocoelum sp.	■			
Fanniidae	■			
Halicryptus spinulosus	■			
Hydrobia ulvae	■			
Idothea viridis	■			
Lepidoptera	■			
Lepidostoma hirtum	■			
Piscicola geometra	■			
Praunus flexuosus	■			
Sergentia sp.	■			
Sigara dorsalis	■			
Arctopelopia sp.	■	■		
Bathyporeia pilosa	■	■		
Endochironomus sp.	■	■		
Gammarus oceanicus	■	■		
Agrypnetes crassicornis		■		
Apatania sp.		■		
Athripsodes cinereus		■		
Athripsodes commutatus		■		
Brychius elevatus		■		
Chironomus sp. salinarius grp.		■		
Chironomus sp.aprilinus grp		■		
Cladotanytarsus sp. mancus grp.		■		
Cricotopus sp. (cricotopus)		■		
Cricotopus sp. fuscus grp.		■		
Cricotopus sp. isocladius.		■		
Cricotopus sp. s. str		■		
Cyrnus flavidus		■		
Dugesia lugubris		■		
Ephemera vulgata		■		
Glyptotendipes sp. grp. A.		■		
Hemerodromiinae sp.		■		
Hydroptila sp.		■		
Limnephilus lunatus		■		
Macroplea mytica		■		
Orthocladius (Orthocladius) sp.		■		
Orthocladius (Pogonocladius) consobrius		■		
Orthocladius sp. s. str.		■		
Paratendipes sp.		■		
Phaenopsectra sp.		■		
Polycentropus flavomaculatus		■		
Potthastia sp. longimana grp.		■		
Procerodes sp.		■		
Psectrocladius sp. psilopterus grp.		■		
Psectrocladius sp.		■		
Psectrocladius sp. sordidellus grp.		■		
Caenis horaria		■	■	
Electra crustulenta	■	■	■	
Gammarus salinus	■	■	■	
Gammarus zaddachi	■	■	■	
Harmothoe sarsi	■	■	■	
Limapontia capitata	■	■	■	
Mytilus edulis	■	■	■	
Corophium volutator	■	■	■	
Jaera albifrons	■	■	■	
Macoma baltica	■	■	■	

Scientific name	SHC	HC	NSB	BB
Marenzelleria viridis	■	■	■	
Stictochironomus sp.	■	■	■	■
Prostoma obscurum	■	■	■	■
Chironomidae	■	■	■	■
Gammarus sp.	■	■	■	■
Microtendipes sp. pedellus grp.	■	■	■	■
Monoporeia affinis	■	■	■	■
Mysidae	■	■	■	■
Oligochaeta	■	■	■	■
Polypedilum sp.	■	■	■	■
Procladius sp.	■	■	■	■
Saduria entomon	■	■	■	■
Lymnaea peregra	■	■	■	■
Pallasea quadrispinosa	■	■	■	■
Paludestrina jenkinsi	■	■	■	■
Tanytarsus sp.	■	■	■	■
Ceratopogonidae	■	■	■	■
Orthocladiinae	■	■	■	■
Bithynia tentaculata	■	■	■	■
Chironomus sp. plumosus grp.	■	■		■
Cladotanytarsus sp. grp A	■	■		■
Cryptochironomus sp.	■	■		■
Chironomus sp. anthracinus grp.	■	■		■
Chironomus sp.	■	■		■
Dicrotendipes sp.	■	■		■
Nematoda	■	■		■
Zalutschia sp. tatrica grp.	■	■		■
Pseudochironomus sp.	■	■		■
Microtendipes sp.	■			■
Physa fontinalis	■			■
Demicryptochironomus sp.	■			■
Dendrocoelum lacteum	■			■
Micropsectra sp.	■			■
Pisidium spp.		■	■	■
Theodoxus fluviatilis		■	■	■
Gyraulus acronicus		■		■
Ablabesmyia sp.		■		■
Asellus aquaticus		■		■
Haliplus confinis		■		■
Paratanytarsus sp.		■		■
Valvata piscinalis		■		■
Spherium sp.			■	■
Ephemera danica				■
Limnephilidae				■
Limoniini sp.				■
Mystacides azurea				■
Protanypus sp.				■
Anodonta cygnea/complanata				■
Bathyomphalus contorta				■
Glossosiphonia complanata				■
Gyraulus albus				■
Gyraulus crista				■
Lymnaea palustris				■
Lymnaea truncatulata				■
Planorbarius corneus				■
Valvata cristata				■
Valvata sibirica				■
Stempellina bausei				■
Valvata macrostoma				■

The inner bays

In the High Coast area are several large bays whose inner regions are fairly well-sheltered from the open sea. The largest of these are Norafjärden, Gaviksfjärden and Omnefjärden, all in the southern part of the area. Gaviksfjärden and Omnefjärden are quite deep, and have the same kind of vegetation as exposed bottoms further out in the archipelago, including *Cladophora*, bladder wrack and various red and brown algae.

There are beds of bladder wrack in the outer portion of Omnefjärden and, despite the fact that there lie several islands in its opening to the sea, near the shore in Gaviksfjärden. (figure 10; see also Kautsky *et al.* 1996). Inside the channel into Gaviksfjärden Bay, there are beds of bladder wrack to depths greater than eight metres, indicating that these waters are also clean and translucent. Bladder wrack is also present further into the more protected areas of the bay, along with vascular plants of the genus *Potamogeton,* and also bird's nest stonewort (*Tolypella nidifica*), which thrives in brackish water.

Based on available information, it is believed that the benthic fauna of Omne- and Gaviksfjärden is the same as that in the mid-archipelago. This means that deep-bottom species and the ice-age relicts, *Saduria entomon* and *Monoporeia affinis*, are also present in the most sheltered bays.

But the situation is different in the southern sector of the High Coast region and in Norafjärden Bay, which is more cut off from the sea. The vegetation in these areas is typical of soft bottoms, and is dominated by such vascular plants as fennel-like pondweed , perfolliate pondweed, awlwort (*Subularia aquatica*), spiked water-milfoil (*Myriophyllum spicatum*) and autumnal water-starwort (*Callitriche hermaphroditica*). Also, stoneworts are more common here than in the more open bays.

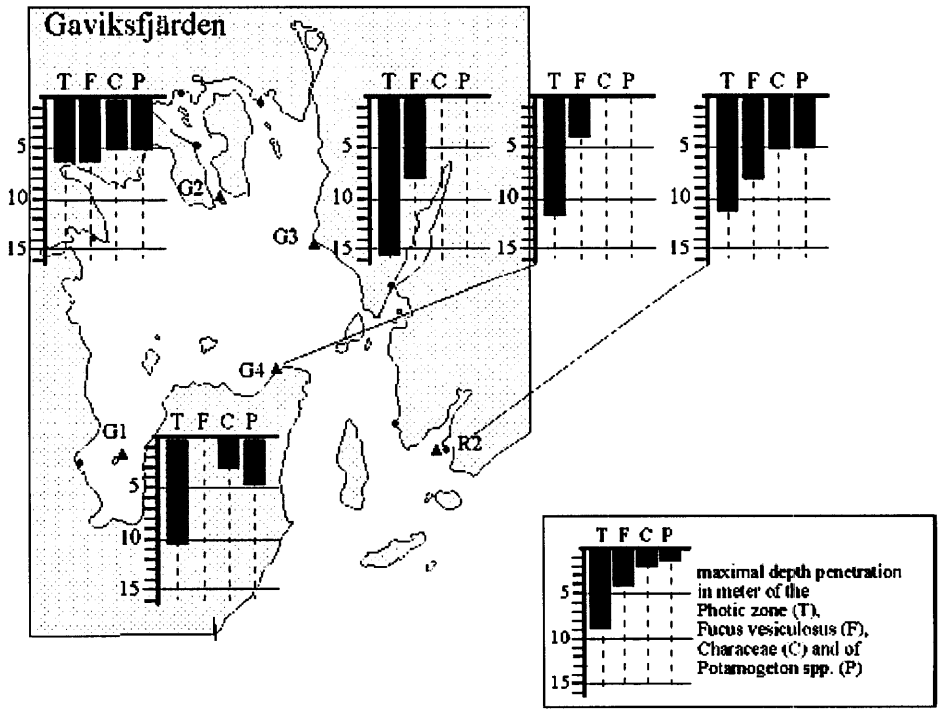


Figure 10. *The vertical distribution in Gaviksfjärden Bay of the vegetation (T), bladder wrack* Fucus vesiculosus *(F), stoneworts (C, Characeae) and* Potamogeton *species (P). From Kautsky et al. (1996).*

On harder bottoms grow green algae of the genus *Cladophora*, and there is an abundance of siliceous algae. The vegetation grows to depths of 5–6 metres, where it often terminates with the bird's nest stonewort. Stoneworts are also abundant in shallower waters, but in the form of *Chara* species. The vegetation of Norafjärden differs from that of the more open bays, in that red and brown algae are very unusual and bladder wrack is entirely absent (figure 11). The fauna also differs. Of course, *Saduria entomon, Monoporeia affinis* and *Macoma balthica* are also present here, and they are not uncommon. But *Mytilus edulis* is absent from the bay, and has only been observed in the outlet. Also, amphipods of the genus *Gammarus* are more sparsely represented in Norafjärden than in the more open Omnefjärden.

Among the fish, freshwater species such as perch *(Perca fluviatilis)* and roach *(Rutilus rutilus)* are much more common in Norafjärden, as is vendace *(Coregonus albula)* during the autumn spawning season. The Baltic herring *(Clupea harengus)* and the four-horned sculpin *(Triglopsis quadricornis)* appear to be more common in Norafjärden during the autumn. However, these two species are, like the white fish *(Coregonus lavaretus)*, more numerous in the open bays (Thorfve 1996).

It is evident that life in the bays of the High Coast is clearly influenced by sea water. In the central areas of Gaviksfjärden Bay, there are depths of up to 85 metres, which makes for good water circulation and helps to explain such phenomena as the great abundance of bladder wrack (figure 10). Marine species are found close to shore among the islands, and the distance between freshwater inlets and marine environments is short. There is also a distinct contrast between the steep shoreline, which is heavily influenced by fresh water, and the saltwater environment at and beneath the surface of the sea (Ericson 1978; see also appendix 7).

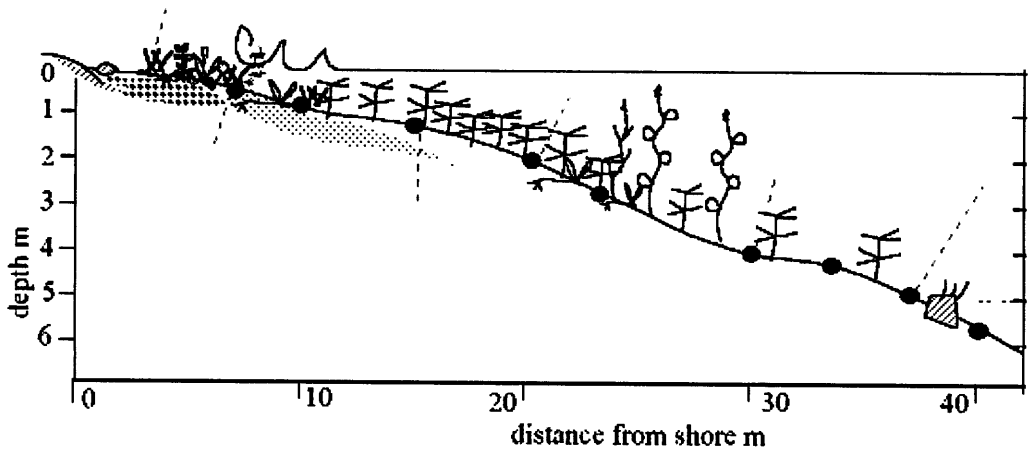


Figure 11. *A sheltered bottom in Norafjärden Bay, dominated by vascular plants and stoneworts. The stoneworts at the upper levels are of the genus* Chara, *while bird's nest stonewort* Tolypella nidifica *is dominating at the lower levels. For legend, see figure 9. From Kautsky & Foberg (1996).*

Fish

The fish fauna of the High Coast region clearly displays the mixture of salt- and freshwater species that is typical of the Baltic Sea. Above all, it demonstrates the importance of salinity variations for the presence of marine organisms. Approximately a dozen saltwater fish species regularly occur and reproduce along the High Coast (table 3). Although the fish fauna is dominated by freshwater species, it is the marine Baltic herring *(Clupea harengus)* together with white fish *(Coregonus lavaretus)* that have the greatest significance for fishing in the Gulf of Bothnia (Andreasson *et al.* 1993).

The fish can be divided into warm-water species which prefer the shallow waters of the archipelago, and cold-water species which can be found near the shore during winter, but spend the rest of the year farther out in deeper waters. The warm-water category consists of freshwater species such as perch *(Perca fluviatilis)* and roach *(Rutilus rutilus)*. In the cold-water category are both salt- and freshwater species, including white fish, Baltic herring, four-horned sculpin *(Triglopsis quadricornis)* and eel pout *(Zoarces viviparus)* (Andreasson & Petersson 1982, Sandström 1994). There are not many pelagic fish species in the Gulf of Bothnia. It is primarily a question of Baltic herring, salmon *(Salmo salar)* and sprat *(Sprattus sprattus)*. The last two, however, do not reproduce in the Gulf. Some freshwater species may, during part of the year, move out into the open sea; examples include white fish and smelt *(Osmerus eperlanus)* (Andreasson & Petersson 1982).

The fish fauna in the Gulf of Bothnia is dependent on the shallow bottoms and estuaries for reproduction. This applies even to the saltwater species, including the Baltic herring which spends most of its life in the open sea, but its first year in shallow water (Sandström 1994). In the spring, the water of the shallow bays, flads and glo-lakes warms up more quickly than the surrounding sea. Many fish species take advantage of this, migrating into flads and along streams to glo-lakes in order to spawn (Berg 1982, Lehtonen & Hudd 1990, Hästbacka 1991, Karås & Hudd 1993, Sandström 1994).

The populations of saltwater species vary widely. The amount of cod *(Gadus morhua)* in the Sea of Bothnia is dependent on the salinity of the Baltic Sea, in general. A precondition for very large cod populations is a large influx of salt water from the North Sea, and a corresponding rise in oxygen levels in the deepest waters of the Baltic. These conditions enable cod to reproduce more effectively and farther north in the Baltic proper. A portion of the cod's offspring move northward and are occasionally common in the Sea of Bothnia; but in between such periods, they are essentially absent (Andreasson & Petersson 1982, Sandström 1994, Wikner 1993 & 1994).

Table 3. *Marine fish species that spawn in the High Coast area, and some fairly common immigrating marine species. From Andreasson & Petersson (1982).*

baltic herring	*Clupea harengus*
straight-nosed pipe-fish	*Nerophis ophidion*
sea-scorpion	*Myoxocephalus scorpius*
common sea-snail	*Liparis liparis*
viviparous blenny	*Zoarces viviparus*
lumpenus	*Lumpenus lampretaeformis*
small sandeel	*Ammodytes tobianus*
sand goby	*Pomatoschistus minutus*
broad-nosed pipe-fish	*Siphonostoma typhle*
greater sand-eel	*Ammodytes lanceolatus*
sandeel	*Ammodytes lancea*
immigrants	
sprat	*Sprattus sprattus*
cod	*Gadus morhua*
European flounder	*Platichthys flesus*

Summary

The cumulative land elevation of the High Coast is the highest in the world, and it is still continuing at a comparatively rapid rate. The High Coast is a prototypical example of a hilly coastline, with broad bays and somewhat more narrow and shallow inlets. It is a region where several different types of aquatic environment are represented and a variety of conditions exist within a concentrated area, including everything from sheltered bodies of fresh water to open seacoast.

In addition, the water is relatively clean. Marine species can be found in the furthest reaches of the deepest bays, not far from freshwater species. The High Coast provides a good example of a mixed fresh–salt water environment, where the distribution of marine species reflects variations in salinity.

The character of the High Coast is determined by its location on the Baltic Sea, the largest body of brackish water on earth. In contrast to other estuaries around the world, the salinity of the Baltic is stable. There are, of course regional variations: Salinity near the High Coast is about 5 psu, but it may be as low as 2–3 psu deep in sheltered inlets with slow rates of water replacement. Unlike the southern regions of the Baltic, the waters near the High Coast are usually ice-covered during winter, a factor with great significance for life along the shoreline and on shallow bottoms.

The Baltic Sea has undergone dramatic changes since the last ice age, including a series of transitions from marine to freshwater to brackish water environments. However, ecological conditions have been stable during the past 7000 years, including a mixture of salt, fresh and brackish water species. The number of species is low, due to the low salinity. Few species have the physiological ability to cope with water that is neither fresh nor salt. However, those that manage are well adapted to these conditions and may occur in large populations.

The bottoms of the deeper waters near the High Coast and in the entire Gulf of Bothnia are dominated by species which, as a result of land elevation, have been separated from the original populations in Siberia, along the coast of the Arctic Ocean. These relicts co-exist with marine and freshwater species, and are also present in lakes that have recently been formed by the process of land elevation. Two examples are *Monoporeia affinis* and *Pallasea quadrispinosa*, both of which occur in the lake Vågsfjärden near Nordingrå, among other locations.

The waters of the High Coast include a number of marine species that are also found further south, for example the characteristic bladder wrack of the Baltic, *Fucus vesiculosus*. This and other marine species do not reach further north than the Northern Quark. As with the shoreline vegetation (see appendix 7), there are benthic organisms which are not found in the Gulf of Bothnia either north or south of the High Coast.

The special combination of biological and geographical features which characterise the Baltic Sea and the High Coast provide a setting for marine life that is unique in a global context.

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THE HIGH COAST

ENCLOSURE 4

CULTURAL LANDSCAPE AND HISTORY

April 2000

The County Adminstration of Västernorrland

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Cultural landscape and History

Henrik von Stedingk

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Abstract

The dramatic isostatic land uplift has contributed in many ways to making The High Coast's cultural landscape particularly interesting. Land uplift effects are clearly reflected in the cultural landscape. The inhabitants have adapted to the conditions created by the land uplift, by moving settlements and ports as contact was lost with the shoreline. The land uplift process has resulted in varied conditions which have determined the land use. The sedimentary land areas have been utilised for cultivation and settlement while the bare-washed slopes and forested land have been used in a more extensive manner. The remains left by the inhabitants of different eras are exceptionally well-preserved and the land uplift has also resulted in the ancient remains being separated spatially, i.e. different time periods are represented at different elevations about the present sea level. The steep topography means that the highest former shoreline is just a few kilometres from today's coast and consequently immovable remains covering a 7,000 year period are present within a limited area. These circumstances give birth to a prehistoric cultural landscape.

Human activities in the area are characterised by diversity. Agriculture, maritime culture, hunting and the Saami culture have co-existed within a limited area, an area which in many respects constituted a dynamic borderland. The maritime activities, i.e. fishing, seal hunting, transportation and commerce, have played a central role and created a maritime cultural landscape. The maritime cultural landscape with a continuity of 7,000 years in the area, consists of remnants from seal hunting settlements, ports, fishing hamlets, cairns and defence fortifications in combination with the barren maritime conditions. Even the agricultural landscape that developed in the centuries after the birth of Christ has been heavily influenced by maritime activities. The cultivated landscape has been spared the effects of measures to increase efficiency and has therefore retained its old-world character.

An assessment of the High Coast's cultural landscape indicates that the area at present does not satisfy the criteria for nomination as a Cultural World Heritage Site. The cultural landscape illustrates the effects of the land uplift. This account of the cultural landscape serves therefore as an important complement to the geological and biological descriptions in the nomination documents concerning the High Coast as a World Heritage Site.

Foreword

The Swedish Government nominated the High Coast for inclusion on UNESCO's World Heritage List in June of 1998. The nomination was based on the area's value with respect to the following World Heritage criteria:

1. Important features in the earth's history and on-going geological processes
2. Important on-going ecological and biological processes
3. Natural beauty.

Following an inspection by an expert appointed by IUCN, which is responsible for the evaluation of the nomination, and a review of the nomination documentation by a panel of experts it was decided at a section meeting in Marrakech 26/11-4/12 1999 that the nomination would be deferred. The grounds given were that the nomination documentation should be supplemented in a number of respects. IUCN recommended that the prospect of nominating the High Coast as a cultural landscape should be investigated.

This report is a description of the cultural landscape of the High Coast and how it has been formed. The emphasis is on human living conditions over time, in relation to the special natural environment offered by the hilly, land uplift coast of the High Coast area. The objective of the report is to illustrate how the land uplift is reflected in the cultural landscape and thereby serve to complement the geological and biological descriptions in the nomination documentation on the High Coast as a World Heritage Site. This account of the cultural landscape also constitutes a basis upon which to assess whether the High Coast satisfies the criteria for inclusion on the World Cultural Heritage List.

Introduction

The High Coast has the world's highest situated prehistoric shoreline, 285 m above sea level. Nowhere else in the world has the isostatic uplift been so great and even today the land continues to rise at a relatively rapid rate, approx. 80 cm per 100 years. The countryside has been transformed from the rocky archipelago that met the first people in the area some 7,000 years ago to today's rolling landscape with forest-covered hills up to 300 m above sea level with arable sedimentary deposits on the slopes and in the valleys.

The cultural landscape is a product of the interplay between nature and society that has occurred throughout history. The area's particular natural conditions, i.e. the topography and emphatic land uplift have resulted in a cultural landscape with characteristics that make the High Coast particularly interesting. Its uniqueness is manifested by the cultural landscape as a mirror of land uplift process and the large quantities of well-preserved immovable archaeological remains that are spatially separated instead of being layered upon each other, as is commonly the case. Consequently, immovable archaeological remains from a period of 7,000 years can be studied within a limited area and in their original locations, undisturbed by the activities of later times.

Many different cultures have contributed to the formation of the High Coast's cultural landscape. The High Coast has, since the Mesolithic period, constituted a frontier zone where cultures have met and influenced each other. During the past 2,000 years the hunting and collecting culture, agrarian culture, maritime culture and later also Saami culture have co-existed within a limited area. This has resulted in a complex culture where these varying expressions have been woven together. The

natural conditions have resulted in traditional practises and behaviour being retained for a considerably longer period than in other locations which offers special opportunities to study central phases in the history of mankind such as, e.g. the transition from hunting and collecting to an agrarian culture. The High Coast's inventory of prehistoric remains therefore constitutes one of several important sources of knowledge concerning the early history of Scandinavia.

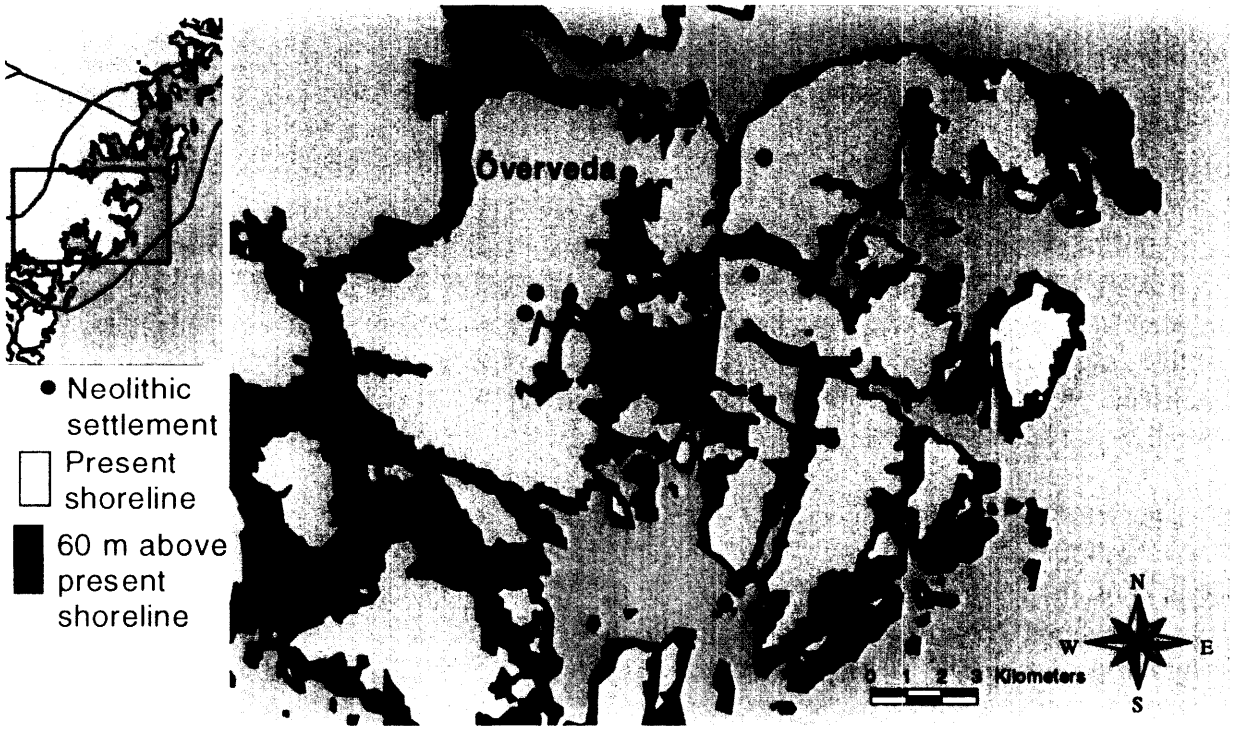
The term cultural landscape is often used synonymously with cultivated landscape where the peasant culture and agriculture are placed in focus. The productivity of the land is regarded as central to the cultural development of humanity. However it was often waterways that determined where people settled. In the High Coast virtually all activities have, in one way or another, been linked to the sea, in terms of economics or transportation. That is to say that the bulk of the remains can be viewed as elements of a maritime cultural landscape, significantly older than the cultivation culture, with a period of continuity extending 7,000 years.

The physical cultural landscape provides clues to the immaterial cultural landscape, i.e. people's conceptions and ideas, which in turn have determined the formation of the landscape. The underlying historical contexts and people's conceptions are essential to an understanding of the physical cultural landscape, which otherwise tends to be perceived as a multitude of isolated, unrelated parts. In the following description of the High Coast's cultural landscape the physical landscape is placed in its historical context based on the maritime culture perspective and with the focus on the consequences of land uplift. Different periods and archaeological remains are presented separately in a prehistoric and a historic segment followed by a summary analysis where the overall situation and the area's distinctive character are illuminated.

A prehistoric overview – landscape of archaeological remains

The Mesolithic (–4,200 BC) and Neolithic Periods (4,200–2,000 BC)

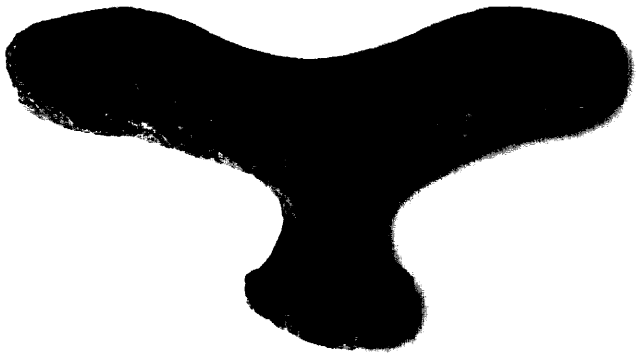
Around 7,300 BC the area that today comprises the High Coast was ice-free but largely submerged. The land uplift during this period was considerably fast, approximately 10 cm annually. The first finds of human activity, simple tools and quartz flakes, have been discovered on old sea shores at levels equated with the period 6,000–5,000 BC. At this time the landscape was a rocky archipelago. Where these people came from is uncertain but they seem to have had connections both with Norway to the west and the Mälaren region to the south. Skeletal remains and tools found at shoreline settlement sites are dated to the period 4,200–2,000 BC, i.e. Neolithicum, indicates the sea's resources: fish, seabirds and seal, were central to sustenance. The settlement sites seem to have been used seasonally and recurrently during a very long time. During the balance of the year the people presumably lived in smaller groups farther inland where moose, beaver and fish comprised the animal diet supplemented by vegetation gathered in coastal land and forests (Baudou 1992). Systems of hunting pits were a very common hunting technique from the Mesolithic period up to 1864 AD when the method was prohibited. The moose were lured into pits, generally about 2 m deep, often with some sort of wooden structure at the bottom that prevented the game from escaping (Westerdahl 1985). Hunting pits of varying dates can be found today throughout the forested land in the High Coast.



This map shows the Neolithic settlements in Nordingrå parsish. The 60 m shoreline corresponds to ca 3000 BC

Överveda – meeting-place for seal hunting.

In Nordingrå, in the heart of the High Coast, lies Överveda, which from 3,500–2,500 BC was a well-protected settlement site at the far end of a deep inlet of an archipelago landscape. Today it lies 6974 m above sea level on a southern-facing slope with a view of the rolling agricultural lands and glimpses of the sea between the hills. Several groups of hunter/fishermen seasonally gathered here annually to hunt seal and fish. Charred bone fragments of ringed seal and different types of sinkers that that can have been used for fishing as well as for seal nets have been found at the site. This indicates that the settlement was occupied in the autumn when the ring seal moved into the inlets and are easy to catch with nets. Characteristic for the settlement is that, in addition to implements of quartz, the residents also made implements of slate. A large number of carefully sharpened arrowheads, knives and a special type of T-shaped shale tools have also been recovered. The purpose of these T-shaped slate tools, which aside from isolated finds have only been found at the Överveda settlement, is unknown but it is probable that they are in some respect related to seal hunting (Westerdahl 1985). It can be deduced that the raw material originates from a slate quarry nearby while quartz veins are widely found in the bedrock of the area. Slate knives and arrowheads create a link with Nämforsen, a meeting-place and ceremonial site that has been used since the Neolithic period and where fishing was the primary activity. Nämforsen is situated about 60 km upstream on Ångermanälven and is the site in northern Sweden with the greatest number of rock carvings (Baudou 1977).



The use of the T-shaped shale tools from Neolithicum is unknown, but a connection to the catchment of seal is probable. (Västernorrlands länsmuseum/Murberget)

The Bronze Age 2,000–500 BC

A variety of different hunting/fishing cultures lived into the Bronze Age. Along the coast however there are a number of indications that the population remained at the coast throughout the year. A new cultural expression are the at least 700 cairns that stretch like a string of pearls along the former shoreline, but which are completely absent inland (Baudou 1968). These monuments were raised adjacent to the shoreline of the day, 1,300–700 BC to delineate territory and hunting grounds (Broadbent 1987). The fact that they were placed clearly visible from the sea indicates that people plied the sea, presumably for both fishing and transport. The boats were less suitable for travel in open waters so the routes predominantly followed the coastline (Baudou 1986). People lived off the sea but it also had an impact on living conditions. The circumstance that all of the cairns are oriented in the same way in relation to the shoreline shows the sea's importance, not only for sustenance, but also for spiritual needs.

The settlement sites are seldom found nearby the cairns. They were situated in the more sheltered inlets, often some distance from the cairns. The coastal settlements were able to exploit the sea's animal life in the form of seals, fish and sea birds, but they were also close to the forest and the primary prey of the inland, beaver and moose. During the winter it was possible to easily cross the ice-covered inlets that facilitated fishing and, not least of all, seal hunting during the early spring. Traces of cultivation, based on pollen analyses, are found farther inland as early as around 2,500–2,000 BC (Huttunen & Tolonen 1972) and in the coastal area south of the High Coast cultivation dates back to the early Bronze Age, about 800 BC (Engelmark 1978). This cultivation was of very little significance for sustenance and might have had a ritual purpose or was a means to manifest cultural affiliation. Along with dogs for hunting the residents began to keep domesticated animals, From which the manure was essential for repeated cultivation in the generally poor soil. The Bronze Age culture can however, despite sporadic attempts at agriculture, be regarded as a hunting culture with animals and fish as the absolutely most significant sources of sustenance (Baudou 1992, Engelmark 1997).

Bronze Age Cairns

The cairn area at Sund is comprised of 26 cairns located on either side of the mouth of the sound situated here about 1,200 BC. They are all built according to the same principle even if there are variations in form. Angular blocks were carefully placed in a circle, oval or rectangle with a radius of 10–20 m. The local rapakivi granite is well-suited for making dry wall edges, i.e. building with stone without filler, since it cracks vertically and angular blocks can be split. At the centre of the cairn a stone caisson was built to accommodate the deceased. During the early Bronze Age the practise of cremation was introduced. It was exceptional that articles were placed in the grave. The area outside the wall was then filled with rounded sandstone. The cairns are monumental constructions that have stood up well over thousands of years (Baudou 1971).

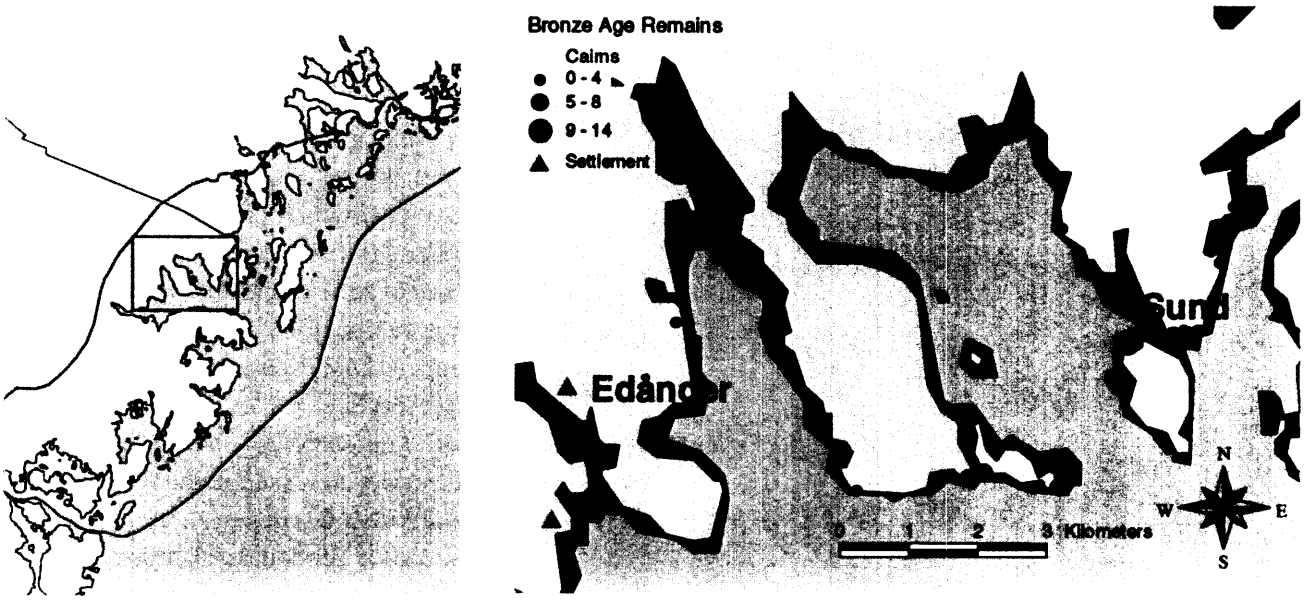
The cairns was built on the shore for burrial but also as territorial landmarks. Today this cairn lies at 40 m above sea level, due to the land elevation. (Örjan Hermodsson)

At Storsjön in the parish of Nora there are a number of well-preserved Bronze Age graves in their original relationship to the seashore. What was earlier an inlet was isolated from the sea during the same time period as the cairns and ship tumulus were built and the land uplift has not affected the shoreline which today is 30 m

above sea level. Since the greater number of cairns along the coast are now located 30–50 m above sea level one can only speculate concerning the relationship to the former shoreline. The cairns at Storsjön provide a unique opportunity to see, experience and study Bronze Age graves in their natural surroundings (Loeffler 1993).

Settlement at Edånger

At Edånger there is a settlement site dated 900 BC. At that time it was located deep in a well-sheltered inlet about 2 km from the closest cairn. At the site there are some ceramic fragments and a considerable quantity of broken stone. The stones were heated on a fire and then placed in water-filled wooden vessels or leather sacks to boil the water. Some charred bones, from e.g. beaver and stone sinkers for net fishing show that hunting and fishing were the primary sources of sustenance (Baudou 1971).



Map showing Bronze Age cairns and settlements in Vibyggerå parish. All the cairns lies close to the 35 m shore line corresponding to ca 1000 BC, while the settlements are found in the inlets some km away from the cairns. Note the sound situated in Sund during this time with the cairns located on both sides.

The Iron Age 500 BC–1050 AD

During the first centuries after Christ a new culture begins to bloom along the High Coast with large farmyards, stock-raising and regular agriculture. The burial mounds were placed near the farms that consisted of three-aisled houses divided into different functional units: housing, barn and storehouse plus a fodder storehouse. Smaller buildings, separated from the main building, could house a blacksmith's workshop, bronze foundry as well as a loom. The main activity was stock raising and the manure was used for the grain fields cultivated annually. The proximity to the sea was however an important factor with respect to fishing and seal hunting. Meadows near the shore were used for grazing or growing fodder. It was also near the shoreline, on sedimentary soil, that the arable land was to be found (Lindqvist & Ramqvist 1993). The sea as a means of communication presumably also played a certain role, particularly concerning the increasingly important trade. The rising agrarian production created the preconditions for population growth and a stronger social structure. The distribution of land, iron production, trade and travel required rules and some form of power structure to enforce such rules. During this period centres of power with large

farms and defence installations, so-called hillforts, developed. The influences for this new social structure came presumably from the west, Norway, given the burial customs, agricultural practises, architecture as well as the social organisation. This new peasant culture did not however replace the old hunting and fishing culture. Parallel with the development of permanent farms there were still groups of people who lived more traditionally on hunting and fishing. They lived in smaller parishs along the shores and in the inlets and continued with the cairn burial customs (Baudou 1992, Lindqvist & Ramqvist 1993).

Nora Parish – a prehistoric landscape

In Nora parish there is a very well preserved prehistoric environment. Many of the place-names in the area originate from the Iron Age (Wallander 1986). In addition to the shoreline Bronze Age cairns mentioned above there are numerous burial mounds and farmsteads from both the early and later Iron Age. A number of silver treasures dating back to the Viking Age have also been discovered in the area. The landscape created by man approximately 2,000 years ago is relatively intact thanks to less intensive agriculture. An archaeological study of two farms on the outskirts of Nora yielded very interesting results. At one site, established around 250 AD, i.e. during the pre-Roman era, at Gallsätter near Storsjön, northern Sweden's best preserved building foundation from this period was uncovered as well as clear evidence of agricultural activities such as clearing cairns, stone lines (remnants of fencing), ardmarks and millstones. The well-preserved so-called fossil finds indicate a relic Iron Age landscape that provides interesting supplementary information to the ancient agrarian landscape we see today. The farmstead at Gallsätter was abandoned about 700 AD and together with the farmstead at Lappnäset, from 600–900 AD, on the other shore of Storsjön, indicates a settlement continuity in Nora parish from the pre-Roman Iron Age to the Viking era. Skeletal remains indicate that hunting and fishing were a very important complement to agriculture and stock raising (Forsberg 1997, Lindqvist et al. 1996).

The agricultural landscape of Nora was established during the Iron-age. (Metria)

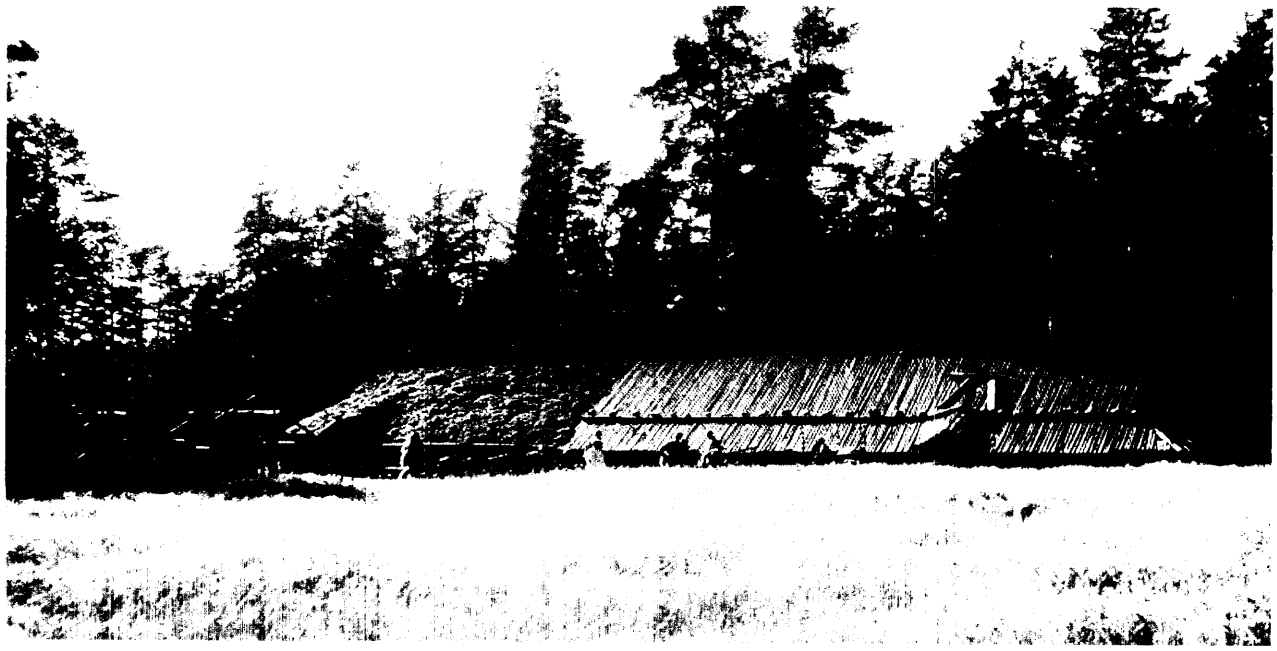
Ancient village at Gene

At Gene, 4 km inland from northerly part of the High Coast, it is possible to experience the lifestyle and crafts of an Iron Age farmstead at close hand. At the site they have repconstructed a homestead based on the excavation of Sweden's most northerly Iron Age farm. This excavation has provided considerable new knowledge of Iron Age resource utilisation and housing in the area (Lindqvist & Ramqvist 1993). Near the reconstructed farm are the remains of the original homestead with all building foundations marked with painted rocks so that visitors can get an idea of what is hidden below ground. The original farmstead is large and covers an area of nearly one hectare.

Hut foundations – the fishing culture endured

On rubble fields along the coast of northern Sweden there are numerous hut foundations of a certain type. These are remnants of the maritime culture living on fishing, seal catching and hunting seabirds, a culture that continued to be of significance long after permanent agriculture and stock raising had

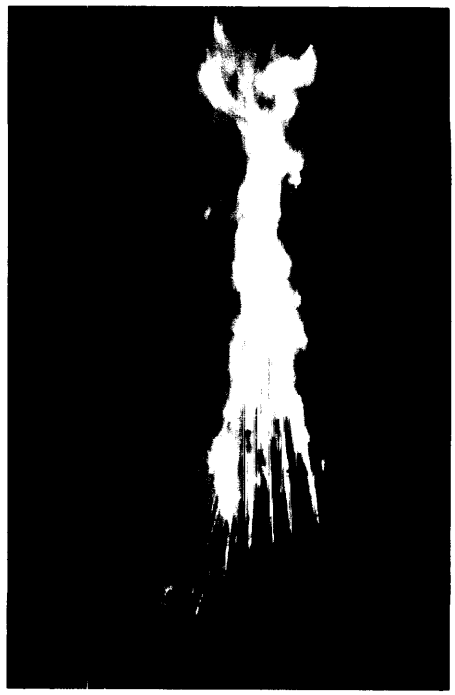
spread to the area. The oldest examples are from the Great Migration (400 BC) but the bulk are from the Viking Age (900–1000 AD), with some from up to the 14th century (Broadbent 1988, Grundberg 1992). That some the foundations originate from temporary housing during seal hunts is substantiated by findings of large quantities of phosphate at the Viking Age shoreline, a short distance away, indicating a prehistoric slaughtering site. As a rule, the huts are grouped suggesting that the hunting was organised into teams (Broadbent 1988). Whether these temporary homes were used during seal hunting on the early spring ice or netting during the autumn when the ringed seal followed small fish into the inlets is a subject of contention (Broadbent 1988, Lindström & Olofsson 1993). The importance of seals for the sustenance of the local population and also for trade in hide and train oil is however clear.



A reconstruction of the Gene village, the most Northernly Iron-Age farm in Sweden. (Lena Edblom)

Hillfort and Beacons –an early defence organisation

At Rödklitten there are remains of a hill fort, on high with a good view of Vågsfjärden, the innermost part of which was the site of an Iron Age settlement. The hillforts were look-out points and defence installations and their location, well-visible from the sea, indicates that they were also important territorial markers. They frequently had a radius of 100–150 m with a stone wall topped by a wooden palisade. Generally, the hillforts are not rich in finds as they were not used for housing. Today, only the stone walls remain as a reminder of a time when enemy threats came by sea (Hemmendorff 1985).



The beacons, on top of the hills, was lit as warning signals and as a call to arms against the approaching enemy. (Per-Olof Engdahl)

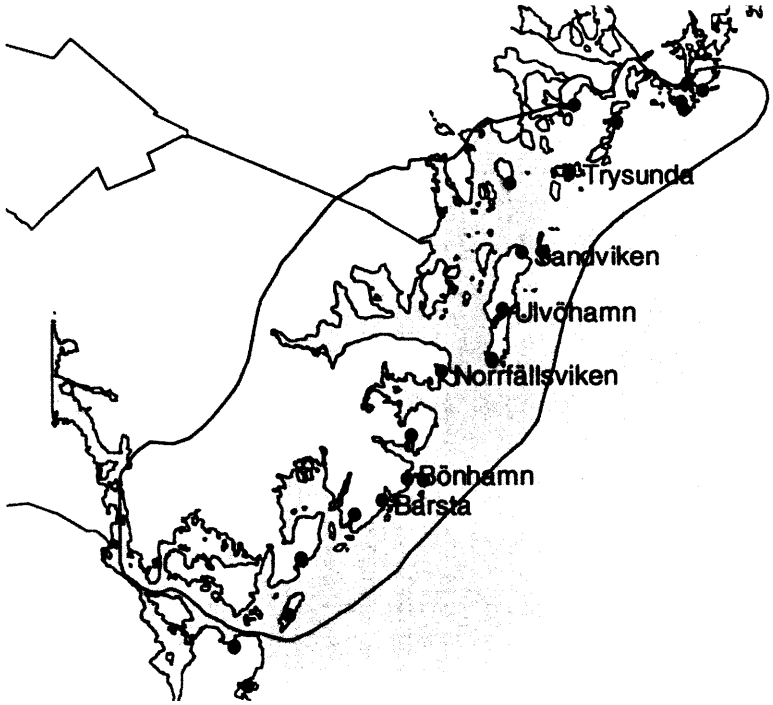
The beacons were a system of woodpiles placed on heights within sight of each other. As the enemy approached the beacons were lit to warn people to seek protection or as a call to arms. They were supplied with fresh wood as soon as a threat was discovered. The beacon fire system may well stem from prehistoric times and was used during wartime until the 18th century. Beacon fire hills can be said to be a characteristic of the High Coast with its high peaks, but the system served a central function for the entire population along the coast of the Baltic Sea. No actual beacon fires remain but beacon hills are distinguishable by a host of place-names thereby contributing to the picture of the maritime cultural landscape (Wallander 1986, Westerdahl 1985).

The High Coast's trade and industry, cultural patterns and cultural manifestations – a historical landscape

Fishing

All along the High Coast, in sheltered inlets, there are several very well preserved fishing hamlets that remind of the importance of fishing in the area. The first period of prosperity was during the 17th and 18th centuries in connection with the advent of long-range fishing. Every spring fishermen would arrive from the south, predominantly from Gävle, to fish herring along the northern Swedish coast. These so-called Gävle fishermen earned well, not only through their intensive herring catch but also by trading along the coast on their way north (Eskeröd 1946). Salt, which was a prerequisite for large-scale herring fishing, was also a sought-after product among the local population and therefore the fishing hamlets tended to serve as marketplaces (Blomkvist 1986). The long-range fishermen headed south during the late autumn and many of the fishing hamlets were entirely deserted during the winter months.

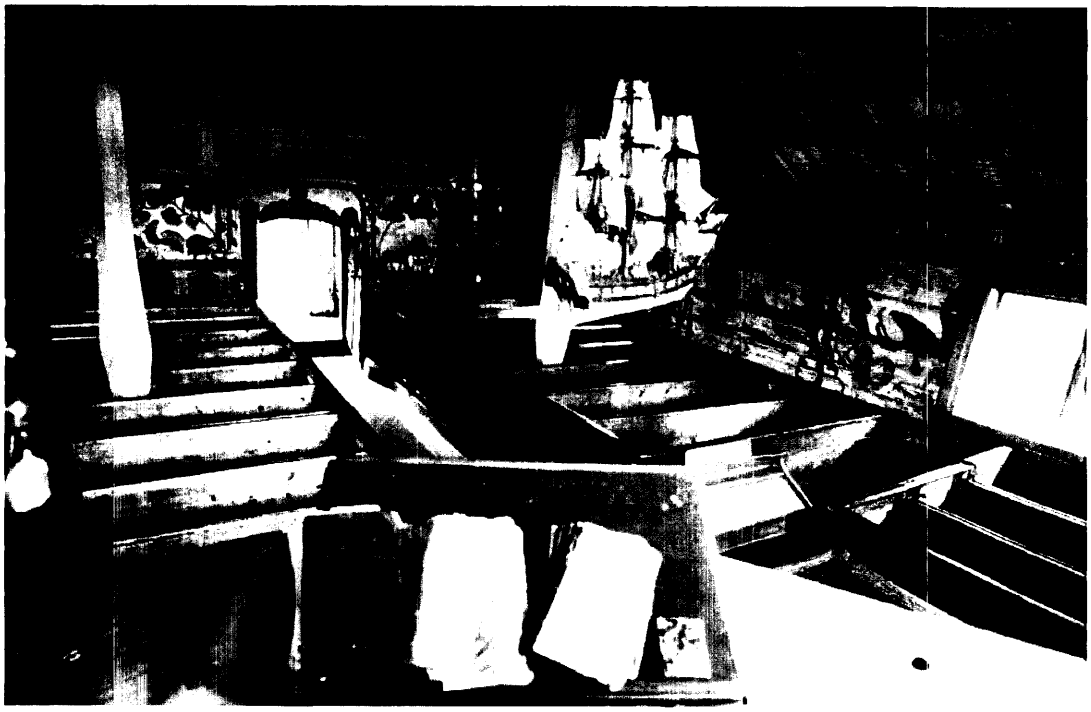
A special culture formed in the fishing hamlets and fishing itself was well-regulated with respect to when and what could be caught. Special chapels were erected in every hamlet and formed a natural centre and meeting-place. From the close of the 18th century long-range fishing declined drastically and the fishing hamlets were overtaken by the local population. At this point the fishing hamlets became permanently populated and a new period of prosperity began. During the 1950s commercial fishing in the area declined and the hamlets lost their earlier function, were abandoned and became popular sites for summer cottages during the 1960s. Many of the fishing hamlets, including Barsta, Bönhamn, Norrfällsviken, Trysunda and Ulvön have retained much of their original and characteristic structure with closely built boat-houses, huts and a chapel (Höga kusten-kommittén 1974).



The hamlets used by the long range fishermen.

Ulvöhamn

The port on Ulvön is one of the most well-known used by the fishermen from Gävle. The port was the centre of long-range fishing and usage began at the end of the 16th century. The boat-houses were owned by the local farmers and were rented each season to the visiting fishermen. Ulvöhamn is a superb natural port where the dovetailed log boat-houses are placed closely together along the shoreline. Above each boat-house there was a hut where the fishermen and the familys lived. The port also has one of the county's oldest fishermen's chapels, built in 1622 by the Gävle fishermen, is adorned with very remarkable paintings on the ceiling and walls (Höga Kusten-kommittén 1974).



Ulvö chapel from 1622 is the oldest fishermen's chapel in Nortern Sweden. The paintings, from 1719, illustrates fishing scenes from the bible with people wearing local clothing. (Västernorrlands länsmuseum/Murberget)

The herring was processed either through pickling in brine or allowing it to ferment under controlled conditions, so-called *surströmming*. Ulvön and the High Coast have long been the leading centres for the production of *surströmming*, the "national dish" of northern Sweden. Parallel with the decline of long-range fishing towards the end of the 18th century there was an increase in summer fishing among farmers living in the parishes near the coast. The character of the fishing hamlets changed when people began living in them all year round during the 19th century. The characteristic wear-worn wooden boathouses were painted red and enlarged. Ulvöhamn was heading towards a new era of prosperity and was, during the 19th century, the largest fishing hamlet in northern Sweden (Söderberg 1982). Seal hunting was also of significance into the 20th century (Westerdahl 1989). During the winter the most southerly occurrence in the Bothnian Bay of the so-called *fälan* departed from Ulvön. This was a cultural phenomenon imported from Österbotten in Finland involving long-range hunting for seal on the late winter ice. The hunting teams ventured out with their special seal hunting boats that could be dragged across the ice. After several weeks on the ice at the seal breeding sites they would return and if the hunt was a sucsess the boats would be filled with valuable fat and sealskin (Ekman 1983). During the 20th century the importance of fishing has declined sharply and today commercial fishing is no longer of significance. The fishing hamlet at Ulvöhamn has however retained its character and is today a cultural historical gem. Sandviken fishing hamlet, also on Ulvön, was more

exposed than Ulvöhamn and was abandoned during the 1940s. The buildings have however been restored piously and the silver-grey colour that was so characteristic for the boat-houses has been retained.

Ulvöhamn has kept the old hamlet structure with closely built boathouses, hut and a chapel. The small islands protect the port from the open sea. (Aerial photo: Metria)

Labyrinths

Something that has given rise to many questions and reflections over the years are the stone labyrinths found all along the eastern coast of Sweden. The building of labyrinths has a very long tradition which is believed to have originated with the labyrinth at Knossos on Crete 1,400 BC. The custom of building labyrinths was widespread throughout Europe but it is in Sweden that the majority, around 300, of known labyrinths remain. This presumably is the consequence of the fact that on the continent and the British Isles the labyrinths were build of sod whereas in Sweden, north of Skåne, they were built of stone (Kraft 1982).

A few of the Swedish coastal labyrinths can possibly be from prehistoric times (Kraft 1982), but dating that has been performed indicates that the majority were built during the 14th – 17th centuries (Sjöberg 1991). There are no written sources on the origins and background of the labyrinths and this has given rise to a number of different theories. Evidence indicates they were built by local fishermen since their locations can either be linked with the fishing hamlets or they are located on barren islands on the outskirts of the archipelago, where only fishermen would have reason to visit. The fact that the verbal traditions related to the labyrinths have been lost can suggest that it was a question of magic which loses its power if the knowledge become widely known. A walk through a labyrinth can have been a means to influence the higher powers in the hope of larger catches or favourable winds (Kraft 1982). There are also theories suggesting that the northern coast labyrinths are related to the pilot services of the Middle Ages (Westerdahl 1991) or as a manifestation of popular protest against the Reformation (Sjöberg 1996). Of the High Coast´s 12 labyrinths 10 are situated in the High Coast´s most notherly part and five of these are founded in close proximity on the island of Stor-Haraskär (Grundberg & Sjöberg)

The labyrinths - a mystery left to be solved. (Örnköldsviks museum)

Häggvik (Jan Lundqvist)

The Agrarian Landscape

Between the forest-covered heights, with barren rockfaces and fields of rubble that have maintained their original qualities, the agricultural district occupies the sedimentary soil deposited in the more sheltered inlets and river mouths. Despite that the natural conditions do not allow for rich agriculture the landscape's character has been marked by farming. During the Viking Age a dramatic expansion populated. When the limited areas of good arable land in the central districts was fully exploited the expansion continued during the Middle Ages, foremost to the surrounding land to the west and in the northern part of the High Coast (Blomkvist 1986). The natural conditions have resulted in agriculture having certain specific features. Family farming remains to this day and consequently the landscape has been largely spared the effects of measures to increase efficiency. This has meant that the agricultural landscape has retained much of its old-fashioned character.

Hunting occurred and the central Iron Age districts became more densely and fishing have always been important complements to agriculture. Stock raising has been central and the summer farming was very pronounced in the area into the 20th century. It was the quantity of harvested winter fodder that determined how many animals could be kept, which in turn influenced cultivation as it was dependent upon the available manure. Supplementary winter fodder was gathered from shore-side meadows and along the shoreline. It also happened that farmers had hay-fields out on the islands. This fodder was brought back to the farm using sleds once the waters were ice-covered in the late autumn/early winter. From the 17th century burn-beating was practised and the farmers grew rye or barley on the forest land. After one or sometimes two harvests the burnt area became good grazing land with herbaceous plants and grass. It also happened that farmers burned forested land primarily to improve grazing conditions.

Summer farming

Summer farming was an extensive stock-raising system based on forest grazing, widespread in central Sweden. During summer the livestock were moved to a semi-permanent settlement, often far from the permanent farm, to graze in the forest. The summer farm consisted of a number of simple buildings with a range of uses; a dwelling house where in addition to sleeping and cooking, the people churned butter and made cheese, a barn and a number of storehouses. The manure was collected and transported down to the fields in the central district. The summer farming organisation in the High Coast differs from the rest of the country in that there is no meadow near the houses. Therefore, the buildings are often directly adjacent to the forest. Summer farming is mentioned as early as the 15th century and prior to its introduction the livestock were allowed to roam freely in the forest. (Blomkvist 1986). Most of the buildings at the summer farms were raised during the 18th and 19th centuries and were in use right up until the 1930s. Consequently, there are a number of relatively well-maintained examples in the area. The summer farming areas were often located at high levels, in beautiful surroundings and are of particular interest as they reflect a traditional method. Many traditional methods that were abandoned much earlier in permanent farms in the continued to be employed for a considerable time at the semi-permanent farms (Nordström1976, Lundqvist 1979).

The summer farming in the High Coast differs from the rest of the country in that there is no meadow near the houses. Therefore the buildings are often directly adjacent to the forest. (Tomas Birkö)

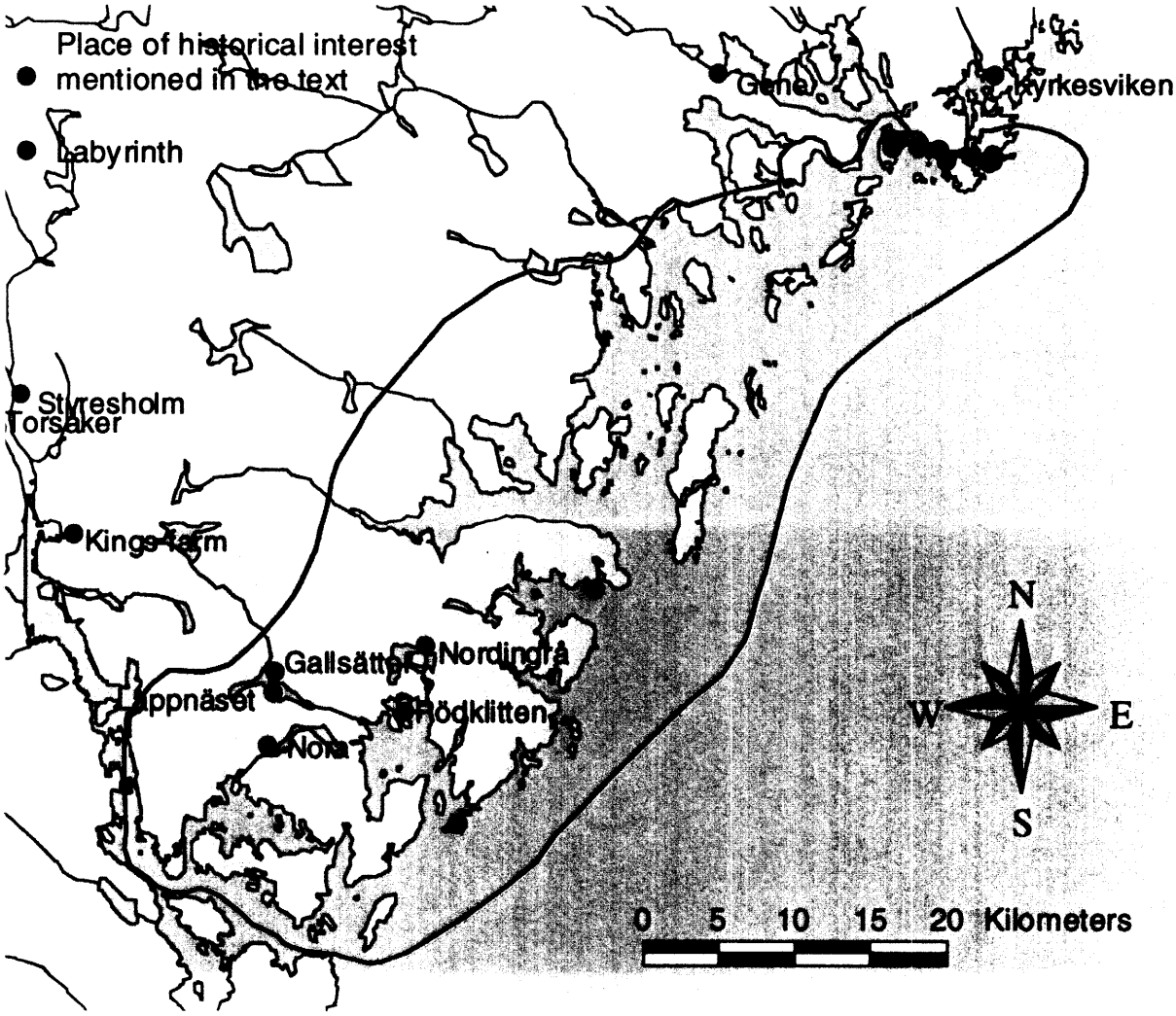
State power, commerce and transport

The area's written history begins during the 14th century, but there are few archaeological finds from the Middle Ages (Grundberg 1997). *Hälsingelagen*, written during the 1320s, reflects the newly-established Swedish state power's efforts to gain control over north-central Sweden. A central settlement was established about 20 km from the coast on the banks of Ångermanälven. The state power represented here by the church; Torsåker Church is from the 13th century, the military; Sweden's most northerly sheriff's stronghold Styresholm, (1390) as well as through an administrative centre at the royal farm of Kutuby, also the most northerly in Sweden. Kutuby is named in documents from 13th century but its location is not established with certainty (Grundberg 1997). This central district from the early Middle Ages increasingly lost its significance as the focus shifted to settlements closer to the coast (Westerdahl 1986b). This shift of focus towards the coast is a well-known process in northern Sweden where the rivers' navigability deteriorated due to the land uplift and heavier maritime shipping (Layton 1973). Part of this process included the installation of a church dean at Nordingrå in 1320 (Blomkvist 1986). What remains of this church from the Middle Ages, demolished and replaced by a new church during the 1850s, is an excavated and preserved ruin (Höga Kusten-kommittén 1974).

Much of the state's interest revolved around taxes, both to the state and church, which during the Middle Ages were paid in kind. Residents at the High Coast were encouraged to engage in cultivation and stock-raising for their sustenance. The taxes were preferably to be paid in the form of skins, seal fat, herring, linen cloth and salmon. These products complemented the state and church tax revenues in the form of grain and meat from the fertile Mälardalen and, at the same time, they were goods with attractive market potential the growing and increasingly international marketplace of the Middle Ages (Blomkvist 1986). The High Coast enjoyed a strategic trade location, at the sea, far from the nearest large city plus the northern contact with the Saamis, from whom furs were purchased. In combination with desirable locally produced goods this

resulted in very brisk trade and a large number of registered merchants. These profitable sidelines contributed to an expansion in the outlying areas particularly in the High Coast's northern part and the area as a whole managed well in comparison with the rest of northern Sweden despite its less favourable agricultural conditions (Blomkvist 1986).

During the Middle Ages maritime commerce increased along the coast of northern Sweden in connection with the introduction of a market economy (Baudou 1987). The many ports and fishing hamlets along the coast were also, in many cases, trading sites. In forestland at Kyrkesviken, 5 km north of the High Coast, an abandoned port from the Middle Ages, in use during the 13th–15th centuries, has been discovered 300 m from the shoreline. The archaeological diggings resulted in a number of interesting finds that indicate contacts from afar and the port's significance for the sailing route along the northern Swedish coast during the Middle Ages (Huggert 1978, Westerdahl 1982). During the Middle Ages the High Coast was situated between two transport zones. To the south, land transport was particularly important during the winter while, to the north, sea transport during the summer was used almost exclusively for long-distance carriage. At the High Coast both modes of transport were common. During the 18th century this "borderline" opened the way for *sörköreriert*, a widespread commercial tradition in the High Coast involving the carriage of attractive northern Swedish goods to Stockholm during the winter which was a lucrative trade (Westerdahl 1989).



Map showing the spread of labyrinths and places of historical interest mentioned in the text.

The Saamis

For a long time the High Coast constituted the southern-most border for the Saami culture. The Forest Saamis, later replaced in the area by the Mountain Saamis, herded their reindeer to the coast for winter grazing. The coastline's rocky landscape, with plenty of reindeer moss (lichen), offered good winter grazing conditions. The reindeer were even herded across the ice to graze on nearby islands. Winter grazing along the High Coast continued at Nordingrå until the 1930s. The nomadic Saamis lived in tepee-like dwellings or log cabins but also a considerable number of Saamis lived permanently in the area. The Coast Saamis travelled to the fishing hamlets and sold handicrafts, including the much appreciated and typically Saami root woodwork, as well as a variety of utilitygoods for the fishermen. Saamis who had stopped keeping reindeer could also work as goat herders, farm hands and maids. Parish Saamis, *sockensamerna*, were Saamis who occupied a special position. They were provided for and protected by the parish and in return they were to perform certain duties such as castrating and putting down horses, flaying and providing the district with their much-appreciated handicrafts.

The relationship between the farming population along the coast and the Saamis seems to have been good. Since the Saamis only used the lands for winter grazing no competition existed with the local farmers at the same time as they supplied the farmers with handicrafts, hides and reindeer meat. It is not possible to establish how long the Saamis have been active around the High Coast since it is very difficult to determine the ethnic origin of ancient remains. At known reindeer grazing grounds near the coast there are historic remains from the hearths of Saami tepees. At the High Coast there are many place-names that serve as a reminder of the Saami influence in the area (Westerdahl 1986a).

Forest Saamis at their annual visit to the High Coast in the 19th century. (Örnsköldsviks museum)

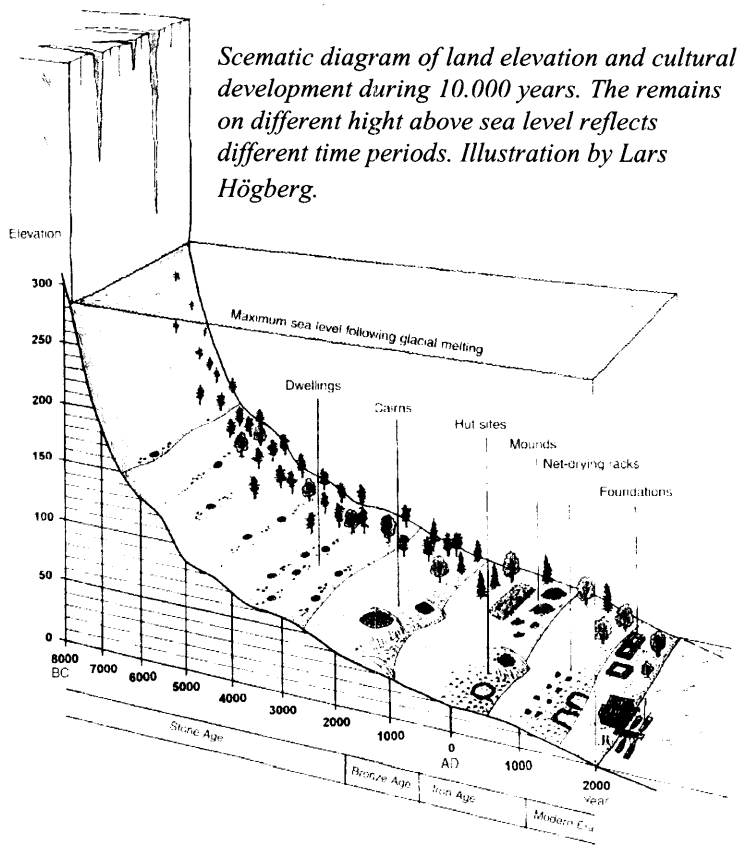
Analysis

The consequences of land uplift

Land uplift has affected the inhabitants all around the Baltic Sea, both locally and regionally. The Baltic has passed through different phases with varying salinity and availability of nutrients due to effects of the land uplift on the Baltic's contact with the Atlantic. This might have affected human life around the Baltic at different times. Most land in the High Coast has been submerged beneath the surface of the sea and has at some point constituted the shoreline. This has resulted in a varied landscape with very different conditions for land usage. The rubble fields have provided material for stone structures such as cairns and simple building foundations. The inaccessible heights, often with only a shallow soil covering, could be used for forest grazing while the arable sedimentary soil was concentrated to the land between the heights. The land uplift also contributed to the shift of focus from the inland to the coast that began during the Middle Ages when maritime commerce increased in importance.

The shore is a natural settlement site for people who are dependent upon the sea's resources for their sustenance. The land uplift has caused displacement of the shoreline, which alters the circumstances for the settlement, i.e. the distance to the sea increases and inlets become shallow or cut-off. Consequently the inhabitants, to retain contact with the shore, left their earlier settlements and moved closer to the sea. By that the remains from different times are spatially separated which is unusual. This can be compared with areas not affected by land uplift, where people have lived for thousands of years. Generally speaking, the remains from different times at such sites are stacked above each other, at best with the oldest layer at the bottom, but often the remains have been disturbed by the activities of later times.

That people moved in response to thedisplacement of the shore means that the remains from different periods are to be found at different elevation above sea level. Coast-bound finds have been made up to 155 m above sea level, which corresponds to about 5,000 BC. Many Bronze Age cairns are at levels about 30 m above sea level which corresponds to 1,000 BC. Coast-bound ancient remains can thereby be dated using shore displacement curves, based on Quaternary geological isostatic studies of lakes. At times it can be difficult to determine if a find is coast-bound. In such cases the shore displacement curves provide an oldest possible age. Archaeological finds connected to certain periods can also contribute for the creation of shore displacement curves.



Scematic diagram of land elevation and cultural development during 10.000 years. The remains on different hight above sea level reflects different time periods. Illustration by Lars Högberg.

Fossil Remains

The stock of anicent along the High Coast is not only large but also uncommonly wellpreserved. The reason is land uplift and its effects combined with low population density. When the land uplift affected the distance between the shoreline and the settlement the site lost its attraction. After move no new groups arrived to take prossecion of the abandoned settlement, which was therefore left undisturbed. The old settlement sites, today found in the fields of rubble or barren rock a substantial height above sea level, have seldom been affected by new forms of use that would have threatened their existence since the barren ground that resulted from the land uplift does not offer any other alternative than very extensive usage. Even in the cultivated areas there are examples of intact remains thanks to the fact that intensive land use has been limited to the best land. At the same time the ownership patterns and landscape structure have not opened the way for large-scale exploitation. Consequently, the degree to which ancient remains have been disturbed by cultivation remains low. Finds from Iron Age farms have been made, beneath the natural overlay, that in principle have remained undisturbed since a fire over a thousand years ago. Such fossil remains can be a source of an incredible amount of archaeological information that is vastly superior to the loose finds that are otherwise found in more heavily exploited cultivated areas. Even fossil fields with ardmarks have been found which provides unique opportunities to understand earlier land utilisation (Lindqvist 1996)

A further reason for the high degree of preservation of many ancient remains is that the inhabitants have made use of the large quantity of easily-accessible stone in the area, foremost from the rubble fields, for building purposes, e.g. markers and labyrinths. The construction of labyrinths has traditions throughout Europe but only individual examples remain in central Europe where they were generally built with sod. On the other hand, the labyrinths along the Swedish the coast were built of stone. Overgrowth also occurs very slowly in fields of rubble and rock where there is virtually no soil cover. Stone cairns are found along the entire Swedish east coast. At certain sites along the High Coast the local rapakivi granite has been used as a building material. It cracks vertically which results in a type of natural building blocks which when stacked without filler are considerably more resistant to weather and wind than cairns built with rounded rocks that easily roll off. Consequently, some of Sweden's best-preserved cairns are found along the High Coast.

This shipformed cairn is well preserved, thanks to due to the use of stones as building material, the slow vegetation growth and extensive land use in the aria (Västernorrlands länsmuseum/Murberget)

It can seem paradoxical that a sparsely populated area like the High Coast has considerably more registered immovable and visible ancient remains, than an area with a long cultural history like Skåne in the far south of Sweden. When a settlement site is abandoned in a densely populated area someone moves in quickly or reuses material. Perhaps even more important is

the later land use that results in the destruction of old remains. Not only is there an abundance of well-preserved ancient remains at the High Coast, it is also the area in northern Sweden that is most thoroughly studied by archaeologists. Many of the finds serve as the basis for archaeological interpretations related to human activity throughout northern Scandinavian (e.g. Gene and Överveda) (Baudou 1992). To sum up, it can be asserted that land uplift combined with low population density provides the High Coast with a special position concerning immovable anicent remains and the degree of preservation.

A Prehistoric Landscape

It is fascinating to think that what meets the eye as you gaze out towards the sea and archipelago is very similar to the landscape encountered by the first inhabitants some 7,000 years ago. The land uplift gives rise to a paradox where change leads to continuity. Vegetation and human activity influence the former shoreline, but since it is constantly reformed, and new islands rise from the sea, the shoreline retains its character. Today's shoreline is very similar to the shores where the first inhabitants landed their newly caught seals for slaughter, despite the fact that today that shoreline is now to be found 150 m above sea level. The extremely limited settlements close to the shore farmingreinforce this impression.

The landscape is very hilly, the bedrock often barren and the soil cover shallow. In the valleys alone, where the finer sediment was deposited, have people influenced the landscape to a greater extent through cultivation. On the whole, the area is sparsely populated. Although forestry is practised today parts of the natural forest of the countryside remains intact thanks to the unproductive land and rugged terrain. The terrain has also contributed to the retention until modern times of the old structure with family farms and forest grazing. Industrial agriculture and large-scale operations have not been profitable here. As a result the cultivated land has in many respects retained the structure that took form as far back as the early Iron Age (200–500 AD).

The hilly landscape also means that the shorelines of different ages are situated near each other. At the same time one can see remains or sites that have been inhabited by people from the Mesolithic period until today. The land uplift has resulted in ancient remains being spatially separated and well-preserved. The considerable differences in elevation have contributed to "compressing" the territory so that all eras are represented within a limited area – a prehistoric landscape.

Unique tapestry of different cultural patterns

As described above the High Coast is rich in well-preserved immovable ancient remains. In the prehistoric and historical overview the area's different types of ancient remains are presented in their context. What makes the High Coast unique is foremost all of the impressions left by different thecultural expressions within a limited area. This is where cultures met at their southerly and northerly boundaries respectively. During various periods the High Coast has served as a frontier, a borderland, between different cultures or activities, as a place where these cultures and activities became integrated and blended together. It is not each culture in itself but the fabric woven with different cultural patterns at a single site during the same period of time that is unique.

As early as the Mesolithic period it is possible to distinguish a north-south frontier zone at the High Coast, i.e. an area where the northern and southern hunting cultures met. With separate finds of picked axes and north Bothnia tools, from 5,000–3,000 BC, the High Coast reaches it northern and southerh boundary respectively (Westerdahl 1989). During the Bronze Age a boundary to the west, between the coast and inland, is accentuated as witnessed by the large number of cairns from the Bronze Age that are found along

the coast but completely absent inland. The cairns from the Bronze Age reflect south Scandinavian models but the bronze artefacts found have their origins toboth the south and east. On the other hand, the High Coast is completely devoid of asbestos ceramics, something that otherwise characterised the north-eastern cultural complex (Baudou 1992).

This borderland function appears to be even more manifest during agrarian times. The practise of agriculture began to spread in the area after the birth of Christ and the High Coast is the site of Sweden's most northerly Iron Age farmstead that indicates permanent buildings. Other borderland phenomenon, in addition to the long houses, are the typical central Swedish grave-fields that reach their northern limit just north of the High Coast. It is interesting that ambulating hunting groups continued to live parallel with these developments. They passed on the Bronze Age tradition of building cairns. Their primary sources of sustenance were fishing and seal hunting but they also hunted moose and beaver. These parallel cultures indicate the complexity of cultures and the different livelihoods that can to be characteristic for the High Coast. Even for the farmers hunting, fishing and seal hunting constituted very important complements right up until modern times. The community made an art of diverse occupations in a landscape characterised by limited arable land and the risk of crop failure due to early frost. All of the central occupations; hunting, fishing, agriculture as well as commerce, are represented in this area during the same period, from the first centuries AD and onwards. An occupation typical of northern Scandinavian, the nomadic reindeer keeping by the Saamis, was at least from 17th century an integrated part of life in the district.

The climate along the Gulf of Bothnia results in very special conditions where extremes like the southern agrarian culture and the Arctic hunting culture meet. The Gulf Stream in the Atlantic, together with the heat storing capacity of the Baltic, provide conditions for the world's most northerly cultivated landscape, with the exception of the Atlantic coast of Norway. The northern latitude means that it is never dark during the summer months. Winter brings a landscape more akin to the sub-arctic. During the darkest winter months the sun only climbs above the hillcrests for a few hours daily. The winter landscape, with snow, the frozen sea and ice hunting for grey and ring seal, the latter more a relic of the Arctic Sea, made the inhabitants part of the special hunting culture of the sub-arctic.

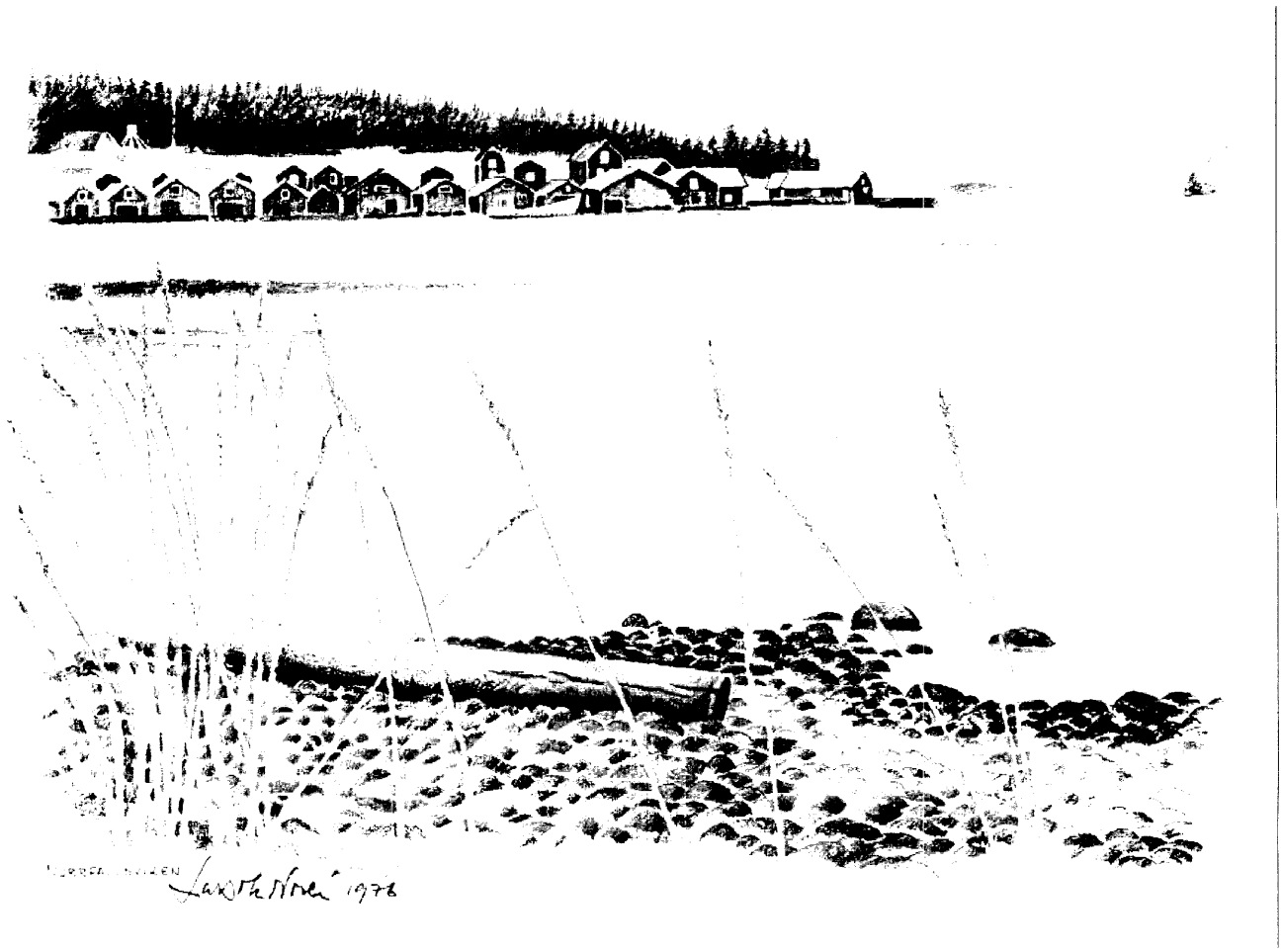
For a long period during the Middle Ages the expanding state power had its most northerly outposts around the High Coast. The area also served as a borderland between southern and northern transport zones of different nations, a circumstance that was to the benefit of merchants in the High Coast. The High Coast is also the most northerly area with an established summer farming organisation. The High Coast as a cultural boundary and tapestry of different cultural patterns combined with the high image of the cognitive maritime cultural landscapedegree of preservation with respect to ancient remains means that a very substantial part of northern Scandinavia's ancient history is represented in this small area.

The maritime cultural landscape

The maritime cultural landscape has been formed by people who adapted to living in surroundings marked by the sea. The natural coastal landscape is distinguished from the inland by the sea's influence on the climate, vegetation and soil. One can speak of a maritime culture where human activity, and also their conceptions, has been strongly associated with the sea. To gain an understanding of the meaning of the concepts maritime culture and maritime cultural landscape they must be viewed from the perspective of the sea. This maritime cultural landscape is considerably older than the cultivated landscape and in this region its continuity exceeds 7,000 years. Most of the High Coast was once under the sea. This means that all land in the area has at some point been shoreline. It was along the shorelines that the maritime culture had its centre, a centre that shifted due to the substantial land uplift in the area.

Seal hunting and fishing were what attracted the first people around 5,000 BC. Fishing has always been an important part of the local livelihood. The arrival of salt during the Middle Ages meant that the inhabitants could fish on a larger scale and from the 17th century until the 1950s fishing constituted one of the most important occupations at the High Coast. Seal hunting continued up to the 19th century and the methods developed in prehistoric times remained largely in use until the advent of firearms during the 17th century. Seal product such as fat, skin and fur, as well as fish, were sought after goods as early as the Iron Age, but their significance increased with the dramatic upswing in commerce during the Middle Ages. The church and state were more than happy to see that taxes were paid with these products. Proximity to the sea as a transportation route was another prerequisite for commercial development.

For many coastal residents the sea is their field. For most farmers in the High Coast fishing and 1986b). Even in stock-raising the proximity to the sea played a role in providing access to winter fodder at the beaches and shoreline meadows. Fish-meal was an important fodder supplement in later times. Without the sea's assets, transportationcapacity and commercial advantages the expansion of the High Coast's agricultural districts during the Viking Age and the Middle Ages would have been considerably more modest.



Many of the High Coast's ancient remains have a maritime connection such as seal hunting settlements, hut foundations, ports, signal beacon hills, fortifications and labyrinths. In later times, from the 17th century, there is the addition of the fishing hamlets. Over and above these firm traces of human activity in the maritime cultural landscape there is another aspect: the cognitive landscape i.e. people's world of ideas in relation to the sea. The cognitive landscape is found in the heads of people and the bulk of its features are gone today. There remains however a few remarkable expressions like the mysterious labyrinths or the fact that the more than 200 Bronze Age cairns found along the High Coast are all placed parallel with the shoreline of the day. Another expression is the peculiar seamen's chapels that were not only visited for religious reasons but also played an important role as meeting place for the creation of a functioning administration and a system of rules within the fishing hamlets. Many of the place names have a maritime flavour, which also contributes to the image of the cognitive maritime cultural landscape.

The same types of maritime cultural remains as described for the High Coast can also be found at other locations around the Baltic Sea. At the High Coast there is however a continuity in the maritime activities over a period of 7,000 years which, due to the limitation on agriculture, has retained its significance. This continuity combined with the land uplift means that there are maritime remains from all periods within this limited area, a maritime cultural landscape. This circumstance makes the High Coast very representative of a type of gainful activity that today has an entirely different character.

Comparative areas

The High Coast's nomination to the UNESCO World Heritage List is based on the geological conditions and the dramatic isostatic land uplift. The only relevant criterion for the selection of comparative areas is coastal areas with a land uplift comparable to the High Coast. Hudson Bay in Canada is the only area meeting that criterion. A comparison with the Kvark area was called for at the IUCN meeting in Marrakech 1999.

Hudson Bay

Hudson Bay is the area most similar to the High Coast both with respect to ice-melting and the land uplift process. To cover a range of 8,000 years of coastline i.e. today's coastline and the highest coastline respectively would require an area many times the size of the High Coast. The arctic climate and tundra vegetation offers completely different conditions for people living around Hudson Bay. The peoples who have long populated the area, Inuit and indians, have been hunting cultures whose impact on the landscape has been small. Knowledge of the cultural development around Hudson Bay is very limited and cannot be compared with the level of knowledge concerning the High Coast. Not only is Hudson Bay an unexplored archaeological area, historical documentation first appears during the 19th century when forestry and fur-trading make their entrance (Bone 1992)

The Kvark area

The highest point of Kvark area is 20 m above sea level, which corresponds to a shoreline 2,000 years ago. This means that the area's cultural history dates back to the early Iron Age. From an archaeological perspective the area has been studied much less than the High Coast. In historical time there are parallels between the Kvark area and the High Coast with respect to the maritime activities.

Conclusions and Assessment

Cultural landscapes with prehistoric remains in situ exist generally in Scandinavia. The combination of the world's highest isostatic land uplift and the cultural landscape that reflects the effects of the land uplift make

the cultural landscape of the High Coast particularly interesting. The dramatic isostatic land uplift, the hilly topography and an interesting and varied cultural history have given rise to a cultural landscape that is in itself unique and important to preserve for future generations. That the highest shoreline is only a few kilometres from the present shoreline contributes to well-preserved shoreline remains from continuous human activity over the course of 7,000 years are to be found within a limited area. The volume of ancient remains in the area is remarkable.

Knowledge of the traces of human activity in comparable areas is extremely fragmentary. The analysis and assessment is therefore, given the current level of knowledge, that the High Coast does not fulfil the criteria for nomination for inclusion on the UNESCO World Heritage List based on its qualities as a cultural phenomenon. Future scientific work might come to change that picture.

The cultural landscape illustrates the effects of the land uplift. This account of the cultural landscape serves therefore as an important complement to the geological and biological descriptions in the nomination document concerning the High Coast as a World Heritage Site.

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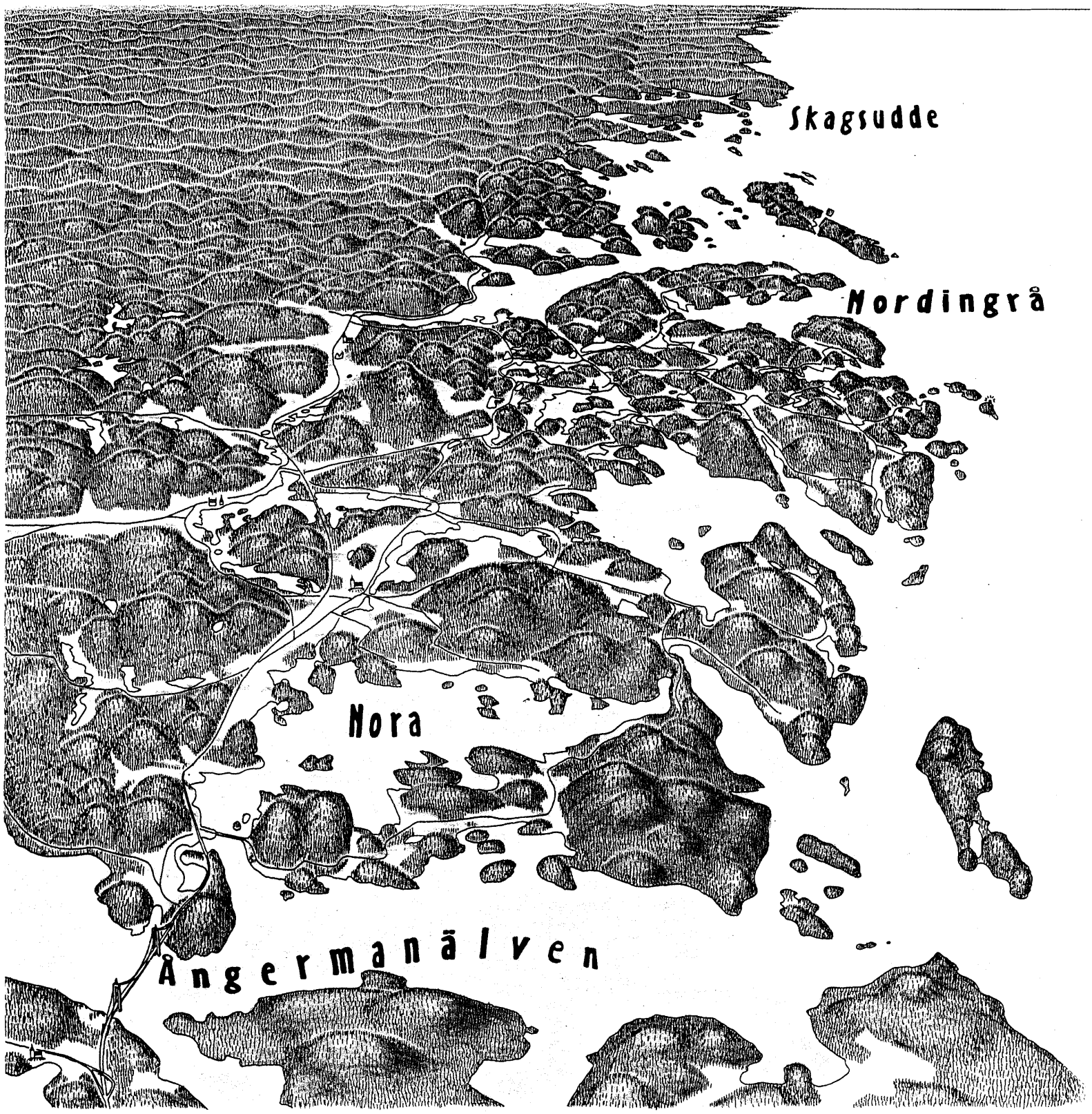
The High Coast

5000 Years of Human History



VÄSTERNORRLAND COUNTY
ADMINISTRATIVE BOARD

ENCLOSURE 5

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Foreword

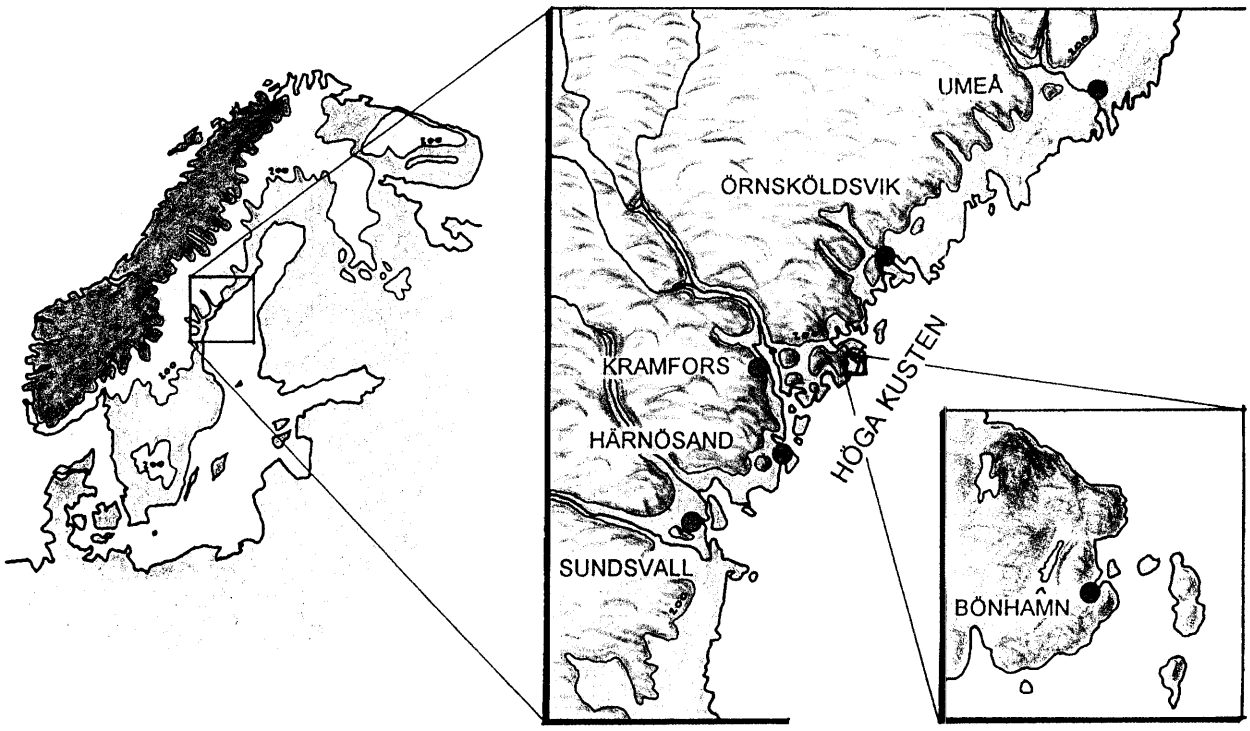
This booklet on the cultural history of the High Coast has been commissioned by the Västernorrland County Administrative Board, in connection with the nomination of the area to UNESCO as a World Heritage site. To be so designated, a historical or natural setting must be regarded as unique on earth and especially worth preserving for future generations.

At present, there are eight World Heritage sites in Sweden. The most recently designated, in 1996, is the Laponia natural area in northern Sweden. In addition to the High Coast, there are two other natural areas currently under consideration: the flatlands of Stora Alvar on Öland, and the Stockholm archipelago.

What makes the High Coast so special is its geological history, which is unique on the planet. That history includes a dramatic elevation of the landmass, which is still in progress. The sharp upward thrust of the land gives the High Coast its special character, providing unusually favourable conditions for the study of geological layers and processes.

Those features of the landscape that have been influenced by human activity provide an additional, and no less important, focus of interest. Due to the distinctive land elevation, it is possible to derive a clear picture of human development in the area from the Stone Age to the present. This booklet attempts to explain the region's history in a way that is interesting and easy to grasp.

Robert Olsson
Regional Inspector of Monuments and Sights



THE HIGH COAST

5000 Years of Human History

The steep cliffs along the northern Baltic coast of Ångermanland are quite distinct from the flat coastal areas to the north and south. The "High Coast", as it is known, ranges in elevation from hilltops at 300-350 metres above sea level to water depths of 250 metres.

The unusual bedrock includes basic granites, diabase, sandstone and gabbro. The landscape is rolling, with steep hillsides, narrow valleys, and numerous lakes and bays.

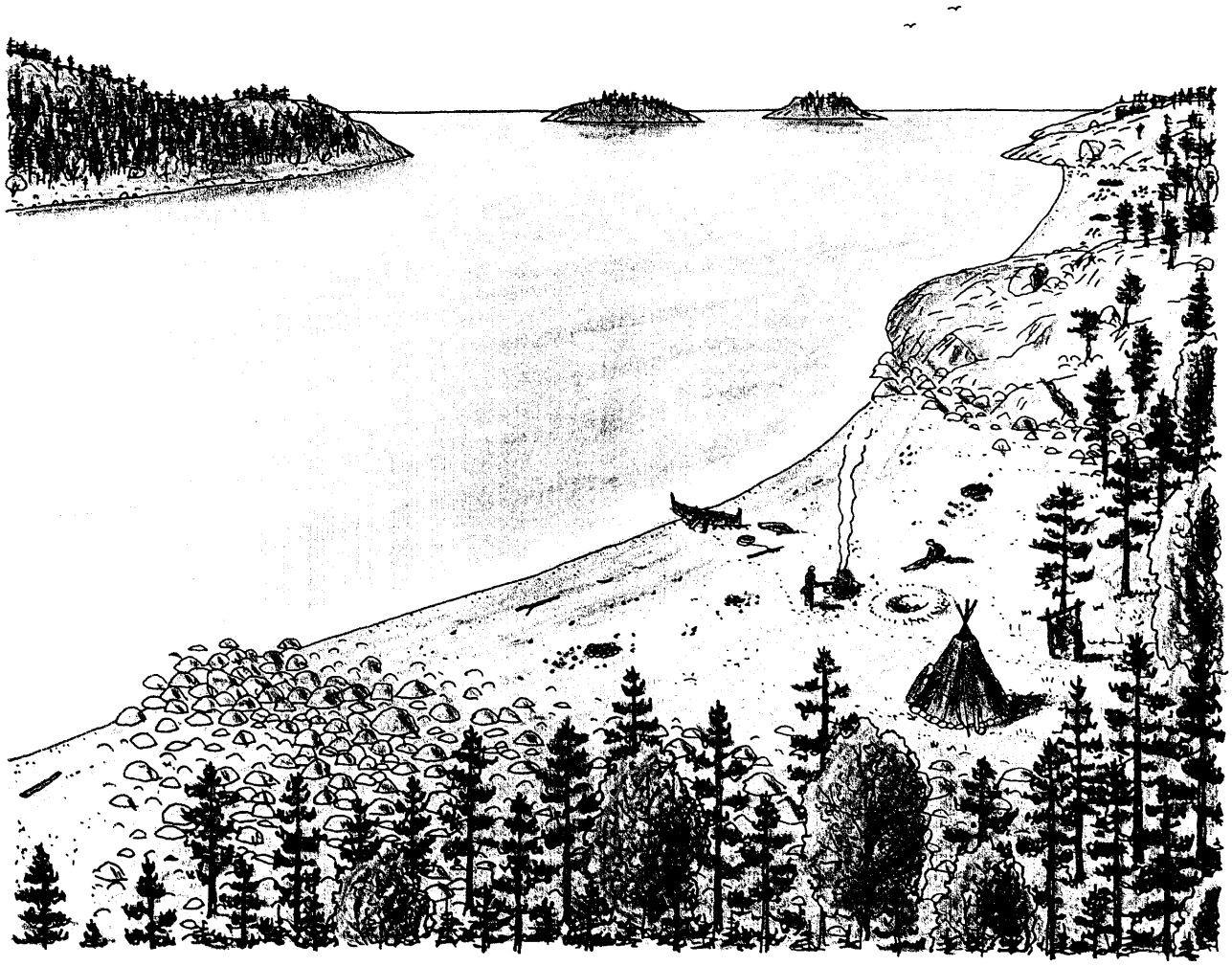
This part of Sweden was pressed down under the weight of the last ice-age glacier, to a depth that may have been as great as 800 metres. Since the retreat of the glacier, the former coastline has in places risen to 285 metres above current sea level. The process of land elevation continues today, at a rate of nearly nine millimetres per year.

This rapid rate of elevation, unique on earth, has strongly influenced the area's natural and human history. The crests of the hills have been washed bare by the waves of the sea, and the sediment has been transported to the valley floors. Traces of ancient shorelines can be seen in the rows of stone rubble lying high up on the hillsides.

Throughout history, humans have sought their livelihood along the shores of lakes and seas. There are many signs of human activity from former times along ancient shorelines, now located inland, high above the present sea level. Since the rate of land elevation is known, it is fairly easy to estimate the ages of these ancient remains on the basis of their current elevation.

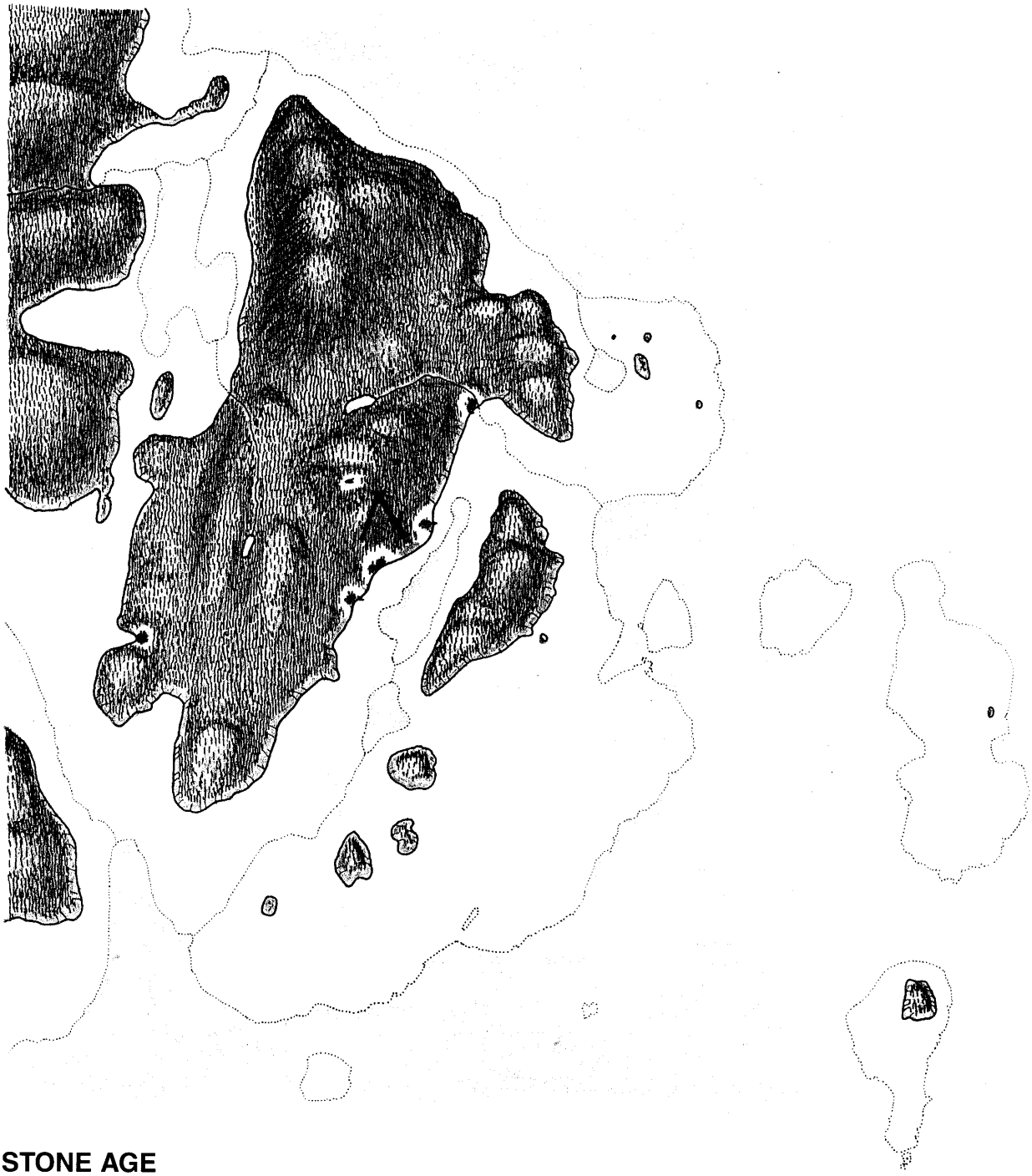
Due to the hilly terrain of the High Coast, the ancient shorelines lie quite near the present-day beaches, despite the large differences in elevation. It is therefore possible to find, within a small area, remains from the Stone, Bronze and Iron ages, and on up to the present.

This is illustrated on the following pages with six depictions of an area near Bönhamn fishing camp in Nordingrå Parish. The area measures five square kilometres, and includes many remains from different eras, including those depicted here: the Stone, Bronze and Iron ages, the Middle Ages, the 19th century and the 20th century. The historic sites shown in the illustrations are documented in a register for Nordingrå Parish maintained by the Central Board of National Antiquities, which may be viewed at the offices of the Västernorrland County Administrative Board and the County Museum.



This small sandy beach lies sheltered behind a chain of islands. A hunting party has set up camp after beaching its canoe. Their tepee has been raised. Stones heated by the fire have been placed in a cooking pit. A catch of seal and fish is being prepared. The flesh is roasted in the cooking pit, and the drippings are processed into oil used for fuel and illumination. The sealskin is stretched for later use as clothing or tent material. Today, no traces of the campsite are visible on the ground. However it is possible to find shattered fire-stones and scorched bone fragments beneath the moss of the sandy soil in the forest above Brattsvedjan croft near the lake Nord-Mjösjön.

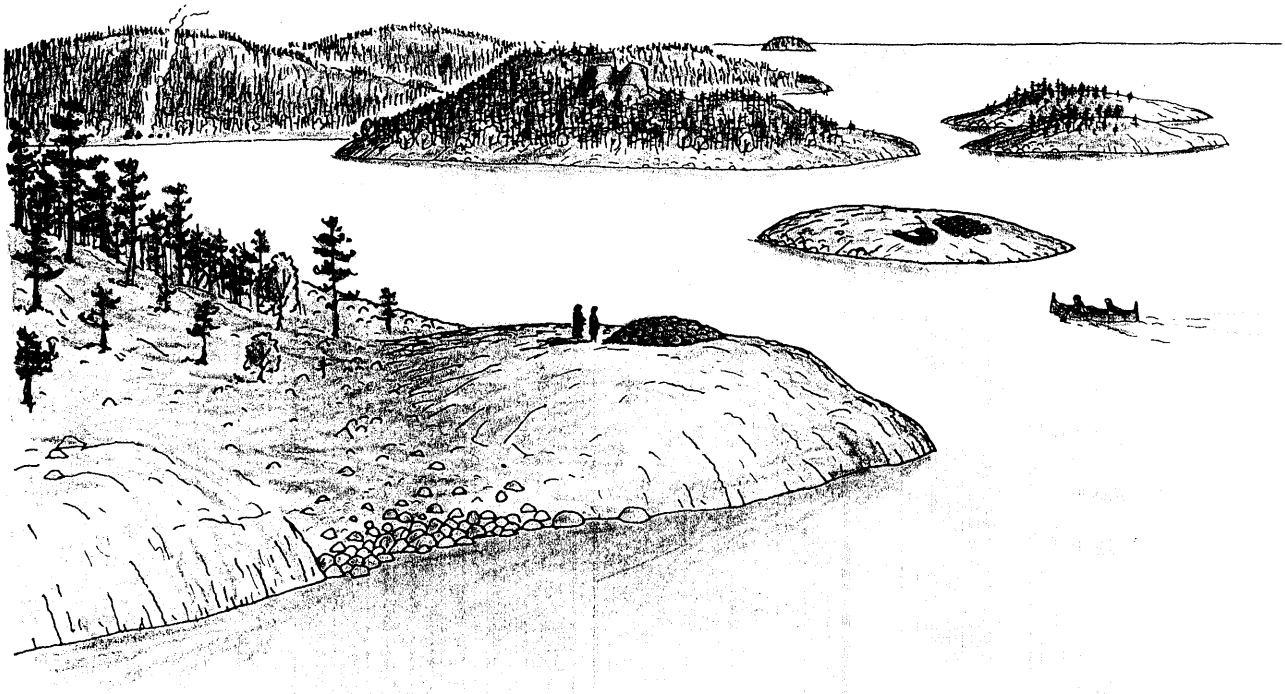
This dwelling site is registered as number 234 by the Central Board of National Antiquities. On the map to the right an inverted black V indicates its location and the direction of the picture.



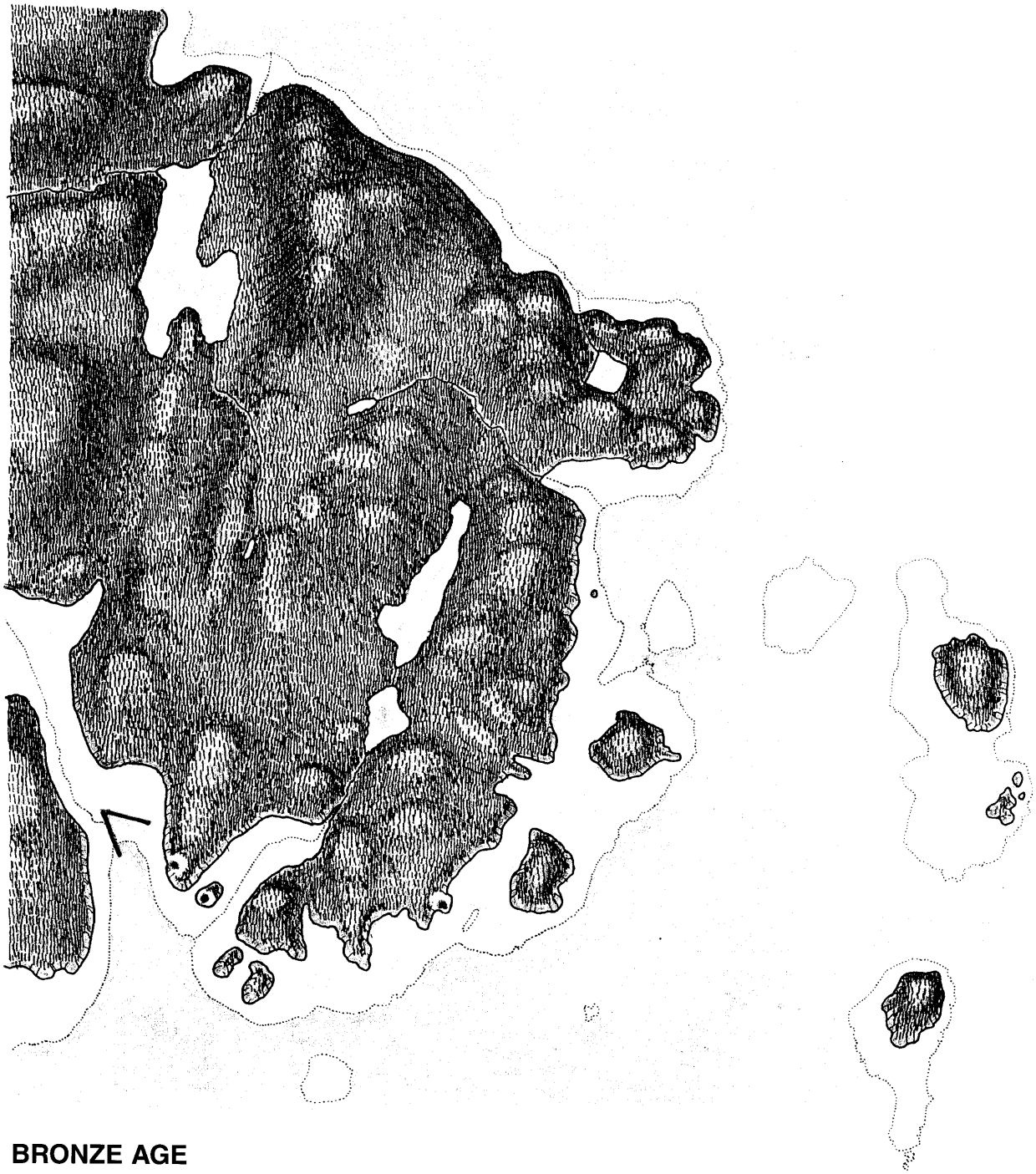
STONE AGE

2500 BC
The land has risen 55 metres since the Stone Age.
The present coastline is indicated by the lighter blue colour.

We see the varied landscape of the archipelago with islands, bays and channels. The climate is warmer than today's, and the forest consists of pine, birch, hazel and other broad-leaved species. Five Stone Age dwelling-sites, indicated on the map in red and yellow, have been discovered along the shoreline of this period. Today, those sites are located deep in the forest at a considerable distance from the sea; but during the Stone Age they were situated on sheltered sand beaches at the head of bays or behind other islands. Remains discovered to date consist of shattered fire-stones and small fragments of scorched bone which indicate the preparation of food from game animals, probably seals. A quartz arrowhead typical of the period has also been found in a cave high up on one of the hills. Most likely, these are simple campsites used by small hunting parties from a semi-nomadic race of hunters and collectors who visited these locations in the outer archipelago during certain times of the year to exploit marine resources such as fish and seals. Their stationary winter dwellings are presumably located further inland.



Heaped on rocky outcrops at either side of the entrance to one of the many bays are stone mounds where a family of hunters and collectors has buried its dead. The bodies were cremated and the mounds carefully constructed over the remains of the funeral pyre. The burial mounds, which are quite visible to anyone travelling by boat along the coast, indicate that there is a dwelling site deeper in the bay. Today, the former bay is a valley floor with farmland. The burial mounds lie on a hilltop overlooking the fishing camp at Mjösand and are registered as national antiquities no. 136 and 137.



BRONZE AGE
1000 BC
The land has risen 30 metres since the Bronze Age.

The land continues to rise from the sea and begins to resemble the present-day landscape, but the bays remain narrow and deep. The climate is gradually becoming colder and damper. Spruce trees begin to encroach from the north, displacing the broad-leaved forest.

The human inhabitants still sustain themselves with hunting and collecting, but have adopted a new burial method of building stone mounds over the remains of their dead. Although many Stone Age dwelling-sites have been found in the High Coast region, no traces of graves from that period have yet been discovered. There are however hundreds of distinctly visible burial mounds from the Bronze Age, although it has not been possible to firmly establish the location of the dwelling-sites.

There are over 2,000 known burial mounds along the coast of northern Sweden. They were built on rocky outcrops near the water's edge in highly visible locations, probably to stake out territorial boundaries claimed by local groups of hunter and collectors. Within the area illustrated above, there are three burial mounds located about 30 metres above current sea level, indicating that there may have been a dwelling-site deeper in one of the bays.

On a rise above a lake, Älgsjösjön, lies a farm with a long house built of timber, birch-bark and clay. The occupants and their domestic animals dwell under the same roof. The farm also has a storehouse and a smithy. On the slope down to the lake, the farmer ploughs a small patch of farmland with a simple wooden plough. Lying amidst the farmland are mounds of cleared fieldstone. A fishing boat is pulled up on shore, and a hay-meadow stretches along the shoreline. Farm animals graze in the nearby woods. In the family graveyard near the main house, the dead lie buried under mounds of earth and stone. Another farm with its family graveyard can be seen on the opposite shore.

According to tradition, King Ramme lies buried here. The site is named Ramåkern, probably after a man with the ancient name of Hrafn who may have been the first settler. The site is occupied today by a farmhouse, and the land consists of overgrown cropland and wooded pastures. A main road runs through the area. The remaining traces of the Iron Age farm consist of some terraced land and two graveyards, one with three and the other with five burial mounds. These are registered as antiquities no. 21 and 22. The farm on the other side of the lake is registered as no. 20.

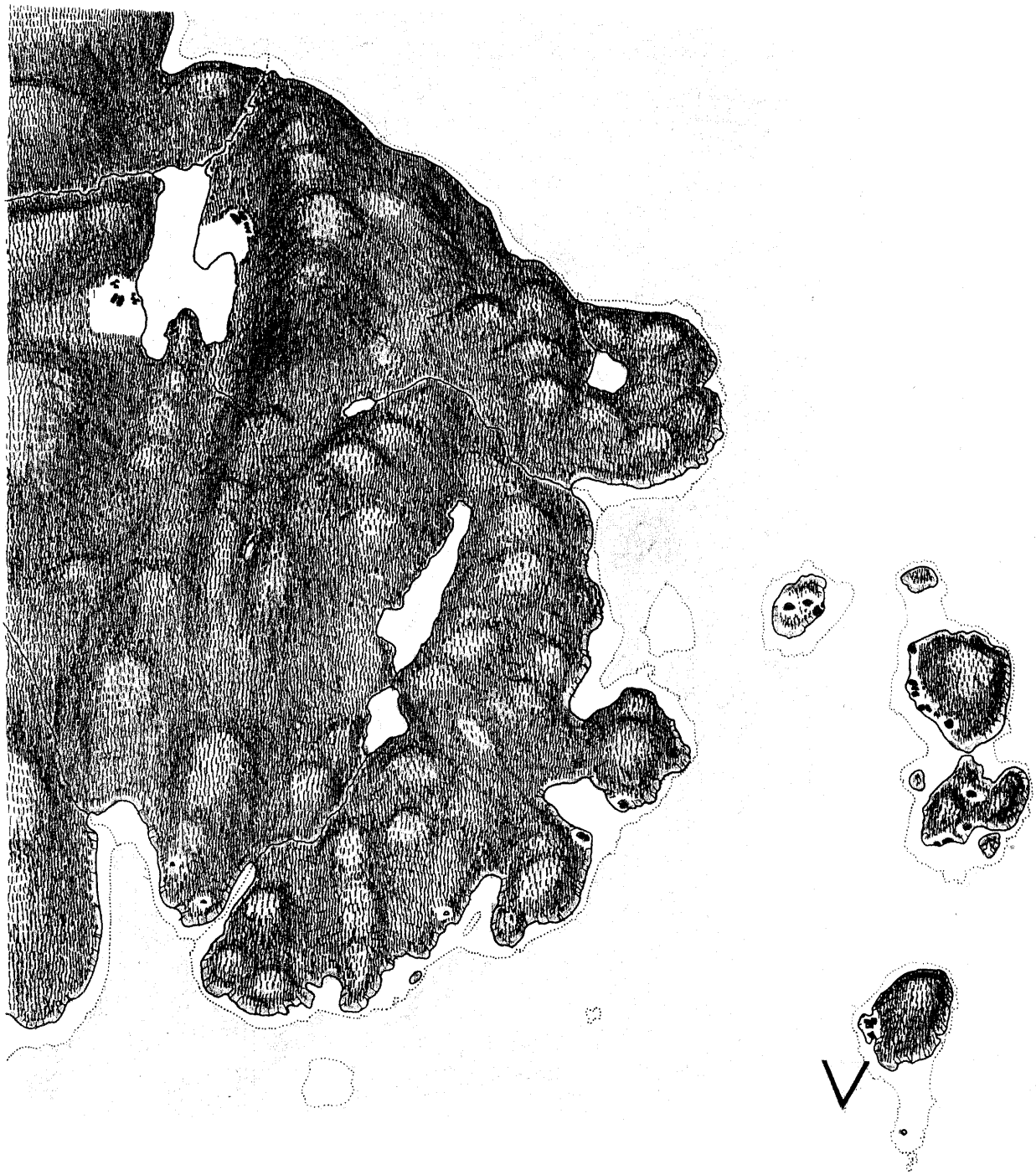
IRON AGE

Agrarian Economy
500 AD
The land has risen 15 metres since the Iron Age.

Agriculture came to this region around the time of Christ and farming made year-round residence in the same location possible. Fields are cleared on the fertile sedimentary soils deposited in ancient bays whose floors now lie high up on the valley flanks. The dwelling-sites are isolated farms surrounded by vast forests. Many of the names given to farms and watercourses during this period have survived to the present day. Farmhouses are long and solid, with room enough for an extended family and its domestic animals. The family graveyard lies nearby.

The two graveyards in the illustration indicate the presence of farms on opposite shores of Älgsjösjön (or perhaps a single farm that changed location).

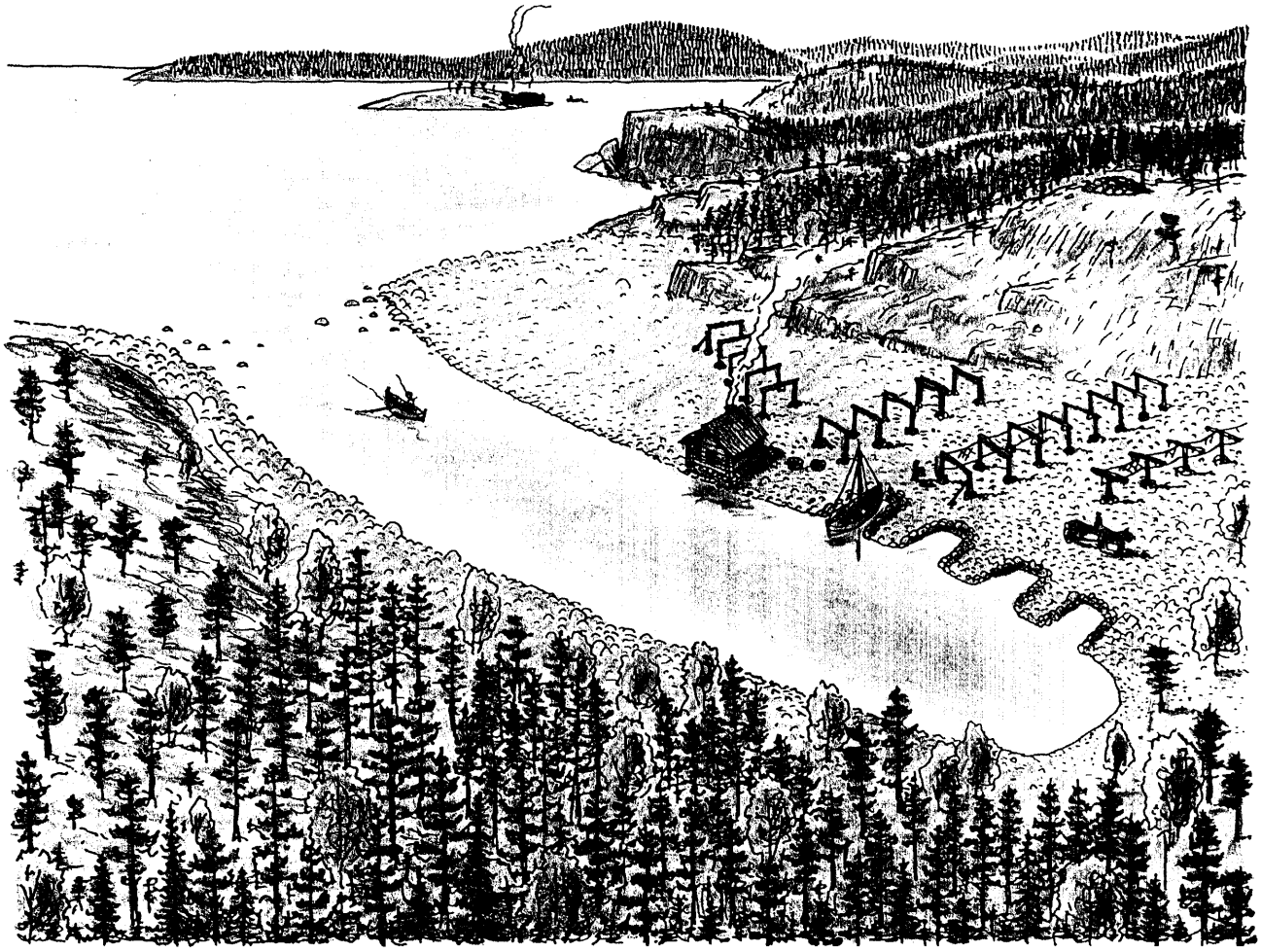
On the island of Högbonden is a seal-hunting camp with five huts that have been erected on a small patch of stone rubble. The camp is situated amidst the shelter of rocky outcrops on the island's leeward shore. The huts are light constructions of wooden poles and animal skins, and the interior floors have been cleared of stones that have been placed around the outside walls. To get within harpooning range of the seals, the hunters use skis and sledges to traverse the late-winter ice, or boats in open water. Today, the site is fifteen metres above current sea level, and lies beside a trail from a boat landing to a tourist hostel on the crest of the island. Only the rows of cleared stones remain, indicating where the huts once stood. There are similar hut remains, as well as some burial mounds, on other islands in the vicinity. This site is registered as antiquity no. 235.



IRON AGE
Hunting-based Economy
500 AD

The land has risen 15 metres since the Iron Age.

Today at the 15-metre level, in addition to the farm-site graveyards, there are four burial mounds of the Bronze Age type along the shoreline from the Iron Age period. These "new-coast cairns", as they are called, suggest the lingering presence of an older form of society based on hunting. On the islands at the outer edge of the archipelago there are also over twenty rubble-stone sites that probably served as seasonal camps for seal-hunters, possibly connected with the new-coast cairns.



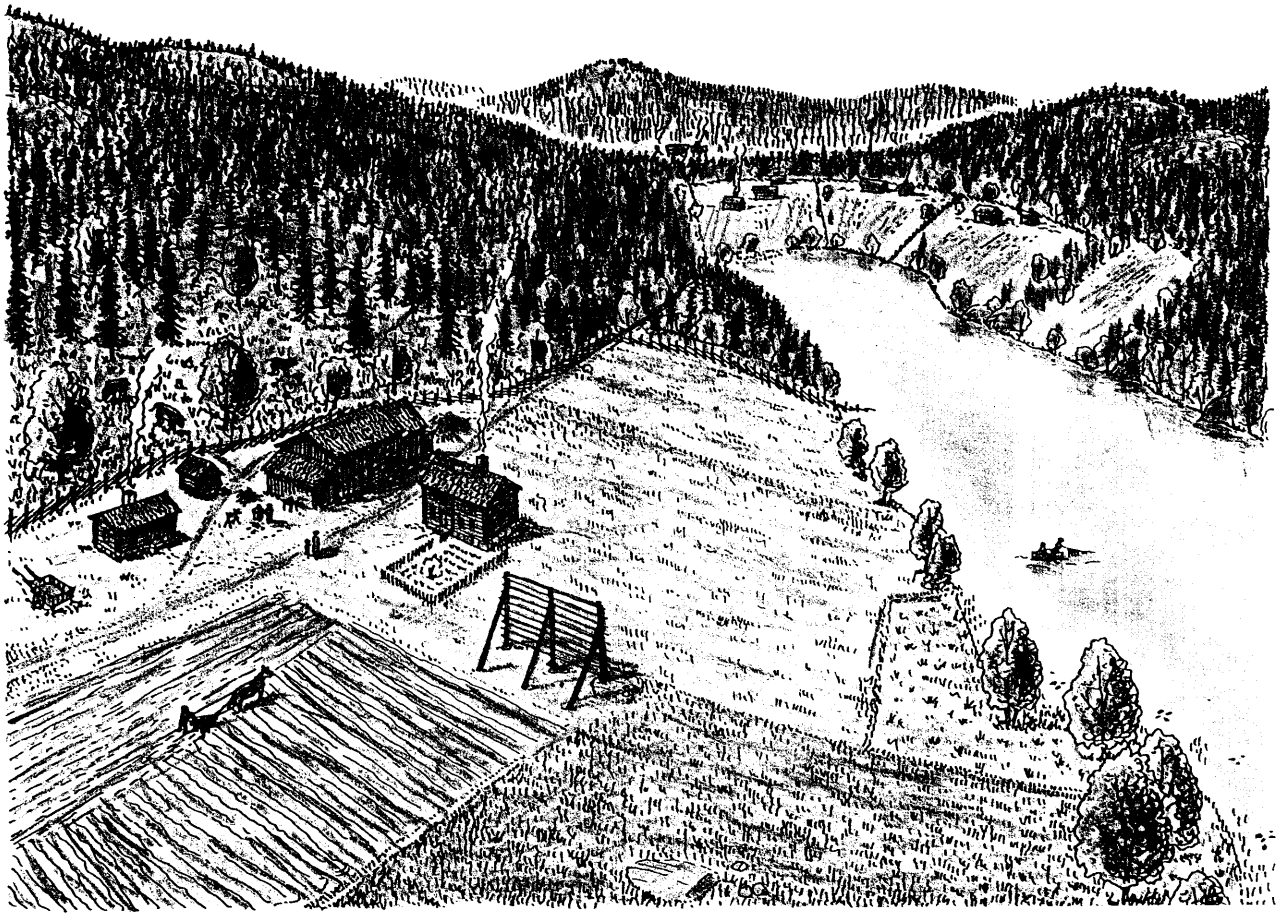
The little fishing camp at Mjöviken includes simple wooden cabins, several small boat-landings and net-drying racks. The site offers excellent shelter deep in the narrow bay. The ancient bay has since been cut off by the process of land elevation, and is now a small lake located a short distance from the sea. On the hill above the camp a Bronze Age cairn can be seen indicating the shoreline of a previous era. On the island of Norrflasen in the background there is another little fishing camp that has also been abandoned.

The remains of the ancient fishing camps consist of simple building foundations of loose stone, shallow depressions in the stone rubble of the former beach and small piles of stone that were used to support the poles of the drying racks. All the wood has rotted away. The fishing camps are registered as antiquities no. 151 and 200, the Bronze Age cairn as no. 34.

MIDDLE AGES
1500 AD

The land has risen 5 metres since the Middle Ages.

Human settlement still consists of two isolated lakeside farms, one at Älgsjösjön and the other at Mjösjö, which form the nuclei of the present-day villages bearing the same names. The long houses of previous times have given way to a larger number of smaller log buildings. The local populace has been converted to Christianity, and the dead are buried at the parish church in Nordingrå. The three small camps with cabins, boat landings, net-drying racks and even a chapel, indicate the central importance of fishing. Local farmers use some of the fishing camps, while others belong to the fishermen who sail north from Gävle at the start of the fishing season. As a result of land elevation, the abandoned camps are now three to five metres above sea level.



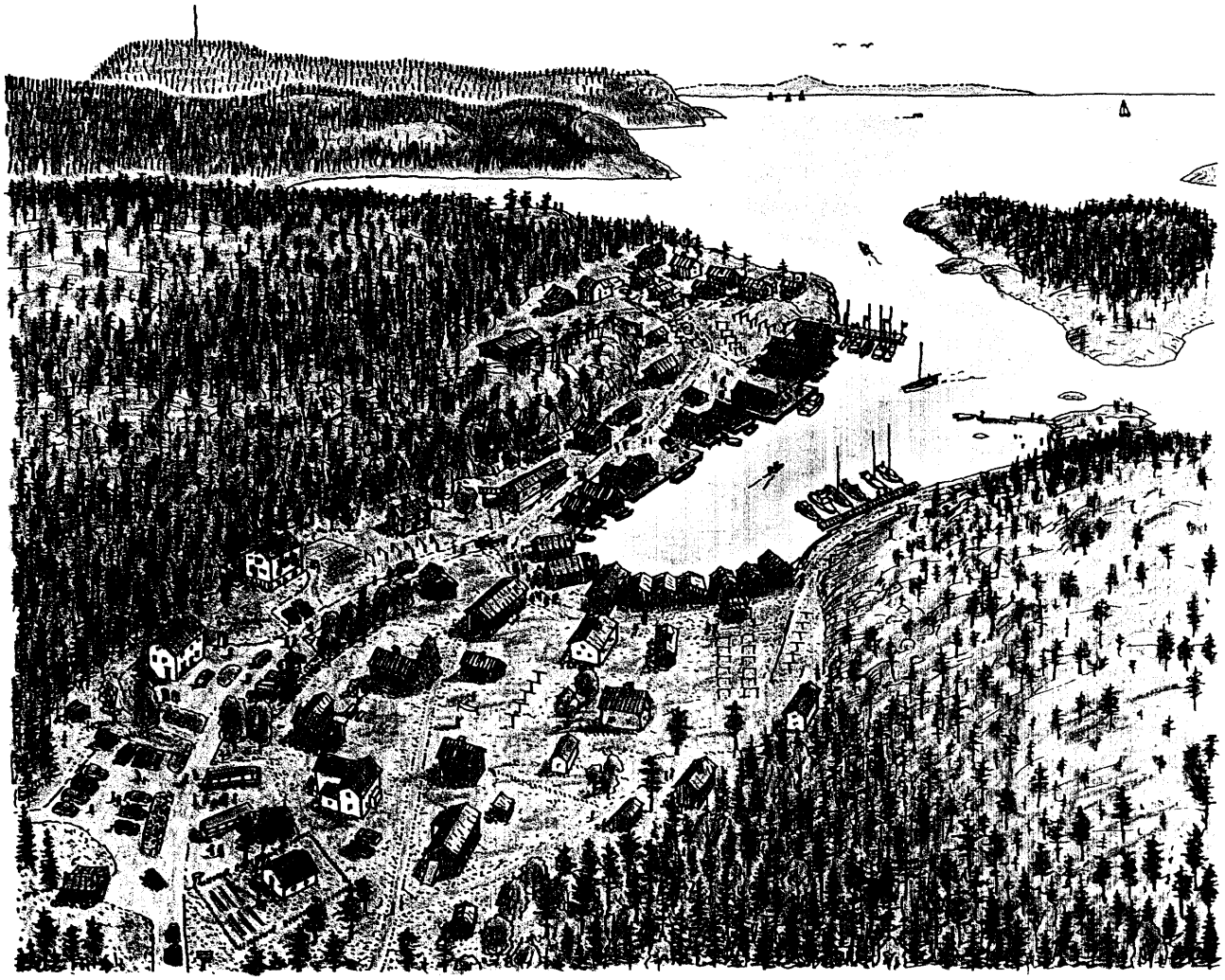
Along the lakeshore of Nord-Mjösjö are five crofts on the poor farmland of the sandy slopes. In the foreground is Brattsvedjan croft, first settled in 1829. The log buildings are typical of the High Coast, including a simple dwelling with a low attic, a barn, a detached bakery and a grain-storage shed. The deed from 1829 stipulates the crofter's right to a boathouse at Bönhamn harbour and a mill on a nearby creek, as well as firewood and timber from the forest, where the grazing of farm animals was also permitted. Today, the barn is torn down and the dwelling is used as a summer cottage. In the forest where the cows are grazing is the Stone Age dwelling-site registered as antiquity no. 234, as described on page 6.

19th CENTURY

The land has risen 1 metre since the 19th Century.

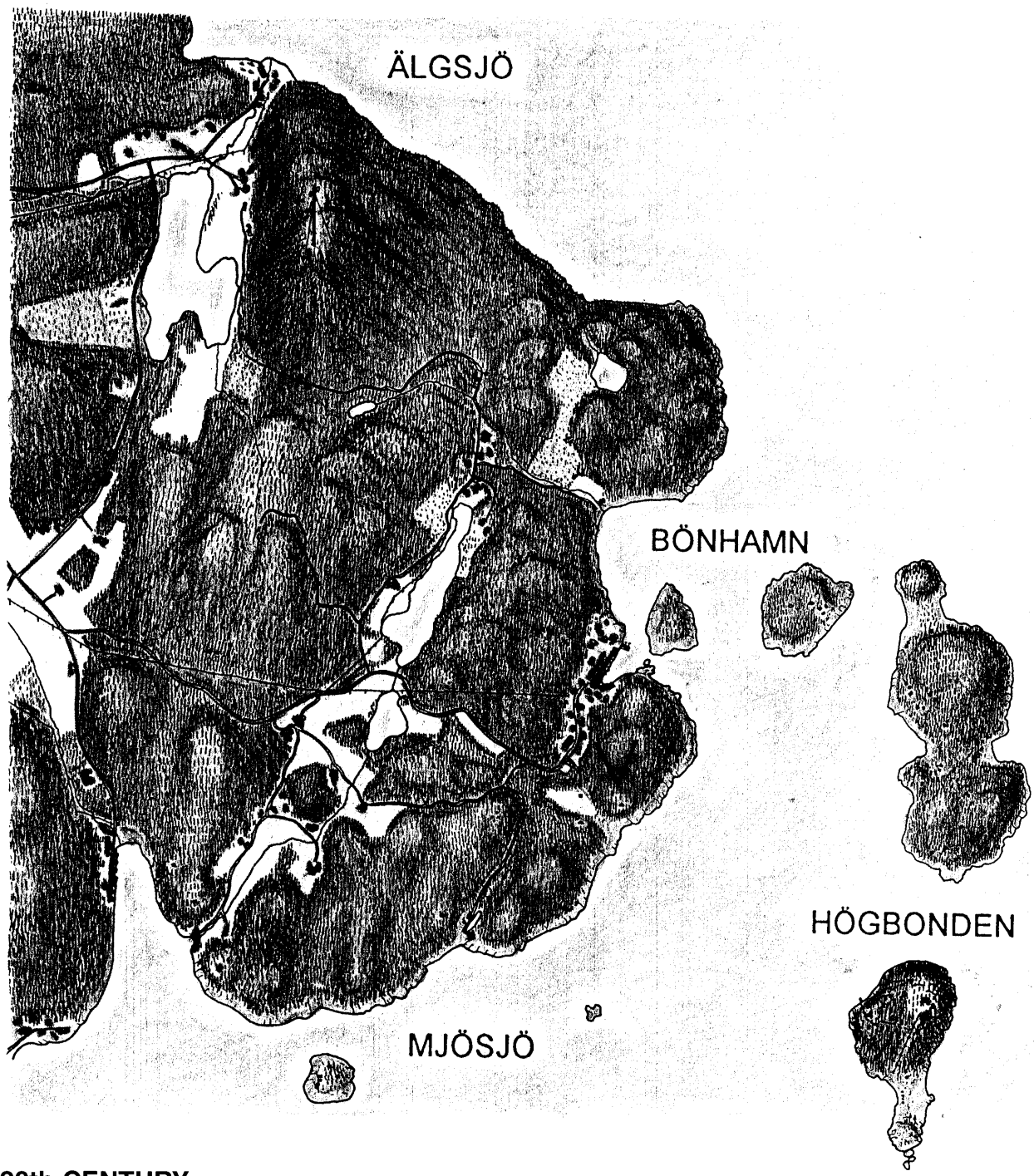
Due to rapid population growth, the number of farms increases and all arable land is put to the plough. Both villages, Älgsjö and Mjösjö, now include two or three homesteads and a dozen or so crofts. A summer grazing area is established. New fishing camps sprout up, the largest at Bönhamn. Narrow wagon-roads link the settlements. Natural resources are put to maximum use, as witnessed by the grain and shingle mills, facilities for linen-processing and brick-making, sand and clay pits, peat bogs and charcoal production.

In winter, the Laplanders drive their reindeer herds to the coast in search of good grazing. There are some twenty hollows in areas of stone rubble that may be traces of their storage pits.



The fishing camp at Bönhamn is a popular destination for summer tourists. The parking lots are filled with cars and busses, the harbour and docks occupied by sailboats and motorboats. The tourist boat to the island of Högbonden departs every other hour. Hordes of visitors in light summer clothes stroll along the narrow lanes between the former cabins and boathouses that have been converted into cafés, shops and galleries. Artists, hikers and bathers frequent the cliffs and rocky outcrops. Far off on the horizon one can see boats of all types and sizes as they explore the waters of the High Coast.

In winter, a pervasive stillness envelops the area. The little community is kept alive by a handful of permanent residents until the following summer's reawakening.

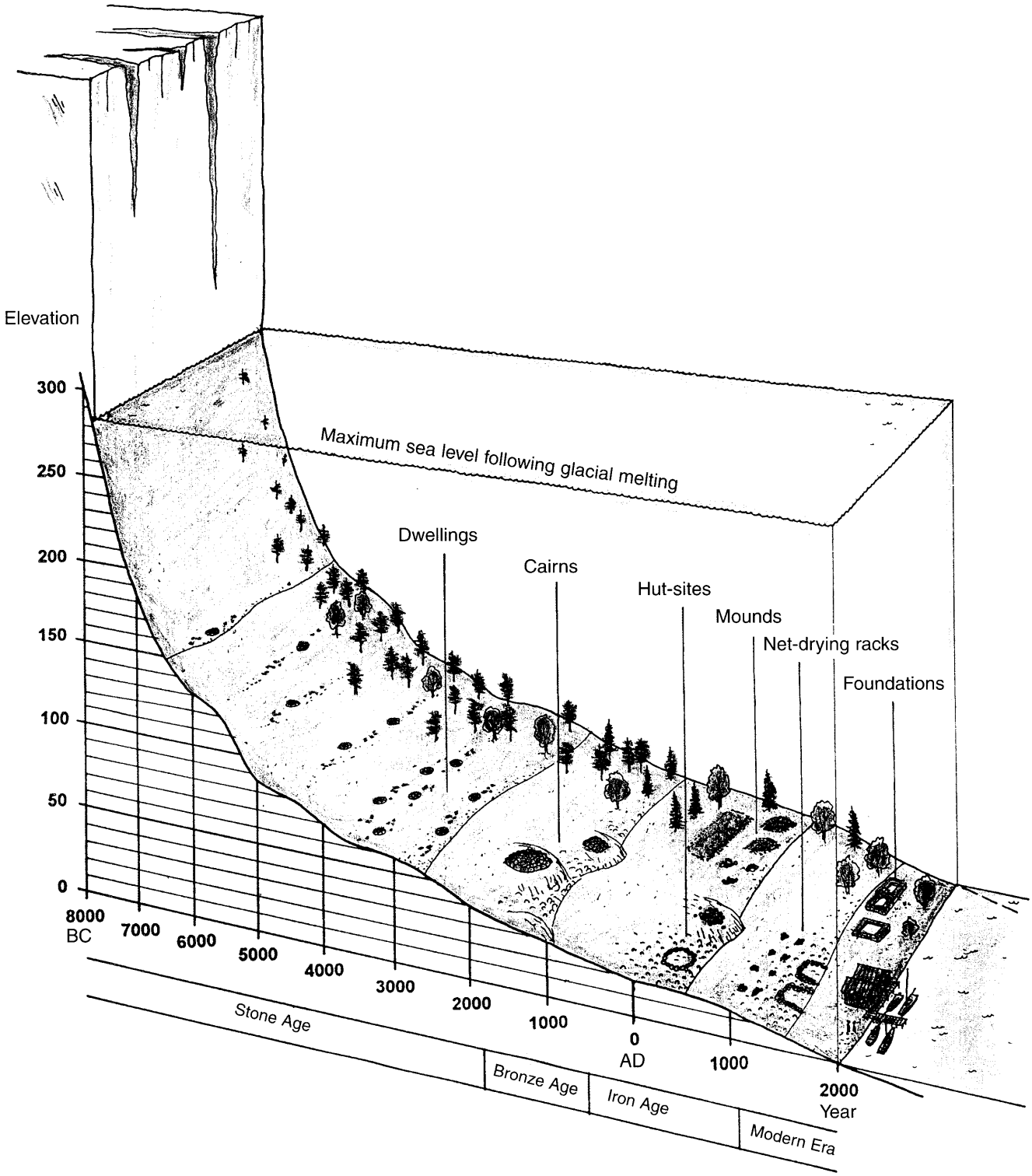


20th CENTURY

Modern industrial society extends its influence, and farming loses its significance. Many farms and crofts are abandoned or converted into recreational homes. The amount of cropland declines, and much of it is overgrown. Logging machines clear-cut the forest, leaving the "open landscape" of modern times. New roads and power lines are cut through the countryside.

A cableway and lighthouse, the second highest on the Swedish coast, are built on the highest point of the island of Högbonden. A telecommunications mast stretches skyward from the 200-metre summit of the hill at Älgsjö. Local industry emerges; a sawmill, a shingle mill, and a manufacturer of tins for the local speciality, fermented Baltic herring. Small clusters of villas are built near the industrial areas.

Technology and communications develop at an increasingly faster pace. Industrial society is being transformed into an information and recreation society. The small industrial operations are closed down or converted to other kinds of production. The lighthouse on Högbonden is now a tourist hostel. Commercial fishing has ceased, and Bönhamn harbour has become a place of sailboats and tourist facilities. The nets of fishermen have been replaced by those badminton enthusiasts.



Schematic diagram of land elevation and cultural development along the High Coast during the past 10,000 years. The various periods are illustrated with typical remains at their current heights above sea level.

THE HIGH COAST

ENCLOSURE 6

PICTURES OF THE HIGH COAST

April 2000

The County Adminstration of Västernorrland

Text: Mats Henriksson
Cover photo: Coastal landscape (Photo: Jan Lundqvist)
Printers: Color Tryck, Härnösand, 2000

NORDIC ENVIRONMENTAL LABEL
341 206

Pictures of the High Coast Area

This report presents pictures of the High Coast area. The presentation is divided into five sections with (1) – the area's landscape and natural beauty, (2) - the geological formations linked with the land uplift process and natural phenomena, (3) – the cultural-historical sights of note, (4) -the flora and fauna plus (5) –art and artistic photography from the area.

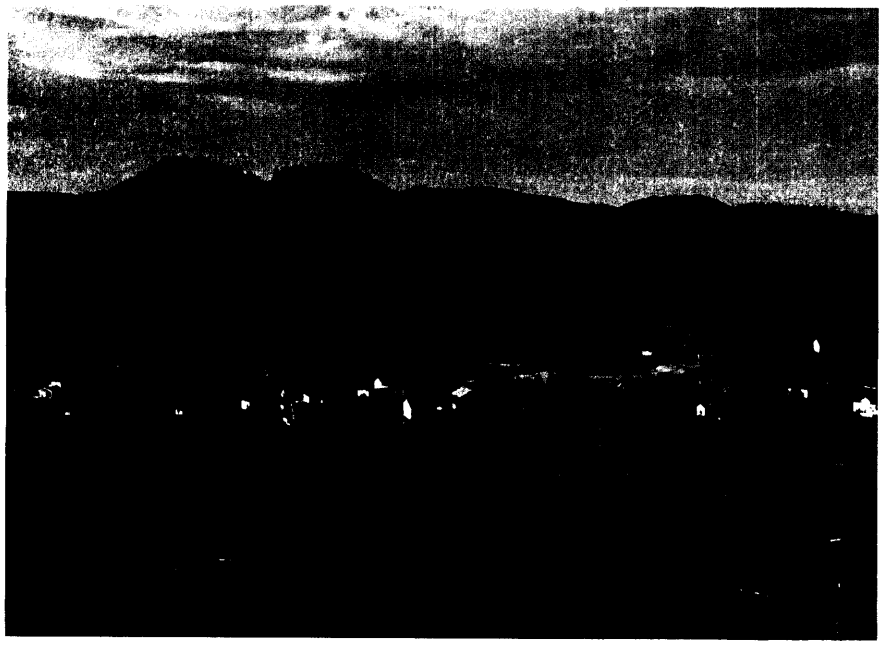
1 The Landscape and its Natural Beauty

Picture 1.1 Aerial view of Skuleberget and Ullångersfjärden. There is a cableway to the summit of Skuleberget which makes it easy to reach this hill with the highest shoreline in the area. From the summit the view of the sea and surrounding hills is marvellous. (Aerial photo: Metria)

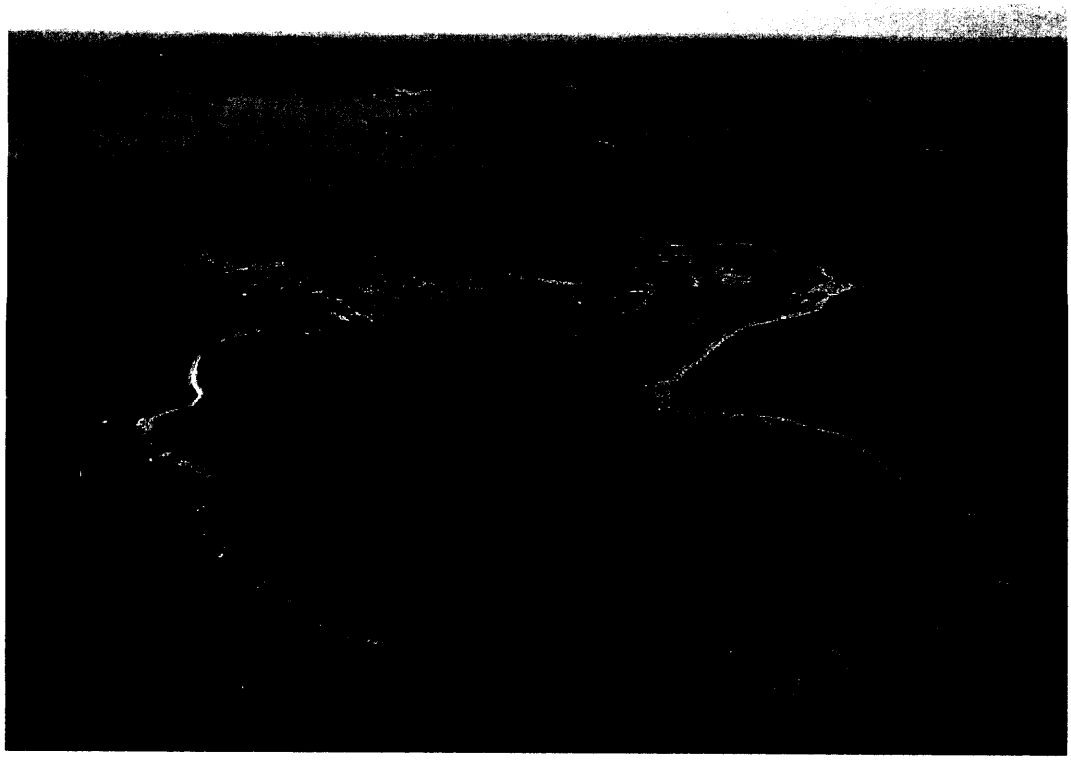
Picture 1.2 Aerial photo of the inland at the High Coast. This is primarily forested land with interspersed, small-scale agricultural land in the valleys. (Aerial photo: Metria)

Picture 1.3 Winter scene captured from the summit of Skuleberget. (Photo: John Chang McCurdy)

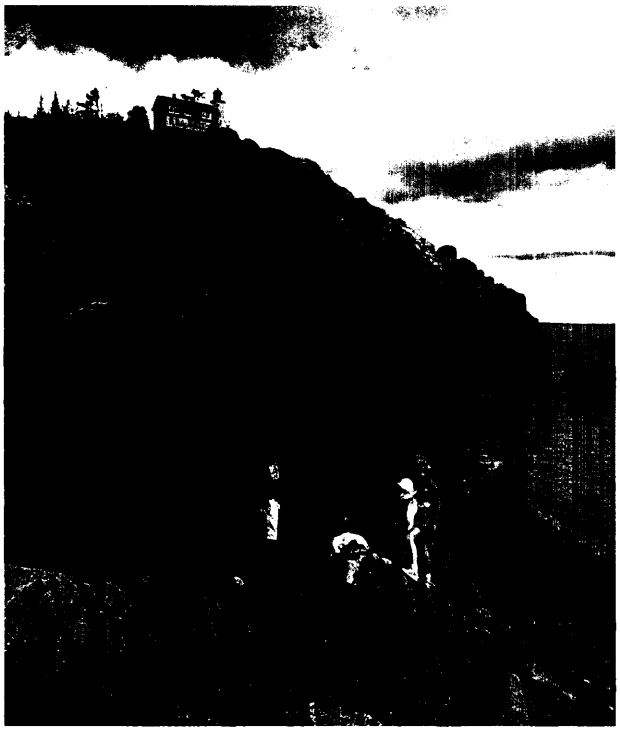
Picture 1.4 Coastal landscape of bare-washed rock, forest and agricultural land in the valleys. An archipelago stretches out to sea. (Aerial photo: Metria)



Picture 1.5 Häggvik is situated at an inlet. A few hundred years ago the lake in the foreground was part of a bay. The inlet is in the process of being cut off from the sea and becoming a lake. (Photo: Kjell Ljungström)



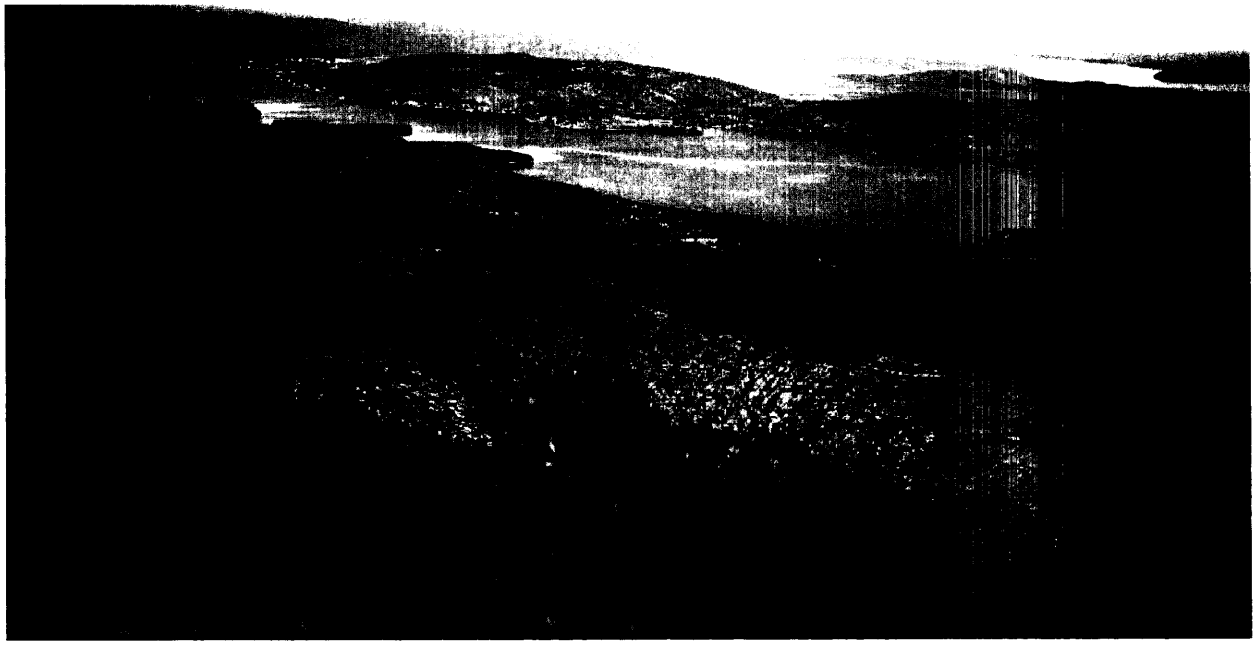
Picture 1.6 In the Norrfällsviken nature reserve there are large shingle fields, created by littoral processes. (Aerial photo: Metria)



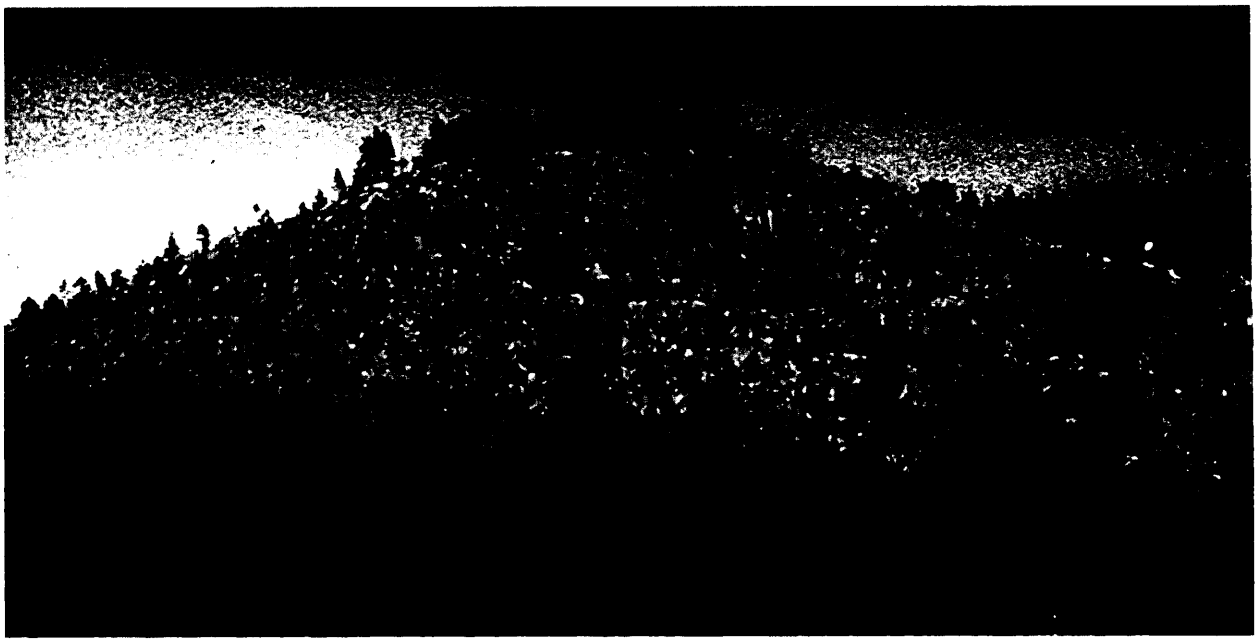
Picture 1.7 Högbonden is a high, steep island with an old lighthouse station, now used as a youth hostel. On the island there are also remains of old hunting cultures and natural phenomena such as a deep cleft and a so-called "onion cave". (Photo: Kjell Ljungström)

Picture 1.8 Trysunda. The fishing hamlets along the High Coast are often situated in protected locations at inlets and sounds. (Aerial photo: Metria)

2 Geological formations created by the land uplift process

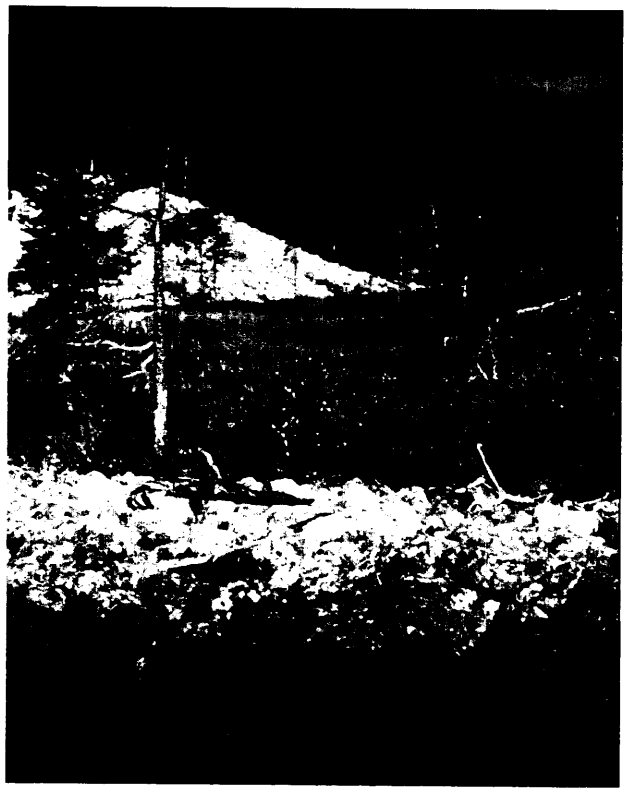


Picture 2.1 Aerial photo of the coastal landscape of Skuleskogen National Park with the High Coast's characteristic bare-washed rock and the archipelago in the background. (Photo: John Chang McCurdy)

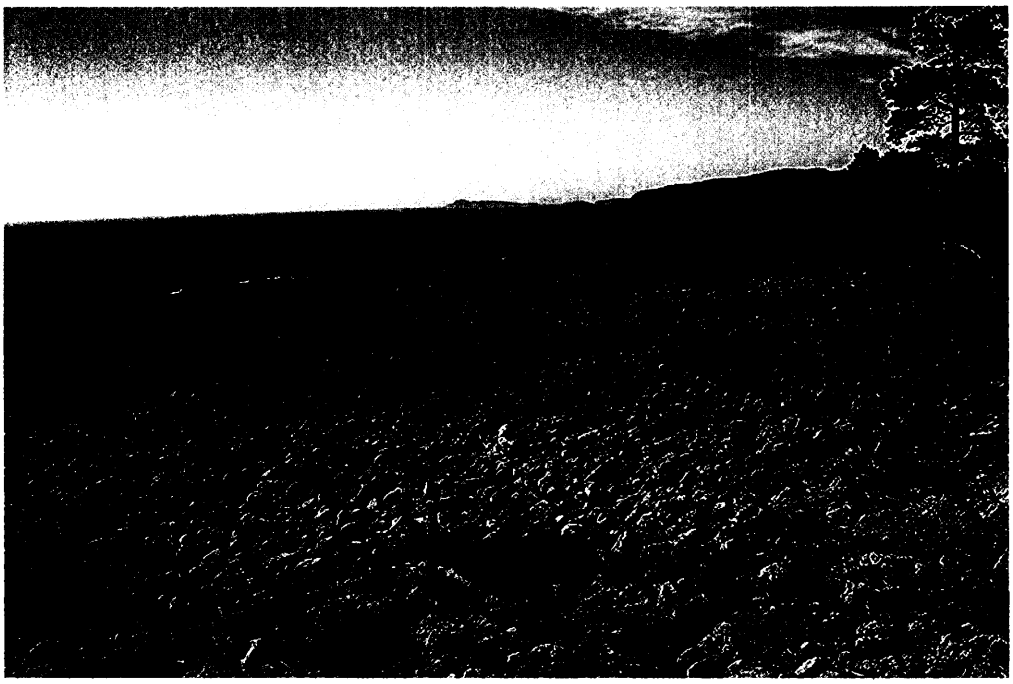


Picture 2.2 Till-capped hill with forested till above the wave-washed zone, 285 m above the present sea level. (Photo: Rolf Löfgren)

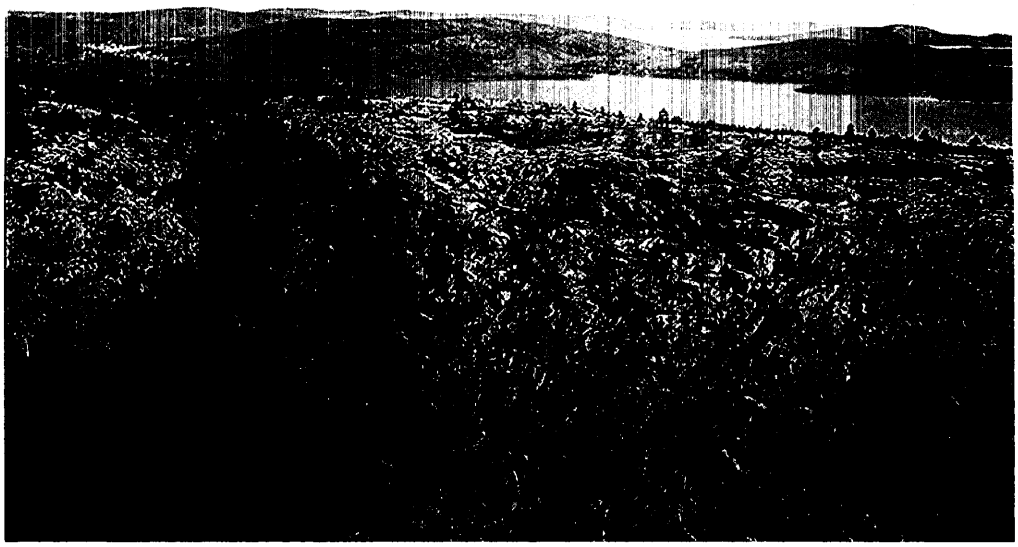
Picture 2.3 The world's highest situated postglacial shingle field is found on the hill of Högklinten. The field is approximately 260 metres above the present sea level. (Photo: Curt Fredén)



Picture 2.4 A small mire at ca 200 metres above sea level, north of Slåttdalsmyren. The mire was ones a lake wich was isolated from the sea ca 9000 years ago. (Photo: Rolf Löfgren)

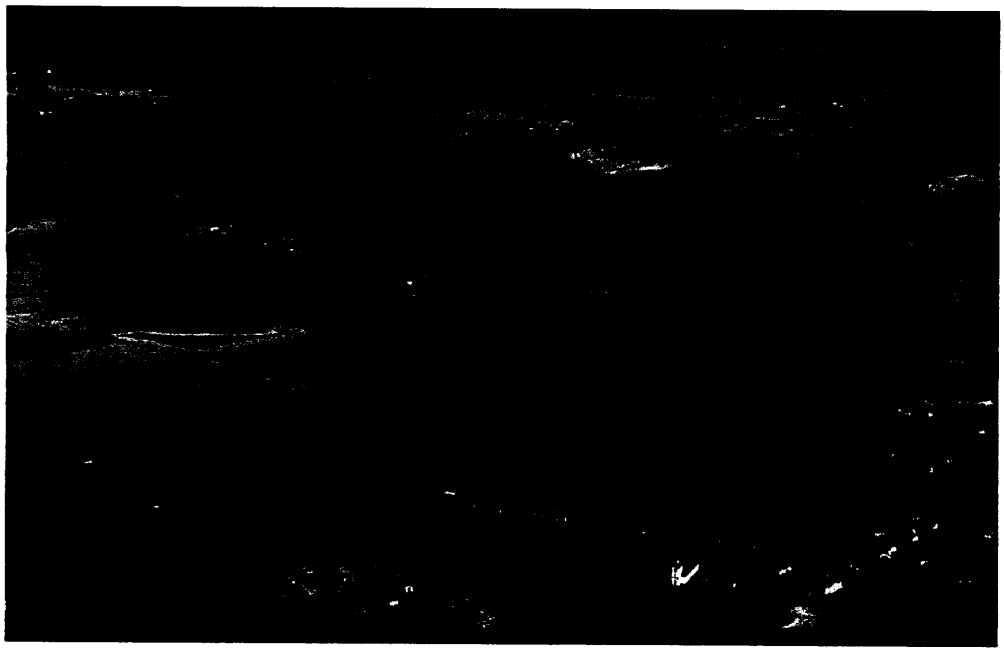


Picture 2.5 Raised beaches on a shingle field at the nature reserve of Norrfällsviken. The shingle consists of wheathered rocks and wave-washed till. At the shoreline stones are rounded by littoral processes and transformed into shingle. (Photo: Curt Fredén)

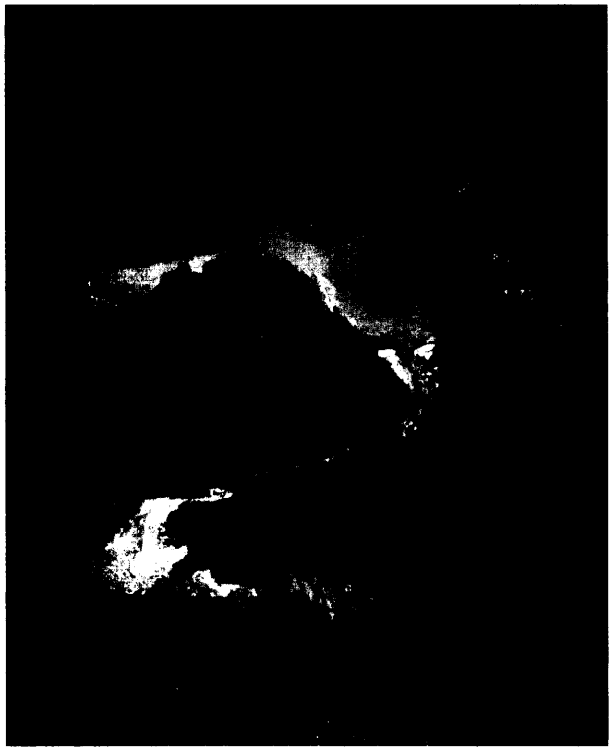


Picture 2.6 Slåttdalsskrevan, a cleft in granite bedrock. The genesis of the cleft is not fully known. It is probable that the cleft was once filled with dolorite that was eroded and washed away by waves in the course of the land uplift. Slåttdalsskrevan is about 40 metres deep, 6 metres wide and 200 metres long. (Photo: Rolf Löfgren)

Picture 2.7 Inside the cleft, Slåttdalsskrevan. (Photo: Britt-Marie Lindström)

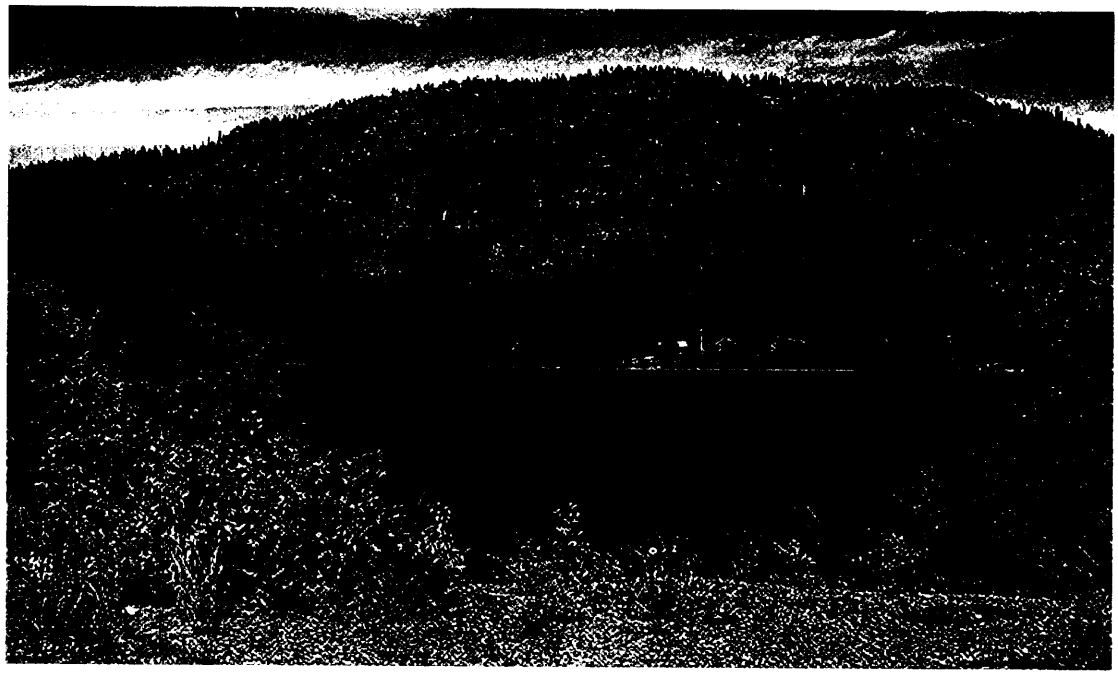


Picture 2.8 Landscape with cut-off lakes, in the area of Nora. The valley was previously a bay. Ancient remains from a number of periods are found around the lakes. (Aerial photo: Metria)

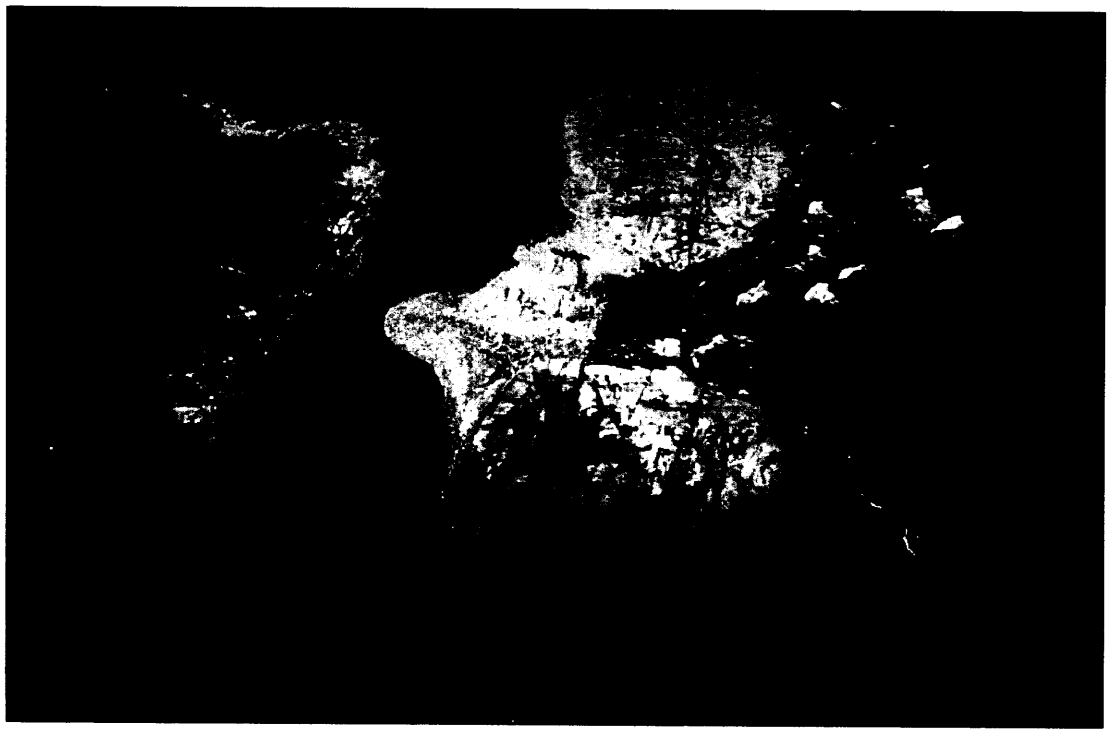


Picture 2.9 On-going cut-off of a little inlet, Salsviken, in the Skuleskog National Park. (Photo: Rolf Löfgren)

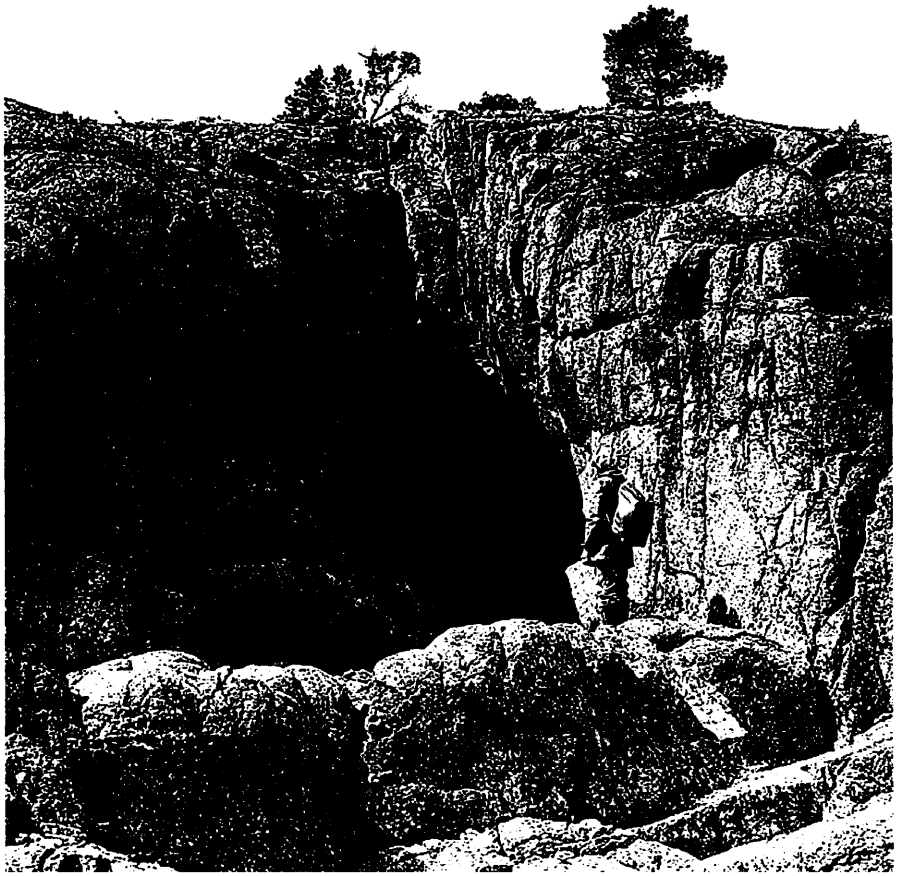
Picture 2.10 Wave-washed sediments has been deposited in the valley. The soil was cultivated very early by the inhabitants. The photo is of Sörleviken. It also shows that the inlet is in the process of being cut off. (Aerial photo: Metria)



Picture 2.11 Omneberget. The top of the hill was washed bare by the waves because it once lay below the sea surface. Sediments from the bare-washed slopes were deposited at the foot of the hill and this is now fertile agricultural land. (Photo: Curt Fredén)

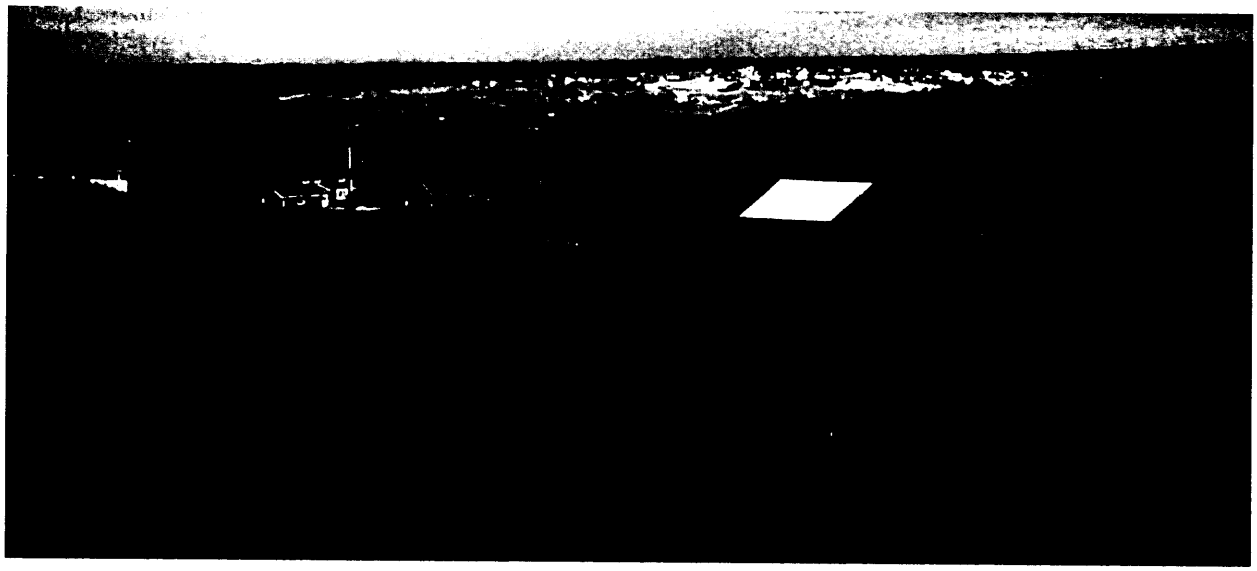


Picture 2.12 New islands emerge from the sea and in time join to form larger islands and then become part of the mainland. (Photo: Rolf Löfgren)



Picture 2.13 In the High Coast there are a number of so-called "lökgrottor", onion-shaped tunnel caves. This type of cave is only known from Scandinavia and most of them are found in the High Coast area due to the bedrock geology of hilly coastal region with rapid land uplift, topography and powerful waves. These caves can be up to 15 metres deep in the bedrock. The photo is from Höglosmen. (Photo: Jan Lundqvist)

Picture 2.14 Comparative picture of the inland area above the highest shoreline. The land above the highest shoreline lacks the bare-washed hills and the washed slopes that are characteristic for the landscape below the highest shoreline, e.g. in the High Coast area. (Photo: Rolf Löfgren)

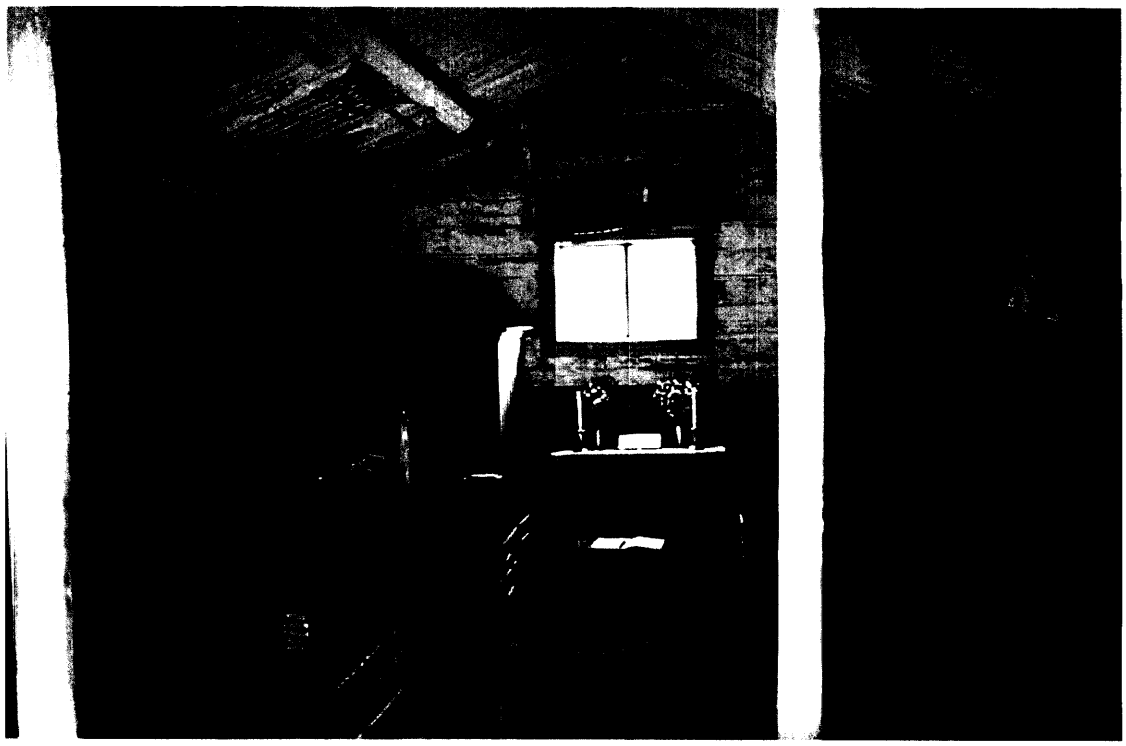


Picture 2.15 Comparative picture of the agricultural land above the highest shoreline. Often the arable land and settlements are located in the highland areas of the countryside as opposed to below the highest shoreline where the arable land is almost without exception found on valley floors. (Photo: Rolf Löfgren)

3 Culture-historical Points of Interest

Picture 3.1 Bronze Age cairns in the Skuleskogen National Park. (Photo: Jan Lundqvist)

Picture 3.2 Barsta Chapel, from the 1660s, one of many fishing hamlet chapels in the High Coast. (Photo: Mats Henriksson)



Picture 3.3 Interior of Barsta Chapel with wall and ceiling paintings by the painter Roland Johansson Öberg, 1699. (Photo: Mats Henriksson)

Picture 3.4 Sandviken, an abandoned fishing hamlet that is now situated well up on land due to the land uplift process. (Photo: Jan Lundqvist)

Picture 3.5 Bönhamn, a traditional fishing hamlet in the High Coast. (Photo: Kjell Ljungström)

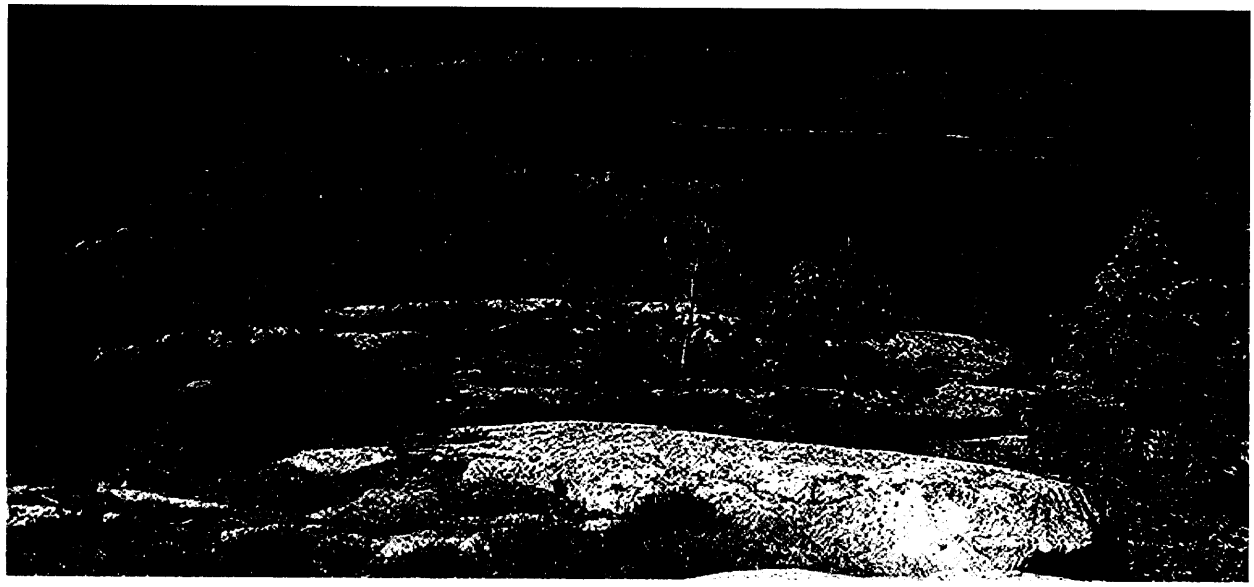
Picture 3.6 Labyrinth. How labyrinths were used remains a mystery. (Photo: Västernorrland County Museum)

Picture 3.7 Gene prehistoric village. A reconstruction of the most northerly situated Iron Age farm in Sweden. (Photo: Lena Edblom)

Picture 3.8 A shealing in the High Coast area. Shealing is a summer living place, often in the forest, where people allowed their animals to graze (Photo: Tomas Birkö)

4 Flora and Fauna

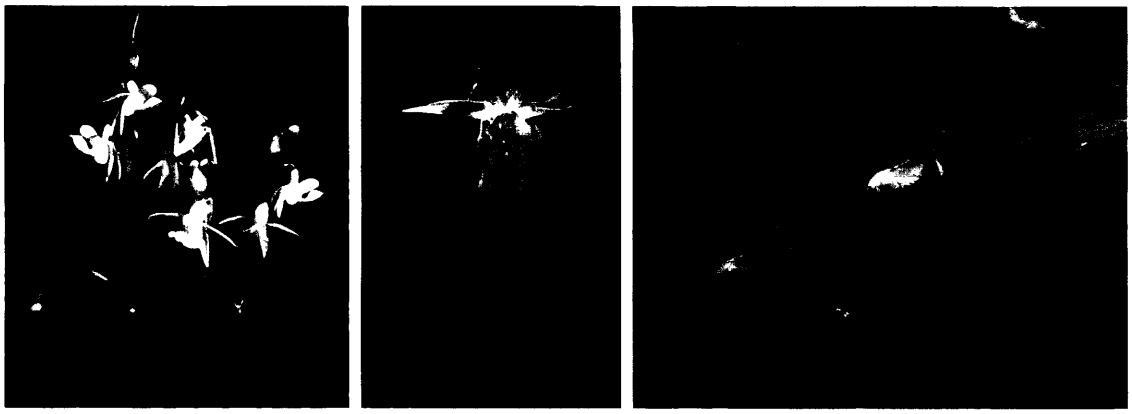
Picture 4.1 Aerial photo of typical High Coast landscape. The photo shows the distribution of forest in the countryside. Bare-washed rock with thin pine forest and, in the valleys, spruce forest interspersed with deciduous trees. (Photo: John Chang McCurdy)



Picture 4.2 Rock land pine forest on hilltops. (Photo: Curt Fredén)

Picture 4.3 Spruce forest flourishes in the valleys. In the Skuleskogen National Park the forest is of primeval character. (Photo: Kjell Ljungström)

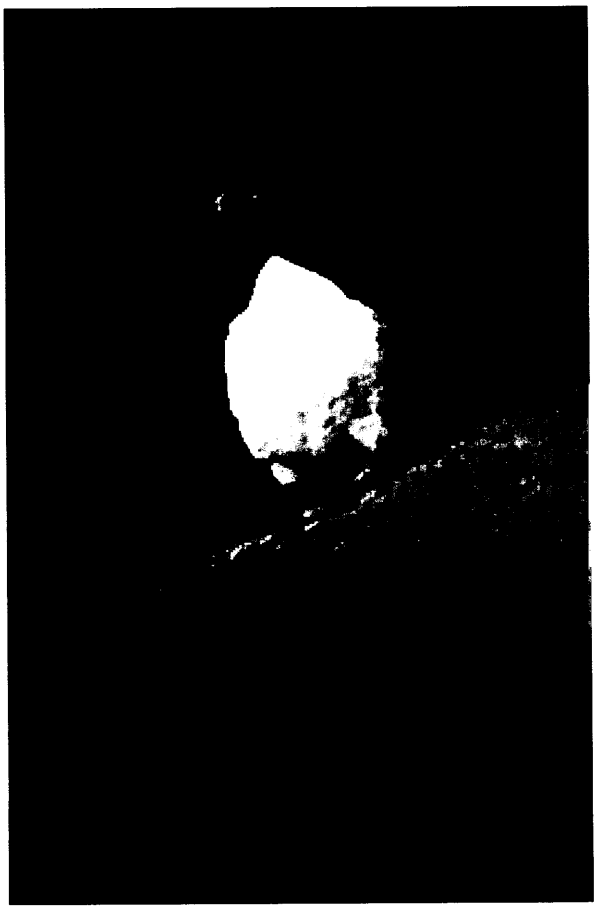
Picture 4.4 On southern slopes, "sydväxtberg", with their favourable local climate are home to stands of deciduous trees that are highly uncommon at this latitude. Several species have survived previous, colder climatic periods. (Photo. Jan W Mascher)



Picture 4.5 The presence of shell deposits in the soil have, e.g. allowed the growth of several orchid species. (Photo. Jan W Mascher)

Picture 4.6 Mountain Rock-Cress is widespread locally in the High Coast. (Photo. Jan W Mascher)

Picture 4.7 Lynx appreciate the steep forestland of the High Coast. (Photo: Kjell Ljungström)

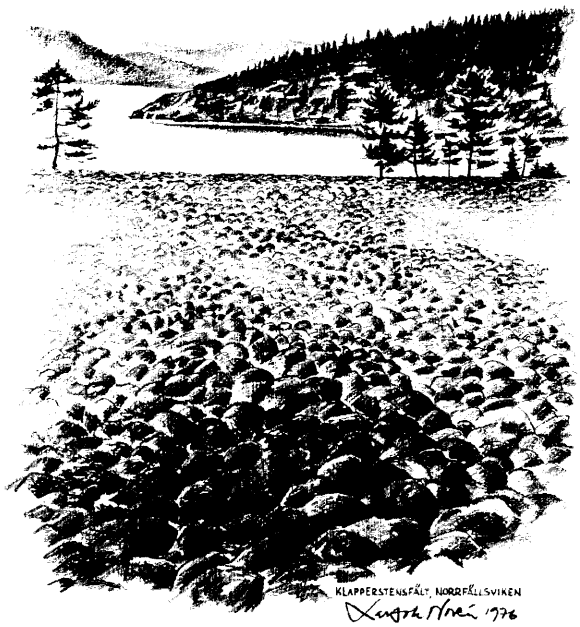


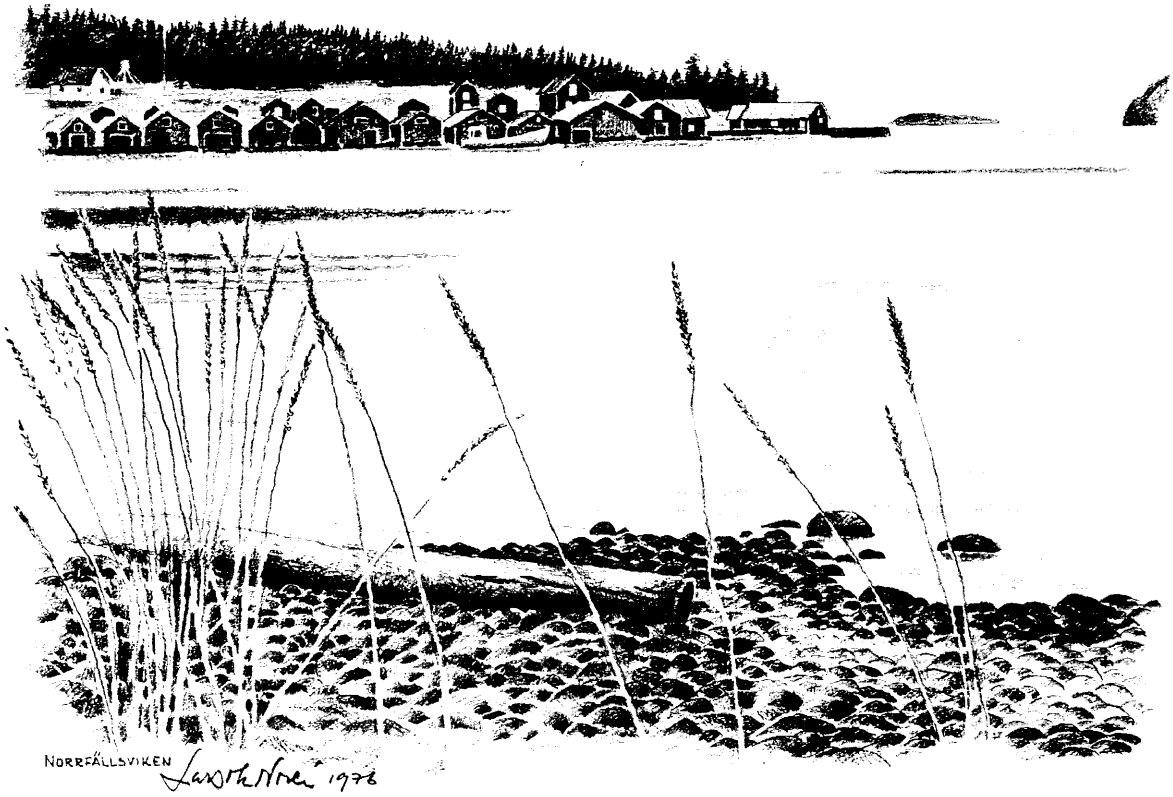
Picture 4.9 A variety of sea birds, e.g. the Razor-billed auk, inhabit the islands of the archipelago (Photo. Jan W Mascher)

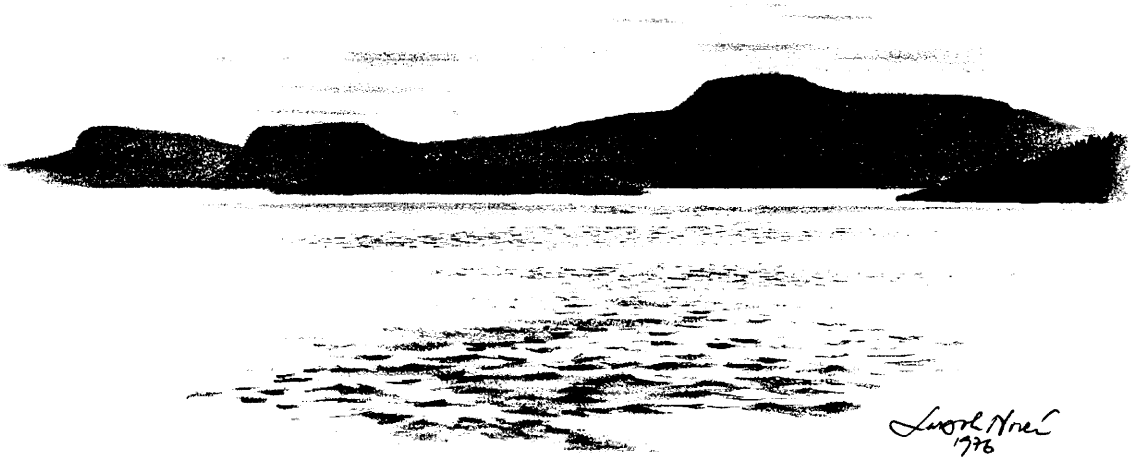
Picture 4.10 Moose. (Photo: Kjell Ljungström)

5 Art and photographs from the area

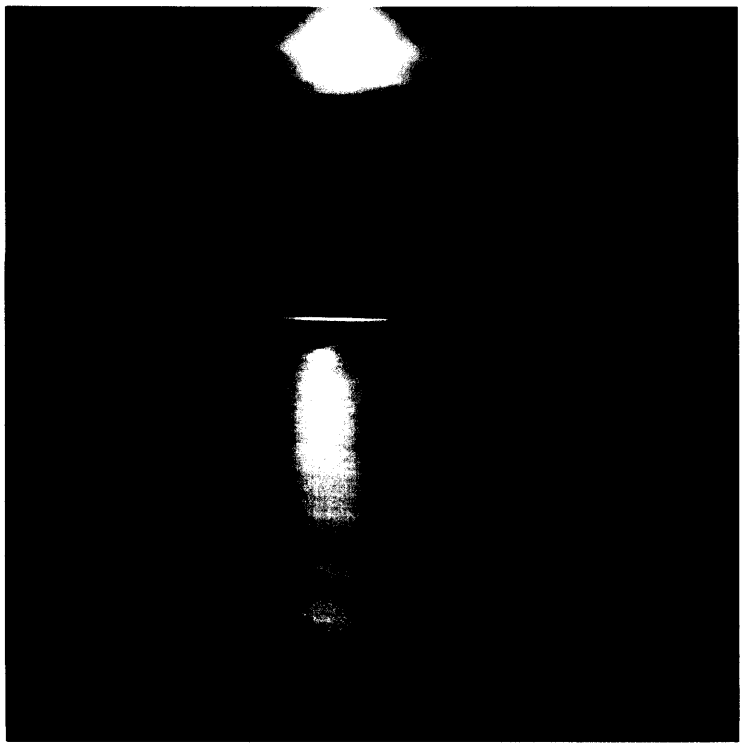
Drawings, Lars-Ola Noren



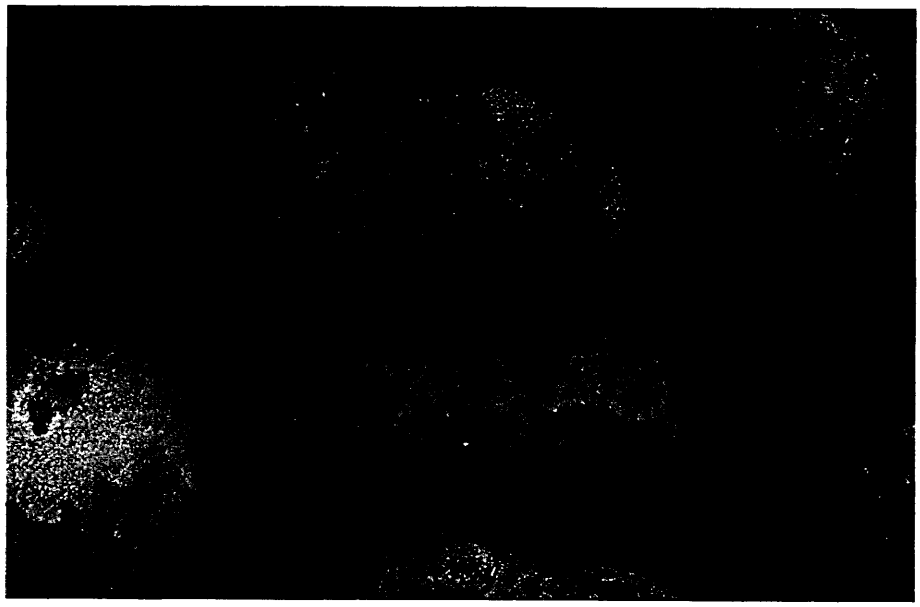

NORRFÄLLSVIKEN

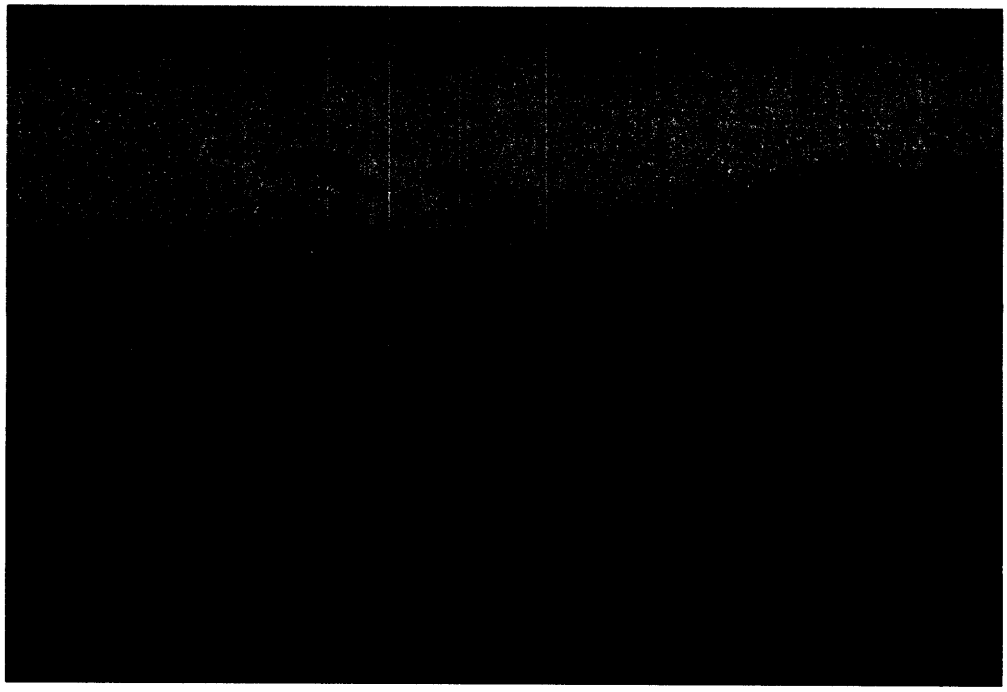


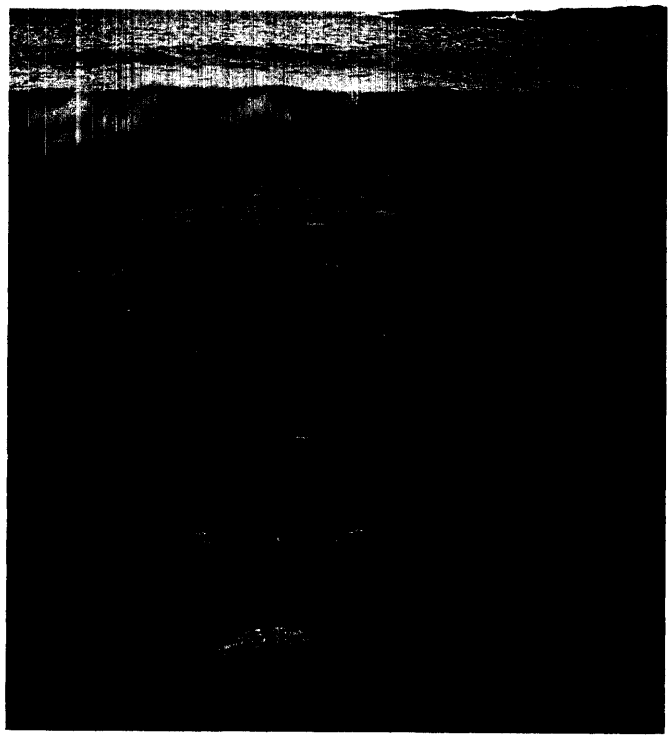
Moonlight, Photo John Chang McCurdy



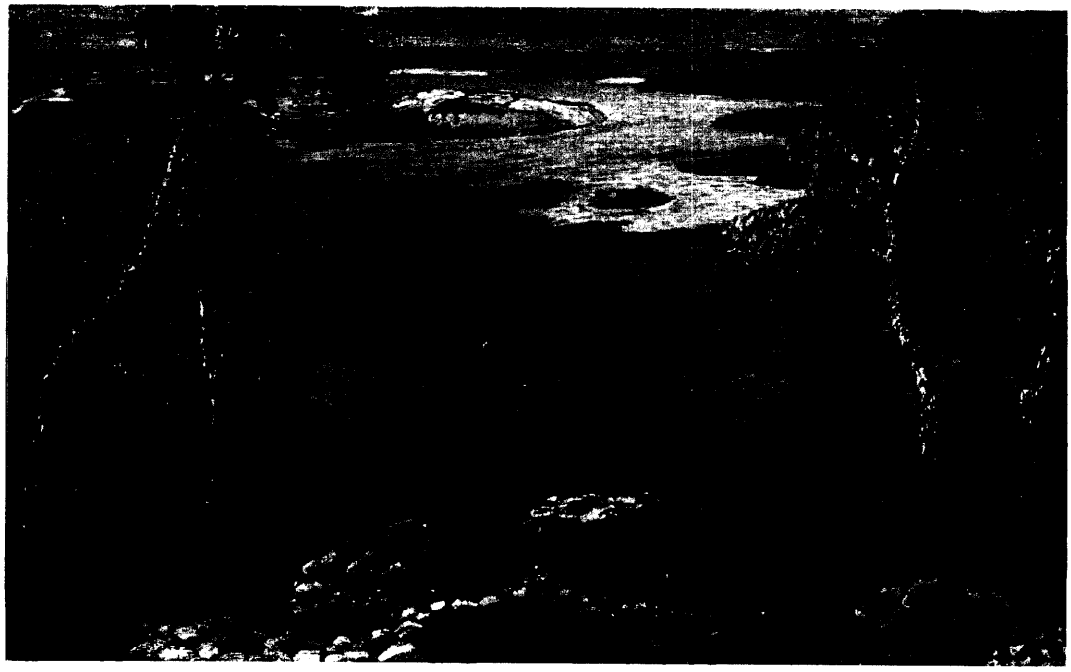
Photos, Kjell Ljungström.



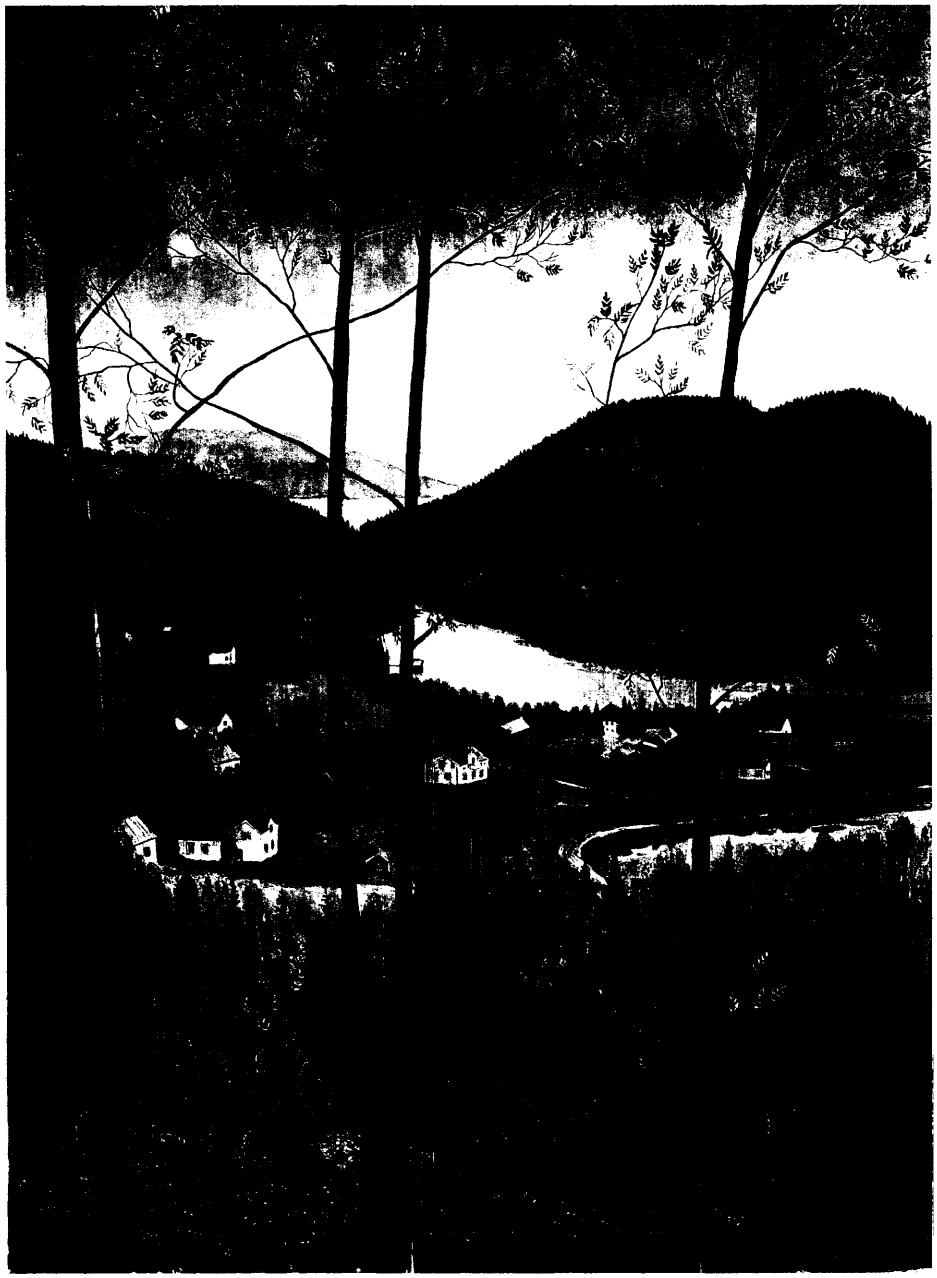


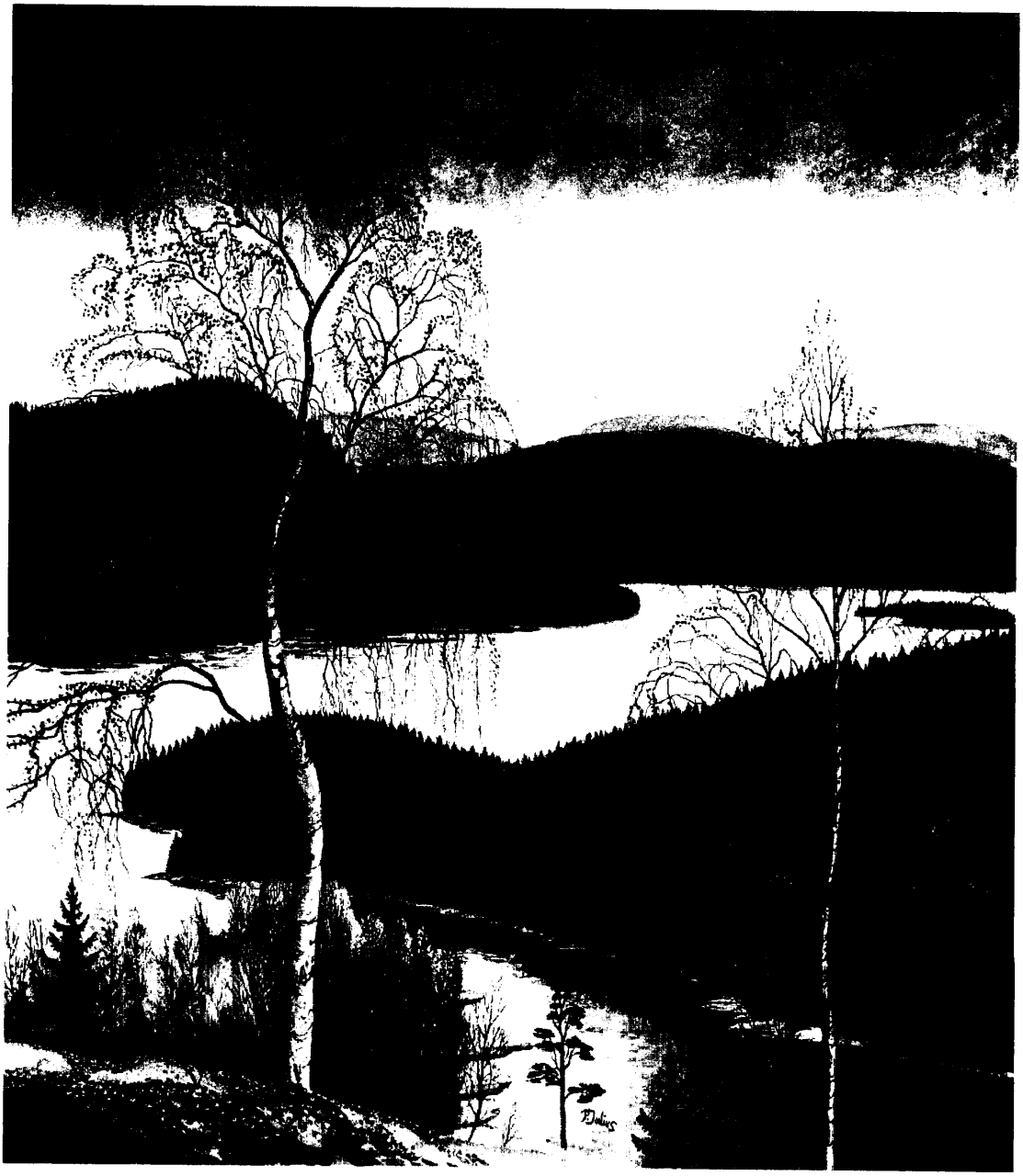


Oil-painting, Helmer Osslund

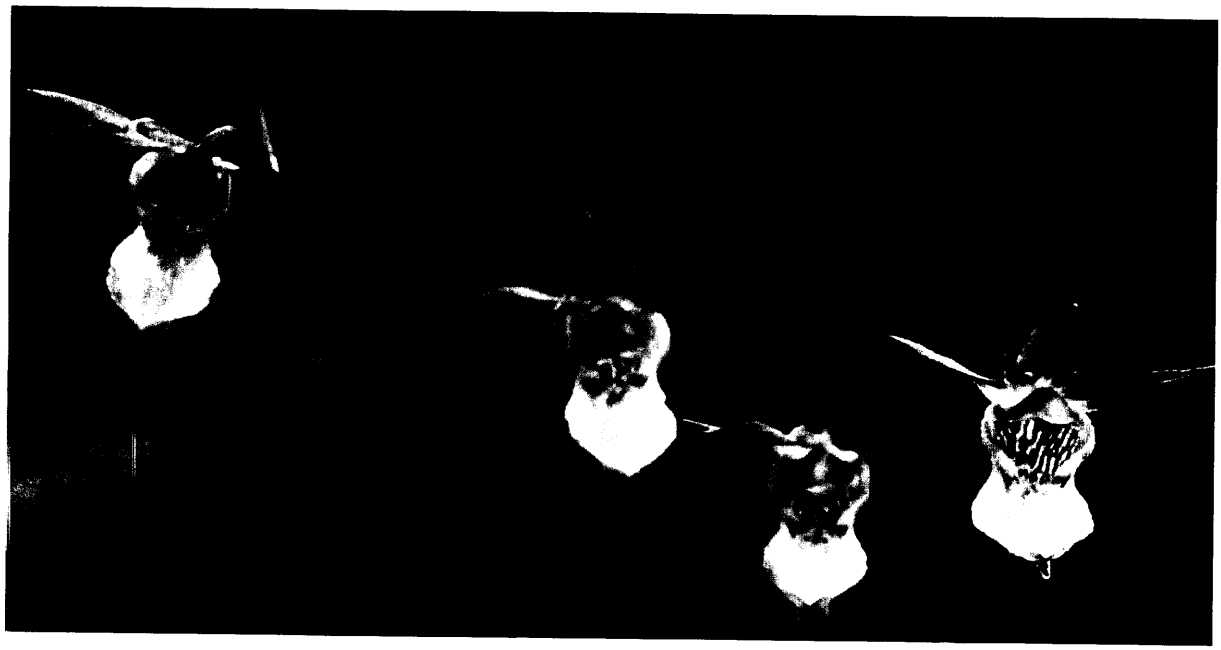


Water-colours, Per Julius





THE HIGH COAST



ENCLOSURE 7

VEGETATION AND LAND UPLIFT IN THE HIGH COAST

April 2000

The County Adminstration of Västernorrland

Text and unnamed photos: Jan W. Mascher

Cover photo: Kjell Ljungström

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Vegetation and land uplift in the High Coast region, Ångermanland

Jan W. Mascher

Introduction

Some of the characteristic features of High Coast vegetation are given. In the first instance important more or less unique traits are emphazied. Such characteristics make the region an area with an outstanding diversity of environments and flora elements of different origins. The importance of the land uplift process for the occurrence and distribution of plants and plant communities is especially focused upon.

Although there is great potential for scientific research, the High Coast region has to date only been sparsely used for systematic studies. An important work on shore vegetation was done by Ericson (1977). In addition, many botanical inventories of smaller areas have been initiated by the county administration in Härnösand. There are now 18 nature reserves in the region and Skuleskogen has been a national park since 1984 (Andersson 1972, Johansson et.al. 1984). The vegetation of the national park has recently been surveyed and described by Nihlén & Uebel (1995, in press). Water plants in a number of lakes were invented by Lundqvist (in manus). Many field investigations of the flora were made as a part of the inventory of the whole province of Ångermanland between 1967-1989 (Mascher 1990). As many facts about plants and environments are taken from this work it is not referred to everywhere in the text. The reference list contains mostly titles from the past few decades. More complete references are given by Mascher (1990) and, as concerns the Skuleskogen National Park, by Lundqvist (1994).

In the text, the post-glacial highest seashore line is referred to as HS.

Land uplift and sediment distribution

During the course of land uplift waves of the postglacial seas, which changed between saline and fresh water stadiums, washed out and sorted finer and coarser till material left behind by the receding ice. Due to the topographical conditions unique for the coast of the Baltic with high and steep mountains separated by many deep ravines and valleys, the finest fractions were concentrated and deposited at the bottom, to begin with below the sea level and later gradually lifted up on land. Higher up on the sides of ravines and valley slopes shingle, gravle and sand was deposited (Lundqvist 1987).

Distinct wood zonation

A distinct zonation is characteristic for the High Coast region. The large open valleys are cultivated. On the rich sediments in ravines, glens and lower parts of mountain slopes very prosperous spruce woods (Norwegian Spruce, *Picea abies*) of high quality with tall and fast-growing trees dominate. A marked border is often seen against the upper zones with gravel, sandy or stony soil where pine trees *Pinus sylvestris* dominate. There are also stands of birch and aspen. Fields of large boulders, stone rubble and bare rock as well as bare-washed mountain plateaus below the HS are almost without trees or with scattered pine trees and solitary spruce trees. On till caps covering mountain tops above HS (285 m. above sea level) and thus not washed by the sea a similar type of spruce wood grows as in highland areas in the inland of the province (Fig.1). Thus the unusually marked wood zonation in the High Coast area is an effect of the comparatively large land uplift and local topography.

Fig. 1. Highest shoreline on Mount Skuleberget. Spruce and pine trees growing on the till-capped plateau.

Mountain plateaus with old pines

On some of the bare-washed mountain plateaus, especially in the Skuleskogen National Park, very old pines are found, often growing low and distorted, some at 280 m. above the sea level, i.e. near the HS (Fig. 2). The bedrock is rapakivi granite of the Nordingrå type. Many of these several 100 year-old trees (in some cases more than 500 years according to Kardell & Andersson 1977) are in different stadiums of deterioration, and they are inhabited by rare insects and *Usnea* lichens grow on them. Most of these environments were only sparsely or never used for forestry and no fire has been noted since the late 18th century (Nihlén & Uebel, in press). They form an important and very unusual habitat unique to the Baltic and Bothnian coasts which has only been superficially studied.

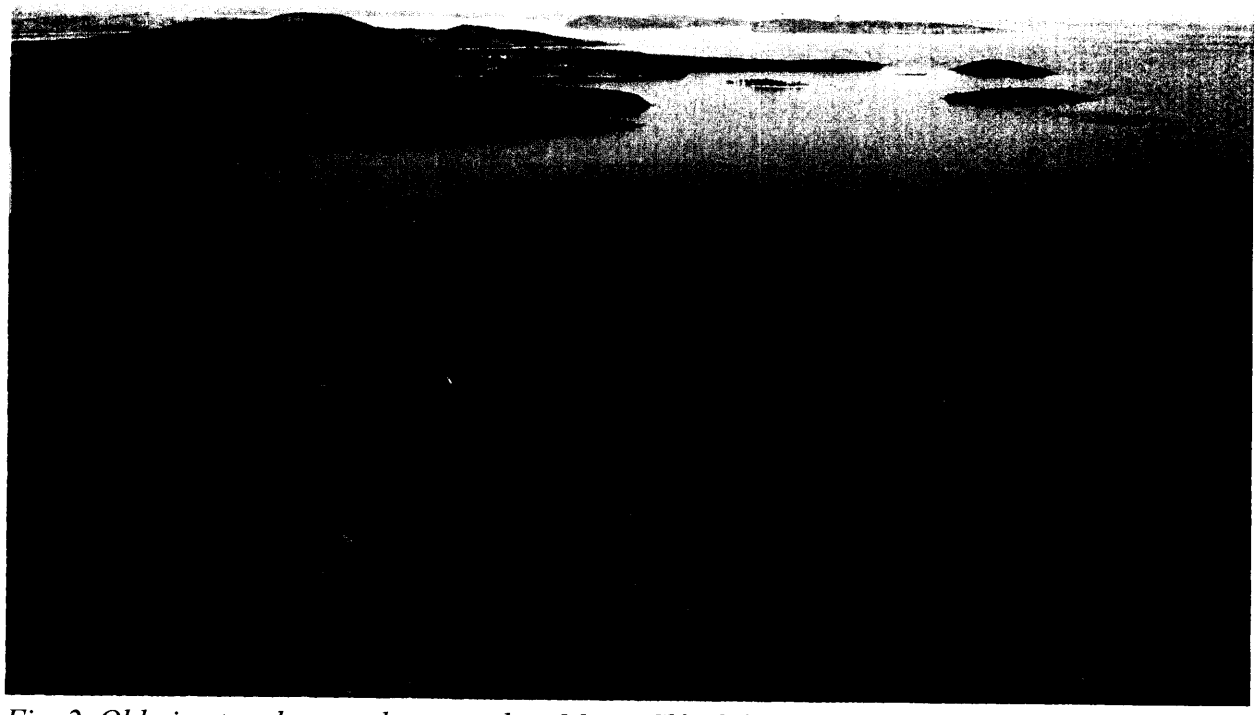


Fig. 2. Old pine tree bent to the ground on Mount Slåttdalsberget, Skuleskogen National Park.

High spruce forest productivity

The fine-grained sediment soils on the floors of valleys, ravines and lower parts of mountain slopes are in some areas enriched by eroded and withered material from basic rocks (especially diabases) prevailing in certain parts of the High Coast region. Calcareous shell sediments lifted out of the sea very markedly enrich many local sites.These edafic conditions combined with regionally favourable climatic conditions (mainly an effect of the Golf Stream), i.e. higher temperatures and a longer vegetation period than normal in this part of Scandinavia, add to the concentration of fine sediments on lower grounds to explain the fact that spruce woods here grow better and faster than in other parts of the province. At favourable sites the growth rate expressed as cubic metres/year may amount to 8 or even 9 as noted e.g. on parts of the island of Mjältön where the average is 5.3. On the mainland in other parts of the High Coast as well as on some of the islands an average of 4.38 has been recorded (Hildingsson 1976). In the Skuleskogen National Park the average productivity rate is 4.3 with maximal values of 6-7 (Kardell & Andersson 1977). The average value for the province of Ångermanland is 4.1 (L. Bergström, pers. comm.).

Almost all woods in the High Coast area have been cut down in earlier or later periods. In the Skuleskogen area however there has been only very limited forestry since the end of the 19th century so that much of the forest is now 100 years old or more. There has been no fire in this area since the end of the 18th century (Kardell & Andersson, 1977, Nihlén & Uebel, in press).

Southern elements in spruce and mixed woods

In many spruce woods growing on rich sediments, with a favourable local climate, there is a very species-rich flora with many basiphilous or even calciphilous herbs, several of them with a southern distribution in Sweden and here near or at their northern borderlines. Some of them also grow on south-faced slopes with spruce, mixed or deciduous woods in the "sydväxtberg" (south-facing mountain slopes with screes and steep cliffs inhabitated by southern species, Du Rietz 1954) which are abundant in the High Coast area. This group of species adds very significantly to the diversity and richness of species on this part of the Bothnian Coast. A few of these species bound to rich soils are: *Botrychium virginianum, Festuca altissima, Gagea lutea, Dactylorhiza fuchsii* (Fig. 3), *Calypso bulbosa, Epipogium aphyllum, Neottia nidus avis, Listera ovata, Cypripedium calceolus, Coeloglossum viride, Dentaria bulbifera, Corydalis intermedia, Acer platanoides, Daphne mezereum, Viola mirabilis, Viburnum opulus, Hepatica nobilis* (Fig. 4), *Actaea spicata, Vicia sylvatica, Lathyrus vernus* (Fig. 5), *Stachys sylvatica, Scrophularia nodosa, Galium odoratum* and *Mycelis muralis.*

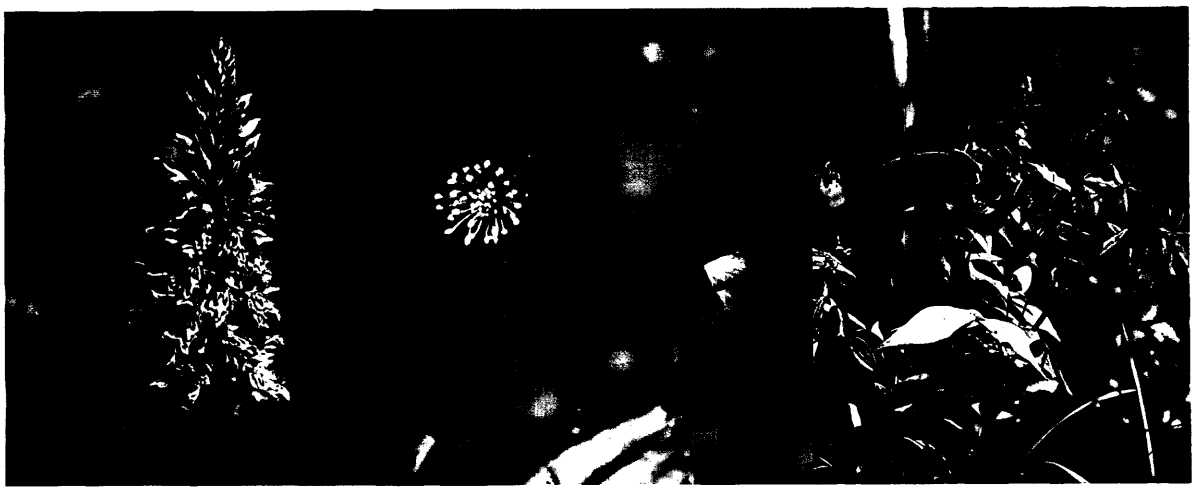
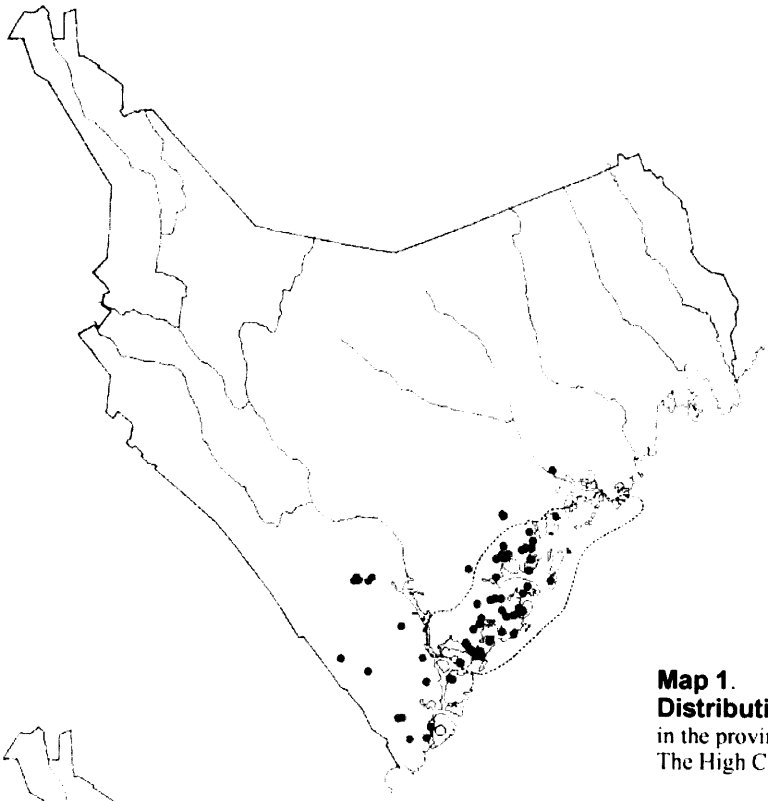
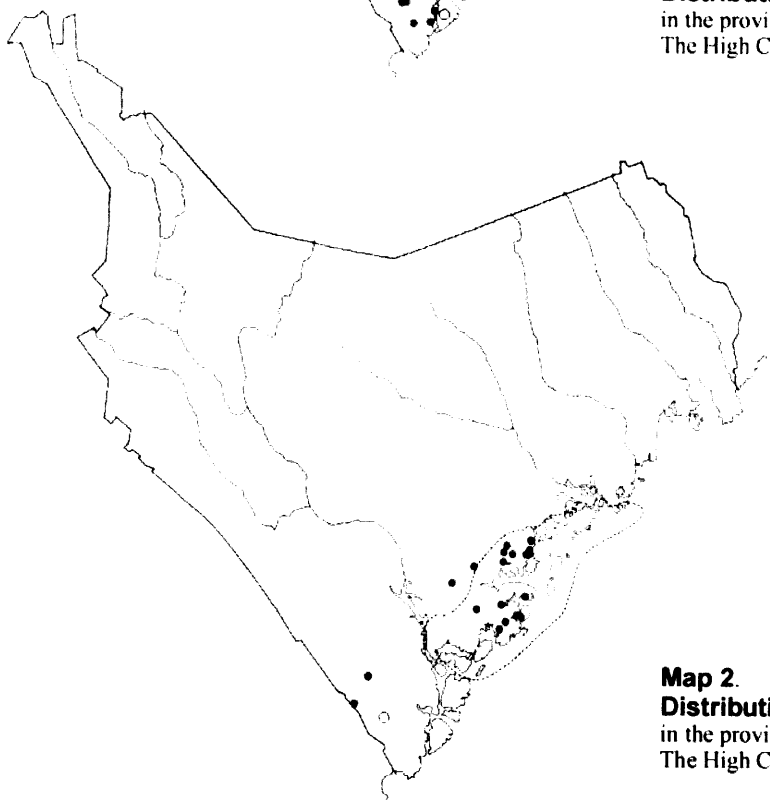


Fig. 3-5. Dactylorhiza fuchsii grows on basic soil in moist herb-rich spruce forests. Hepatica nobilis occurs only on rich basic soil, especially abundantly on shell banks. Lathyrus vernus is bound to very rich basic soils or shell banks. It is not found north of the High Coast region.



Map 1.
Distribution of Mycelis muralis
in the province of Ångermanland.
The High Coast region is outlined



Map 2.
Distribution of Acer platanoides
in the province of Ångermanland.
The High Coast region is outlined

Often, the spruce stands in ravines and glens are to some extent mixed with deciduous trees, even southern broad-leaved species such as *Acer platanoides* (17 localities in the High Coast, Map 1) which reaches its northernmost spontaneous outpost in the Skuleskogen National Park. As is clear from the distribution map this species shows a distinct concentration in the High Coast area where it often grows on rich ground in the land uplift zone down to about 15 m. above sea level though there are also occurrences in "sydväxtberg", even on a south-faced scree on Mount Lillruten above the HS level in Skuleskogen. Here it occurs together with *Tilia cordata* (Fig. 6). The latter species has its northernmost locality a short distance to the north of Skuleskogen close to the border of the High Coast area.
level.

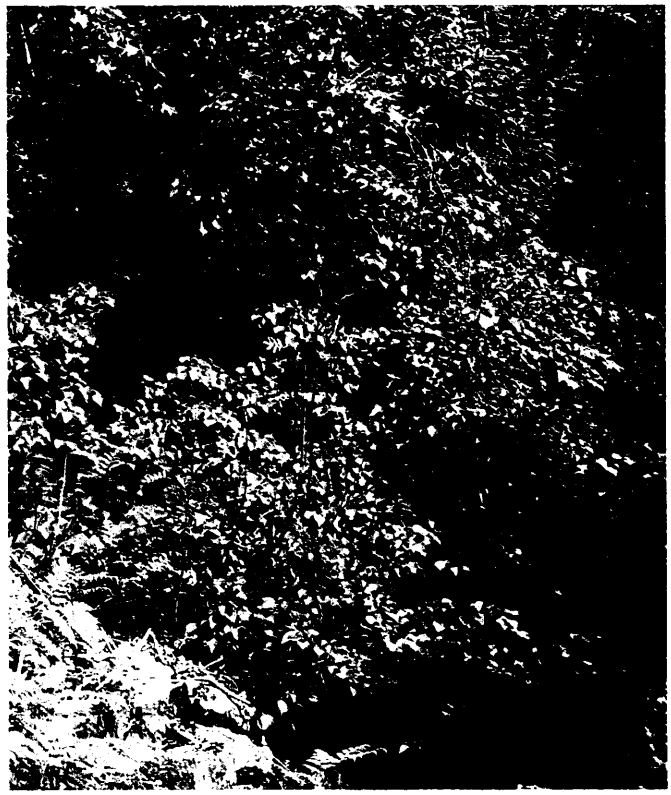


Fig. 6. Maple and linden grow on Lillruten, a mount of the type "sydväxtberg" above the HS level in the Skuleskogen National Park.

Shell layers

Many of the calciphilous (or basiphilous) species mentioned and some others are especially abundant in localities with depositions of shell gravel embedded in sediment layers lifted up on land. Mostly, such shell layer (consisting of mollusc shells of *Mytilus edulis*, *Macoma baltica*, *Cerastoderma edule* and others, Halden 1921, Lundqvist 1987) are found about 2-10 dm. beneath the sediment surface (Fig. 7). Detailed studies are not available in this province, but in the province of Västerbotten, to the north, the thickness of shell layers varies between 0.1 and 1.5 m., whereas the horizontal extension is between 10 and 100 m. or even more (Halden 1921). In close proximity to such sites the soil is enriched by a substantial addition of calcium resulting in a profound effect on the local flora. Often this is best seen on slopes with shell layers which are percolated by ground water seeping into marshy depressions or small mires below where several more or less calciphilous plants grow.

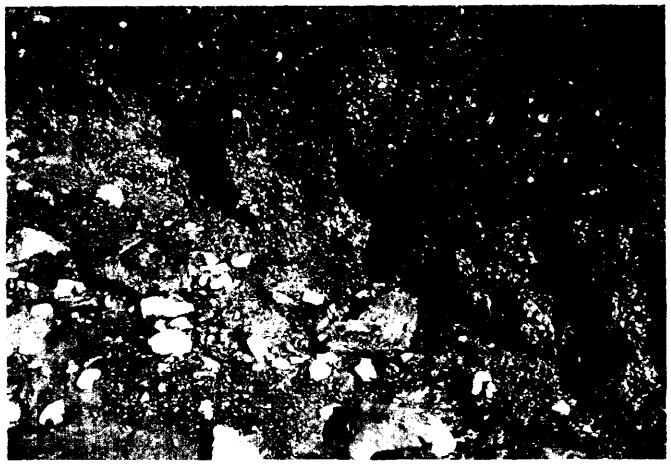


Fig. 7. Shell bank exposed when a ditch was dug out along a new road on the island N. Ulvön.

Calciphilous herbs on shell banks

In fact, there is a number of markedly calcium demanding herbs which seem to be highly bound to the occurrence of shell layers. They would probably not survive in the High Coast area otherwise. They are generally not found above the maximal level of shell layers of about 80 m. (Lundqvist 1987). These species are *Botrychium virginianum*, *Calypso bulbosa*, *Epipogium aphyllum*, *Neottia nidus-avis*, *Listera ovata*, *Microstylis monophyllus* and *Cypripedium calceolus* (Fig. 8-11). 47 finds of these species are known. *Epipogium* is the most common of them, known on 16 localities. Two of these are near the upper border of shell bank occurrences. Of 15 localities with *Listera ovata* 14 are within the shell bank zone, the only exception being the mire Slåttdalsmyran in Skuleskogen 175 m. above sea level where the source of the local richness is unknown. It should be noted that in some localities several of these calciphilous species are found. Therefore, the total number of sites with one or more of the species mentioned is 24, scattered all over the coastal zone, but there is a somewhat higher concentration in the parish of Nordingrå and on the island of N. Ulvön.

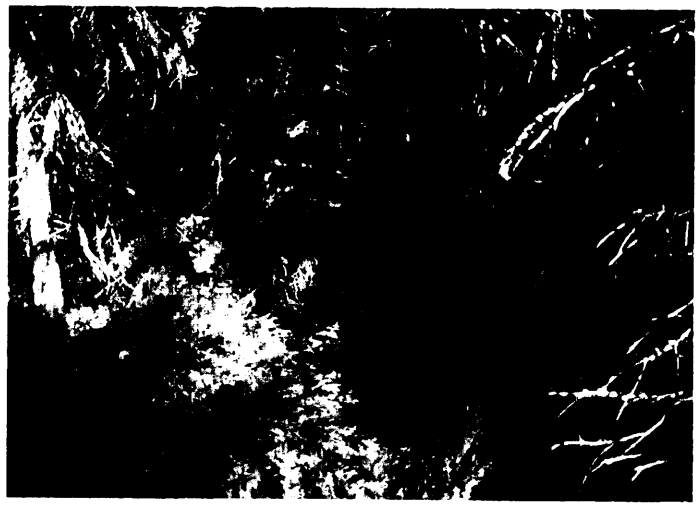


Fig. 8. Calciphilous spruce forest on shell bank with Botrychium virginianum, Calypso bulbosa, Epipogium aphyllum, Neottia nidus avis, Hepatica nobilis etc. Island of N. Ulvön.

The real number of shell sites in the coastland is of course much larger, but this has not been investigated. For comparison it may be mentioned that nearly 150 such sites were found in the province of Hälsingland by Halden (1951).

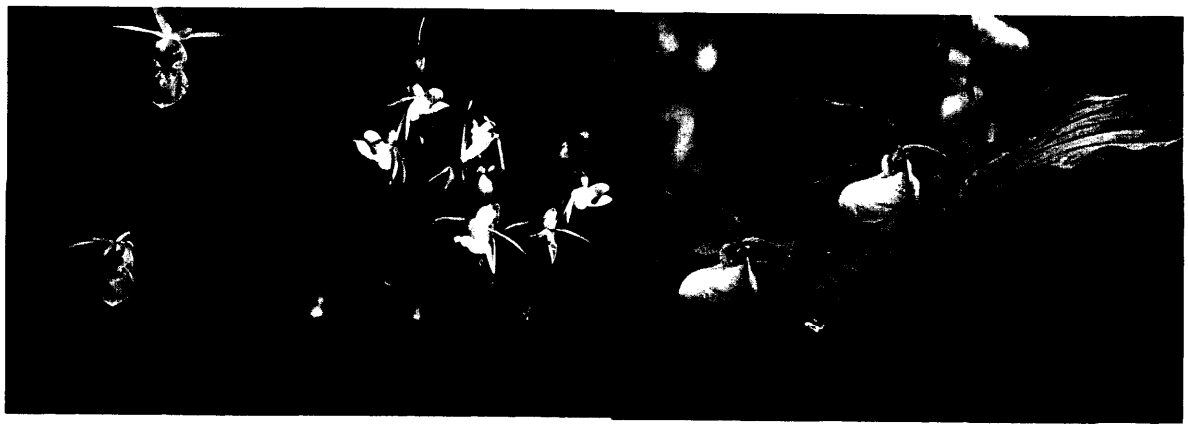


Fig 9-11. The orchids Calypso bulbosa, Epipogium aphyllum, Cypripedium calceolus and others are bound to shell banks in the High Coast region.

Field detection of shell bearing sediments

It must be stressed that in only a few cases has the occurrence of shell layers been actually confirmed by direct observation where ditches or pits etc. have been dug. Otherwise, the conclusion has been drawn from a strikingly rich vegetation with representation of one or more of the strongly calciphilous species mentioned above. In the absence of direct proof only such localities are treated as supposed shell bank sites here, but there are a number of other sites within the High Coast area where shell gravel has been noted though none of these species are known. Nevertheless, a species-rich flora is seen at most such localities. It is evident from several such observations that the occurrence of some other species such as *Carex capillaris* and *Vicia sylvatica* as well as markedly rich populations of especially *Hepatica nobilis* is a strong indication, but not conclusive, of an underlying shell layer. This is a field worthy of further investigation including analyses of vegetation (the flora of mosses and mushrooms must also be considered as certain species have an affinity to shell sites, cf. Halden 1920, 1921, Nitare 1992, 1995) and soil samples as well as a general investigation of the localisation of shell layers in the topographically unique land uplift zone of the High Coast.

Flora on soils enriched by basic rock

There is another larger group of evidently less calcium-demanding species which occur not only in the zone of shell layers but also on higher levels, in some cases even above the HS level. Though often especially abundant at shell localities these species evidently grow well on soils enriched by basic bedrock, i. e. diabase and anorthosite. The moderate basic effect on the local soil compared to shell layers is favourable enough for them. Mire species such as *Eriphorum latifolium* and *Dactylorhiza incarnata* (Fig. 12) as well as species growing in spruce, mixed or deciduous woods (e.g. *Hepatica nobilis*, *Acer platanoides*, *Lathyrus vernus*, *Stachys sylvatica* and *Mycelis muralis*) are included. A few, e. g. *Hepatica nobilis* and the mire species *Eriophorum latifolium* and *Dactylorhiza incarnata* are even found on levels above HS in the Skuleskogen National Park.

Fig. 12. Dactylorchis incarnata grows on mires enriched by basic mineral water at different altitudes, even above the HS.

Calcium-rich coniferous forests

Such habitats as the species-rich spruce woods on basic ground have been described as "basiphilous spruce forests" (Björndalen 1980), and it has been pointed out that they have the richest flora of herbs and mushrooms of all coniferous forest types (Nitare 1992, 1995). In the High Coast area they are of particular interest because they are located on varying elevations in the land-uplift zone either on shell banks or on basic soil originating from withered bedrock. The broken topography adds to the environmental variety in which these habitats are found. However, these aspects have only been superficially studied to date.

Not only spruce woods are of interest in this connection. There are also "basiphilous pine forests" (Björndalen 1980) on basic rock along the High Coast. Such habitats have been described by Björndalen (1986) e.g. on the island Barstaön in Nordingrå parish. Here the pine trees grow on withered diabase bedrock, partly on steep slopes, and the rich herb flora is dominated by *Convallaria majalis. Hepatica nobilis* is common. This local type of herb-rich pine wood is considered to be of an unusual character and is ranked among the most important representatives of its kind in Scandinavia. Therefore it is strongly recommended for protection. Other such localities may be found in the region as the basic requisites concerning bedrock, topography and climate characterize especially several of the islands in the High Coast area.

Fig. 13. Mount Omneberget, a very species-rich "sydväxtberg" in Nordingrå parish. Cliff and scree with deciduous wood (including hazel, maple) facing south.

Southern species with northern outpost occurrences

A very large number of species in the flora of the High Coast area have their main distribution in southern Scandinavia. Some of them have already been mentioned, e.g. the broad-leaved deciduous trees *Acer platanoides* and *Tilia cordata* which reach their northern borderlines here on the Bothnian coast. This is the case concerning no less than a total of 48 species of southern origin, though a few of them grow slightly more to the north in the inland. Most of them are found in "sydväxtberg" (Fig. 13) or wooded ravines on rich soils, some on sunny, dry, still cultivated meadows. Examples of such species growing in ravines, rich spruce woods and "sydväxtberg" are: *Gagea lutea, Festuca altissima, Epipactis helleborine, Neottia nidus avis, Dentaria bulbifera, Vicia sylvatica, Lathyrus sylvestris, Lathyrus vernus, Chelidonium majus, Stachys sylvatica, Galium odoratum, Campanula persicifolia* (Fig. 14),

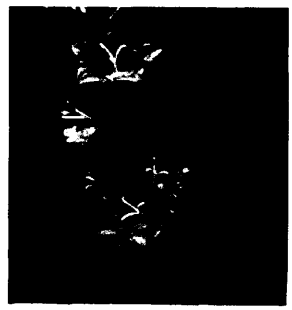


Fig. 14. Campanula persicifolia does not occur north of the High Coast region.

Mycelis muralis. On dry meadows and in similar environments the following have their northern borderlines here: *Briza media, Scleranthus annuus* ssp. *polycarpos, Cerastium semidecandrum, Erophila verna, Ranunculus ployanthemos, Potentilla tabernaemontani* (Fig. 15-16), *Linum catharticum, Sedum album* (Ståhl 1997a,b, Ericsson 1992, Mascher 1981a, 1999). There are few fresh-water species among them but *Potamogeton polygonifolius* has a very isolated northern outpost 15 m. above sea level on the island Södra Ulvön.

Fig. 15-16. Herb-rich dry meadow with Potentilla tabernaemontani on withered diabase, Berg, Nora parish.This species has its northernmost occurrence at a single locality in the High Coast region.

Furthermore, another 65 southern species show a markedly diminishing frequency within the High Coast region and are only found as scattered outposts farther to the north. The following are a few examples: *Asplenium trichomanes, A. septentrionale, Carex muricata* ssp. *muricata, Polygonatum odoratum* (Fig. 17), *Fallopia dumetorum, Corylus avellana, Rosa dumalis, Geranium bohemicum, G. robertianum, Drosera intermedia, Verbascum thapsus* (Fig.18). On dry meadows: *Helictotrichon pubescens, Silene nutans, Gentianella campestris, Thymus serpyllum, Veronica verna, Myosotis stricta, Centaurea jacea.*

Fig. 17. Polygonatum odoratum, a southern inhabitant of open crevies and shelves on several "sydväxtberg".

The most species-rich environments with respect to southern plants are "sydväxtberg" and

Fig. 18. Verbascum thapsus, a southern species on a south-facing scree, Mount Rödåsen, Nora parish.

Fig. 19. Large stands of Matteuccia struthiopteris are characteristic of ravines with rivulets and rich sediments.

ravines. Striking examples are the two "sydväxtberg" Skuleberget (Johansson 1975) and Omneberget (Svärd & Vänström 1971, Fig. 13) with 56 and 50 species of southern origin respectively, corresponding to 21,5 % and 22 % of all species growing in each mountain. Even some ravines have a very rich vegetation with similar large numbers and proportions of southern plants, e.g. Halsviksravinen in Nordingrå parish (Lundqvist 1970, 1978) where 48 such species are known, i.e. 21,5 % of all (Mascher 1990). There are usually small rivulets in the bottom of these rich ravines and here large stands of ferns often dominate, e.g. *Matteuccia struthiopteris* (Fig. 19).

As mentioned, there is also an appreciable proportion of southern plants in herb-rich dry meadows along the coast, especially on shell gravel or weathered basic rock. Such environments are man-made and they are nowadays mostly found in old fishing villages or where there is still some grazing. The eastern species, *Draba nemorosa,* with its main Swedish distribution in the middle part of the country, also belongs to this plant community. This type of herb-rich dry meadow along the Bothnian coast has its northernmost outpost at Skeppsmalen, Skags udde, in the northern part of the High Coast region (Mascher 1999).

An important reason for the remarkable concentration of southern species with northern outpost and borderline occurrences is no doubt the described combination of basic bedrock, topography, climate and favourable soil conditions in "sydväxtberg", ravines and mountain slopes. This is largely a result of sediment assortment and accumulation in favourable locations during the comparatively fast process of land uplift that has occurred here.

It should be pointed out that many lichens with their main distribution in southern Scandinavia also have similar, in some cases extreme, outpost occurrences i the High Coast area. Thus, *Ochrolechia arborea* and *Pertusaria pupillaris* have their only known localities in northern Sweden here. Other outpost species on different mountains are among others *Pertusaria*

coronata, P. flavida, P. leucostoma, Psilolecia lucida, Rhizocarpon viridiatrum, Rimularia insularis and *Tephromela grumosa* (Moberg & Thor 1993). On a steep south-faced cliff on Mount Ögeltjärnsberget in the northern part of the region *Umbilicaria polyrrhiza* is found, another outpost from southern Scandinavia (H. Sundin, pers. com.). Furthermore, *Graphis scripta, Phlyctis argena* and *Chaenotecopsis fennica* have their northernmost localities in a rich marshy wood in the vicinity (H. Sundin, pers. comm.).

Fig. 20. The inland taiga species Carex disperma occurs within the Skuleskogen National Park.

Fig. 21. Tofielda pusilla, a western inland species, grows on mires on high levels in Skuleskogen.

Boreal woodland species

Several species typically belonging to the boreal coniferous wood belt (taiga) but which are usually rare in the coastland occur in the Skuleskogen area. For instance, *Cicerbita alpina* is quite abundant. *Carex disperma* (Fig. 20), *Salix myrtilloides* and *Epilobium davuricum*, mostly inland species, are also found there.

Western and alpine species in the High Coast

Another remarkable feature of the flora in the High Coast area is the occurrence of several species which otherwise have a western or even alpine distribution in Sweden. On the higher elevated mires between 170 – 215 m. above sea level in the Skuleskogen National Park two such species grow which are not found (with one exception) elsewhere in eastern parts of the province. There are 5 known localities for *Tofieldia pusilla* (Fig. 21) and 3 for *Saussurea alpina*. The only site outside Skuleskogen is a mire with *Tofieldia pusilla* on the southern slope of Mount Stordalsberget in the parish of Nordingrå, within the High Coast region. The mire is located on 170 m. above sea level and thus fits well into the picture. In addition,

Fig. 22. The inland and alpine fern Blechnum spicant unexpectedly grows on many localities in the Skuleskogen National Park.

another distinctly western species, *Blechnum spicant* (Fig. 22), occurs in 13 localities in the Skuleskogen area between 110 – 285 m. above sea level as well as at one locality on Mount Stordalsberget (Andersson 1972, Mascher 1973, 1984a). This is another feature of the flora in the High Coast area with no counterpart elsewhere in coastal areas around the Bothnian sea.
In the Skuleskogen area near the shore of lake Dalsjön there is an isolated occurrence of *Lycopodium alpinum* (Fig. 23), 165 m. above sea level. It is very rare in the province and otherwise not found in the coastal parts (Mascher 1979c).

Fig. 23. Lycopodium alpinum, an alpine species, has a very isolated occurrence in the Skuleskogen area.

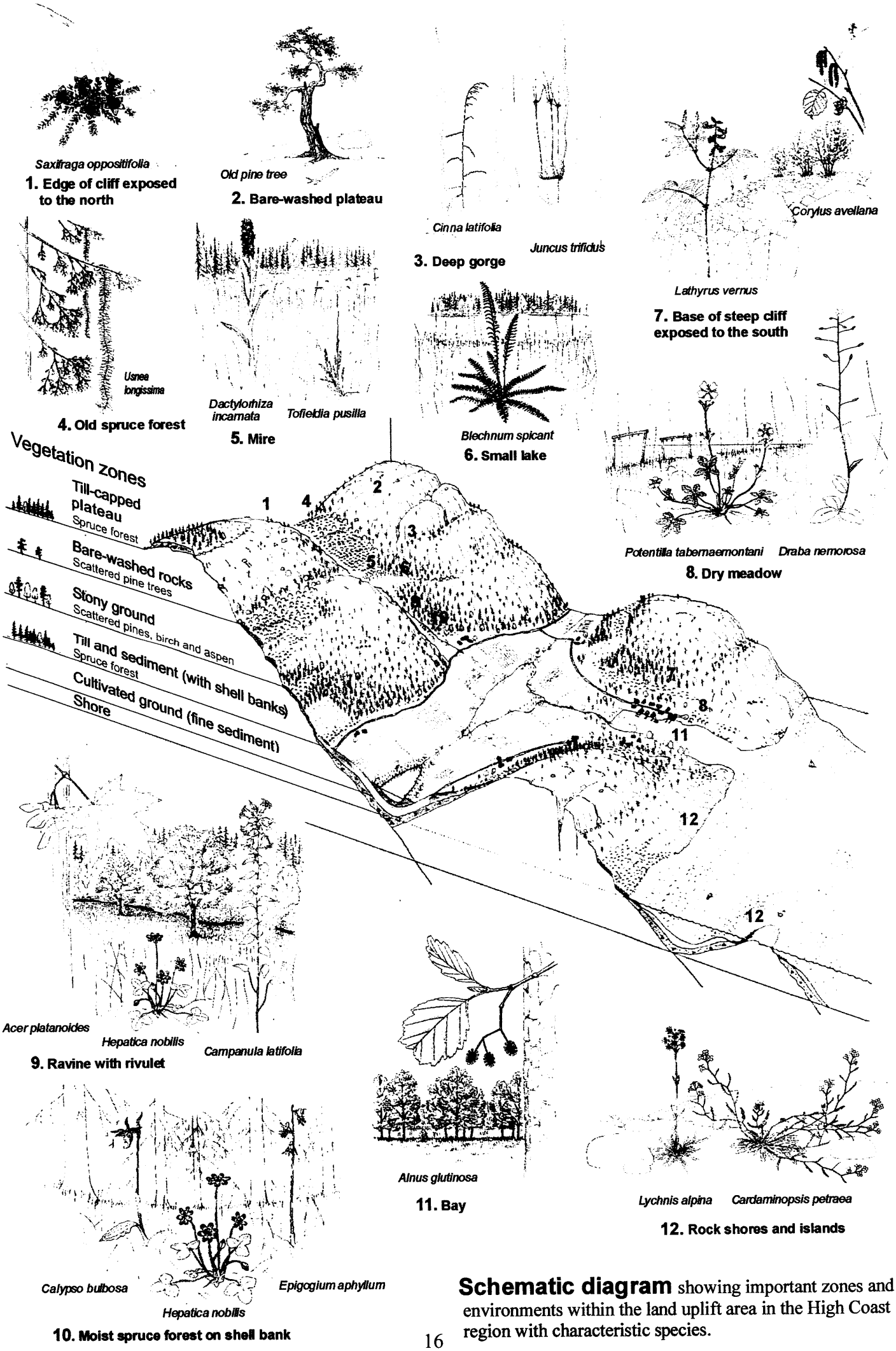
Also belonging to the group of western elements, though not an alpine species, is the Atlantic, white-flowered form of *Campanula latifolia* (Fig. 24) which predominantly occurs in several ravines in the southern parts of the High Coast region where it reaches the vicinity of the Bothnian coast (Mascher 1979b). Its northernmost outpost locality, on the eastern slope of Mount Hästråberget in the Skuleskogen area, to the west of the highway E4, is another example illustrating the status of the High Coast region as an area of borderlines for many different floral elements.

Fig. 24. The atlantic, white-flowered form of Campanula latifolia has probably invaded from Norway eastwards to the Bothnian Coast.

Alpine species on shaded rocks

Several alpine species occur in an exceptional concentration along the High Coast, mostly in shaded crevices and steep cliffs on the northern side of several mountains. The species in question are: *Polysthicum lonchitis* (1 loc.), *Asplenium viride* (4), *Juncus trifidus* (4), *Alchemilla alpina* (6), *Saxifraga cespitosa* (11, Map 3, Fig. 25) and *Saxifraga oppositifolia* (2, Fig. 26-27), (Henkel 1966, Ericson 1977, Mascher 1971, 1978c). Only *Asplenium viride* and *Saxifraga cespitosa* are found outside the High Coast area in the province of Ångermanland, at 1 and 5 localities respectively, but there are a few isolated and very scattered occurrences elsewhere in the boreal woodland east of the Scandes. All

Fig. 25. Saxifraga cespitosa is an alpine relict known on 12 localities in the High Coast region.



Schematic diagram showing important zones and environments within the land uplift area in the High Coast region with characteristic species.

species except *Juncus trifidus* grow only on diabase rocks, *Asplenium viride* also on amphibolite. *Saxifraga oppositifolia* has its two only occurrences east of the Scandes in two steep diabase cliffs in the parish of Nordingrå. The alpine species mentioned mostly grow on cliffs in the higher parts of the High Coast mountains below the HS level. An interesting exception is *Saxifraga cespitosa* which has a few occurrences at lower levels near the present surface of the Bothnian sea. Here, this species grows on perpendicular or very steep diabase cliffs down to about 1 – 1.5 m. above sea level, i. e. on comparatively recent land uplift rock zones.

Fig. 26. The shady, northern side of the diabase cap on Mount Själandsklinten, Nordingrå parish, is inhabited by the alpine species Saxifraga oppositifolia

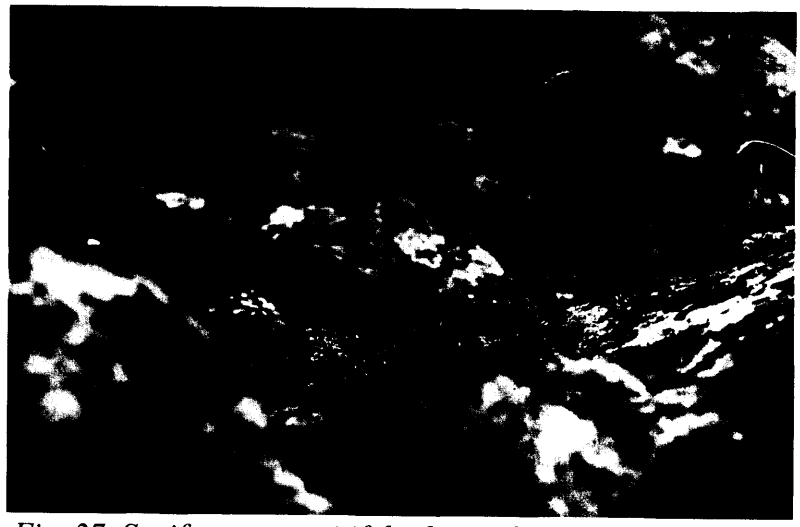


Fig. 27. Saxifraga oppositifolia has only two occurrences in the lowland east of the Scandes, both in the High Coast region.

The species mentioned are considered as relicts from the alpine post-glacial period and the small populations of *Saxifraga cespitosa* near sea level must have spread slowly in crevices down the steep cliffs. The competition from other species is minimal on the surface of the newly uplifted rock surface which emerges almost perpendicularly from the sea so that the spreading distance is extremely short.

In addition, several northern and alpine lichens also have very isolated, and in some cases unique outpost occurrences, on the higher mountains in the High Coast region. Ahlner (1953) reported about 30 such species, on mountain plateaus, perpendicular cliffs or coastal rocks, such as *Alectoria nigricans, Bryoria nitidula* and *Umbilicaria crustulosa*. Several more recent finds of such species have been made, e.g. *Cladonia luteoalba, Helocarpon crassipes* and *Pertusaria dactylina* on cliffs or boulders on the shady north-eastern side of Mount Ringkalleberget in Nordingrå parish whereas *Caloplaca grimmiae, Rhizoplaca subdiscrepans* and *Dimelaena oreina* and others occur in more exposed environments near the seashore on Mount Valaberget in Vibyggerå parish (Moberg & Thor 1993). *Alectoria ochroleuca*, another northern, mostly alpine species is found on Mount Ögeltjärnsberget further to the north (H. Sundin, pers. comm.).

Oceanic mosses and lichens

Among mosses and lichens there is also a remarkable concentration of south-western or western oceanic species within the High Coast area, especially in Skuleskogen. The reason for this is no doubt the elevated terrain, to a large extent higher than 250 m. above sea level with summits reaching 330 m. in the near proximity to the Bothnian sea. Thus the temperature is comparatively low and there is a low evaporation rate which results in a higher humidity than elsewhere in the eastern parts of Scandinavia.

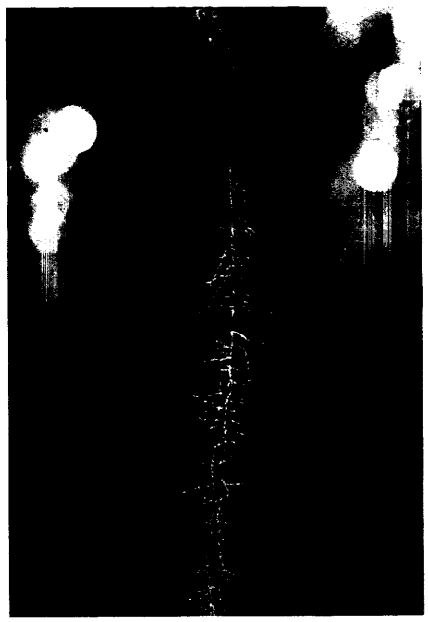


Fig. 28. The endangered lichen Usnea longissima grows on about 350 spruce trees in the Skuleskogen National Park. Photo: Ove Kjällström.

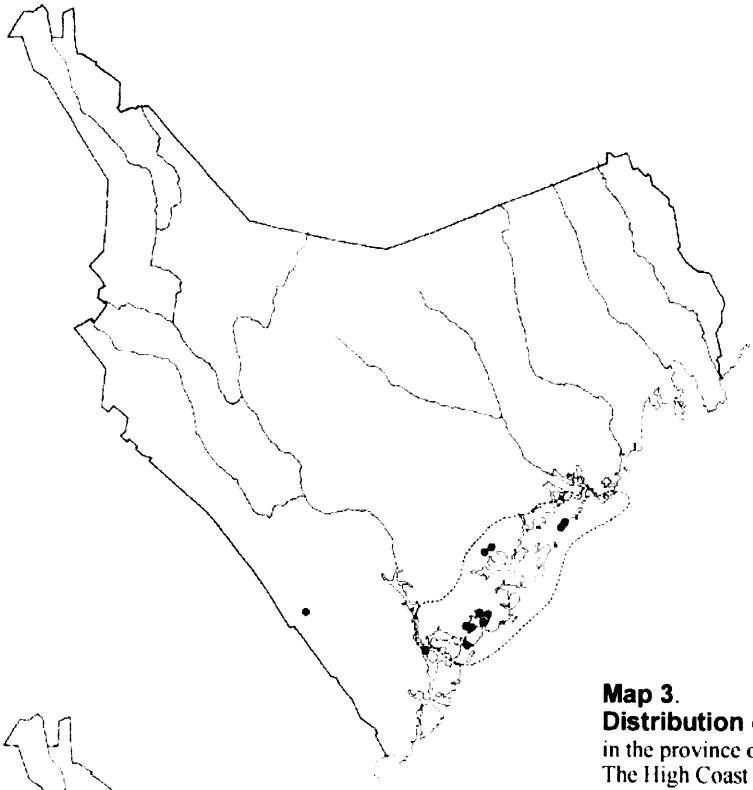
Söderström (1983) reported more or less isolated occurences in the Skuleskogen area of several oceanic mosses: *Plagiothecium undulatum, Rhytidiadelphus lorens, Leucobryum glaucum, Harpanthus scutatus* and *Mylia taylorii.*

In the Skuleskogen area *Usnea* lichens are unexpectedly abundant on pine trees quite near the Bothnian Sea (B.G. Jonsson, pers. comm.), which is also in accordance with a locally oceanic climate. A large population of the disappearing species *Usnea longissima* (Fig. 28) which is threatened in the Northern Hemisphere grows on about 350 spruce trees, mostly within the national park (Esseen et.al. 1992). In the southern part of the High Coast region, on Mount Ringkalleberget, Nordingrå parish, the oceanic lichen *Lobaria amplissima* has its only known occurrence in eastern Sweden (Mascher 1991, Moberg & Thor 1993).

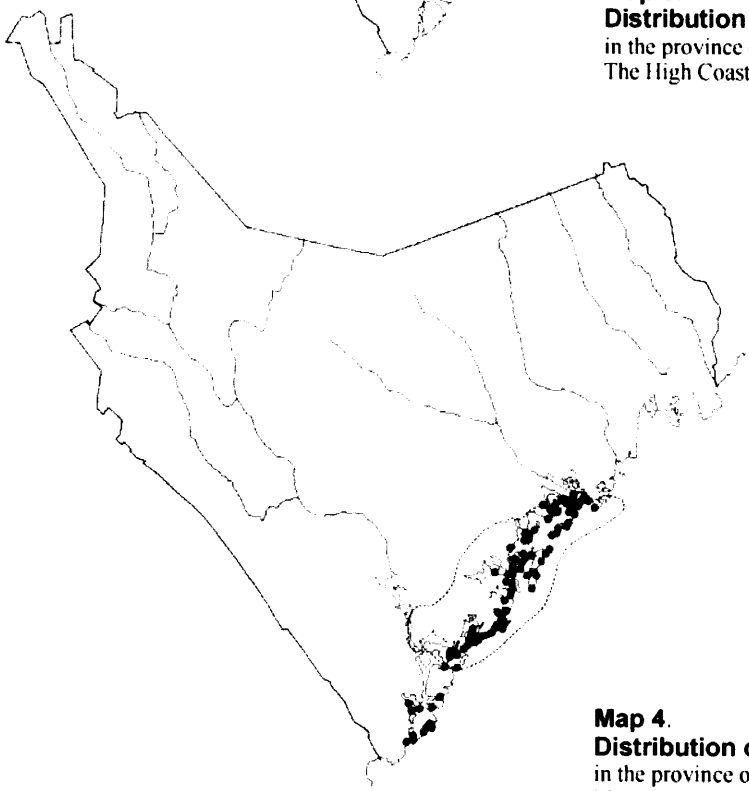
Post-glacial alpine and warm period relicts meet

One of the most remarkable among the alpine species in the High Coast area is *Polysthicum lonchitis*, which grows abundantly on a steep scree at an altidue of about 175 m. above sea level on the north-east side of Mount Ringkalleberget in the southern part of Nordingrå parish. No other locality is known along the Bothnian coast. The site is well below the HS, rised above the sea surface by land uplift about 8,800 years ago (Lundqvist 1987, Cato 1992). It is not the only alpine species here. On the steep shaded diabase cliffs, above the scree,

Fig. 29. On the shady, north-eastern side of Mount Ringkalleberget, Nordingrå parish, alpine species meet outposts from the south. The alpine fern Polystichum lonchitis is seen together with Acer platanoides and Lathyrus vernus.



Map 3.
Distribution of Saxifraga cespitosa
in the province of Ångermanland.
The High Coast region is outlined



Map 4.
Distribution of Cardaminopsis petraea
in the province of Ångermanland.
The High Coast region is outlined

both *Saxifraga cespitosa* and *S. oppositifolia* occur (Mascher 1971). Interestingly enough, these relict alpine species grow here together with three markedly southern species, *Corylus avellana*, *Acer platanoides* and *Lathyrus vernus* (Mascher 1971, 1975, 1991, Fagervall & Stenberg 1974, Fig. 29). They have several other outpost occurrences in the eastern parts of the province, mostly within the High Coast region, where two of them, *Acer platanoides* and *Lathyrus vernus*, reach their northernmost borderlines only 20-25 km. to the north of Ringkalleberget.

Fig. 30. The mostly alpine species Lychnis alpina is quite frequent on rocky land uplift shores along the High Coast.

This constellation of several alpine and southern relict occurrences from the alpine and warm post-glacial periods at the same locality near the Bothnian coast is quite unique and most interesting ecologically as well as with regard to dispersal history in connection with the process of land uplift. In all probability, the alpine species were established very soon after the ice regression which was in a relatively short time space followed by the post-glacial warm period so that the southern species *Corylus avellana* and *Acer platanoides* may have been able to invade the region and this site perhaps 1,000-2,000 years later. Since a herb such as *Lathyrus vernus* requires rich soil at the surface it may be assumed to have reached the actual site somewhat later, after a period of time necessary for the establishment of a humus layer on the scree where finer sediments were no doubt essentially washed out by the waves when the site emerged from the sea.
Also in the local lichen flora, some of the already mentioned southern and northern (alpine) species meet on certain mountains, such as Ringkalleberget in Nordingrå parish, Valaberget in Vibyggerå parish (Moberg & Thor 1993) and Ögeltjärnsberget further to the north in Själevad parish (H. Sundin, pers. comm.).

Remarkable species on land uplift rock shores

The constantly rising cliff shores which dominate along the High Coast are inhabited by another species with a predominantly alpine distribution in Scandinavia, although it also occurs on inland mountains: *Lychnis alpina*. It has a markedly high frequence here and often grows in the upper geolittoral belt (Ericson 1977) and even quite near the water front among other pioneer species which colonize new rock ground (Mascher 1981b, Fig. 30). It is sometimes found together with *Cardaminopsis petraea*, a species which has its Swedish distribution restricted to the coast of the province of Ångermanland (Map 4). On rocky shores, the latter species belongs to the very first pioneers close to the water edge such as *Puccinellia capillaris*. *Cardaminopsis petraea* also grows on sand and rubble on stable ground some distance from the shore but always exposed to the open sea (Fig. 31-32). It is mostly found on diabase rocks but also on rapakivi granite and sandstone (Ericson & Mascher 1977).

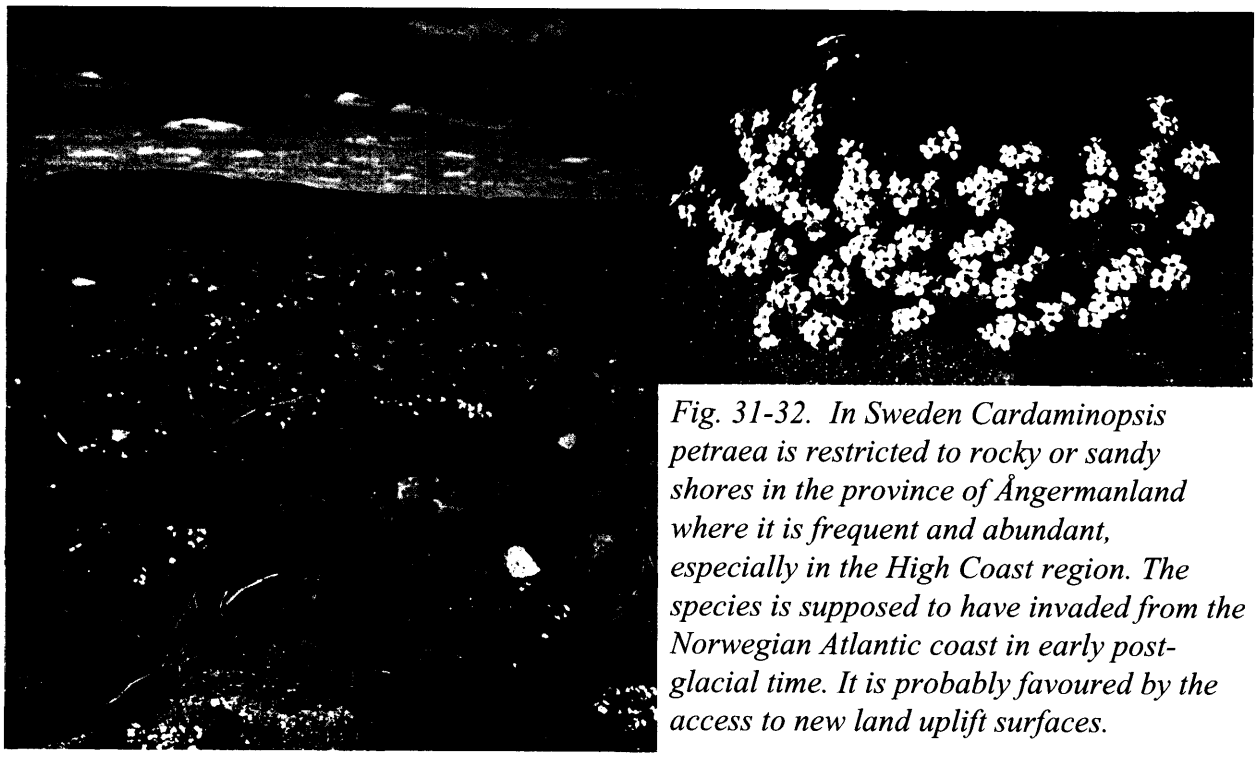


Fig. 31-32. In Sweden Cardaminopsis petraea is restricted to rocky or sandy shores in the province of Ångermanland where it is frequent and abundant, especially in the High Coast region. The species is supposed to have invaded from the Norwegian Atlantic coast in early post-glacial time. It is probably favoured by the access to new land uplift surfaces.

The limited Swedish distribution of *Cardaminopsis petraea* is probably explained by its supposed dispersal from the Atlantic coast soon after the inland ice regression when the distance to the post-glacial Bothnian shore was relatively short. During the course of land uplift it followed the rising shore eastwards and as it is dependent on minimal competition from other species the High Coast area with its maximal land uplift offers good conditions for the species to prevail here whereas it seems to have been unable to expand further south or north of its known borders (with the exception of a presumably recent small population at the coast of the Nordmaling parish, north of the High Coast area, but still within the same province, Ericsson 1993). The occurrence of *Cardaminopsis petraea* is a most remarkable feature of the High Coast flora which probably has to be seen in connection with bare bedrock and the relatively substantial land uplift. A third species with a marked concentration of localities along the rocky shores of the High Coast is *Juncus compressus* which is a southern element with its main distribution along the Baltic coasts (Ericson 1977).

A remarkable fact with respect to the shores of the High Coast, in contrast to seashores in general, is that there are no noticeable tidal water fluctuations in the Bothnian Sea basin. This contributes to a relative stability in the seashore vegetation which facilitates the establishment of species such as *Cardaminopsis petraea, Lychnis alpina* and *Juncus compressus* in the land uplift zone. The distribution, ecology and dependence on local land uplift conditions of these species with remarkable occurrences and frequencies along the High Coast shores, has still to be more thoroughly studied.

Eastern species

Of great interest is the occurrence among large boulders in the deep shaded gorge Slåttdalsklyftan in Skuleskogen National Park of the rare grass *Cinna latifolia*. It belongs to a group of species of eastern or south-eastern origin with a poorly understood distribution in central Sweden and south-eastern Norway (Mascher 1990 and references). This locality is the northermost in Sweden. The previously mentioned dry meadow species *Draba nemorosa* that mostly grows near small fishing villages, is another member of this group (Fig. 33).

Shore vegetation characteristics at the High Coast

The shore vegetation along the southern part of the High Coast region has been investigated and closely described by Ericson (1977) and the following presentation is mostly based on his work. There are several notable conditions that characterise the High Coast, and distinguish it from other parts of the Bothnian Sea coast.

Fig. 33. Draba nemorosa is an eastern species growing on dry meadows only in the middle part of Sweden.

Because of the steep coast, the shore belts are very narrow and strongly influenced by ground water. As a consequence, the geolittoral flora is dominated by species growing on soils moistened by seeping fresh water such as *Equisetum arvense, Triglochin palustre, Calamagrostis stricta, Eriophorum angustifolium, Lathyrus palustris, Eleocharis uniglumis* var. *fennica, Carex*-hybrids and on drift material in the upper geolittoral even species unexpected near sea shores such as *Circaea alpina, Impatiens noli tangere, Stellaria nemorum* and others may occur. This is in contrast to other parts of the Bothnian coast where most of these species occur only in the innermost parts of the bays and skerries near or on the mainland. In the *Alnus incana* and *A. glutinosa* belts in sheltered bays *Deschampsia cespitosa, Filipendula ulmaria, Valeriana sambucifolia* and *Rubus arcticus* often dominate.

On the other hand, several species growing mostly on saline shore-meadows along other parts of the Bothnian Sea are rare or even lacking at the High Coast, e.g. *Ophioglossum vulgare, Triglochin maritimum, Juncus gerardii, Rumex pseudonatronatus, Hippophae rhamnoides, Glaux maritima, Euphrasia bottnica, Plantago maritima, Aster tripolium.* The sparse occurrence of shore meadows along the steep coast, in combination with the strong influence of groundwater on the shores accounts for this in most cases. Furthermore, the frequencies of even other species, e.g. *Schoenoplectus tabernaemontani, Rhinanthus angustifolius, Linaria vulgaris, Valeriana salina* and *Sonchus arvensis* are reduced along the High Coast.

There is also a marked difference in the occurrence of the endemic species *Deschampsia bottnica* which is quite common along other parts of the Bothnian coast. At the High Coast it is very scarce as a consequence of the fresh-water influence which is unfavourable for this species. Instead, the more fresh-water tolerant hybrid *Deschampsia bottnica X cespitosa* is dominating. Together with *Agrostis gigantea* it characterizes especially open shore belts in front of the *Alnus* belts where erosion by storm waves and ice often forms marked shore edges with sometimes naked roots and fallen stems of *Alnus*.

A fact probably connected with a relatively high salinity in more shallow shore waters is the comparatively high frequence at the High Coast of the southern species *Eleocharis parvula*, growing on shallow clay bottoms in *Phragmites* belts of sheltered bays, where the *Phragmites* stands are loosened by ice erosion, intense grazing or boat landings. It is otherwise scarce at the Bothnian coasts but commoner along the shores of higher salinity in the Baltic.

As is the case regarding land species, the High Coast also is a pronounced borderline area for several southern and northern sea-shore species.

The solifluction of clay and silt into the sea which takes place from the steep shores is another peculiar phenomenon at the High Coast otherwise normally observed along river beds.

In spite of the strong freshwater influence on the geolittoral, the hydrolittoral has a contrasting, relatively high salinity beacuse the water is deep quite near the shore (often the 6 m. depth level is located only 6-7 m. from land) so that deep water with relatively high salinity is readily brought up to the surface. The hydrolittoral flora along the High Coast therefore is largely the same as in other parts of the Bothnian sea.

Colonization on land uplift surfaces

On the steep coast, the yearly area of land added to the shore by land uplift is quite small and insignificant in a short term wiew. Normal yearly and seasonal fluctuations in water level as well as extreme conditions such as heavy storms especially in combination with ice erosion, tend to obscure the phenomenon of land uplift in periods shorter than about 10 years (Ericson 1977, 1981). For instance, an unusually heavy storm may derange several years of vegetation development so that the process has to be restarted.

Long-lived, competitive species such as *Calamagrostis stricta, Eleocharis uniglumis* var. *fennica* and *Carex* hybrids with a vegetative manner of expansion are favoured by these conditions peculiar to the High Coast because they are relatively resistant and can extend slowly over the yearly gained new land. Short-lived, annual or biennial, species on the other hand, spreading by seeds, do not expand easily beacuse of the very restricted accessible free surface where seeds can germinate. In addition, they are more vulnerable when exposed to competition by other species and erosion. During certain summer seasons with low water they may temporarily establish readily on a level which would be equivalent of a 10-20 year period of land uplift, but they perish to a great extent when the water level is restored to normal. Long-lived species spreading vegetatively are much more resistant against such year-to-year fluctuations (Ericson 1977).

The occurrence of *Alnus glutinosa* along the High Coast

The High Coast region is the northernmost part of the Bothnian coast where *Alnus glutinosa* still forms continuous stands bordering the seashore in sheltered bays (Fig. 34). The species grows along the land uplift shores in the upper geolittoral zone closer to the water than *Alnus incana* which is found in an epilittoral belt behind the dark-green wall of *A. glutinosa* trees. North of the High Coast, where the shores are low with shallow waters, the last-mentioned species mostly occurs in smaller stands and as isolated trees (Ericson 1972). Behind the *A. incana* zone spruce often grows. As a result of the land uplift process the trees are of gradually increasing age with increasing distance from the shore. Also *Sorbus aucuparia* individs

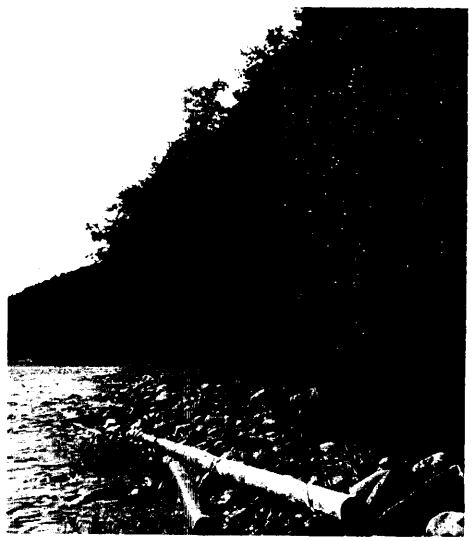


Fig. 34. Alnus glutinosa forms dense belts along the land uplift shores of sheltered bays.

dispersed in the deciduous belts and the neighbouring spruce belt tend to show the same age distribution. Fallen trunks in old stands of *Alnus glutinosa* gradually pushed further out in the lower parts of the geolittoral belt partly by land uplift, partly and often more evidently by wave erosion on open shores are often seen. The development of these distinct tree belts along the High Coast in relation to the comparatively large land uplift is clearly displayed.

At several localities on different levels below the HS level *A. glutinosa* is found as a relict at the shores of lakes cut off from the former sea within the High Coast region as well as further inland in the province where it often occurs quite close to but never above the HS (Westman 1985).

Lakes cut off from the sea

The flora of lakes cut off from the sea and bays with shallow outlets on the verge of being isolated by land uplift has been studied very little. Only in the High Coast area the impact on e.g. rock shore species such as *Juncus compressus, Cardaminopsis petraea* and *Lychnis alpina* of diminishing water salinity and exposure of shores to the open sea can be studied.

Vågsfjärden in Nordingrå parish was isolated from the sea in historic time about 100 years ago, but the possible survival of seashore species as relicts here has not been investigated. Bäckfjärden north of the Skuleskogen area is a large basin with a narrow and shallow connection to the sea. In the 19th century *Cardaminopsis petraea* and *Lychnis alpina* were collected on the inner shores and at the outlet of this bay. Both species were still found in 1947 (*C. petraea* only at the outlet) but 30 years later they had disappeared. Obviously, very little saline water is still transported into the basin. Within some 100 years Bäckfjärden will have turned into a lake.

Ericson (1977) described the interesting occurrence at the southern part of the High Coast of small rich fens in the littoral belt developed in depressions cut off from the sea on the diabase shore bedrock. Sometimes strongly basiphilous plants such as *Carex capillaris* and *Linum catharticum* occur, suggesting some influence of seeping fresh water enriched by nearby shell layers.

Vegetation history

There are few actual facts illustrating the postglacial dispersal of trees, bushes and plants in the High Coast area. Macrofossil finds are very scattered. Fossil hazel-nuts have been found in a bog 65 m. above sea level in Nora parish (Andersson 1902), which was cut off from the sea as a small lake about 3,000 years B.C. Thus the hazel seems to have invaded the shores of this lake after the height of the warm period. Fossil remnants of elm have been found in the same parish. Macrofinds have also been made of some other southern species which evidently occurred in the region during the boreal-atlantic warm period but later perished: *Carex pseudocyperus, Najas marina, Ruppia maritima, Lycopus europaeus* (Andersson 1902, Backman 1955).

An interesting aspect to be studied is the postglacial development of vegetation in the High Coast area considering e.g. the dipsersal of alpine species, some of them still living here, as well as southern elements such as broad-leaved deciduous trees and hazel. Pollen analyses have been performed to some extent in and not far outside the region though in the first hand the aim was to study cultural development (Huttunen & Tolonen 1972, Miller et al. 1979, Wallin 1996, cf. also Lundqvist 1987). Mostly lake sediments, not so well suited for the study of natural vegetation,

have been taken into account. It is clear from the pollen analyses available e.g. that *Rumex* and *Salix* species dominated the seashores soon after the ice recession. *Hippophae rhamnoides* was also an important inhabitant of the post-glacial sea coast until at least 5,500 years BC. Nowadays the species only grows at one single locality along this part of the Bothnian Sea. Several studies confirm that spruce invaded this part of the Bothnian coast about 1,400 years BC.
Further work with an emphasis on vegetation history would be of great interest, especially pollen diagrams from mires at higher elevations, beacuse of the unique diversity in the region's vegetation with several contrasting elements which reached the area at different times during the land uplift process.

Summary

To sum up, the following features are most important for the status of the High Coast region as an outstanding area of concentrated environmental and floral diversity.

1. Mountainous coastal landscape, unique topography around the Baltic and the Bothnian Sea.

2. Acid archaean rock and volcanic basic bedrock, mostly diabases.

3. The highest vertical land uplift zone in the world.

4. Unique mosaic of varied environments within an only 8-18 km wide coastal zone.

5. Steep land uplift shores in brackish water without the impact of tidal water.

6. Land uplift dependent vegetation zonation on rich sediments and shell layers.

7. Mild climate (Golf Stream) with a long vegetation period. Locally oceanic climate with high humidity, which is unique around the Baltic and the Bothnian Sea.

A. *Floral diversity*

For topografical, geological and climatical reasons, and as a consequence of the land uplift process, the High Coast region is a remarkable meeting-place for a species-rich flora with elements of very different origins.

a). Southern partly calciphilous or basiphilous species in various environments.
Many species reach their northern distribution limits within the area.
Several extreme relict occurrences.
b). Boreal woodland (taiga) species, rare near the coast.
c). Western and oceanic species in different environments. Several extreme outpost occurrences.
d). Alpine relict species, mostly bound to basic bedrock. Several extreme outpost occurrences.
e). Eastern-south-eastern species in different environments.

B. *Remarkable types of vegetation largely develloped as a result of the land uplift process*

a). Calciphilous vegetation on shell bearing sediments (below 80 m.a.s.l.). Species-rich spruce woods, ravines, dry meadows, small mires.
b). Basiphilous vegetation on rich sediments (in and above the shell bank zone) in valleys, ravines, lower parts of mountain slopes, mires.
c). Vegetation on (sometimes steep) land uplift rock shores.
d). Shore vegetation belts with special traits adapted to land uplift conditions on a steep coast (rich fresh-water outflow, relatively high salinity etc.).
e). Partly relict vegetation of lakes and fens cut off from the sea.
f). Mountain plateaus bare-washed by the post-glacial sea, with very old pine trees.
g). Wood belts along the seashore with land uplift related age gradients.

C. *Other outstanding types of vegetation and environments adding to the complex diversity of the High Coast region*

a). Remarkable concentration of species-rich mountains of the type "sydväxtberg" with many borderline occurrences of southern species and several alpine relicts on the shady northern sides.
b). Environments on high elevations with oceanic local climate and oceanic outpost occurrences (of herbs, mosses, lichens).
c). Remarkable meeting places for extreme outpost occurrences of southern and alpine species (herbs and lichens) on mountain cliffs and screes.
d). Dry meadows on withered basic rock
e). Basiphilous pine forests on basic bedrock.

The High Coast region as a whole must be regarded as a remarkable "hot diversity spot".

The concentrated environmental and floral diversity in the High Coast region is also important for animal life, e.g. birds and especially insects (see p. 32). Clearly, there are unusual opportunities for a variety of comparative ecological studies in and between different zones and environments from the coastal cliffs which continue to emerge from the sea through the shell bank zone and the highest sea-shore line to the till-capped mountain plateaus never reached by the post-glacial sea waves. There is a very great potential for scientific fieldwork.

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Notes on larger mammals, birds and insects in the High Coast region

Jan W. Mascher

There are attractive environments for several large **mammals** in the High Coast region.
The woods and wilderness of the Skuleskogen National Park and its surroundings are sometimes visited by *bears*. Many *lynxes* (Fig. 1) live not only here but also in other parts of the region such as in Nordingrå parish. There are attractive environments for this species with excellent hiding-places on the numerous High Coast mountains with large boulders at the bottom of steep cliffs etc. In addition there is a rich population of *roe deer* which are predated on by the lynxes. The *moose* (Fig. 2.) is quite common and sometimes crosses the water or the ice to the islands.

Fig. 1. Many lynxes live in the High Coast region. Photo: Kjell Ljungström.

Birdlife is rich and varied in the High Coast area because of the mosaic diversity of environments concentrated in a narrow coastal zone. Especially in the land uplift area rich soils nourish a very rich and varied vegetation with many southern elements such as broad-leafed deciduous trees. Thus, there are many different habitats attracting rare birds of southern or south-eastern origin which are found especially on the larger islands such as N. and S. Ulvön and also in the eastern parts of the mainland near the coast. Such species occurring more often than elsewhere in this part of the country are e.g. *Corncrake, Spotted Crake, Quail, Thrush Nightingale, Red-brested Flycatcher, Grashopper Warbler, Marsh Warbler, Blyth's Reed Warbler* and *Greenish Warbler.*

Fig. 2. High Coast moose. Photo: Kjell Ljungström.

In the undisturbed woodlands, ravines, marshes and on the mountain plateaus of the Skuleskogen National Park some inland bird species occur which are otherwise very uncommon near the Bothnian Coast, e. g. *Willow Grouse, Siberian Jay* (Fig. 3) and *Rustic Bunting* (Fig. 4). Even the *Waxwing* has bread in this area. This phenomenon is similar to the occurrence of boreal woodland (taiga) plants as members of the flora of the National Park and its surroundings. In addition, all seven woodpecker species living in the boreal forests of northern Sweden are found here, though the *White-backed Woodpecker* is nowadays very sporadic. The *Grey-headed Woodpecker* (Fig. 5-6) which has its Swedish distribution remarkably restricted to the central parts of the country occurs in several parts of the region. This is explained by the species preference

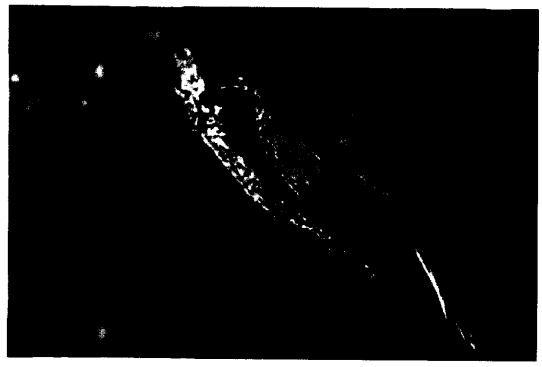

Fig. 3. The Siberian Jay, an inland taiga species, sometimes occurs in the Skuleskogen area. Photo: Ove Källström.

for mountain slopes with stands of large aspen trees which is an unusually common type of environment here. One of the most reliable places where a visitor can wiew this rare woodpecker is the Skuleskogen National Park. The *Three-toed Woodpecker* is mostly an inland species but also breeds here (Fig. 7).

Fig. 4. The Rustic Bunting, an inland species, lives in the swampy forests and mire edges of the Skuleskogen National Park. Photo: Jörgen Wiklund.

Coastal birdlife is mainly ordinary. There is a colony on the small rocky island Gnäggen near S. Ulvön of *Razorbills* (Fig. 8) and *Guillemots* (Pettersson 1999). Only one more such colony exists along the Bothnian coast, in the Kvarken area.

The **insect** fauna is still only sparsely known.
However, some finds in different parts of the High Coast indicate that in this field too, there are many outposts and isolated occurrences of different origins. This is in accordance with the same phenomenon as described concerning the flora. The large variety in plant life is expected to be expressed in the insect fauna e.g. because many species are more or less bound to certain host species or species groups.

Fig. 5. Grey-headed Woodpecker. Photo: Sune Näslund.
Fig. 6. Old aspen tree, breeding-place for the Grey-headed Woodpecker, Nordingrå parish. Photo: J.W.Mascher.

A rich fauna of butterflies and moths is found on the flower-rich dry meadows near the coast. It is hardly unexpected that several northern outposts of southern lepidopterids are known here as is also the case in the flora. For example, the moths *Pyrausta aurata* and *P. cingulata* and the geometrid *Scopula incanata* reach their northern borderlines here (R. Pettersson, unpubl.). Especially the two last-mentioned species mostly live on *Thymus serpyllum*, which is known on few localities to the north of the High Coast region.
In Nordingrå parish, the rare beetle *Badister lacertosus* reaches its northernmost border near the coast on the peninsula Rävsön (R. Pettersson, pers. comm.).

On several hundred year old pine trees which characterise some of the bare mountain plateaus in the Skuleskogen area the very rare beetle *Dicerca moesta* has a rich isolated population and probably its most convenient habitat in the country (Pettersson 1985 and pers. com.). This draws attention to the remarkable environment with old, partly decaying pines of different ages, exceeding five hundred years, on these coastal mountain plateaus which are of great faunal and floral interest in particular with respect to lichens and insects.

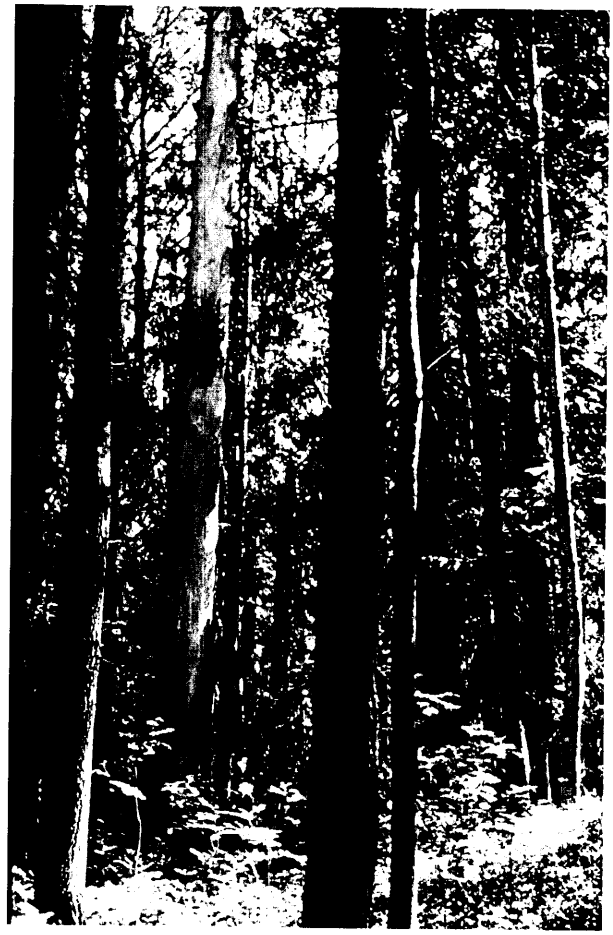

Fig. 7. Herb-rich spruce forest with an old dead trunk, breading-place for the Three-toed Woodpecker, Älvdalsbäcken, Skuleskogen National park. Photo: J. W. Mascher.

The scattered knowledge of today is enough to draw great attention to the High Coast as an interesting meeting place and border area for very different species groups of insects.

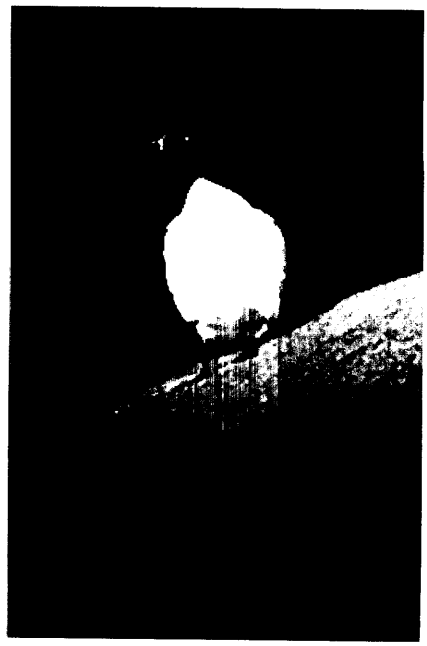

Fig. 8. Razorbills breed on the island Gnäggen. Photo: Jörgen Wiklund

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Many thanks to Roger Pettersson, Umeå for important facts on insects in the High Coast area, and to Thomas Birkö, Örnsköldsvik for discussions on the bird fauna.

THE HIGH COAST

ENCLOSURE 8

ECO-LABELLING OF THE HIGH COAST

April 2000

The County Adminstration of Västernorrland

Text: Erika Larsson

Cover photo: The fishing village Bönhamn

Photo: Kjell Ljungström

MILJÖMÄRKT TRYCKSAK
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1. ECO-LABELLING OF THE HIGH COAST REGION

The Miljömerke High Coast project was launched in 1999 after a preliminary study indicated that there was interest in eco-labelling of the High Coast area. The Miljömerke High Coast project was inspired by the *Beatha Eco-labelling Project* on Ireland's west coast where interesting work has been conducted to eco-label an entire geographical area. The project is an important element in the county's development of the tourism industry and is linked to the area's candidacy for inclusion on UNESCO's World Heritage List.

To eco-label an entire geographic area is a relatively new means to increase its attraction. Miljömerke High Coast is the first region in Sweden to be eco-labelled. It is also unique in that the undertaking focuses on tourism and that the tourist industry initiated the project. This makes it possible to export working methods and the labelling system to other regions in Sweden and elsewhere in the world.

Miljömerke High Coast's overall aim is to *strengthen tourism and the area as a whole by highlighting and developing environmental and natural assets.* The goal is to attain long-term, sustainable tourism in the area. This involves, for example:

- Sustainable social development at the regional level.
- Successive improvement in the environmental characteristics of different activities in the High Coast.
- Balance between the demands for natural and environmental consideration and the demands of the activities conducted there.
- Increased competitiveness for the business community.
- Positive effects on profitability and employment.
- Greater understanding among the local population for the area's unique natural and cultural heritage.

The project denotes an important position on the part of the entire society concerning the significance of sustainable development.

Through the active participation of public bodies and individual companies in the development work and a joint effort to achieve established environmental goals, where the objectives are steadily extended, it is possible to attain a successive improvement in environmental quality. Within the project considerable focus is placed on the relationship between demands for environmental consideration and the activities. Undertakings must be possible to realise in practice and the cost of environmental adaptation that is borne by the company must be in proportion to the benefits to the company and the environment for the measures implemented.

Since ISO 14000, EMAS and other international environmental certification systems demand corresponding environmental awareness on the part of all suppliers, including hotels, conference centres and restaurants, companies who operate in an environmentally conscious manner improve their chances of being chosen as a supplier to environmentally certified businesses. The environmental work being conducted in the High Coast region means that the participating companies are acting in anticipation of future customer demands.

Effects on profitability and employment are realised indirectly through the increase the area's attractiveness. Everyone, businesses, society and the environment, benefit in the long-term from environmental work regardless of labelling or not.

1.1 Geographical Boundaries

To permit practical management of the work associated with the first generation of the project it was decided to limit the area geographically. To the south the boundary is formed by a river, Ångermanälven, to the west by European Highway 4, the Mosjön campground to the north and the sea forms a natural boundary to the east. In other words, the entire area nominated for inclusion on the World Heritage List is included in the eco-labelling area. When the first term of the project is concluded the area covered by generation two will be extended.

2. Environmental Work

Labelling does not only apply to businesses only but also a considerable portion of the landscape at the High Coast. For practical reasons the project has been split into two parallel sub-projects: inventory and labelling of the natural environment and a business segment. Only when both of these sub-projects have achieved their environmental objectives can the entire area receive its award. Work involving the natural environment is being conducted at the municipal and regional levels.

The eco-labelling project can be briefly described as containing five stages. 1) Resource inventory and analysis, incl. existing data, 2) Drawing up of a programme for continued environmental work and improvements. 3) Assessment by an international jury, 4) Voluntary eco-labelling in accordance with EU criteria and 5) Continual improvement.

Resource Inventory

The inventory is conducted in two parallel activities. External impact on the natural environment via an inventory of water, air, waste management and existing nature protection. This includes, for example, drinking water, surface water, bathing water, air quality in built-up and rural areas, waste from boats and ships, tourist waste, coverage and type of nature protection. The other, parallel inventory, is concerned with tourism companies and their environmental work.

All work conducted within the framework of the project has a strict tourism perspective and the important factors for tourists depend upon their background. Swedish tourists are likely to assume that the water in taps is suitable for drinking whereas many other visitors regard tap water that is fit to drink as a sign of quality. Being able to swim in lakes is not always self-evident either. The air we breathe can also be seen as an indicator of sound environmental quality. Air can be considered clean according to measurement results but unfamiliar odours from a nearby industry can leave another impression. Questions such as these must be dealt with when the inventory is concluded and the criteria are to be established in preparation for the official labelling.

To be able to implement improvements and measure their effects demands that the starting-point be known. What is the state of our waterways? How is the air? During the course of the project two people are investigating the current situation by reviewing existing material and taking new measurements. This work is being conducted in association with the local Agenda 21 work that is underway in the municipalities of Kramfors and Örnsköldsvik.

At the same time, a study of what is important for the companies is being conducted within the business sub-project. The expense of adapting operations to satisfy higher environmental requirements cannot be excessively high and is to provide returns in parity with the investment in time and capital. The business community's awareness is an aspect of development that is beneficial to the companies participating in the project and the development of tourism in the area as a whole. The possible acceptance of the area as a World Heritage Site also affects environmental work in that the value of the environment will become more evident to both businesses and the population in general.

Create a program for continued environmental work and improvement

The plan that results from the inventory phase is to contain certain objectives that must be achieved before the area can be considered for first generation eco-labelling. Based on the results of the conducted inventory a distinction will be made, in part, between the criteria that are important to the natural environment and businesses and, in part, which environmental issues need to be addressed. Experts in environmental issues and the public authorities concerned will set the programme for future environmental work with respect to the natural environment.

An intermediate goal for the business segment is the adoption of an environmental strategy for each company. This is also an element of the work with the environmental programme. These environmental strategies will lead to concrete environmental goals, specifically linked to the companies' own requirements. When an evaluation shows that the objectives are satisfied the next step is to set new, higher goals. This method leads to a rising spiral with respect to the companies' own environmental undertakings as well as an upward progression for the environment of the High Coast.

All businesses in the geographic area delineated above have been offered the opportunity to participate in the project. Work is conducted in collaboration with local business organisations along with an environmental consultant. In addition to contributing working time the participating companies pay for educational courses.

Assessment by an international jury and voluntary eco-labelling in accordance with EU criteria

The label is based on existing labels, quality norms and standards that have been modified to increase their attraction for other regions interested in advancing to this label. The jury's verdict will be based on the results of the inventory phase and the action plan for the entire area.

To be credible, the labelling criteria must be approved by a respected third party which assumes an active role as "home" for the label. In doing so, this third party also assumes responsibility for evaluation of the natural environment in the area as well as the companies' work to satisfy the established criteria. A label for the destination cannot be issued until both sub-projects have achieved their aims.

Attention will be brought to the companies that have completed the educational course and been approved in the third party evaluation through the issue of a diploma with a local eco-label in order to demonstrate appreciation of their efforts right from the outset.

Continual Improvement

A system of recurring checks is to be developed when the plan has been fulfilled and the area labelled. As goals are reached new goals must be set to advance towards new improvements and generation two labelling. The improvements must be made with respect to both the natural environment and company performance. The participants in the business segment must be monitored constantly to ensure that environmental work continues. The companies that wish are to be able to strive towards higher environmental goals and in so doing be afforded the opportunity to attain a higher level of eco-label. As the companies reach the established levels such accomplishments shall clearly be allowed for use in marketing activities. This will allow potential customers to readily see that the operations are in keeping with environmental activities.

This continuous improvement is positively influenced by the network that is formed linking the companies that have completed the educational course and which work actively with environmental questions as the network members incite one another to action.

3. Project significance for World Heritage nomination

The same region to be eco-labelled is also nominated for inclusion on the UNESCO World Heritage List on the grounds of its unique geological and natural characteristics. This nomination is of major significance for tourism and its future development in the area.

High Coast as a World Heritage site would mean an increase in the number of visitors to the area which, in turn, could result in a dramatic increase in wear and tear on the local environment. Therefore, measures must be taken in a World Heritage area to maintain the heritage that is to be preserved. The eco-labelling project now underway means that the first step towards minimising the environmental impact of tourism on the High Coast has already been taken. Given that more and more enterprises are joining the project, and that on-going checks of the natural environment are conducted, the prerequisites are good for sustainable development in keeping with the area's circumstances despite an increase in tourism at the High Coast.

A segment of the High Coast has national park status which means there are protective measures already in place that aim to preserve the natural environment. The High Coast is also protected by a widespread commitment in the area to preserve the unique legacy of the High Coast. The eco-labelling project is just one example of this commitment. Interest in the project has been expressed by the local population, business community, public bodies engaged in matters related to the environment and sustainable development, tourism organisations etc. This mutual understanding between public authorities, businesses and individuals is beneficial to our natural environment and therefore also to the World Heritage Site should the High Coast be granted that status. The High Coast's development is in tune with the conditions set down by the unique environment and thereby the legacy is preserved for future generations.

4. Time Schedule

Work within the project has been underway since 1999. The inventory work launched in the autumn of 1999 is to be concluded about mid-March 2000. By the end of April 2000 the criteria are to be established and contact made with the prospective environmental "home" in order to create credibility for the label. At the same time an action plan is to be produced for the High Coast.

Education of enterprises is conducted continuously and a diploma is awarded to those enterprises that have completed the course and satisfied the environmental criteria. The first successful candidates are expected to receive their diplomas at the end of May 2000.

Labelling of the destination will likely occur towards the end of year 2000 when the requirements on the natural environment are expected to be satisfied and a majority of the companies have completed the prescribed educational programme.

The eco-labelling of enterprises is based on ISO 14001 and EMAS and has been given the status "en route to EMAS". Consequently, there is a clear link with existing standards and the label therefore has greater potential for recognition. This means that the conditions are good for the future development of the label into a European standard for eco-labelling of entire tourism areas, i.e. a label with export potential.

5. Organisation

Formally the project is owned by the regional tourism body, the Mitt Sweden Tourism Economic Association, which is also responsible for project leadership. The environmental movement, businesses and public authorities are represented in the management committee via the Swedish National Board for Industrial and Technical Development (NUTEK), the National Environmental Protection Agency (SNV), the Swedish Society for Nature Conservation (SNF), entré Höga Kusten, the Västernorrland County Administrative Board, the Västernorrland County Council and the municipalities of Kramfors and Örnsköldsvik. The project also has ties with the Swedish Environmental Management Council.

The practical work involved in the environmental inventory and education course is conducted via a consultant company along with project assistants employed by the Environment and Public Health Offices of the municipalities of Kramfors and Örnsköldsvik. Administration, information and marketing are conducted via the regional tourism body.

6. Financing

The project is funded by EU structural funds, the Västernorrland County Council, the Västernorrland County Labour Board, SNV, NUTEK, the municipality of Kramfors, the municipality of Örnsköldsvik and private contributors. Project turnover is estimated at approximately SEK 2.1 million for the period 1999-2000.

7. Information and Marketing

In the initial phase the project's information and marketing have been primarily focused on the local area. The main emphasis has been on information to the local population and enterprises to make them aware of the undertaking and how it can influence their lives and business. Municipal and regional decision-makers have received information concerning Miljömerke High Coast to facilitate decisions and to generate support for the project. Information is updated on a regular basis. Information to bodies and individuals who influence public opinion has also been regarded as important as they constitute an important channel for the dissemination of information. Miljömerke High Coast collaborates with the media to keep the public informed of developments in the project.

The spread of information as well as marketing activities are done by means of printed matter, articles, participation in information meetings, personal contact and, to a considerable extent, via the Internet where it is possible to quickly update information for those wishing to follow the project's development more closely.

As the project has a number of international contacts the organisation is ready and willing to assist in the organisation of study visits for the parties concerned.

THE HIGH COAST

ENCLOSURE 9

DESCRIPTION OF THE HIGH COAST LANDSCAPE

April 2000

The County Adminstration of Västernorrland

Cover: "Motif from the Nordingrå area"(oil), Helmer Osslund 1918

(Västernorrland County Museum), (Photo: Anna Porsmyr, Sundsvalls museum)

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Landscape Description – The High Coast

By Bengt Schibbye and Eva-Lisa Anderson

The High Coast is generally regarded as an extremely magnificent landscape. The beauty of the countryside can largely be attributed to the distinct and varied character of the landscape, the organisation of the elements, the spatial qualities and scale. Throughout the ages people have been fascinated by this landscape, its timelessness, breathtaking views and unspoiled state. This description of the countryside offers a presentation of, and explanation for, the character of the High Coast with an emphasis on the impression made on people by the landscape.

Sörleviken, Water-colour (41 X 35 cm), Per Julius

"Now lie the mighty, steep hills embellished by forest and flowers. Like hunch-backed giants they rest there through time with the sound around them from thousands of years of thundering waves. Like an enormous army, where the worriers have reclined in fantastic positions beneath the pleated cape of the pine forest ..." (Albert Viksten, 1936)

The Landscape's Form

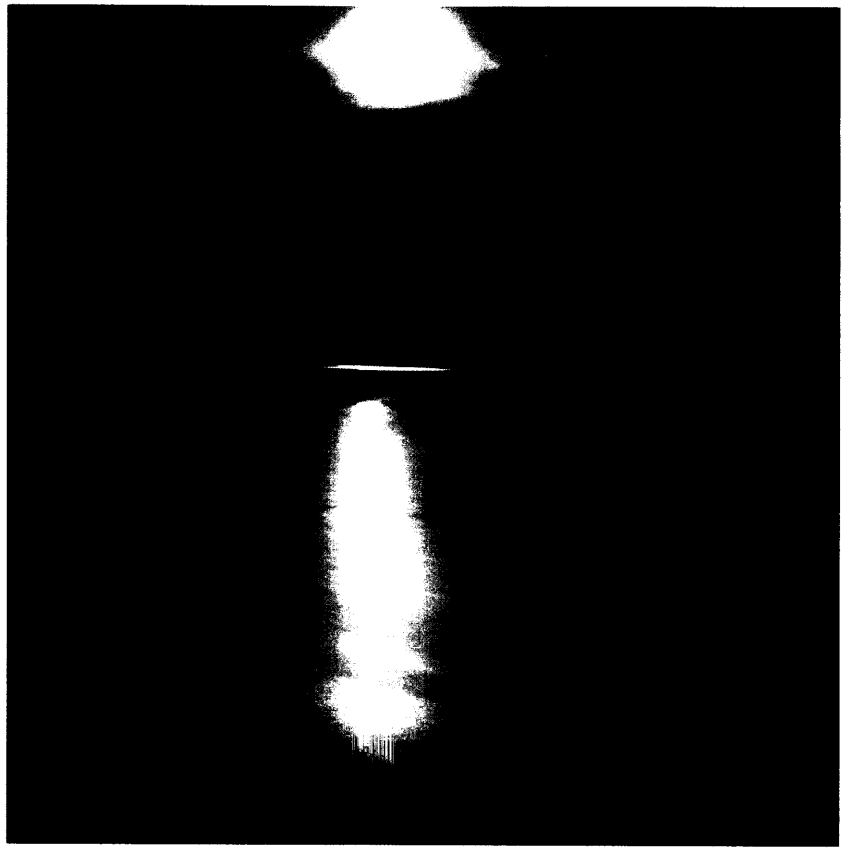
The High Coast stretches from the mouth of Ångermanälven, along the coast of Ångermanland, north to Örnsköldsvik. The rolling highland terrain of the northern Swedish inland here reaches all the way to the shoreline and is classified as the landscape type "steep, tree-covered coast". The High Coast contains considerable differences in elevation and depth, with peaks up to 350 metres and the seabed in places as deep as 250 metres. A mosaic of rock types and a system of major crevices has given the landscape an extremely varied and mosaic structure, with high, rounded peaks, craggy faults, narrow cultivated valleys, forest, lakes, archipelago and deep, penetrating inlets. In the district around Nordingrå the landscape is, if possible, even more varied than the surrounding area and it is here the High Coast is at its most impressive. The High Coast is distinctly different from the surrounding lowlands to the north and south as well as from the forest-covered inland highlands.

The Landscape Experience

Images and Symbols

The landscape is brimming with symbols that in various ways influence the beholder's experience. What these symbols are, and the significance assigned to them, differs from person to person and hinges upon the beholder's relationship and connection with the landscape. The farmer working the land of his forefathers, the newly resident commuter, the summer cottage owners, the chance visitor, all place different values on different symbols. The value people assign to the landscape's symbols varies not only from person to person, but also over time.

Several of the images or notions that have become symbols of the High Coast have proven to be held by many people and have remained relatively constant through the passage of time. Studies of literary, artistic and generally descriptive works have shown that certain characteristic symbols are experienced and viewed in much the same fashion. Depictions of the landscape by writers, artists and photographers capture and describe in a similar manner the symbolic value of the landscape which can be regarded as a general understanding and thereby serve to describe the High Coast.



Månsken, Photo, John Chang McCurdy

Distinction and Beauty

The High Coast is widely described as beautiful countryside, a landscape with steep hills and breathtaking views, a landscape that constantly catches the attention of visitors with "High hills and deep valleys, hidden inlets, serene lakes and contented farmland."

In the visual landscape experience the concepts of scale, structure and contrast play a central role. That which provides a sense of pleasure is often closely related to the possibility to easily organise the impressions made by the landscape. The simplicity and clarity of the landscape's structure can largely explain the beauty of the High Coast.

The High Coast's structure is latticed with clear veins where cultivated land, communities and lakes are found in succession along the valleys between the forest-covered hills. This structure, which is foremost a consequence of the nature of the bedrock and the dramatic land uplift, is plainly visible in the topography and land use. The boundaries between the High Coast's large-scale landscape elements, the forested heights, the cultivated valleys and water surfaces are also very concrete and distinct. The High Coast displays distinctive features in both structure and content which allows the visitor to easily grasp and absorb the impressions made by the landscape.

....

Variation

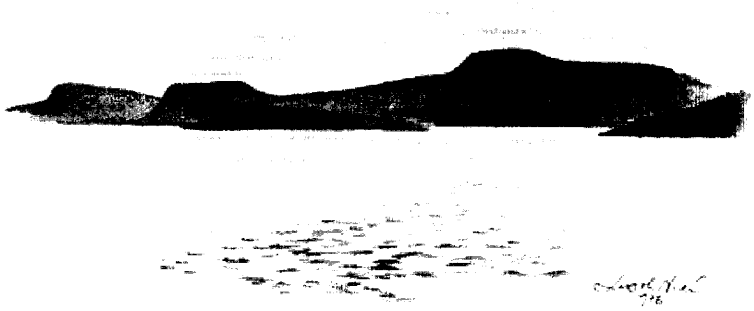
Along with distinctiveness, the tremendous variation and diversity in the landscape have become central symbols for the High Coast. The variation consists of the sudden, unexpected transitions from the distinct and clearly defined structures and landscape elements. Moving through the landscape one is surprised at the frequent and drastic changes, from the imposing and wild, forested hills and bare bedrock to the small-scale farms in the valleys. In 1885 Carl Wilhelm Karlsten wrote of Nordingrå parish *"The villages around the parish are separated from each other by peaks and steep slopes, and are hidden from view by the hills until one comes very near... ".*

Vägen, Sketch, Lars-Ola Norén

Views

The High Coast is a landscape of views, magnificent vistas. The entire area is like a stage, the slopes are steep, and exposed in their entirety, the field of view only limited by the topography. Travelling through the landscape one moves from room to room, clearly delineated, with eyes often trained on the surrounding heights at the end of the valley or the other side of an inlet.

Two visual experiences dominate a journey through the High Coast. One is the timeless image of the sea, the sky and the rock. Unaffected, static and monumental. *"The rocky world of Ullångerfjärden, pitch-black, immutable, divine, indifferent"* in the words of Ludvig Nordström. It is a breathtaking image from many vantage points on land and is also open to those approaching by sea.

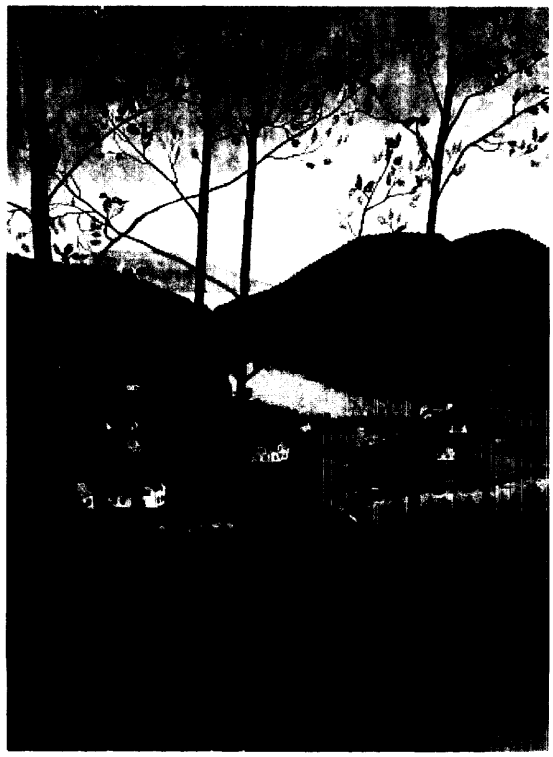


Ullångersfjärden, Sketch, Lars-Ola Norén

Before us, rising above the Red Sea, and then over the foaming whitecaps lies the rocky world of Ullångerfjärden, pitch-black, immutable, divine, indifferent. How many times must I see it to be able to describe it?" (Ludvig Nordström)

In one of the many descriptions of the area it is mentioned that *"The High Coast seems at a distance, both barren and desolate "* or as one of the local artists expresses it *"... an unspoiled patch of countryside, mountain-like and yet not harsh and still gentle."*

The other type of view is offered by the cultural-historical areas with the small farms, villages and roads, which are almost without exception situated in the valleys and along waterways. Here the horizon is edged by the hills that fade into a blue haze at the ends of the valleys. The multitude of lakes and inlets is deceptive and it can at times be difficult to distinguish the sea from the lakes.



Utsikt från Stortorget, Water-colour (74 X 54 cm), Per Julius.

Space

"This is of course Ångermanland – hill beyond hill, ridge beyond ridge, contours that create and accentuate distance, but also a spatial landscape, that can have a dual effect. ... The landscape in the mind's eye is transparent against the one before you. It must be so in the home of rapid and dramatic change." (Birger Norman).
The landscape's scale, spatial characteristics and horizons are of central importance to perspective and the visual depth effect – the three-dimensional experience. It is said of Ångermanland and the High Coast that there is a *"the very tangible impression of space created by the hills of Ångermanland"* (Lars Guvå). Others have written of the "double scales", the small-scale, clearly defined cultivated land and the enormous, unchanging blue forested areas.

Timelessness and Tradition

The High Coast exudes timelessness and historical tradition. Traditions are embodied by the small-scale farming and the way people make use of the soil. This is often symbolised by the flowering meadows, barns, gravel roads and farms at the edge of the great forests. Timelessness is in turn symbolised by the distant blue hills and the boundlessness of the sea. The hills and sea also represent the monumental and untouched, qualities often associated with the High Coast. The contrast between that which symbolises the traditional and the timeless is great. The small-scale, reflecting human activity, and the dominating hills and sea, seemingly undisturbed by the influence of mankind.

Landscapes Types – The High Coast

Based on the landscape's exterior forms and how these are regarded it is possible to divide the High Coast into three landscape types – areas with common features, characteristics and qualities.

<u>The coast and islands – the barren, undeveloped coast with wide vistas.</u>

The High Coast has an archipelago coast with a multitude of islands, inlets, sounds and bays. This lacination means that visitors can be surprised by an open view of the horizon way out at sea even relatively "far inland". The coastal hills and islands are among the highest in Sweden and along the Baltic Sea coast thus making a monumental impression not found elsewhere around the Baltic. The bare-washed rocks and pine forests dominate and from the sea the coast often appears barren and desolate.

Utsikt Nordingrå, Oil, Helmer Osslund, (Västernorrlands Länsmuseum)

On the outskirts of the archipelago there are virtually no buildings – the fishing hamlets and smaller areas of holiday cottages are found in sheltered inlets and within the boundary formed by the islands. The roads occasionally follow the shoreline deep in the inlets and only rarely skim the outskirts of the archipelago. Deep in Ullångersfjärden and Dockstafjärden are the towns that have lent their names to the bays. The balance of the area is only thinly populated.

The islands are characterised by barren ground but they have a long history as bases for fishermen. In his book entitled "Ulvön bottenhavets pärla" Lars Bergström writes that *"It is foremost the encounters with nature one recalls after a visit to Ulvön. The sea, the fishing hamlets, sun-bathing on the warm, polished stone slabs, the view from the summit of Lotsberget overlooking Ulvöhamn and the boat-trip to and from justify the nickname the island has been given in literature, "The Pearl of the Gulf of Bothnia".*

<u>The cultivated areas – the small-scale agricultural area, dotted with lakes, with its powerful spatial impact and limited vistas.</u>

The contrast is sharp between the coastal zone and the small-scale cultivated areas that spread at the base of the coastal hills, deep in the inlets and around the lakes. Even this landscape is marked by the great differences in elevation and its rugged nature. The differences between the massiveness of the mountains and the small-scale valley fields and buildings is fascinating. This is where the bulk of the buildings along the High Coast are situated, bound to the valley slopes, ridges and hillocks of the cultivated landscape and along the roads. The high hill faces emphasise the space and embrace the small farms and communities. The scene is commonly limited to the immediate surroundings but at times the view extends along a valley or through a pass into the next landscape room.

Skuleskogen and the inland – forest land with a wilderness touch

The highland, wilderness area inland from the coast. The area lacks the deep valleys found to the north and south, and cultivated fields are rare. One of perhaps the strongest symbols for the entire High Coast is Skuleberget that stretches skyward like a centrepiece in the area.

Skuleberget i vinterskrud, Photo, Kjell Ljungström

"...standing alongside the road was a dreadfully steep and high hill, called SKULEBERGET, within which was a crypt. I wanted to go there, but people said it was impossible; after great effort a couple of men agree to accompany me and show the way, we scaled cliffs, crawled, slid, drew ourselves forward ..."
(Carl Linneus, Lapplandsresa år 1732)

The Skuleskogen National Park is described as a wilderness and one lyrical description reads: *"The interesting geological formations, the wild forest, the open slabs of rock, the views, the precipices, bird life and the floral combination of southern elements and alpine-like species are ingredients in a fascinating entirety that is not possible to describe in a few short sentences. It must be experienced."*

WORLD HERITAGE NOMINATION - IUCN TECHNICAL EVALUATION

THE HIGH COAST (SWEDEN)

ADDENDUM TO 1999 IUCN TECHNICAL EVALUATION

1. DOCUMENTATION

The above nomination was reviewed by the 23rd extraordinary session of the Bureau of the World Heritage Committee (29 November-4 December 1999) which reached the following conclusion:

"Following comments of IUCN concerning the need for better documentation of the values of the marine portion of the area, the relation to the proposed Quark World Heritage nomination and integrity issues, the Bureau decided to defer this nomination. The Bureau noted that the State Party might also wish to consider nominating the area as a cultural landscape."

In its evaluation report, submitted to the November 1999 Bureau, IUCN also requested a more complete comparative analysis of the area.

In April 2000, the State Party provided the World Heritage Centre with additional information addressing the Bureau's concerns. This Addendum to the original IUCN 1999 technical evaluation is based on the additional material submitted by the State Party, and takes into account the results of a second field evaluation in August 2000. In preparing this report IUCN has also considered the draft World Heritage nomination document of the Kvarken (Quark), and a field visit to the site in August 2000.

Additional Literature Consulted: Freden, C. (Ed.) 1994. **National Atlas of Sweden - Geology**. 208p. Sjoberg, B. (Ed.) 1992. **National Atlas of Sweden - Sea and Coast**. 128p. Geological Survey of Sweden, 2000. **The Importance of Basic Geological Perspective in Society**. 18p. Nordic Council of Ministers, 1996. **Nordic World Heritage: Proposals for New Areas for the UNESCO World Heritage Lis***t*. Nord 1996:31 (Copenhagen), 194p. Embleton, C. & King, C.A.M. 1968. **Glacial and Periglacial Geomorphology**. Edward Arnold, 608p. Flint, R.F. 1971. **Glacial and Quaternary Geology**. Wiley and Sons, 892p.

Consultations: 4 additional external reviewers, relevant scientists and representatives of provincial and municipal government in Finland and Sweden.

Field Visit: Paul Dingwall, August 2000.

2. REVIEW OF SUPPLEMENTARY DOCUMENTATION

a) Additional Information on Natural Values

i) Terrestrial Biota:
The vegetation of the High Coast (HC) displays marked altitudinal zonation and great spatial variability, with high floristic diversity, due to the complex pattern of soils and substrate on an uplifted, high-relief land surface. For example, a full range of forest types is concentrated within a small area, with mature forests on till-capped plateau surfaces above the highest shoreline (285m asl) being particularly noteworthy. The geological, topographical and climatic conditions also combine to make the HC a distinctive vegetation boundary zone, with a rare blend of southern plants with northern Boreal, western oceanic and eastern continental species. There is also intermixing of southern and relict alpine plant species from warmer and colder periods, respectively.

The HC contains large mammal species, such as bear, lynx and moose, which are widespread in Scandinavia. While the coastal birdlife is typical of the region, the terrestrial birdlife is rich and varied due to the altitudinal range and topographic diversity which also provide habitats attractive to some rare

birds of southern origin. Invertebrate fauna is not well known, though insects may be richer than elsewhere because of the floristic diversity, and landscape evolution may have produced some anomalous distributions.

The region's terrestrial biota in general, and its plants and vegetation history in particular, have not been extensively studied. However, the terrestrial flora and fauna appear essentially undistinguished in the region overall. They derive their greatest distinction and scientific significance from their connection with the process of land uplift.

ii) The Marine Realm:
The biological character of the HC's marine environment is a consequence of several major controlling influences such as: brackish waters of very low salinity; the most sharply contoured submarine topography in the Baltic, extending to depths in excess of 200m close inshore; little tidal influence, with shifting water levels determined mainly by changing weather conditions of air pressure and wind; and seasonal ice cover. Natural environments have undergone dramatic changes since glacial times, passing through marine, brackish and freshwater conditions. The resultant mosaic of shallow, sheltered embayments and deep, open waters provides a range of habitats for a mix of marine, brackish and freshwater species, low in species diversity but high in population numbers for some macrofauna species. Some species are relics of earlier periods, and others are at the extremes of their latitudinal and environmental limits. For the most part, however, the marine biota are described as being typical and representative of that found throughout the Baltic, rather than special or unique.

The special feature of the marine realm, imparting the greatest scientific significance, is that it represents the submarine extension of the topographical continuum of landscapes undergoing isostatic uplift. Continual elevation of the land results in inlets becoming progressively cut off from the sea, transforming them into estuaries and ultimately lakes (some of which retain their name as bays). Meanwhile, shorelines are constantly reshaped, new islands are born offshore, and others become peninsulas as they unite with the mainland. The terrestrial influence progressively extends seawards into the Bothnian Sea. This process has major effects for the associated plants and animals that must constantly adapt to the changing environments. Thus, the nearshore marine area constitutes an integral part of the ongoing geological evolution of the HC and, as such, it is an important natural component of the entire property.

iii) Natural Beauty
The HC derives its scenic attractiveness from its uncommonly (in the Baltic) hilly terrain and from the closely interrelated landscapes and seascapes of islands, bays, shores, lakes, slopes and plateau summits. The site also demonstrates forested tracts interspersed with sheltered valleys harbouring picturesque fishing and tourist villages and small towns surrounded by neatly tended pastures and cropland. The whole creates a landscape of great scenic value and aesthetic appeal. However, the area derives much of its aesthetic value from the interaction of its natural and cultural heritage rather than its natural values. Many of the aesthetic attributes are also typical of coastal regions in Sweden and the Baltic generally.

b) <u>Comparison with Other Areas</u>

i) Glaciation and Isostacy in World Geology:
Glacial periods are very rare in the overall geological history of the earth. Repeated glaciation is the outstanding feature of the Pleistocene Era of geological time, beginning about 1.5 million years ago, when ice covered an area of the world more than three times greater than at present. The indirect impacts of glaciation, particularly through changes in sea level, affected much of the earth. Northern Hemisphere glaciation was manifested by two huge continental-scale icesheets; the Laurentide (North American) and Fenno-Scandian (European) icesheets, extending from polar to middle latitudes. Both have essentially disappeared through post-glacial melting over the past 10-20,000 years. But their legacy is seen in characteristic erosional and depositional landforms (e.g. till plains, drumlins and eskers), and in raised shorelines due to isostatic rebound of the earth's crust that was depressed as much as 800m under the weight of icesheets up to 3km thick. Ice loading keeps the bedrock below sea level under the two remaining massive icesheets of Antarctica and Greenland. However, in North America and Scandinavia slow uplift continues as the crust adjusts to removal of the ice cover. This process of post-glacial crustal rebound, known as isostacy, is therefore a global geomorphological phenomenon of importance for shaping landscapes.

ii) Comparative Analysis:
The only comparable area in the world exhibiting regional scale isostatic land uplift like that seen at HC is centred on Hudson Bay in Northern Canada. Over the past 8-10,000 years, both areas have experienced an approximately equivalent total uplift above present sea level in excess of 280m, and both are continuing to rise currently at a similar rate of 8-10mm per year. However, HC is rather more exceptional in several respects. Its steeper relief confines relict shorelines into a 2km-wide coastal zone, compared to a 50km belt at Hudson Bay where the topography is gentler. Biological affinities with the geological history are, thus, more starkly displayed on HC. The HC also has a warmer climate, with a diversity of biotypes compared to the ubiquitous tundra vegetation at Hudson Bay.

The HC is far better known and documented scientifically, and is essentially the "type area" for research on isostacy, the phenomenon having been first recognised and studied there (Flint, 1971). While the highest shoreline in the Baltic was mapped as early as 1888, the pattern of isostatic rebound in Hudson Bay remains poorly recorded and mapped (Embleton and King, 1968). The HC also differs in having a long (5,000 year) history of human settlement with an abundant archaeological record, while Hudson Bay has been only sparsely populated by a largely hunting culture.

iii) Relation of the High Coast to the Kvarken Area
The Kvarken (Quark) area, a possible World Heritage nomination, is the narrow threshold of shallow, brackish sea and till archipelagos separating the Bothnian Sea and Bothnian Bay. Located near the centre of the Fenno-Scandian isostatic uplift area, like the HC it is rising at a rate of 8-9mm per year. Uplift is expected to continue for another 10,000 years, to a height of 130m above present levels. Within 3,000 years a land bridge will arise from the shallow (25m deep) waters, thus joining the mainlands of Finland and Sweden. This process will cut Bothnian Bay off from the Bothnian Sea thus forming the largest lake in Europe.

Unlike the predominantly erosional HC, the Kvarken is a moraine archipelago. Its flat topography comprises glacial till deposited by the melting icesheet and formed into hummocky moraines and drumlins rising only 20-30m above sea level. The archipelagos are mostly less than 1,000 years old. Uplift of the shallow seabed rapidly transforms bays into fladas and glo-lakes, then into freshwater lakes, even over the lifetime of a single human generation. Plant succession is equally rapid on the newly created land, displaying marked shoreline zonation. Each phase of uplift has its own characteristic vegetation assemblage, with young marshes of sedges at sea level extending through a series of successional stages to mature spruce forest furthest from the shore.

While the HC and the Kvarken have isostatic rebound in common, they are geologically contrasting areas with marked differences in topography. This in turn has important implications for differences in plant and animal life. The HC has a dramatic land surface of bedrock hills, high islands, steep shores and deep bays and straits - features that do not otherwise occur in the Baltic region. The Kvarken is a low-relief area of extensive archipelagos of till and intervening shallow sea. The HC is also much older, revealing 10,000 years of geological evolution, as opposed to the corresponding 2,000-year history of the Kvarken. The HC is, therefore, a relatively stable biological environment, while the Kvarken, whose low-lying landscape is constantly changing due to rising land, is biologically highly dynamic, with plants and animals continuously colonising newly emergent land surfaces and successional habitats. Thus, the HC and Kvarken areas differ considerably in the ways land uplift processes act on the biota. They are, in fact, complementary in terms of their biophysical evolution. They represent, respectively, the high and low topographical extremes of post-glacial uplifted landscapes in the Baltic.

c) <u>Cultural Values</u>

Archaeological sites, some remarkably well preserved, reveal 7,000 years of human agrarian and maritime settlement in the HC, all confined by the steep topography into a narrow coastal strip of 2-3km. Displacement of coastal settlements by isostatic land uplift has created a relict cultural landscape with evidence of different peoples at successive levels above the sea. The oldest remains, from the Stone Age of 5,000 years BC, now stand at 150m above sea level, and corresponding Bronze Age (1,000 years BC) and Iron Age (15 years AD) sites are found, respectively, at 30m and 15m above the present shoreline. Adaptation of peoples to conditions created by land uplift means the geological history and cultural history are, thus, closely entwined.

The remarkable imprint of 7,000 years of human occupancy on a landscape experiencing the world's highest isostatic uplift is a significant cultural heritage asset, and one that is important to preserve for future generations. However, cultural landscapes and prehistoric remains are widespread throughout Scandinavia, and at the current state of knowledge it is difficult to assess the comparative significance of the HC. At this stage, the qualities of the cultural resources of the HC are not considered by the State Party to be of World Heritage standard, though subsequent research may alter this view.

d) Integrity

Boundaries

The boundaries of the nominated property are located to encompass the principal area of national conservation interest, extending inland to include the full zonation of uplifted land and some of the highest shoreline, while excluding areas under large-scale forestry management by forestry companies. Seaward, the boundary incorporates key offshore islands and marine areas that are a logical extension of the topographic continuum of uplifted land surface, thus taking account of ongoing geological processes. Industrial areas are excluded.

However, very little of the High Coast is legally protected with 82% of the area allowing for some form of development. External reviewers also raised concerns about the inclusion of villages and towns within the nominated area and raised the question of consistency with previous recommendations of the Bureau and Committee. For example, in the case of the Aeolian Islands (Italy), also nominated under criteria (i), the 1999 July Bureau recommended the State Party address "the exclusion of human use areas" from the nominated area. However, in the case of the High Coast it is the entire landscape that is undergoing isostatic uplift and that is, axiomatically, required to be included to paint the overall geological picture. Moreover, the presence of such developed sites does not compromise or detract from the geological values. Also, much of the human-use of the HC is limited to small villages and traditional farming rather than the larger urban areas of the Aeolian Islands. Given good management practices, this low-level human use is unlikely to threaten the conservation status of the property. There are also many existing natural World Heritage sites with human populations as outlined in IUCN's Global Theme Study working paper "Human Use of World Heritage Natural Sites – A Global Overview."

The 1999 IUCN technical evaluation report noted some large-scale developments within the site such as a major highway running through the area, the construction of a new bridge, the visual intrusion of a large television tower and proposed expansion of wind turbine generating stations. IUCN is concerned about this type of development within the site and believes that these issues could complicate future monitoring of the site.

Management

The State Party has advised that work has commenced on preparation of a management plan for the nominated property, and a management committee is being formed, representative of the County Administrative Board and the Forestry Board, and of the two local municipalities. The management plan addresses long-term management objectives and prescriptions, particularly with reference to geological and biological phenomena associated with land uplift, the marine environment, natural landscape and forest management. Emphasis is given to legal protection mechanisms under 1999 environmental legislation.

The Centre received additional information from the State Party on 27 September including a "Proposal for the Management Programme and Management Committee for the High Coast" and minutes from the inaugural meeting of the "Management Committee and Reference Group for the High Coast." The information includes an overview of Swedish environmental legislation, which will serve as a basis for the Management Committee. The goals of the Committee are: 1) to promote long-term sustainable development in the High Coast; and 2) to secure the values which form the basis of the nomination, encompassing the geological values and the other major natural and cultural values.

IUCN concludes that, if implemented effectively, the proposed management regime and legislative basis for the management of the HC would satisfy the Conditions of Integrity as laid out in the Operational Guidelines. The management of the site should therefore be reviewed in the near future to evaluate its effectiveness.

3. CONCLUSION

The additional documentation submitted by State Party has allowed IUCN to assess the following issues relating to HC:

a) biological and scenic values;

b) the value of the marine portion;

c) the site's potential as a cultural landscape;

d) the site's comparative value;

e) the relationship of HC to the proposed Kvarken World Heritage nomination; and

f) the integrity of the site.

In relation to these issues IUCN finds as follows:

a) biological and scenic values
The biological and scenic values of the HC are regarded as undistinguished and typical of those found elsewhere in the Baltic region, even though the former are inadequately known from a scientific and conservation viewpoint. IUCN concludes that the site does not merit inscription under criterion (ii) or criterion (iii)

b) the importance of the marine area;
The marine portion of the nominated sites is a submarine extension of the emergent land surface, and is thus an integral physiographic element in the paramount on-going geological process of land uplift.

c) the site's potential as a cultural landscape;
The cultural resources and landscapes of the HC complement and amplify the geological history. They are considered to be of considerable conservation value and of national importance, but their relative significance in the Nordic region is undetermined. Thus, it remains to be demonstrated from further study whether the HC meets the qualifying cultural standards for World Heritage.

d) the site's comparative value
A review of the documents and the field observations confirms that the he High Coast is the best, and most scientifically renowned, demonstration anywhere in the world of the geological phenomenon of isostatic uplift of land. It is an illustration of the processes accompanying the growth and recession of a Pleistocene continental ice sheet and their effects on glacial landform evolution. High Coast is considered by IUCN to meet criterion (i).

e) Relation of HC to the possible Kvarken World Heritage nomination
The Kvarken shares with the HC the phenomenon of land uplift. However, in its lower topographic expression and consequently more dynamic attendant biological development, the Kvarken contrasts rather than compares with the HC. They are complementary biophysical extremes in the pattern and process of post-glacial rebound of land in the greater Baltic region. There would, thus, be merit in further documenting and assessing the scientific and conservation values of the terrestrial and marine environments of the Kvarken.

f) Integrity
IUCN is concerned about the inclusion of the human-use sites within the nominated area. However, it is the entire landscape that is undergoing isostatic uplift and that is, axiomatically, required to be included to paint the overall geological picture. Moreover, the presence of such developed sites does not compromise or detract from the geological values, nor threaten the conservation status of the property. Under these circumstances, IUCN concludes that the exclusion of sites of human occupation is unwarranted.

Given effective implementation, the proposed management regime and legislative basis for the management of the HC would satisfy the Conditions of Integrity as laid out in the Operational Guidelines. However, IUCN believes that the management of the site should be reviewed in two years time to evaluate its effectiveness.

4. RECOMMENDATION

That the Committee **inscribe** the High Coast under natural criterion (i). In light of the evolving management regime, the Committee may wish to recommend a review of the effectiveness of the management of this site in two years time.

1999 WORLD HERITAGE NOMINATION - IUCN TECHNICAL EVALUATION

THE HIGH COAST (SWEDEN)

1. DOCUMENTATION

i) WCMC Data Sheet

ii) Additional Literature Consulted: Nordic Council of Ministers. 1996. **Nordic World Heritage**. Copenhagen; Trenhaile A.S. 1997. **Coastal Dynamics and Landforms**. Clarendon Press. Oxford; Marsh, J. 1998. A Global Overview of Geological Features in Natural Heritage Sites. Draft theme study report to IUCN; Thorsell, J.R. Levy and T. Segaty. 1997. A Global Overview of Wetland and Marine Protected Areas on the World Heritage List. IUCN; IUCN. Summary and Technical Evaluation, The Lapponian Area,(Sweden), 1996; **National Parks in Sweden**, Environment Protection Board, 1984; Lofgren, 1998. **Sweden's National Parks**; Curt Freden (Ed.), 1994. **National Atlas of Sweden**, Swedish Academy of Sciences; County Administration of Vasternorrland. 1998. The High Coast, 5000 Years of Human History; Rapakivi granites and related rocks in Central Sweden, Research Papers, SGU series Ca87, Uppsala 1997; Classification of Coastal Landforms; F.C. Bird, **Coasts: An Introduction to Coastal Geomorphology**, MIT Press 1968; Pirazzoli, Paolo Antonio, 1996. **Sea Level Change the Last 20,000 years**, John Wiley & Sons.1996; Kvarken Council (Sweden/Finland). 1999. Proposed World Heritage Nomination for Kvarken – The Quark.

iii) Consultations: Five external reviewers, relevant officials from Swedish Environment Protection Agency, country administration, State geologist and local university specialists.

iv) Field Visit: June 15-18, 1999. Harold Eidsvik.

2. SUMMARY OF NATURAL VALUES

The nominated site lies within the specific area known as the "High Coast" of Sweden (HCS). HCS is located on the west shore of the southern Gulf of Bothnia, a northern extension of the Baltic Sea. The size of the nominated area is 1,425km^2 including the marine component of 800km^2. There are a number of off-shore islands. Two villages exist within the site which has a resident human population of 4,500 people. The HCS is a mosaic of human and natural landscapes with agriculture, fishing and tourism as the main economic activities. Approximately 9% of the total area is protected in 28 different protected areas with most of the remaining land under private ownership. The site has a long history of human use dating from late Stone Age dwellings and remains of an Iron Age village.

Physically, the archipelago has irregular topography with a series of lakes, inlets and flat hills rising to 350m. Vegetation is typical of the west eurasian taiga with a mix of alpine, boreal forest and wetland communities. The offshore islets support small seabird populations. The main natural values of the HCS are geological and relate to the glacial history of the area. Since the retreat of the last ice cap, 18,000 – 9,600 b.p., the land began to uplift. The geomorphology of the region is largely shaped by the combined processes of glaciation, glacial retreat and the emergence of new land from the sea which continues today at a rate of 0.9m/century. Total uplift of the area since the greatest extent of the last ice age is estimated to be 800m. Since the final retreat of the ice from the HCS 9,600 years ago, the uplift has been in the order of 285-294m which is the highest evident "rebound" known. Raised shorelines and the shifting location of glacial moraines are two of the marks left on the landscape which, in turn, gives rise to variations in soils and vegetation types. The extent of the "isostatic rebound" in the region is of scientific importance in demonstrating the original size of the ice sheets and their impact on northern Europe.

3. COMPARISON WITH OTHER AREAS

There are 200 protected areas in the West Eurasian Taiga Biogeographic Province, including one mixed site in Sweden (The Laponian Area) and one natural site in Russia (the Virgin Komi Forest). Both of these existing sites are much larger and also display a wide range of geological features. They do not, however, illustrate the isostatic uplift phenomena that occurs in the HCS. Many other protected areas in the Baltic Sea region display raised coastlines including several identified in the 1996 **Nordic World Heritage** report of proposed natural sites.

There are 47 sites inscribed on the World Heritage under geological criteria, many of which contain glacial landforms and several of which have and are experiencing uplift (e.g. Gros Morne, Los Glaciares, Macquarie Island). There are also 39 natural World Heritage sites with a coastal and marine component, some of which (e.g. St. Elias Parks, Henderson Is. Southwest New Zealand and the nominated St Lucia property) illustrate raised coastline phenomenon. The distinctiveness of the HCS site is the extent of the total isostatic uplift which, at 294m, exceeds all of the above except those that have been raised as a result of tectonic forces. The only other site with comparable isostatic uplift is found in Richmond Gulf in south-eastern Hudson's Bay (Canada) which has been measured at between 275-290m. This area is very remote and extends over a great distance while the HCS can be seen in a small and accessible area.

In conclusion, the HCS is one of many places in the world that is experiencing uplift as a result of deglaciation. Isostatic rebound is well-illustrated in this site which is among the highest of such sites known. Other natural features of the HCS are relatively common and do not stand out as particularly unique at an international level. Similarly, the HCS scenic values, consisting of a blend of farmland, coastline and hills, are harmonious, but typical of much of the rural landscape of northern Europe.

4. INTEGRITY

The HCS nomination is a region inhabited by an estimated 4,500 people who practice small-scale agriculture and fishing. One national park of 2,950ha and 18 nature reserves (size ranging from 2-934ha) are contained within the region. According to IUCN's protected area management categories, HCS is Category V-Protected Landscape. The nomination notes that 9% of the total area is under protected status with most of the rest being the marine component and private lands. About 2% of the marine component is protected but the nomination does not provide details of the natural values that occur there (56% of the size of HCS is marine).

The HCS boundaries are sufficient to include the values for which it is nominated except for the western upland boundary which omits a portion of the highest paleocoast. Past mining and quarrying are claimed not to have damaged geological features, but agricultural and forestry activities have led to some disturbance of superficial deposits. The impact of marine fisheries on sea bed habitats is not known but bottom fishing and mineral exploration would affect its geological values. Only 15km^2 of the 800km^2 marine component of the area is under protective status.

Management plans exist for all the nature reserves and the national park but these lands constitute only 9% of the total area. The two relevant municipalities do have development plans and the National Natural Resources Law recognises the HCS as an area of national interest. Although the largest proportion of the HCS is marine, there is no information on its management status except to note that 2% of it is protected.

It is also noted that a major highway runs through the area and a new bridge is being constructed. The field review expressed some concerns over a visual intrusion of a large television tower and proposed expansion of wind turbine generating stations. The nomination states that World Heritage status will assist in more protection of the geological features as well as encourage the continuation of small-scale farming. Management of such multiple use and privately owned areas, however, will be difficult to achieve as there is no single management agency responsible for the area.

In sum, IUCN believes that the legislation, if applied effectively, would be reasonably adequate to protect the land area of the HCS, even though 82% of it allows for some form of development. However, without a unified management framework and without sufficient attention given to the 56% of the area that is marine, assurances of long-term integrity as per Operational Guidelines 44 (v, vi) would be cause for concern.

5. ADDITIONAL COMMENTS

Since the field inspection of the HCS, UNESCO's World Heritage Centre has received a draft of a joint Finland/Sweden nomination for an adjacent area known as "The Quark". The document was submitted on 11 June, 1999 by the Kvarken Council who are the cross-border organisation between the two countries. This site is also proposed in the **Nordic World Heritage** report prepared by the Nordic Council of Ministers. A substantial part of the rationale for the proposed Quark nomination is based on similar isostatic phenomena as well as what appear to be other substantial biological and landscape values. The nomination has yet to be formally submitted by the two State Parties but it has been endorsed by a number of municipalities and country administrations. As there is such a close proximity of the Quark and the HCS, and as there is a large duplication of heritage values, the relation between the two sites needs clarification.

6. EVALUATION

As discussed above, there are a number of questions and uncertainties over various aspects of the nomination of the HCS. These include:

- The lack of an adequate comparative analysis in the nomination which does not allow a clear and convincing case to be made on the international significance of the isostatic rebound issue and related ecological processes;
- The lack of documentation in the nomination of the natural heritage values of the marine environment which comprises 56% of the total area; and
- The lack of an assessment of the potential overlap of HCS with the proposed transborder nomination of the Kvarken/Quark site;

In addition there are a number of concerns over management issues that would mean that the HCS would not fulfil the Conditions of Integrity as provided in the Operational Guidelines for the Convention.

Finally, both the **Nordic World Heritage** report and the report of the IUCN field inspection, recommend that the site may be considered as a potential cultural landscape nomination. Certainly with its strong historical traditions and attractive rural landscape features, the feasibility of this would seem worthy of investigation.

7. RECOMMENDATIONS

That the Bureau recommend to the Committee that the High Coast nomination be **deferred** to allow the Swedish authorities to (i) more fully document the values of the marine portion of the area; (ii) to provide a more complete comparative analysis including its relation to the proposed Quark World Heritage nomination; and (iii) address the various issues relating to integrity. The Bureau may also wish to suggest that the State Party consider the prospect of nominating the site under cultural criteria.

CANDIDATURE AU PATRIMOINE MONDIAL - ÉVALUATION TECHNIQUE UICN

LA HAUTE CÔTE (SUÈDE)

ADDITIF À L'ÉVALUATION RÉALISÉE PAR L'UICN EN 1999

1. DOCUMENTATION

La présente proposition a été examinée par le Bureau du Comité du patrimoine mondial à sa vingt-troisième session extraordinaire (29 novembre-4 décembre 1999). Le Bureau a conclu :

" *Suite aux commentaires de l'UICN concernant la nécessité d'une meilleure documentation quant aux valeurs du secteur marin du site, les rapports avec la proposition d'inscription du site du Quark au patrimoine mondial et les problèmes d'intégrité, le Bureau décide de renvoyer cette proposition. Le Bureau note que l'État partie pourrait également souhaiter envisager de proposer l'inscription de ce site en tant que paysage culturel.* "

Dans son rapport d'évaluation présenté au Bureau en novembre 1999, l'UICN a également demandé une analyse comparative plus complète de ce site.

En avril 2000, l'État partie a fourni au Centre du patrimoine mondial une information complémentaire répondant au souci du Bureau. Cette information a été évaluée par l'UICN qui a recommandé en juin/juillet 2000 au Bureau : " *Que la proposition de la Haute Côte (Suède) soit examinée en 2001 et qu'un complément d'information soit fourni concernant la possibilité de proposer un site transfrontalier entre la Suède et la Finlande* ". Toutefois, le Bureau a décidé que l'information technique ayant été fournie par l'État partie, la proposition serait examinée lors de sa vingt-quatrième session extraordinaire, en novembre 2000.

Cet additif à l'évaluation technique originale de l'UICN en 1999 est fondé sur la décision ci-dessus, prise par le Bureau en novembre 1999, et sur le complément d'information fourni par la Suède, et tient compte des résultats d'une seconde évaluation sur le terrain en août 2000. Pour la préparation de ce rapport, l'UICN a aussi étudié le projet de proposition d'inscription du site au patrimoine mondial de la région du Quark (Kvarken) ainsi qu'une évaluation préliminaire du site en août 2000.

Littérature consultée : Freden, C. (Ed.) 1994. **National Atlas of Sweden - Geology**. 208p. Sjoberg, B. (Ed.) 1992. **National Atlas of Sweden - Sea and Coast**. 128p. Geological Survey of Sweden, 2000. **The Importance of Basic Geological Perspective in Society**. 18p. Nordic Council of Ministers, 1996. **Nordic World Heritage: Proposals for New Areas for the UNESCO World Heritage Lis***t*. Nord 1996:31 (Copenhagen), 194p. Embleton, C. & King, C.A.M. 1968. **Glacial and Periglacial Geomorphology**. Edward Arnold, 608p. Flint, R.F. 1971. **Glacial and Quaternary Geology**. Wiley and Sons, 892p.

Consultations : 4 évaluateurs indépendants, scientifiques éminents et représentants des gouvernements provinciaux et municipaux de Finlande et de Suède.

Visite du site : Paul Dingwall, août 2000.

2. ÉVALUATION DES INFORMATIONS COMPLÉMENTAIRES

a) Information complémentaire sur les valeurs naturelles

i) Biote terrestre

La végétation de la Haute Côte (HC) possède une diversification zonale marquée en fonction de l'altitude et une grande variabilité spatiale avec une très forte diversité floristique due à la complexité de répartition des sols et des substrats sur un terrain soulevé à fort relief. Par exemple, une gamme complète de types forestiers est concentrée dans une aire très réduite, où l'on remarque particulièrement des forêts matures sur les plateaux couverts de till au-dessus du plus haut littoral (285 mètres). Les conditions géologiques, topographiques et climatiques se combinent

également pour faire de la Haute Côte une zone frontière végétale remarquable, avec un mélange rare de plantes méridionales et d'espèces nordiques boréales, occidentales océaniques et orientales continentales. On constate aussi le mélange d'espèces méridionales et d'espèces reliques alpines ayant subsisté respectivement à des périodes plus chaudes et plus froides.

La HC abrite des espèces de grands mammifères tels que l'ours, le lynx et l'élan, très répandus en Scandinavie. Si l'avifaune côtière est caractéristique de la région, l'avifaune terrestre est riche et variée en raison de la gamme altitudinale et de la diversité topographique qui assurent aussi des habitats attrayants à certains oiseaux rares d'origine méridionale. La faune d'invertébrés n'est pas bien connue, quoique les insectes soient peut-être plus riches qu'ailleurs en raison de la diversité floristique, et l'évolution du paysage peut avoir provoqué certaines répartitions anormales.

Le biote terrestre de la région en général et l'histoire de ses plantes et de sa végétation en particulier n'ont pas fait l'objet d'études approfondies. Toutefois, la flore et la faune terrestres semblent essentiellement peu remarquables dans l'ensemble de la région. Elles tirent leur plus grand intérêt et leur importance scientifique de leur liaison avec le processus de surrection des terres.

ii) Le domaine maritime

Le caractère biologique du milieu maritime de la HC est la conséquence de plusieurs fortes influences : eaux saumâtres de très faible salinité ; topographie sous-marine plus brutale qu'ailleurs dans la Baltique, descendant à des profondeurs de plus de 200 mètres tout près de terre ; faible influence des marées, les changements de niveau de l'eau étant déterminés surtout par la modification des conditions météorologiques, pression de l'air et vent ; et couverture glaciaire saisonnière. Les environnements naturels ont subi des transformations considérables depuis la période glaciaire, traversant des conditions maritimes saumâtres et d'eau douce. La mosaïque qui en résulte, de baies peu profondes abritées et d'eaux ouvertes profondes, fournit une gamme d'habitats pour tout un mélange d'espèces d'eau salée, saumâtre et douce, avec une faible diversité des espèces mais des populations importantes pour certaines espèces de la macrofaune. Certaines de ces espèces sont les reliques de périodes antérieures, et d'autres se trouvent à leur limite extrême en latitude et en matière d'environnement. Pour la plupart, toutefois, le biote marin est décrit comme caractéristique et représentatif de ce que l'on trouve dans l'ensemble de la Baltique plutôt que spécial ou unique.

La caractéristique particulière du domaine maritime, qui lui assure sa plus grande importance scientifique, est qu'il représente l'extension sous-marine du continuum topographique de paysages subissant une surrection isostatique. La remontée continuelle des terres a pour conséquence que les criques sont progressivement coupées de la mer, se transforment en estuaires et finalement en lacs (dont quelques-uns conservent le nom de baie). En même temps, le littoral est constamment modifié, de nouvelles îles apparaissent au large, et d'autres, s'unissant à la terre ferme, se transforment en péninsules. L'influence terrestre s'étend progressivement vers le large dans la mer de Botnie. Ce processus a des effets majeurs pour les plantes et les animaux qui doivent constamment s'adapter à l'évolution de leur environnement. Ainsi, la zone maritime proche fait partie intégrante de l'évolution géologique continue de la HC et, en tant que telle, représente un important élément naturel de l'ensemble de cette zone.

iii) Beauté naturelle

La HC tire son attrait pittoresque de son relief vallonné peu commun (en Baltique) et des relations étroites entre les paysages terrestres et maritimes, îles, baies, côtes, lacs, pentes et plateaux élevés. Le site possède aussi des zones forestières entrecoupées de vallées abritées où se logent de pittoresques villages de pêcheurs et de tourisme et de petites villes entourées de pâturages et de terres agricoles bien tenues. L'ensemble crée un paysage extrêmement pittoresque et très attrayant sur le plan esthétique. Toutefois, la région tire une bonne part de sa valeur esthétique de l'interaction de son patrimoine naturel et culturel plutôt que de ses valeurs naturelles. Beaucoup de ses attributs esthétiques sont également caractéristiques des régions côtières de Suède et de la Baltique en général.

b) Comparaison avec d'autres aires protégées

i) Glaciation et isostasie dans la géologie mondiale

Les périodes glaciaires sont très rares dans l'histoire géologique générale de la terre. Les glaciations répétées sont la caractéristique remarquable de l'ère géologique du pléistocène, ayant débuté il y a environ 1,5 million d'années, où la glace couvrait une surface du monde à peu près trois fois plus grande qu'aujourd'hui. L'impact indirect de la glaciation, en particulier par les modifications de niveau de la mer, a affecté une bonne part de la Terre. Dans

l'hémisphère nord, la glaciation s'est traduite par deux énormes nappes de glace à l'échelle continentale, les boucliers glaciaires laurentide (Amérique du Nord) et finno-scandinave (Europe), qui s'étendaient du pôle aux latitudes moyennes. Tous deux ont pour l'essentiel disparu par fonte post glaciaire au cours des 10 à 20 000 années passées. Mais l'on retrouve leur héritage dans des formes de terrains dues à l'érosion et aux dépôts (par exemple plaine de till morainiques, drumlins et eskers) et dans les littoraux surélevés dues à la remontée isostatique de la croûte terrestre, enfoncée parfois de 800 mètres sous le poids de couches de glace pouvant atteindre 3 km d'épaisseur. Le poids de la glace maintient le substratum rocheux au-dessous du niveau de la mer sous les deux grandes masses de glace restantes, Antarctique et Groenland. Toutefois, en Amérique du Nord et en Scandinavie, une lente remontée se poursuit à mesure que la croûte s'adapte à la disparition de la couverture glaciaire. Ce processus de remontée post glaciaire de la croûte que l'on appelle isostasie est donc un phénomène géomorphologique important pour la constitution des paysages.

Si beaucoup d'évaluateurs ont remarqué que l'isostasie est un phénomène géologique de valeur universelle, l'UICN estime qu'il constitue une base trop étroite pour l'inscription d'un site sur la Liste du patrimoine mondial. Le paragraphe 44.b(i) des Orientations précise : " … [un site inscrit en fonction du critère (i)] *devrait contenir tout ou la plupart des éléments connexes et interdépendants dans leurs rapports naturels ; ainsi, une zone de ''l'ère glaciaire'' devrait comprendre les striations, moraines, premiers stades de la succession des plantes, etc.) ;… ".* Si l'isostasie est sans aucun doute un " processus géologique en cours ", ce n'est que l'un des processus géomorphologiques accompagnant la récession des boucliers glaciaires du pléistocène. Manifestement, il n'est pas possible d'inclure les glaciers eux-mêmes dans une proposition, mais d'autres processus pertinents pourraient être représentés par l'inclusion des plaines de till morainiques, drumlins, eskers, etc. Par conséquent, l'UICN conserve le sentiment que l'isostasie ne représente pas totalement " une étape dans l'histoire de la terre ".

ii) Analyse comparative

La seule région comparable dans le monde où l'on constate à l'échelle régionale une surélévation isostatique des terres ressemblant à ce que l'on voit dans la HC est centrée sur la baie d'Hudson, dans le nord du Canada. Au cours des 8 à 10 000 années écoulées, ces deux régions ont subi une remontée totale au-dessus du niveau actuel de la mer à peu près équivalente, qui dépasse 280 mètres, et l'une comme l'autre continuent à remonter actuellement au même rythme, 8 à 10 mm par an. Toutefois, la HC est un peu plus exceptionnelle par un certain nombre d'aspects. Son relief plus accentué confine les littoraux reliques dans une zone côtière de 2 km de large, alors que sur la baie d'Hudson, où la topographie est plus modérée, cette ceinture fait 50 km. Les affinités biologiques avec l'histoire géologique sont donc plus évidentes dans la HC. Cette région a aussi un climat plus doux, avec une diversité de biotypes par comparaison avec la végétation générale de toundra de la baie d'Hudson.

La HC est beaucoup mieux connue et documentée sur le plan scientifique, elle constitue essentiellement la " zone type " pour les recherches sur l'isostasie, le phénomène ayant été reconnu et étudié d'abord à cet endroit (Flint, 1971). Alors que le littoral le plus élevé de la Baltique a été cartographié dès 1888, le phénomène de soulèvement isostatique en baie d'Hudson reste mal reconnu et cartographié (Embleton et King, 1968). La HC diffère aussi par une longue histoire (5 000 ans) de colonisation humaine avec d'abondantes archives archéologiques alors que la baie d'Hudson n'a été que très pauvrement peuplée par une culture essentiellement de chasseurs.

iii) Relation de la Haute Côte avec la région du Quark

La région du Quark (Kvarken), proposée comme site possible du patrimoine mondial, est un étroit seuil d'eau peu profonde, saumâtre, et d'archipels de till séparant la mer de Botnie et la baie de Botnie. Située près du centre de la zone de surrection isostatique finno-scandinave, elle remonte comme la HC au rythme de 8 à 9 mm par an. Cette remontée devrait se poursuivre encore 10 000 ans, pour atteindre 130 mètres au-dessus des niveaux actuels. Dans un délai de 3 000 ans, un pont terrestre surgira des eaux peu profondes (25 mètres), joignant les masses continentales de Finlande et de Suède. Ce processus séparera la baie de Botnie de la mer Baltique, en formant le plus grand lac d'Europe.

Au contraire de la HC, essentiellement érosive, le Quark est un archipel morainique. Sa topographie plate comprend des dépôts de till glaciaire abandonnés par la fonte de la couche de glace et qui ont constitué des moraines en hummock et des drumlins s'élevant à 20 ou 30 mètres au-dessus du niveau de la mer. Ces archipels ont pour l'essentiel moins de 1 000 ans. La remontée du fond peu profond transforme rapidement les baies en *fladas* et en *glolakes*, puis en lacs d'eau douce, même en une seule génération humaine. La succession des plantes est tout aussi rapide sur les terres nouvellement créées, avec un zonage littoral marqué. Chaque phase de la remontée a son assemblage végétal caractéristique, avec les jeunes marécages de carex au niveau de la mer se transformant par une série d'étapes successives en forêts matures d'épicéas plus loin du rivage.

Si la HC et le Quark ont en commun la remontée isostatique, ce sont des zones différentes sur le plan géologique avec des différences topographiques très marquées. Cela entraîne des implications importantes pour les différences en vie animale et végétale. La HC possède un terrain spectaculaire de collines rocheuses, de hautes îles, de rivages abrupts avec des baies profondes et des détroits – caractéristiques que l'on ne retrouve nulle part ailleurs dans la Baltique. Le Quark est une zone à relief bas d'archipels extensifs faits de till dans une mer peu profonde. La HC est aussi beaucoup plus vieille, elle révèle 10 000 ans d'évolution géologique contre les 2 000 ans correspondants de l'histoire du Quark. La HC constitue donc un environnement biologique relativement stable alors que le Quark, dont le paysage plat change constamment du fait de la remonté des terres, est hautement dynamique sur le plan biologique, avec des plantes et des animaux qui colonisent continuellement les surfaces de terre nouvellement émergées et les habitats successifs. Les régions de la HC et du Quark diffèrent donc considérablement dans la manière dont la remontée des terres agit sur le biotope. Elles sont en fait complémentaires par leur évolution biophysique et représentent respectivement les extrêmes topographiques hautes et basses des paysages à remontée post glaciaire de la Baltique.

c) Valeurs culturelles

Les sites archéologiques, dont certains remarquablement bien préservés, révèlent 7 000 ans de colonisation humaine agraire et maritime dans la HC, toujours confinée par la topographie abrupte dans une étroite bande côtière de 2 à 3 km. Le déplacement des colonies côtières par la remontée isostatique a créé un paysage culturel relique mettant en évidence des peuples différents aux niveaux successifs au-dessus de la mer. Les plus anciens restes, de l'âge de pierre, 5 000 ans av. J.-C., se trouvent désormais à 150 mètres au-dessus du niveau de la mer et l'on trouve des sites correspondants de l'âge du bronze (1 000 ans av. J.-C.) et de l'âge du fer (15 ans apr. J.-C.) à 30 mètres et 15 mètres au-dessus du littoral actuel. L'adaptation des peuples aux conditions créées par la remontée des terres entraîne donc une liaison étroite entre l'histoire géologique et l'histoire culturelle.

L'influence remarquable de 7 000 ans d'occupation humaine sur un paysage subissant la plus forte remontée isostatique du monde est un atout significatif en matière de patrimoine culturel, et qu'il est important de préserver pour les générations futures. Toutefois, les paysages culturels et les restes préhistoriques sont très répandus dans toute la Scandinavie et, dans l'état actuel des connaissances, il est difficile d'évaluer l'importance comparative de la HC. À ce stade, les qualités des ressources culturelles de la HC ne sont pas considérées par l'État partie comme du niveau du patrimoine mondial, mais des recherches ultérieures pourraient modifier cette vision.

d) Intégrité

Limites
Les limites de la zone proposée sont fixées de manière à enclore la principale région intéressante pour la conservation sur le plan national ; elles s'étendent dans les terres pour inclure toutes les zones de remontée et une partie des littoraux les plus élevés tout en excluant les régions faisant l'objet d'une gestion forestière à grande échelle par des compagnies forestières. Du côté de la mer, les limites incluent les principales îles et les régions maritimes qui sont l'extension logique du continuum topographique de surface terrestre soumise à remontée pour tenir compte des processus géologiques en cours. Les zones industrielles sont exclues.

Toutefois, une part très faible de la Haute Côte est protégée légalement, 82% de cette aire autorisant des formes de développement variées. Les évaluateurs externes ont également exprimé leur souci quant à l'inclusion de villages et de villes dans la zone proposée et ont soulevé la question de la cohérence avec les précédentes recommandations du Bureau et du Comité. Par exemple, dans le cas des Iles Eoliennes (Italie), proposées également selon le critère (i), en juillet 1999 le Bureau a recommandé à l'État partie d'envisager " l'exclusion des zones d'utilisation humaine " de la région proposée. Toutefois, dans le cas de la Haute côte, c'est l'ensemble du paysage qui subit une remontée isostatique et qu'il faut par conséquent inclure pour constituer le tableau géologique général. De plus, la présence de ces sites développés ne compromet ou ne diminue en rien la valeur géologique. Par ailleurs, une bonne part de l'utilisation humaine du site est limitée à de petits villages et à des exploitations agricoles traditionnelles, et non aux vastes régions urbaines des Iles Eoliennes. Avec de bonnes pratiques de gestion, cette utilisation humaine de faible niveau ne risque guère de menacer le statut de conservation de la zone.

Le rapport d'évaluation technique 1999 de l'UICN a remarqué la présence de certains développements à grande échelle à l'intérieur du site, par exemple la traversée de la zone par une grande route, la construction d'un nouveau pont, l'intrusion visuelle d'une grande tour de télévision et l'expansion envisagée de stations éoliennes. L'UICN s'inquiète de ce type de développement à l'intérieur du site et pense que ces questions pourraient rendre difficile la surveillance ultérieure.

Gestion
L'État partie a prévenu que la préparation d'un plan de gestion pour le site proposé a commencé et qu'un comité de gestion est en cours de formation, représentant l'Office administratif du comté et l'Office forestier ainsi que les deux municipalités locales. Le plan de gestion s'attaque aux objectifs et prescriptions de gestion à long terme, en particulier en ce qui concerne les phénomènes géologiques et biologiques liés à la remontée des terres, l'environnement maritime, le paysage naturel et la gestion forestière. L'accent est mis sur les mécanismes de protection légale en vertu de la législation 1999 sur l'environnement.

Le Centre a reçu de l'État partie le 27 septembre une information complémentaire, y compris une " Proposition pour le programme de gestion et le comité de gestion de la Haute Côte " ainsi que le compte rendu de la réunion inaugurale du " Comité de gestion et du Groupe de référence pour la Haute Côte ". Cette information comprend une vue d'ensemble de la législation environnementale suédoise qui servira de base au Comité de gestion. Les buts du Comité sont : 1) promouvoir le développement durable à long terme de la Haute côte, et 2) garantir les valeurs sur lesquelles s'appuie la proposition, et qui touchent aux valeurs géologiques et aux autres valeurs naturelles et culturelles importantes.

L'UICN conclut que les bases d'organisation et de législation pour la gestion de la Haute Côte satisfont aux conditions d'intégrité telles qu'elles sont définies dans les Orientations.

3. CONCLUSION

La documentation complémentaire fournie par l'État partie a permis à l'UICN d'évaluer les points suivants concernant la Haute Côte :

a) Valeurs biologiques et pittoresques;

b) Valeur du secteur marin:

c) Potentiel du site en tant que paysage culturel:

d) Valeur comparative du site;

e) Rapport entre HC et la proposition envisagée du Quark au patrimoine mondial; et

f) Intégrité du site.

En ce qui concerne ces différentes questions, l'UICN estime ce qui suit :

a) Valeurs biologiques et pittoresques

Les valeurs biologiques et pittoresques de la HC sont considérées comme non remarquables et caractéristiques de ce que l'on peut trouver ailleurs dans la région de la Baltique, même si elles sont mal connues sous l'angle scientifique et de la conservation. L'UICN conclut que le site ne mérite pas d'être inscrit en fonction des critères (ii) ou (iii).

b) Valeur du secteur marin

Le secteur marin des sites proposés représente une extension sous-marine de la surface terrestre émergente et constitue donc un élément physiographique inséparable du processus géologique continu de remontée des terres.

c) Potentiel du site en tant que paysage culturel

Les ressources culturelles et les paysages de la HC complètent et renforcent l'histoire géologique. Elles sont considérées comme d'une valeur remarquable sur le plan de la conservation, et d'importance nationale, mais leur signification relative dans la région nordique n'est pas déterminée. Il reste donc à démontrer par des études ultérieures si la HC répond aux normes culturelles du patrimoine mondial.

d) Valeur comparative du site

Une revue des documents et les observations sur le terrain confirment que la Haute Côte est la meilleure, et la plus renommée sur le plan scientifique, des démonstrations du phénomène géologique de remontée isostatique des terres dans le monde. Elle constitue une illustration remarquable de l'un des processus accompagnant la croissance et la récession d'une énorme masse de glace continentale datant du pléistocène et de l'évolution des terres sous l'influence des glaces qui en découle. La Haute Côte est considérée par l'UICN comme remplissant le critère (i).

e) Rapport entre HC et la proposition envisagée du Quark au patrimoine mondial

Le Quark partage avec la HC le phénomène de remontée des terres. Toutefois, sa topographie plus basse et son développement biologique, plus dynamique, font du Quark un contraste plutôt qu'un point de comparaison avec la HC. Ce sont des extrêmes biophysiques complémentaires dans le schéma et le processus de remontée postglaciaire des terres de la région de la Baltique dans son ensemble. Il pourrait donc être utile d'étudier et d'évaluer plus profondément les valeurs scientifiques et de conservation des environnements terrestres et marins du Quark en vue d'une éventuelle possibilité d'addition, dans l'avenir, du Quark au site HC du patrimoine mondial.

f) Intégrité du site

Malgré l'inquiétude que peuvent faire naître certains développements à grande échelle dans la zone proposée, l'UICN conclut que les limites du site sont satisfaisantes. L'UICN conclut aussi que la base organisationnelle et législative pour la gestion de la HC satisfait aux conditions d'intégrité telles qu'elles sont définies dans les Orientations.

4. RECOMMANDATIONS

Que le Comité **inscrive** le site en fonction du critère naturel (i). Le Comité pourra aussi souhaiter encourager l'État partie à poursuivre sa collaboration avec les autorités finnoises dans la préparation d'une candidature du Quark en tant que zone transfrontière du patrimoine mondial, pour être éventuellement ajouté dans l'avenir au site de la Haute Côte.

CANDIDATURE AU PATRIMOINE MONDIAL - ÉVALUATION TECHNIQUE UICN

LA HAUTE CÔTE (SUÈDE)

1. DOCUMENTATION

i) **Fiche technique UICN/WCMC**

ii) **Littérature consultée:** Conseil nordique des ministres. 1996. **Nordic World Heritage**. Copenhagen; Trenhaile A.S. 1997. **Coastal Dynamics and Landforms**. Clarendon Press. Oxford; Marsh, J. 1998. A Global Overview of Geological Features in Natural Heritage Sites. Draft theme study report to IUCN; Thorsell, J.R. Levy and T. Segaty. 1997. A Global Overview of Wetland and Marine Protected Areas on the World Heritage List. IUCN; IUCN. Summary and Technical Evaluation, The Lapponian Area,(Sweden), 1996; **National Parks in Sweden**, Environment Protection Board, 1984; Lofgren, 1998. **Sweden's National Parks**; Curt Freden (Ed.), 1994. **National Atlas of Sweden**, Swedish Academy of Sciences; County Administration of Vasternorrland. 1998. The High Coast, 5000 Years of Human History; Rapakivi granites and related rocks in Central Sweden, Research Papers, SGU series Ca87, Uppsala 1997; Classification of Coastal Landforms; F.C. Bird, **Coasts: An Introduction to Coastal Geomorphology**, MIT Press 1968; Pirazzoli, Paolo Antonio, 1996. **Sea Level Change the Last 20,000 years**, John Wiley & Sons.1996; Kvarken Council (Suède/Finlande). 1999. Proposed World Heritage Nomination for Kvarken.

iii) **Consultations:** cinq évaluateurs indépendants; fonctionnaires pertinents de l'Agence suédoise de protection de l'environnement, administration régionale, Géologue d'État et spécialistes de l'université locale.

iv) Visite du site: 15 au 18 juin 1999. Harold Eidsvik.

2. RÉSUMÉ DES CARACTÉRISTIQUES NATURELLES

Le site proposé pour inscription se trouve dans la région connue sous le nom de «haute côte» de Suède (HCS), située sur la rive occidentale du sud du golfe de Botnie, qui prolonge la mer Baltique vers le nord. Le site proposé couvre 1,425km^2 ce qui inclut un élément marin de 800km^2 et avec un certain nombre d'îles côtières. Il y a deux villages dans le site où résident 4,500 personnes. La HCS est une mosaïque de paysages naturels et façonnés par l'homme avec pour activités économiques principales, l'agriculture, la pêche et le tourisme. Environ 9% de la superficie totale sont compris dans 28 aires protégées différentes tandis que l'essentiel du territoire restant est propriété privée. Le site a de nombreux vestiges qui témoignent d'une présence ancienne de l'homme, avec des habitations datant de l'âge de la pierre et les ruines d'un village de l'âge du fer.

Du point de vue physique, la topographie de l'archipel est irrégulière, présentant une série de lacs, de baies et de collines plates s'élevant à 350 mètres. La végétation est typique de la taïga ouest-eurasienne avec un mélange de forêts alpines et boréales et de communautés des zones humides. Les îlots côtiers abritent de petites populations d'oiseaux marins. Les caractéristiques naturelles les plus importantes de la HCS sont géologiques et tiennent à l'histoire glaciaire de la région. Depuis le retrait de la dernière calotte glaciaire, entre 18,000 et 9,600 ans avant notre ère, la terre a commencé à se relever. La géomorphologie de la région est essentiellement le résultat de l'association des processus de glaciation, de recul des glaciers et d'émergence de nouvelles terres dans la mer, ce dernier processus se poursuivant aujourd'hui encore au rythme de 0,9 mètre par siècle. Le relèvement total de la région ,depuis que le dernier âge glaciaire a atteint sa plus grande extension, est estimé à 800 mètres. Depuis le retrait final des glaces de la HCS, il y a 9,600 ans, le relèvement est de l'ordre de 285 à 294 mètres, ce qui correspond au «rebond» évident le plus haut qui soit connu. Un littoral relevé et l'emplacement variable des moraines glaciaires sont deux des marques laissées sur le paysage qui, lui-même, présente des variations dans les sols et les types de végétation. L'étendue du «rebond isostatique» est d'importance scientifique car elle témoigne des dimensions de la calotte glaciaire et de son impact sur l'Europe septentrionale.

3. COMPARAISON AVEC D'AUTRES AIRES PROTÉGÉES

Dans la province biogéographique de la taïga ouest-eurasienne, il y a 200 aires protégées dont un Bien mixte en Suède (Laponie) et un Bien naturel en Russie (les forêts vierges de Komi). Ces deux deniers sont beaucoup plus grands et ont une large palette de caractéristiques géologiques mais ne présentent pas le phénomène de relèvement isostatique que l'on trouve dans la HCS. Beaucoup d'autres aires protégées de la région de la mer Baltique présentent des littoraux relevés et plusieurs ont été mentionnées dans le rapport de 1996 sur le **Patrimoine mondial nordique** concernant les sites naturels proposés.

Sur la Liste du patrimoine mondial, 47 sites sont inscrits sur la base de critères géologiques. Beaucoup contiennent des phénomènes géomorphologiques glaciaires et plusieurs ont subi des relèvements (par exemple, Gros Morne, Los Glaciares, l'île Macquarie). Il y a aussi 39 biens naturels du patrimoine mondial qui possèdent un élément littoral et marin et certains d'entre eux (par exemple, les Parcs St. Elias, l'île Henderson, le sud-ouest de la Nouvelle-Zélande et le bien de Sainte-Lucie proposé pour inscription) illustrent le phénomène d'un littoral relevé. Ce qui distingue la HCS, c'est l'étendue du relèvement isostatique total qui, à 294 mètres, dépasse tous les autres à l'exception de ceux qui ont été relevés par les forces tectoniques. Le seul autre site présentant un relèvement isostatique comparable se trouve dans le golfe Richmond, au sud-est de la baie d'Hudson (Canada) et mesure entre 275 et 290 mètres. Cette région est très reculée et de vaste étendue tandis que la HCS peut être observée dans des zones de petites dimensions et accessibles.

En conclusion, la HCS est l'un des nombreux lieux de la terre ayant subi un relèvement suite au recul des glaces. Le rebond isostatique est bien illustré dans ce site qui est parmi les plus hauts des sites connus. Les autres caractéristiques naturelles de la HCS sont relativement communes et ne présentent pas d'intérêt particulier au niveau international. De même, la HCS, mélange de terres agricoles, de littoraux et de collines présente un paysage harmonieux certes, mais typique de la plupart des paysages ruraux de l'Europe septentrionale.

4. INTÉGRITÉ

La HCS est une région habitée par 4,500 personnes environ qui pratiquent l'agriculture et la pêche à petite échelle. On trouve dans la région un parc national de 2,950 hectares et 18 réserves naturelles (allant de 2 à 934 hectares). Selon les Catégories de gestion des aires protégées de l'UICN, la HCS serait dans la Catégorie V – Paysage protégé. Le texte de candidature indique que 9% de la superficie totale sont protégés tandis que le reste est essentiellement composé d'éléments marins et de terrains privés. Environ 2% de l'élément marin sont protégés, mais le texte de la proposition ne fournit aucun détail sur les valeurs naturelles de cet élément (qui constitue pourtant 56% de la superficie de la HCS).

Les limites de la HCS permettent d'inclure de manière adéquate les valeurs qui font l'objet de la proposition à l'exception de la limite occidentale qui omet une partie du paléolittoral le plus élevé. Les mines et carrières actives autrefois n'auraient pas endommagé les caractéristiques géologiques mais les activités agricoles et forestières ont causé quelques perturbations dans les dépôts superficiels. L'impact de la pêche marine sur les fonds marins n'est pas connu mais la pêche dans les grands fonds et l'exploration minière affecteraient les valeurs géologiques. Quinze kilomètres carrés seulement des 800km² de l'élément marin sont protégés.

Il existe des plans de gestion pour toutes les réserves naturelles et pour le parc national mais ensemble ils ne couvrent pas plus de 9% de la superficie totale. Les deux municipalités responsables ont des plans d'aménagement et la loi nationale sur les ressources naturelles reconnaît que la HCS est une région d'intérêt national. Bien qu'une grande proportion du site proposé soit marine, il n'y a pas d'information sur la gestion si ce n'est une mention indiquant que 2% de cette superficie est protégée.

À noter également qu'une grande route traverse la région et qu'un nouveau pont est en construction. La mission a exprimé ses préoccupations vis-à-vis de l'intrusion visuelle que constituent une haute tour de télévision et un projet d'expansion de centrales de production d'énergie à turbine éolienne. Le texte de la proposition précise que le statut de patrimoine mondial contribuera à renforcer la protection des caractéristiques géologiques ainsi qu'à encourager la poursuite d'une agriculture artisanale. Toutefois, la gestion d'une telle région utilisée à des fins multiples et privées sera difficile car il n'y a pas d'agence unique chargée de la gestion du site.

En résumé, l'UICN estime que la législation, si elle était appliquée réellement, suffirait raisonnablement à protéger la partie terrestre de la HCS bien que 82% d'entre elle se prête à une forme de développement ou une autre. Toutefois, sans cadre de gestion unifié et sans attention suffisante portée aux 56% du site se trouvant dans la zone marine, il serait difficile, à long terme, de garantir l'intégrité, conformément au Principe opérationnel 44 (v, vi)

5. AUTRES COMMENTAIRES

Depuis que la visite du site a eu lieu, le Centre du patrimoine mondial de l'UNESCO a reçu un projet de proposition d'inscription conjointe (Finlande/Suède) pour une zone contiguë appelée «le Quark». Le document a été présenté le 11 juin 1999 par le Conseil Kvarken qui est une organisation mixte entre les deux pays. Le site est également proposé dans le rapport sur le **Patrimoine mondial nordique** préparé par le Conseil nordique des ministres. Une bonne partie du justificatif pour l'inscription du Quark se fonde sur un phénomène isostatique semblable ainsi que sur ce qui semblerait être d'importantes caractéristiques biologiques et paysagères. La candidature doit encore être soumise officiellement par les deux États mais elle a été approuvée par plusieurs municipalités et administrations locales. Étant donné qu'il existe une proximité certaine entre le Quark et la HCS et qu'il y a là un dédoublement notable des valeurs du patrimoine, il importe d'apporter des éclaircissements sur les relations entre les deux sites.

6. CHAMP D'APPLICATION DES CRITÈRES NATURELS DU PATRIMOINE MONDIAL

Comme discuté ci-dessus, un certain nombre de questions se posent et des incertitudes planent sur les différents aspects de la proposition d'inscription de la HCS, notamment:

- l'absence d'une analyse comparative adéquate dans le texte de la proposition, ce qui empêche d'établir clairement si le rebond isostatique et les processus écologiques associés sont d'importance internationale;

- l'absence de documentation, dans le texte de la proposition sur les valeurs de patrimoine mondial du milieu marin qui constitue 56% de la superficie totale; et

- l'absence d'évaluation du chevauchement potentiel de la HCS avec la proposition de site transfrontière Kvarken/Quark.

En outre, les questions d'administration soulèvent d'autres problèmes qui laissent à penser que la HCS ne satisfait pas aux conditions d'intégrité établies dans les principes opérationnels de la Convention.

Enfin, le rapport du **Patrimoine mondial nordique** et le rapport de la mission de l'UICN recommandent tous deux que le site soit étudié comme candidat potentiel dans la catégorie des paysages culturels. Si l'on en juge par les traditions historiques et les caractéristiques attrayantes du paysage rural, il serait intéressant d'étudier cette possibilité.

7. RECOMMANDATION

Que le Bureau recommande au Comité de **différer** la candidature de la haute côte pour permettre aux autorités suédoises (i) d'expliciter les valeurs de la partie marine du site proposé; (ii) de fournir une analyse comparative plus complète notamment par rapport à la proposition du Quark pour l'inscription au patrimoine mondial; et (iii) de traiter les différentes questions relatives à l'intégrité. Le Bureau souhaitera peut-être également suggérer à l'État Partie d'envisager de proposer le site sur la base des critères culturels.

World Heritage Scanned Nomination

File Name: 898bis.pdf **UNESCO Region:** EUROPE AND NORTH AMERICA

SITE NAME: **Kvarken Archipelago / High Coast**

DATE OF INSCRIPTION: 16 July 2006

STATE PARTY: Finland / Sweden

CRITERIA: N (viii)

DECISION OF THE WORLD HERITAGE COMMITTEE:
Excerpt from the Decisions of the 30th Session of the World Heritage Committee

Criterion (viii): The Kvarken Archipelago with its 5,600 islands and surrounding sea is of exceptional geological value for two main reasons. First, it is an area of rapid glacio-isostatic uplift with rates that are among the highest in the world. The uplift is ongoing and is associated with major changes in the water bodies in post glacial times. The Kvarken, along with the existing High Coast, its Swedish equivalent on the west coast of the Gulf of Bothnia, are key areas for the understanding of the processes of crustal response to the melting of the continental ice sheet. Second, the Kvarken area possesses a distinctive array of glacial depositional landforms, such as De Greer moraines, which add to the variety of glacial landscapes features in the region and reinforce the previous validity of the High Coast inscription.

BRIEF DESCRIPTIONS

The High Coast is located on the west shore of the Gulf of Bothnia, a northern extension of the Baltic Sea. The area covers 142,500 ha including a marine component of 80,000 ha, which includes a number of offshore islands. The irregular topography of the region - a series of lakes, inlets and flat hills rising to 350 m - has been largely shaped by the combined processes of glaciation, glacial retreat and the emergence of new land from the sea. Since the last retreat of the ice from the High Coast 9,600 years ago, the uplift has been in the order of 285 m which is the highest known 'rebound'. The High Coast site affords outstanding opportunities for the understanding of the important processes that formed the glaciated and land uplift areas of the Earth's surface.
The Kvarken Archipelago (added in 2006 as an extension to the World Heritage site of the High Coast) numbers 5,600 islands and islets and covers a total of 194,400 ha (15% land and 85% sea). It features unusual ridged washboard moraines, "De Greer moraines", formed by the melting of the continental ice sheet, 10,000 to 24,000 years ago. The Archipelago is continuously rising from the sea in a process of rapid glacio-isostatic uplift, whereby the land, previously weighed down under the weight of a glacier, lifts at rates that are among the highest in the world. As a consequence of the advancing shoreline, islands appear and unite, peninsulas expand, lakes evolve from bays and develop into marshes and peat fens. This property is essentially a "type area" for research on isostacy; the phenomenon having been first recognized and studied here.

La Haute côte est située sur la rive occidentale du golfe de Botnie, qui prolonge la mer Baltique vers le nord. D'une superficie de 142 500 ha, le site comprend un domaine marin de 80 000 ha et un certain nombre d'îles côtières. La topographie irrégulière de la région présente une série de lacs, de baies et de collines plates d'une altitude de 350 m, qui résulte essentiellement de l'association de processus de glaciation, de recul des glaciers et d'émergence de nouvelles terres. Depuis le retrait final des glaces de la Haute côte, il y a 9 600 ans, le relèvement est de l'ordre de 285 m, ce qui correspond au « rebond » manifeste le plus important jamais observé. La Haute côte est un site exceptionnel pour la compréhension des processus importants qui ont formé les glaciers et les zones de relèvement de la surface de la Terre.
L'archipel de Kvarken (inscrit en 2006 en tant qu'extension du site Haute Côte) est composé de 5 600 îles et îlots et couvre 194 400 ha (15 % terrestres et 85 % marins). Ce site se singularise principalement par ses curieuses moraines à crête bosselées, ou moraines de Geer, formées par la fonte de la nappe de glace continentale, il y a entre 10 000 et 24 000 ans. De nouvelles îles émergent continuellement de la mer du fait d'un relèvement glacio-isostatique rapide, phénomène qui se produit lorsqu'une terre précédemment comprimée par le poids d'un glacier se relève après la disparition de ce dernier. Le taux de relèvement dans la région est l'un des plus élevés au monde. Du fait de l'avancée du littoral, des îles apparaissent et s'unissent, des péninsules grandissent, des lacs se forment depuis les baies et deviennent des marais et des fagnes tourbeuses. Ce site est avant tout la « région type » pour la recherche sur l'isostasie, le phénomène ayant été reconnu et étudié pour la première fois dans cette région.

1.b State, Province or Region:

Serial ID Number	Name	Locations	Coordinates	Date Inscribed
898-001	High Coast	Sweden	N63 00 E18 30 2000	2000
898-002	The Kvarken Archipelago - Zone A	Finland	N63 18 00 E21 18 00 2006	2006
898-003	The Kvarken Archipelago - Zone B	Finland	N62 58 00 E20 57 00 2006	2006

Nomination of the Kvarken Archipelago for the inclusion in the World Heritage List

EXECUTIVE SUMMARY

State Party: Finland

Province and Landscap: Western Finland, Ostrobothnia

Name of Property: The Kvarken Archipelago

Geographical coordinates to the nearest second:
The nominated site is located at approximately 62°41'7'' to 64°3'0.8'' N and 19°13'34.2 to 22°14'56''E.

Textual description of the property boundary:
The Kvarken Archipelago extends about 70 kilometres in an east-west direction, and 60 kilometres in a north-south direction. Northern Kvarken is a narrow strait between Sweden and Finland across the Gulf of Bothnia. It is only the Finnish part of the Kvarken area that is proposed for the World Heritage list.
The Kvarken Archipelago is proposed as a serial nomination and complement of the High Coast World Heritage Site situated in Sweden. The distance between the areas is 150 kilometres.

A4 size Map of the property nominated:
See the attached map

Justification and statement of significance:
The Kvarken Archipelago has outstanding universal value for the understanding of how glacial and deglaciation processes form a landscape. The Kvarken Archipelago is the most representative area in the world for studying moraine archipelagos and the land uplift phenomena.The High Coast World Heritage and the Kvarken Archipelago represent complementary examples of post-glacial uplifting landscapes.
The unique landscape and landforms of the Kvarken Archipelago are mostly built up by the glacial events and formations of the last Ice Age. The Kvarken Archipelago is characterised by extensive moraine archipelagos, a shallow brackish sea (= low salinity 0,4 - 0,5 per cent). The area includes 6,550 islands and a total shoreline of 2,840 kilometres.
The major geomorphologic feature, which makes the Kvarken Archipelago area extraordinary, is the spectacular De Geer moraine fields, showing the gradual deglaciation of the continental ice sheet. The De Geer moraines are exceptionally well formed, representative, and frequently appear in large fields within the area. Also, hummocky moraines and other types of transversal moraine ridges occur.
The nominated area is situated in the centre of the Fennoscandian land uplift area, with an overall net uplift rate of 8 to 8.5 mm per year. At a maintained uplift rate, Finland and Sweden will become connected with a land bridge across the Kvarken strait in 2,500 years. The Bothnian Bay will then become the largest freshwater lake in Europe.
The most visible evidence of land uplift is the morphological and topographic consequences of the advancing shoreline; new islands emerge from the sea, islands unite, peninsulas expand, lakes evolve from bays and develop further towards marshes and fens. The vegetation belts on the shore illustrate the land uplift: from pioneer plant communities closest to the water to the forest ecosystem in climax-phase further up.

Criteria under which property is nominated:
As a complement to the High Coast World Heritage Site, The Kvarken Archipelago is proposed to the World Heritage List based on Natural criterion (i): "be outstanding examples representing major stages of the earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features".

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Nomination of
the Kvarken Archipelago
for the inclusion in
the World Heritage List

METSÄHALLITUS
FORSTSTYRELSEN

LÄNSI-SUOMEN
YMPÄRISTÖKESKUS
VÄSTRA-FINLANDS
MILJÖCENTRAL

Österbottens förbund
Pohjanmaan liitto

THE KVARKEN ARCHIPELAGO
Presentation of World Heritage site as a transboundary nomination and complement to the High Coast World Heritage.
Editors: Susanna Ollqvist and Leena Rinkineva-Kantola
Design: Heikki Järvinen
Cover illustrations: Front: Aerial view of the De Geer moraine-landscape at Björköby. Photo Korsholm municipality ©.
Inside back: Historical map "Charta Marina" 1539, Historical map of the Kvarken area from 18th century, Nautical chart of the Kvarken area year 2003. Finnish Maritime Association ©.

The Kvarken Archipelago

Presentation of World Heritage site

as a transboundary nomination and complement

to the High Coast World Heritage.

Preface

The preparation of the World Heritage proposal of the Kvarken Archipelago started in 1997. A year earlier, the Nordic Council of Ministers published a report listing potential Nordic World Heritage candidates. Both the Kvarken Archipelago and the High Coast were included on the list. The High Coast was awarded the status of a World Heritage Site in 2001. The preparation of the World Heritage proposal has been a co-operation between Finland and Sweden. As a result of the formal expert report of 2002, the Swedish part of the Northern Kvarken was dropped from the proposal. The present proposal includes the entire archipelago on the Finnish side of the Northern Kvarken. The Kvarken Archipelago is proposed to be a complement to the High Coast World Heritage Site.

It has been a long process to prepare the World Heritage proposal for the Kvarken Archipelago. Innumerable meetings for information and discussion have been held to obtain broad support from all regional and local stake holders. The proposal has been officially submitted for consideration three times.

All concerned municipalities were quite positive about World Heritage status in the Kvarken Archipelago from the beginning, and have realised that it is an opportunity to improve the image of the area. The inhabitants were more hesitant, but information produced and distributed during the process has increased both the acceptance and the awareness of the area's values. At the same time, the Kvarken Archipelago has become more well-known, both nationally and internationally.
The World Heritage project has received a lot of attention in the press, radio, and television, and two movies about the Northern Kvarken have been produced.

This application could not have been prepared without the assistance and support of many people and institutions. We are particularly grateful to the Geological Survey of Finland and the Ostrobothnian Museum – our key co-operation organisations. Special thanks also to the Finnish Ministery of Environment for their financial support and encouragement through the entire process.

We, the people responsible for the preparation of the World Heritage proposal, are very proud of our land uplift archipelago. We sincerely hope that the Kvarken Archipelago will be the first Nature Heritage site of Finland, and that this will create opportunities for sustainable development of the region and for the protection of the geological values.

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SWEDEN
Sverige
Ruotsi
Holmön
21°
22°
PROPOSED BORDER OF WORLD HERITAGE AREA
FÖRESLAGEN VÄRLDSARVSGRÄNS
MAAILMANPERINTÖKOHTEEN RAJAUSEHDOTUS
BUFFER ZONE
BUFFERTZON
PUSKURIVYÖHYKE
Northern Kvarken
Norra Kvarken
Merenkurkku
Valsörarna
Valassaaret
Mickelsörarna
Mikkelinsaaret
Björkögrunden
Lappörarna
Utgrynnan
Slättskäret
Märaskäret
Rönnskär
Björköby
Rödgrynnorna
Punakarit
Köklot
Kaukaluoto
Norrskär
MAXMO
MAKSAMAA
Replot
Raippaluoto
Norra Vallgrund
Södra Vallgrund
VÖRA
VÖYRI
KORSHOLM
MUSTASAARI
Rönnskären
VAASA
VASA
Torgrund
63°
Bergö gaddarna
Bergö
Söderfjärden
MALAX
MAALAHTI
Molpehällorna
Hälsön
KORSNÄS
N
0
5
10
15 km

Identification of the site 1.

1.a Country

Finland

1.b Province / Landscape

The site is located in the western portion of Ostrobothnia.

1.c Name of the site

The site is called *the Kvarken Archipelago* and it comprises the eastern part of Northern Kvarken. Northern Kvarken is a shallow strait in the Gulf of Bothnia between Finland and Sweden. *The Kvarken Archipelago* is nominated as a transboundary serial nomination to the High Coast World Heritage.

In this proposal, the name *"Kvarken Archipelago"* consequently refers to the nominated site only. The names:" Northern Kvarken" and "the Kvarken area" are used to describe conditions prevailing on both the Finnish and the Swedish side of the strait.

1.d Geographical coordinates

The site is located 7000 km north of the equator, between latitudes 62°41´7´´N and 64°3´0,8´´N, and between longitudes 19°13´34,2´´E and 22°14´56´´E. The site extends about 70 km in an east to west direction, and 60 km in a north to south direction. A 150 km wide sea area separates the Kvarken Archipelago from the High Coast World Heritage (between lon 17°54´ and 19°13´ E and between lat 62°44´ and 63°13´ N).

1.e Maps

Figure 1. The location of the proposed site in the world and in the Northern Europe.

Figure 2. The border of the proposed World Heritage site.

Appendix 2. Geology maps.

1.f Area of the site

The total area of the nominated site is 323 200 ha , of which 81 % is nature protection areas. The core area covers 185 500 ha, of which 13,6 % is land and 86,4 % is sea. The buffer zone covers 137 700 ha, of which 7 % is land and 93 % is sea.

Figure 1. The location of the proposed site in the world and the Northern Europe. National Land Survey of Finland, permit nr 7/MYY/04. Layout Päivi Anttila.

Figure 2. Left: The border of the proposed World Heritage site. National Land Survey of Finland, permit nr 7/MYY/04. Layout Päivi Anttila.

Justification for inscription 2.

2.a Criteria under which inscription is proposed

With reference to Article 2 of the World Heritage Convention and the criterion in paragraph 44(a) of the Operational Guidelines for the Implementation of the World Heritage Convention, the Kvarken Archipelago is considered to have an outstanding universal value as a nature heritage area. The Kvarken Archipelago is nominated for the inscription on the World Heritage List as a complement to the High Coast World Heritage in Sweden on the basis of criterion (i):

"to be an outstanding example representing major stages of the earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiogeographic features."

The Kvarken Archipelago, with a land uplift rate of 8 mm per year, is the most representative site in the world for the study of the land uplift process in flat and shallow moraine archipelagoes (Aartolahti 1988, Johansson (ed) 2000). The geomorphology of the Kvarken Archipelago is the result of a series of glacial and deglaciation processes. The geomorphologic feature that makes the Kvarken Archipelago unique is the spectacular De Geer moraines (Aartolahti *et al.* 1995). The De Geer moraines form clusters and are well shaped and representative. Other types of hummocky moraines and moraine ridges occur as well. The site is important in order to understand how glacial and deglaciation processes form the landscape. The Kvarken Archipelago is easily accessible and offers visitors a good general view of ongoing geological processes and the resulting landscape.

The shallow Kvarken strait between Finland and Sweden will rise above sea level within 2000-2500 years, forming a land bridge between Finland and Sweden (Taipale & Saarnisto 1990). As a result, the Bothnian Bay will become the largest lake in Europe (24 000 km^2 and 900 km^3). Today, Lake Ladoga in Russia is the largest European lake (17 600 km^2 and 900 km^3).

The land uplift process is a mechanism that continually preserves the geological formations of the current landscape. In deeper parts of the site, where the sea floor has not yet been exposed to disturbances, the moraine ridges have exactly the same shape as when formed by the inland ice. The ongoing land uplift will gradually lead to their elevation above sea level.

The flat topography and the mosaic characteristics of the archipelago leads to a rapid change in the landscape once it is exposed. The change in the shoreline is proof of the land uplift: new islets rise from the sea, islands join, peninsulas grow, and inlets develop into lagoons and then into lakes and wetlands.

Figure 4. The landscapes of the High Coast World Heritage and the Kvarken Archipelago. Photos Västernorrlands länsstyrelse © and Metsähallitus ©.

Figure 3. Left: Aerial view of different types of moraines at Märaskär . Photo Maxmo municipality ©.

The geomorphology and land uplift in the Kvarken Archipelago forms the foundation for the ecological and biological processes in the area. The site is nominated on the basis of geological and geomorphological values (criterion i), but these values are intimately connected with criterion ii: "to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals". The Kvarken Archipelago offers excellent opportunities to study the development of terrestrial, freshwater, and brackish water ecosystems. Of particular interest and importance is the primary succession from exposed shorelines to climax forests on moraine shores, the development of meta-populations, the transition from brackish ecosystems into freshwater ecosystems and the development of the successive stages of peatland ecosystems (Figure 5).

The nominated site includes both coastal and open sea areas with several environmental gradients. This contributes to the variation in geomorphology and influences the ongoing biological processes, increasing the complexity of the ecosystem over time.

The Kvarken Archipelago is an exceptional area in which to study the geologic principle of actuality: ongoing geological processes that constantly reshape the landscape, creating new environments and areas for colonization by plants and animals, thus maintaining unique succession processes in terrestrial and aquatic environments. In other words, the nominated site illustrates the process of how nature and the landscape have developed throughout the Holocene era, from the outer archipelago to the mainland.

2.b Statement of significance

The Kvarken Archipelago is nominated as a complement to the High Coast World Heritage in Sweden, which was approved in Cairns on November 29th, 2000. The justification of the High Coast World Heritage states that the site is "one of the places in the world that is experiencing isostatic uplift as a result of deglaciation. The isostatic rebound is well-illustrated and the distinctiveness of the site is the extent of the total isostatic uplift which, at 286 m, exceeds others". The High Coast and the Kvarken Archipelago are located within the central part of the Fennoscandian land uplift area. In a 1996 publication, the Nordic Council of Ministers proposed Nordic candidates for World Heritage status, including the Vaasa archipelago, which is now part of the nominated site. The Vaasa archipelago has also been suggested as a World Heritage candidate by the project "Geodiversity in Nordic nature conservation" (Johansson 2000). A workshop organised by IUCN (World Heritage Boreal Zone Workshop, St. Petersburg 2003) recommended the Kvarken Archipelago as a complement to the High Coast (IUCN 2004).

To the north of the High Coast, the landscape changes and the typical hilly terrain of Norrland, with peaks higher

Figure 5. Isolation of lakes and ponds from the sea and development of freshwater and peat land ecosystems at Lappören. Photo Korsholm municipality ©.

Figure 6. The ice has a great impact on the landscape and ecosystems in the Kvarken Archipelago. Photo Metsähallitus ©.

Figure 7. Rödgrynnorna islets with bedrock crags and moraine tails, created by the last inland ice. Photos Korsholm municipality and Metsähallitus©.

than 200 m above sea level, is replaced by a flat and extensive sub-Cambrian peneplain, known as the Kvarken area (Fredén (ed.) 1998). The low relief of the coast in the Kvarken area is 20-25 meters.

Northern Kvarken is the narrow and shallow strait between Finland and Sweden that separates the Bothnian Bay in the north from the Bothnian Sea in the south. The steep High Coast and the flat Kvarken Archipelago are topographical opposites, which means that different types of landscape development are illustrated within the same land uplift area. The two sites compliment each other in terms of the post-glacial land uplift patterns and processes. The High Coast and the Kvarken Archipelago together serve as a unique example of ongoing geological and biological processes and ecosystem development in time and space.

The Kvarken Archipelago is nominated for inclusion on the World Heritage List on the basis of the geological features created by the last inland ice sheet, deglaciation, and isostatic rebound. The nominated site exhibits a large number of landforms of excellent geologic and geomorphological value. As a result of the ongoing land uplift, new land continuously emerges from the sea, exposing glacial and deglacial traces and patterns. Most of the Quaternary sediments were deposited during and after the last glaciation, around 10 000 – 24 000 years ago (Lunkka *et al.* 2001). The Precambrian bedrock, the peneplain and the enduring erosion form a distinctive basis for the dynamic geological and biological processes. Traces of these processes are recorded in the Söderfjärden meteorite crater (age 520 Ma), which is situated about 10 km south east of the nominated area. Fossil bearing Cambrian sediments and marks of several glaciations are preserved in the crater.

The present land uplift rate in the nominated site is about 8,0 mm/year. The highest rate in Fennoscandian today is 9,2 mm/year in the western Bothnian Bay (Ekman 1993). Due to the low relief, the effects of the ongoing land uplift are very evident. For example, the land increase is 35 ha/year in the Replot-Björköby area (Palomäki 1988). One-third of Maxmo municipality lies less than five meters above sea level and land increase is 888 ha per hundred year (Jones 1972). According to calculations made by the Geological Survey of Finland in 2003, the land area of Kvarken Archipelago grows by 1 km^2/year.

Figure 8. A result of the land up-lift phenomenon on Valsörarna. In the 1970's, the old bridge was situated at the shoreline (upper photo), while today it cannot be reached by boat (lower photo). Photos Tuukka Pahtamaa ©.

The Kvarken Archipelago is distinguished by its diverse archipelago landscape, a variety of ecosystems and a comparatively mild climate. The annual ice cover is 140-150 days. The sea is shallow and the water is brackish with a low salinity of 4-5 ‰. There are about 6550 islands and islets, a large number of peninsulas and bays and extensive stony seashores. The total shore length is about 2840 km. Despite the small differences in altitude, the topography of the Kvarken Archipelago is highly variable. New land continuously emerges at the seashores and ecosystems develop along topographical and hydrographical gradients, thus leading to a never-ending change in the landscape. The rapid decrease of extensive bays, the cutting off from the sea of inlets between moraine ridges and the development of coastal lakes into swamps are all effects that can be experienced during a single human lifetime (Figure 8).

A large-scale environmental gradient extends from the mainland to the open sea in the deeper parts of the Kvarken Archipelago. Another smaller gradient stretches from the luxuriant coastal surroundings in the inner parts to the harsher environments in the outermost parts of the archipelago. On an even smaller and more local scale, new islets and shores emerge from the sea, continuously maintaining the succession processes in water and land ecosystems.

The main succession trend is a development from wet to dry environments, and from maritime to terrestrial ecosystems. For example, the vegetation belts range from pioneer plant communities close to the waters edge to the inland climax forest ecosystems (Svensson 2002). To survive on a long timescale, the pioneer communities are forced to constantly "move" and colonise newly exposed land. The lower the altitude, the younger the site, and the higher the

altitude, the older the habitat with more developed plant communities. Very often the plant communities form orderly zones in a chronological sequence.

Over time, the sea inlets develop into lagoons (=flads) and lakes (Figure 5) (Munsterhjelm 1987). The transition stages between the brackish and fresh water environments are often very productive and of high ecological value. These environments are well represented in the Kvarken Archipelago. The flat landscape also offers unique opportunities for peat forming wetlands. Peat formation occurs continuously when inlets and lakes become overgrown and forests stagnate (Rinkineva & Bader 1998).

Northern Kvarken plays a crucial role in the study of the glacial geomorphological and isostatic processes. Even at the outset of the 18th century, it was known that the sea level once had been much higher and "sea withdrawal" was the subject of extensive research. It was not until the end of the 19th century that it was demonstrated that land uplift was the reason for the coastal changes. In 1890, Gerard De Geer had compiled all the relevant information about the highest coastline using geological maps (De Geer 1890). He presented a map showing a concentric and elliptic pattern of the highest coastline with the epicentre located between the Oslo Fiord and the Bothnian Bay. Therefore, De Geer proved that the land uplift phenomenon was caused by the inland ice, and glacial isostasy.

The High Coast is a key global site for studies into the significance of land uplift on geology, biology, and cultural history. The Kvarken Archipelago has been a focus for geo-scientific studies on isostatic land uplift (Mörner 1981), the moraine geomorphology of the last deglaciation (Aartolahti 1972, Zilliaccus 1987), and the development of postglacial coasts in the Gulf of Bothnia (Ristaniemi *et al.* 1997).

2.c Comparative analysis

Archipelago areas in the Gulf of Bothnia

In the Gulf of Bothnia, there are many archipelagoes containing moraine landforms and glacially sculpted bedrock morphology, like the Larsmo and Luleå archipelagos situated north of the nominated site. However, the geomorphologic and geological significance of these sites does not reach the geological diversity of the Kvarken Archipelago. The Replot and Björköby areas in the Kvarken Archipelago are the best examples of De Geer moraines in Finland (Aartolahti 1988).

The Kvarken Archipelago, a complement to the High Coast World Heritage, Sweden

The High Coast World Heritage site and the Kvarken Archipelago lowland compliment each other with regards to understanding former and present land uplift processes (Figure 9). This is also pointed out in the IUCN technical evaluation of the High Coast, which states that the both areas are complementary in terms of their biophysical evolution (IUCN 2000). The High Coast is the only hilly coast in the Baltic Sea area with altitudes of more than 300 meters above sea level. Its steep shores have a long and well-documented history of landscape development – 286 m of land uplift during 10 000 years. The highest coastline is located 2 km from the present shoreline. The Kvarken Archipelago, with its flat topography, extensive archipelagoes, shallow coast areas, and large annual land addition area represents a shorter period of 2000 – 3000

Figure 9. A schematic view of the Gulf of Bothnia, showing the future of the area and differences between the landscapes of the Swedish High Coast and the Finnish Ostrobothnian low coast. GTK ©.

Figure 10. The shallow and boulder-rich archipelago area in Korsnäs municipality. Photo Hans Hästbacka ©.

years. The moraine formations reach 3-10 meter above the surroundings.

Both sites display the spatial aspect of land uplift and dynamic landscape development. The Kvarken Archipelago contributes significantly to the measuring of time, facilitating a dating precision of about 10 years. This is also evident in the ecosystem development, illustrated by the plant communities that occur in distinct belts along topographical and hydrographical gradients. The steep topography of the High Coast site makes the plant communities more stable and influenced less by the land uplift timescale. Instead, species specialization and adaptation are favoured, as well as long-term survival of relict species. The succession reflects a timescale precision of 10-100 years.

Land uplift, brackish water environments, sea level fluctuations, and a lack of tide are features that the Kvarken Archipelago and High Coast have in common. Ecosystems and plant communities are also similar, but differences in topography and geomorphology imply different ways of adaptation to the ongoing land uplift in time and space.

Hudson Bay and James Bay, Canada

The area around James Bay, in the southeastern part of Hudson Bay has a similar history of glaciation and land uplift as the Gulf of Bothnia. The deglaciation of James Bay occurred about 1000 years later and the present land uplift rate is somewhat higher, 11-13 mm per year (Peltier & Andrews 1983). Differences in climatic, topographical, and geomorphological conditions are quite considerable however, and these differences strongly affect the biophysical development of the ecosystems and landscapes. The effects of land uplift are therefore more obvious in the Kvarken Archipelago than in Hudson Bay.

Both Hudson Bay and the Kvarken Archipelago have Precambrian bedrock, eroded to a peneplain on which paleozoic sediments are deposited. These deposits have to a large extent been preserved and are several hundred meters deep. The Kvarken Archipelago lacks paleozoic rocks. Unlike the boulder-rich moraine in the Kvarken Archipelago site, the moraines of Hudson Bay are poor in boulders, due to softer rocks. De Geer moraines, drumlin fields, transverse moraines of Rogen type and hummocky moraines occur at the coastal lowlands. However, these moraines do not form archipelagos (Figure 11).

In the Hudson Bay area, a subarctic macroclimate prevails. Permafrost, salt water, strong winds, and a deep, long lasting snow cover are factors that significantly affect the structure and dynamics of the coastal ecosystem, rather than the land uplift process (Lescop-Sinclair & Payette 1995). Due to the south boreal macroclimate, the ecosystems in the Northern Kvarken are more nutrient rich and more diverse than the Hudson Bay area.

The extensive and low-lying western parts of the Hudson Bay area (Ontario and Manitoba) exhibit a succession towards a wetland-dominated landscape (Sims *et al.*1979), which is lacking in the Northern Kvarken. The east side (Quebec and Labrador) of Hudson Bay and James Bay resembles the Kvarken Archipelago, having a more broken topography. The long-term successional trend reaches from marine tundra along the coast to thinly forested land dominated by conifers in the interior. Trees

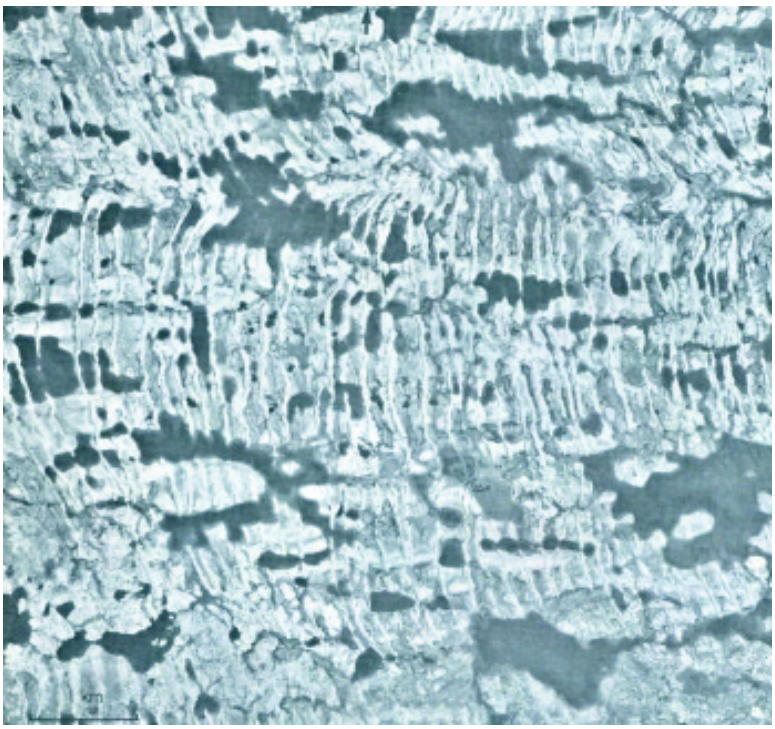


Figure 11. Aerial and oblique photo of De Geer moraines from Hudson Bay area (Prest 1983).

along the coast normally do not grow taller than 3 m (Lescop-Sinclair & Payette 1995). In general, the successional gradient is not as evident as along the shores of the Kvarken Archipelago.

The White Sea area, Russia

The northern and western shores of the White Sea are at the periphery of the land uplift area and are a part of the Fennoscandian shield. The land uplift rate is 1,0-2,5 mm per year. Compared to the Kvarken area, the land uplift is insignificant. Drumlins, end moraines, and De Geer moraines occur in the areas around the White Sea, but do not form archipelagoes.

2.d Integrity

The past, present, and future morphology of the Kvarken Archipelago shows traces from the last Weichselian glaciation and the subsequent deglaciation and land uplift. Due to ongoing land uplift, these geological formations are continuously exposed when new land emerges from the sea. Below the sea surface, the formations are still relatively unaffected by erosion, overgrowth, large-scale disturbances, other natural changes, and human impacts. Since parts of the shallow sea are included in the nominated site, these geological formations and deposits are preserved for the future.

The nominated site includes the mainland, archipelago, and sea. A variety of formations are represented, of which the main part has been influenced by glaciation and deglaciation. Some landscape transformations have happened later due to land uplift, winds, and wave erosion on former shores. The site is large enough to represent different biophysical effects of the land uplift, among them natural terrestrial ecosystems and water ecosystems. Plants and animals living in the Kvarken Archipelago are typical for the region.

The proposed World Heritage area exhibits the best examples of geologic and geomorphological values in the Kvarken area. The buffer zone harbours a number of flat islands where the rapid land uplift contributes considerably to the biological values of the nominated site. Within the buffer zone, there are also sea floor areas with large moraine fields of mainly De Geer moraines along with other moraine ridges, which have been confirmed by acoustic-seismic soundings.

National laws and international agreements protect the Finnish coastal landscape. They regulate all activities and operations and guarantee the integrity of the geologic and biological values. The most important areas of the Kvarken Archipelago site are included in nature conservation programmes, and are under the protection of the Nature Conservation Act. They are also included in the Natura 2000 network. There are special directives for the protected areas that regulate land-use. The preparation of management plans for all Natura 2000 areas has begun and environmental authorities in consultation with interest groups, will prepare detailed management plans for the protected areas. A plan for tourism and recreation has been produced within a Nordic EU project.

Description 3.

3.a Description of the site

THE GEOLOGY OF THE KVARKEN ARCHIPELAGO

The unique terrain of the Kvarken Archipelago is, to a large extent formed by the last inland ice sheet and its melting process. Some landscape transformations have occurred later due to land uplift, wave erosion on ancient shores of the Baltic Sea stages (Ancylus Lake, Litorina Sea, and present) and the continuously growing peatlands. See Appendix 1 for a more comprehensive description of the geology of the nominated site.

Quaternary deposits

The Quaternary period includes the last 2 million years in the Earth's history, and is characterized by glacial and interglacial stages. Most of the Quaternary deposits in the Kvarken Archipelago were formed during and after the latest phase of the Weichselian glaciation, some 10 000 – 24 000 years ago. In Fennoscandia, the term Quaternary deposit refers to the loose overburden on the surface of the Earth.

The Quaternary deposits in this area are divided into two main groups according to their genesis and the environment in which they were formed. Glacial deposits were formed by the ice sheet or its melt-water and include till, glaciofluvial sediments, and glacial clay. Postglacial deposits were formed independently of the melting ice sheet.

Glacial deposits

Till consists of varying amounts of boulders, stones, gravel, sand, silt and clay. Till generally lies directly on the bedrock and largely follows its surface configurations. Till also commonly forms its own surface configurations (Figure 13). The landscape in the Kvarken Archipelago is dominated by till with characteristic moraine formations. On the sea floor, there are also abundant sediment deposits.

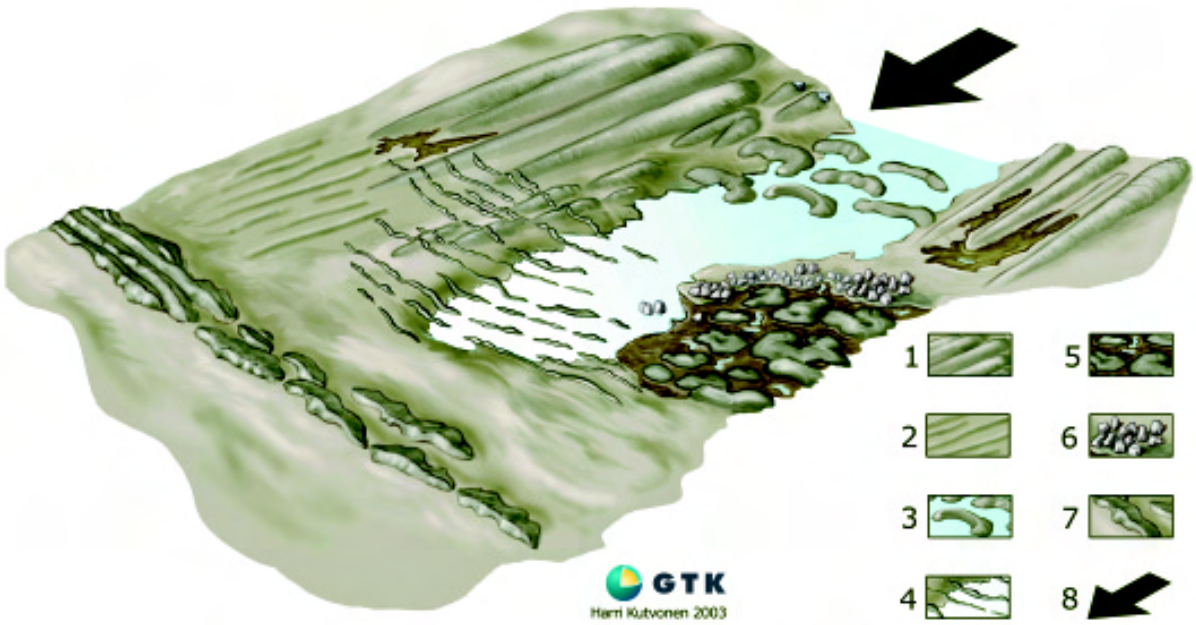


Figure 13. Schematic figure of the moraine formations in the Northern Kvarken area. 1. Drumlins, 2. Flutings, 3. Transversal moraines (Rogen type), 4. De Geer moraines, 5. Hummocky moraines, 6. Boulder-rich surface, 7. End moraines, 8. Latest ice flow direction. Drawing by Harri Kutvonen 2003, GTK ©.

Figure 12. Left: Aerial view of the De Geer moraines at Björköby. Photo Korsholm municipality ©.

Figure 14. Typical shape of a De Geer moraine ridge. Photo GTK ©.

Moraines parallel to the ice flow direction

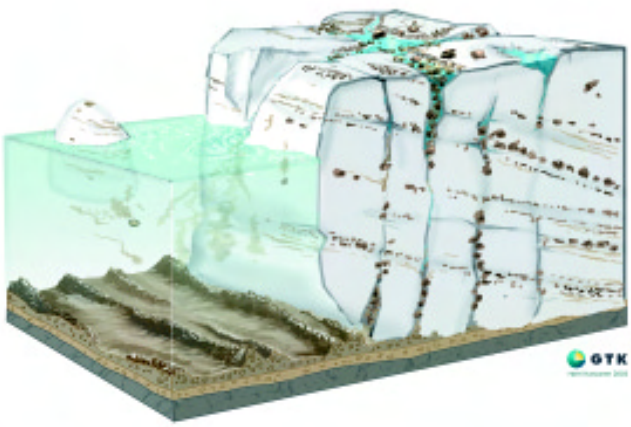
A drumlin is an oval-shaped ridge formed beneath an ice-sheet as it moved over the terrain. Drumlins and similar formations are often found in clusters and the ridges may extend over several kilometers. Drumlins are often composed of basal or lodgement till. Drumlins are not typical for the proposed area but occur in the central part of Replot.

Fluting ridges are either small glacial deposits or erosion remains on the basal till surface, indicating the direction of the last glacial flow.

Moraines at right angle to the ice flow direction

End moraines belong to this class and they may either be large or small, short or long. The end moraines were formed along the ice margin and have an asymmetrical shape with a gentle stoss-side (proximal) and a steeper lee-side (distal) (Figure 14).

A closely related type of moraine, the De Geer moraine, occurs in clusters in lowland areas. De Geer moraines were first described in Sweden by Gerard de Geer (1889) and were called De Geer moraines by Hoppe (1957) or washboard moraines by Mawdsley (1936). De Geer moraines are till ridges up to 5 m high, 10-50 m wide, and in some cases 1000 m or more in length. The moraines occur in large groups at 40 - 300 m intervals, mostly in low-lying landscape areas. The Kvarken Archipelago has the highest number of De Geer moraines and they occur in compact clusters (Laaksonen 1994). In the northern and eastern parts of the proposed area, the moraines seem to be related to, or deposited on the top of, drumlins and other moraine formations.



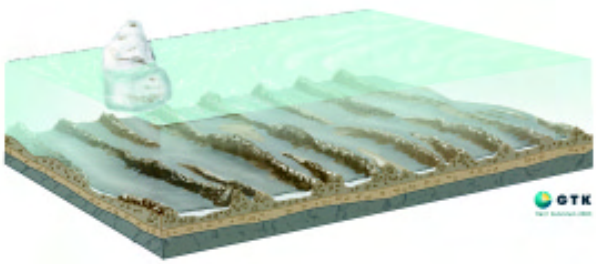


Figure 16. Large transversal moraine ridges at Valsörarna. Photo Metsähallitus ©.

According to the current moraine genesis theory, the moraine ridges were formed beneath the ice in crevasses running parallel to the ice margin. In the Kvarken Archipelago, the water depth during deglaciation was 250-280 m (National Board of Survey 1990). Huge icebergs were released from the ice front and the De Geer moraines reflect the probable position of the retreating ice margin (Figure 15).

Laaksonen (1994) put forward a hypothesis of stable laminar basal flow of ice as an explanation for the wave like pattern of the De Geer moraines. It is evident that both De Geer moraines, transverse basal till ridges (Rogen type moraines) and radial streamlined moraine ridges (drumlins) occur in the same area of Replot and Björköby islands. There may also be a connection between the clusters of De Geer moraines and glaciotectonic features (Lundqvist 2000).

Large transversal moraine ridges (Rogen type)

A Rogen moraine is a type of hummocky moraine, characterized by irregular ridges that are more or less oriented at right angles to the ice flow direction. Rogen moraines are mainly older than the latest stage of deglaciation. They are often composed of basal till or lodgement till, and are subglacially deposited, probably in the same zones as the drumlins. Rogen moraine ridges occur in the Valsörarna, Mickelsörarna and Köklot areas (Figure 16).

Drumlins and Rogen type moraines were formed 11,000–10,000 years ago about 200 - 700 km behind the ice margin. At the time, huge ice lobes filled the Bothnian Bay area and the ice flow was roughly south-southeast as shown by striations and drumlin orientations (comp. Bargel *et al.* 1999).

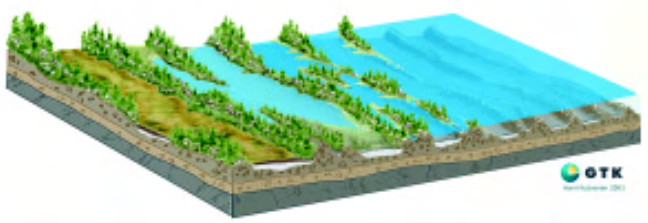


Figure 15. The origin and genesis of De Geer moraines. Drawings made by Harri Kutvonen 2003, GTK ©.

Figure 17. View of a flat and boulder-rich moraine in Korsnäs. Photo Metsähallitus©.

Hummocky moraines

The term hummocky moraine is used to describe all kinds of hilly moraines. Cuts into the moraines and documentation of the various sections provides the basis for a more detailed division of moraine type.

Hummocky moraines mainly occur in valleys and flat-lying areas. The hillocks and ridges are irregular and non-oriented, usually 5-20 m high, and form a mosaic of lakes, tarns, and peatlands. The moraines were deposited in the Kvarken Archipelago beneath the melting and thinning glacier front. The material is usually washed and composed of coarse-grained till. Most of the hummocky moraine formations were deposited in the final stage of the last deglaciation. In some places, the texture of the faulted and fissured glacier front is visible in the hummocky relief.

One striking feature of the Kvarken Archipelago is the boulder-rich moraine terrain. Some of the boulders are huge erratics, transported by the inland ice or by the icebergs in Ancylus Lake. Granitic rock types and their earlier weathering formations, such as tor, are susceptible to cubic cracking. Large boulders and erratics were thus easily torn off from rock outcrops by the inland ice. This boulder-rich, undulating moraine terrain represents the youngest till deposits and moraines in the area (Figure 17).

Glaciofluvial deposits

Glaciofluvial sediment consists of boulders, stones, gravel and sand that have been transported, sorted and deposited by melt water from the inland ice. The glaciofluvial sediment is stratified according to particle sizes. The particles are usually rounded.

The shape of the deposits depends on the environment in which they were formed. The meltwater from the inland ice joined rapidly running rivers in tunnels that emerged at the ice margin. The finer silt and clay material was deposited at greater distances from the mouth of the subglacial river and in calmer depositional environments.

Eskers are elongated, ridge-shaped glaciofluvial deposits that were formed in tunnels within the inland ice sheet. A few eskers occur on the mainland and in the Kvarken Archipelago on the sea floor.

Glacial clay

During the melting of the inland ice sheet, the finest particles of glaciofluvial origin, clay, were dispersed in the sea and in large lakes. During the Ancylus Lake stage, mainly homogeneous gray clays and black sulphide bearing clays were deposited. The varved clays were deposited closest to the ice front.

The particles remained suspended for long periods and sedimentation occurred slowly in freshwater. Depending on seasonal changes during deglaciation, and thus the flow of water, there were regular changes in the rate of sedimentation. During spring and summer, the water flow in the glacial rivers was high and large amounts of clay and silt particles were transported. However, the supply of sediment was slow during autumn and winter. Thus, a thicker and a thinner layer together form an annual varve. The winter varve is usually darker in colour than the summer varve and has higher clay content. Dropstones and other material transported by the icebergs are occasionally found in clay profiles.

No clear pattern of varves is formed in saline water since the sedimentation rate is higher due to the electrolytic properties of the saline water.

Postglacial sediments

Later in the course of the isostatic land uplift, Baltic water broke through the Danish straits into the Atlantic Ocean. The arrival of brackish water during the transition to the Litorina Sea stage is marked by an exceptionally sharp litostratigraphic boundary. This bears witness to a dynamic change in the hydrographic conditions of the Baltic Sea. Greenish mud rich in organic matter, methane gas, and brackish water diatom flora was deposited on the floor of the Litorina Sea. Today, these sediments are the most fertile agricultural land in the coastal areas of the Bothnian Bay.

The land uplift exposed older deposits to the influence of wave washing and there was complete restratification of sediments. Wave-washed material was deposited along and close to the shorelines as shingles, gravel and sand with decreasing particle size away from the shore.

Figure 18. The developmental stages of the Baltic Sea afterSvendsen et al 2004. Drawnings modified after National Board of Survey 1990 by Harri Kutvonen.

The youngest deposits in the Kvarken Archipelago are mud and peat. The peat layer of most mires is less than 1 metre thick. The first stage in the development towards a peatland is an herb-rich marsh with a minerotrophic nutrient-rich sedge peat. The vegetation is often luxuriant. In peatlands more than 10 m above sea level, nutrient-poor moss peat (*Sphagnum*-peat) dominates and the marsh has changed into a raised bog.

Deglaciation and the development of the Baltic Sea

The heavy inland ice depressed the Earth's crust at least 800 m below its current position. When the pressure lightened, the crust slowly started to rebound. The highest traces of the shoreline (the highest shoreline) are found at different altitudes throughout Scandinavia, depending on how much the crust was depressed, how much the local sea surface had risen, and the time at which the area became ice-free. During deglaciation, low-lying areas were covered by sea water (Figure 18).

Ancylus Lake stage, 10 700 – ~ 9 000 years ago

The melting and disintegrating ice front reached the Kvarken area 10 600-10 400 years ago. At the time, the Kvarken area was covered by a 250-270 m deep glacial lake. A floating and fracturing ice front with calving icebergs was typical of glacial marine conditions during the Ancylus Lake stage. The varved clay chronology has shown that the annual withdrawal of the ice margin was fast, up to 200-500 m per year.

The Ancylus Lake stage lasted from 10 700-9 000 years ago. Deglaciation continued in the Kvarken area during the Ancylus Lake stage. The highest shoreline in the province of Ostrobothnia, (190-210 meters above sea level), was reached in the beginning of the Ancylus Lake stage. (Glückert *et al.* 1993).

Litorina Sea stage, 8 000 years ago – present sea stage

In the end of Ancylus Lake stage fresh water conditions gradually change to brackish with the opening of connection trough the Danish straits to the World Ocean caused by glacio-isostatic land uplift. In the sedimentary record this onset of the Litorina Sea stage is defined over the whole Baltic Sea area. In the clay strata, the arrival of brackish water at the transition to the Litorina Sea stage is marked by exceptionally sharp litostratigraphic boundary. These witnesses of a dynamic change in the hydrographic conditions of the Baltic Sea. The widely spread greenish mud rich in organic matter, methane gas and saline diatom flora was deposited on the bottom of Litorina Sea. Today these sediments are the most fertile agricultural areas in the coastal land of the Bothnian Bay area.

Most of the ancient beach deposits on the mainland date back to the Litorina Sea stage, less than 7000 years ago (Winterhalter *et al.*1981). The most prominent beaches in the Kvarken Archipelago were formed during the present Baltic Sea stage (Figure 19).

Figure 19. Beach formations on Östra Norrskär. Photo Metsähallitus ©.

The land uplift – past, present, and future

Land uplift studies have a long history in Finland and Sweden. As a result, both countries can thank Mother Earth, who has blessed both her children with powerful isostatic rebound, so powerful in fact, that changes can be easily observed during a human lifetime. The writer Zachris Topelius was one of the first to describe land uplift (Topelius 1873).

One encounters many names of renowned scientists' in the field of isostatic rebound, like the Swede Gerard De Geer who proved that land uplift was a residual phenomenon from the Ice Age. The Finnish geologist Wilhelm Ramsay conceptually separated the isostatic land uplift and the eustatic change of sea level.

Land uplift started 20 000 years ago, at the beginning of deglaciation. During the first thousand years of land uplift, the rebound rate was up to 100 mm per year (10 m in 100 years). The total initial depression is assumed to have been in the magnitude of 900–1000 m when the Scandinavian Ice Sheet was 3400–3700 m thick (Taipale and Saarnisto 1990, Eriksson and Henkel 1994). Isostatic rebound presumably will continue for 10 000 to 12 500 years in the Kvarken area and the remaining land uplift will probably be 100-125 metres (Kakkuri 1991, 1997). The land uplift will continue until the depression in the geode has fully rebounded or until the next glaciation begins to depress the Earth's crust. A shallow sill with a maximum water depth of about 25 m is present in the Kvarken area and in about 2500-3000 years it will be land, cut through by a river that discharges from the Bothnian Bay.

Isostatic land uplift not only exposes new land but it also creates many practical problems in the Kvarken area. For example, all old harbours are now far from the coast. The old harbour of Wasa-Korsholm from the 13th century is now situated 10 km inland from the present Vasklot harbour

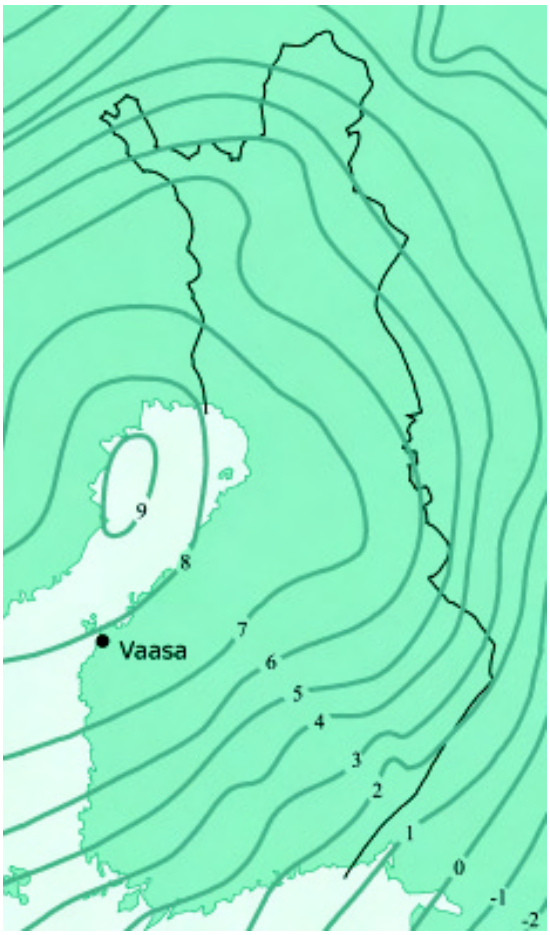


Figure 20. Present isobases of land uplift (mm/year) in Finland. Drawnings modified after National Board of Survey 1990 by Harri Kutvonen, GTK ©.

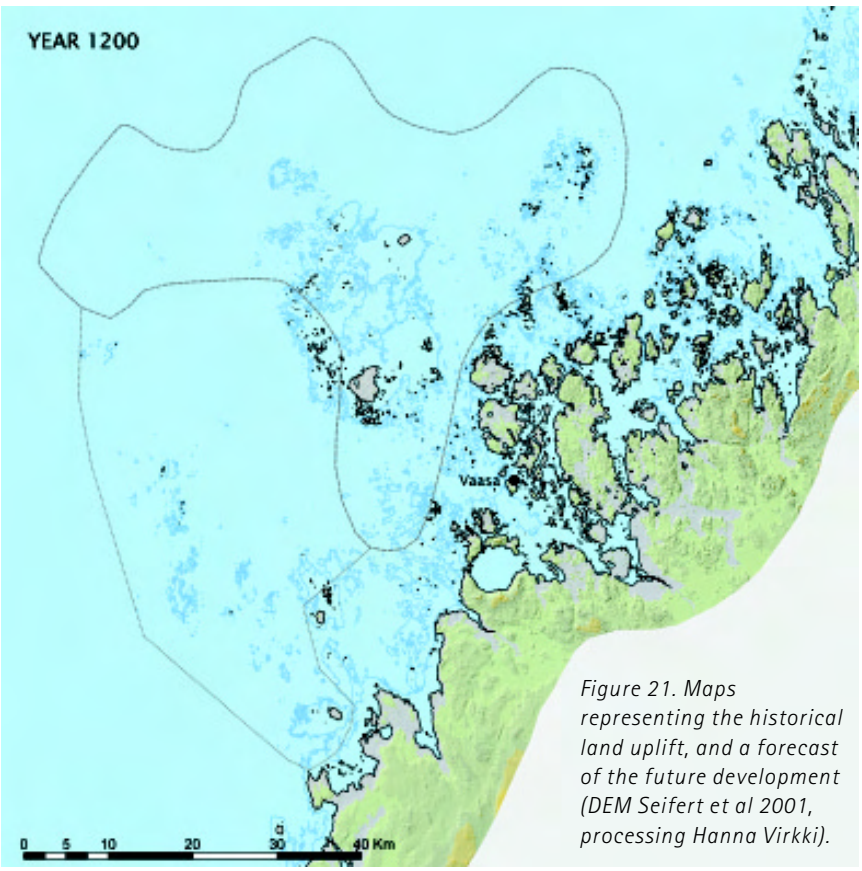
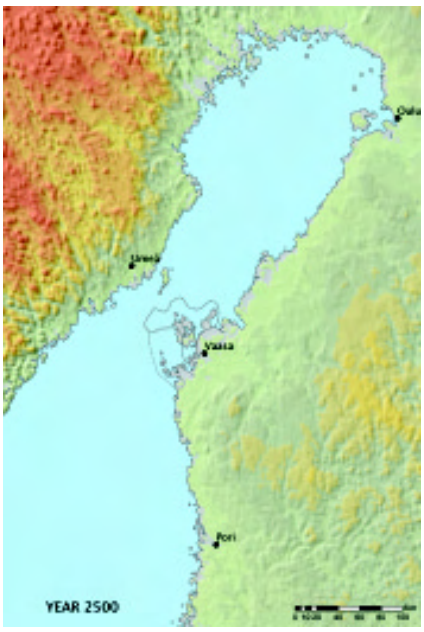


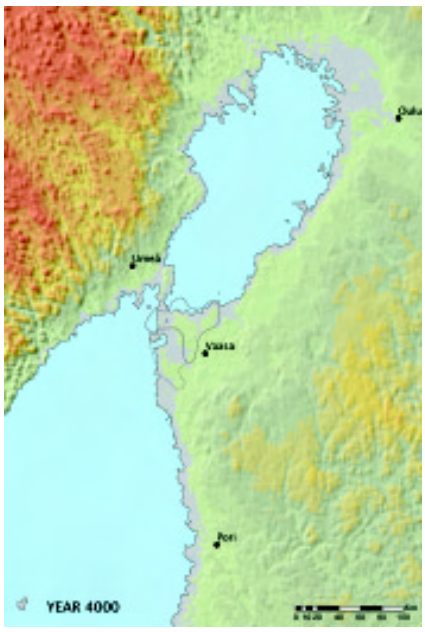
Figure 21. Maps representing the historical land uplift, and a forecast of the future development (DEM Seifert et al 2001, processing Hanna Virkki).

founded in 1890. New land emerges rapidly from the shallow sea, for example, 35 ha annually in the Replot and Björköby villages (Palomäki 1988). Palomäki (1988) has estimated that the total land gain is approximately 3 km^2 per year along the Ostrobothnian coast.

The construction of deeper harbour basins, canals, and fairways is a continuous necessity to deal with the land uplift. Another evident result of land uplift is that the summer cottages and boat shelters are lying far from the present shoreline on many low-lying islands and peninsulas (Osala 1988). In fact, a human may actually experience the rising of land from the shallow sea during their lifetime. At first, some elongated boulder-rich ridges emerge that form reefs. Then the moraine ridges join into elongated islands that finally enclose the small lagoons.

According to the current results from three precise levellings in Finland, the current absolute annual land uplift is about 8.0 mm on the Finnish side and about 8.5 mm on the Swedish side of the Northern Kvarken (Ekman 1996, Mäkinen and Saaranen 1998) (Figure 20). The Fennoscandian land uplift is associated with mass flow in deep mantle layers of the Earth. In relation to the Earth's centre, the land uplift rate in the Vaasa area is approximately 10 mm per year. This means that the gravity in this area has diminished by 0,06 milligals in 26 years. (The Finnish Geodetic Institute, http://www.fgi.fi/yleis/historia_eng.html).





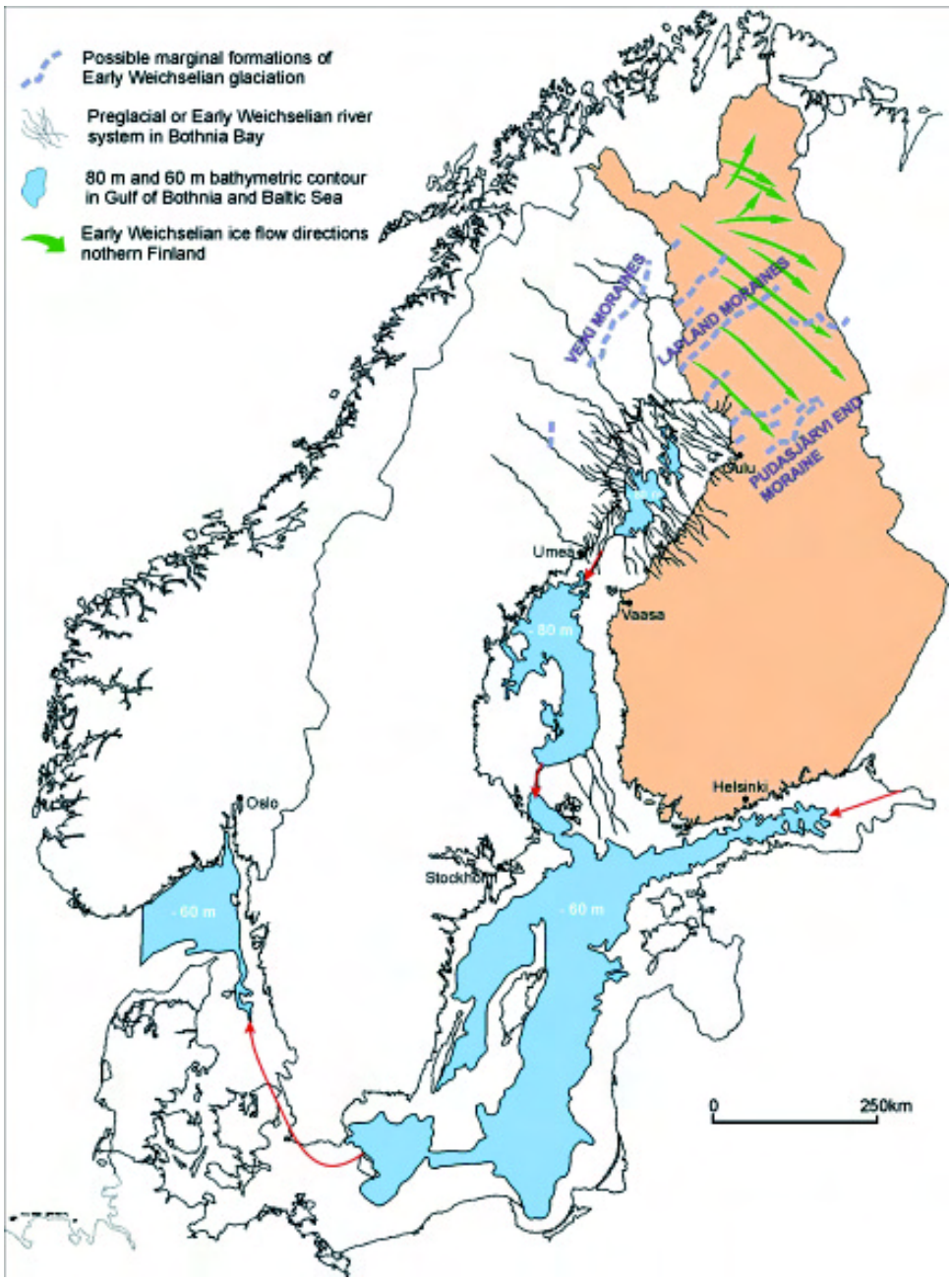


Figure 22. Bothnian Bay and Baltic Sea area during the Weichselian interglacial stage.

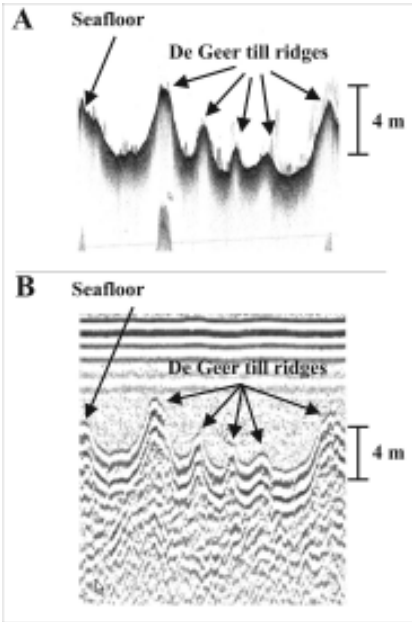


Figure 23. Echo sounding (A) and acoustic reflection profiles (B) of De Geer moraines.

Marine geology of the Kvarken Archipelago

Northern Kvarken, the narrowest part of the Gulf of Bothnia, forms a submarine sill (25 m) that separates the Bothnian Sea in the south from the Bothnian Bay in the north. The Kvarken Archipelago also includes areas outside the sill where deeper parts sparsely occur (83 m at maximum). The sea floor morphology is characterized by tectonic lines in Vaasa granite, and hummocky and De Geer moraines. In deeper parts of the sea floor, the moraine formations have the same shape as when formed by the inland ice sheet.

Due to the relatively rapid land uplift, the bathymetry of the Kvarken Archipelago has changed dramatically since the last deglaciation. The major part of the Kvarken Archipelago is very shallow (0-25 m) and shoaly. The fairways are shallow, boulder-rich, and on average less than 10 metres deep. During, and just after the last deglaciation (around 10,000 years ago), the nominated site was submerged more than 200 m.

The rugged sea floor topography of the Kvarken Archipelago is controlled by the bedrock (Ignatius *et al.* 1980). The crystalline bedrock is similar on both sides of the Northern Kvarken and thus it is assumed that this is true also for the sea area, although no actual data are available (Winterhalter 2000). Sedimentary rocks exist on the sea floor of the Bothnian Bay but have not yet been found in the Kvarken Archipelago. However, Lower Cambrian sedimentary rocks occur in the coastal area (Söderfjärden), close to the city of Vaasa.

The entire Baltic Sea has undergone several glaciations during the Late Pliocene and Pleistocene (the past ~2.7 million years). During this time, the Northern Kvarken and Baltic Sea areas have been repeatedly subjected to glacial erosion and accumulation. However, information on possible interglacial deposits in the present marine area is still very scarce. From earlier geological stages, there are indications of land uplift in the Bothnian Bay area of even 100 m above present level. As well, lowering of the sea level would have changed the hydrography of the whole area.

The Bothnian Bay and the entire Baltic Sea were isolated from the ocean during the Early and Mid-Weichselian substages (115 000- 50 000 years ago). The ocean level was lower than present and the area was undergoing uplift after the Saalian and Early Weichselian glaciations (Lundqvist 1992, Lundqvist and Robertsson 1994, Nenonen 1995). Old preglacial river channels, tens of metres deep, have been found on the sea floor of the Bothnian Bay and the Bothnian Sea as extensions of present-day rivers (Tulkki 1977). The channels extend to the central parts of the marine area, to a depth of 80 m below present sea level, thus illustrating the probable ancient shoreline (Figure 22).

The sea floor consists mainly of till. Due to strong currents and wave action, varved clay sediments are generally absent. Postglacial clays and gyttja-clays cover the sea floor in basins, protected from current activity (Ignatius *et al.* 1980). According to the available data, the thickness of the Quaternary deposits in the Northern Kvarken is relatively low.

The geomorphologic feature that makes the Kvarken Archipelago unique is the occurrence of spectacular De Geer moraines (Aartolahti *et al.* 1995). These moraines also occur on the sea floor in the Kvarken Archipelago (Nuorteva 1988)(Figure 23).

The glacial morphology of the sea floor has not undergone coastal deformation, as is the case with the land areas. In the marine area, it is possible to study the nature of glacial features in a mostly natural and in-situ state (Winterhalter 1972).

Bedrock geology

Geologic history of the Kvarken Archipelago

The bedrock in the Kvarken Archipelago is generally covered with a thin overburden which is mainly composed of till. The bedrock outcrops are often glacially eroded and polished. Whale back rock outcrops with glacial striation and erosion marks are common on rocky islands and beach cliffs of the larger islands (Figure 24).

Figure 24. Fresh diabase outcrop with marks of glacial erosion, Storskäret. Photo GTK ©.

The bedrock of the Kvarken area belongs to the Precambrian Svecofennian schist belt and is composed of ancient, hard crystalline rock, which developed 2000 to 1300 million years ago. Palaeozoic sediments were deposited on the eroded Precambrian peneplain 520 million years ago. Evidence of this sedimentation can still be seen in a meteorite impact basin in Söderfjärden, where a 200 meter thick pile of Palaeozoic sedimentary rocks (Cambrian) was preserved from erosion. The Palaeozoic sedimentary blanket was eroded away during the last 500 million years. The extensive Kvarken area belongs to the sub-Cambrian, or primary, peneplain between northern Finland and southwestern Sweden (Lundqvist 1994). In the north, the peneplain surrounds the Bothnian Bay and consists of the flat land areas of Norrbotten and Ostrobothnia.

The geologic history of the crystalline rocks in the Kvarken Archipelago began as a turbiditic sedimentation of sand and mud on a sea floor with unknown bedrock. During the Svecofennian orogeny 1880 million years ago, the sedimentary pile sank about 15 kilometres deep into the Earth's crust, and recrystallized into micagneisses, veined gneisses and amphibolites, and also partly fused into granodioritic melt (diatexites). As well, around 1800 million years ago, a post-orogenic thermal pulse produced granitic magma expressed as small plutons in the western part and as minor felsic dikes and pegmatites in the eastern part of the Kvarken area.

After a quiet period of about 200 million years, the rapakivi magma intruded and crystallised as batholites in upper parts of the crust, about 1570 million years ago. The felsic rapakivi magmatism was accompanied by mafic magmatism, expressed as diabase dikes (Sub-Jotnian) and gabbros intruding into the bedrock. Boulders of quartz-feldspar porphyry can be seen along the coastal area around Vaasa, and are considered to be near-surface equivalents to the rapakivi magmatism. These porphyries are also found in the drift on the bottom of the Gulf of Bothnia near the Northern Kvarken. Around 1270 million years ago, a set of olivine diabases (so called Post-Jotnian diabases) intruded through the crust and were the last rock forming event of the crystalline bedrock in the Kvarken area. After the intrusions of Post-Jotnian dikes, there is no record of significant magmatic activity in the Svecofennian area. Stable tectonic conditions were established and remained until the beginning of the Palaeozoic era, 540 million years ago.

The Svecofennian orogenic belt had already lost much of its mountainous grandeur during the Mesoproterozoic time. This is indicated by thick, Jotnian sandstone deposits 1400 – 1200 million years old, within the Svecofennian schist belt in Satakunta and Muhos in Finland, and in Nordingrå, Gävle, Dalarna and Småland in Sweden. Extensive distributions of Jotnian sandstone have also been verified on the sea floors of the Gulf of Bothnia, around the Kvarken area. Small boulders of sandstone are frequently found on the shores.

Figure 25. The most frequently occurring rock type, Vaasa granite. Photo GTK ©.

Palaeozoic rocks

The entire Kvarken area was once covered with Palaeozoic sedimentary rocks. Since the beginning of the Palaeozoic era, 540 million years ago, the uninterrupted erosion and sedimentation (like the 540 million years old Lauhanvuori sandstones, Finland) has continued and flattened the Svecofennian surface to the peneplain of Ostrobothnia, the low coast.

During the Cambrian, 520 million years ago, a meteorite impact created a basin on Earth's surface in the southeastern corner of the Kvarken area (Lehtovaara 1992). The impact crater at Söderfjärden has sheltered the Cambrian sediments against erosion and abrasion until present time and the Palaeozoic sedimentary record is unique for the Svecofennian schist belt.

The existence of Lower Cambrian siltstone in the Bothnian Sea, and comparable seismic velocities of this siltstone with velocities in the Bothnian Bay, north of the Kvarken area are evidence that Söderfjärden belonged to a once widespread Cambrian sedimentary strata (Axberg 1980, Winterhalter 2000).

The Söderfjärden crater, 10 km south of Vaasa, is a mostly circular depression with a diameter of 6 kilometers and an irregular rim 30-40 m in height (Laurén *et al.* 1978). Gravimetric studies and drilling show that the crater bottom has a raised centre (Lehtovaara 1992).

Sandstone and siltstone comprise sedimentary strata 250 m thick in the lower part of the depression, which is also overlain by glacial and post-glacial deposits more than 50 m thick. The sedimentary rocks have been dated to Lower Cambrian using micropaleontology (Tynni 1978, Anneli Uutela, pers. com.).

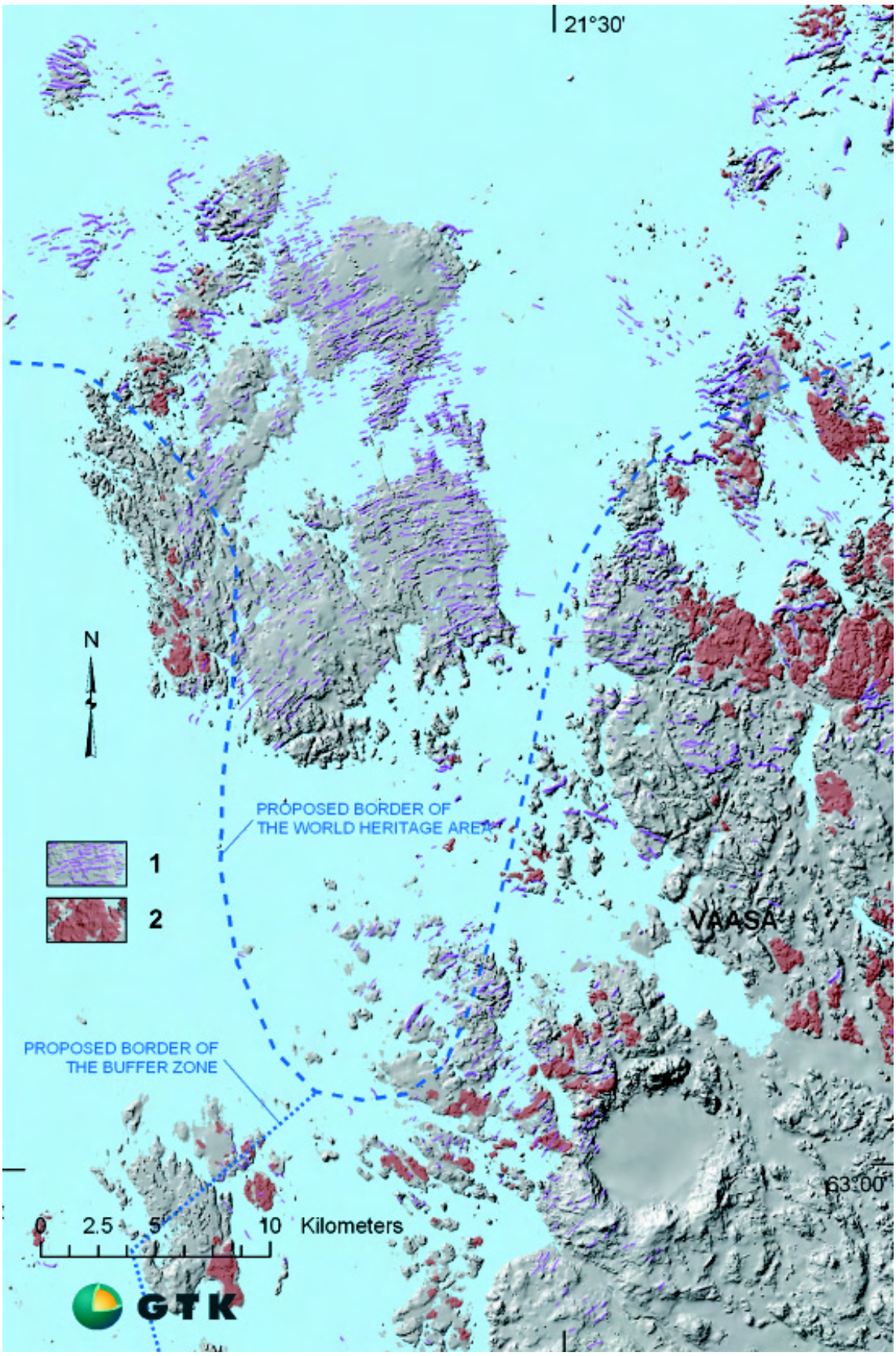


Figure 26. The diverging of the De Geer moraine and large transversal moraine ridge clusters in the north shown by geographical elevation model. The Söderfjärden meteorite impact crater is shown near Vaasa in the southern part of the image.

1 = De Geer moraine and large transversal moraine ridge
2 = hummocky moraine. (DEM National Land Survey of Finland, processing Tapio Väänänen & Miikka Paalijärvi).

Figure 27. The Sea buckthorn in winter and autumn. The berries are an important source of food for migrating birds. Photos Metsähallitus © and Eero Murtomäki ©.

THE NATURE OF THE KVARKEN ARCHIPELAGO

Climate

The Kvarken Archipelago belongs to the southern boreal climate zone that extends in a narrow strip along the Finnish coast. The maritime influence is evident as the sea cools the local climate during spring and summer, and warms it during autumn and early winter. The annual precipitation is lower along the coastal area (450 mm), compared to a few kilometres inland (600 mm). The number of sun-hours in the Kvarken Archipelago is, on average 1900 hours, which is higher than in the interior. The sea is frozen for up to 140-150 days and the snow cover lasts about 150 days (Heino 1988). The annual mean temperature is 3-4 °C, which is comparable to interior temperatures at two latitudes to the south. The growth period is 150 –160 days, during which the daily mean temperature is more than +6 °C (Helminen 1987).

This maritime climate provides special conditions for biological processes and vital ecosystems at these northern latitudes. As a result, the coastal ecosystems of the Kvarken Archipelago are very productive and diverse.

Features of the sea

The salinity in the Kvarken Archipelago varies between 2 ‰ and 5 ‰ and approaches zero at the river mouths. The tide is less than 10 cm. However, winds and changes in the air-pressure make the sea water level highly variable, in some cases as much as 250 cm (Svensson 2002). Low water levels are common in spring, while higher water levels are common in the autumn.

Northern Kvarken is characterized by a continuous and rapid water exchange, maintained by the supply of fresh water from the large rivers draining the northern parts of Finland and Sweden. On average, 17 000 m^3 water pass through the Northern Kvarken strait every second, and the velocity of the current may reach 1 m per second (Sevola 1988). The currents and counter currents transport brackish water to the south and saline water to the north.

Figure 28. The northern distribution limit of the Eider in the Baltic Sea is situated in the middle of the Northern Kvarken. The distribution is limited by the availabiltiy of its main food source, the Common mussel, which requires a salinity of at least 5 ‰. Photo Metsähallitus ©.

The currents, wave action and especially movements of the ice during the winter effectively erode the shores, affecting both the morphology and the vegetation.

Effects of land uplift on the landscape in time and space

The Kvarken Archipelago is a dynamic landscape, continuously changing in time and space as the land area increases and the sea area decreases. These effects are most obvious in flat and shallow areas. The land area growth might actually exceed the expected rate of the land uplift due to the sedimentation of organic and non-organic material.

The low-lying landscape has extensive shore habitats where early pioneer plant species colonize newly emerged land. The plant communities follow the "moving" seashore and maintain their position in relation to the shoreline. Pioneer plant communities are replaced by others as the altitude increases, and plant succession takes place. On very flat shore slopes, the successional order of these plant com-munities is evident as vegetation belts.

Biotic and abiotic conditions change with increasing altitude from the sea, in turn affecting the abundance and the species diversity of colonizing plants (Ericson and Wallentinus 1979, Väre 1994).

A variety of succession pathways are represented in the ecosystems of the Kvarken Archipelago. They are the result of the large number of environmental gradients present, like the degree of wave and ice-drift exposure, seawater salinity, and distance to the mainland. The seashore habitats are very heterogeneous in space and time (substrate, topography, micro climate, chemical and physical properties), which strongly affects the plant communities and favour biodiversity. (Rinkineva and Bader 1998).

Figure 29. Boulder-rich and stony shores are common in the Kvarken Archipelago. This makes it hard to get ashore, even from smaller boats. Photo Eero Murtomäki and Pertti Malinen ©.

According to the classic theory of island biogeography (Wilson and MacArthur 1967), the biodiversity of islands depends on three factors: isolation from the seed source, the size and age of the island. As a result of the continuous land uplift in the Kvarken Archipelago, these three factors vary in time and space and are easily studied and analysed.

Early plant colonization on young islands is totally dependent on seeds dispersed from the surroundings (Molander 1999). Species may become isolated on islands and lose the genetic exchange with other populations of the same species. Meta-populations can therefore evolve. The knowledge of the life histories of such metapopulations is a crucial factor for the conservation of threatened species. From this point of view, the large number of islands of different sizes and ages in the Kvarken Archipelago is an important scientific resource.

Marine ecosystems

The Kvarken Archipelago is highly productive compared to adjacent areas. This is mainly due to the surface currents with phosphate-rich water from the north and nitrate-rich water from the south. (Kautsky 1988, Wulff 1994).

Figure 30. Fish is an important prey for the rare White-tailed Eagle. The shallow bays and inlets offer excellent hunting areas for fish-catching birds. Photo Eero Murtomäki ©.

The species composition of the maritime ecosystem is a unique combination of fresh water species and marine species. One reason for this is that the salinity decreases from 5-6 ‰ in the southern part to 3-4 ‰ in the northern part of the Northern Kvarken (Kautsky 1983, Sevola 1988). The marine species live at their limits of distribution, with respect to salinity. They represent local ecotypes that may significantly contribute to the genetic variation of their species.

Here are examples of important marine habitats in the Kvarken Archipelago:

- **Hard and stony bottoms outside moraine shores with big boulders, stones and gravel.** The upper part, from 0-0,5 m, is sparsely vegetated, and the deeper parts are mainly dominated by annual filamentous algae *(e.g. Cladophora* spp*)* and benthic diatoms. It is an important breeding habitat for fishes, like the Baltic herring *(Clupea harengus mebras)* and Grayling *(Thymallus thymallus)*. Strong exposure to ice movements limits the number of species that are able to live here.
- **Shallow and vegetated soft bottoms with mud and sludge** are dominated by submerged phanerogams, such as Pondweeds *(Potamogeton* spp.*)*, Water milfoils *(Myriophyllum* spp.*)*, and Stoneworts *(Chara* spp.*)* that often form meadow-like fields. These are important spawning habitats for fish like Perch *(Perca fluviatilis)* and Pike *(Esox lucius)*.

Altered land use management and changes in coastal water quality are some factors threatening these habitats.

See Appendix 3 for more information about the marine ecosystems.

Fresh water ecosystems

The succession from a brackish water ecosystem to a fresh water ecosystem and further into terrestrial ecosystems is a striking example of the landscape transitions that prevail in the Kvarken Archipelago. The main driving force is the land uplift and the decreasing seawater influence.

The succession pathway that results in a freshwater ecosystem starts with a bay, which then is transformed into a flad (lagoon) and then into a gloe, and finally to a glo-lake due to land-uplift (Figure 31). A flad is a shallow bay that is connected to the sea through one or more inlets, but whose ecosystem is increasingly influenced by fresh water. A gloe is a shallow bay closed off from the surrounding sea and affected by seawater only through high sea level events. A glo-lake ecosystem still retains traces of the earlier brackish succession stages even though it is completely cut off from any seawater influence. This geomorphological transition is accompanied by biological changes, and each stage has its own typical plant community. (Munsterhjelm 1989).

The main succession stages from sea to fresh water ecosystem are as follows (Rinkineva and Molander 1997):

- *Shallow sea inlets and bays* are formed between two parallel moraine ridges, oriented along the inland ice flow direction. Moraine ridges at right angles to the ice flow direction form sills, a threshold that gradually will cut off the bay from the surrounding sea. The vegetation is dominated by Fennel pondweed *(Potamogeton pectinatus)*, Brackish water-crowfoot *(Ranunculus baudotii)*, and the Spiked water-milfoil *(Myriophyllum spicatum)*.
- *Flads and gloes* are seldom larger than 10 ha, and not deeper than 1-2 meters. They may freeze solid in the winter, but the limited water volume is rapidly warmed up spring, to the benefit of breeding fishes, frogs and insects. The bottom vegetation of flads and gloes typically occur in zones, from stonewort meadows in deeper (~2 meters) parts, to Holly-leaved naiad *(Najas marina)*, and to the Common reed *(Phragmites australis)* closest to the shoreline.
- The *glo-lakes* are often less productive and the vegetation is dominated by fresh water species like the Ivy-leaved duckweed *(Lemna trisulca)*, Broad-leaved pondweed *(Potamogeton natans)*, and Waterlilies *(Nymphaea alba)*.

All these succession stages are abundant in the Kvarken Archipelago and they represent the Natura 2000 habitat "Coastal lagoons", a priority habitat of the European Habitats Directive.

A number of streams and one large river empty into the sea inside the nominated site. The land uplift forces the stream and river mouths to move continuously outward, and deltas constantly form. The accumulation of organic and non-organic matter transported by the rivers may significantly contribute to the increase in land area. The river mouths are highly productive and diverse and are very important habitats for fish reproduction and migration, like salmonids *(Salmo* spp*)*. (Meriläinen 1989).

The flat and fragmented landscape also allows for numerous lakes and wetlands. Due to the relatively young age of the landscape, few lakes have yet developed into mires. The abundance of small water bodies is especially characteristic for the young forest-dominated landscape on larger islands. Most of the lakes are oligotrophic, rich in humus and algae and fringed with swampy shores dominated by sedges *(Carex* spp.*)* or peat mosses *(Sphagnum* sp*)*.

Figure 31. In the varied moraine landscape the development goes from bays to fladas and glo-lakes. Photos Timo Hissa (1) and Korsholm municipality (2,3) ©.

Figure 32. Narrow brooks connect the gloes with the sea or a flad. In spring, Pike force their way up to ideal spawning habitats. Photo Eero Murtomäki ©.

Terrestrial ecosystems

The succession pathway starts with open seashore meadows dominated by grasses and sedges and continues through an herb-rich stage with grey alder and broad-leaved saplings towards a climax forest dominated by conifers. Low-lying areas and flads often develop into wetlands through a different pathway. In many areas, the succession has been affected by human interaction, though the effects are usually slight.

Seashores

Boulder-rich and stony shores are the most common shore types in the Kvarken Archipelago, while beaches with sand and gravel are relatively rare. On exposed sites the soil layer is thin and a nutrient-rich and thicker soil layer only builds up in more sheltered sites through accumulating organic and non-organic matter. In the outer archipelago, floating plant parts are washed ashore to form decomposing, nutrient-rich banks that have a unique flora type.

All these types of seashores are abundant in the Kvarken Archipelago and they often represent the Natura 2000 habitats: "Perennial vegetation of stony banks", "Boreal Baltic coastal meadows", "Annual vegetation of drift lines" and "Boreal Baltic sand beaches with perennial vegetation".

Depending on the location in the archipelago, the succession of the plant community on seashores and islands is affected to different degrees by the wind, waves, ice, snow, salinity, degree of isolation, and island size.

Shore plant communities occupying the zone between the low and high seawater mark are subjected to intense stress, particularly during the winter when the fluctuating sea levels combined with ice causes heavy abrasion. Erosion caused by pack ice, drifting ice, and ice movements favours annual plant species, as they recolonize exposed patches every year. The endemic Hair-grass, *Deschampsia bottnica,* is well adapted to this habitat (Figure 33).

Figure 33. The endemic Hair-grass is found only along the shores of the Gulf of Bothnia. Photo Hans Hästbacka ©.

The chronological order of a schematic plant succession on islands in the inner archipelago is as follows (Molander 1999, Palomäki 1963, Valovirta 1950):

Altitude (m. a. s. l.)	Years above sea level	Vegetation establishment
< 0,20	< 16	Grasses and sedges: e.g. Slender spike-rush, Sea arrow grass, Creeping bent (*Eleocharis uniglumis, Triglochin maritima, Agrostis stolonifera*).
0,20 – 0,40	16 - 32	Herbs: e.g. perennial Saw-thistle, Tufted vetch (*Sonchus arvensis maritima, Vicia cracca*)
0,35 – 0,60	32 - 48	Nitrogen fixing species and high herbs: e.g. Alder (mainly grey alder), Sea buckthorn, Meadowsweet, Common valerian (*Alnus* spp., *Hippophaë rhamnoides, Filipendula ulmaria, Valeriana officinalis*)
0.60 – 0,80	48 - 64	Broad-leaved trees: e.g. Rowan, Birch (*Sorbus aucuparia, Betula* spp.)
> 0,80	> 64	Coniferous trees: e.g. Spruce (*Picea abies*)

In the inner archipelago, reed is common and the accumulation of organic matter favours the development of heavy reed thickets that can out-compete other species.

In the outer archipelago, the establishment of broad-leaved trees is hindered by the large distances between seed sources on the mainland and by the fierce storms occurring regularly during the autumn and winter seasons.

Forest ecosystems

There are mainly two types of forest stages. Grey alder mainly dominates the deciduous stage, which is prevalent during the early succession stages. The later spruce-dominated stage usually develops into a climax stage (Svensson and Jeglum 2000). In the transition between the two stages, rowan, birch, and aspen may occur in a mixture with spruce (Figure 35). Pine occurs sparsely, but is more common in the northeast parts of the area. A more or less continuous belt of alder is the most characteristic feature along the shores of the Kvarken Archipelago site.

Owing to the favourable climate in the Bothnian region spruce communities are fairly productive. A well-stocked, old-growth Norway spruce forest can develop within a short ecological time, two to three centuries (Svensson 1998). Despite the fact that the forests are relatively young, some have developed features characteristic of old-growth, such as considerable amounts of coarse smags and fallen logs, uneven-aged and uneven-sized structures, and sometimes rare and threatened species (Suomi et al 1997).

All these succession stages are abundant in the Kvarken Archipelago, and they represent the Natura 2000 habitat "Natural forest of primary succession stages of land upheaval coast", a priority habitat of the European Habitats Directive.

Coastal birch forests, similar to the alpine birch forests, are common and typical on islands in the outer archipelago. Rowan and large old aspen trees can also be found on the same islands. The dominance and abundance of birch can be explained by the climate, which limits spruce growth, but also to some extent by human impact. In earlier days, selective cutting was used to improve grazing for cattle, horses, and sheep and this has favoured the birch as it occurs in the early succession stages.

Humans have influenced the forests of the Kvarken Archipelago throughout its history, with the impact decreasing towards the outer archipelago. Many forests have been used for firewood and construction woodcuttings, but succession stages from virgin primary forests to old spruce forest can still be found. Despite the young geologic and ecological age of the Kvarken Archipelago, there are forests with typical attributes of old-growth forests, such as multi-

Figure 34. Typical forest succession in the Kvarken Archipelago (Slåttskäret) with a belt of Alder along the shore and Spruce in the central part of the island. Photo Korsholm municipality ©.

Figure 35. The Alder belt is often followed by a flourishing birch and rowan forest. Photo Tuukka Pahtamaa ©.

layered structures, regeneration gaps and plenty of dead wood. Many rare and threatened species live in these forests, particularly on the islands of Lappören and Björköby.

Wetland ecosystems

The flat landscape provides excellent conditions for wetland development. The succession in shallow bays and lowlands can progress towards wetlands in three different ways. First, terrestrialization (overgrowth) of inlets under decreasing moisture conditions will lead to swamps or swamp forests. Second, paludification occurs when the succession proceeds along a gradient of increasing moisture and when peatland forming species *(e.g. Sphagnum* sp. and *Polytrichum* sp.*)* first colonise and then maintain the wet conditions (Figure 36). Third, primary wetland formation takes place when peat-forming species become established directly on the newly exposed shore surface. All three processes are represented at the nominated site.

Due to the short geologic and ecological history of the archipelago, the bogs have rarely had the time to develop. A few upland oligotrophic bogs have already formed, though the rich and deciduous forest swamps are much more common. The wetlands are initially mesotrophic and become more nutrient-poor with increasing age and altitude.

The wetlands of the Kvarken Archipelago are influenced by the accumulation of organic matter, land uplift, variations in the sea level, and erosion by ice and water. Interactions between these processes create heterogeneous environments and habitat diversity, from young sedge-dominated shore swamps to complex mires and bogs.

Peat mosses *(Sphagnum* spp.*)* are the dominant species in wetland habitats. Other typical wetland plants include various sedges, like Bottle sedge *(Carex rostrata)*, White sedge *(C. canescens)*, Common bog-sedge *(C. limosa)*, Tall bog-sedge *(C. magellanica)*, as well as Marsh cinquefoil *(Potentilla palustris)*, Common cotton-grass *(Eriophorum angustifolium)*, Bogbean *(Menyanthes trifoliata)*, and Cranberry *(Vaccinium oxycoccus)*.

Hay-field and pasture land

Pasture grazing and haymaking were common until the 1950's and animals were transported by boat to larger islands and fenced off peninsulas. Even today, more than 1000 ha are still grazed by sheep in the Kvarken Archipelago. Coastal meadows and wetlands have been very important hayfields. To increase the production of hay, coastal mixed forests in the upper part of the alder belt were frequently partially cut down to create forest meadows.

Humans have also influenced the coastal landscape by burning moors to improve grazing conditions. One type of slash and burn technique has been practised until recently on some islands, like Björkögrunden until the beginning of the 1990's, while Sondasören in the Björköby archipelago was burned in 2000 (Figure 38).

Figure 36. A typical glo-lake with peat-forming species along the shore. Photo Hans Hästbacka ©.

Figure 37. Hundreds of years of pasturage have affected the vegetation, but nowadays there is only a hand-full of sheep farmers left in the archipelago. Photo Lise-Lotte Molander ©.

Figure 38. Burning is an effective method to get rid of Junipers and to favour grasses, herbs and berries. Photo Leena Rinkineva-Kantola ©.

Species of ecological interest

Several species in the Kvarken Archipelago are relicts or remnants from the glacial and postglacial periods. Others have evolved in, and are unique to, the Baltic in response to the land uplift processes, or are at their northern limit of distribution.

There are about 15 shoreline species in the Kvarken Archipelago that originate from the Barent Sea and the White Sea *(e.g. Potamogeton vaginatus)*, and the most important species of the water ecosystem are glacial relicts from the White Sea, like the isopod *Saduria entomon* (Figure 39), and the amphipod *Monoporeia affinis*. These glacial relicts have not had any genetic exchange with the populations along the Russian Arctic Sea coast in a very long time. (Ericson and Wallentinus 1979).

The occurrence of endemic species in the Kvarken Archipelago reflects the evolutionary process resulting from land uplift and variations in sea level. Endemic species of the terrestrial Fennoscandian flora occur mainly in the Fennoscandian mountain range and on the shores of the Baltic Sea. There are 24 endemic taxa restricted to the shores, of which 16 are found in the Kvarken Archipelago (e.g. the Hair-grass *Deschampsia bottnica*, and the Eye-bright *Euphrasia bottnica)*.

As a result of the salinity gradient, prevailing currents and the mild climate, many southern plants and animals are at their northern limit of distribution in the Kvarken area, like the Beaked tasselweed *(Ruppia maritima)*, Dwarf spike-rush *(Eleocharis parvula)*, Bladder wrack *(Fucus*

Figure 39. The brackish water isopod is one of the most common bottom dwelling animals in the Kvarken Archipelago. Photo Curt Nyman ©.

vesiculosa), Baltic clam *(Macoma baltica)*, Common mussel *(Mytilus edulis),* and Barnacle *(Balanus improvisus).* The barnacle is a brackish water species that originates from the Sarmantic Sea, which covered southwestern Europe and western Asia 3 - 20 million years ago.

The old forests in the Kvarken Archipelago are important habitats for some rare and threatened species, such as *Phellinus populicola, Ramalina roesleri* and *Clavicorona pyxidata.*

See Appendix 4 for a more comprehensive list of important species.

Birds and mammals

The Kvarken Archipelago offers excellent breeding habitats for sea birds. The strait is also the most constricted part of the Baltic Sea and serves as an important migratory route for birds on their way to the breeding areas in the Scandinavian Mountains.

The Black guillemot *(Cepphus grylle)* (Figure 40) and the Razorbill *(Alca torda)* are characteristic species of the outer archipelago. A significant portion of the Baltic Sea populations of these two species breed at the nominated site (6000 pairs or one fourth of the population for the Black Guillemot and 1000 pairs or one tenth of the Razorbill population). Among the birds listed in the European Birds Directive, the Caspian tern *(Sterna caspia),* the Arctic tern *(Sterna paradisea)*, the White-tailed eagle (*Haliaetus albicilla)*, and the Osprey *(Pandion haliaetus)* all breed in the area.

About 300 000 to 400 000 birds migrate across the nominated site each year, among them 2000 Rough-legged buzzards (*Buteo lagopus*) migrating to their breeding-grounds in the Fennoscandian mountains. Thousands of migrating cranes rest and feed in the fields of the former meteorite crater at Söderfjärden.

Two species of marine mammals live in the Kvarken Archipelago, the Grey seal *(Halichoerus grypus)* and the Ringed seal *(Phoca hispida)* (Figure 41). Both are included in the European Habitats Directive. Grey seals inhabit islets throughout the area, whereas the Ringed seal mostly exists in the northern parts because its main population inhabits the Bothnian Bay. Both species breed on the ice in early spring.

Figure 40. One fourth of the Baltic Sea population of Black Guillemot breeds in the Kvarken Archipelago. Photo Juhani Koivusaari ©.

Figure 41. The Ringed seal population has slowly recovered from the depression during the 1950s, which was caused by toxic substances (DDT, DDE and PCB). Photo Metsähallitus ©.

Figure 42. A long time ago, a giant boy played in the Kvarken area. He filled his hands with stones from the Swedish side and dropped them all over the Finnish side of the archipelago. That's why the Swedish High Coast became deep and free of stones and the Kvarken Archipelago filled with islands and shoals. Drawing by Liselott Nyström, 2003.

3.b Culture history

Introduction

Our concept of "Finland's face" is due to Zachris Topelius, the 19th century man of letters, who also planted the image of "the daughter of the Baltic Sea" in our minds. It is less known that he also found an analogy between the Greek Goddess of Love and the brave Maid of Finland – they both originated from the sea:

> *"Finland has risen, like Aphrodite in ancient times, from the embrace of the sea. There was a time when the Baltic Sea was a bay of the Arctic Ocean, its waves and icebergs were then rolling high above our firm land in this remote corner of Europe. The walrus stretched its formless body; the innumerable flights of arctic birds traced their ways through the hazes over this inhospitable sea. Only the summits of the Scandinavian mountain ridges rose above the void open sea...*
>
> *On both coasts of the Gulf of Bothnia people have long known the strange phenomenon of the sea gradually fleeing from the shores. Where once ships sailed there a boat can hardly move nowadays; where a fisher in his youth rowed to his nets there we see now his cattle grazing at a green seashore meadow. Reefs and shallows are rising up at places where before there was nothing ... islands grow into each other and join together to form mainland. .... New soil is coming up from the sea for every generation, and every century bestows a new principality to Finland.* (Topelius 1873, 4-5).

The first reefs emerged from the sea about 2000 years ago and people started to settle in the area a thousand years later. Humans have not only left behind many cultural tracks in the archipelago, but also adapted their living to nature. For example, seal hunting and fishing, as well as farming, have left their imprints on the landscape. These activities are on-going there, although to a much lesser extent and summer guests have mostly replaced the permanent inhabitants.

The Kvarken Archipelago is one of the National Landscapes in Finland, reflecting the origin of the culture and the landscape development (Putkonen 2001).

Ancient remains

During the Middle Ages, humans moved between islands in the Kvarken Archipelago, but permanent settlement was only established in areas with cultivable seashores exposed by land uplift. Permanent settlements were possible at some places during the Middle Ages, possibly in the 13th century, but the islands of Mickelsörarna were not inhabited until the 19th century. Pieces of jewellery dating back to the Viking Age are the oldest objects found in the area, for example, close to cultivated fields on Replot (Risla 2000). Younger period jewellery has been found together with harbour constructions on land that has emerged from the sea.

The Kvarken Archipelago is an open-air museum filled with tracks from human activities of various periods. Simple

Figure 43. Ancient remains in the Kvarken Archipelago. After the last Ice Age, the entire province of Ostrobothnia remained below sea level (except the Lauhanvuori mountain at 231 m. a. s. l), until the Earth's crust started to rebound. According to ancient remains, maritime hunting and fishing has been practised since the early Stone Age in Ostrobothnia. Finds of elk bone harpoons together with seal bones bear witness to seal hunting along the coast (Edgren 1998). National Land Survey of Finland, permit nr 7/MYY/04. Layout Päivi Anttila.

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Figure 44. Ancient remains at Mickelsörarna: 1. Field-labyrinth 2. Net-drying cairns 3. Compass rose 4. Navigation cairns 5. Hunting shelter 6. Russian owen 7. Small harbour. Photos Ostrobothnian Museum ©.

accommodations were made on the stony island shores and the foundations are still visible as areas of levelled out ground, enclosed by a stonewall, or made close to a rock. Some kind of roof covered the top, probably using a sailcloth. Later, fishermen replaced these shelters with small wooden cabins.

In addition to shelters, other stone constructions for different purposes are abundant in the archipelago, like field-labyrinths, so called Russian ovens, and compass roses. Compass roses are stone rows laid out as a cross to indicate the cardinal points. Net drying cairns, walls, small harbours, navigation cairns and beacons are other examples (Figure 44). Even temporary food storing pits used by hunters are still visible in this stony landscape.

Seal hunting

Archaeological finds confirm that seal hunting took place in Finland during the Stone Age, and has continued to be an important means of livelihood until recently. The first written proof of seal hunting in the province of Ostrobothnia is from the year 1335. The seals were hunted along the coast by inhabitants of the coast and archipelago and by inland farmers who had usufructs at the coast (Vuorela 1983).

Spears, nets and guns were the most common hunting tools or devices. The net was only used in the autumn and this practice ceased in the middle of the 19th century. Guns were introduced in the 16th century and became common in the 18th century.

During the long hunting journeys in late winter, a special boat or "fälbåt", was used, which also served as simple place to live in (Figure 45). It was 8 m long, 2.5 m wide, and included a mast. A boat-team consisted of 5-8 men, including a skipper and a cook and several boat-teams often joined the hunting journeys. These journeys lasted for many weeks, sometimes for more than three months. The seal oil, meat and fur were taken care of, and together with a bounty, the hunting income was considerable.

Due to low demand for seal oil and a decreasing number of seals, seal hunting diminished in the middle of the 1960's. The grey seal was protected from hunting in the 1970´s, but nowadays hunting has started again on a small scale.

Figure 45. Seal hunting took place under harsh conditions, which demanded both courage and patience from the hunters. Photos Ostrobothnian museum ©.

Figure 46. Baltic herring fishery at Replot in the 1960´s. The baltic herring was once one of the most important fish species for human consumption, but today it is mainly used for animal-food production. Photo Pentti Paschinsky ©.

From small scale fishing to trawling

During the 16th and 17th centuries, everyone was allowed to fish for Baltic herring in the sea, as long as they paid a sixth of the catch to the Crown. A decrease in herring fishing was noticed in the 17th and 18th centuries and fishing places were abandoned, due to the land uplift. During the years of famine in the 19th century, fishing increased and became the livelihood of non-landowners. These fishermen rented fishing grounds from the farmers and founded a branch of professional fishermen.

Figure 47. Fisherman from Björöby attach stone weights to the nets. Photo Ostrobothnian Museum ©.

Fishing grounds were divided between the different fishing teams in a village. The farmers of the village together built several fishing cottages that were used in turn by the fishing teams. Fishing cottages were built by farmers from Replot, Björköby, Bergö and the mainland (Smeds 1935, Andersson 1937). Very few original fishing huts are left and the fishing villages that were in common use in the beginning of the 20th century have almost disappeared. Sometimes, the fishing cottages were moved to new places as the fishing-grounds changed. Nowadays, about ten fishing cottages are in use by fishermen. Some have been changed into summer cottages, but most of them have decayed.

The importance of fishing has decreased drastically in the Kvarken Archipelago during the last decades, but almost every village still has one fishing harbour. Today, the Baltic herring is trawled and the whitefish and salmon have become commercial fish species.

Figure 48. Remains of an old fishing village at Rönnskären. Photo Society of Swedish Literature ©.

Figure 49. The fishing village at Norrskär is still used by a few fishermen, but most of the old fishing cottages serve as summer houses. Photo Korsholm municipality ©.

Figure 50. The grazing season is over and sheep are brought back home from the outer archipelago. The Village of Björköby 1952. Photo Ostrobothnian museum ©.

Farming

Farming has not been as important a livelihood compared to fishing. Many islands are barren and hard work is needed to transform them into a cultivable condition. The first information about the cultivated areas at Vallgrund on Replot and on Björköby is from 1557 (Åkerlund 1958).

Pastures and hay-fields were abundant in the Kvarken Archipelago. The hay was stored in barns on islands in the outer archipelago and transported home during the winter. The sheep were transported to graze on the islands in early summer and traditionally brought back on "sheep day", in the beginning of October. Until 1970, horses and sheep were released in the summer time for free grazing around the villages of Replot and Björköby (Westergård 1996).

An island summer pasture system with chalets was in practice in the province of Ostrobothnia at the end of the 19th century. Women who lived in huts on the islands during the summer took care of the animals and processed the milk into butter and cheese. This system ended in the late 1960's and many of the huts are now summer cottages.

The culture landscape

Nature, the sea, and terrain features have strongly influenced the structures of the villages. Log houses with one or two floors characterize the culture landscape of Replot, Björköby, and Bergö. The houses have ridge roofs and vertical boarding and are painted red or yellow. The oldest houses date back to the 18th century. Life and nature

Figure 51. Today there more than 600 summer cottages in the Kvarken Archipelago. Photo Metsähallitus ©.

in the Kvarken Archipelago have been described by European explorers like Guiseppi Acerbi and Edward Clarke, a teacher at Cambridge who visited the area in 1799 (Luukko 1979).

The villages were generally built close to a good harbour and the houses were placed in groups or rows along roads and bays. Smokehouses for fish smoking were built in the archipelago. In connection with the great redistribution of land holdings in the middle of the 19th century, the houses were moved from the village core to the private fields in the surroundings.

The village of Björköby has probably been inhabited since the 14th century. It is mentioned for the first time in a written source from 1510 in connection with a land purchase 40 years earlier (Dahlström 1996). The main part of the village is built on De Geer moraines. Over the centuries, the village has been isolated at times and the centre of lively activity other times. Oarsmen from Björköby periodically operated the postal services and also to some extent the passenger traffic between Finland and Sweden.

The first inhabitants of Replot and Vallgrund are assumed to have settled in the 14th century. The oldest farm of Replot dates back to 1544 and 15 farmers lived in the village in 1557. The name "Vallgrund" is mentioned for the first time in 1407 in connection with a land purchase and therefore the village is assumed to be of older origin.

The village of Bergö, formerly named Wargö, was an annex parish to Malax and an independent municipality until 1973 when it was integrated into the Malax municipality. Fourty-eight people inhabited Bergö in 1548 and they maintained themselves on farming, fishing, and seal hunting. The culture, landscape and buildings partly resembled the villages on Replot.

Other characteristic wooden buildings are the churches, meeting chapels, schools, cabins and boathouses. The church at Replot was completed in 1781 and the wooden long church at Björköby in 1859. The wooden church on Bergö was completed in 1802. For a long period, these churches were the only painted buildings in the villages.

In the late 18th century, civil servants built the first large summer cottages. The large summer cottages offered places of work for the inhabitants, particularly in the summer. From the beginning of the 20th century, an increasing number of summer cottages have been built along the seashores of the Kvarken Archipelago.

Trade and shipping in dangerous waters

Between the 14th-17th centuries, the surroundings of the present City of Vaasa were the most important trading centre in the Gulf of Bothnia. Korsholm was the metropolis in the 14th century, and later the City of Vaasa, founded in 1606. The most important export commodities were train oil (1300-1600), fish, butter, timber, furs and hides.

Sailing and rowing boats have always brought the inhabitants together on the islands of the Kvarken Archipelago. The official traffic across the Northern Kvarken increased during the 17th century and a guesthouse was built at Björköby. The postal services, which delivered post by boat, began in the 17th century in the Kvarken area and continued until 1895. This tradition was revived 1982 and once a year "The Post Row" takes place between the islands of Björköby and Holmön (on the Swedish side).

The large number of wars during the period of greatness of the Kingdom of Sweden-Finland (1600-1700) drained the

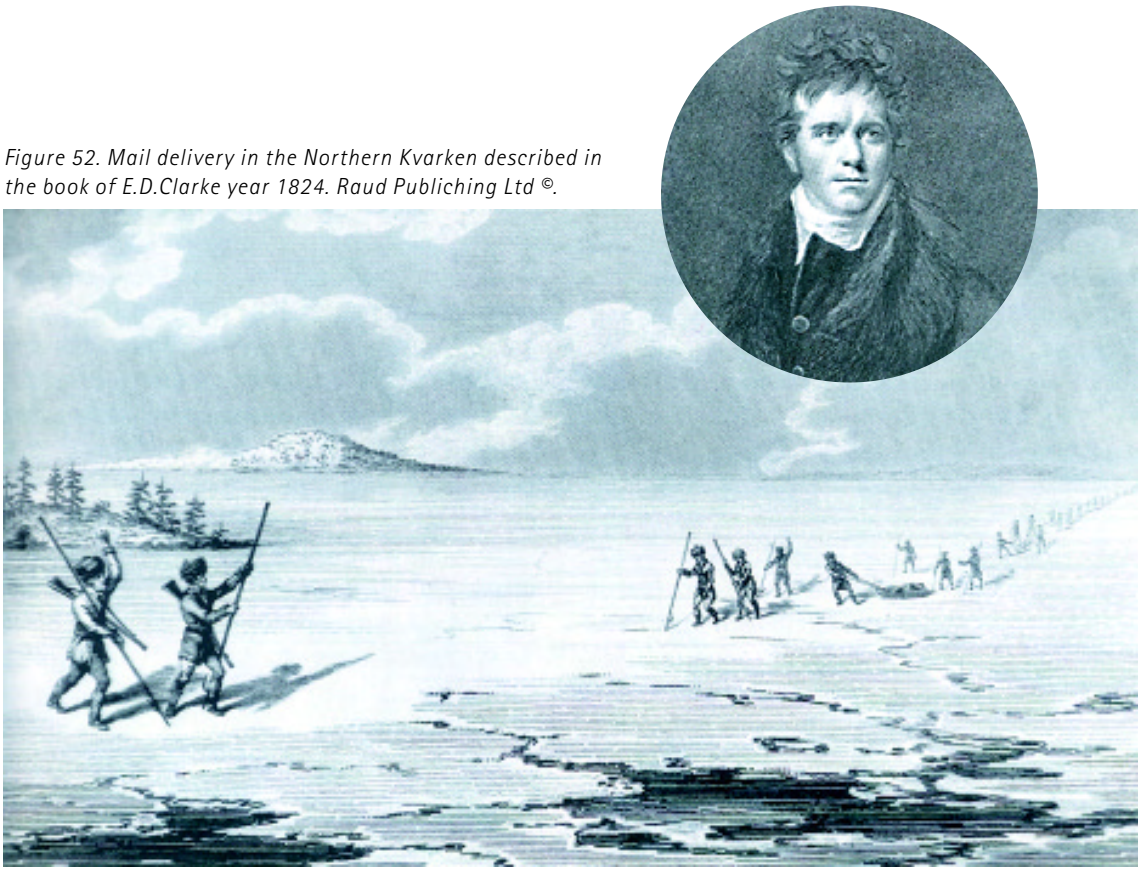


Figure 52. Mail delivery in the Northern Kvarken described in the book of E.D.Clarke year 1824. Raud Publiching Ltd ©.

welfare in the Kvarken area. The Great Northern War left behind many wrecks from the Russian galley fleet and along with simple stone ovens, so called "Russian ovens" (Figure 44), which were used for cooking and baking (Westergård 1996).

The number of citizens increased in towns around the Kvarken area and trade and shipping flourished in the late 18th century. Abraham Falander, a merchant in Vaasa, had a frigate built at the Svartö shipyard in 1786 (Figure 53). The frigate was one of the largest in the Nordic countries at that time. (Luukko 1979).

As a result of the Swedish-Russian War (1808-1809), Finland, including the eastern part of the Kvarken area, was integrated into Russia. This did not, however, prevent further contacts with the Swedish side. In winter 1809, the Russians attacked the Swedish city of Umeå to speed up the peace negotiations. In March 1809, 3000 men were led over the ice by General Mikhail Barclay de Tolly. Many Russian soldiers froze to death during this march, and some of them are buried on the island of Valsörarna (Karlsson 1996). It is told that de Tolly said "I have marked the way to Umeå with the bones of my soldiers" (Figure 54).

War raged in the area again just half a century later. The English warships Hecla and Firefly sailed to the Kvarken area during the Crimean War (1853-1856), and 10 ships from Vaasa were captured or destroyed along with some buildings in Palosaari.

Before the independence of Finland from Russia in 1917, independence activists travelled across the Northern Kvarken on ice, and further to Germany to be trained as soldiers. They returned and formed the core of the legal government army during the 1918 Civil War in Finland. Later on, at the beginning of the Second World War and during the Finnish-Soviet Winter War (1939-1940), the winter road over the Kvarken area was used again to transport relief consignments from Sweden to Finland. About 2000 lorry loads are said to have crossed the Northern Kvarken (Orre 1996).

The steamboat traffic between Finland and Sweden started in the mid-1800's and the first ocean shipping company in Finland was established in Vaasa in 1873. Regular passenger traffic from the larger islands in Kvarken Archipelago to Vaasa started in the beginning of the 20th century, where people went to work and to sell their products. A permanent ferry connection between Replot and the mainland was established in 1952 and in 1997, the ferry was replaced by a bridge, the longest in Finland. The ferry to Bergö opened in 1962.

Many shipping companies have sailed within the Kvarken area and employed area inhabitants. Year round traffic started in 1972 and the number of passengers increased until 1999 when Silja Line closed down, due to low profits. The companies RG-line and Bothnia Link opened regular passenger traffic in 2001.

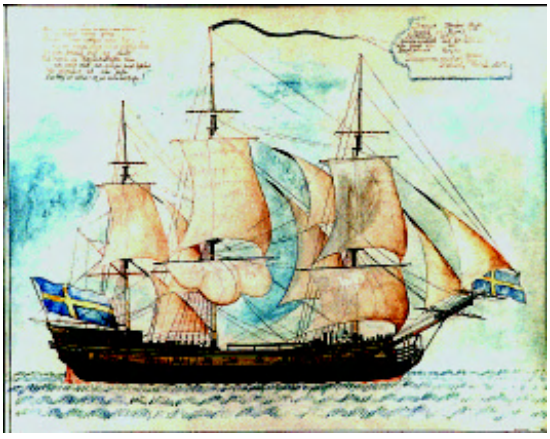


Figure 53. The name of the frigate was "Allmänt Bästa = the Best One", built in Vaasa in 1786. Photo Ostrobothnian museum ©.

Figure 54. Crimean war. General Barclay de Tolly and his army crossed the Northern Kvarken in March 1809. Painting by Kotzebue. Matti Ruotsalainen ©.

Figure 55. The English warship "Firefly" attacks the town of Vaasa during the Crimean war. Ostrobothnian museum ©.

"The water reduction"

In the 17th century, land uplift had confused the academics in Finland. In a collection of sermons from 1821, the Bishop Erivus Erici wrote: "in some places the water has sunk down to a lower level and stones and shoals that earlier had been beneath water, and of which no one has known about, now are visible high above the water level; and where it was water before there are meadows now". The Swede Urban Hjärne concluded that this "Water reduction" was due to sea currents that enlarged the Danish straits. Since more water flowed into the North Sea when the strait was enlarged, the seawater in the Baltic Sea decreased. Emmanuel Swedenborg, on the other hand, literally believed in the Holy Bible story about the Flood. According to the story, water was decreasing everywhere. Carl von Linné and Anders Celsius investigated the phenomenon in the 18th century. Celsius wrote: " The fishermen on the low land shores of the Ostrobothnia have to find new fishing places every 30 years and three times within a period of 60 years move their houses nearer the shore." Chydenius made several calculations and measurements in the Kvarken area (Bonns 2001, Peltola 2002). Water level marks were cut into rocks and boulders to follow the phenomenon. One such water level mark is found in the southern part of the Bergö. It reads: "v. 1775 Erik Klingius, v. 1890".

E. O. Runeberg, the chief of the National Land Survey of Finland, first introduced the concept of "land uplift". He put forward the theory that the phenomenon was not caused by a water reduction, but by the emergence of land from the water. Runeberg based his investigation on old maps from different parts of the Bothnian Bay. In the 19th century, several publications put forward the glacio-isostatic explanation of the land uplift phenomenon (Palomäki 1987).

Figure 56. Water level marks at Strömmingsbådan. Without modern scientific methods this was the only way to measure land uplift. Photo Hans Hästbacka ©.

Figure 57. Lighthouses and beacons in the Kvarken Archipelago. National Land Survey of Finland, permit nr 7/MYY/04. Layout Päivi Anttila.

Day beacons and light houses in the archipelago of shipwrecks

The shallow archipelago and the land uplift make navigation in Northern Kvarken dangerous. The Kvarken Archipelago is usually called the archipelago of shipwrecks since several hundreds of ships foundered here during the sailing ship era. The waters around the many islands of Bergögaddarna were feared during the Swedish empire and are mentioned as "the graveyard of ships" (Laurell 1989).

According to the principle that what the sea gives is mine, people often plundered ships that had sailed aground. The goods were often valuable and people took advantage of these ships. They took care of the cargo, hid it and maybe sold it further. Shipwreck plundering was criminalized during the Holy Crusades in 1110, but continued until the 19th century in the Kvarken Archipelago. Smuggling started in the 17th century and became rather extensive, particularly during the period of prohibition. The type of smuggled goods changed during the centuries, from salt, tobacco, alcohol, scissors, to cars.

Due to the many shipwreck incidents, fairways were marked early on with cairns and day beacons and the shoals with buoys. The first known lighthouse in Ostrobothnia was the "vippbåk" of Molpehällorna (Figure 58). It was a primitive lighthouse construction with a tall wooden rocker arm and topped with a fire. It was built at the end of the 17th century along the dangerous but important sailing route to Old Vaasa. All merchants from adjacent towns contributed to construction costs (Luukko 1971).

The worst shipwreck in Finland during times of peace occurred in the archipelago of Rönnskär, in October 22, 1913. The SS Vestkusten was destroyed and 34 people drowned and only one was rescued (Lintala 1987). Shipwrecks and strandings have also happened as late as the end of the 20th century.

From an international perspective, the preserved day beacons in Finland and the Gulf of Bothnia in particular, are interesting buildings that have disappeared elsewhere. An exceptionally large number of historical day beacons have been preserved along the coast of the Bothnian Bay (Nyman 2001).

In 1784, merchants from Vaasa built the oldest remaining wooden day beacon and pilot station on Fäliskär, in the archipelago of Rönnskär.

The first lightship in Finland, the Snipan (later Qvarken) served the Kvarken area from 1868 and was replaced by the lighthouse on Utgrynnan in 1960. Three lightships operated in the area until 1960. The Vaasa lighthouse at Korsögrundet was completed in 1981 (Laurell 1999). The sector lights of Nikolai and Edvard, Sundom, were constructed during the Russian period. Other navigation aids worth mentioning are the beacons at Norrgrynnan (1882), Rönnbuskö (1885), Tummelsön (1859), and the lighthouse on Korsören, south of the present pilot station at Vallgrund (Söderholm 2001).

The most important lighthouse in the area is on Norrskär (1848). The lighthouse guides ships into the Northern Kvarken and to the fairways towards Vaasa, and is called the Eye of Vaasa, or the Gate of Vaasa. The island of Strömmingsbådan built a lighthouse in 1885 and the beacon on Ritgrund (1863) is the only beacon in Finland that has been reconstructed into a lighthouse. The beacon on Ensten (1887) replaced a 9 m high mast from 1858. The lighthouse of Valsörarna is a frame construction, designed and built by the Henry Lepaute factory in France (Figure 59 and 80). The lighthouse is 38.4 m high and was completed in 1886, a few years before the same factory built the Eiffel Tower in Paris probably Lepaute´s most famous work (Laurell 1999).

Figure 58. The "vippbåk" of Molpehällorna served as a big torch, leading ships on a safer sailing route to Old Vaasa. Drawing by Lise-lott Nyström.

Figure 59. Visitors to Valsörarna can follw a nature path, locally called "the love trail", to the famous lighthouse. Photo Tuija Warén ©.

Tar boiling, ship building and other industrial activities

Tar boiling and timber export were significant sources of income for the farmers in the area during the 17th century. Shipbuilding was also important for the economy until the 1920's. There were shipyards in Vaasa, Södra Vallgrund on Replot and at Björköby. The production of saltpetre produced extra money for the archipelago inhabitants. Tar boiling increased the trade considerably between the towns of Vaasa and Umeå.

The pitch factory in Vaasa was established in 1647 by merchants with Finnish, German and Scottish backgrounds and was the first industry in the Kvarken area. The tar trade flourished and tar was exported to Sweden, England and the rest of Europe.

The ship owner Johan Grönberg founded a glass factory in 1812 in Iskmo, Korsholm. The location was excellent since there was a good harbour for the import of raw material and export of products. The Grönvik factory became the largest and most modern producer of window glass in the Nordic countries (Annala 1946).

From the late 1850's, granite was quarried on Rödgrynnorna, between Mickelsörarna and Björköby, to be used in various buildings in the new town of Vaasa, like the church, court of appeal, and Hartman's tradepalace (Ojaharju 1988).

The industry of the Kvarken area is still strongly connected to maritime businesses such as fish net production, boat building and fish processing. At the end of the 20th century, almost one third of the working population was occupied with fishing or farming, and one third with industrial or construction work. Professions such as pilot and lighthouse keeper were passed from fathers to sons in older days. About 2000 people live in the Kvarken Archipelago, of which 40 % are in service occupations.

Mythology and folklore in the Kvarken Archipelago

From the beginning to the end of the 19th century, a sea monster was observed in Northern Kvarken by many, including the chief lighthouse keeper on Norrskär, some fishermen and their wives and the County Sheriff of Replot. The County Sheriff of Replot, who had seen the monster most frequently, gave it the name of "Confusarius Maris Baltici" – the Monster of the Baltic Sea. The monster was reported to the County Governor of Vaasa and to the Fishery Inspector in Helsinki many times by the County Sheriff of Replot.

Figure 60. The sea monster as illustrated in the magazine "Suomen kuvalehti" 1932.

Snapshots of the Kvarken Archipelago history:

**) The harbour of Vaasa is moved closer to the sea, due to the effects of land uplift*

1800-1600 B.C.	Traces of human activity on the Öjbergsgrynnan. The charcoal is dated 3500 years later.
200- 100	A hunter/fisherman builds a temporary, stone enclosed shelter at the Djupskärsbacken in Sundom.
150 A.D.	A merchant drops Roman coins on an islet in the area of Old Vaasa, i.e. Kapellbacken.
1000	A clasp from the Viking Age is dropped in the area of the present Södra Vallgrund.
1249	According to legends, Birger Jarl, Regent of Sweden, disembarks in the Old Vaasa area.
1348	Permanent settlements established in the village of Mussor.
1360-1370	The Mussor harbour is built at Krytzeborgs Castle (the first harbour of Old Vaasa). Later the name was changed to Korsholms castle.
1407	Vallgrund is mentioned for the first time in a written source.
1500	Replot and Wargö (Bergö) are mentioned for the first time.
1510	Björköby is mentioned for the first time in a written source in connection with a land purchase.
1596-1597	The Klubbe War, the last peasant rebellion of importance in Scandinavia.
1600	The postal services begin around the Northern Kvarken and continue regularly until 1895.
1606	Karl IX founds the town of Vaasa which was named "Mustasari stadh" The name of the city changed to Vaasa in 1611.
**)* 1630	Vaasa gets a new harbour at Hästholmen. The old one (1,5 km east) had silted up due to the land uplift.
1650	The "Vippbåken" a kind of a seamark on Molpe, was built to make ship trading secure.

1655	Louis Henri Loménie de Brenne travels across the Northern Kvarken in wintertime and describes the journey in his travel book.
1700-1721	The Great Northern War. The merchant fleet of Vaasa was burned.
1752	The pilot station on Rönnskär is established.
1776	The first ships sail from Vaasa to Lübeck.
1781	The church at Replot is completed.
1784	Merchants of Vaasa build the oldest remaining wooden day beacon and pilot station in Finland on Fäliskär, under the supervision of Abraham Falander.
*) 1785	Vaasa gets a new harbour at Brändö. The harbour at Hästholmen had silted up.
1802	The wooden church at Bergö is completed.
1808-1809	The Swedish-Russian war. Finland is ceded to Russia and gains autonomy. The Russian General Barclay de Tolly marches across the Kvarken Archipelago with 3000 men in March 1809. Many soldiers freeze to death.
1840	Regular boat traffic in the Northern Kvarken starts.
1846	The lighthouse on Norrskär is completed. It was lit in 1848.
1849	The pilot district of Ostrobothnia is founded.
*) 1852	The town of Vaasa is destroyed by fire. The new town is built on Klemetsö, to providea better harbour area, as the former is shallow and unusable. The town opened in 1862.
1853-1856	The Crimean War. Some battles took place in the Northern Kvarken.
1859	The wooden long-church at Björköby was completed.
1868	The first lightship of Finland, the Snipan (later Qvarken) begins to operate in the Kvarken area.
1874	The SS Gustaf Wasa opens boat services from Vaasa to Härnösand and Sundsvall.
1886	The lighthouse on Valsörarna is ready for use. It was built by the Henry Lepautes factory, some years before the Eiffel Tower.
*) 1893	A new deep harbour is constructed on Vasklot, Vaasa.
1913	The passenger ship SS Vestkusten goes down at Rönnskär and 34 people drown
1917	Finland becomes independent.
1918	The Finnish Civil War.
1921	The pilot station on Norrskärs is established.
1939	The Winter War breaks out. Soviet bombers travel via the Kvarken area to bomb Vaasa, and the Norrskär lighthouse is used as landmark.
1939-1940	During the Second World War and at the beginning of the Finnish Winter War (1939-1940), the ice road across the Northern Kvarken was used to transport relief consignments from Sweden to Finland. About 2000 lorry loads were delivered.
1944	The Continuation War ends.
1952	Ferry service opens between Replot and the mainland.
1954	A road connection between Björköby and Replot is established.
1966	The new pilot station on Rönnskär is completed.
1972	Passenger traffic opens all year around.
1984	The Finnish freighter m/s Eira runs aground and causes a large oil spill.
1997	The Replot bridge; the longest in Finland opens.
2002	Terranova, the Nature Center of the Kvarken Archipelago was opened in the Ostrobothnian museum, Vaasa.

State of Conservation of the Site 4.

4.a Present state of conservation

The Finnish government adopted legislation regarding various Nature Conservation Programmes during the 1970-1990´s. The Natura 2000 Network is a joint network of bird protection areas and valuable habitats within the European Union. The main part of the Kvarken Archipelago is included in Nature Conservation Programmes and the Natura 2000 Network (Figure 62 and 63). The Finnish government has approved a financing programme, under which all conservation programmes and the Natura 2000 Network are to be realized no later than 2007.

The realization of Natura 2000 and the Nature Conservation Programmes implies that the environmental authorities will negotiate with landowners regarding the implementation of the nature conservation. Nature conservation areas are either purchased by the state, or remain privately owned. At present, one third of the Kvarken Archipelago land area is protected in one way or another. The process of establishing conservation areas takes several years and requires statutory regulation for each conservation area.

A decision about state and privately owned conservation areas includes usufruct restrictions. All activities that significantly threaten the conservation status are prohibited. It is, however, generally allowed to visit the areas, collect berries and mushrooms, and to fish and hunt. It is prohibited to visit some parts of the Kvarken Archipelago during the bird breeding period. Today, 26 500 ha of land and sea areas are within nature conservation areas, which ensures very good protection for the geologic and ecological values.

About 52% of the total area of the Kvarken Archipelago is not included in Nature Conservation Programmes. These are mainly sea areas administered by the Finnish Government, but also some land associated with the villages on Replot and Björköby. There are no plans to include these areas in Nature Conservation Programmes or the Natura 2000 Network. The geologic and ecological status is guaranteed by legislation that demands permits or consultations for all activities that affect the natural environment, like building or exploitation of gravel.

Figure 61. Left: A Grey seal protection area (Snipan-Medelkallan, 3259 ha), is situated in the outer part of the Kvarken Archipelago. Hunting, fishing and boating are generally prohibited in the area. Photo Metsähallitus ©.

Nature Conservation Programmes and Decisions in the Kvarken Archipelago

The following Nature Conservation Programmes include the archipelago (Figure 62).

- Programme for the protection of shores, 1990
- Decision in principle by the government regarding the protection of Mickelsörarna, 1989
- Programme for the protection of bird-rich lakes and sea bays, 1982
- Programme for the protection of old-growth forests, 1993, 1996
- Landscape area of national interest: Björköby

International status

Natura 2000 Network

A large part of the Kvarken Archipelago is included in the Natura 2000 Network (Figure 63). The total Natura 2000 area is 122 968 ha, of which 10 376 ha is land, and 112 592 ha is sea. The Habitats Directive and the Birds Directive regulate nature conservation issues within the European Union. The two directives create a common framework for the protection of animals, plants and habitats and prescribe the establishment of a European network of protected areas, called Natura 2000. Areas should be protected with the aim of maintaining or restoring the favourable conservation status of habitats and species that are included in the two directives. The Habitats and Birds Directives are implemented within Finnish legislation.

Baltic Sea Protected Areas and Ramsar areas

The Helsinki Commission (Helcom) has approved the Natura 2000 area of the Kvarken Archipelago for inclusion in the network of Baltic Sea Protected Areas (BSPA). The site is also included in the Ramsar Convention on Wetlands since it is important for breeding and migrating wetland birds.

List of international agreements about the sea:

- Nordic agreement combating the pollution of the seas (1993).
- OSPAR Convention (1992). Convention for the protection of the marine environment of the northeast Atlantic.
- Helsinki Convention (1992). Convention on the protection of the marine environment of the Baltic Sea Area.
- Water Framework Directive of the European Union (2000).

Figure 62. Nature Conservation Programmes in the Kvarken Archipelago.

The most important nature conservations areas in the nominated site:

		Name	*Status*	*Land (ha)*	*Sea (ha)*	*Total (ha)*
❶	■	Mickelsörarnas skärgård	SSP	546	11 450	11996
❷	■	Mickelsörarna	PB	1950	20 159	22 109
❸	●	Kvarkens skärgård	SSP	2819	14 796	17 615
❹	■	Norra Vallgrund-Sjudarsgrundet	SPS	89	–	89
❺	■	Finnvekan-Rudskärsfjärden	SFP	271	243	514
❻	■	Torgrunds skärgård	SSP	720	9116	9 836
❼	▲	Halsön-Rönnskär-Norrskär	SSP	2 578	68 752	71 330
❽	■	Valsörarna-Björkögrunden	NR	650	14 350	15 000
❾	■	Snipan-Medelkallan	SR	1	3259	3260
				9535	**133 214**	**151 749**

■ = core area
● = both core area and buffer zone
▲ = buffer zone
SSP = Programme for the protection of shores
PB = Decision in principle by the government
NR = privately-owned conservation area
SPS = Programme for the protection of old-growth forests
SFP = Programme for the protection of bird-rich lakes and sea bays

Figure 63. Areas included in the Natura 2000 Network.
National Land Survey of Finland, permit nr 7/MYY/04.
Layout Päivi Anttila.

4.b Factors affecting the site

The land uplift influences the everyday life of people in the Kvarken Archipelago. The need to adapt the roads, harbours, fairways to land uplift will remain for a foreseeable future.

Communications

It is necessary for the region that the ferry traffic between Finland and Sweden operate year round. Larger channels demand maintenance, but there is no need to change the ferry route. There are plans, however, to build a new ferry harbour on Replot to shorten the route. The best location is close to the pilot station at Södra Vallgrund, which is in the buffer zone of the nominated site. The planned harbour area is located at open sea, with very minor effects on the geologic status. According to the legislation, all harbour construction work must be preceded by a comprehensive environmental impact assessment and should be included in the regional land-use plan.

Another important issue is to maintain and develop the communications within the archipelago and to places where people live and work.

The possibility of building a bridge or tunnel across the Northern Kvarken has been investigated and a report written in 2000. At present, there is no plan to undertake this connection.

The fairways for small boats need continuous maintenance, like dredging, and channels sometimes have to be moved. Through careful planning of the dredging and material deposits, it is possible to avoid prolonged negative effects on the geology, biology, and water quality of the area.

There will always be a need to maintain and develop the road network along the coast and on inhabited islands. If the ferry harbour is moved to Replot, it will be necessary to improve the road network. Finnish legislation requires that the natural environment and landscape be taken into consideration when new roads are planned.

Business and industry

To promote the sustainable development of an inhabited archipelago, it is important that practices like farming, forestry, fishing, and other small-scaled business continue. World Heritage status should not be detrimental to these businesses. These small-scaled businesses promote high values within the rural landscape and the cultural history and should therefore be supported.

Pit and mining activities

There are only very small deposits of sand, gravel and minerals in the Kvarken Archipelago and large-scale pit or mining activities would not be profitable. Small-scale pits for household requirements are made and these are regulated by the Land Extraction Act.

Wind power

A number of investigations about the establishment of wind power stations in the Kvarken area are in progress in Finland. The plans are so far only preliminary. The establishment of wind power stations in Finland requires an environmental impact assessment and should be included in the land-use plan (see chapter 5.d).

Living

In the Kvarken Archipelago, there is an old and sound tradition of building houses on moraine ridges. Construction work is regulated in the Land-use and Building Act. The World Heritage status will not change the application of the laws.

Figure 64. The fishing harbour of Klobbskat at Replot is used by fishing boats from all around the Gulf of Bothnia. Photo Korsholm municipality ©.

4.c Environmental Pressures

Eutrophication

The increased loading of mineral nutrients from land-based sources is one of the most serious threats against the sea environment in the Baltic Sea. Data from long term studies on the water quality and phytoplankton in the open sea areas of the Kvarken Archipelago show very small, but significant signs of eutrophication. Large algal blooms, however, occur mainly in sheltered or cut off bays. The signs of eutrophication are summarized below:

- Increasing trend in the amount of chlorophyll-a during the summer
- Increasing trend in the production of soft-sediment macrofauna (abundance and biomass)
- Lower quality of the sea bed due to increased sedimentation and drifting algae
- Decreasing trend in the water visibility depth.

Oil accidents

Cargo ship traffic in the Bothnian Bay involves risks with regards to soil and chemical discharge accidents. Until now, only one large oil accident has occurred in the northern Kvarken. The freighter m/s Eira ran aground south of the Nordvalen lighthouse in 1984. About 200 tonnes of heavy fuel oil was spilled and almost 3600 birds died. Official co-operation in combating the oil pollution improved following the accident. Dispersal models for oil and other drifting pollutants are now available.

Environmental toxins

The loadings of persistent toxic organic compounds have been a problem in the Bothnian Bay. Wastewater from the bleaching process of the pulp industry is the most significant source of stable organic substances. Loadings from the forest industry have decreased during the last few decades. The levels of DDT and PCB have also decreased in the last two decades and the level of DDE for instance is just a tenth of that in 1970. The use of chlorinated PCB-compounds as insulation in transformers has been strongly restricted and the PCB-levels in Baltic herring have decreased significantly from the 1970's until the 1990's, when it increased again. Seals have been most affected by these environmental toxins, but the population has recovered. Dioxins were found in the bleaching wastewaters and in paper pulp in the 1990's. Although the levels have decreased, dioxin is still a problem in fish.

Air pollution

The level of sulphur dioxide in the air is now low in the Northern Kvarken, both in populated and rural areas. The nitrogen dioxide levels are also relatively low in the archipelago. The levels of ozone, considered to be harmful to the vegetation, exceed the critical limits every year. The archipelago lakes are easily acidified due to their weak buffer ability.

4.d Natural disasters

There are no foreseeable natural disasters. The Fennoscandian area is one of the most geologically stable areas in the world.

4.e Visitors and tourism

In the Kvarken Archipelago, small boat traffic and cottage living has played a larger role than tourism. The tourism pressure is small, but increasing, and it has not yet caused any larger problems. The tourists are mainly visiting villages outside the protected areas where different kinds of services and events are offered.

To be prepared for an increased number of visitors, the authorities have begun to take the following measures:

1. Plan for recreation and tourism with the purposes of channelling the tourism to areas that can support visitors and to suggest suitable forms of tourism in these areas.
2. Development of systems to monitor visitors in protected areas.
3. Development of indicators of ecological, social, and cultural changes.
4. Improvement of supervision, guidance, service, and infrastructure such as:
   - Training of guides
   - Signing agreements with entrepreneurs that are active in Natura 2000 areas. In the agreement, the entrepreneurs agree to follow an environmental policy and to train guides.
   - The Nature Station Project – to repair and improve old coast guard and pilot stations.

4.f Number of inhabitants within site

There are about 2 500 inhabitants within the nominated site, of which 400 live on Björköby and 2000 on Replot. Within the Natura 2000 areas, there is one permanent resident and more than 600 summer cottages.

Figure 65. The signs of eutrophication are evident in the sea. For example the amount of filamentous algae as epiphytes on Bladder wrack (Fucus vesiculosus) is increacing. Metsähallitus ©.

Management 5.

5.a Ownership

The total area of the proposed site is 323 200 ha. It is divided into a core (185 500 ha) and a buffer (137 700 ha) area (Figure 2). A large part of the proposed site is sea, which has been included to obtain a more representative and uniform World Heritage Site. About 13,6 % (25 545 ha) of the core area is land, and the main part of the land is privately owned or owned by village communities. The Finnish State, municipalities, or companies own the rest of the area. The Finnish State owns the larger parts of the sea areas, while the village communities own sea areas close to the villages.

The most important areas, from a nature conservation point of view, are included in Nature Conservation Programmes and Natura 2000 (see chapter 4a). The Finnish government has approved a financing programme, under which all conservation programmes and the Natura 2000 Network are to be implement by 2007 at the latest. Therefore, ownership will partly change during the coming years. Until now, the environmental authorities have protected 48% of the Natura 2000 land areas in the Kvarken Archipelago. Of this, the Finnish State has obtained 2194 ha, and the private landowners have protected 2742 ha of their land.

The main landowners in the Kvarken Archipelago:

- The Finnish State:
  - Metsähallitus, West Finland Natural Heritage Services 65100 Vaasa, Finland.

- The largest village communities in the core area:
  - Björköby skifteslag, 65870 Björköby, Finland
  - Replot skifteslag, 65800 Replot, Finland
  - Norra Vallgrunds skifteslag, 65920 Norra Vallgrund, Finland
  - Södra Vallgrunds skifteslag, 65930 Södra Vallgrund, Finland
  - Maxmo skärgårds samfällighet, 65140 Sundom, Finland
  - Sundom samfällighet, 65140 Sundom, Finland

5.b Legal status

Finland adopted new nature conservation legislation in 1997, the Nature Conservation Act. The aims of the act are to preserve biodiversity, protect the beauty of nature, and to support sustainable use of nature resources. In addition to this act, there are other laws concerning nature and environmental protection. In Appendix 12, the most important chapters and paragraphs of the laws that regulate activities on land and in the waters of the Kvarken Archipelago are listed.

The environmental conservation legislation in Finland provides good protection of the nature conservation values of the Kvarken Archipelago. Not all areas have yet received final protection but the Nature Conservation Act provides some protection during the ongoing implementation process.

5.c Protective measures and means of implementing them

Laws described in Chapter 4b and Appendix 12 protects geologic formations and ecological systems in land uplift areas. Authorities on a national level, mainly the Ministry of the Environment, have the overall governing roles for environmental protection including planning work. The West Finland Regional Environmental Centre and Metsähallitus (Forest and Park Service) are mainly responsible for the observance of the environmental legislation within their administration area, and the municipalities are responsible for the observance of the Land Use and Building Act. Through legislation, central and regional authorities and municipalities have full control over the World Heritage Site and the values associated with it. Increased knowledge about the Kvarken Archipelago among the public and the community administration will also add to the protection of World Heritage values.

Since the World Heritage Site includes protected and non-protected land in both private and state possession, a broad and co-operative approach is needed for the management and development of the site. This co-operation will be organized when the Kvarken Archipelago becomes a World Heritage Site according to the description in Chapter 5e.

Figure 66. Left: The rare White-tailed Eagle population has increased since 1980´s. Nowadays there are about 35 breeding pairs in the Kvarken Archipelago. Photo Eero Murtomäki ©.

5.d Existing plans and agreements related to the site

Responsible authorities

The central authorities of the West Finland Regional Environmental Centre and Metsähallitus (Forest and Park Service) have the main responsibility for nature conservation and environmental protection questions. The municipalities are responsible for planning and land use in their administrative areas. The Regional Council of Ostrobothnia makes regional land-use plans. The Regional Environmental Centre supervises and controls most of the land-use matters.

List of plans

• Regional Plan of the Vaasa coast area *(Regional Planning Council 1981, 1990, 1995*). This regional plan covers the entire coast of Ostrobothnia. The objective is to secure the region´s developmental potential of the region for the future. The plan includes for instance areas set aside for recreation and nature conservation. The plan is applied until the landuse plan is established (see below).

• Land-use Plan for the County of Ostrobothnia *(Regional Council of Ostrobothnia, in preparation*). According to the new Landuse and Building Act (2000), a regional landuse plan has to be made. The purpose is to coordinate different landuse needs regarding living, working, traffic, and recreation as well as nature, the landscape and water protection. The landuse plan focuses on the sustainable use of the environment and natural resources. (Appendix 5)

• Local Shore Master Plans for the Kvarken Archipelago (*Malax Municipality, 1996; Town of Vaasa, 1987; Korsnäs Municipality, 2000).* A non-established local shore master plan exists for the Replot-Björköby area (*Korsholm Municipality, 2000*). Maxmo Municipality has started to prepare their shore master plan. The municipalities also make Local Detailed Shore Plans for smaller areas that need more detailed planning, like the common lands of the Björköby village. The Regional Plan governs the municipalities in their preparation of the shore master plan, which in turn governs the detailed shore plan that controls building activities.

• Landscape Management Plan for the Björköby area *(West Finland Regional Environmental Centre)*. The surroundings of the Björköby village are a Landscape Area of National Interest. The status implies a particular consideration of landscape values by the authorities when plans and decisions are executed. The plan presents a model for the management of the landscape and cultural environments (Appendix 6)

• Plan for Tourism and Recreation (*West Finland Regional Environmental Centre, 2001)*. The Archibal project, part of the Interreg IIC-programme for the Baltic Sea, prepared a plan for tourism development in the Kvarken Archipelago (Appendix 7). The plan includes criteria and indicators for sustainable tourism, a strategy for the development of infrastructure and guiding activities within the Kvarken Archipelago Site.

5.e Managements plans and statements of objectives of the site

Guidelines and objectives of management

The Natura 2000 network has stated that the Finnish environmental administrations will invest in landuse and management planning. During 2002-2003, Finnish and Swedish environmental authorities completed a study together with the Kvarken Council to find a common basis for all landuse and management planning in the Northern Kvarken (Appendix 9). The study identifies objectives and guidelines for the conservation and management of habitats and species in protected areas. The overall objective is that Sweden and Finland should follow the same principles when detailed conservation and management plans are prepared for different parts of the Kvarken area.

Landuse and management plans

At present, there are two landuse and management plans in the Kvarken Archipelago (Appendix 8). They concern an 1800 ha area close to Björköby and the Mickelsörarna Archipelago (23 000 ha). These plans are the result of broad cooperation between all concerned parties. The objective has been to combine and consider all interests regarding nature conservation, recreation, and traditional landuse on private and state owned land.

The following landuse and management plans are in preparation (Figure 67); Norrskär-Rönnskär-Molpehällorna (2004-2007), and the Torgrund Archipelago (2005-2008), Valsörarana-Björkögrundet (2006-2009) and the Grey seal protection area Snipan-Medelkallan (2006-2007).

The sea areas owned by the village communities is divided into fishery areas. According to the Fichery Act each fishery area is obligated to have a management plan. These plans were completed in 1980´s and renewed in the late 1990´s.

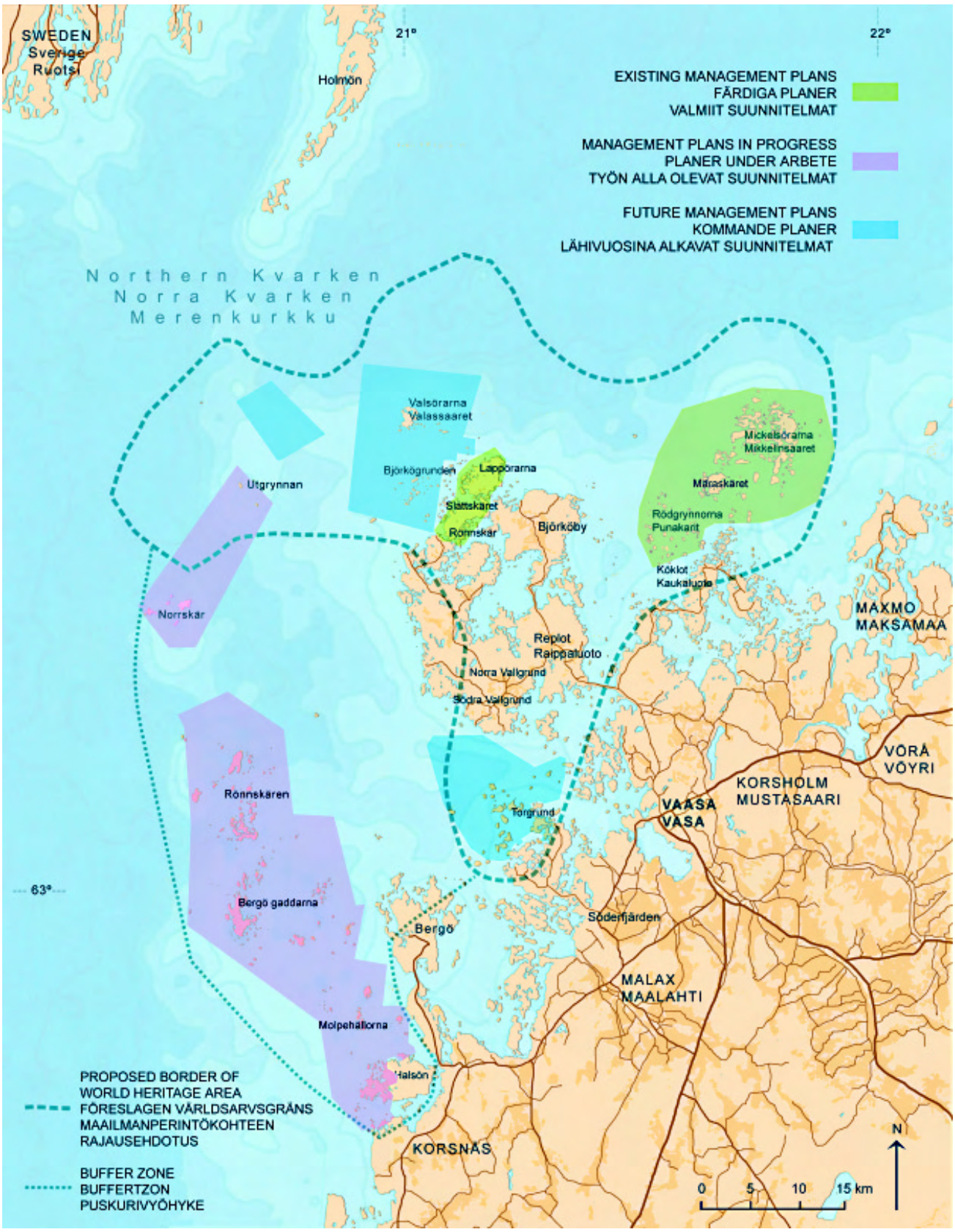


Figure 67. Management plans in the Kvarken Archipelago. National Land Survey of Finland, permit nr 7/MYY/04. Layout Päivi Anttila.

Co-operation between the Kvarken Archipelago and the High Coast

When the Kvarken Archipelago will be awarded the World Heritage status, a consultation group will manage the international co-operation issues with the High Coast World Heritage area. The High Coast and the Kvarken Archipelago will have their own management plans according to common guidelines.

The Kvarken Archipelago will also establish two national working groups:

1) A management group that is responsible for local co-operation regarding management, land-use, and conservation of protected areas, and

2) A group that will promote the development of sustainable tourism and other enterprises.

5.f Sources and levels of finance

National

Each year, the Finnish Ministry of the Environment allocates financial resources to purchase nature conservation areas and to develop their management and landuse. The Ministry also supports research, development and investigation concerning nature conservation and environmental protection. The Geological Survey of Finland is financed by the Finnish state to perform soil and bedrock surveys. They also receive funding from the European Union (EU) for different studies. The state and the municipalities will finance spatial planning. Agriculture, forestry and fisheries are allotted subventions by the state.

Regional

The Regional Council of Ostrobothnia distributes financial EU-support together with the Employment and Business Development Centre. The main focus of the EU-programmes is to strengthen the agriculture and forestry industry, increase the competitiveness of the rural areas and to protect the environmental and rural heritage. The EU-supported regional programmes in this region of Finland are:

- Objective 2 – programme (Maxmo municipality, the islands of Replot and Bergö)
- ALMA – a regional rural development programme aimed at balanced population development, pleasant living and nature conservation
- Horizontal programmes to support the fishery industry and rural development.

The Kvarken area is also included in the EU-financed programme of Interreg Kvarken MittSkandia, which promotes interregional co-operation. The principles for the Interreg-programmes are that national borders must not put limitations on balanced and concordant development in Europe. The programmes support activities that decrease developmental differences that have arisen between the border districts and the central part of the countries. The programmes also encourage extensive environmental protection measures that are more likely to be implemented together with other countries. The projects Kvarken Miljö I and II (see Chapter 5i) are financed by Interreg.

The European Union also supports nature conservation projects through the Life Nature fund and environmental protection projects through the Life Environment fund. With the support of Life Nature funding, the European nature conservation policy, based on the Birds (79/409/EEC) and Habitats (94/43/EEC) Directives, is realized. In the Kvarken Archipelago, one Life Nature project has finished while another is on going (see also Chapter 5i).

5.g Sources of expertise and training in conservation and management techniques

The West Finland Regional Environmental Centre and the West Finland Natural Heritage Services of Metsähallitus are responsible for the management and landuse within conservations areas. The administrations have competent staff who are familiar with the conditions in the Kvarken Archipelago. Central authorities like the Ministry of the Environment, the Finnish Environmental Institute, and Metsähallitus mainly arrange training of administration staff. Regional centres also arrange internal training.

To manage the conservation areas in the best way, administrations co-operate with many organizations. The most important include Åbo Academy, University of Umeå, the Swedish University of Agricultural Sciences, Finnish Game and Fisheries Research Institute, Finnish Environmental Institute, Finnish Institute of Marine Research, Finnish Forest Research Institute, and museums and geologic research centres.

5.h Visitor facilities and statistics

Basic facilities for accommodation and information

In 2002, the permanent exhibition Terranova opened in Vaasa in connection with the Ostrobothnian Museum. The exhibition displays the nature, geology and land uplift of the Kvarken Archipelago. (Figure 74)

The old coast guard and pilot stations will serve as bases for nature tourism and guiding activities in the outer archipelago. Metsähallitus (Forest and Park Service) owns the buildings and is responsible for their development into Nature Stations (Figure 69 and 70) in co-operation with municipalities and entrepreneurs. The Nature Stations are located in the Arhcipelagos of Mickelsörarna, Rönnskär and Molpehällorna. At Kvicksund on Replot, there are facilities for a small-scale guiding and accommodation activity.

Figure 68. The present visitor facilities. National Land Survey of Finland, permit nr 7/MYY/04. Layout Päivi Anttila.

Figure 69. Open house at the nature station of Mickelsörarna in the summer 2003. The nature station has about 2500 visitors each year. Photo Pertti Malinen ©.

Guiding

The Association of Nature and Wildlife Guiding and entrepreneurs organise guided tours in the Kvarken Archipelago. They offer nature guiding, canoeing tours, bird-watching excursions and fishing trips. Many bed and breakfast entrepreneurs also offer guided archipelago trips.

Nature paths and hiking tracks

There are several nature paths and hiking trails with information along the path about nature and culture. On Valsörarna, Molpehällorna and Mickelsörarna there are nature paths, some many kilometres long. A longer hiking trail runs through the islands in the Björköby archipelago.

Figure 70. The nature station of Rönnskär is an old pilot society where the pilots lived permanently with their families. The last pilot left the station in 1983. Photo Metsähallitus ©.

Figure 71. The hiking trail in Björköby archipelago is 12 km long and Metsähallitus is responsible for its maintenance. Photo Metsähallitus ©.

Events

The most important and spectacular event in the Kvarken area is the "Post row", which takes place every year between the islands of Holmön in Sweden and Björköby in Finland. (Figure 72)

Fairways, small boats traffic and transports

There are plenty of fairways maintained by local boat clubs for small boats in the area. The small boat traffic is busy and there are more than 5000 registered boats in the area.

There are 15-20 entrepreneurs that arrange boat trips to the archipelago, mainly from the town of Vaasa.

Visitor statistics

The number of visitors in the Kvarken Archipelago is quite small at present, over 200 000 yearly. Metsähallitus is responsible for monitoring visitors on state owned land.

Figure 72. In the "Post row" you can only participate with traditional boats and clothes. Photo Korsholm municipality ©.

5.i Policies and programmes related to the presentation and promotion of the nominated site

Statement of intention

A signed agreement has been established between the West Finland Regional Environmental Centre, Metsähallitus (Forest and Park Service), the Regional Council of Ostrobothnia and the municipalities concerned. The statement of intention is a policy document that includes objectives and guidelines for future activities and co-operation in the area (Appendix 10). The aim is to protect geologic, biological and cultural values for future generations.

Site development

The development of the site is mainly governed by landuse plans (Chapter 5d), legislation (Chapter 5b, 5c), and nature conservation programmes (Chapter 4a). The development work is realized by regional programmes and projects, which are financed by the municipalities, government authorities and the European Union.

Regional programmes

The Regional Development Programme (2003-2006) governs the regional development work in the county of Ostrobothnia. Its goals are to find solutions for sustainable development of the archipelago, and to protect and develop natural and cultural environments in the region. In the future, this programme will be replaced by a landscape survey that will establish the long-term development of the landscape. The landscape survey work began in 2001.

An environmental programme for western Finland (including the Kvarken Archipelago) has been prepared under the guidance of the West Finland Regional Environmental Centre. One of the aims is to bring together different landuse interests in the archipelago and coastal areas, like recreation and conservation.

A forest programme for 2001-2005 has been prepared under the guidance of Coastal Forestry Centre with the aim of sustainable management and use of forest resources. It is applied outside Natura 2000 areas of Replot and Björköby, for instance.

Projects

The Kvarken Council is a Nordic cross-border association for the co-operation between the Finnish and Swedish municipalities on both sides of the Northern Kvarken. In 2000, the Kvarken Council initiated the project "*Kvarken Miljö*", a broad environmental co-operation with authorities, municipalities and interest organisations. The project is financed by the European Interreg-Kvarken-MittSkandia programme until 2006.

The preparation of this application has been done within the Kvarken Miljö-project, as well as management and landuse planning of nature protected areas in Northern Kvarken, production of nature information material and improvement of the tourism services in these areas. The movie "Spåren av istiden" (Traces of the ice-age) and the Internet guide "Kvarkens Natur" (The nature of Northern Kvarken) are examples of the production of the project.

Figure 73. In winter, the sea is frozen for almost five months. The thick ice cover makes it possible to discover and utilize the archipelago in different ways than in summer. Cross-country skiing, ice-fishing, skating and even driving cars on the ice is common. Photo Alexander Henriksson ©.

In the coming years, the project will investigate the expectations of inhabitants and entrepreneurs on the management and use of nature protected areas, focus on participatory planning with environmental objectives, and provide information about the environmental status.

"Geonat" is another project that is financed by the Interreg Kvarken-Mittskandiaprogramme. The project is a co-operation between the Geological Survey of Finland, the Geological Survey of Sweden, environmental authorities, and municipalities. The objective is to survey and present detailed data about the geology and geomorphology of eastern and western Kvarken between the years 2003-2006.

Tourism development in the Kvarken Archipelago takes place through different projects. The Interreg Kvarken-MittSkandiaproject "*Botnia Tour*" develops a booking system for various tourism packages and has produced an Internet home page with virtual fairways in the coast region. The Employment and Business Development Centre has, together with the Regional Council of Ostrobothnia, initiated a tourism team with the task of developing archipelago tourism. The Centre for Continuing Education in Vaasa educates guides in a special training programme for nature guiding in the Kvarken archipelago.

The *"Integrated management system for the Bothnian Bay"* is a Life Environment project that began in 2001. The objectives are to provide a comprehensive picture of the sea status of the Bothnian Bay, to improve the exchange of information between different actors and to develop guidelines for joint management and environmental monitoring of the Bothnian Bay.

5.j Staffing levels

Metsähallitus (Forest and Park Service) in Vaasa has eight employees that administer the nature-protected areas owned by the state. A number of agreements between Metsähallitus and entrepreneurs, fishermen and local organisations have been signed regarding maintenance, supervision, management, and guiding.

The Department of Nature Conservation at the West Finland Regional Environmental Centre has 20 employees who are responsible for the management of privately owned nature conservation areas. This work is mainly implemented through project funding and in co-operation with the municipalities. All planning work is carried out together with local interest groups such as village communities, hunting clubs, and youth associations.

Waste disposal management is taken care of by the organization "Håll skärgården ren" (Keep the archipelago tidy) and the municipalities. The Frontier guards, Customs, Police, and Metsähallitus supervise the observance of legislations, regulations, and safety.

Figure 74. Visiting the Terranova exhibition is a good introduction to the Kvarken area. It covers different aspects including geology, ecology and species occurring in the archipelago. European Union projects have funded parts of the exhibition. Photo Metsähallitus ©.

Monitoring 6.

6.a Key indicators for measuring state of conservation

	Indicators	Methods	Repositories	Frequency
1. Geomorphology and land uplift	1A Moraine formations on land (ha).	Landscape monitoring by remote sensing using satellite and aerial photographs.	Geological Survey of Finland	20 year
	1B. Land uplift (mm/year)	Precise levelling of Finland.	Finnish Geodetic Institute	20 year
	1C. Exploited land area (ha)	Measurement of the number of administered exploitation matters, permits, and reports.	West Finland Regional Environmental Centre and the Municipalities	5 years
2. Natura 2000 habitats	2A. Primary succession forest on land uplift areas (ha)	Measurements of changes in the habitat structure and species diversity by remote sensing (IR and B/W aerial photographs) and field studies.	West Finland Regional Environmental Centre	20 years
	2B. Flads and gloes (ha)	Measurements of changes in the habitat structure and species diversity by remote sensing (IR and B/W aerial photographs) and field studies.	West Finland Regional Environmental Centre	20 years
3. Nature conservation	3A. Number of established nature conservations areas	Statistics from the environmental authorities.	West Finland Regional Environmental Centre and Ministry of the Environment	1 year
	3B. Nature conservation area (ha)	Statistics from the environmental authorities.	West Finland Regional Environmental Centre and Ministry of the Environment	1 year
4. Visitors	4. Number of visitors	Information from guest books, entrepreneurs and automatic counters as well as boat counts.	West Finland Regional Environmental Centre and Metsähallitus	1 year

Figure 75. The Crane is a typical bird in the Kvarken Archipelago. The migratory route of the Cranes passes through the Northern Kvarken. Photo Metsähallitus ©.

Other monitoring and surveillance

Birds

Migrating birds are counted yearly on the islands of Valsörarna and Norrskär. The breeding sea bird population is frequently monitored on the islands of Valsörarna-Björkögrunden and Mickelsörarna by ornithologists' associations and private persons. A joint monitoring programme for breeding sea birds in Kvarken will be developed and tested in the Kvarken Miljö project 2004-2006.

The following threatened species are monitored: white-tailed eagle (*Haliaeetus albicilla*) (Figure 66), osprey (*Pandion haliaetus*), caspian tern (*Sterna caspia*), lesser black-backed gull (*Larus fuscus*), greater scaup (*Aythya marila*), common kestrel (*Falco tinnunculus*), and white-backed woodpecker (*Dendrocopos leucotos*) (Figure 76). Indicators for these species are population size, breeding success and environmental toxin content in the eggshells. The environmental authorities are responsible for the monitoring, which occurs every year.

The Sea

The sea areas of Kvarken Archipelago are monitored according to international (HELCOM), national and local control programmes. They include surveillance of water quality, benthic invertebrate fauna, discharge and environmental toxins.

The macro-vegetation on shallow and hard seabeds is monitored regularly at Malax-Rönnskär using methods recommended by HELCOM. It is part of a national monitoring programme. The Finnish Game and Fisheries Research Institute estimatea the population sizes of Baltic herring, cod, and salmon every year. Within a national programme for environmental toxins, the West Finland Regional Environmental Centre is responsible for yearly analysis of the toxin content in perch, pike, Baltic herring, the isopod *Mesidotea sp*, and the bivalve *Macoma baltica*.

Some of the sea environment monitoring in the Kvarken area is co-ordinated between the West Finland Regional Environmental Centre and the County Administration of Västerbotten in Sweden.

Figure 76. The endangered White-backed Woodpecker has returned to the Kvarken Archipelago after a 30 year absence. A few pairs nest in the birch- and alder forests in the area. Photo Juhani Koivusaari ©.

6.b Administrative arrangements for monitoring the site

Responsible authorities

West Finland Regional Environmental Centre
Koulukatu 19
PB 262 FIN-65101 Vaasa
Finland
www.ymparisto.fi/lsu

Metsähallitus (Forest and Park Service)
West Finland Natural Heritage Service
Hovioikeudenpuistikko 16
FIN-65100 Vaasa
Finland
www.metsa.fi

Geological Survey of Finland, GTK
Betonimiehenkuja 4
PB 96 FIN-02151 Espoo
Finland
www.gtk.fi

Finnish Geodetic Institute
Geodeetinrinne 2 PB 15
FIN-02431 Masala
Finland

Some of the monitoring results will be present on the home page www.kvarken.org/miljo

6.c Results of previous reporting exercises

Ecosystems in the Kvarken Archipelago have been subject to many investigations over the years. Most of the studies have been published or are filed in databases at Metsähallitus or the West Finland Regional Environmental Centre. The most important investigations are presented below.

Geology

The Geological Survey of Finland has produced a report and maps of the geology of the Kvarken Archipelago (Appendices 1 and 2).

Vegetation

The effects of landuse and land uplift on vegetation have been investigated in the archipelago of Björköby through the establishment of permanent plots in 1999 (Höglund 2000). The plots are used to monitor the structure of tree, bush, and vegetation layers. In other parts of the Kvarken Archipelago, extensive vegetation surveys have been done, which are the basis for future monitoring. The results are stored in databases at Metsähallitus or West Finland Regional Environmental Centre.

Bird populations

The two key species of the Kvarken Archipelago, the black guillemot *(Cepphus grylle*) and the rare razorbill (*Alca torda*) have been monitored for many years and the populations have increased between 1950 and 1990. The rare greater scaup (*Aythya marila*) breeds mainly in the outer archipelago and the population size has fluctuated heavily over the last 50 years. About 80% of the Finnish population is found in the Kvarken Archipelago (Väisänen 1998). The White-tailed eagle population, which was seriously threatened by environmental toxins during the 1960's and 1970's has recovered since the mid 1980's (Stjernberg 1995). The population size of the White-tailed eagle is now 35 pairs.

Sea

The bladderwrack (*Fucus vesiculosus)*, and the stonewort (*Chara tomentosa),* are adapted to moderate to nutrient-poor environments. Both grow in more shallow conditions today than 20 years ago, probably due to increased turbidity. The presence of the amphipod *Monoporeia affinis*, an indicator of polluted sediments, has decreased in coastal areas (Leonardsson 2003).

The population sizes of many fish species are assumed to have decreased during the last decades due to the acidification. The acidification is due to large areas of agriculture land on former sulphurous seabeds from the Litorina Sea Stage. The acidified drainage water is discharged to the sea. The following fish species have decreased in numbers: bleak (*Alburnus alburnus*), dace (*Leuciscus leuciscus*), ide (*Leuciscus idus*), bream (*Abramis brama*), silver bream (*Blicca bjoerkna*), vimba bream (*Vimba vimba*), and burbot (*Lota lota*) (Rautio (ed.) 1998, Hudd 1984).

Due to environmental toxins, seal populations decreased dramatically during the 1950's and 1960's, but the grey seal has recovered successfully (Helle 1990).

New species have dispersed into, and become established in the Baltic Sea and northern Kvarken. For example, the North American polychaete (*Marenzelleria viridis*), can dominate communities on soft sea beds (Westberg and Lax 2003).

Documentation 7.

7.a Photographs, slides and other audiovisual materials

Photographs, colour slides (35 mm) from the nominated area and a presentation video from The Northern Kvarken are attached (Appendix 13, 14 and 15).

In appendix 11 is a list of all photographs and slides.

7.b Copies of management plans and extracts of other plans relevant to the site

Extracts of relevant plans are included in the Appendices to the nomination as follows:

Appendix 5. Regional Plan of the Vaasa coast area
Appendix 6. Landscape Management Plan for the Björköby area
Appendix 7. Plan for Tourism and Recreation
Appendix 8. Management plan for the Lappören-Slåttskäret-Rönnskär area and Mickelsörarna-Rödgrynnorna
Appendix 9. Objectives of landuse and management

7.c Form and date of most recent records of the site

Bedrock and geology

The Geological Survey of Finland (GTK) has produced bedrock and Quaternary geology maps of the Kvarken Archipelago area on a scale of 1:200 000, (Appendices 2).

The bedrock map is based on the following data:

1. Bedrock map B3 of Vaasa, 1:400 000 (Saksela 1934).
2. Bedrock map of Korsnäs. Scale 1:100 000 (Nykänen 1960a).
3. Bedrock map of central Fennosscandia. Scale 1: 1 000 000 (Lundqvist et al. 1996).
4. Bedrock map of the southern Ostrobothnian. Scale 1:200 000 (Lehtonen M.I. at al 2004).

Quaternary geology map is based on the following data:

1. Nine available geologic map sheets of Quaternary deposits, scale 1:20 000 by the Geological Survey of Finland (Huttunen 2004, Kukkonen E 1989, 2001, Kukkonen M 1989, 2001, 2002).
2. Interpretation of digital elevation model, aerial photos, digital base maps and land use and forest interpretation by National Land Survey of Finland.

The geologic maps are also available in a digital form.

Figure 77. Shingle shore at Östra Norrskär. This type of shore with round stones of a uniform size is very rare in the Kvarken Archipelago. Photo Pertti Malinen ©.

Land uplift

The moraine archipelagos formed by the inland ice and exposed by land uplift have been a topic of research for a long time. The first record of such research came from Chydenius, who cut the first water level mark on a rock at Ratan, Sweden in 1749 and from E. O. Runeberg who was the first to present the theory of isostatic land uplift in 1765. During the 20th century, many researchers have investigated the land uplift in eastern Kvarken: Renqvist (1923), Palomäki (1988), and Jones, a British geographer who spent the 1970's and 1980's studying the complexity of the land uplift phenomenon. The latest records are based on three precision levellings made in Finland (Ekman 1996, Mäkinen 1996, Mäkinen and Saaranen 1998).

Aerial photographs

There are both infrared and black/white aerial ortho-photographs available for monitoring the Kvarken Archipelago. The West Finland Regional Environmental Centre and Metsähallitus (Forest and Park Service) have aerial ortho-photographs in their archives and databases. Both old (back to 1940) and new ortho-photographs on a scale of 1:15 000 to 1:50 000 may be purchased from the National Land Survey of Finland and FM-kartta Oy.

Geographical databases

The environmental administration of Finland has a comprehensive geographical database including contour lines, shorelines, bedrock data, soil type, landuse, borders of protected areas, property borders, watersheds, and roads.

Vegetation

Vegetation changes have been investigated by Palomäki (1963) and Valovirta (1937). Vegetation has been mapped on Mickelsörarna (Ehnholm 1937), Replot-Björköby (Westman 1969), Lappören (Rinkineva and Väre 1992) and Valsörarna (Rosenblad 1990). The natural habitats were investigated in 1996 on 200 islets in the Kvarken Archipelago. The results are filed in databases at the West Finland Regional Environmental Centre. The vegetation mapping continues on Mickelsörarna and Norrskär by Metsähallitus.

The Swedish University of Agricultural Sciences has studied the succession and dynamics of the forest ecosystem (Svensson and Jeglum 2000, 2001). These investigations include primary peatland formation and paludification of wetland ecosystems, spruce colonization and the development of species diversity on young islands and comparative analyses of land uplift ecosystems in northern Kvarken, Hudson Bay and James Bay.

The population genetics and dispersal ecology of plants and parasitic fungi are studied on young islands of different ages in the archipelago by Umeå University, Sweden.

The Finnish Forest Research Institute has studied the soil microbial dynamics on the uplifted coast (Merilä 2002).

Lichens and fungi

Extensive mapping of lichens and fungi was done in the Kvarken Archipelago, mainly during the 1990's. The occurrence of conks was investigated by Savola and Pasanen (1995). Threatened lichens were surveyed by Rinkineva (1993) and Jääskeläinen (1997).

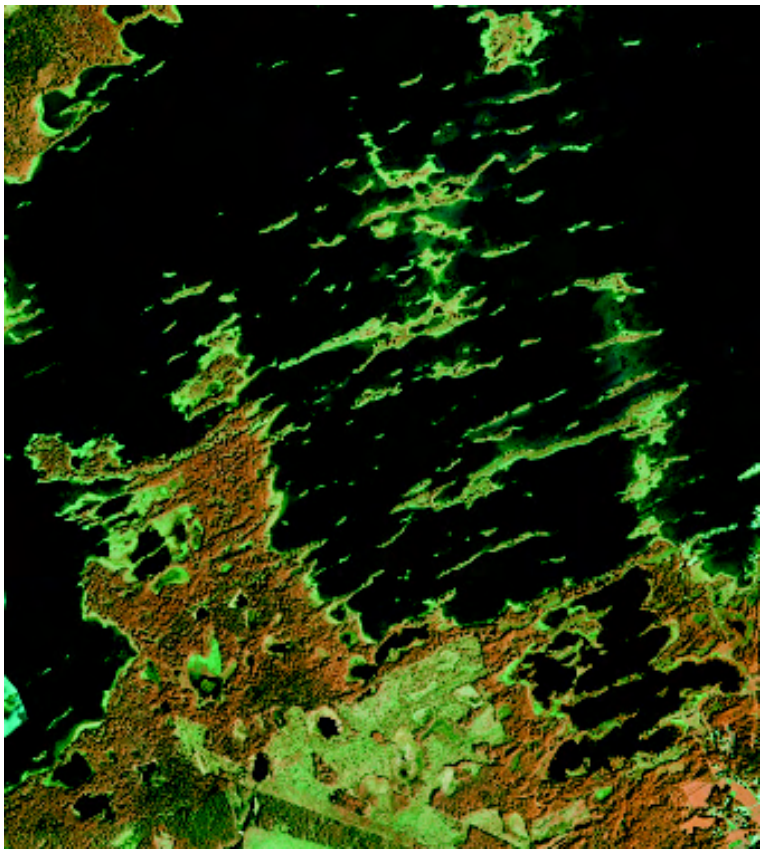


Figure 78. Infrared aerial photographs are an excellent tool to identify different habitats. These photos from the Björköby archipelago (Svedjehamn–Lappören) shows flads, gloes, glo-lakes, primary landupheaval forests, De Geer moraines etc. FM-Kartta Oy ©, permit nr FMKO15/2004.

Birds

Surveys and monitoring of the sea bird populations are frequently carried out by the members of ornithologists' associations, and by consultants commissioned by the environmental authorities. On Valsörarna, the association Ostrobothnia Australis surveys the breeding sea bird populations every second year and counts the migrating birds every year. The latest survey of non-sea bird populations was conducted by Veijalainen 1993 (Veijalainen 1994).

Sea areas

Fish spawning areas in flads and gloes have been investigated along the Ostrobothnian coast by Wistbacka and Snickars (2000).

Cultural history

Information about the history of the Kvarken Archipelago is filed at the Ostrobothnian Museum, the Ostrobothnian Archives of Traditional Culture, and in databases at the Regional Council of Ostrobothnia.

7.d Address where inventory, records and archives are held

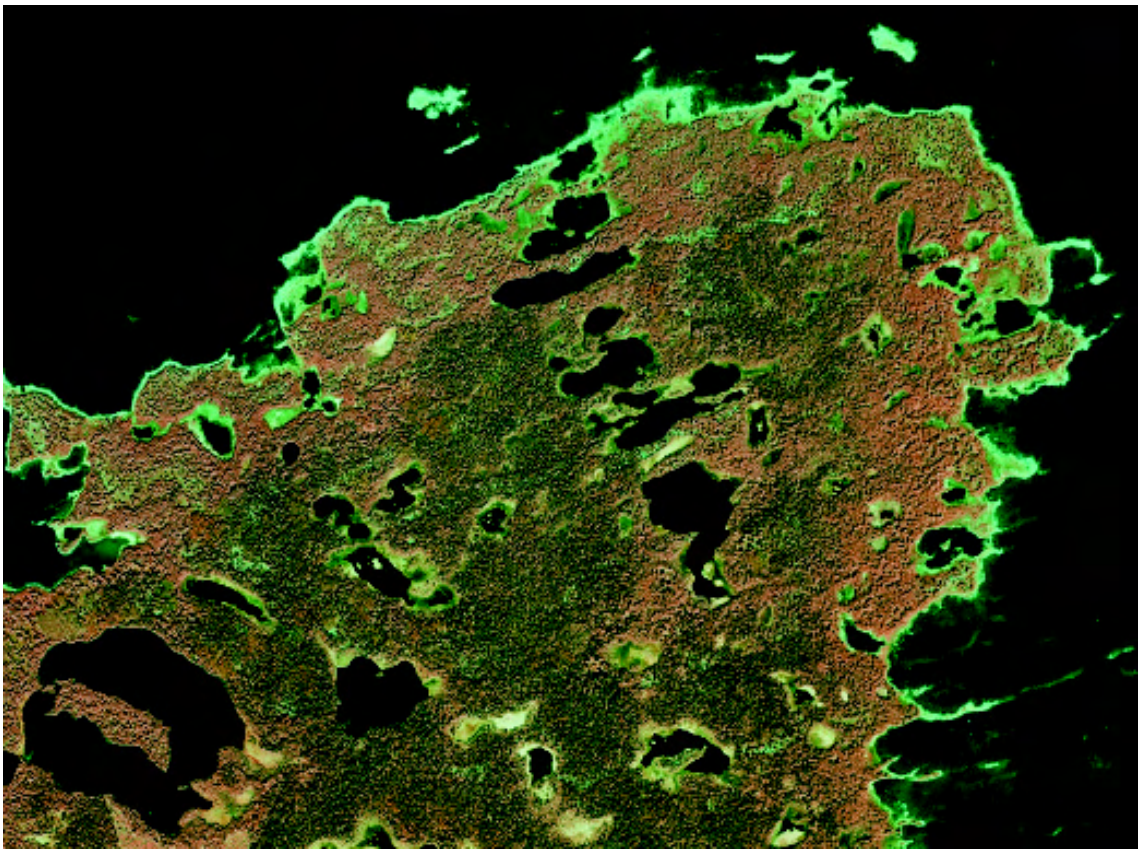
The most important surveys, data bases and plans are filed at the following authorities and associations:

West Finland Regional Environmental Centre
PB 262
FI-65101 Vaasa
Finland

Metsähallitus (Forest and Park Service)
West Finland Natural Heritage Services
Hovioikeudenpuistikko16
FI-65100 Vaasa
Finland

Regional Council of Ostrobothnia
Vaasanpuistikko 20 B
FI-65100 Vaasa
Finland

Geological Survey of Finland, GTK
Betonimiehenkuja 4
PB 96 FIN-02151 Espoo
Finland



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Vörå municipality

8.d Official web site

No official web site exists yet, but there is one planned for the future.

Figure 79. Left: The park-like character of Birch forests that grow in the Kvarken Archipelago are results of the sea climate as well as from pasturage. Photo Eero Murtomäki ©.

8.e Appendices

Appendix 1. Geology of the Northern Kvarken area
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Appendix 9. A study of the objectives of land-use and management in the Kvarken area
Appendix 10. Statement of intention
Appendix 11. List of photographs and slides
Appendix 12. Legislation
Appendix 13. CD with photographs
Appendix 14. Slides
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C = comments on drafts
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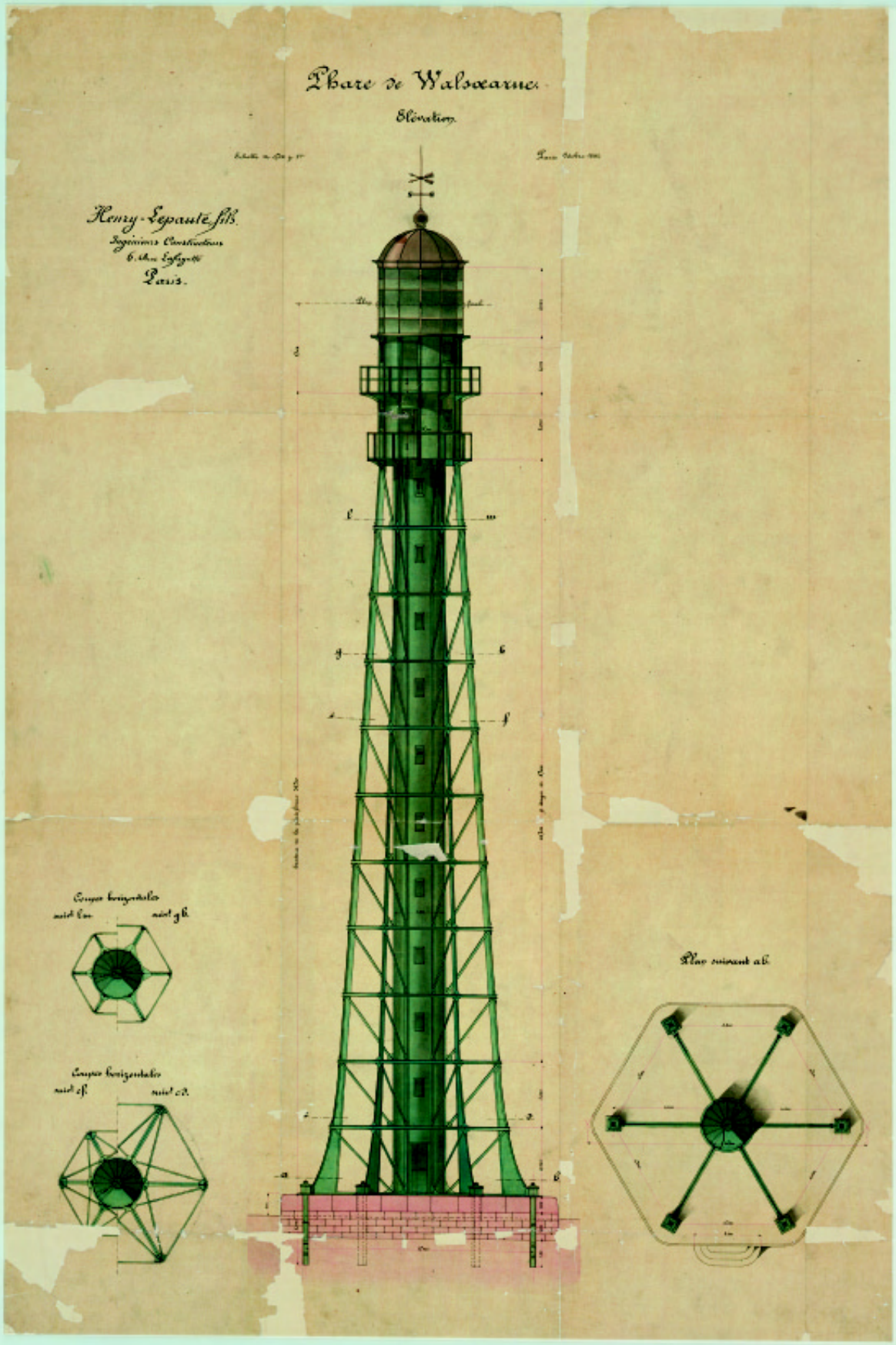
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Plan suivant ab

Signature on behalf of the State Party 9.

Signed on behalf of the State Party

Full name:

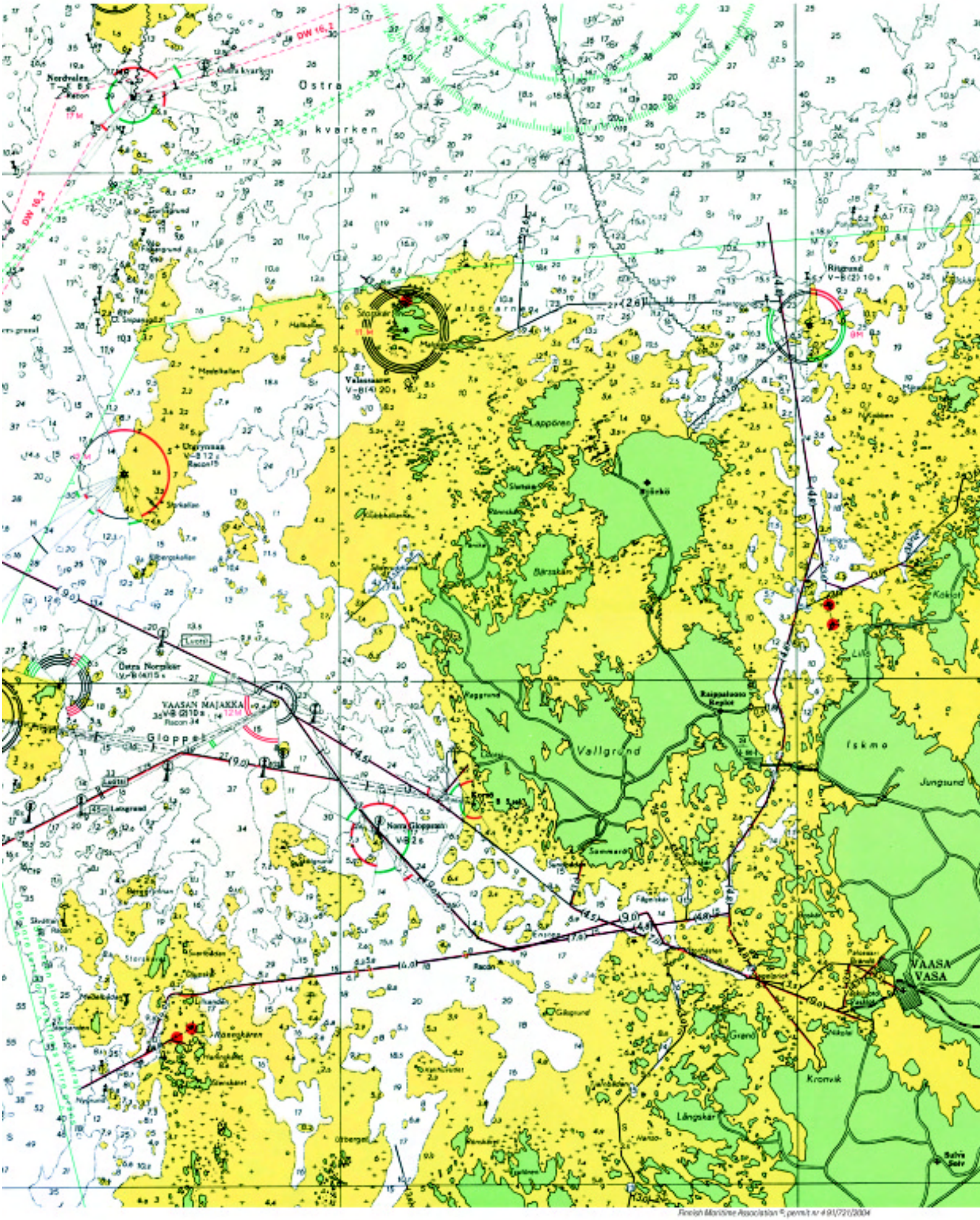
Title:

Date:

Figure 80. The construction drawing for the Valsörarna lighthouse. Finnish Maritime Association ©.

This pair of maps shows the land up lift effects on the shoreline during the last 200 years.

The map on the left, from the late 18th century, is one of the first orthographic maps of the Kvarken Archipelago. The modern nautical chart (2003) on the right shows how straits have disappeared and sea routes have changed. The yellow colour on the chart represents shallow areas. Ostrobothnian Museum ©.


Ostra
kvarken
Nordvalen
Valassaaret
Ringsund
Lappören
Vallgrund
Iskmo
Jungsund
YAASAN MAJAKKA
Glappe
Nara Glappen
VAASA
VASA
Kronvik
Långskär
Grönö
Raippaluoto
Replot
Bärsskär
Kokkolan
Lillo
Sommaro
Fägenskär
Gäsgrund
Rosengården
Storskär
Sundskär
Lappfjärden
Bjurkö
Stora Norgskär
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Carta Marina, a map by the famous swedish archbishop Olaus Magnus, was published in Venice in 1539. On the map the Kvarken area is covered with ice and several sledges are on their way to Sweden. This reflects the area´s importance as a communication route between Finland and Sweden.

” Finland has risen, like Aphrodite in ancient times, from

the embrace of the sea. There was a time when the Baltic Sea

was a bay of the Arctic Ocean, its waves and icebergs were

then rolling high above our firm land in this remote corner of Europe.

On both coasts of the Gulf of Bothnia

people have long known the strange phenomenon

of the sea gradually fleeing from the shores.

Where once ships sailed there a boat can hardly move nowadays;

where a fisher in his youth rowed to his nets

there we see now his cattle grazing at a green seashore meadow.

New soil is coming up

from the sea for every generation, and every century bestows

a new principality to Finland. ”

{ Topelius 1873, 4-5 }

APPENDIX 1

GEOLOGY OF THE KVARKEN ARCHIPELAGO

Olli Breilin, Aarno Kotilainen, Keijo Nenonen,
Petri Virransalo, Jukka Ojalainen and Carl-Göran Stén

GTK

The Geology of the Kvarken Archipelago - report is an appendix (appendix 1) to the application for nomination of the Kvarken Archipelago to the World Heritage list (Ollqvist & Rinkineva-Kantola 2004).

This report is prepared under the Geonat-project (GEOLOGICAL INFORMATION AND NATURE VALUES FOR THE SUSTAINABLE DEVELOPMENT OF THE KVARKEN AREA), which is a co-operation project between Geological Survey of Finland (GTK) and Geological Survey of Sweden (SGU).

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Cover illustration: De Geer moraines western from Björkö island
(photo Arto Hämäläinen 1996, © Korsholm municipality).

Geological Survey of Finland, 2004, (www.gtk.fi)
Base maps © National Land Survey of Finland (643/MYY/04)

GEOLOGY OF THE KVARKEN ARCHIPELAGO

Olli Breilin, Aarno Kotilainen, Keijo Nenonen,
Petri Virransalo, Jukka Ojalainen and Carl-Göran Stén

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Introduction

The Kvarken Archipelago has undergone a long sequence of geological processes. What we can see today is one part of the geologic evolution of the earth's crust: crystalline bedrock from ancient times and overburden representing young geologic processes as a heritage of the ice age. Ongoing geologic processes are rapidly and invariably changing the face of this unique area over the course of a human's lifetime.

The glacial events and formations of the Quaternary ice age have built up the unique landscape and landforms of the Kvarken Archipelago. The long lasting erosion and peneplanation of the Precambrian bedrock form a peculiar platform for the dynamic, ongoing geological processes. Since the early days of glacial geology, the Kvarken area has been the focus of scientific research dealing with postglacial land uplift, moraine morphology and deglaciation.

The Northern Kvarken is the narrowest part of the Gulf of Bothnia in the northern Baltic Sea, connecting Finland's Ostrobothnia (Pohjanmaa) and Sweden's Västerbotten. The distance from the Finnish to the Swedish coast is 80 km, with only 25 km between the outermost islands. Northern Kvarken also forms a submarine sill, which separates the Bothnian Sea in the south from the Bothnian Bay in the north. Situated at the eastern part of the Northern Kvarken is the Kvarken Archipelago, where there are more islands than at any other place in the Gulf of Bothnia. However, only few islands are located along the Swedish coast.

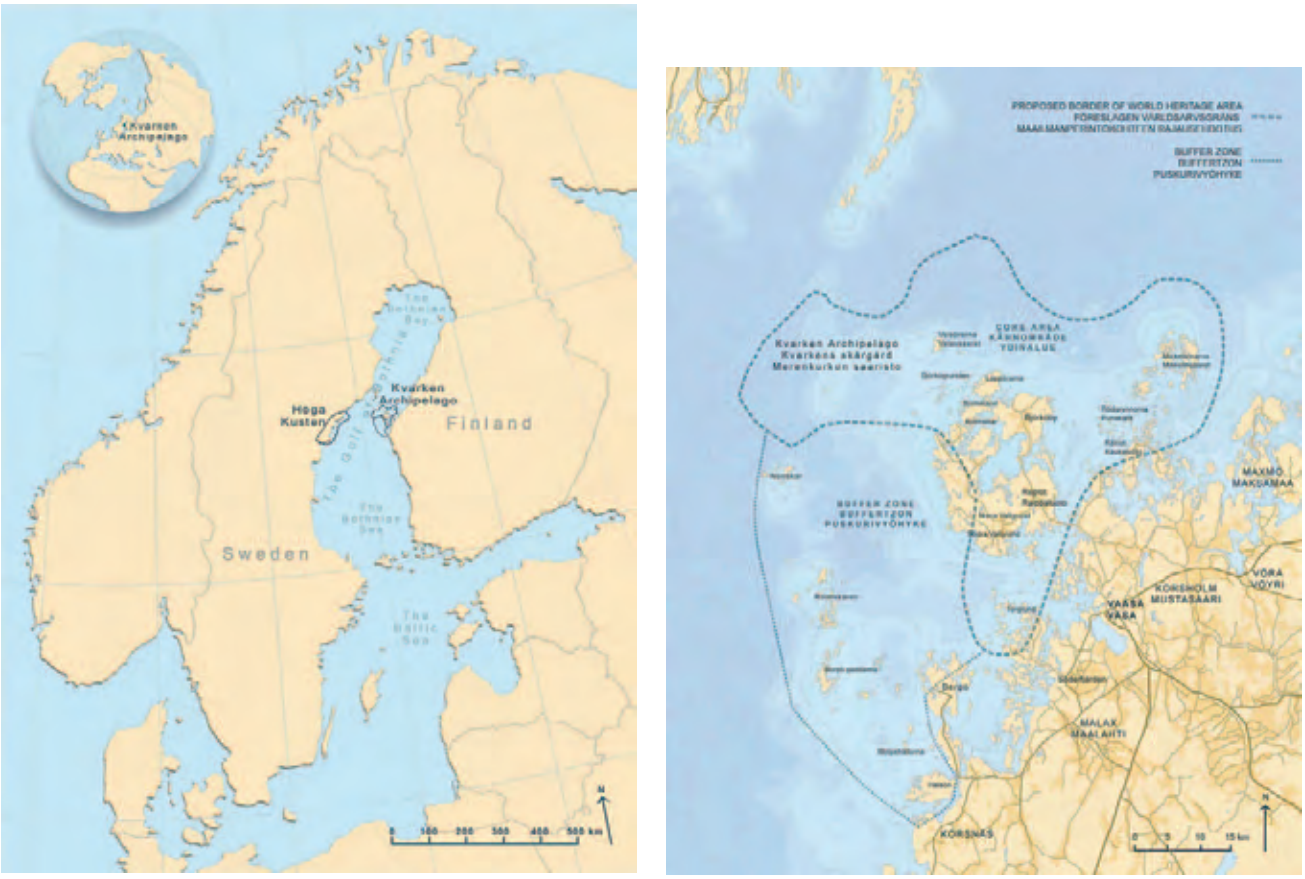

Figure 1. Location of the proposed world heritage area (Ollqvist & Rinkineva-Kantola 2004).

The bathymetry of this area has changed considerably since the last deglaciation, mainly due to the relatively strong land uplift. At present, the Northern Kvarken is very shallow (0-25 m) and shoaly, but during and just after the last deglaciation (around 10,000 years ago) it was submerged 250 – 280 meters. Today, there are about 7000 islands and islets, a large number of peninsulas and bays, and extensive stony seashores in the Kvarken Archipelago area. The total shore length is about 3000 km and the land increase in the area is about 100 ha/year based on calculations from 1:20 000 scale digital base maps of different ages. The highest hill peak (17,5 m.a.s.l.) is situated on Replot Island.

During the last glaciation, the Northern Kvarken was located close to the centre of the Weichselian ice sheet, which reached ~ 2800 m thickness during the glacial maximum (Svendsen et al 2004). The islands of the region are smooth, glacially eroded, low rocky islands, which are characterized by till boulders on the shores. Also typical for the very special landscape of the Kvarken area are boulder-rich ridges, or so-called De Geer moraines. On the Swedish side of the Northern Kvarken, the shoreline is steeper and the archipelago smaller with just a few islands.

GEOLOGICAL FEATURES OF THE KVARKEN ARCHIPELAGO

QUATERNARY DEPOSITS

- Quaternary deposits consist of young mainly glacial sediments approx. 13 000 – 10 000 BP years old. Maximum thickness up to 100 m, average 10 m.
- Complex deglaciation pattern with several active ice-flow stages.
- Main soil types are glacial till, boulder fields and marine/littoral sediments and young organic sediments like gyttja and peat.
- Typical glacial formations are De Geer moraines and large traversal “Rogen type” moraines, which form large moraine fields with thousands of formations. Also, some hummocky moraine fields and minor drumlins occur.
- Rapid glacial isostatic land uplift (8 – 9 mm/y) and new land emerges from under the sea with an area of 100 ha/year.

BEDROCK

- The hard crystalline bedrock belongs to the Precambrian Svecofennian schist belt.
- The bedrock consists mainly of gneiss, diatexite, granites and diabase.
- The history of bedrock contains 11 different phases, aging from 1,9 Ga to 520 Ma.
- Palaeozoic sediments began to deposit on the eroded Precambrian peneplain 520 million years ago.
- The main part of these sediments is also missing (due to peneplanation erosion processes).

Quaternary deposits

The Earth's youngest period, the Quaternary, which has lasted for 2.6 million years, is characterized by alternating glacial and interglacial stages. The term Quaternary deposit in Finnish geologic stratigraphy refers to the loose overburden on the surface of the Earth. Most of the Quaternary deposit were formed during and after the latest, Weichselian glaciation, some 13 000 – 10 000 years ago in the Kvarken area. At that time, the depth of the ancient Baltic Sea in the Kvarken area was approximately 250 – 280 m.

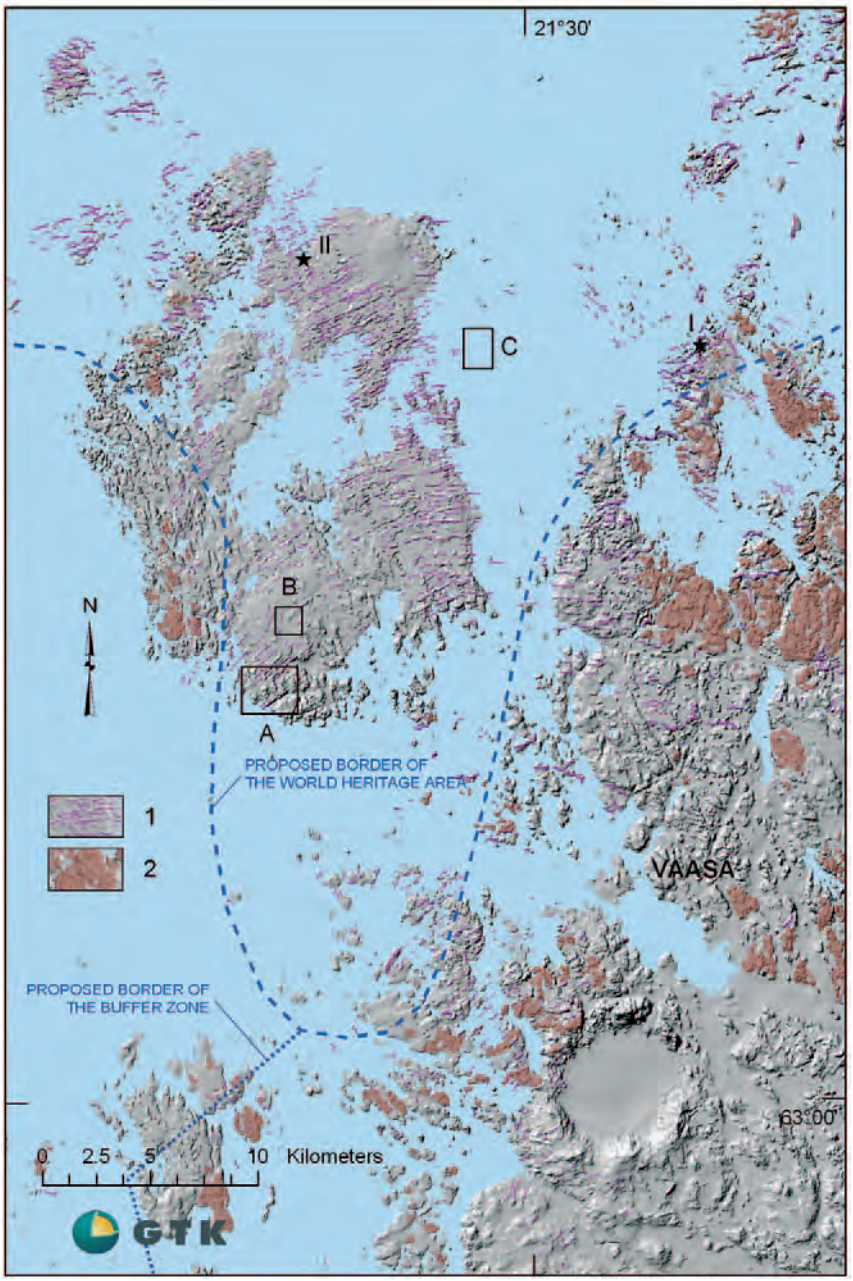

Figure 2. The diverging of the de Geer moraine and large transversal moraine ridge clusters in the north shown by geographical elevation model. The Söderfjärden meteorite impact crater is shown near Vaasa in the southern part of the image.
1 = de Geer moraine and large transversal moraine ridge, 2 = hummocky moraine, A = location of a map of different moraine fields (Figure 3). B = location of the Storslätmossen peat bog (Figure 17). C = location of the marine geological map (Figure 28). Star dots I and II = locations of excavations on moraine ridges (Figure 10 and Figure 12), (compilation Miikka Paalijärvi).

The classification of Quaternary deposits according to genesis and the environment in which they were formed consists of two main groups: glacial and postglacial. An ice sheet or its melt water formed glacial deposits. This group includes till, glaciofluvial sediments, and glacial clay. Postglacial deposits (clay, silt, gyttja, peat, marine/littoral sediments) were formed independently of the melting of an ice sheet.

Geologic mapping of Quaternary deposits

The detailed settings and composition of Quaternary deposits and formations is surveyed by geologic mapping of Quaternary deposits to a 1:20 000 scale. The mapping is based on interpretation of aerial stereo photographs and revisions from the field. Also, digital processing and digital 3D interpretation is used. The size of the area of one soil type is 2 hectares minimum and mapping depth is one meter based on the use of a steel stick. By excavations, drillings, laboratory analysis and geophysical surveys, more detailed information of texture and structure of different formations is investigated. Quaternary deposit formations like eskers, drumlins, De Geer moraine ridges, and hummocks are mapped with special consideration. Special features like potholes, caves, kettle holes, and raised beaches are documented. Some extra observations of striations, road or gravel pit cuttings are also done along with the mapping. An example of a detailed Quaternary deposit map is shown in Figure 3 where the De Geer moraines form a tight field with 100 to 200 meter intervals between separate formations.

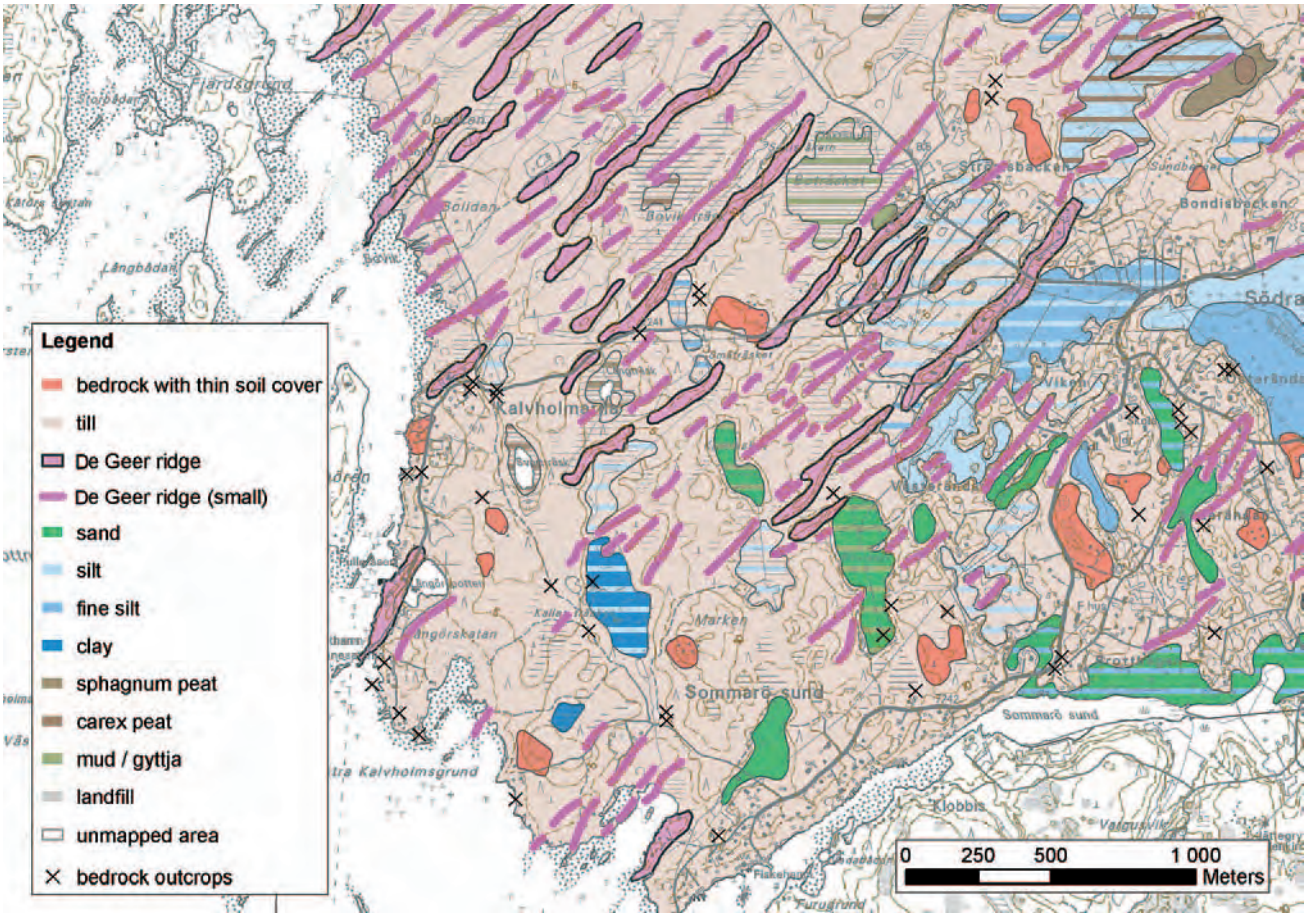

Figure 3. An example of Quaternary deposits map from Replot (location A in figure 2, compilation Jukka Ojalainen).

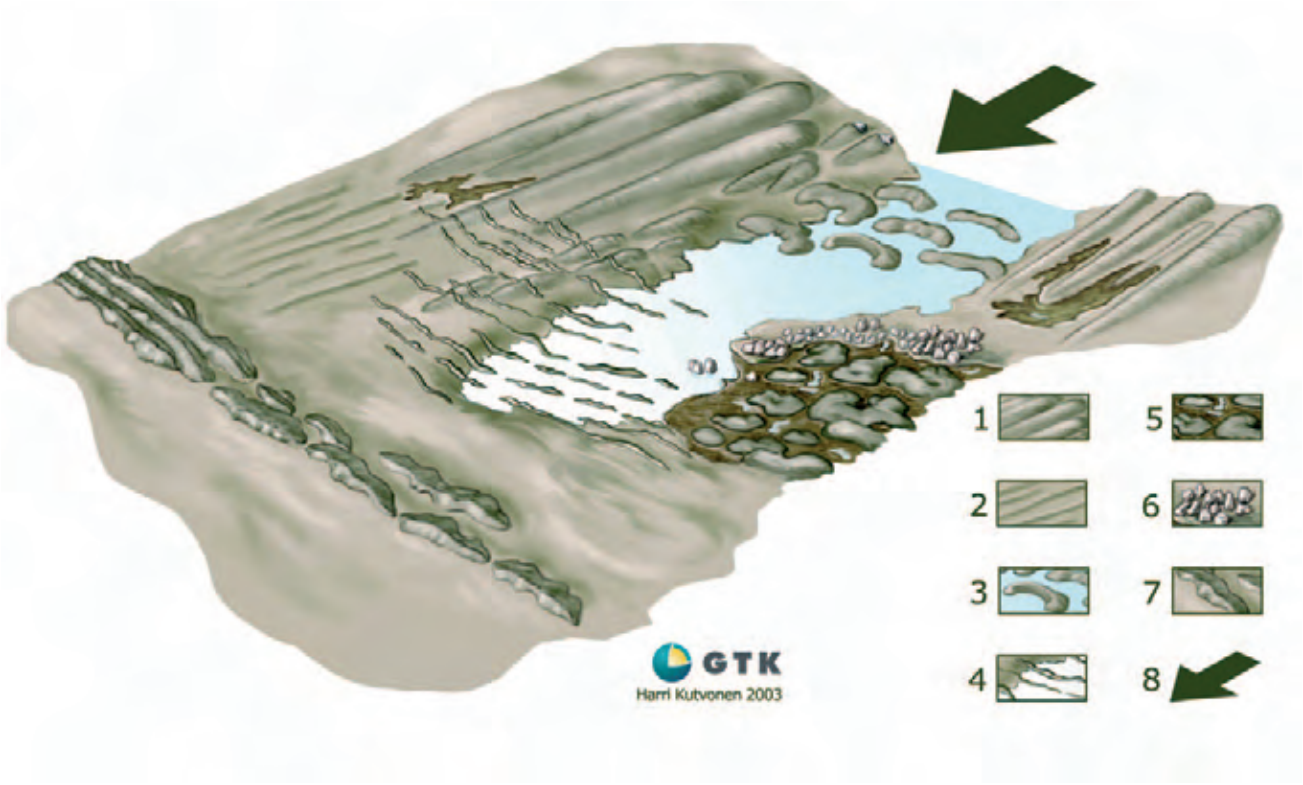

Figure 4. Schematic figure of the moraine formations in the Kvarken area. 1=Drumlins, 2=Flutings, 3=Large transversal moraines (Rogen type), 4=De Geer moraines, 5=Hummocky moraines, 6=Boulder-rich surface, 7=End moraines, 8=Latest ice flow direction (drawing Harri Kutvonen).

Glacial formations

The most widespread surficial and seafloor sedimentary deposit in the Kvarken area is glacial till and its moraine formations. Till consists of varying amounts of boulders, stones, gravel, sand, silt and clay. Till generally lies directly on the bedrock and largely follows its surface configuration. Till also commonly forms its own surficial configurations like various moraine ridges and hummocks (Figure 4). Numerous De Geer moraines are a specific feature of the Kvarken Archipelago. The best area to study De Geer moraines is in the Björkö Svedjehamn area (Figure 5).

Moraines parallel to the ice direction

A drumlin is an oval-shaped ridge formed beneath an ice-sheet as it moved over the terrain. Drumlins and drumlinoid formations are often found in groups and the ridges may extend for several kilometers. Drumlins are composed of basal till or lodgement till.

Fluting ridges are either depositional or erosional small glacial features on the basal till surfaces, indicating the last ice flow direction.

Both drumlins and flutings form a small field at Norra Vallgrund where the younger transversal moraines cover the streamlined parallel moraine forms.

Figure 5. Helicopter view of the De Geer Moraines. Björkö Svedjehamn (photo Arto Hämäläinen 2000).

Figure 6. Typical shape of De Geer moraine ridge, proximal side on the right (photo Jukka-Pekka Palmu 2002).

Moraines parallel to the ice margin

End moraines belong to this class and may either be large or small, short or long. The end moraines were formed along the ice margin and often have an asymmetrical shape with a gentle stoss-side and a steeper lee-side. A closely related type of moraine, the De Geer moraine, occurs in clusters in lowland areas (Figures 5 and 6). Earlier, it was thought that the moraines were formed at the ice margin and were a type of end moraine. De Geer moraines are most commonly till ridges up to 5 m high, from 10-50 m wide and a couple of hundred meters long. In rare instances, the height exceeds 5 m and length 1000 m. The moraines occur at 40 – 300 m intervals in large groups, mostly in low-lying landscape areas. The Replot and Björkö areas in the Kvarken Archipelago are the best examples of clusters of De Geer moraines in Finland (Aartolahti 1988).

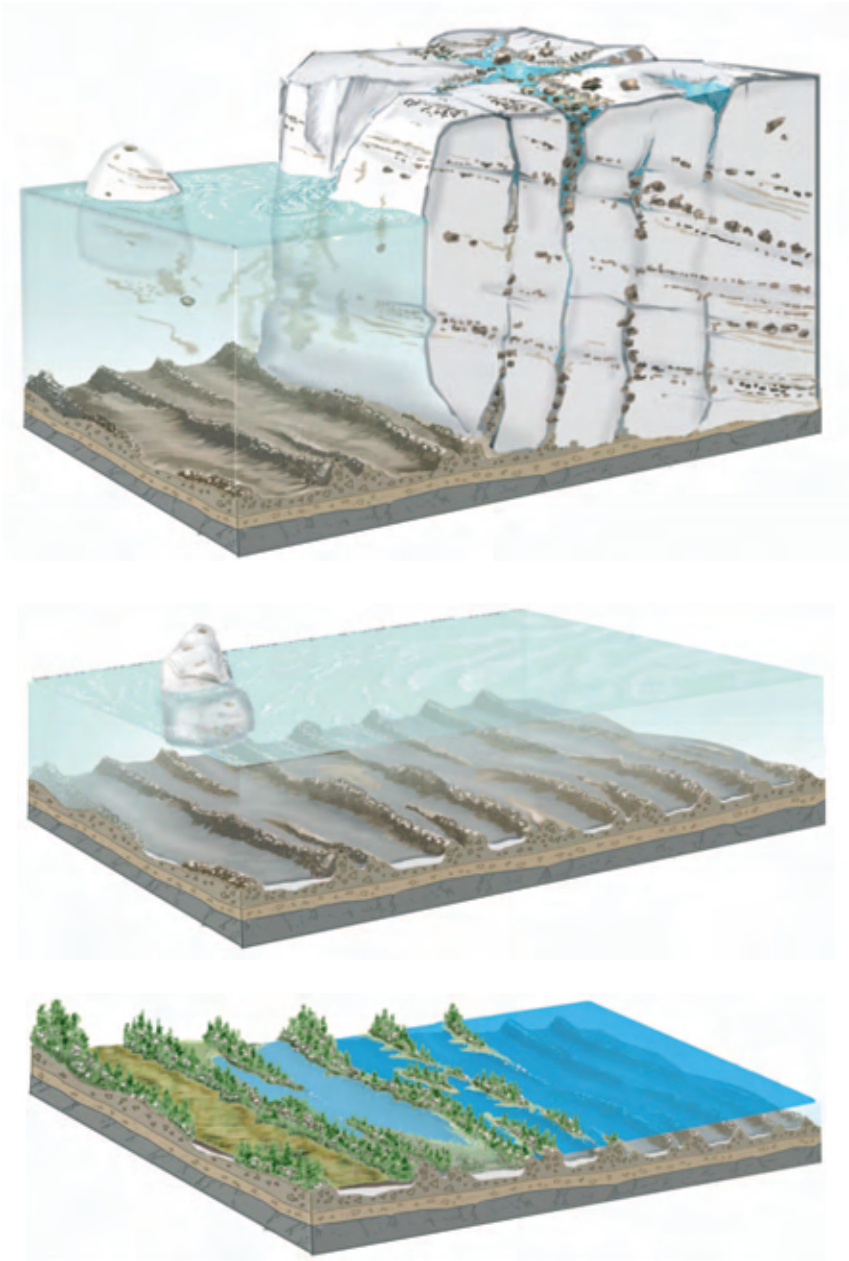

Figure 7. The origin and genesis of De Geer moraines (drawings by Harri Kutvonen 2003).

In the Kvarken Archipelago area, the amount of De Geer moraine ridges is greatest and they occur in very compact formation swarms. The width of the formations is often over 50 m and the formations are symmetrical (Laaksonen 1994). In some areas, the formations seem to be related or deposited on top of drumlin forms and other hummock moraine forms like large transversal Rogen type ridges. In the Märaskär and Köklot areas, De Geer moraines are deposited on top of larger Rogen type moraine formations and the log axis of both moraine formations forms a network pattern in the terrain and archipelago. Laaksonen (1994) put forward a competing hypothesis of stabile laminar basal flow of ice as an explanation of the wave like pattern and symmetric forms of the De Geer moraines and swarms. It is evident that both De Geer moraines, transverse basal till ridges (Rogen type moraines) and radial streamlined moraine ridges (drumlins) occur in the same area of Replot and Björkö islands. There may also be a connection between the clusters of De Geer moraines and tectonic features (Lundqvist 2000). The De Geer moraine formation were first described in Sweden by De Geer (1889) and called De Geer moraines by Hoppe (1957) or washboard moraines by Mawdsley (1936).

In the case of the Kvarken Archipelago, the water depth during deglaciation and formation of the moraine ridges was 250-280 m. According to the current moraine genesis explanation, the moraine ridges were formed in the crevasses running parallel to the ice margin in sub -aquatic conditions. Huge icebergs calved at the ice front and the De Geer moraine reflects the probable position of the retreating ice margin (Figure 7).

Hummocky moraines

Hummocky moraines principally occur in valleys and in flat-lying areas. Hummocky moraines are irregular and non-oriented formations, usually 5-20 m high, and form a mosaic of lakes, tarns, and peatlands. The moraines were deposited in the Kvarken area beneath the melting and thinning glacier front in sub-aquatic conditions. Material in these formations is usually washed and coarse grained till (melt out till). Most of the hummocky moraine formations were deposited in the final stage of the last deglaciation. In a way, they witness the non-oriented deposition of till material during the formation of De Geer moraines (unclear). In some localities, the texture of the faulted and fissured glacier front can be seen in the hummocky relief. Some hummocks are just heaps of till that were deposited, squeezed or that flowed in a crevasse or cavity beneath the melting glacier.

A Rogen moraine is a type of hummocky moraine, characterized by ridges that are irregular in detail but largely at right angles to the direction in which the ice was moving. Rogen type moraines are often composed of basal till or lodgement till and deposited clearly in sub glacial conditions probably in the same zones as the drumlins. Transversal basal till ridges occurs in swarms and often inside drumlin fields. Some Rogen type moraine formations in the Kvarken area have developed elongated tails parallel to the last ice flow directions, thus showing a relationship to the drumlin forming processes. Rogen-like transversal moraine formations occur in the Köklot, Mickelsörarna and Valsörarna areas.

The drumlins and large transversal moraine ridges (Rogen type) were formed below the ice sheet, some 20 – 200 km inside ice margin. At that time, huge ice lobes filled the Bothnian Bay area and the ice flow was roughly south-southeast as shown by striations and drumlin orientations on maps (comp. Bargel et al. 1999). The term hummocky moraine is used to describe all kinds of moraine hummocks. Cuts in the moraines and documentations of the sections give tools for a more detailed classification. In recent investigations, new evidence of complex ice flow directions have been discovered (Geonat 2004). Therefore, the Kvarken Archipelago might become one of the key areas for understanding the Early and Mid phases of Weichselian glaciation.

One striking phenomenon in the Kvarken Archipelago is the boulder rich till surfaces even in shallow sea areas, like in the Iskmo Lillön area, Halsön Island and the Bergö Gaddarna rocky islets (Figure 8). Some of the boulders are huge erratics transported by flowing glacier ice or floating icebergs in the Ancylus Lake. The granitic rock types are susceptible to intensive cubic cracking and thus large boulders and erratics are easily carried by the glacier from rock outcrops and possible preglacial inselberg or tor like bedrock formations. This boulder rich undulating moraine terrain is an example of glaciomarine subaquatic till deposition and represents the youngest till deposit and moraines in the area.

Figure 8. View of a rocky terrain in Korsnäs Archipelago (photo Hans Hästbacka).

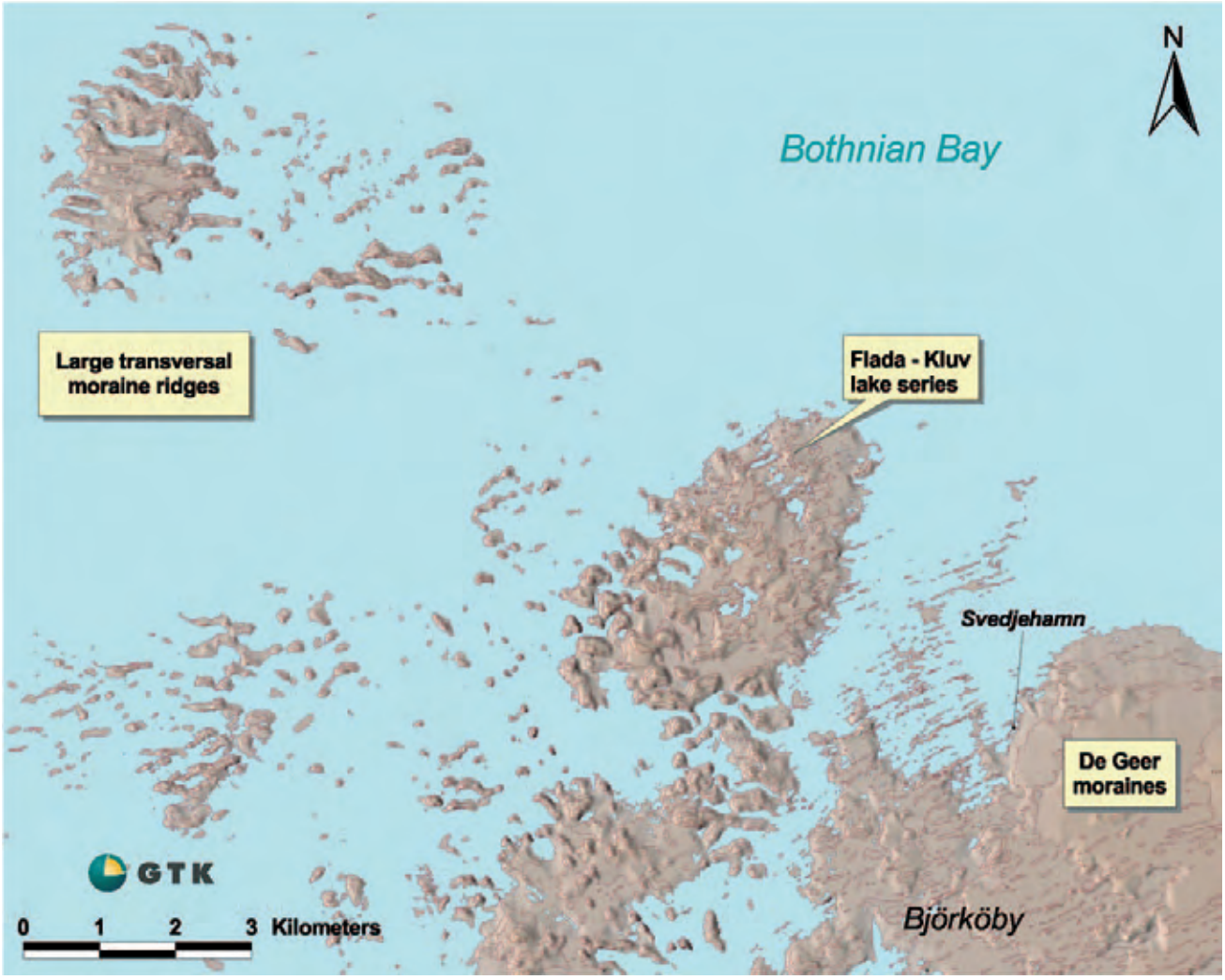

Figure 9. Shaded relief map from the northwest part of the Björkö Island showing an example of the De Geer moraines, large transversal moraine ridges and the Flada – Kluv lake series. Shape of the large transversal moraine ridges is sometimes winding, which is clear evidence of the complexity of the deglaciation pattern of the area (DEM National Land Survey of Finland, processing Olli Breilin).

Structure of the De Geer moraine and large transversal moraine ridge at Björköby and Köklot

Three representative moraine formations in the GEONAT research area were chosen for further studies. The Björkö Skagback De Geer moraine formation represents a well-shaped prominent higher moraine ridge with a smooth proximal side and steeply dipping distal side. Two test pits and one trench were excavated in this formation. The Björkö Ohls De Geer moraine formation represents a lower moraine ridge were the proximal and distal sides are both smoothly dipping (location II in Figure 2). One study trench was excavated in this formation. Both De Geer ridges are located within the Björköby De Geer moraine field where the terrain is covered with numerous higher and lower moraine ridges at less than 100- meter intervals. The third chosen formation at Köklot Furuskäret represents larger, more prominent transversal moraine formations of Rogen type (location I in Figure 2). De Geer moraine formations are on a transversal position and overlie the larger Köklot moraines especially north from Köklot in the Mickelsörarna area.

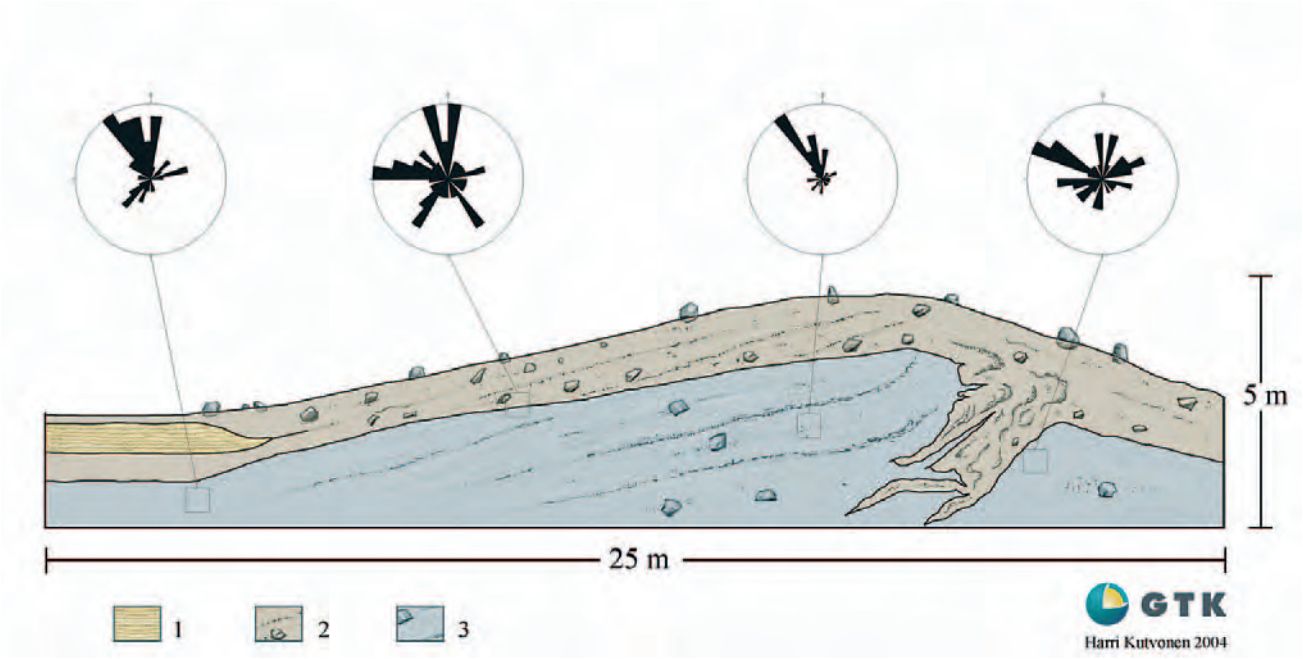

Figure 10. Schematic cross section from test pit excavated in the low-lying De Geer moraine Björkö Ohls (see Figure 11). Ice flow direction from left to right in drawing. 1= sandy loam, 2= melt out till with deformation structures and 3= basal till with some deformation structure (location II in Figure 2, drawing Harri Kutvonen).

Three test pits were excavated in the formation at Köklot. The cuttings and trenches in the Björkö Skagback and Björkö Ohls De Geer moraine formations revealed that both lodgement till and melt out till are present in the formations. The till fabric in both moraine types showed relatively good preferred orientation along the latest ice flow direction though some fabric analyses also showed transversal peaks or were not oriented (Figure 10).

The structure of the till material shows that shearing and deformation was present during the depositional process. Shear planes, glaciotectonic folds, thrust structures and good preferred orientation in the till fabric shows the presence of actively flowing ice and deposition in a subglacial environment. The texture of the till material is a matrix supported in the lodgement type till and both the matrix and clast were supported in the melt out till type, which also shows sorting of sand and gravel material. The sorting and coarser texture of the melt out till type demonstrates the presence of water in the depositional process. The petrographic composition of the till types in the Björkö formations shows quite similar transport conditions in both formations and moraines and results are typical of subglacial basal tills.

Results of the excavations of the larger Köklot Furuskäret moraine formation differ considerably from the Björkö formations. The till type in the Köklot formation is a melt out type. The structure of the till shows sorting, sandy wrappings under and over stones and boulders, abundantly sorted sandy and gravelly lenses, bed and layer structure in till and some folding and bending of the sorted layers (Figure 12). The till fabric is poorly oriented. One fabric analysis shows a northerly fabric, which coincides with younger northerly striations and De Geer moraines deposited by a northeastern ice flow. The moraine in the Köklot formation is over consolidated and was clearly deposited in subglacial conditions. The petrographic composition differs clearly from the Björköby area showing abundant granites and porfyric granodirites in the ice flow direction.

Figure 11. Excavation of the De Geer moraine at the Björkö Ohls formation. Test pit is situated across the De Geer moraine. Photo was taken from proximal to distal side of the moraine (photo Jukka Ojalainen 2003).

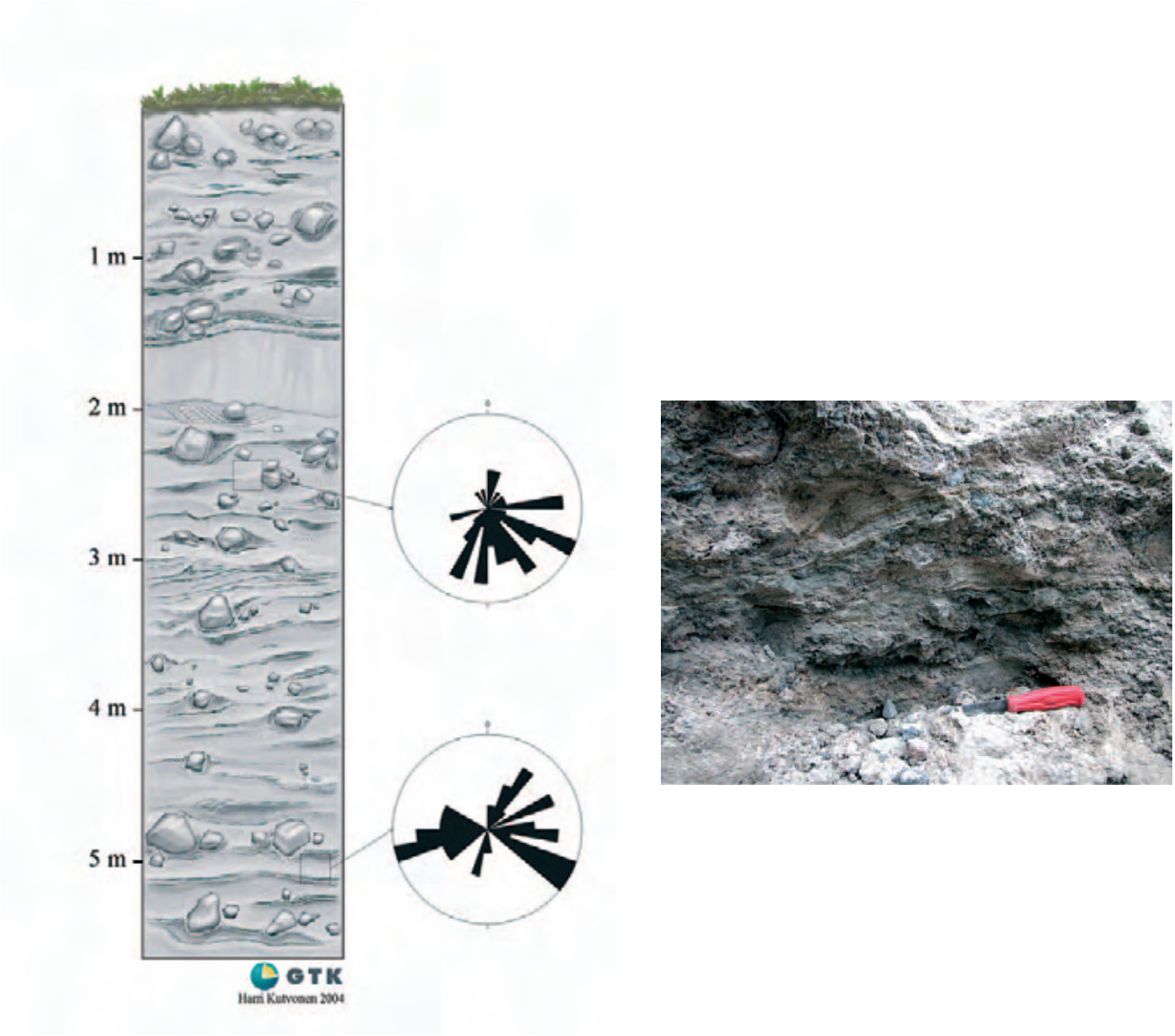

Figure 12. Schematic profile and photograph from the test pit excavated in large transversal moraine ridge in Köklot. The length of the red knife grip is 10 cm (location I in Figure 2), (drawing Harri Kutvonen, photo Jukka Ojalainen 2003).

The studied moraine formations in Björkö and Köklot are clearly of subglacial and subaquatic origin (comp. Benn and Evans 1998 p. 512-514). The Björkö De Geer moraine formations shows actively flowing, deforming and pushing behavior of the ice edge rather than the melting, loading and convoluting, crevasse fill phenomena of subglacial ice crevasses (Figure 13). The depositional environment indicates sub marginal formation of parallel moraine ridges at a calving ice margin (comp. Aartolahti 1995 and Linden et al. 2004). The Köklot large transversal moraine formations show abundant subglacial melting, glacial loading, consolidating of melt out till and probably reactivation of the glacier sole. The Köklot formations probably have a complex origin and there are still riddles to be solved in these formations (comp Benn and Evans 1998 p. 437-447 and Aartolahti 1995).

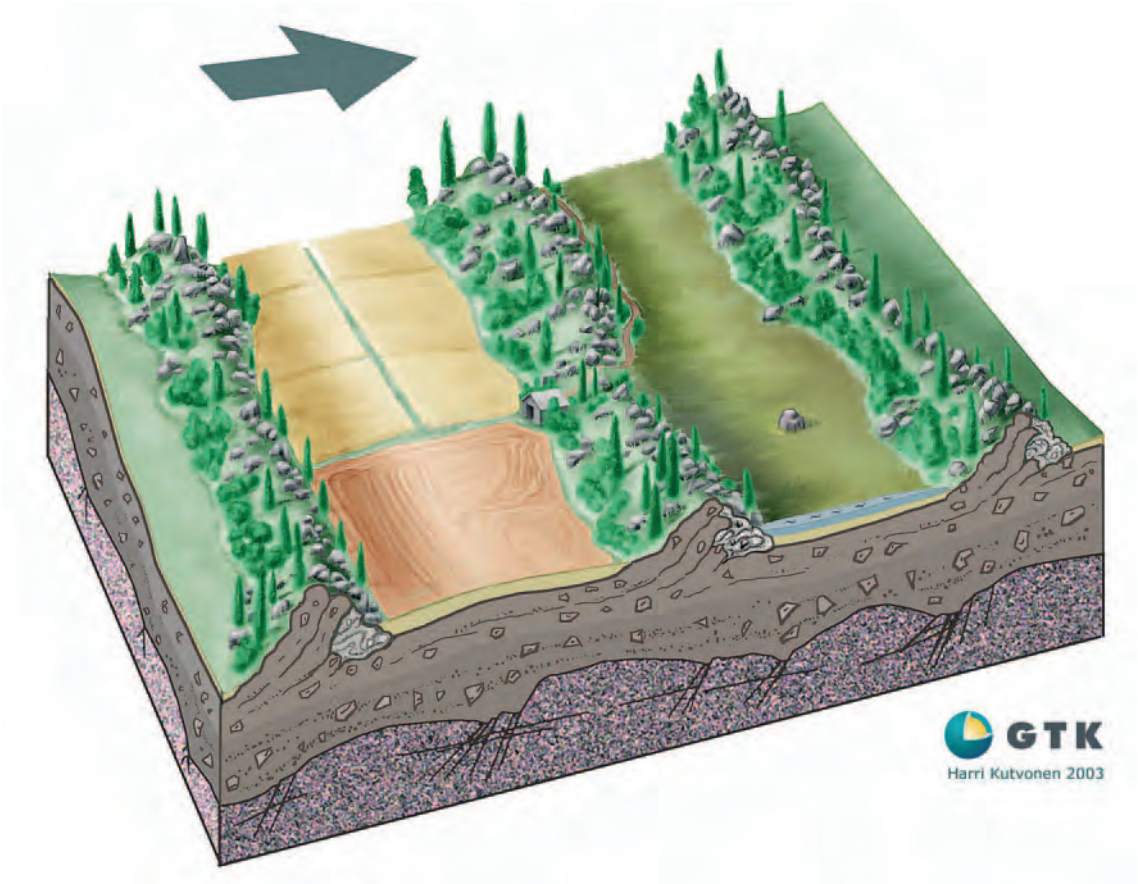

Figure 13. Schematic picture of the De Geer moraines in the Björkö area. Arrow indicates the last ice flow direction, which is perpendicular to the De Geer moraine ridges. Wedge-like brown basal moraine in the formations illustrates shearing and pushing behaviour of ice edge. Gray moraine inclusions illustrate the melt out facies of the basal till at the distal side of moraine formations (drawing Harri Kutvonen).

Figure 14. Example of Svedjehamn gyttja sample. Blue areas in sample shows vivianite – mineral, which is typical for till covered organic deposits (photo Jukka Ojalainen 2004).

Svedjehamn gyttja

Excavations at Svedjehamn, Björköby in the northern part of the archipelago discovered a new till covered organic deposit under a 3 – 4 meter thick till cover (Matti Räsänen pers. com.). A test pit was excavated at the De Geer moraine's distal site. The till cover over the organic deposit is composed of a sandy till (melt out type). After preliminary laboratory investigations, the organic deposit is interpreted to be gyttja deposited in fresh water conditions. Pollen flora is mainly Betula, representing interstadial conditions of Early- or Mid-Weichselian stages (Matti Räsänen pers. com.). The gyttja is just a few meters above the present sea level and is in the lowest topographic position compared with any other till covered organic deposit in Ostrobothnia. This deposit is clear evidence of a much lower sea level stage in the Bothnian Bay area before last glacial maximum (see Figure 26).

Glaciofluvial deposits and varved glacial sediments

Glaciofluvial sediment consists of boulders, stones, gravel and sand that has been transported, sorted and deposited by melt water from the inland ice. Glaciofluvial sediment is stratified in layers with one or several particle sizes and the particles are usually rounded.

The shape of the deposits depends on the environment in which they were formed. The melt water in the inland ice formed strongly flowing rivers in tunnels emerging at the margin of the ice. The finer material, silt and clay, was deposited at greater distances from the mouth of the subglacial river. Few glaciofluvial eskers appear in the Kvarken area on land or seafloor in the Mickelsörarna area. Eskers are a long, ridge-shaped glaciofluvial deposit that was formed in a tunnel in the continental ice sheet.

Figure 15. Littoral wave washing and sea ice pushing with glacial isostatic land uplift have enclosed a fisherman's old boat harbour (photo Olli Breilin 2004).

Glacial clay

During the melting of the continental ice sheet, the finest particles of glaciofluvial origin, clay, were dispersed in the sea and in large lakes. These particles formed clays with varying properties.

In freshwater, the particles remained suspended for long periods and sedimentation took place slowly. Depending on the seasonal changes in the melting of the ice, and thus in the flow of water, there was a regular change in the rate of sedimentation. During the spring and summer, the flow of water in the glacial rivers was great and large amounts of clay and silt particles were transported. The supply of sediment during autumn and winter was, on the other hand, low. Thus, a thicker and a thinner layer together formed an annual varve. The winter layer is usually darker in colour than the summer layer and has higher clay content. Dropstones and other iceberg-transported material are occasionally found in clay profiles.

In saline water, the sedimentation of clay took place faster on account of the electrolytic properties of the saline water and consequently, there is no clear varve pattern. In the peneplain of Ostrobothnia, the clay sediments make the terrain really flat as smaller valleys and the roughness of the glacially sculptured terrain are covered and filled. The youngest layers of the marine strata are muddy clays that make the soil fertile. Thus, most of the clay and mud areas are cultivated fields and pastures forming the cultural landscape “the archipelago of thousands barns” that is typical of the Vaasa region.

Figure 16. Top part of a large transversal moraine ridge has been submerged under the sea. Due to strong littoral wave washing, the fine sediments are washed away and copples and boulders remain (photo Olli Breilin 2004).

Postglacial sediments

Land uplift exposed older deposits to the influence of wave washing and there was a more or less complete re-stratification. Wave-washed material was deposited along and close to shorelines as shingle, gravel and sand with decreasing particle size away from the shore. Alluvial sediments are deposited as banks along the reaches of the river or as a delta at the river mouth.

The youngest sediments and deposits in the Kvarken Archipelago area are shallow peatlands and recent mud/clay deposits. Most of the peat deposits are less than one meter deep. The first stage in the Kvarken area peatland development is minerotrophic sedge peat accumulation, which is rich in herb plant subfossils in strata and luxurious vegetation on the surface. On peatlands more than 1000 years old and located 10 m above sea level, Sphagnum peat is dominate and the peatlands are of raised bog type. At Replot Island, the peat bog growth is very fast, with two meters of peat build up in less than 900 years.

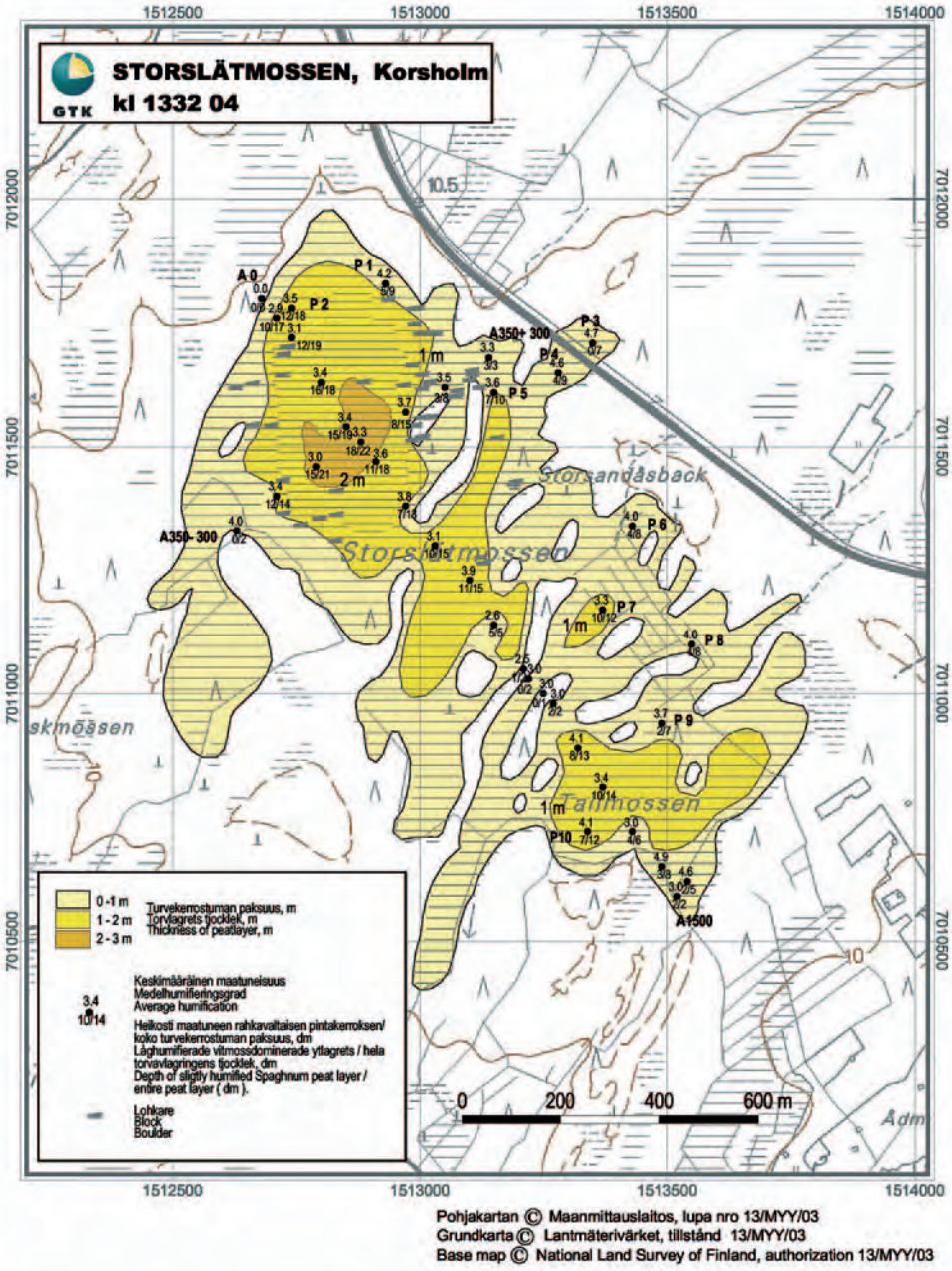

Figure 17. Map of the Storslätmossen peat bog, which is the largest and deepest peat bog on the island of Replot. The location of the map is marked with B in figure 2 (GTK).

An outstanding example of organic deposits is the Storslätmossen Sphagnum bog, which is situated in the western part of Björkö Island near Södra Vallgrund (Figures 17 and 18). In the lower profile, the peat consists of Carex and in upper profile Sphagnum moss. At the bottom of the peat layer (2,4 m), the calibrated C-14 age is 819 +/- 25 years B.P. The bottom of the bog is currently approximately 8,6 m.a.s.l. This means that the area has emerged from the Bothnian Bay Sea approximately 1200 years ago (Figure 24). Based on peat age and the thickness of the peat layer, the annual peat growth rate has been 3 mm, which is a record peat growth rate in Finland.

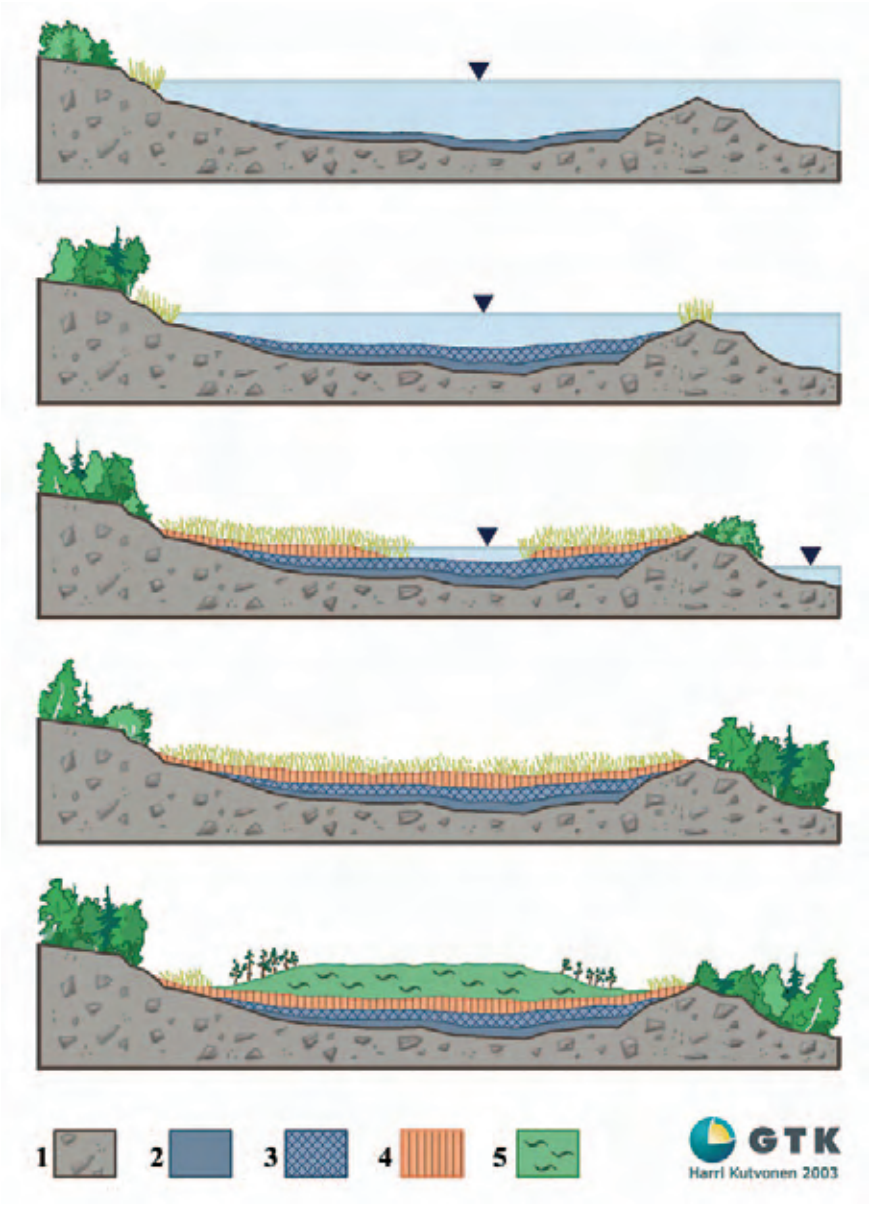

Figure 18. The evolution of the Storslätmossen peat bog. A schematic picture of different phases of the peat bog development on Replot Island. Legend: 1) till, 2) silt and clay, 3) gyttja, 4) Carex peat, 5) Sphagnum peat. (Drawing Harri Kutvonen and Carl-Göran Stén).

One very rare example of peat forming processes can be followed on Lappörarna Island. Small lakes and ponds (Flada – Kluv lake series) become separated from the sea and peat-forming plants gradually fill the ponds with peat moss finally occupying the depression. The whole island is in a pristine natural stage and as such, a very valuable natural area. In Lappörarna, the postglacial history of the Baltic Sea area can be experienced on a small scale as a powerful ongoing dynamic process (Figure 9).

Complex Ice flow pattern in the Kvarken Archipelago

Based on field observations, the phenomena of weak glacial erosion and complex ice flow pattern in the Kvarken Archipelago are strong (Geonat 2004). Evidence of these phenomena is formed in different phases of glaciations. Part of striae and the Svedjehamn organic layer could be of Mid or Early Weichselian age. Field observations of several boulder fields show that rock types are local and in many cases boulder fields are interpreted as erosional remains. This supports the theory of weak glacial erosion in the Kvarken area.

Glacial striaes

On fresh outcrops, glacial striaes are clearly seen in shore areas of thousands of islands and islets (Figure 19). Faceted, polished surface also appear in some outcrops. Based on field observations of these glacial striae (Figure 20), ice flow direction has been between 330° – 80° degrees. In the same

Figure 19. Crossed glacial striaes (350° – 65°) on a bedrock outcrop on Storskäret Island. Direction of the GPS receiver is 65° (photo Olli Breilin 2003).

outcrops, the angle of different directions could be nearly 90° degrees. Also, a direction near 360° degrees has been observed. In some outcrops, the youngest and oldest directions are not same through the area (Geonat 2003, 2004). In some outcrops, the youngest direction is 40° - 65° and in some outcrops 335° – 360°.

Geomorphology

De Geer moraines and large transversal moraine ridges are the main formations of the Quaternary deposits in the Kvarken Archipelago. The direction of the longitudinal axis of moraine formations is complex, which supports the complex glacial striae directions (Figure 9). Moraines overlying each other can be seen in some areas. The angle of overlying formations could be up to 90° degrees in northeast parts of the Mickelsörarna area of the archipelago. On the Swedish side, the deglaciation morphology is different. The main feature is a large and intensive drumlin field, which continues from the mainland to the sea bottom (Geonat 2003). The morphology of the sea bottom changes rapidly from drumlin fields to De Geer and large transversal moraine fields approximately 5 km east of Holmö Island on the Swedish coast.

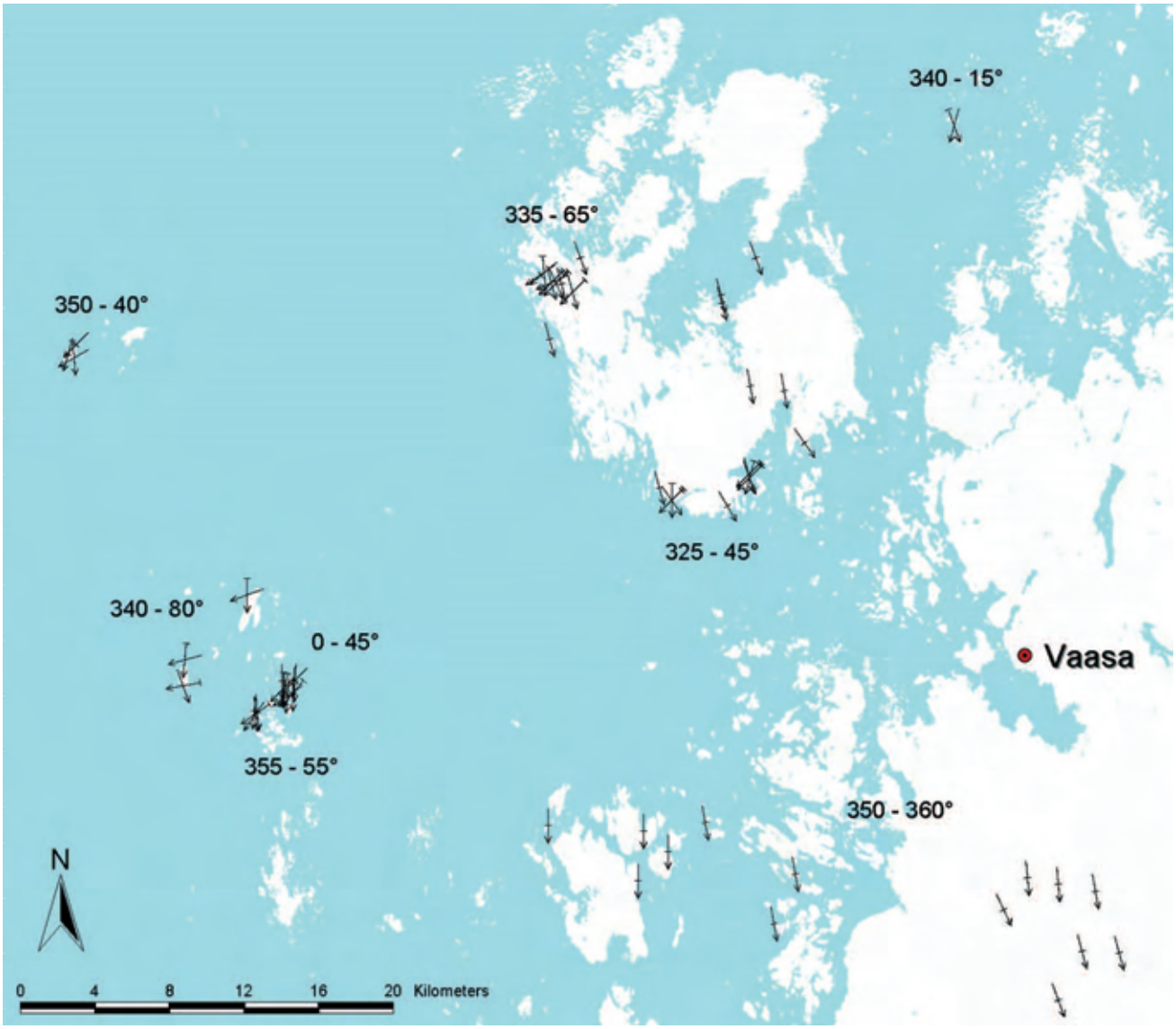

Figure 20. Location and direction of glacial striations at Kvarken Archipelago (compilation Jukka Ojalainen, Geonat 2003).

Deglaciation and development of the Baltic Sea

The heavy load of the approximately 2 800 meters of thick ice depressed the Earth´s crust at least 800 m below its present position (Svendsen et al 2004). As soon as the pressure started to decrease, the crust began to slowly rebound. The highest situated traces of the shoreline (the highest shoreline) are at different altitudes throughout Scandinavia, depending on how deep the crust was depressed, how much the sea had risen, and the time when the area became ice-free. During deglaciation, low-lying areas were covered by seawater (Figure 21). The nearest supraglacial areas are in the Lauhavuori Mountains in southern Ostrobothnia, where the highest shoreline is 203 m.a.s.l. and in the High Coast area on the Swedish east coast, where the highest shoreline is 293 m.a.s.l. Based on these observations, the depth of the sea was approximately 250 – 280 m at the Kvarken Archipelago just after deglaciation. The Baltic Ice Lake and Yoldia Sea stages never reached the Kvarken Archipelago area due to the continental ice sheet. In recent years, research on the last phases of glaciations has been conducted to construct a new deglaciation model (Lunkka et al 2004).

Ancylus Lake stage 10 700-9 000 years ago

The Ancylus Lake stage lasted from 10 700 to 9 000 years ago. The lowest clay strata are glacial clays with clear varved texture, typical of the sedimentation in a glacial basin. Fracturing of the floating ice front and calving of icebergs were typical of glacial lacustrine conditions during the beginning of the Ancylus Lake stage. According to current concepts, deglaciation still continued in the Kvarken area during the Ancylus Lake stage. The sediments that were deposited in the Kvarken area were mostly homogenous gray clays and black sulphid bearing clays. The highest shorelines on the Ostrobothnian side of the Kvarken area are all from the beginning of the Ancylus Lake stage between 190-210 m.a.s.l. (Glückert et al 1993).

It was earlier thought that the De Geer moraines and their clusters were also deposited in an annual deglaciation rhythm. Later studies, especially varved clay chronology, showed that deglaciation at beginning of the Ancylus Lake stage in the Kvarken area was rapid, between 200-500 m annually. Thus, moraine ridges that occur in intervals less than 100 m imply the formation of several moraine ridges in a single year (Zilliacus 1987, Aartolahti et al 1995).

Litorina Sea stage 8000 years ago – present stage

At the end of Ancylus Lake stage, rising global ocean level resulted in an opening through the Danish straits to the ocean causing fresh water conditions to gradually become brackish. In the sedimentary record, the onset of the Litorina Sea stage is defined over the whole Baltic Sea area. In the clay strata, the arrival of brackish water at the transition to the Litorina Sea stage is marked by an exceptionally sharp litostratigraphic boundary, indicating a dynamic change in the hydrographic conditions of the Baltic Sea. The widely spread greenish mud rich in organic matter, methane gas and saline diatom flora was deposited on the bottom of Litorina Sea. Today, these sediments are the most fertile agricultural areas in the coastal land of the Bothnian Bay area. All ancient shore marks and beach deposits on the Finnish side of Kvarken area date back to the Litorina Sea stage less than 7000 years BP (Winterhalter et al. 1981).

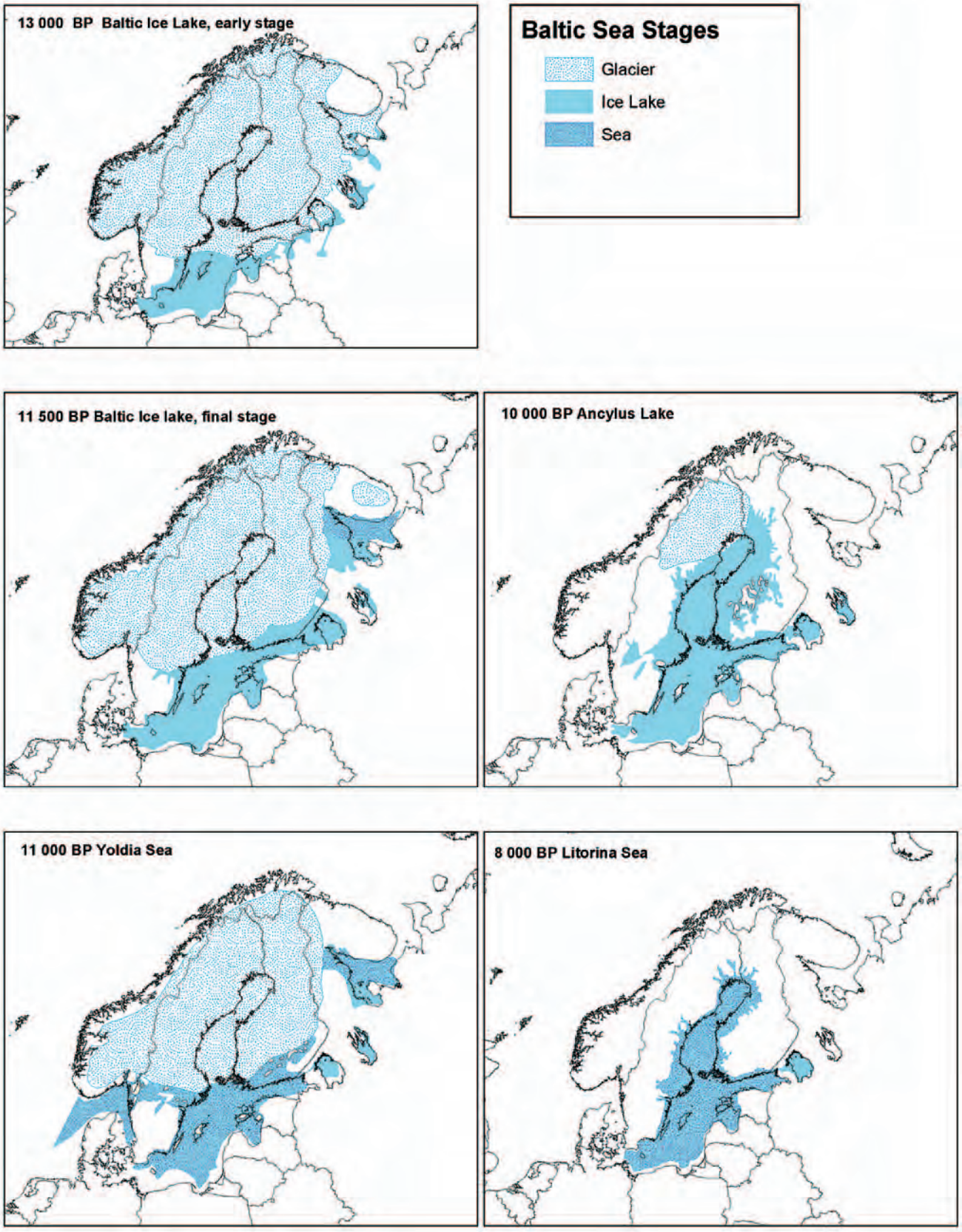

Figure 21. Evolution of the Baltic Sea (Saarnisto 2003, drawing Olli Sallasmaa).

Land uplift – historic, present and future

Land uplift studies have a long and respectable history in Finland and Sweden. Changes in shoreline during a human lifetime can be easily observed and had been noticed early. The writer Zachris TOPELIUS depicted late 19th Century the land uplift thus:

"Most noticeable are the effects of this, partly still unexplained, phenomenon. The land rises from the sea, the sea flees, shores are exposed, and the slope is moving forward. Where in days of old ships were sailing, now hardly a ship can travel; where once the fisherman cast his net, now his cows go grazing on the coastal meadow. Banks and rocks appear out of the water, of which no sea chart has had knowledge before; banks expand into islets, these grow together and connect with the mainland. Beaches expand; harbours dry up, seaports must move after the fleeing sea. Every generation of men, new arable land rises from the sea, every century grants Finland a kingdom" (Edlund 1893).

One encounters many a renowned scientist's name in the field of land uplift research, like the Swede Gerard DE GEER who proved land uplift to be a residual rebound phenomenon from the ice age Finnish geologist Wilhelm RAMSAY, who separated conceptually the isostatic land uplift and the eustatic change of sea level from each other (The Finnish Geodetic Institute, http://www.fgi.fi/yleis/historia_eng.html).

The total depression of the earth surfaces is calculated at 800-1000 m (Taipale & Saarnisto 1990, Eriksson & Henkel 1994, Kakkuri & Virkki 2004). It is assumed that the land uplift will continue some 10 000 to 12 500 years in the Kvarken area and it will still probably result in 100-125 m of isostatic land uplift (Kakkuri 1991). So the uplift will continue until the depression of the geoid is reversed or the next oncoming glaciation begins to load and submerge the Earth's crust in the Kvarken area. The sub-aquatic Kvarken area is a shallow sill with a maximum water depth of 30 m. According to the shore level displacement curve, the sill will be just a strip of water in about 2 500 years (Figures 22 and 23).

The land uplift had already begun during the melting and thinning of ice 15 000 years ago during the glacial retreat from the Baltic area. During the first thousand years, the land uplift in the deglaciated areas was calculated to be up to 10 m in 100 years or 100mm/ year (Saarnisto 1981). According to the latest Weichselian ice sheet LGM models, the maximum thickness of the ice had been approximately 2 800 m (Svendsen et al 2004).

The isostatic land uplift creates not only new land but also many practical problems for the northern Kvarken area. All old harbours are, at present, dry land. The Vaasa-Korsholm harbour that was founded in 12th century is situated 10 km inland from the present Vaskiluoto harbour that was founded in 1890. New land emerges from the shallow sea at a rate of several hectares for individual villages per year. For example, in Replot and Björkö villages 35 hectares of land emerges annually. It is estimated that the total new land gain is approximately 7 square kilometres along the Finnish coast (Kakkuri & Virkki 2004).

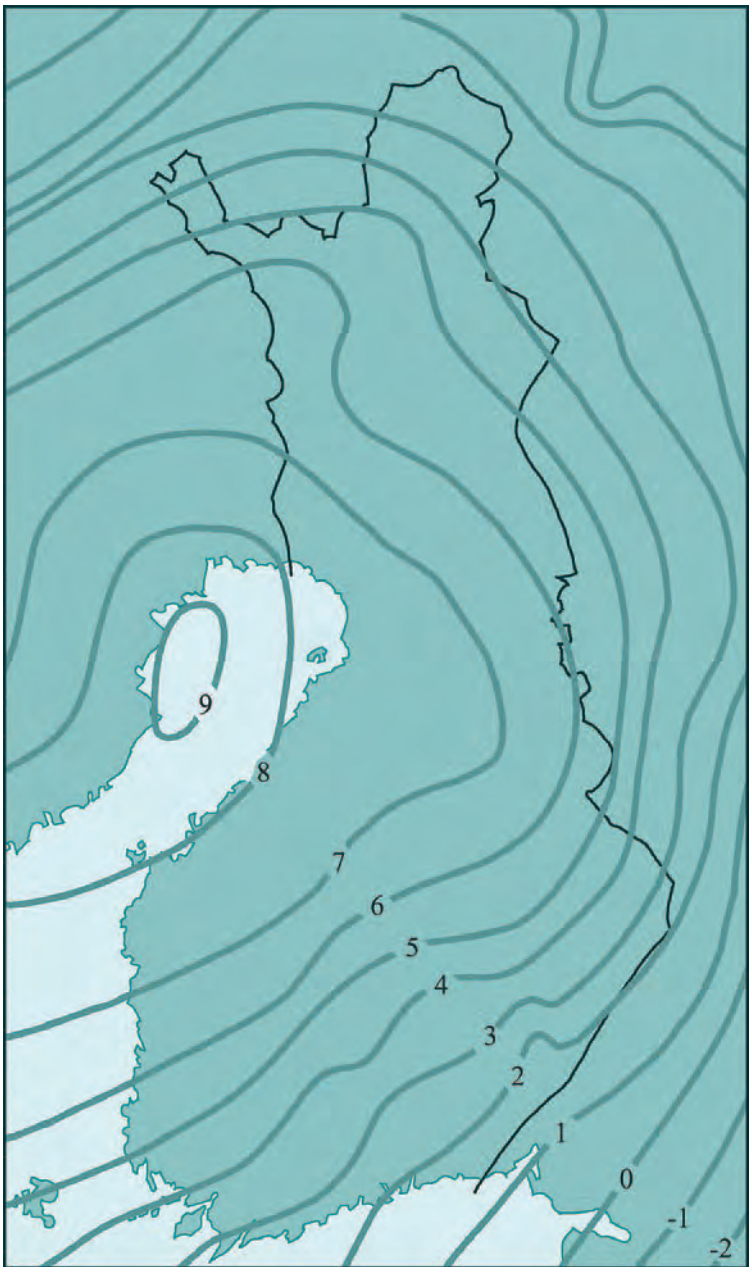

Figure 22. Present isobases of land uplift (mm per year) in Eastern and Central Scandinavia (National Board of Survey 1990, drawing Harri Kutvonen)

Also, the construction of deeper harbour basins and canals is a continuous struggle against sea and marine routes that are becoming shallower. A typical phenomenon is summer cottages and their boat shelters lying far inland from the present day shallow shoreline of many low lying islands and peninsulas along the Finnish side of the Kvarken area (see Osala 1988). The land virtually rises from the shallow sea during the span of a human's lifetime. At first, some elongated boulder rich ridges and reefs emerge and seabirds begin nesting there, then the moraine ridges grow together to form elongated bushy moraine islands and finally close into small lagoons. The new soil is fertile and plant cover appears to become established on the shores almost immediately. As land uplift continues, the lagoons become separated from the sea and develop as freshwater ponds or "fladas" and lakes that occasionally get saline intrusions of flooding water from the sea during stormy days. As the vegetation occupies the freshwater ponds wetland development begins, which continues to form raised peatlands in a span of thousand years.

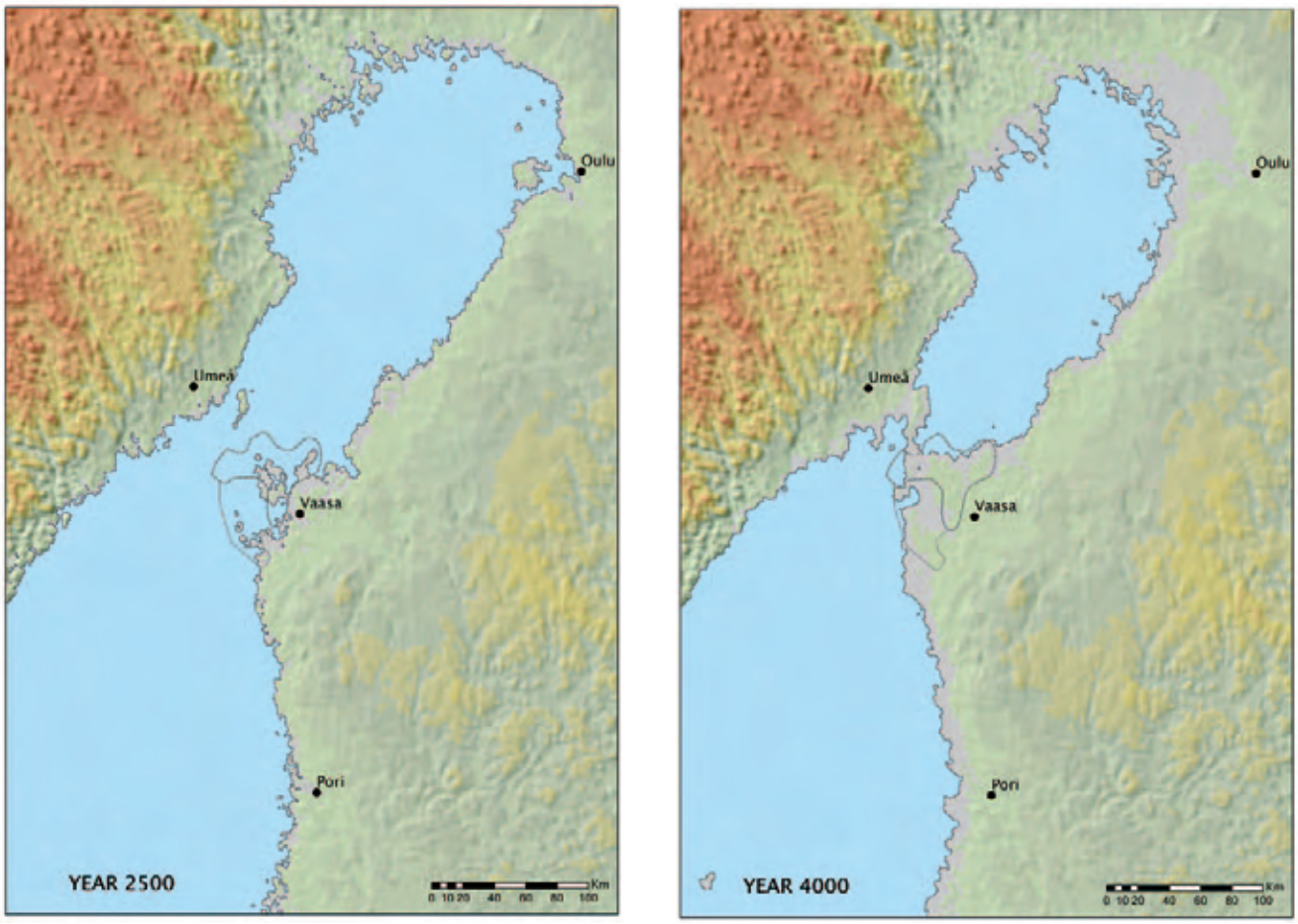

Figure 23. Future of the Bothnian Bay, the northern part of the Baltic Sea. (DEM Seifert et al 2001, processing Hanna Virkki).

The current relative uplift is about 8.0 mm on the Finnish side of Kvarken area and about 8.5 mm on the Swedish side according to the current postglacial land uplift information from three precise surveys in Finland (Ekman 1996, Mäkinen & Saaranen 1998) (Figure 22). On the basis of gravimetric surveys of the Geodetic Institute, the Fennoskandian land uplift is associated with some mass flow in the deep mantle layers of the Earth. When, for example, the land uplift in the Vaasa area in relation to the centre of the Earth is approximately 10 mm/y, gravity has diminished in 26 years (0.24×10×26 microgals), or about 0.06 milligals (The Finnish Geodetic Institute, http://www.fgi.fi/yleis/historia_eng.html).

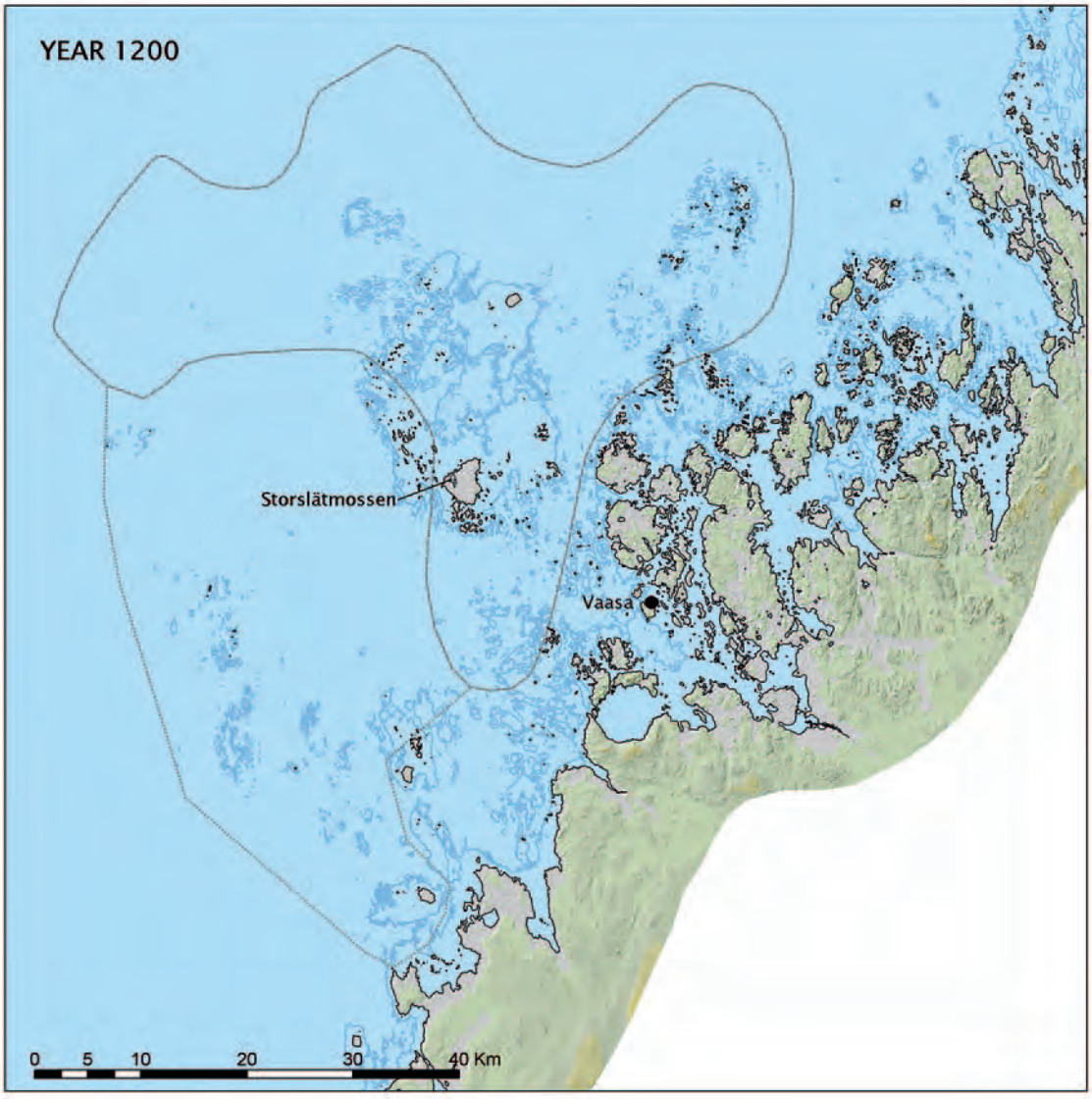

Figure 24. Map showing the shoreline when Storslätmossen – peat bog started to grow (Figure 17). The present shoreline is also shown with a darker line (DEM Seifert et al 2001, processing Hanna Virkki).

Marine geology of the Kvarken Archipelago

The narrowest part of the Gulf of Bothnia, Kvarken area, forms a submarine sill (25 m) that separates the Bothnian Sea in the south from the Bothnian Bay in the north. The Kvarken Archipelago also includes areas outside the sill where greater depths occur sparsely (>83 m). Due to the relatively rapid land uplift, the bathymetry of the Kvarken Archipelago has changed dramatically since the last deglaciation. The majority of the Kvarken Archipelago is very shallow (0-25 m) and shoaly. The fairways are shallow, boulder-rich, and mostly less than 10 meters deep. During, and just after the last deglaciation (around 10,000 years ago), the archipelago was submerged more than 200 m.

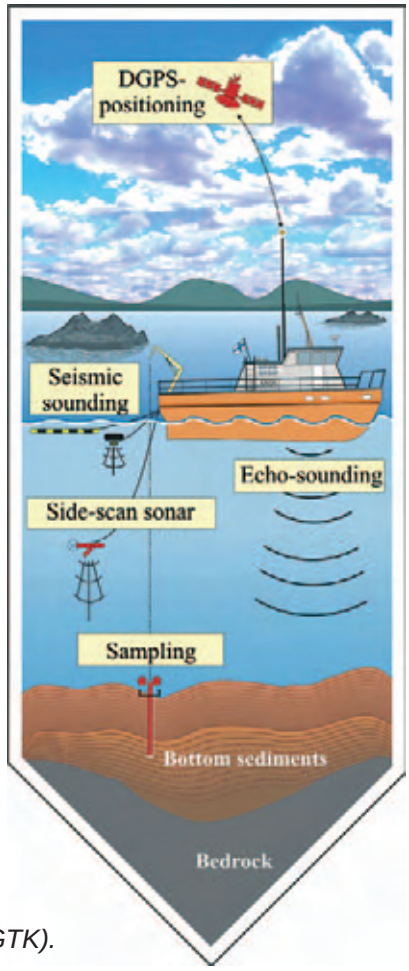

Figure 25. Marine geological survey methods (GTK).

Seafloor geologic information was obtained using acoustic-seismic investigation methods and sediment sampling (Figure 25). Acoustic-seismic methods used include echo sounding (MeriData MD 28 kHz transmitters); single-channel seismic reflection (Electro Magnetic implosion type sound source, ELMA, 400-700 Hz, depth resolution of ± 2 m) and side scan sonar (Klein SA 350, 100 kHz) surveys.

The seafloor morphology is characterised by tectonic lines in Vaasa granite, and hummocky and De Geer moraines. The crystalline bedrock is similar on both sides of the Northern Kvarken and thus it is assumed that this is true also for the sea area, although no actual data are available (Winterhalter

2000). Sedimentary rocks exist on the seafloor of the Bothnian Bay but the rocks have not yet been found in the Kvarken Archipelago. However, Lower Cambrian sedimentary rocks occur in the coastal area (Söderfjärden), close to the city of Vaasa.

The entire Baltic Sea has undergone several glaciations during the Late Pliocene and Pleistocene (the past ~2.7 million years). During this time, the Kvarken and Baltic Sea areas have been repeatedly subjected to glacial erosion and accumulation. However, information on possible interglacial deposits in the present marine area is still very scarce. From earlier geological stages, there are indications of land uplift in the Bothnian Bay area of 100 m above present level, and a lowering of the ocean sea level would have changed the hydrography of the whole area.

The Bothnian Bay and the entire Baltic Sea were isolated from the ocean during the Early and Mid-Weichselian sub stages, 115 000- 50 000 years ago, when the ocean level was lower than it is today and the area was undergoing uplift after the Saalian and Early Weichselian glaciations (Lundqvist 1992, Lundqvist and Robertsson 1994, Nenonen 1995). Old preglacial river channels, tens of metres deep, have been found on the seafloor of the Bothnian Bay and the Bothnian Sea as extensions of present-day rivers (Tulkki 1977). The channels extend to the central parts of the marine area, to a depth of 80 m below present sea level, thus showing the probable ancient shoreline (Figure 26).

The seafloor consists mainly of till. Due to strong currents and wave action, varved clay and post-glacial clay sediments are often absent. Postglacial clays and gyttja-clays cover the sea floor only in basins, protected from current activity (Ignatius et al. 1980). According to the available data, the thickness of the Quaternary deposits in the Kvarken area is relatively low.

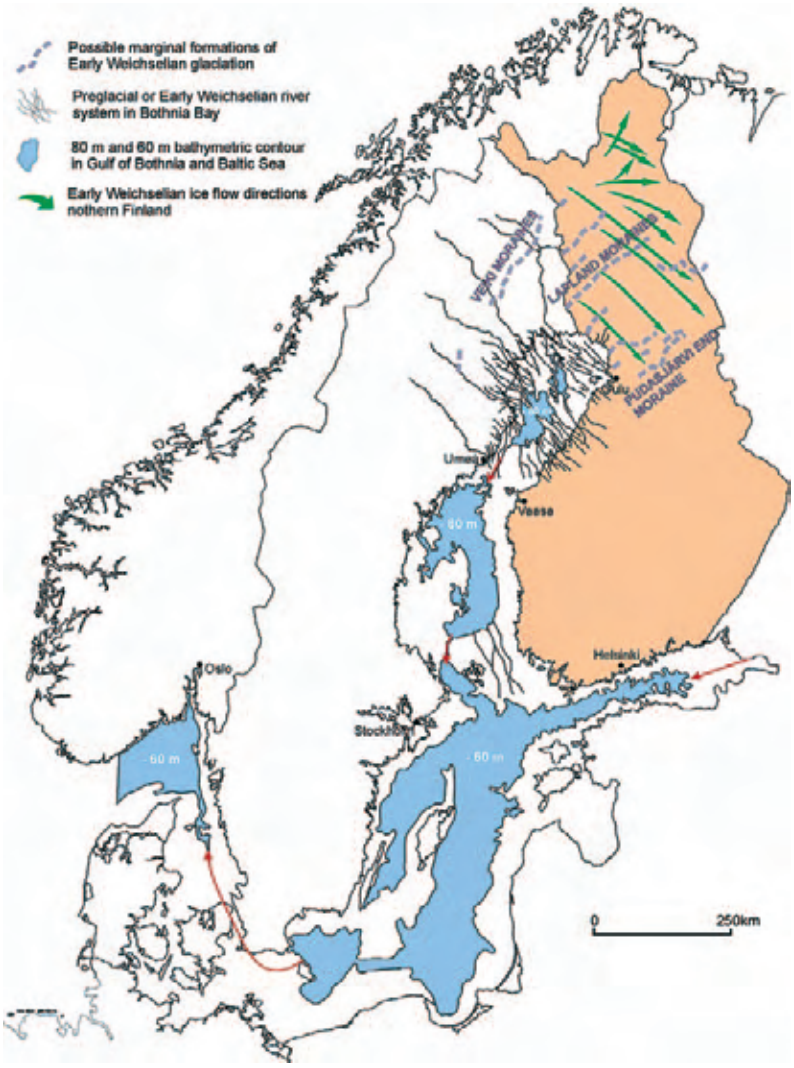

Figure 26. Bothnian Bay and Baltic Sea area during Weichselian interstadials (Nenonen 1995).

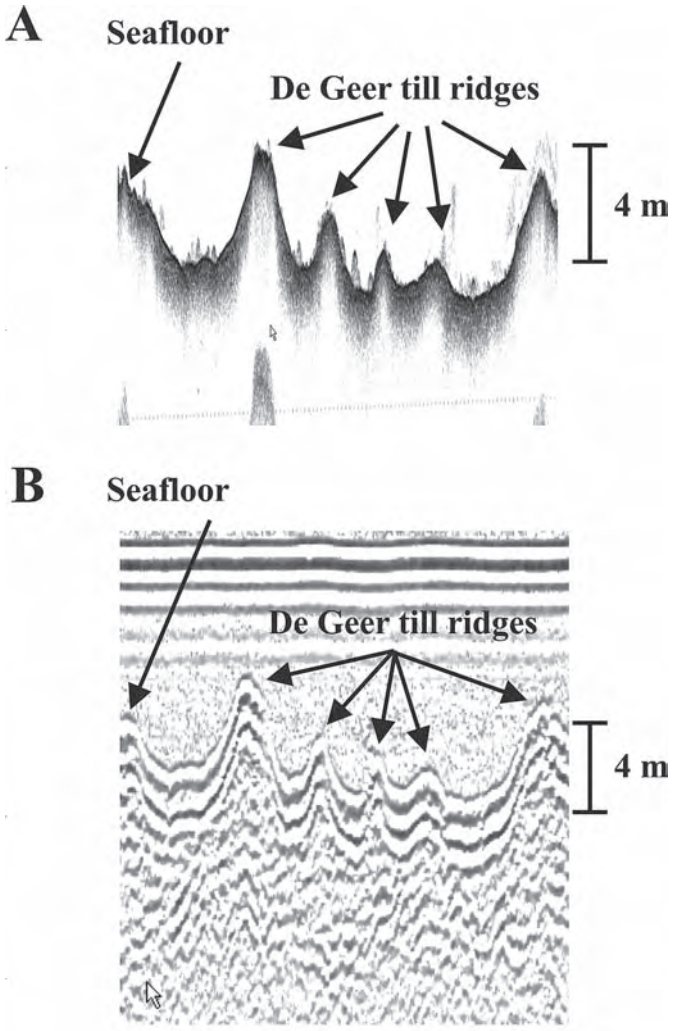

Figure 27. Echosounding (A) and acoustic reflection profiles (B) of De Geer moraines (compilation Aarno Kotilainen).

The geomorphologic feature that makes the Kvarken Archipelago unique is the occurrence of spectacular De Geer moraines (Aartolahti et al. 1995). These moraines also occur on the seafloor in the Kvarken Archipelago (Nuorteva 1988, Reijonen & Kotilainen 2004, Figures 27 and 28).

The glacial morphology of the seafloor has not undergone coastal deformation, as is the case with land areas. In the marine area, it is possible to study the nature of glacial features more or less in the state they were formed (Winterhalter 1972).

Despite the sparse occurrence of glacial and post-glacial clays in the Kvarken Archipelago, the Ancylus Lake and the Litorina Sea stages of the Baltic Sea are relatively well represented in submarine sediments of sheltered basins as shown in Figures 29 and 30. However, the latest history of the Baltic Sea is rarely recorded in submarine sediments of the Kvarken Archipelago.

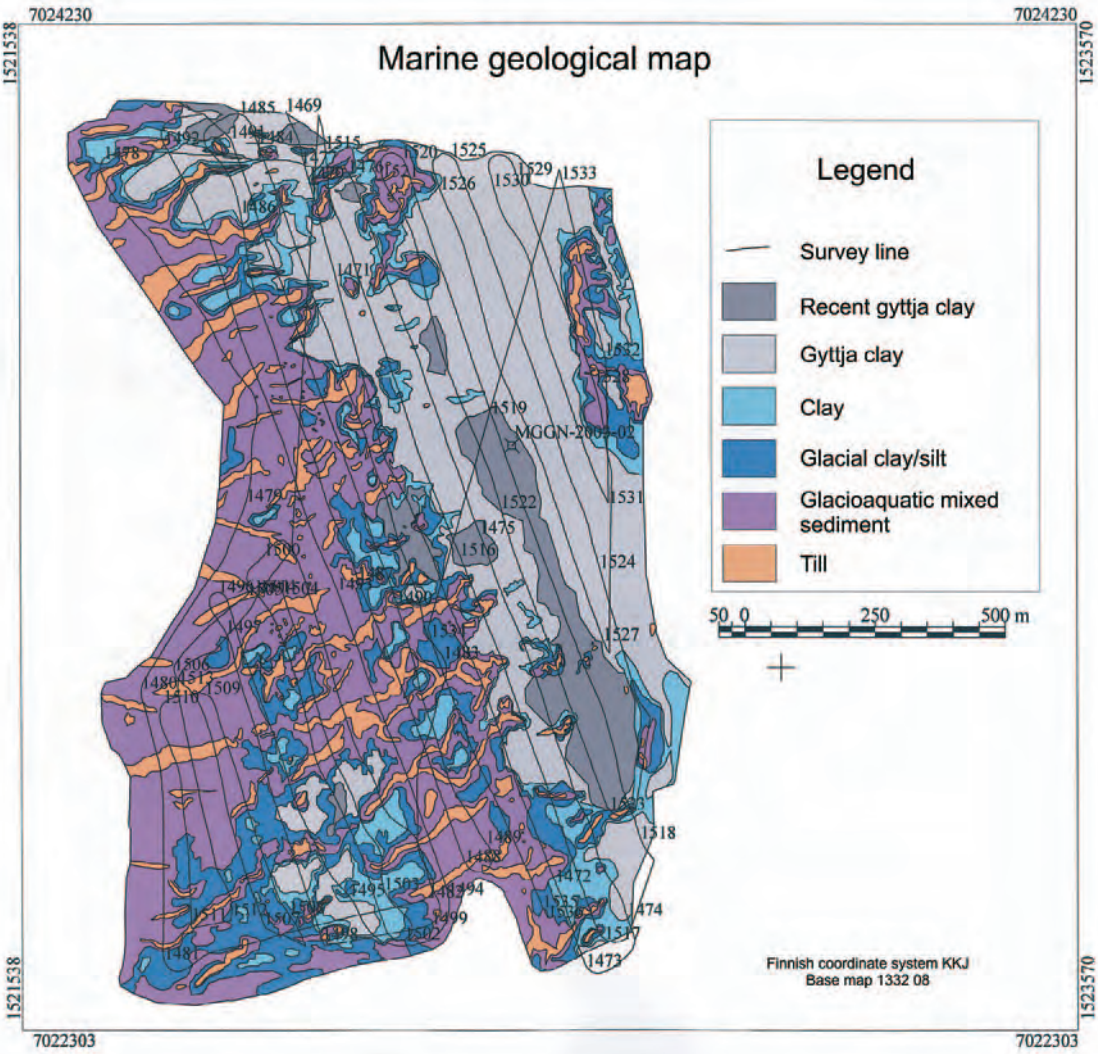

Figure 28. Example of Quaternary deposit map from sea area (water depth of 5 –12 m) of the Kvarken Archipelago (Reijonen & Kotilainen 2004). Location of the map is indicated by C in Figure 2.

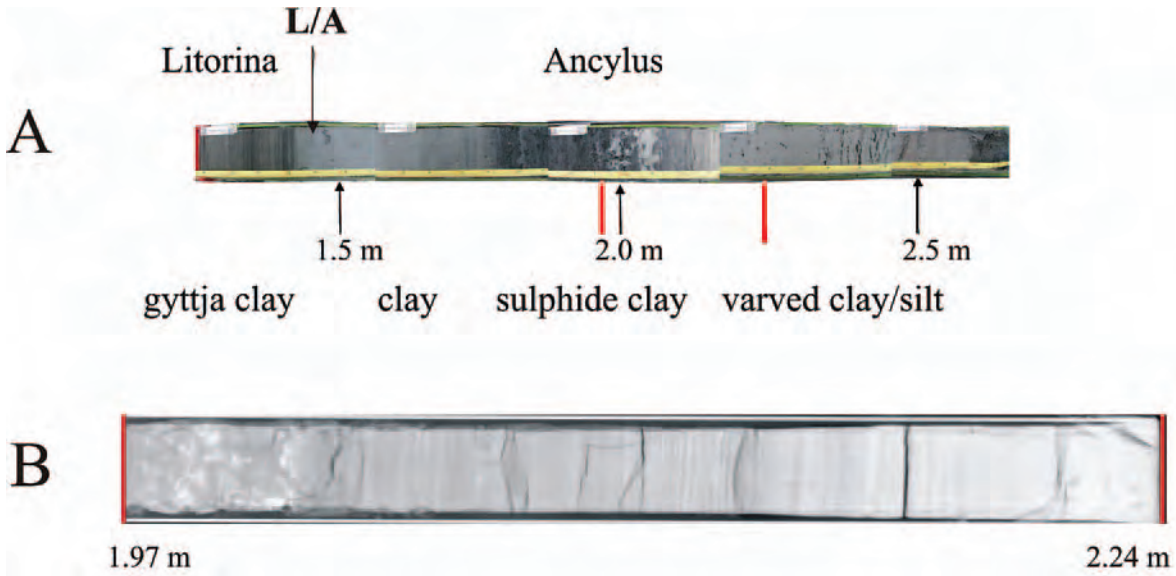

Figure 29. Early Holocene litostratigraphic in vibrohammer core MGTK-2003-14 of the Kvarken Archipelago (A). The onset of the Litorina Sea stage is indicated by L/A in figure. X-ray radiograph of sulphide clays and varved clays (1.97-2.24 metres below seafloor, red bars in figure A) is shown in Figure B. (Compilation Aarno Kotilainen).

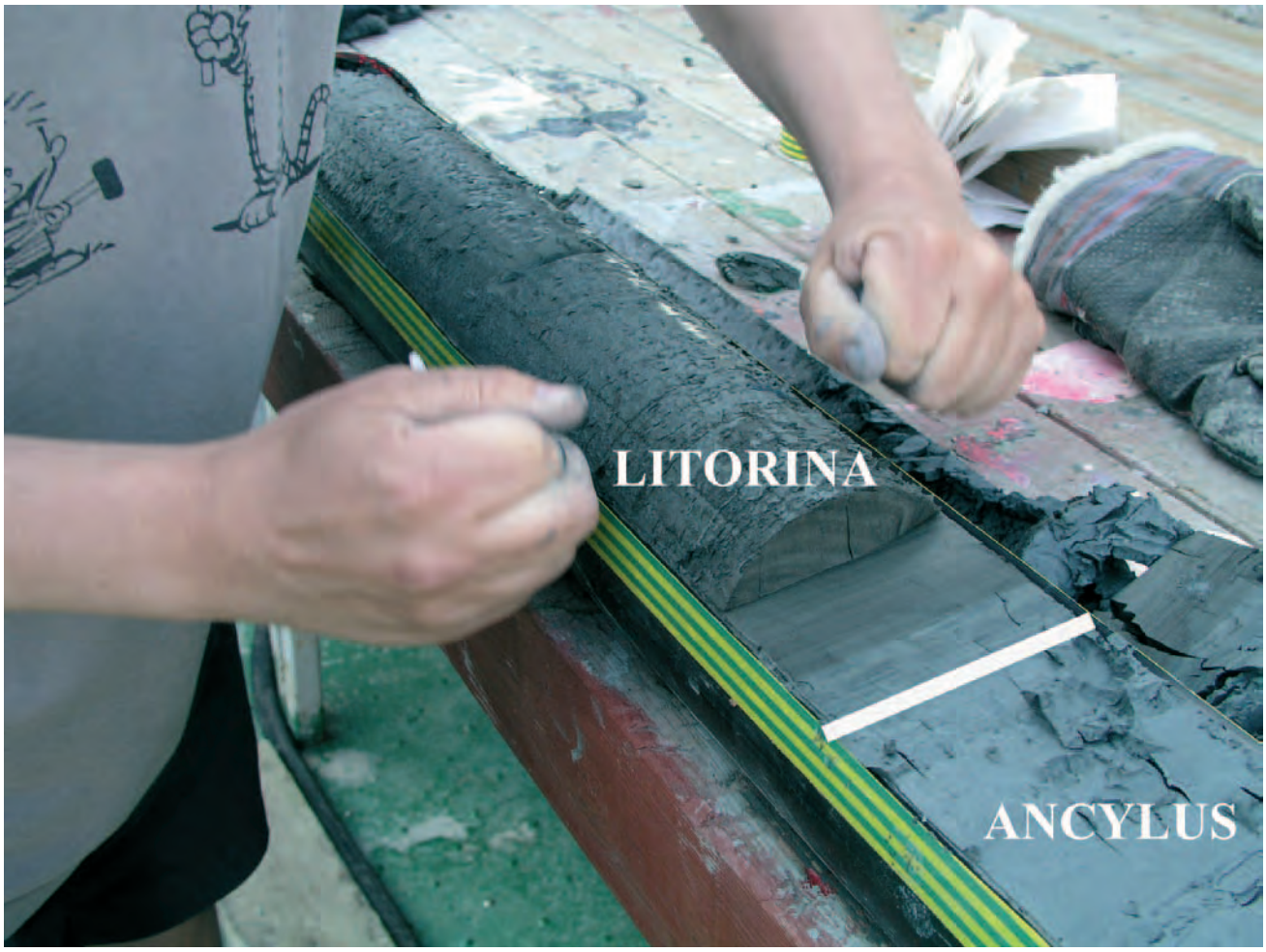

Figure 30. Splitting the sediment core onboard r/v Geola. White line in figure indicates the onset of the Litorina Sea stage in lithostratigraphy (photo Jyrki Hämäläinen 2003).

Bedrock geology

Geologic history of the Kvarken area

The bedrock of the Kvarken area belongs to the Precambrian Svecofennian schist belt and is composed of ancient, hard crystalline rock, which developed during the 700 million year (Ma) time period starting at the Paleoproterozoic, 2000 Ma ago and ending at Mesoproterozoic, c. 1300 Ma ago. On the eroded and peneplane surface of Precambrian crystalline rocks, Paleozoic sediments were deposited 520 Ma ago. The Paleozoic sedimentary blanket was eroded away over the last 500 million years to the present. Evidence of this sedimentation still can be seen in the Söderfjärden meteorite impact basin, where a pile of Paleozoic sedimentary rocks (Cambrian) tens of meters thick was preserved from erosion.

The geologic history of the crystalline rocks in the Kvarken area starts with the turbiditic sedimentation of sand and mud beds on a seafloor with an unknown basement. Volcanic rocks, lavas and pyroclastites were deposited as interbeds and minor constituents within the turbidites. Subsequently, during orogenic movements 1880 Ma ago (Svecofennian orogeny), the sedimentary pile sank about 15 kilometers deep into the earth's crust, recrystallized into mica gneisses, veined gneisses and amphibolites and also partly fused into granodioritic melt (diatexites). Around 1800 Ma ago, a post-orogenic thermal pulse produced granitic magma expressed as small plutons in the western part and as minor felsic dikes and pegmatites in the eastern part of the Kvarken area. After a period of magmatic quietism that lasted for about 200 Ma, rapakivi magma aroused, intruded and crystallised as batholites in upper parts of the crust about 1570 million years ago. The felsic rapakivi magmatism was accompanied by mafic magmatism, expressed as diabase dikes (Sub-Jotnian) and gabbros intruding the bedrock. The boulders of quartz-feldspar porphyries that one can see in the coastal area around Vaasa are considered as near surface equivalents to the rapakivi magmatism. These porphyries are also seen in the moraines on the bottom of the Bothnian Sea near the Kvarken area. Around 1270 million years ago, a set of olivine diabases (Post-Jotnian) intruded the crust and this was the last rock-forming event of the crystalline basement in the Kvarken area (Suominen 1991).

The Svecofennian orogenic belt had already lost much of its mountainous grandeur during the Mesoproterozoic time. This is indicated by thick, 1400 – 1200 Ma old, red Jotnian sandstone deposits within the Svecofennian schist belt in Satakunta and Muhos, in Finland and in Nordingrå, Gävle, Dalarn and Småland in Sweden. Extensive distributions of Jotnian sandstone (Figure 31) have also been verified on the bottoms of the Bothnian Sea and the Bothnian Bay, around the Kvarken area. Small boulders of red sandstone are frequently seen in the Finnish coastal area near Vaasa and further inland. After the intrusions of Post-Jotnian dikes 1270 Ma ago, there is no record of significant magmatic activity in the Svecofennian area. Stable tectonic conditions were now established and until the beginning of the Paleozoic era 540 Ma ago, uninterrupted erosion and sedimentation (e.g. 600 Ma old, grayish Lauhanvuori sandstones, Finland) continued and flattened the Svecofennian surface to a peneplain.

During the Cambrian, 520 million years ago, a meteorite impact created a basin on the Earth´s surface in the southeast corner of the Kvarken area (Lehtovaara 1992). The Söderfjärden impact crater has provided a shelter for the Cambrian sediments, unique to an extensive land area within the Svecofennian schist belt, against erosion and abrasion until present time.

Figure 31. Ripple marks in bedding plane of a Jotnian sandstone boulder in Storskäret (photo Petri Virransalo 2003).

Existence of Lower Cambrian siltstone in the Bothnian Sea and comparable seismic velocities of this siltstone with velocities in the Bothnian Bay, north of the Kvarken area is evidence that Söderfjärden belonged to a once widespread Cambrian sedimentary strata (Axberg 1980, Winterhalter 2000). Also, sandstone erratics found in many places in western Finland have similarities to the sandstones at Söderfjärden (Laurén et al. 1978).

Structure of the bedrock

At the time of orogeny, sedimentary rocks deformed under plastic conditions. Therefore polyphase fold structures are common in gneisses. Bedrock later deformed rigidly causing jointing and faulting. A huge shear zone (the Merenkurkku shear) runs from the south of the Söderfjärden crater northwest towards the Kvarken area. According to seismic reflection data, the thickness of the Earth's crust in the Kvarken area is over 50 kilometers (Korja et al. 2001).

Precambrian crystalline rocks

Supracrustal rocks

Mica gneisses, veined gneisses, diatexites (Figures 32 – 34). In the Kvarken area, mica gneisses, veined gneisses and diatexites have a common origin as turbiditic sediments, sand and mud deposited on an ancient sea floor. Subsequently, varying metamorphic conditions caused recrystallisation, partial melting and, in an ultimate case, total melting of these sediments to produce the crystalline rocks seen presently on the Earth's surface. Concretions, round nodules, which were produced at the time of sediment consolidation, are common in metasediments.

Figure 32. Open fold in veined mica gneiss, Molpehällorna (photo Petri Virransalo 2003).

Figure 33. Mica gneiss fragments in even grained diatexite at Vaasa (photo Petri Virransalo 2003).

Figure 34. Example of coarse grained diatexite, Vaasa granite at Norrskär. In the middle of the picture is feldspar twin (photo Petri Virransalo 2003).

Mica gneisses are the least metamorphosed Precambrian metasediments in the Kvarken area. They are light gray in color and show clear primary bedding structures. Scant veining is common. An increase in vein generation and in grain size alters the mica gneiss to veined gneiss. Bedding structures are still observable. In addition to the main mineral constituents, quartz, plagioclase, biotite and garnet are frequently seen in these rocks. Cordierite, sillimanite and pyroxene occur together with increasing metamorphism.

Graphite and sulphide schists occur as interbeds within the mica and veined gneisses. These rocks are eroded deeper than the surrounded gneisses and are rarely seen in outcrops. In geophysical maps, the graphite and sulphide schists can be traced as long and narrow anomalies, which display the general structures of the gneiss complex.

The diatexites are coarse grained, often feldspar porphyritic rocks that have an igneous looking appearance and granodioritic composition (Figure 34). These rocks are often called Vaasa granites. Relics of partly melted mica gneisses, fragments of arkosic calc-silicate beds and calcareous concretions in some areas refer to the host rock. Garnet is an appreciable mineral component and together with biotite and cordierite, it occasionally exists as small dark restite ‘drops’. In terms of migmatite classification, the diatexites can be regarded as schollen migmatites with floating ‘rafts’ of veined gneiss in homogeneous granodioritic neosome. Zonation from mica gneisses to veined gneisses and further to diatexites is found in some areas.

Most of the Kvarken area in Finland, including the archipelago, is covered solely by geologic mapping carried out during the early 20 th century with a map scale of 1:400 000 (Saksela 1934, Laitakari 1942). As a result, for the major part of the Kvarken area only a very generalized geologic picture can be presented and the above-mentioned rock divisions of mica gneisses, veined gneisses and diatexites cannot be shown accurately on the map. In the Vaasa area, there are several large in production and abandoned aggregate rock quarries in diatexites.

Quartz-feldspar gneisses. Due to the gently or nearly horizontally dipping beds, the quartz-feldspar gneisses in the southeast part of the Kvarken area covers areas wide enough to plot on a map. The feldspar gneisses occur as light colored interbeds in the mica gneiss usually with gradational contacts. Bedding is a common primary sedimentary structure, but grading has also been noted (Nykänen 1960b).

Amphibolites in the Kvarken area are basaltic and andesitic volcanogenic rocks that occur as narrow tongue-like interbeds within the mica- and veined gneisses. These greenish, hornblend-bearing schists have a metamorphic striped and foliated appearance but in some places pyroclastic and pillow lava structures are still recognized (Figure 35).

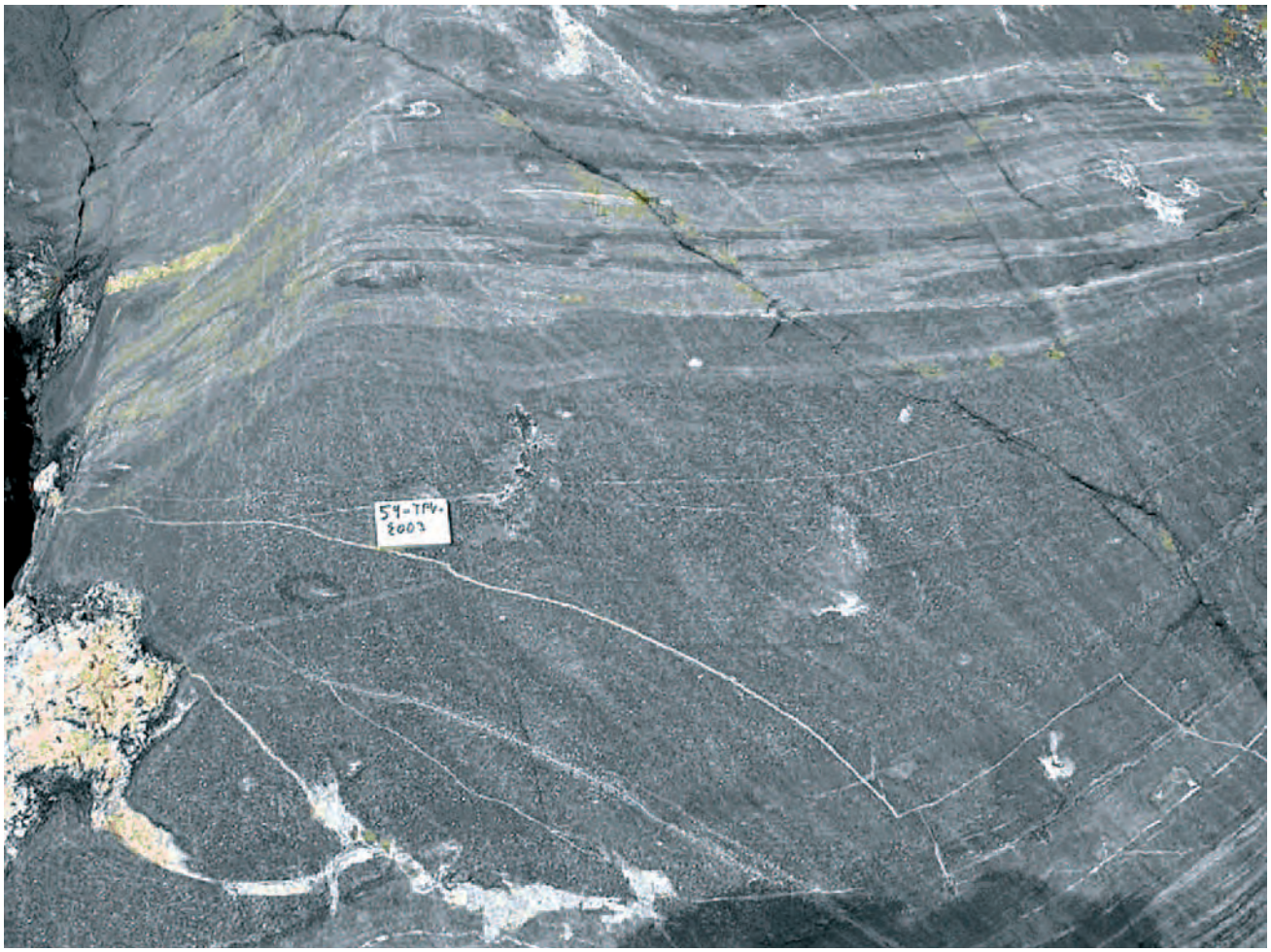

Figure 35. Deformed pyroclastic structure in mafic metavolcanite at Rönnskär (photo Petri Virransalo 2003).

Deep seated rocks

Granites and pegmatites. Coarse grained, reddish or white pegmatites are common in the areas occupied by mica and veined gneisses. Pegmatites usually form conformable bodies, but occasionally crosscut the gneisses. Red granites in the southeast corner of the Kvarken area intrude mica gneisses and their deformation structures. The granites are mediun to coarse-grained rocks with a texture of both even grained and porphyritic. About ten kilometres outside the Kvarken area in the southeast, a zircon dating from a cross cutting, post-kinematic granite shows an age of 1800 Ma. In the area of Rödgrynnorna islands southeast of Replot, there is red porphyritic coarse-grained granite often with magmatic flow structures (Figure 36). This granite was quarried as dimension stone in the 19th century and was used in many buildings in the Vaasa area. An age determination this rock is forthcoming.

Grandiorites. In the southeast of the Kvarken area, in Mope, there are grey, medium grained and foliated grandiorites, which typically have breccia fragments of mica gneiss near the contact (Figure 37). In the inner parts of intrusion, the grandiosity is homogenous and carries enclaves, typical for intrusive bodies. One boulder of rare orbicular grandiorite or tonality is found in Replot. The boulder is now situated on the yard of the Headquarters of Geological Survey in Espoo (Laitakari and Lahti 1984).

Figure 36. Magmatic flow structure in coarse post-kinematic granite, Rödgrynnorna (photo Petri Virransalo 2003).

Gabbros. The Tistronskär gabbro, south of Replot, is exposed only on a few small islands. On the geologic map, this magnetic gabbro is traced from an anomaly pattern on the geophysical map. The dimensions of this subaqueous anomaly are 1 x 13 kilometres. Geochemically, the Tistronskär gabbro is quartz monzonitic in composition and has slightly alkaline chemical characteristics. The age of the gabbro is not known, but rapakivi magmatism as a possible source cannot be excluded.

Ultramafites. In connection with ore exploration, the diamond drilling at Korsnäs has revealed tens of meters of thick, conformable horizons of ultramafites in mica gneiss (Nykänen 1960 a, b). The ultramafites are medium grained hornblendites, pyroxenites and serpentinites. Under the sea at Oravainen, there is a nickel deposit in metadunite. Ultramafic rocks are found as boudinaged fragments in mica and veined gneisses as well as in diatexites in the Kvarken area. These fragments originate from ultramafic magma that intruded the sedimentary deposits before the main phase of deformation.

Dike rocks

Feldspar porphyrites. At the beach in Vaskiluoto, a camping site in the city of Vaasa, dikes of light red feldspar porphyrite intrude mica gneiss. The dikes range from a few centimetres to five meters in thickness. Feldspar phenocrysts occur even in the thinnest dikes. There appears to be no prevalent direction to the dikes, which crisscross in mica gneiss and also brecciate it. Radiometric dating on the zircon gives an age of 1800 Ma to the dike.

Figure 37. Quartz vein in even grained granodiorite, Särkimo (photo Petri Virransalo 2003).

Post-Jotnian diabases (Figures 38 – 40). The Post-Jotnian dark diabases in the Kvarken area form voluminous sills and dikes, which in the Vaasa Archipelago run in a mostly north- northwest direction and are nearly horizontal. The diabases are unmetamorphosed and have an ophitic texture typical of diabases even in fine-grained variations. Contacts with migmatites are crosscutting, but no contact metamorphism is recognized. In diabases, there is a meter or so of fine-grained chilled margins showing that intrusion happened in hybabyssal conditions near the ancient surface of the earth. As olivine is a common constituent in the Post-Jotnian diabases, these diabases are called olivine diabases. In Post-Jotnian diabases in the Rönnskär area, there is often narrow feldspar, carbonate and amphibole veins and roundish weathering structures. Radiometric age determination of the olivine diabase from Molpe, Korsnäs gives an age of 1268±13 Ma to this rock (Suominen 1991).

Paleozoic rocks

Söderfjärden sandstone and the Söderfjärden meteorite crater. The Söderfjärden meteorite crater, 10 kilometres south of Vaasa, is a more or less circular depression, which has a diameter of 6 kilometres and shows a discontinuous rim 30-40 m in height (Laurén et al. 1978). Based on gravimetric studies and drilling, the crater has an uplifted central part in its basal topography. The age of the impact has been set at 520 Ma, the time only shortly before sediment deposition (Anneli Uutela pers. com.).

Sandstone and siltstone make up 250 m thick sedimentary strata in the lower part of the depression and are overlain by glacial overburden 80 m in thickness. The sedimentary rocks have been dated micropaleontologically to the Lower Cambrian (Tynni 1978).

Figure 38. Ophitic structure in olivine diabase, Rönnskär (photo Petri Virransalo 2003).

Figure 39. Roundish weathering structure in olivine diabase, Rönnskär (photo Petri Virransalo 2003).

Figure 40. Feldspar and amphibole combined vein in olivine diabase, Strömmingsbådan (photo Petri Virransalo 2003).

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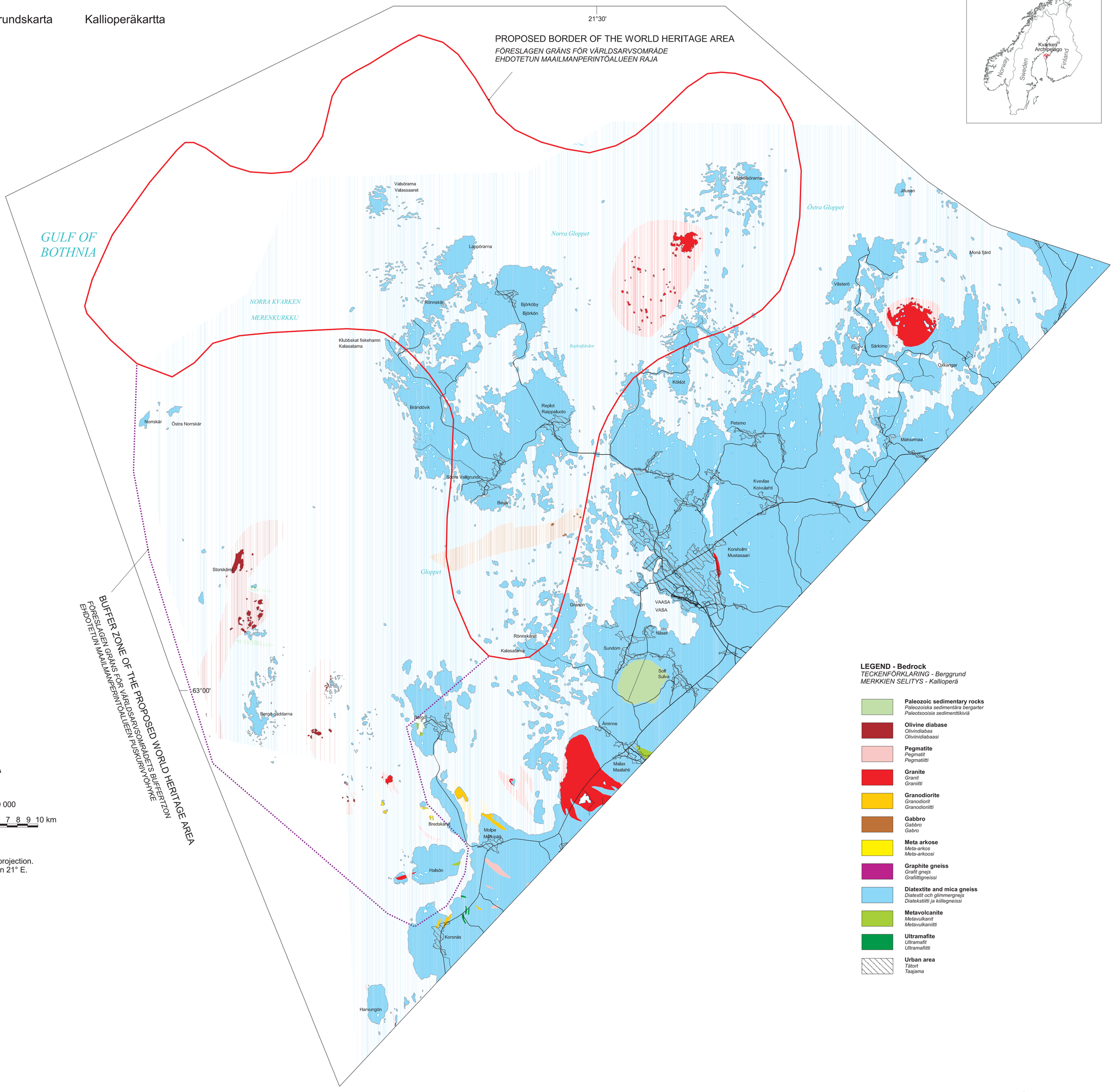
Appendix 2

GEOLOGY OF THE KVARKEN ARCHIPELAGO

Bedrock map Berggrundskarta Kallioperäkartta



GTK

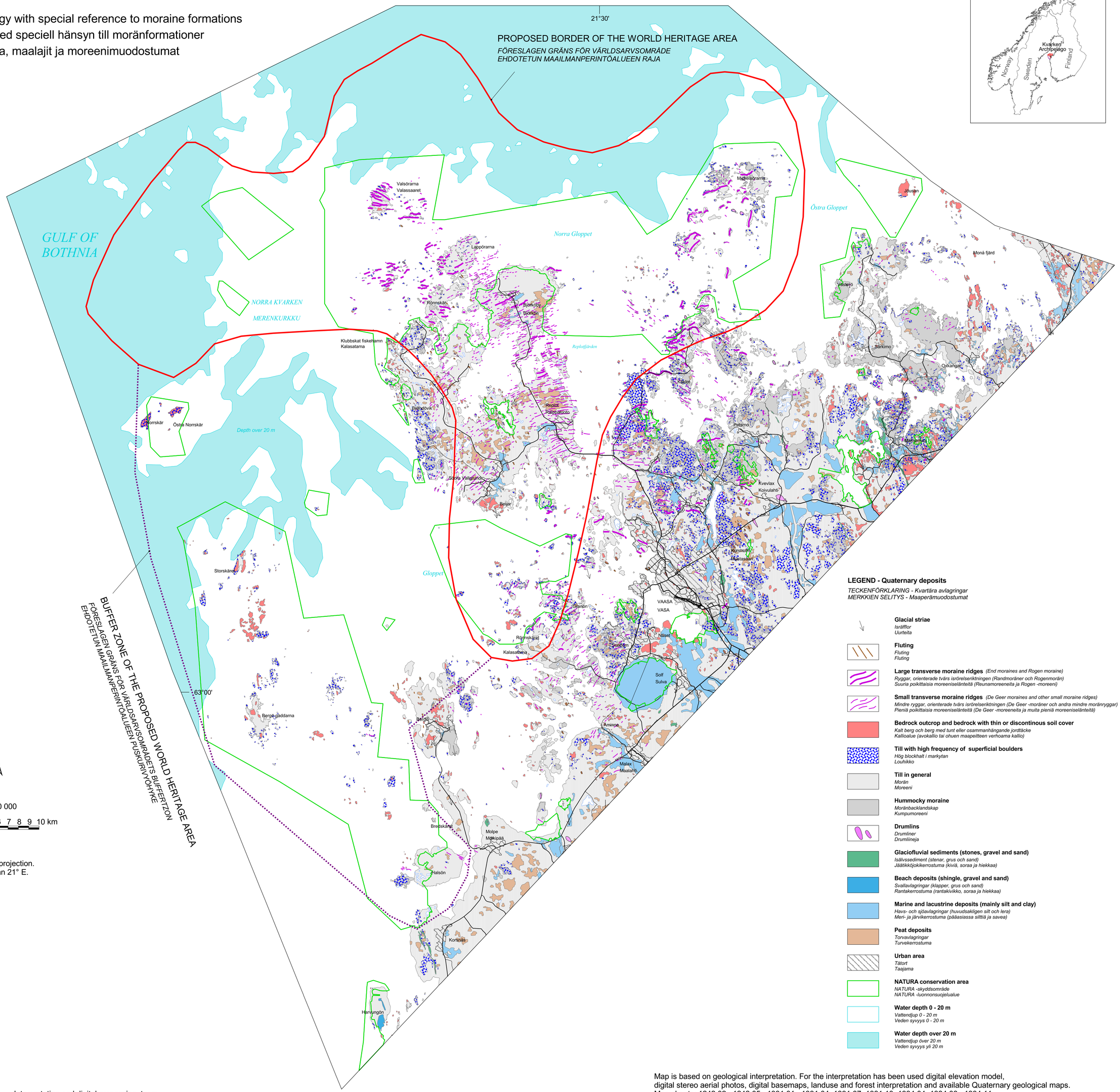
Compilation: Petri Virransalo, GTK

Map is based on available geological bedrock maps and recent fieldworks.
Base map (modified) © National Land Survey of Finland

Appendix 2

GEOLOGY OF THE KVARKEN ARCHIPELAGO

Map of Quaternary geology with special reference to moraine formations
Kvartärgeologisk karta med speciell hänsyn till moränformationer
Maaperägeologinen kartta, maalajit ja moreenimuodostumat



GTK

Interpretation and digital prosessing team:
Keijo Nenonen GTK, Miikka Paalijärvi GTK, Eija Vallimies GTK
and Tapio Väänänen GTK. Ver. 14092004

Map is based on geological interpretation. For the interpretation has been used digital elevation model, digital stereo aerial photos, digital basemaps, landuse and forest interpretation and available Quaternary geological maps.
Map sheets: 1242 02, 1242 05, 1331 01, 1331 04, 1331 07, 1331 10, 1334 04, 1334 08, 1334 11
Features and formations marked on maps have not been revised on the field.
Base map (modified) © National Land Survey of Finland

APPENDIX 3

Lena Bergström 2001

THE NORTHERN KVARKEN

The Aquatic Environment

The aquatic environment

Lena Bergström, 2001

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West Finland Regional Enviroment Centre 2001/2003

Fig. 1. Area proposed for natural world heritage and the bufferzones

1. Physical characteristics

1. 1. The Northern Kvarken - A sea of changes

Biologically, the Kvarken area is best described as an area of continuous change. One major reason for this is *land upheaval*, which steadily turns sea areas into bays, bays into sea inlets, and inlets into dry land. A certain geographic area may be subject to successive alterations at a rate that is readily conceivable within the life span of a human being. In the characteristically very flat landscape, these changes may involve large areas of the seafloor each year (Fig. 2).

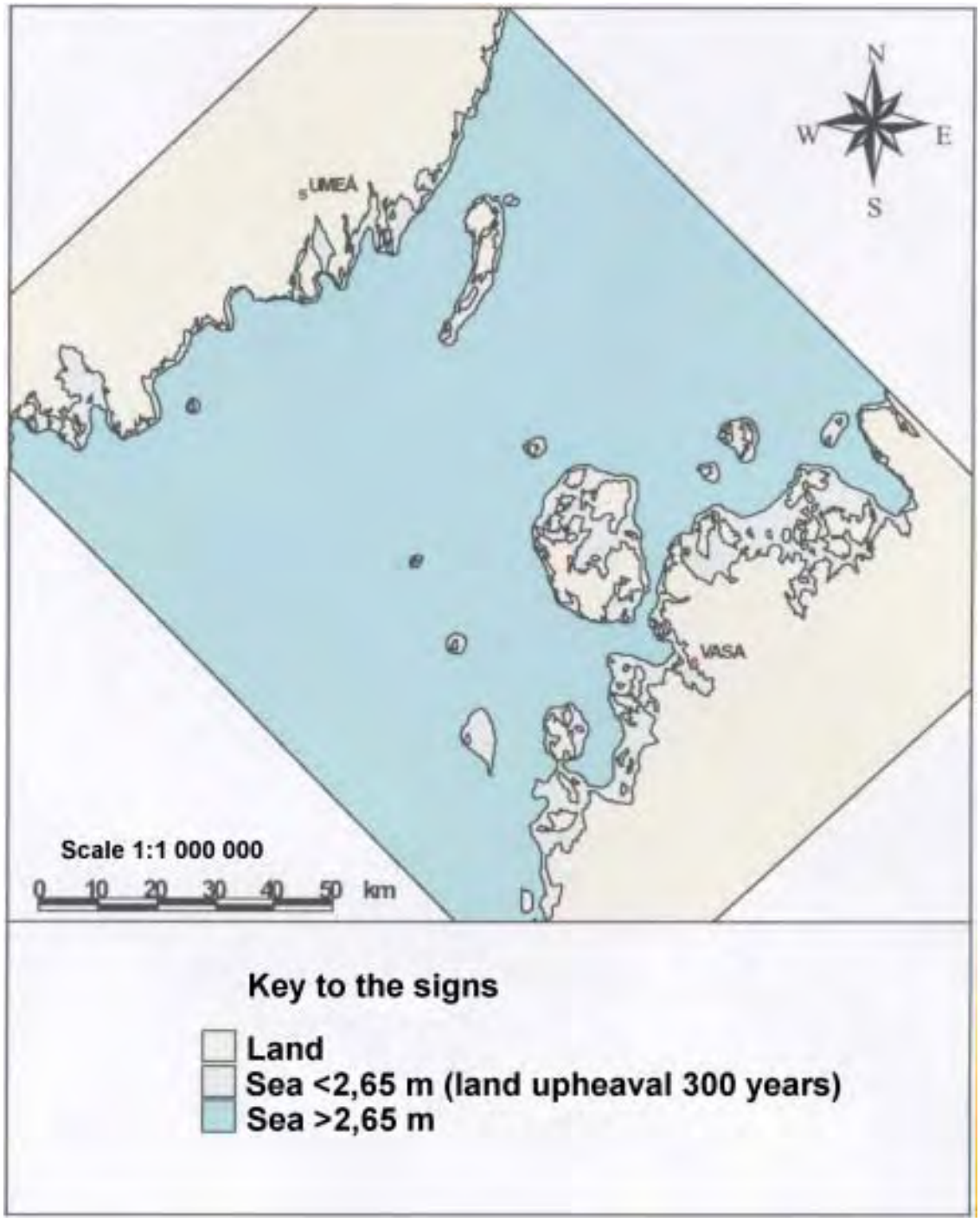
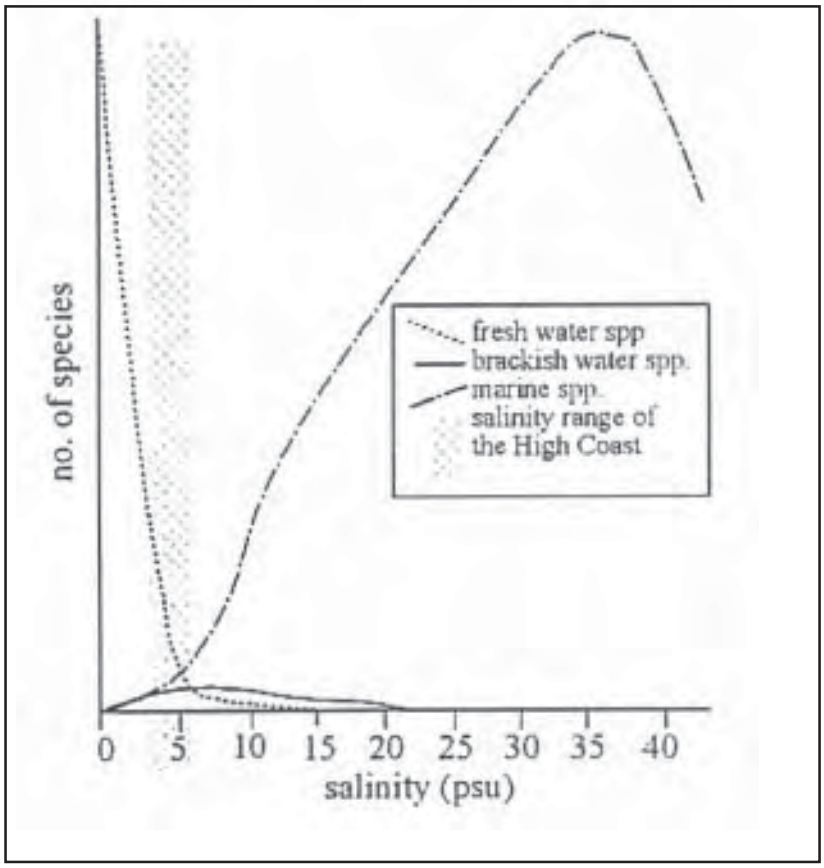


Fig. 2. In the Kvarken area land upheaval involve large areas of the seafloor each year. Situation after 300 years.

Besides land upheaval, another effect of the ice age is that a mosaic pattern of moraine ridges was created during the withdrawal of the glacial ice. This provides the foundation of the vast archipelago seen today. The proportion of land gradually diminishes with distance from the main land, so that a *gradient in wind and wave exposure* is evident from the inner to the outer islands (Fig. 3). The characteristics of the biotic communities in the gradient reflect the conditions of exposure. A similar pattern may also be seen at a small scale on individual island groups.

Fig. 3. Archipelago zones and shallow open sea areas. Schematic presentation.

Fig. 4. Total number of marine, brackish water and fresh water species in relation to salinity. Shaded area shows the salinity range at the High Coast. From Remane (1940).



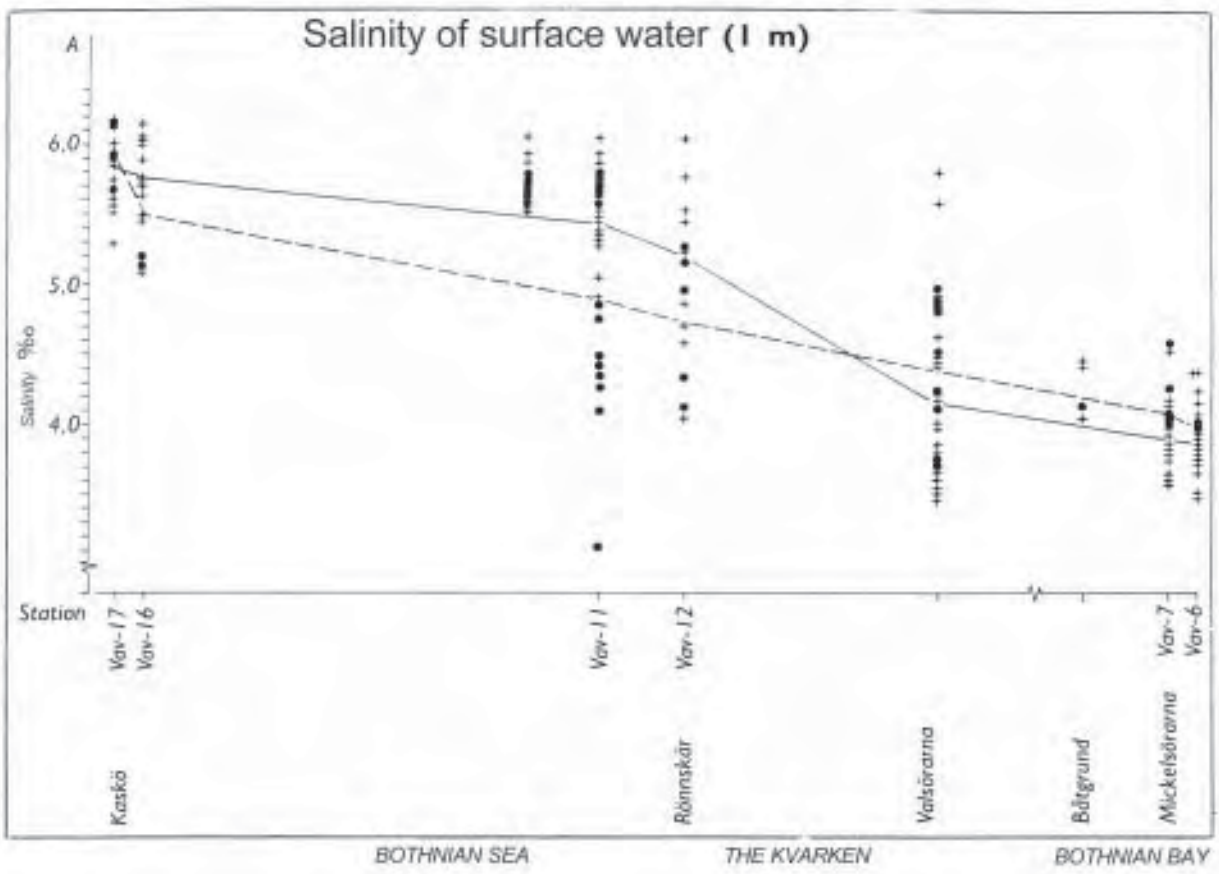
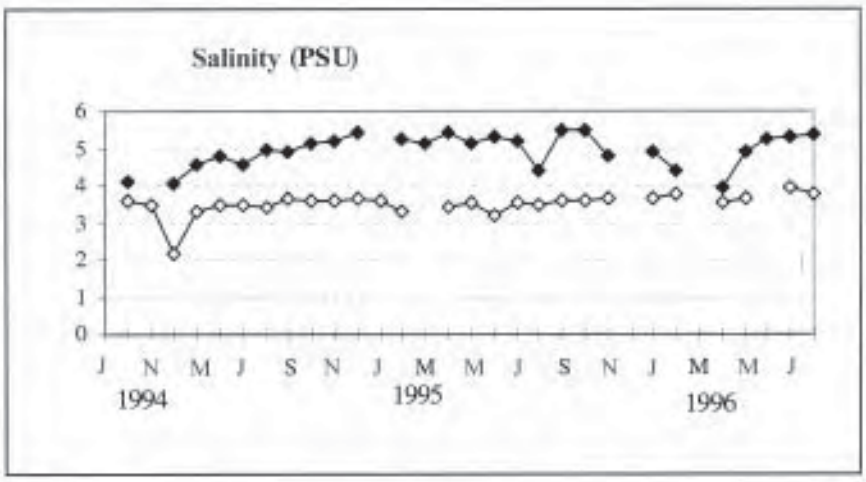


Fig. 5. The change in salinity between Bothnian Sea, The Northern Kvarken and Bothnian Bay.

The Northern Kvarken is situated in the northern part of the Baltic Sea, which is one of the largest brackish water areas of the world. It has a species composition that is a unique mixture of freshwater and marine species. The Baltic Sea received its present brackish characteristics only 3000 years ago. Thus, its organisms are subject to a *still ongoing evolutionary change* towards adaptation to the present conditions. The marine organisms of the Northern Kvarken are at their extreme limit of distribution with respect to salinity. They represent local ecotypes that may significantly contribute to the genetic variation of their species.

Further, the Northern Kvarken is the *transition area* between the northernmost sub-basins of the Baltic Sea, namely the Bothnian Bay in the north and the Bothnian Sea in the south. The underwater communities change in character from predominately brackish communities in the south to mainly lacustrine ones in the north of the area (Fig. 4). This occurs over a geographical distance of 120 kilometres, and is due to a small change in salinity from 5-6 to 3-4 l (Fig. 5). The salinity regime is locally stable in comparison to that of tidal estuaries. This is due to a balance between the inflows of marine water from the south and freshwater from the rivers. The sill is 25 m at its deepest parts.

Finally, at this northern latitude, 63-64 °N, *strong seasonal variation* in temperatures and light regime are seen. All of the area is covered by ice for 3-5 months in the winter (Seinä & Peltola 1991). During the peak season of growth, the water temperature reaches 16 ° C (Fig. 6, Haapala & Alenius 1994). Rapid water exchange in the area is ensured by strong currents that bring saline water northwards and fresh water from the large rivers of northern Sweden and Finland southwards. The low salinity and harsh climatic conditions involve formidable adaptive challenges to the organisms that reside in the Kvarken area.



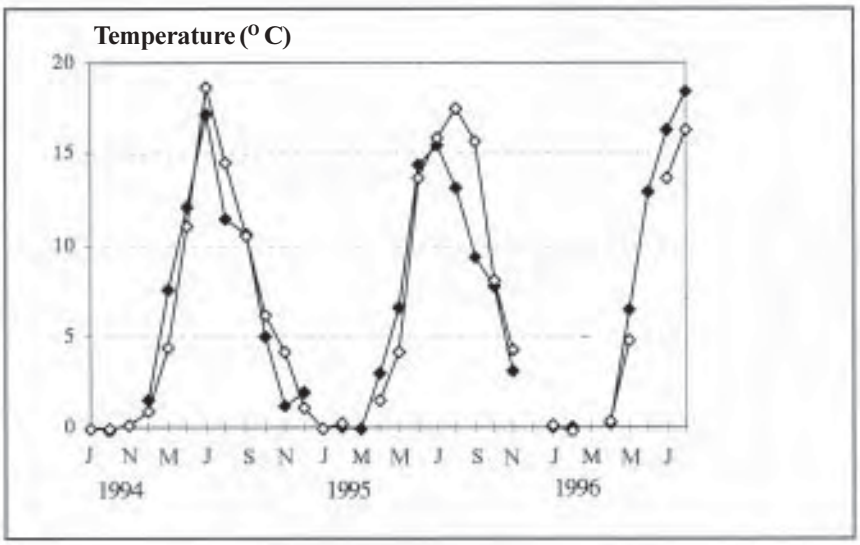


Fig. 6. The salinity and temperature in one meter in different months in the study areas Märaströmmen and Storbådan in the Kvarken area.

2. The biota

2. 1. Habitats

Land upheaval can be readily observed in the Kvarken area. In most parts of the area, all successional stages of land upheaval can be studied within a short geographic distance. The rate of land upheaval in the area is 8.5 mm/year. In the aquatic milieu, land upheaval is most obvious in shallow areas. There, the rate of change of the landscape is enhanced by increased vegetative growth and changes in water flow that alters sedimentation patterns.

When land upheaval proceeds, the local communities change successionally in response to changes in the environmental conditions. The environmental conditions mainly include decreases in wind exposure, salinity and pH, and an increased sedimentation. The terminology of the successional stages related to land upheaval was developed by Munsterhjelm (1997, Fig. 7).

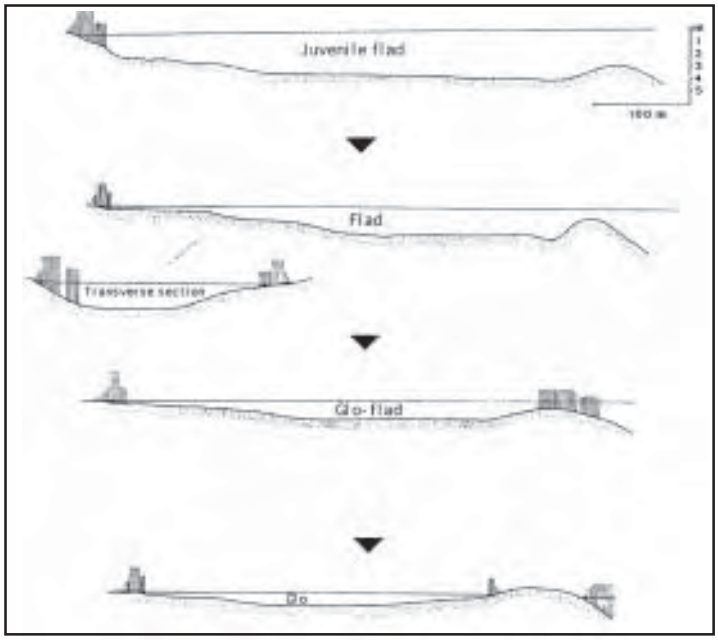


Fig. 7. Morphological development of a flad.

Due to land upheaval, the same geographic area may, potentially, experience each transitional stage from the *shallow exposed zone*, and *shallow sheltered zone*, to *flad*, *glo*, and *glo-lake* before the glo-lake eventually turns in to land. In the following, each of these habitats will be described. The emphasis will be on features of special ecological significance, and characteristics of the Kvarken area. There will also be a description of the *river mouths*, the *deeper benthic*, and the *pelagic* ecosystems within the Kvarken Archipelago.

2. 1. 1. Shallow exposed zone

A large part of the Kvarken Archipelago belongs to the outer archipelago zone. It is affected by strong winds, but also by the strong currents that transport water between the two sub-basins of the Gulf of Bothnia. The archipelago zone is generally broad and shallow (Fig. 3). Shallow exposed habitats are found in e.g. the Rönnskären, Mickelsörarna and Valsörarna island groups. The typical substrate is boulders and stone, but bare rock and non-vegetated sand occur locally.

The vegetation of the shallow exposed zone displays a zonation pattern that is unrelated to tides. Like in the rest of the Baltic Sea, tides are absent in the Kvarken Archipelago. Instead, ice scour during winter prevents perennial species from establishing on shallower depths. Perennial vegetation generally occurs only deeper than 2-3 meters (Bergström & Bergström 1999, Albertsson 1997). At very exposed localities, the effects of ice scour can be noticed down to 5-10 meters depth. Fluctuations in water level occur seasonally due to a combination of changes in air pressure and the dominating wind direction.

There is a transitional change in community composition from south to north over the area, as a response to a decrease in salinity. Marine organisms dominate in the south (the *Fucus vesiculosus* community) and lacustrine organisms in the north (the *Cladophora aegagropila* and diatom communities) (Bergström & Bergström 1999). The evertebrate community is dominated by herbivorous crustaceans and gastropods (Bergström 1997, Kautsky 1993). The shallow exposed zone is an important reproductive area for fish, such as Baltic herring (*Clupea harengus membras*), whitefish (*Coregonus lavaretus*), and grayling (*Thymallus thymallys*) (Koli 1990). It is also the feeding area of large colonies of auks that inhabit the skerries. Some of the major haul-out grounds of the Baltic grey seal (*Halichoerus grypus*) are also located in the outer archipelago of the Northern Kvarken.

2. 1. 2. Shallow sheltered zone

Shallow soft bottoms are common in the inner archipelago. They are also found in the island groups of the outer archipelago, where islands and skerries may provide enough shelter to allow the deposition of sediments.

The shallow sheltered zone is characterized by silt substrates. Due to high turbidity of the water, the vegetation is often limited to the upper 2-5 meters of depth. Fresh water phanerogams are the most abundant submerged plants. At 1-2 m depth, characeans commonly form dense mats (e.g. *Chara aspera*). The shoreline is covered by reed (*Phragmites australis*). The benthic evertebrate fauna is dominated by depository feeders (gastropods, insects, and crustaceans). Roach (*Rutilus rutilus*) and perch (*Perca fluviatilis*) are characteristic fish species (Table 1).
The species composition of the most sheltered shallow soft bottoms is similar to that of the early flad stage, which is the next successional stage as the land rises.

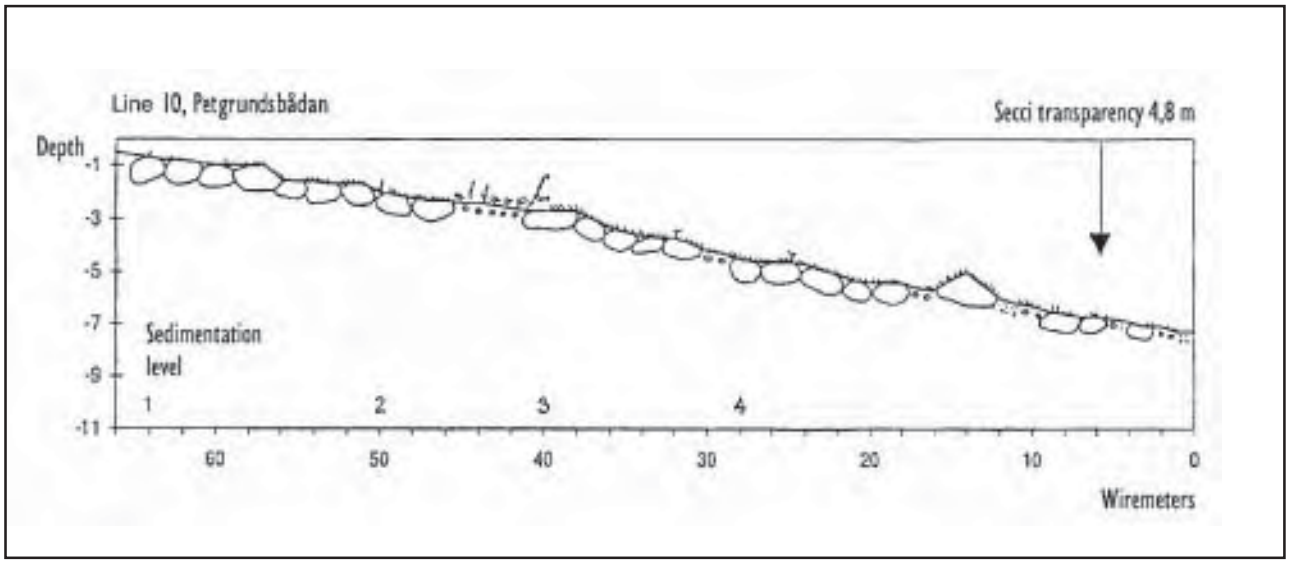


Fig. 8. Zonation of a typical exposed locality in the southern Kvarken area.

Shallow hard bottoms		Shallow soft bottoms	
flora		**flora**	
Fucus vesiculosus	blåstång	*Vaucheria dichotoma*	sjalgräs
Pilayella littoralis	trådslick	*Cladophora glomerata*	grönslick
Sphacelaria arctica	brunborsting	*Chara tomentosa*	rödsträfse
Ceramium tenuicorne	ullsleke	*Chara aspera*	borststräfse
Furcellaria lumbricalis	gaffeltång	*Tolypella nidifica*	havsrufse
Polysiphonia furcoides	fjäderslick	*Zannichellia palustris*	hårsärv
Cladophora aegagropila	klotalg	*Potamogeton perfoliatus*	ålnate
Cladophora glomerata	grönslick	*Potamogeton pectinatus*	borstnate
Chara aspera	borststräfse	*Myriophyllum spp*	slingor
Potamogeton filiformis	trådnate	*Callitriche hermafroditicum*	hostlänke
fauna		**fauna**	
Theodoxus fluviatilis	algsnäcka	*Palodestrina jenkinsi*	vandrarsnäcka
Lymnaea peregra	oval dammsnäcka	*Bithynia tentaculata*	bithyniasnäcka
Lymnaea palustris	kärrdammsnäcka	*Macoma baltica*	östersjömussla
Gammarus zaddachi	en märlkräfta	*Monoporeia affinis*	vitmärla
Gammarus salinus	en märlkräfta	*Saduria entomon*	ishavsgråsugga
Neomysis integer	en pungräka	*Corophium volutator*	slammärla
Electra crustulenta	tångbark	*Tubifer costatus*	en daggmask
Prostoma obscurum	fyrägd slemmask	*Potamothrix hammoniensis*	en daggmask
Cordylophora caspia	brackvattenhydroid	*Limnodrilus hoffmeisteri*	en daggmask
Macoma baltica	östersjömussla	*Clitellio arenarius*	en daggmask
Gasterosteus aculeatus	storspigg	*Marenzelleria viridis*	en havsborstmask
Pomatoschistus minutus	sandstubb	*Gammarus salinus*	en märlkräfta
Phoxinus phoxinus	elritsa	*Perca fluviatilis*	abborre
Cottus gobio	stensimpa	*Rutilus rutilus*	mört
Thymallus thymallus	harr	*Esox lucius*	gädda
Clupea harengus	strömming	*Gymnocephalus cernuum*	gers
Coregonus lavaretus	sik		

Table 1. Some common species of the shallow hard and soft bottoms of Quark.

2. 1. 3. Flads, gloes, and glo-lakes

Due to the mosaic character of the landscape, a continuous establishment of new flads and gloes is effective through land upheaval in many places of the Kvarken Archipelago. Successive zones, where all the different stages of isolation from the sea can be observed in connection to each other, occur e.g. in Valsörarna and Lappören.

A *flad* is a water body that is connected to the sea only through one or a few small openings. This prevents full water exchange, but the water of the flad is still brackish. The *glo* is the successional stage that follows flad. The openings of the glo have risen above sea level, but inflow of brackish water is still possible during strong winds and periods of high water. The glo is slowly transformed into a *glo-lake*, as the degree of isolation increase and the salinity and pH of the water decrease. The difference between a glo-lake and a lake is seen in that the glo-lake is predestined to extinction as land upheaval proceeds, slowly transforming the glo-lake into land (Munsterhjelm 1997, Fig. 7).

Most flads and gloes in the Kvarken Archipelago are small and shallow. Their area is typically less than 10 ha and their mean depth 1-2 meters. The water of the flads and gloes is often frozen all the way to the bottom in the winter. On the other hand, it is rapidly warmed up in the spring. The high spring temperatures make both flads and gloes important reproductive areas for many fish, frogs and insects (Wistbacka & Snickars 2000, Rinkineva & Bader 1998).

The flad is a highly productive ecosystem that has a, by brackish water standards, rich species diversity (Andersson 2001). The flad provides shelter, high summer temperatures, good light conditions due to its shallowness, and thick mud bottoms that provide nutrients. All of this favours a high productivity of macrophytes. (Munsterhjelm 1997). Further, organic material that is transported towards land by winds is easily trapped inside the sill of the flad (Fig. 9). The characteristic species composition of each flad is dependent on its depth, degree of exposure, salinity and substrate. Due to climatic variation, the vegetation may also differ between years in the same basin (Rinkineva & Bader 1998). The most typical components of the flad vegetation are reeds and rushes (*Phragmites australis, Schoenoplectus tebernaemontanii)*, which form dense belts on the upper shore. The submersed vegetation is mostly composed of phanerogams (*Potamogeton* spp.), and various stoneworts (*Chara* spp.). The fauna is dominated by insects (Chironomidae, Odonata, Ephemeroptera) and crustaceans (Andersson 2001, Rinkineva & Molander 1997).

The productivity of a glo and glo-lake, on the other hand, is typically low. The productivity and diversity will decrease with the age of the water body. This may be explained by an increasing homogeneity of the environmental conditions, and by the fact that their isolation hinders a re-colonisation of once outcompeted species. Poor water exchange also makes the glo and glo-lake more sensitive to changes in the water quality of the drainage area than the flad is (Munsterhjelm 1997).

Fish species that use flads and gloes as nursing grounds include the roach (*Rutilus rutilus*), pike (*Esox lucius*), and perch (*Perca fluviatilis*). The fish generally display a local breeding behaviour, and tend to return to the same breeding area every year (Karås & Hudd 1993). The flads are also important feeding grounds for many birds, including osprey (*Pandion haliaetus*) and white-tailed eagle (*Haliaetus albicilla*).

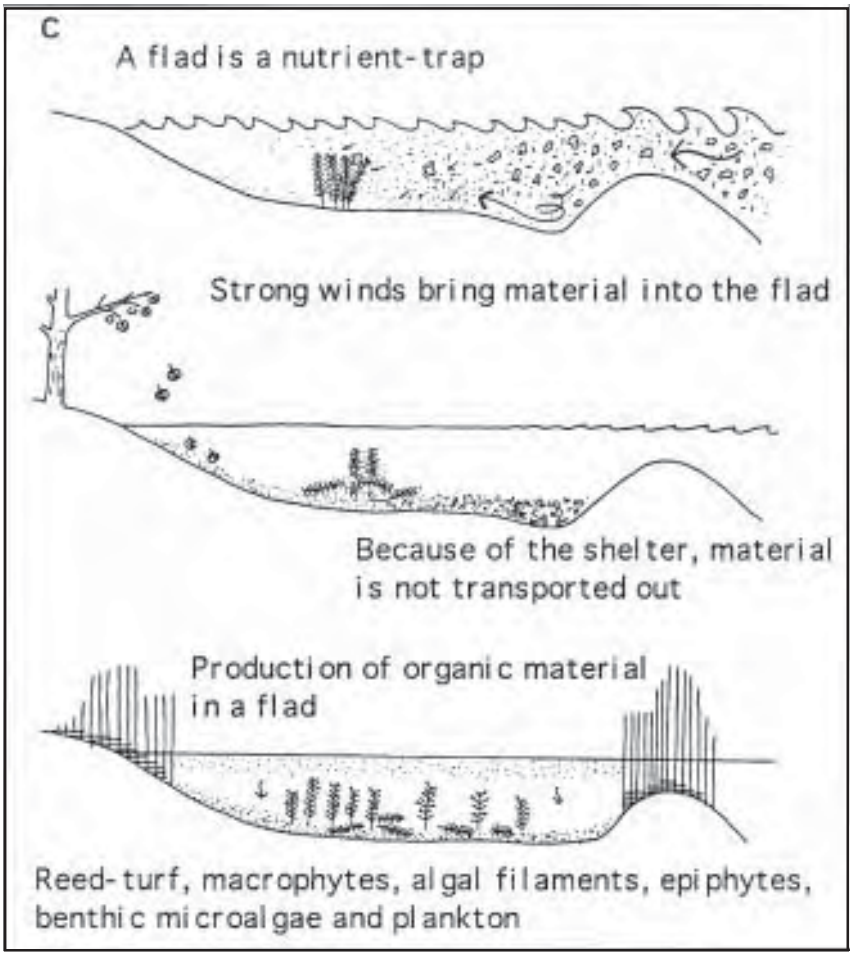


Fig. 9. Accumulation of material in a flad.

| Total | Stora Sandviken | Mjälsnäsviken | Yttre Ruddjärden | Gällskärsfjärden | Trenäsvan | Lappviken | Lillskärsfjärden | Ytterskärsfjärden | Rävsundet | Ovanjärdsfjärden | Skärgården | Stor-Bölsundet | Lill-Bölsundet | Mjälsnäsfjärden | INGRIDMALING | Vikarviken | Ostnäsviken | Gladhuvudet | Vistarvidjet | Ostnäsvidjet | Bäckfjärden | Granskärsviken | Lillgrundet | Lillgrundet | Hällskärsundet | Längviken | Rovsundet | Sandskärsfjärden | Hjertsundet | Jungfrun | Hällskärsfjärden | Gäddfjärd | Nötskärsfjärden | Revviken | Sorfjärden | Sandskärsfjärden | Hällskärsviken | Sodsjön | Sommarnäsgrundfjärden | UMEÅ | Östra Stakviken | Hällfjärden | Nyhamnsfjärden | Rössfjärden | Dåkenbodafjärden | Storvarpet | Storfjärden | Smörhällviken | Bergnäsfjärden | Sandfjärden | Gunnarsnäsundet | Lägviken | Sorfjärden | Lillfjärden | Ursviken | SKIBERTSFORS | | |
|---|---|---

2. 1. 4. River mouths

Large amounts of fresh water and particulate material are brought to the Northern Kvarken by rivers. The largest delta area is created in the mouth the Kyrö River. Other estuaries in the area include the Petalax å, and Ume River, Sävarån, Öre älv on the Swedish side. The mouths of the rivers are characterised by high productivity and species richness. They are, in particular, significant reproductive and feeding areas for birdlife and fish in the area (Wistbacka & Snickars 2000).

Esox luxius	gädda	*Coregonus lavaretus widegreni*	sik
Perca fluviatilis	abborre	*Salmo trutta*	*öring*
Rutilus rutilus	mört	*Lota lota*	lake
Leuciscus idus	id	*Clupea harengus*	strömming
Abramis brama	braxen	*Coregonus albula*	siklöja
Osmerus eperlanus	nors	*Carassius carassius*	ruda
Lampetra sp.	nejonöga	*Leuciscus leuciscus*	stäm
Gymnocephalus cernum	gärs		

Table 3. Fish species that reproduce in the coastal zone (Wistbacka och Snickars 2000, page 17.)

2. 1. 5. Deeper bottoms

Deeper areas are relatively sparse in the Northern Kvarken. Smaller areas with depth down to 100 meters can be found on the slopes of the sill (Fig. 10). The actual sill is maximally 25 meters deep. The photic zone reaches to at a depth of 10-20 meters.

A characteristic of the deeper areas of the Northern Kvarken is the erosion bottoms. They are dominated by hard substrates, such as stone and gravel. Strong currents that transport large amounts of water in both directions across the sill cause the erosion. Deep depository soft bottoms are found mainly on the northern and southern slopes of the sill.

The ecosystem of the deeper bottoms is nearly completely dominated by three organisms. These are the deposit feeding amphipod *Monoporeia affinis*, and its main predator, the isopod *Saduria entomon*. These two crustaceans are found at all depths. The bivalve *Macoma baltica* is abundant at 5-30 meters, but may be found down to 50 meters depth. Fish species that feed on deep bottom macrofauna include the whitefish (*Coregonus lavaretus*) and the four-horned sculpin (*Myoxocephalus quadricornis*).

2. 1. 6. The pelagic

Due to the mixing of phosphate rich water from the north and nitrate rich water from the south, the pelagic primary productivity in the Kvarken area is relatively high. The pelagic primary producers are not only an important source of energy for the pelagic system, but also for the shallow and deeper soft bottoms (Fig. 12, Kuparinen *et al.* 1996). The organisms of the benthic areas are mainly deposit and filter feeders.

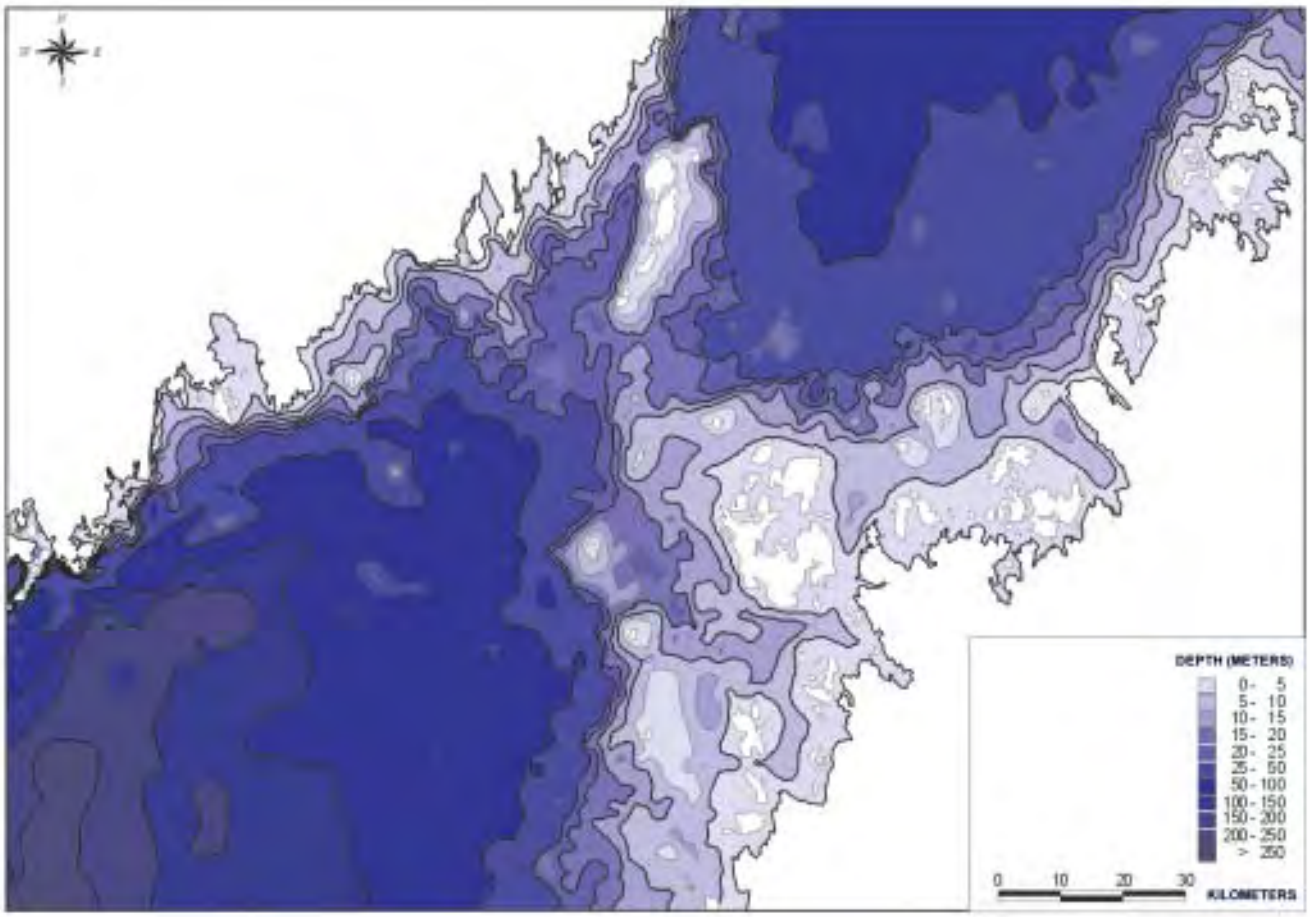


Fig. 10. Seabed forms in the Kvarken area.

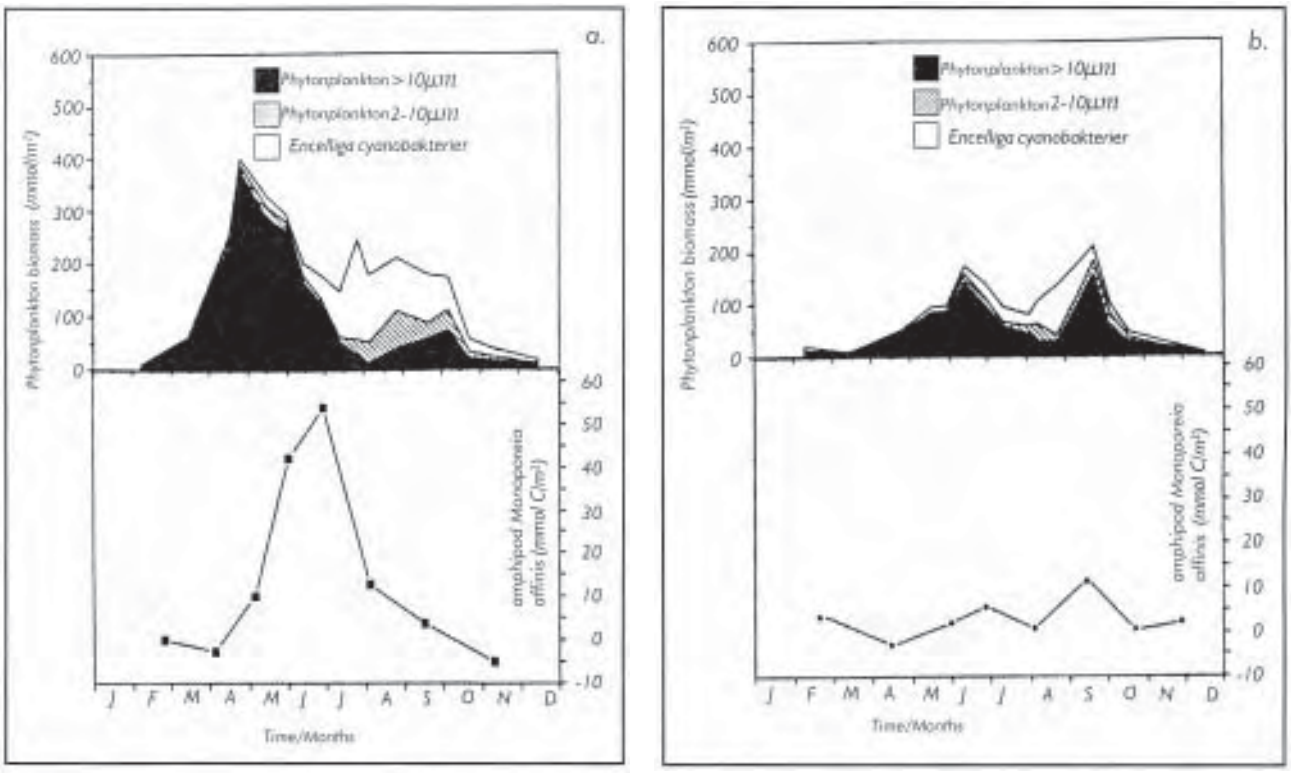


Fig. 11. Phytoplankton biomass and production of Monoporeia affinis *in a) Bothnian Sea and b) Bothnian Bay in year 1991. Phytoplankton biomass has been calculated at the basin average depth of 66 and 44 meters.*

The peak of the spring bloom is in May, directly after ice melt. Before this, some photosynthesis takes place in the ice and close under it. The spring bloom is dominated by microphytoplankton. As the water gradually becomes nutrient depleted, the most important primary producers become the nanoplanktonic flagellates, which maintain their position during most of the growth season. A large part of the energy production also takes place through bacterioplankton. They utilise carbon from humic substances that are deposited in the area from the rivers. They are, thus, non-dependent on light (Andersson *et al.* 1996, 1994). There is no autumn bloom. This is probably due to a combination of two factors: 1) short days, which leads to low photosynthesis and 2) comparatively warm water temperatures, which causes high respiration. This does not support a net photosynthesis in the primary producers (Andersson *et al.* 1994).

The microphytoplankton is dominated by dinoflagellates, diatoms and green algae. Copepods, rotifers, and cladocerans dominate the zooplankton. The most important pelagic fish species are the Baltic herring (*Clupea harengus membras*) and salmon (*Salmo salar*).

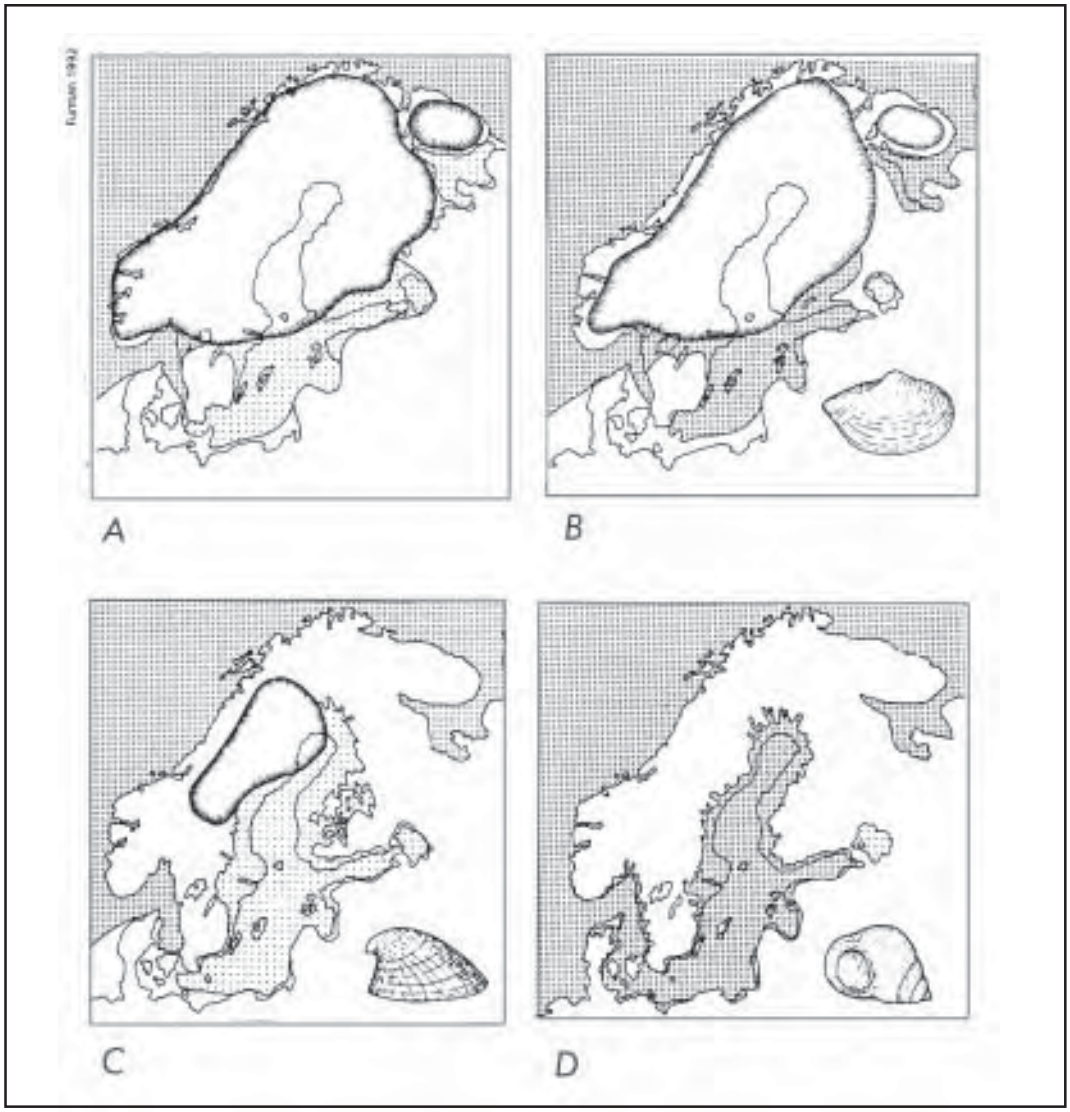


Fig. 12. Different development stages of the Baltic Sea. A) The Baltic Ice Sea approx. 10,000 to 8,200 BC was a freshwater lake blocked by the glacier. b) The Yoldian Sea approx. 8,200 to 7,000 BC was a salt water sea for a short period. The name of the sea originates from a bivalve called Yoldia arctica*. c) The water in the Ancylus Lake, approx. 7,000 to 6,000 BC, was fresh once again. The name originates from a gastropod called* Ancylus fluviatilis*. d) the Littorina Sea approx. 6,000 to 1,500 BC, was a predecessor of the present Baltic Sea. The name of the sea orginates from gastropods of the genuis* Littorina*, which are to be found abundantly in the brackish water.*

2. 2. Species

2.2.1. Colonisation routes

The discontinuous history of the Baltic Sea (Fig 12) is reflected in a species pool of variable origin. Because of its geologically young age, there are no truly endemic species in the Baltic Sea. The degree of speciation of the Baltic organisms, as compared to their marine/lacustrine counterparts can be seen as an ecotypic speciation in terms of salinity tolerance (Russell 1988).

1. Some organisms of *lacustrine origin* have colonised the Baltic Sea through its estuaries. These are generally found only in a salinity below 6 l, that is, within the salinity range of the Kvarken area.

2. The main part of the present flora and fauna is likely to originate from the *western Atlantic* and the time of the Littorina Sea (8000 years ago). This was the latest period of marine conditions in what is presently the Baltic Sea. The salinity in the northernmost areas was then 8 l, as compared to 2 l today. The Littorina Sea came to a gradual end 3000 years ago when its connection to the Atlantic was reduced through land upheaval, and its water became progressively less saline.

3. Some organisms of western origin are known to have occurred already in the Yoldia Sea (10 000 years ago). These species endured the low saline conditions of the intermittent lacustrine period of the Ancylus Lake (Fig 12c). They include the mysid shrimp *Mysis mixta*, the priapulid *Halicryptus spinulosus*, and the brown alga *Sphacelaria arctica*, which are all found in the Kvarken.

4. There are also species known as *glacial relict species*: These include some of the ecologically most important species of the Kvarken area (Table 4). They are thought to have colonised the Baltic Sea from the White Sea, through a series of glacial lakes in eastern Fennoscandia some 10 000 years ago. Some of these relict species are presently found both in the Baltic Sea and in Fennoscandian lakes. Their counterparts in the White Sea are found primarily in estuaries.

5. In the past century, there have been a number of species introductions that may have occurred through anthropogenic routes. A noticeable example is the recent establishment of the estuarine polychaete *Marenzelleria viridis* (Fig. 13). It is a burrowing deposit feeder that apparently has adopted an empty niche in the simple food web of the northern Baltic Sea. Its ecological impact remains to be studied.

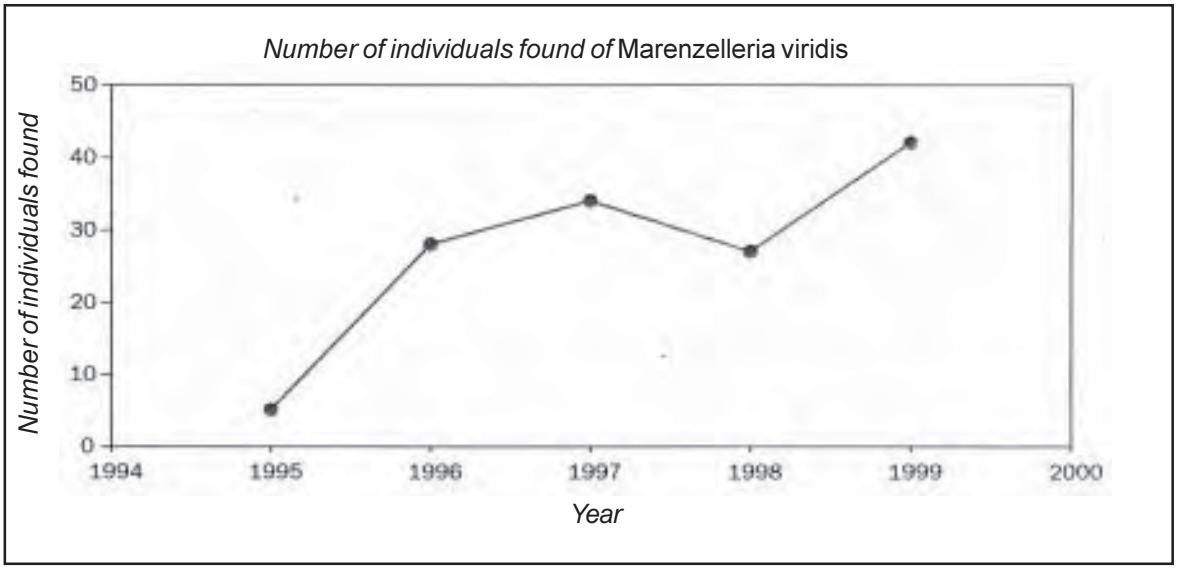


Fig. 13. The invading *polychaeta Marenzelleria viridis* continue to disparse along the coasts of the Bothnian Bay.

2. 2. 2. Species descriptions

The following is a brief introduction to some relict species and key stone species of the Kvarken area.

Saduria entomon. Phylum: Arthropoda, Class: Crustacea, Order: Isopoda. Length: up to 90 mm. Carnivorous/ Omnivorous. A glacial relict species that is well adapted for both the lacustrine and the brackish environment. Abundant at all depths (0 to over100 meters) and types of substrates. Important as a scavenger and as a population regulator of *Monoporeia affinis*.

Monoporeia affinis. Phylum: Arthropoda, Class: Crustacea, Order: Amphipoda. Length: up to 11 mm. Detrivorous. A glacial relict species that occurs in the lacustrine and the brackish environment. Abundant at all depths (0 to over 100 meters) on soft substrates. *Monoporeia* is the principal prey of *Saduria*, and also an important prey species of demersal fish. It is the most abundant macroscopic evertebrate in the Kvarken.

Macoma baltica. Phylum: Mollusca, Class: Bivalvia. Length: up to 10 mm in the Kvarken area. Detrivorous/ Filter feeding. Soft substrates, 2-60 m depth. The only marine bivalve that reaches the Northern Kvarken. It occurs in high abundances.

Clupea harengus membras. Baltic herring. Phylum: Vertebrata, Class: Pisces. Length: up to 20 cm. Pelagic. The most common marine fish species in the Kvarken and one of the economically most important species. A traditional food source of people living in the archipelago. The Baltic herring is a subspecies of Atlantic herring

Fig. 14. Saduria entomon.

Fig. 15. Monoporeia affinis.

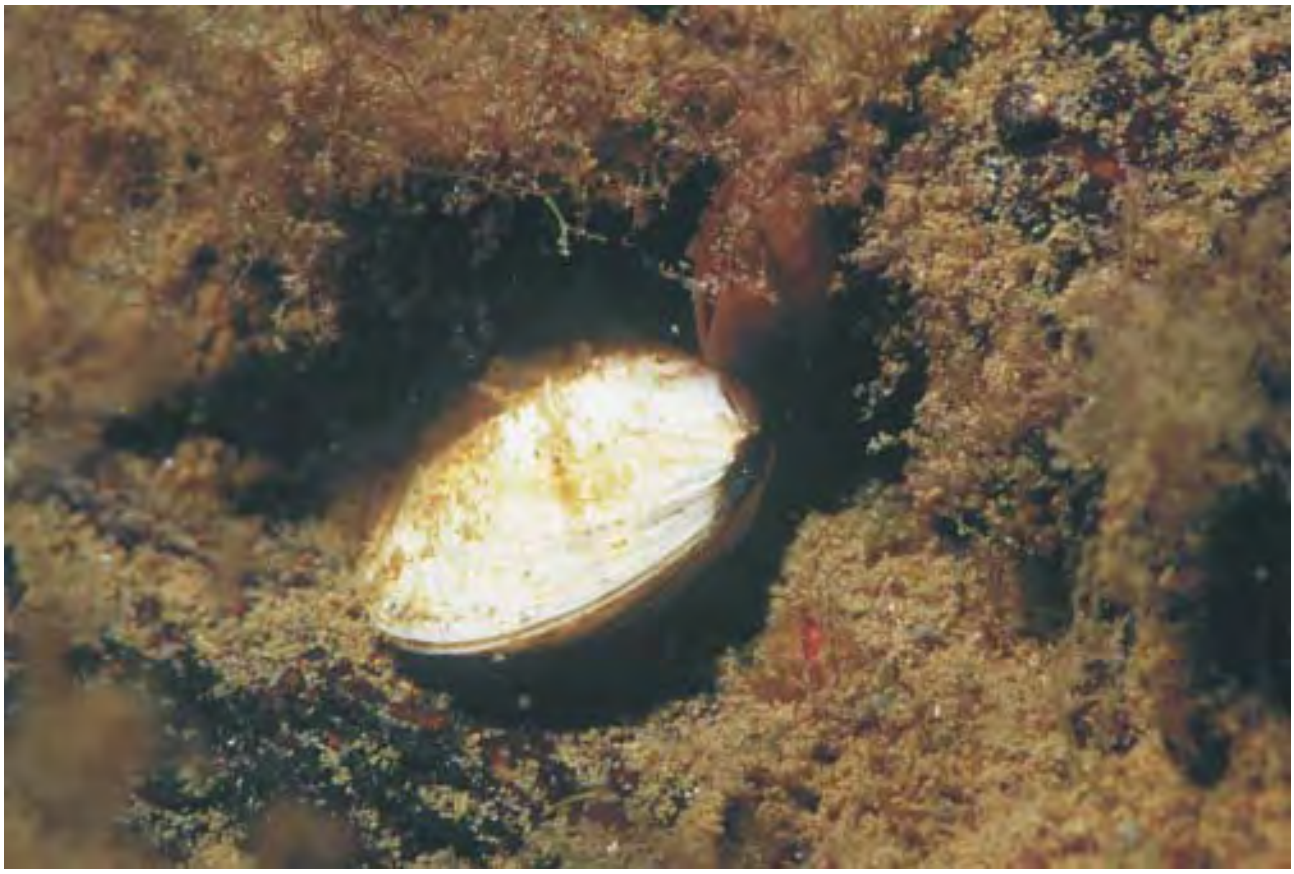


Fig. 16. Macoma baltica.

Fig. 17. Clubea harengus membras.

Fig. 18. Halichoerus grypus.

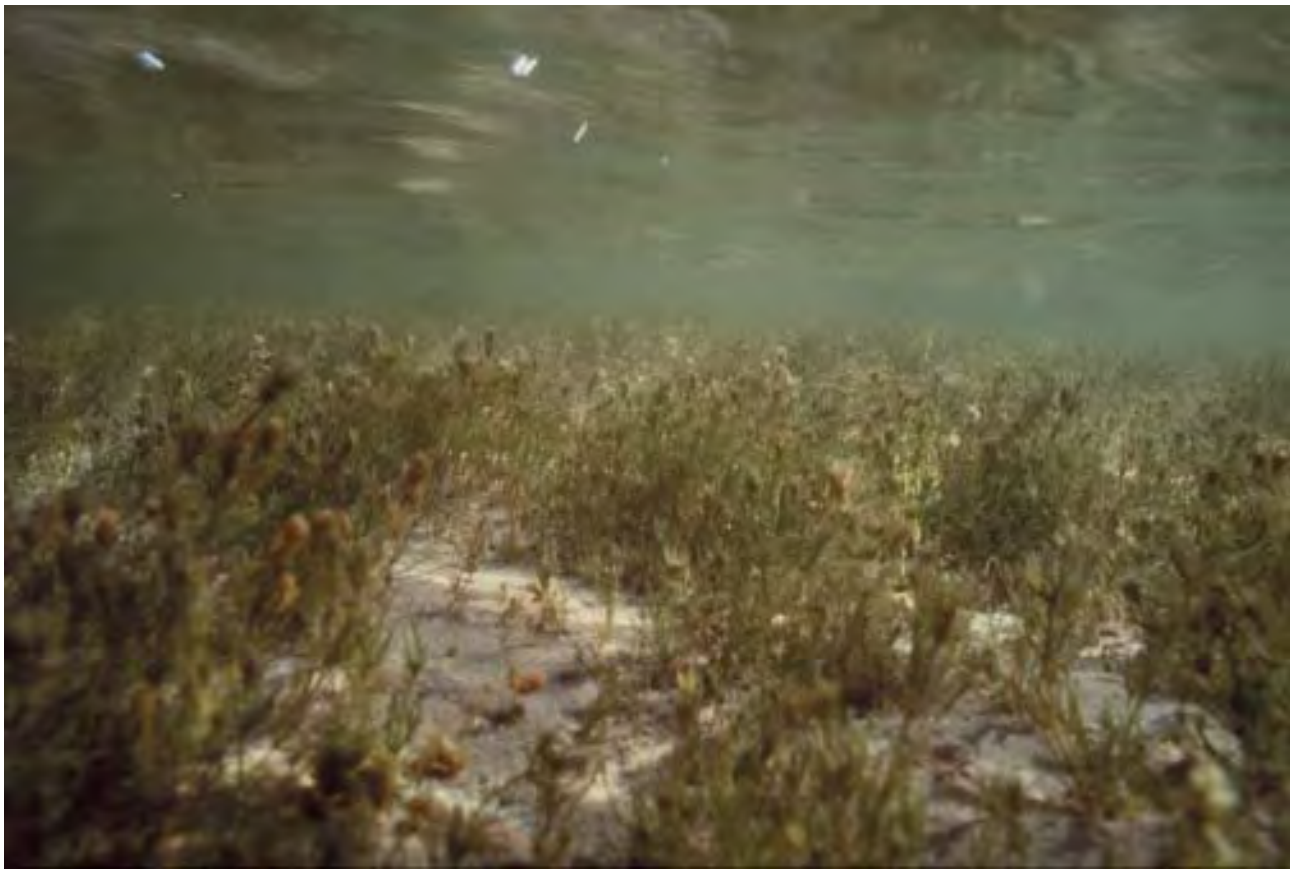


Fig. 19. Chara spp.

Fig. 20. Fucus vesiculosus.

Halichoerus grypus. Grey seal. Phylum: Vertebrata, Class: Mammalia. The most abundant of the two species of seal that are found in the Kvarken. The other seal is the ringed seal (*Phoca hispida bottnica*), which is a glacial relict species. Seals were highly abundant before the mid 1900s, when overhunting and a reduced fecundity due to PCB and DDT toxicity caused a drastic reduction of the seal populations. Protection and a decreased pollutic load have had a positive effect on the seal populations during the past decades. The seal populations are now increasing in the Gulf of Bothnia (Fig 18). Some of the largest haulouts of the grey seal are found in the Kvarken area.

Chara aspera. Phylum: Charophyta. Order: Charales. The most common species of stonewort in the Baltic Sea. The characeans are used widely as indicator species of good water quality. They are threatened by eutrophication in many areas of the Baltic Sea.

Fucus vesiculosus. Bladderwrack. Phylum: Phaeophyta. Order: Fucales. Bladderwrack is the only widespread Fucoid in the Baltic Sea. It is the key stone species of the rocky shores. Bladderwrack houses a rich evertebrate fauna and is also an important nursing area for many fish. The northernmost populations of bladderwrack in the Baltic Sea are found within the Kvarken area. They are of a narrow, evesiculate morph that is characteristic of the Gulf of Bothnia.

3. Summary

The Northern Kvarken is situated in the northern Baltic Sea, which is one of the largest brackish water areas of the world. It is the transition area between the southern and the northern sub-basins of the Gulf of Bothnia. In the Kvarken area, a small change in salinity from 5-6 to 3-4 ppt is accompanied by a distinct biological change from predominantly brackish water communities in the south to lacustrine communities in the north.

The area is characterized by rapid water exchange. Currents running counter clockwise bring saline water northwards and non-saline water from the large rivers of northern Sweden southwards. The currents, in combination with regular strong waves, and ice scour in the winter, efficiently erode the shores. Boulders and stones are clearly visible in the landscape both above and beneath the water surface. There are no tides in the area, but the water level is regulated by air pressure, with low water levels predominating in the spring and long lasting periods of high water in the autumn. The area is ice covered in the winter for on average 130 days.

Due to the mixing of phosphate rich water from the north and nitrate rich water from the south, the pelagic primary productivity is relatively high. In addition to phytoplankton and zooplankton, bacteria are an important component of the pelagic food web. Their main carbon sources are land derived humic substances, supplied by the large rivers.

A common benthic habitat of the Northern Kvarken is the shallow hard bottom of the outer archipelago. The vegetation is characterized by annual or pseudo-annual filamentous macroalgal species and well-developed communities of benthic diatoms. The northernmost populations of bladderwrack (*Fucus vesiculosus*) in the Baltic Sea are found in the southern areas of the Kvarken. This brown alga is a keystone species of the Baltic coastal zone, and houses a rich invertebrate fauna. The outer archipelago also includes some of the largest haulouts of the grey seal (*Halichoerus grypus*) in the Baltic.

Vegetated soft bottoms are common in the inner archipelago and on sheltered localities in the outer archipelago, such as in the bays, flads, and glos created by land upheaval. They are dominated by submersed phanerogams (*Potamogeton* spp., *Myriophyllum* spp.) and stoneworts (*Tolypella nidifica, Chara* spp.). Shallow soft bottoms of this type are threatened in many parts of the Baltic Sea, due to changes in land use and water quality. *Flads* and *glos* are also important nurseries for many fish species, including pike (*Esox lucius*), perch (*Perca fluviatilis*), and roach (*Rutilus rutilus*).

Other important fish species in the area include the pelagic Baltic herring (*Clupea harengus membras*), and the semi-pelagic salmon (*Salmo salar*) and whitefish (*Coregonus lavaretus*). The predominant soft bottom macrofauna are the crustacean amphipod *Monoporeia affinis*, the isopod *Saduria entomon*, and the bivalve *Macoma baltica*. They often occur in high abundances below the photic zone.

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The species or taxa (plants and lichens) which are endemic, near to the their distribution limits or which have a disjunct distribution in the Kvarken Archipelago.

Endemic taxa:

There are about 24 endemic taxa that are confined to the sea shores around the Baltic Sea. 16 of these occurs in the Kvarken Archipelago.

Agrostis gigantea var. glaucescensl
Agrostis stolonifera var. bottnica
*Artemisia bottnica ** (Artemisia campestris var. Bottnica)*
Artemisia vulgaris var. coarctata
Cakile maritima ssp. baltica
Carex nigra var. recta
Deschampsia bottnica
Eleocharis palustris var. lindbergii
Eleocharis uniglumis var. fennica
Euphrasia bottnica
Euphrasia frigida var. botniensium
Hierochloe odorata ssp. baltica
Juncus articulatus var. hylandri
Myosotis laxa ssp. baltica
Sonchus arvensis var. bottnicus
Valeriana salina
Veronica longifolia var. maritima
The *Primula sibirica* group

Plants with a disjunct distribution that occur on the sea shores of the Baltic and of the White Sea and the Barents Sea:

Carex glareosa
Carex mackenziei
Carex paleacea
Hippuris tetraphylla **
Potamogeton vaginatus
Potentilla anserina ssp. egedii
Rumex pseudonatronatus

Plants with a southern distribution that reach their northernmost occurrences in the Kvarken area:

Atriplex litoralis
Eleocharis parvula
Isatis tinctoria
Lychnis flos-cuculi
Ruppia maritima
Solanum dulcamara
Zannichellia major

** = species listed in the Habitats Directive of the European Union.

Plants with a northern distribution that appear as common characteristic species on the shores in the Kvarken Archipelago:

Cornus suecica
Rubus arcticus

Lichens with a northern distribution

Alectoria minuscula
Alectoria pubescens
Alectoria ochroleuca
Cetraria cucullata
Cetrarria nivalis
Parmelia alpicola
Rhizocarpon alpicola
Rhizocarpon oreites
Umbilicaria proboscidea
Xanthoria elegans (also on sites affected by wave-wash)

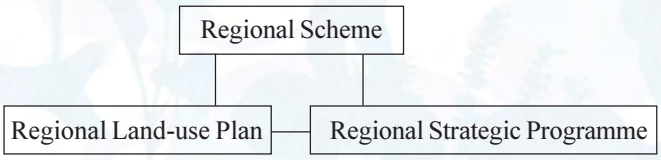
A number of lichens occur on wind-exposed heaths in the Fennoscandian mountain range and in the Kvarken area. They constitute a characteristic feature of the lichen vegetation of wind-exposed, snow-free (from mid-winter and onwards) epilittoral cliffs and boulder fields.

The Regional Scheme, the Regional Land-use Plan, and the Regional Strategic Programme – Three Central Planning Documents

The regional planning is a considerable part of the strategical development of the region. The vision, the strategic outlines, and the special action fields are given by the regional scheme which is further concretized by the regional land-use plan and the regional strategic programme. A regional land-use plan states the physical strategies, the prerequisites and forms of the development of the region.

Regional Scheme

The regional scheme is the supreme document for regional planning and it is implemented in the regional land-use plan and the regional strategic programme:



A regional scheme is a statutory, strategic plan that states the desired long-term development and the necessary strategic outlines. The regional scheme of Ostrobothnia has economic growth and welfare as an overall objective. It is named "Two Languages, One Objective: Landscape Plan of Ostrobothnia 2020". The land-use and building act (132/1999) regulates the regional survey.

Regional Land-use Plan

A regional land-use plan is a plan for the land-use of a region, or a part of it. It establishes the principles of land-use and community structure in the region and states the necessary action fields for the benefit of the regional development. Land-use matters of national and regional interests are decided upon in the regional land-use plan. The plan governs the planning work of the municipalities and other official authorities regarding land-use. The land-use and building act (132/1999) regulates the regional land-use plan.

A draft of the regional land-use plan of Ostrobothnia is presented for considerations and all instances are asked to give their opinion. The preparation of the final plan starts in the autumn of 2004.

The plan has to be approved by the regional council assembly and established by the Ministry of the Environment. According to the current schedule the plan will be submitted to the Ministry of the Environment in 2006.

Regional Strategic Programme

The regional strategic programme implements the regional scheme and deals with developmental objectives that are based on the possibilities and needs of the region, the most important projects from a developmental point of view, and other substantial actions needed to fulfill the objectives. The regional development act (602/2002) regulates the regional development programme.

The implementation of the regional strategic programme

A plan for the implementation of the regional strategic programme is made annually. The prioritized measures and actions for the next year are identified and noted. Financial guidelines for other activities are also mentioned. In practice, this plan is like a kind of regional budget that is used to increase the influence on the state budget, and to improve the co-ordination between measures taken in the region. The regional development act (602/2002) regulates the regional development programme.

Landscape Management Plan for the Björköby Area

The Björköby area is one of the landscape areas of national interest, decided by the Government in January, 1995. The landscape management plan of this area was prepared in 1996-1997 by the West Finland Regional Environmental Centre in co-operation with the Korsholm Municipality, the inhabitants of Björköby, and the Vaasa Rural Industry District. Inhabitants and representatives from the municipality and Government authorities have actively participated in the planning process.

The content of the plan (main headings only):

Preface

Introduction

The cultural landscape (including a definition of the different cultural elements of the landscape

Documentation (including history, current situation, descriptions of the vegetation and landscape elements)

Objectives and actions (a complement to the maps with suggestions of measures)

References

Maps

Archibal – Plan for tourism and recreation in the Kvarken area.

During the years 1999-2001 a project called ARCHIBAL was carried out in the Kvarken area (ARCHIBAL – Archipelago Baltic Networking – planning and management of the natural and cultural heritage an tourism in the Baltic arcipelagos).

The part of the project that was carried out in the Kvarken area was a co-operation between West Finland Regional Environmental Centre and the County Administration of Västerbotten in Sweden. It resulted in a plan for the public use of nature conservation areas in the Kvarken Archipelago.

The plan considers Northern Kvarken as one geographical area. The starting point of the work was to prepare the area for an increased amount of visitors without devastating the high values of the nature and culture, which are the attraction factors of the area. An increased tourism activity must not effect other industries negatively, mainly the fishery. The plan has focused on existing conservation areas or areas that are reserved for conservation purposes in the archipelago.

The plan presents guidelines about how to use conservation areas for tourism purposes in the future. A realisation of the plan requires a more detailed planning and agreements with the land-owners. Archipelago areas that are identified to be suitable for intensive tourism are those that sustain an increased amount of visitors, according to different investigations in this area, and others. In these places it is possible to develop new service facilities for the tourism industry.

The content of the plan (main headings only):

1. Introduction
2. General description of the Kvarken area
3. Values of the nature and culture in the Kvarken area
4. Description of Natura 2000 areas
5. Nature based tourism in the Kvarken area
6. Plan for the public use
7. Plan for the improvement of service facilities
8. Principles of the management and land-use of conservation areas
9. Consequences of nature based tourism, and monitoring indicators
10. Implementation of the plan
11. Demonstration objects
12. Investigations and methods used during the planning work.

Management plans for the areas Lappören-Slåttskäret-Rönnskär and Mickelsörarna-Rödgrynnorna

A summary of the "Management and Land Use Plan of Lappören, Rönnskäret, and Kvicksund

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Summary

Within the frame work of a Life Nature project, partly financed by the EU, the management and land use of an area in the Kvarken Archipelago has been planned. The main objective of the project was to secure the protection of forested islets of high natural value. Many valuable habitats and threatened or rare animal and plant species are found within the planning area of Lappö-ren-Slåttskäret-Rönnskäret-Kvicksund. The entire site belongs to the Natura 2000 network and large parts are also included in the Finnish "Programme for the Protection of Shores". The site has been used by the inhabitants of the archipelago for a long time and one objective is to conserve the cultural environments that have been created.

The final implementation of the nature protection takes place when the site has been established as a nature reserve. This is a process including voluntary protection of private owned land, land exchange or the purchase of private owned land by the state.

To combine the conservation objectives, recreation, and traditional land use, the plan outlines principles for the use and management of the site based on these different land use needs. The plan is also a platform and support during the protection negotiations with land owners, and functions as a recommendation for the protection regulations. The plan comprises both private owned and state owned land and has been prepared in co-operation with the steering group of the project.

In the endeavor to retain a vital archipelago the conservation objectives have been adapted to desires and needs of the inhabitants of the archipelago. Among the objectives of site protection is, besides the protection of habitats and species, also the conservation of cultural values and the securing of economical och social values.

The plan is carried out by various authorities and organisations that are responsible for different measures. The plan suggests that a co-operation group, composed by representatives from land owners, authorities and associations, supervise the site use and management.

A summary of the "Management and Land Use Plan of the Mickelsörarna-Rödgrynnorna Archipelagos"

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Summary

The management and land use plan of the Mickelsörarna-Rödgrynnorna archipelagos conserns a 22 109 ha large area of which 1950 ha is land and 20 159 ha is sea. The site is part of the Natura 2000 object "Kvarken Archipelago" and belongs to the municipalities of Maxmo, Vörå, and Korsholm. The site is presently used for second home living and boat recreation. In total there are more than 100 summer cottages. Metsähallitus and the West Finland Regional Environmental Centre are the main administrators.

The site includes three archipelago areas that partly border on open sea, the Rödgrynnorna, the Märaskär, and the Mickelsörarna, including more than 300 islands. The Mickelsörarna alone comprises 200 smaller skerries and reefs, and the two large islands of Villskär and Källskär. All three areas have a very variable archipelago nature with a mixture of barren outer archipelago and more sheltered achipelago types. The shores are typically stony, boulder rich, and rather deep. The finest rock-islands of the region are found in the north western parts of the Rödgrynnorna. There are many different morain ridges which often are higher, broader, and steeper then elsewhere in the Kvarken area. The most common moraines are Rogen type moraines and de Geer moraines. As a result of the land uplift there are about 140 ha of flads, gloes, and small lakes at the site. Streams are an essential part of the nature and are of particular importance for the bird and fish populations. The Mickelsörarna archipelago has been important for the fish industry and the household fishery. Whitefish and Baltic Herring are the most important commercial fish species.

The main objective with the protection of the Mickelsörarna-Rödgrynnorna is to conserve all habitats so that the survival of species living there is not jeopardized.
It is particularly important to allow the land uplift habitats in their natural state to develop freely without any interference by man. The planning area is divided into four land use zones, a subdivision mainly based on the presence of valuable species and habitats. The objective with the zones is to meet different needs concerning land use and nature protection. Other objectives with the management and land use plan concern the habitat conservation, recreation, public knowledge about the site, culturally historical objects, and the survival and development of the archipelago community. The implementation of the plan will be done in co-operation with concerned private persons, organisations, and authorities.

If the measures mentioned in the plan are realized, the negative effects at the site will be negligible, and the protection of several habitats and species will be improved, e.g. flads och gloes, primary succession forests, Baltic skerries and small islands, Caspian Tern, White-tailed Eagle, and Black Guillemot.

The Nature of Kvarken

Preliminary study

Conservation –Management - Land use

A SUMMARY

The preliminary study is meant to serve civil servants at the West Finland Environmental Centre, Metsähallitus (Forest and Park Service) and the County Administration of Västerbotten in their work with conservation, management and land use plans of areas reserved for nature protection. The aim is to identify conservation objectives, threats and planning needs in the Kvarken region, and to put forward a template for the conservation, management and land use plans. The term "areas reserved for nature protection" in the Kvarken area signifies the already established nature reserves (in Sweden), nature conservations areas (in Finland), Natura 2000 areas, and areas included in the Finnish nature conservation programmes.

THE NATURE

In the Kvarken area 25 habitats occur out of the 91 Swedish and Finnish habitats included in the Natura 2000 network.

Seven of these are given priority, which means a greater responsibility for preserving or improving the conservation status. The Kvarken has 71 species which are threatened nationally or are included in the Habitats or Bird Directives of the EU, most of which are found on the Finnish side. For 8 taxa the information about abundance and distribution in the Kvarken area is very unsatisfactory.

OBJECTIVES

The conservation, management, and land use plans should fulfil five objectives concerning:

Conservation Preserve the diversity of habitats in the Northern Kvarken in such a way that the survival of the organisms living there is not put at risk (central objective).

Recreation More people are given the possibility to be acquainted with the nature conservation areas of the Northern Kvarken. Commercial tourism activity in these areas should be environmentally standardized.

Knowledge The general level of knowledge about the nature in the Northern Kvarken, and the acceptance of conservation, should be improved, in particular among children and young adults. The biological and ecological knowledge about species and proces ses should be improved.

Socio-cultural Protection, management, conservation and use of the nature conservation areas should be performed in a way that does not jeopardize the future survival and development of the communities in the archipelago. The cultural history values of the Northern Kvarken should be protected for the future. (*This is a horisontal objective*)

Cooperation Land owners, local stakeholder organisations, municipalities and other concerned authorities and parties should participate in the planning process for the protection, management, conservation and use of the nature conservation areas. (*This is a horisontal objective*)

Working model for the design of a conservation and management plan for a protected nature area.

1. Make nature surveys and collect information about cultural history
2. Identify the most valuable species, habitats and cultural environments
3. Present the overall objective for the nature conservation area
4. In all steps take into consideration the socio-cultural objective and the cooperation objective
5. Decide whether the recreation objective is to be fulfilled, identify area of recreation
6. For each conservation object the following should be specified:
   - Conservation objective: distribution, quality and function
   - Threats
   - Possible action program to reach the conservation objective
7. Program for monitoring of the conservation objective and actions, if any
   - For recreational objects the following should be stated
   - Recreational objective and knowledge objective
   - Actions that facilitate visits and canalise the visitors
   - Program for monitoring of recreation objective and actions

Guidelines and objectives for the use of areas reserved for conservation

The use must not endanger the conservation objective. The present use is at an acceptable level, but it may need to be limited and/or canalized to fulfil the conservation objective.

Guidelines for the most important areas of use:

1. Hunting
   - Natural animal populations should be kept viable (objective)
   - Hunting should generally be permitted in areas reserved for conservation
   - Hunting must not interfere with threatened species
   - Hunting may need to be limited for reasons of conservation
2. Fishing
   - Natural fish populations should be kept viable
   - Fishing may be carried on in most areas reserved for conservation
   - Fishing must not interfere with threatened species
   - Fishing may be limited if there are important reasons of conservation or fishery management
3. Forestry
   - Primary succession forests of land uplift coasts should be allowed to develop freely without human interference (objective)
   - Forestry should be strongly limited or prohibited
   - Buildings for leisure purposes
   - The areas should not be exploited further for construction purposes
4. Recreation and tourism
   - Tourism and recreation should be canalized to suitable areas
   - The legal right of access should generally be applied
   - It should be permitted to visit all areas except special bird sanctuary areas at certain times of the year, as well as seal protection areas and military areas

Need for interregional surveying and investigation

The following biological surveys should be made:

- Marine invertebrates, macro-vegetation, and fish in shallow areas
- Tree-living fungi and invertebrates
- Other terrestrial invertebrates
- Spiders
- Mosses
- Amphibians and reptiles

The following investigations should be made:

- Dredging policy
- Hunting investigation
- Fishing investigation
- Investigation of the extent of boat traffic
- Canalising of the commercial forestry

Criteria indicating the need for a detailed conservation and land use plan

- Nationally and locally threatened species occur in the area
- The area is important for priority Natura 2000 habitats
- The area is exposed to a large pressure of use from various user groups
- There are valuable habitats in the area that demand management or restoring
- The area has a fragmented landownership
- The area has a history of conflicts between landowners, environmental authorities and other stakeholders

The Kvarken Archipelago as a World Heritage Site

STATEMENT OF INTENT

The Kvarken Archipelago and the High Coast are together a unique geological entity, where traces from the inland ice and thousands of years of land uplift have formed the nature and culture. The ongoing land uplift is also a unique example of a landscape in continuous change.

The Government of Finland shall, on the basis of the geological values, propose the Finnish part of the Northern Kvarken to be inscribed on the World Heritage List of Unesco as an complement of the existing World Heritage of the High Coast.

The aim of the World Heritage is to protect the geological, biological and cultural values of the Kvarken Archipelago. If the "Kvarken Archipelago" is inscribed on the World Heritage List of Unesco, Finland guarantees that the values of the site will remain and develope.

The aim of the World Heritage proposal is to increase the knowledge about the geological, biological and cultural values of the Kvarken Archipelago, both internationally, nationally, regionally, and locally.

The"Kvarken Archipelago" World Heritage may contribute to stimulate the economical development in the area by taking advantage of the attention it will create.

The World Heritage area shall be administered according to the Finnish legislation. There is no need to establish new laws, regulations, conservation areas, or any sharpening of the existing conservation regulations for the Kvarken Archipelago as a World Heritage.

The management and land-use of the conservation areas included in the World Heritage proposal shall be planned and implemented in co-operation between local inhabitants and responsible authorities.

A classification as a World Heritage shall not have any negative influence on housing or on the agrarian branches of economy such as fishery, hunting, fur farming, agriculture, forestry, or traditional building in the area.

A regional consultation group will be established with the aim to deal with questions regarding the administration, management and development, accessability, service, marketing, etc, of the World Heritage Site.

Signed by the following instances:

West Finland Regional Environmental Center

Metsähallitus (Forest and Park Service)

Regional Council of Ostrobothnia

The municipalities concerned (Malax, Vaasa, Korsnäs, Maxmo, Korsholm, Vörå)

APPENDIX 11

WHC REGISTRATION
Date 29.06.05
Id N° 898515
Copy 1 Item 19

List of photographs and slides

Type	Figure number in the application	Cover illustration	Slide number (Powerpoint)	Slide number (35 mm)	Caption	Date	Photographer	Illustrator/ Layout	Copyright	Contact information	Non exklusive cession of rights
aerial photograph		front	1	1	Aerial view of the De Geer morainesand fishing harbour at Björköby	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
map	1		28		The location of the proposed sitein the world and the Northern Europe.	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/ 04
map	2		27		The border of the proposed World Heritage site	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/ 04
aerial photograph	3		2		Aerial view of different types of moraines at Märaskär.	october 2001	Hannu Vallas		Maxmo municipality	Maxmo municipality, Michael Ek, Tottesund 529, 66640 Maxmo, Finland, michael.ek@maxmo.fi	X
aerial photograph	4a				The landscape of the High Coast World Heritage.		Metria		Länsstyrelsen Västernorrland	Länsstyrelsen Västernorrland, Mats Henriksson, 87186 Härnösand, Sverige, mats.henriksson@y.lst.se	
aerial photograph	4b				The landscape of the Kvarken Archipelago.	august 2003	Metsähallitus		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph	5		9		Isolation of lakes and ponds from the sea and development of freshwater and peat land ecosystems at Lappören.	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	6				The ice has a great impact on the landscape and ecosystems in the Kvarken Archipelago.	april 2002	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph	7		12		Rödgrynnorna islets with bedrock crags and moraine tails, created by the last inland ice.	summer 2003	Hannu Vallas		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	8a				A result of the land up-lift phenomenon on Valsörarna. In the 1970's, the old bridge was situated at the shoreline, while today it cannot be reached by boat.	autumn 1975	Tuukka Pahtamaa		Tuukka Pahtamaa	Pohjois-Pohjanmaan ympäristökeskus, Tuukka Pahtamaa, PB 124, 90101 Oulu, Finland, tuukka.pahtamaa@ymparisto.fi	X
photograph	8b				A result of the land up-lift phenomenon on Valsörarna. In the 1970's, the old bridge was situated at the shoreline, while today it cannot be reached by boat.	summer 1995	Tuukka Pahtamaa		Tuukka Pahtamaa	Pohjois-Pohjanmaan ympäristökeskus, Tuukka Pahtamaa, PB 124, 90101 Oulu, Finland, tuukka.pahtamaa@ymparisto.fi	X
map	9				A schematic view of the Gulf of Bothnia, showing the future of the area and differences between the landscapes of the Swedish High Coast and the Finnish Ostrobothnian low coast.	spring 2004		Harri Kutvonen	Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X

Type	Figure number in the application	Cover illustration	Slide number (Powerpoint)	Slide number (35 mm)	Caption	Date	Photographer	Illustrator/ Layout	Copyright	Contact information	Non exklusive cession of rights
photograph	10		14	3	The shallow and boulder-rich archipelago area in Korsnäs municipality	july 1987	Hans Hästbacka		Hans Hästbacka	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
aerial photograph	11				Aerial and oblique photo of De Geer moraines from Hudson Bay area	1983	Prest		Prest	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	
aerial photograph	12		3		Aerial view of the De Geer moraines at Björköby	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
illustration	13				Schematic figure of the moraine formations in the Northern Kvarken area.	autumn 2003		Harri Kutvonen	Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X
photograph	14		4		Typical shape of a De Geer moraine ridge.	summer 2003	Jukka-Pekka Palmu		Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X
illustration	15				The origin and genesis of De Geer moraines.	autumn 2003		Harri Kutvonen	Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X
aerial photograph	16		5		Large transversal moraine ridges at Valsšrarna.	july 2001	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph	17		10		View of a flat and boulder-rich moraine in Korsnäs.	august 2003	Metsähallitus		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
map	18				The developmental stages of the Baltic Sea after Svendsen et al 2004.	summer 2004		Harri Kutvonen	National Land Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	
photograph	19		16		Beach formations on östra Norrskär.	april 2002	Timo Hissa		Metsähallitus	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X
map	20				Present isobases of land uplift (mm/year) in Finland.	2003		Harri Kutvonen	National Land Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X
map	21		36		Maps representing the historical land uplift, and a forecast of the future development	summer 2004		Hanna Virkki	Seifert	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	
map	22				Bothnian Bay and Baltic Sea area during the Weichselian interglacial stage.	summer 2004			Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	
illustration	23				Echo sounding (A) and acoustic reflection profiles (B) of De Geer moraines.	autumn 2003			Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	
photograph	24				Fresh diabase outcrop with marks of glacial erosion, Storskäret.	july 2003	Olli Breilin		Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X
photograph	25				The most frequently occurring rock type, Vaasa granite.	summer 2003	Petri Virransalo		Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X
map	26		35		The diverging of the De Geer moraine and large transversal moraine ridge clusters in the north shown by geographical elevation model. The Söderfjärden meteorite impact crater is shown near Vaasa in the southern part of the image.	summer 2004		Tapio Väänänen, Miikka Paalijärvi	Geolocial Survey of Finland	GTK, Olli Breilin, PB 96, 02151 Espoo, Finland, olli.breilin@gsf.fi	X

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photograph	27a				The Sea buckthorn in winter. The berries are an important source of food for migrating birds.	january 2003	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	27b				The Sea buckthorn in autumn. The berries are an important source of food for migrating birds.	december 1968	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	
photograph	28				The northern distribution limit of the Eider in the Baltic Sea is situated in the middle of the Northern Kvarken. The distribution is limited by the availabiltiy of its main food source, the Common mussel, which requires a salinity of at least 5 ‰	april 2002	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	29a				Boulder-rich and stony shores are common in the Kvarken Archipelago. This makes it hard to get ashore, even from smaller boats.	august 2002	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	
photograph	29b		15		Boulder-rich and stony shores are common in the Kvarken Archipelago. This makes it hard to get ashore, even from smaller boats.	june 2000	Pertti Malinen		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	30				Fish is an important prey for the rare White-tailed Eagle. The shallow bays and inlets offer excellent hunting areas for fish-catching birds.	may 1997	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	X
aerial photograph	31a				In the varied moraine landscape the development goes from bays to fladas and glo-lakes.	september 2004	Timo Hissa		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
aerial photograph	31b		7		In the varied moraine landscape the development goes from bays to fladas and glo-lakes.	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
aerial photograph	31c				In the varied moraine landscape the development goes from bays to fladas and glo-lakes.	summer 1996	Arto Hämäläinen		Mustasaari municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	32				Narrow brooks connect the gloes with the sea or a flad. In spring, Pike force their way up to ideal spawning habitats.	may 1997	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	
photograph	33			5	The endemic Hair-grass is found only along the shores of the Gulf of Bothnia. Photo Hans HŠstbacka	july 1984	Hans Hästbacka		Hans Hästbacka	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
aerial photograph	34			2	Typical forest succession in the Kvarken Archipelago (Slåttskäret) with a belt of Alder along the shore and Spruce in the central part of the island.	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X

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photograph	29b		15		Boulder-rich and stony shores are common in the Kvarken Archipelago. This makes it hard to get ashore, even from smaller boats.	june 2000	Pertti Malinen		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	30				Fish is an important prey for the rare White-tailed Eagle. The shallow bays and inlets offer excellent hunting areas for fish-catching birds.	may 1997	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	X
aerial photograph	31a				In the varied moraine landscape the development goes from bays to fladas and glo-lakes.	september 2004	Timo Hissa		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
aerial photograph	31b		7		In the varied moraine landscape the development goes from bays to fladas and glo-lakes.	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
aerial photograph	31c				In the varied moraine landscape the development goes from bays to fladas and glo-lakes.	summer 1996	Arto Hämäläinen		Mustasaari municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	32				Narrow brooks connect the gloes with the sea or a flad. In spring, Pike force their way up to ideal spawning habitats.	may 1997	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	
photograph	33			5	The endemic Hair-grass is found only along the shores of the Gulf of Bothnia. Photo Hans HŠstbacka	july 1984	Hans Hästbacka		Hans Hästbacka	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
aerial photograph	34			2	Typical forest succession in the Kvarken Archipelago (Slåttskäret) with a belt of Alder along the shore and Spruce in the central part of the island.	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	35		19		The Alder belt is often followed by a flourishing birch and rowan forest.	summer 1995	Tuukka Pahtamaa		Tuukka Pahtamaa	Pohjois-Pohjanmaan ympäristökeskus, Tuukka Pahtamaa, PB 124, 90101 Oulu, Finland, tuukka.pahtamaa@ymparisto.fi	X
photograph	36			4	A typical glo-lake with peat-forming species along the shore.	october 2003	Hans Hästbacka		Hans Hästbacka	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
photograph	37				Hundreds of years of pasturage have affected the vegetation, but nowadays there is only a hand-full of sheep farmers left in the archipelago.	summmer 1995	Lise-Lotte Molander		Lise-Lotte Molander	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	X
photograph	38				is an effective method to get rid of Junipers and to favour grasses, herbs and berries.	may 2000	Leena Rinkineva-Kantola		Leena Rinkineva-Kantola	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	X
photograph	39				The brackish water isopod is one of the most common bottom dwelling animals in the Kvarken Archipelago.	1990´s	Curt Nyman		Curt Nyman	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	

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photograph	40				One fourth of the Baltic Sea population of Black Guillemot breeds in the Kvarken Archipelago.	july 1962	Juhani Koivusaari		Juhani Koivusaari	Länsi-Suomen ympäristökeskus, Juhani Koivusaari, PB 262, 65101 Vaasa, Finland, juhani.koivusaari@ymparisto.fi	X
photograph	41				The Ringed seal population has slowly recovered from the depression during the 1950s, which was caused by toxic substances (DDT, DDE and PCB).	february 2002	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
illustration	42				A long time ago, a giant boy played in the Kvarken area.	2003		Liselott Nyström	Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
map	43		29		Ancient remains in the Kvarken Archipelago.	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/04
photograph	44a				Ancient remains at Mickelsörarna - Field-labyrinth	summer 1999	Erkki Salminen		Ostrobothnian Museum	Pohjanmaan museo, Pentti Risla, PB 3, 65101 Vaasa, pentti.risla@vaasa.fi	X
photograph	44b				Ancient remains at Mickelsörarna - Net-drying cairns	summer 1999	Erkki Salminen		Ostrobothnian Museum	Pohjanmaan museo, Pentti Risla, PB 3, 65101 Vaasa, pentti.risla@vaasa.fi	X
photograph	44c				Ancient remains at Mickelsörarna - Compass rose	summer 1999	Erkki Salminen		Ostrobothnian Museum	Pohjanmaan museo, Pentti Risla, PB 3, 65101 Vaasa, pentti.risla@vaasa.fi	X
photograph	44d				Ancient remains at Mickelsörarna - Navigation cairns	summer 1999	Erkki Salminen		Ostrobothnian Museum	Pohjanmaan museo, Pentti Risla, PB 3, 65101 Vaasa, pentti.risla@vaasa.fi	X
photograph	44e				Ancient remains at Mickelsörarna - Hunting shelter	summer 1999	Erkki Salminen		Ostrobothnian Museum	Pohjanmaan museo, Pentti Risla, PB 3, 65101 Vaasa, pentti.risla@vaasa.fi	X
photograph	44f				Ancient remains at Mickelsörarna - Russian oven	summer 1999	Erkki Salminen		Ostrobothnian Museum	Pohjanmaan museo, Pentti Risla, PB 3, 65101 Vaasa, pentti.risla@vaasa.fi	X
photograph	44g				Ancient remains at Mickelsörarna - Small harbour	summer 1999	Erkki Salminen		Ostrobothnian Museum	Pohjanmaan museo, Pentti Risla, PB 3, 65101 Vaasa, pentti.risla@vaasa.fi	X
photograph	45a				Seal hunting took place under harsh conditions, which demanded both courage and patience from the hunters.	1920´s	G.Rosenholm		Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
photograph	45b				Seal hunting took place under harsh conditions, which demanded both courage and patience from the hunters.	1920´s	G.Rosenholm		Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
photograph	46				Baltic herring fishery at Replot in the 1960-s. The baltic herring was once one of the most important fish species for human consumption, but today it is mainly used for animal-food production.	1960´s	Pentti Pashinsky		Pentti Pachinsky	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
photograph	47				Fisherman from Björköby attach stone weights to the nets.	1924	Sverre Boucht		Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
aerial photograph	48				Remains of an old fishing village at Rönnskären.	1920´s			Society of Swedish Literature	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X

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aerial photograph	49				The fishing village at Norrskär is still used by a few fishermen, but most of the old fishing cottages serve as summer houses.	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	50				The grazing season is over and sheep are brought back home from the outer archipelago.	autumn 1952	Sverre Boucht		Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
photograph	51				Today there more than 600 summer cottages in the Kvarken Archipelago.	october 2003	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
illustration	52				Mail delivery in the Northern Kvarken described in the book of E.D.Clarke year 1824.	1824			Raud Publishing Ltd	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
painting	53				The name of the frigate was Allmänt Bästa = the Best One, built in Vaasa in 1786.		Ostrobothnian Museum		Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
painting	54				Crimean war. General Barclay de Tolly and his army crossed the Northern Kvarken in March 1809.	1809	Matti Ruotsalainen		Matti Ruotsalainen	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
painting	55				The English warship Firefly attacks the town of Vaasa during the Crimean war.	1856	Kaj Höglund		Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
photograph	56				Water level marks at Strömmingsbådan. Without modern scientific methods this was the only way to measure land uplift.	august 2002	Hans Hästbacka		Hans Hästbacka	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
map	57		30		Lighthouses and beacons in the Kvarken Archipelago.	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/ 04
illustration	58				The "vippbåk" of Molpehällorna served as a big torch, leading ships on a safer sailing route to Old Vaasa.	2002		Liselott Nyström	Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	59				Visitors to Valsörarna can follw a nature path, locally called "the love trail", to the famous lighthouse.	may 2004	Tuija Warén		Tuija Warén	Metsähallitus, Tuija Warén, Hovrättseplanaden 16, 65100 Vaasa, Finland, tuija.waren@metsa.fi	X
photograph	60				The sea monster as illustrated in the magazine Suomen kuvalehti 1932.	1932			Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	X
photograph	61		22		A Grey seal protection area (Snipan-Medelkallan, 3259 ha), is situated in the outer part of the Kvarken Archipelago. Hunting, fishing and boating are generally prohibited in the area.	march 2002	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
map	62		32		Nature Conservation Programmes in the Kvarken Archipelago.	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/ 04
map	63		33		Areas included in the Natura 2000 Network.	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/ 04

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photograph	64				Areas included in the Natura 2000 Network.	july 1999	Pertti Malinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	65				The signs of eutrophication are evident in the sea. For example the amount of filamentous algae as epiphytes on Bladder wrack (Fucus vesiculosus) is increacing.	july 2004	Metsähallitus		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	66		21		The rare White-tailed Eagle population has increased since 1980-s. Nowadays there are about 35 breeding pairs in the Kvarken Archipelago.	april 1998	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	
map	67		34		Management plans in the Kvarken Archipelago	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/ 04
map	68		31		The present visitor facilities.	january 2004		Päivi Anttila	National Land Survey of Finland	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X, permit nr 7/MYY/ 04
photograph	69				Open house at the nature station of Mickelsörama in the summer 2003. The nature station has about 2500 visitors each year.	june 2003	Pertti Malinen		Pertti Malinen	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
aerial photograph	70				The nature station of Rönnskär is an old pilot society where the pilots lived permanently with their families. The last pilot left the station in 1983.	july 2001	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	71				The hiking trail in Björköby archipelago is 12 km long and MetsŠhallitus is responsible for its maintenance.	february 2002	Metsähallitus		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	72				In the "Post row" you can only participate with traditional boats and clothes.	1990´s	Korsholm municipality		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph	73				In winter, the sea is frozen for almost five months. The thick ice cover makes it possible to discover and utilize the archipelago in different ways than in summer. Cross-country skiing, ice-fishing, skating and even driving cars on the ice is common.	february 2004	Alexander Henriksson		Alexander Henriksson	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
photograph	74				Visiting the Terranova exhibition is a good introduction to the Kvarken area. It covers different aspects including geology, ecology and species occurring in the archipelago. European Union projects have funded parts of the exhibition.	may 2002	Metsähallitus		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X

Type	Figure number in the application	Cover illustration	Slide number (Powerpoint)	Slide number (35 mm)	Caption	Date	Photographer	Illustrator/ Layout	Copyright	Contact information	Non exklusive cession of rights
photograph	75				The Crane is a typical bird in the Kvarken Archipelago. The migratory route of the Cranes passes through the Northern Kvarken.	september 2002	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
photograph	76				The endangered White-backed Woodpecker has returned to the Kvarken Archipelago after a 30 year absence. A few pairs nest in the birch- and alder forests in the area.	june 1960	Juhani Koivusaari		Juhani Koivusaari	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	X
photograph	77				Shingle shore at Östra Norrskär. This type of shore with round stones of a uniform size is very rare in the Kvarken Archipelago.	july 2001	Pertti Malinen		Pertti Malinen	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
aerial photograph	78				Infrared aerial photographs are an excellent tool to identify different habitats. These photos from the Björköby archipelago (Svedjehamn/Lappören) shows flads, gloes, glo-lakes, primary landupheaval forests, De Geer moraines etc.	summer 1995	FM Kartta Oy		FM Kartta Oy	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
photograph	79		20		The park-like character of Birch forests that grow in the Kvarken Archipelago are results of the sea climate as well as from pasturage.	october 1983	Eero Murtomäki		Eero Murtomäki	Länsi-Suomen ympäristökeskus, Leena Rinkineva-Kantola, PB 262, 65101 Vaasa, Finland, leena.rinkineva@ymparisto.fi	
illustration	80				The construction drawing for the Valsšrama lighthouse.	1880´s		Henry Lepaute	Finnish Maritime Association	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
map		inside back			Carta Marina, a map by the famous swedish archibishop Olaus Magnus.	1539		Olaus Magnus		Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	
map		inside back			The modern nautical chart of the Kvarken Archipleago.	2003			Finnish Maritime Association	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	
		inside back			The first orthographic map of the Kvarken Archipelago.	before 1790´s			Ostrobothnian Museum	Pohjanmaan museo, Kaj Höglund, PB 3, 65101 Vaasa, kaj.hoglund@vaasa.fi	
aerial photograph			6		The development of bays, fladas and glo-lakes at Lappören.	april 2004	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph			8		The development of fladas and glo-lakes at Björköby.	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
aerial photograph			11		The development of fladas and glo-lakes at Molpehällorna.	august 2003	Metsähallitus		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph			13		Sand beaches and grass heaths in the Norrskär archipelago	summer 1996	Arto Hämäläinen		Korsholm municipality	Korsholm municipality, Pertti Malinen, Centrumvägen 4, 65610 Korsholm, Finland, pertti.malinen@korsholm.fi	X
photograph			17		Drift lines in the Norrskär archipelago	june 2000	Pertti Malinen		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X

Type	Figure number in the application	Cover illustration	Slide number (Powerpoint)	Slide number (35 mm)	Caption	Date	Photographer	Illustrator/ Layout	Copyright	Contact information	Non exclusive cession of rights
photograph			18		A typical glo-lake at Mickelsörarana	june 2000	Pertti Malinen		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph			23		An aerial view of the Mickelsörarana archipelago	july 2001	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph			24		An aerial view of Bergögaddarna	july 2001	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph			25		An aerial view of the Rönnskären archipelago	july 2001	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X
aerial photograph			26		An aerial view of Norrskär	july 2001	Timo Hissa		Metsähallitus	Metsähallitus, Susanna Ollqvist, Hovrättseplanaden 16, 65100 Vaasa, Finland, susanna.ollqvist@metsa.fi	X

List of laws that concern land and sea areas, with their most important chapters and paragraphs. The content of the paragraphs are shortened.

NATURE CONSERVATION ACT

Chapter 3	Nature protection areas
Chapter 4	Habitat conservation
29§	The characteristic features of certain habitats must not be destroyed, e.g. coastal meadows and alder marshes.
Chapter 5	Landscape management
32§	Landscape management areas may be established to conserve and maintain important features of the landscape
Chapter 6	Species conservation
5§	All wild mammals and birds are protected with exception for the game species and non-protected species according to the Game Act.
38§, 42§	Animals and plants may be protected if their existence becomes threatened.
47§	It is forbidden to destroy or deteriorate the habitats of protected species.
Chapter 7	Implementation of nature conservation.
50§	The nature conservation programme must be implemented without any delay.
Chapter 10	Special statutes about the Natura 2000 network
65-66§	A project or a plan must not considerable deteriorate the natural values.
68§	The Natura 2000 areas have to be protected as soon as possible and in a way that corresponds to the conservation objectives.

LAND EXTRACTION ACT

1a§	Ground exploitation (e.g. gravel pits) have to be located, and ground exploitation activities have to be arranged, in such a way that the harmful effects on nature and the landscape are minimised. Ground material must not, without special reasons, be extracted from the shores of seas and other bodies of water, unless the site has been assigned by a Local Detail Plan or a Local Master Plan for this purpose.
3§	Ground exploitation activities must be performed in such a way that a beautiful landscape will not deteriorate, and that considerable aesthetic values of nature, or specific natural phenomena, are saved.

Land-use and Building Act

6a§ Construction work is forbidden on the shores of Finland, unless this is regulated by an established Local Master or Local Detail Plan.

9§ All plans have to include an impact assessment

28§ Requirements on the content of the Regional Land-use Plan.

Nature conservation programmes and decisions that are referred to in the Nature Conservation Act, 7§ and 77§, and decisions about the establishment of landscape management areas, referred to in the same act, 32§, should guide the work with the Plan. The planning work has to attach great importance to the protection of the landscape, the values of nature and the cultural heritage.

39§ Requirements on the content of Local Master Plan.

The municipality land-use is mainly governed by the master planning, which must consider the Regional Land-use Plan, the conservation of the landscape and the values of nature.

72-73§ The need of planning of shore areas and special demands on these.

Water Act

Chapter 1 General provisions

15a§ Exploitation that threatens the natural state of flads and gloes of up to 10 ha, and lakes up to one ha, is forbidden.

30§ All significant exploitation (dredging, digging etc) has to be communicated to the water owner and the Regional Environmental Centre in advance.

Chapter 2 General provisions for construction work in running water

2§ If construction work in running water, or the use of a construction, will result in changes or consequences described in chapter 1, 15§, a permission is required from the Environmental Permit Authority

3§ Construction must, if the costs are relatively reasonable, be performed in such a way that the purification ability of the water and the water environment itself is not deteriorated, and the beauty of the nature is not reduced.

Chapter 4 Fairways and other traffic areas

6§ For the placement of dredging-masses that have been removed from the sea bed a permission from the Environmental Permit Authority is required, if the activity may result in the consequences mentioned in Chapter 1, 12§, 15§, or 19§.

Act on the Prevention of Marine Pollution

According to the act all activities that may cause pollution in other countries' territorial water or economical zone are forbidden.

Act on environmental impact assessment

4§ Applicability. The environmental impact assessment procedure is applied on projects that may cause very serious consequences for the environment, due to the distinctive features of nature and other environments of Finland. The environmental impact assessment concerns permit procedures of 18 acts, and has to be executed before the exploitations permit is given.

Environmental Protection Act

7§ Prohibition of soil pollution.

9§ Special prohibitions applied on the sea: no activities are allowed in lakes and territorial waters that may cause a pollution, referred to in the Sea Protection Act, in waters outside the Finnish territorial waters.

28§ General authorization duty. Permits are required for activities that involve environmental pollution (environmental permits).

Waste Act

19§ Prohibition of littering: litter, dirt or a machine, construction, ship or other discarded objects must not be left in the environment.

Antiquities Act

1§ All ancient remains are protected.

Forest Act

6, 10§ Areas of special importance for the forest biodiversity or the landscape have to be managed with regard to these values.

Forest Improvement Act

2§ The realisation of a forest improvement activity, e.g. drainage, must not significantly prevent a nature conservation project that is included in a programme, approved by the Government, which aims at the establishment of a nature conservation area.

Fichery Act

Björköby
Korsholm municipalty ©

Märaskär
Maxmo municapality©

Björköby

Korsholm municipality ©

GTK ©

Valsörarna
Metsähallitus ©

Lappören

Björköby
Korsholm municipality ©

Björköby
Korsholm municipality ©

Lappören
Korsholm municipality ©

Marskärsberget
Metsähallitus ©

Molpehällorna

Rödgrynnorna

Korsholm municipalty ©

Norrberget
Korsholm municipality ©

Bergögaddarna

Bergögaddarna

Norrskär
Metsähallitus ©

Norrskär
Pertti Malinen ©

Mickelsörarna
Pertti Malinen ©

Lappören
Tuukka Pahtamaa ©

Björköby
Eero Murtomäki ©

White-tailed eagle
Eero Murtomäki ©

Grey seal
Metsähallitus ©

Mickelsörarna

Metsähallitus ©

Bergögaddarna

Rönnskär

Metsähallitus ©

Norrskär

Metsähallitus ©

15°
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Kvarken
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The
Bothnian
Bay
The Gulf of Bothnia
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SWEDEN
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PROPOSED BORDER OF WORLD HERITAGE AREA
FÖRESLAGEN VÄRLDSARVSGRÄNS
MAAILMANPERINTÖKOHTEEN RAJAUSEHDOTUS
BUFFER ZONE
BUFFERTZON
PUSKURIVYÖHYKE
Northern Kvarken
Norra Kvarken
Merenkurkku
Valsörarna
Valassaaret
Mickelsörarna
Mikkelinsaaret
Björkogrunden
Lappörarna
Utgrynnan
Maraskäret
Slättskäret
Rödgrynnorna
Punakarit
Rönnskär
Björköby
Koklot
Kaukaluoto
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MAXMO
MAKSAMAA
Replot
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Södra Valigrund
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PUSKURIVYÖHYKE
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BEACON - BÅK - POOKI
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KALASTUSLOISTO
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Norra Kvarken
Merenkurkku
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Mikkelinsaaret
Björkögrunden
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PUSKURIVYÖHYKE
Northern Kvarken
Norra Kvarken
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Molpehällorna
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SWEDEN
Sverige
Ruotsi
Holmön
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NATIONAL NATURE CONSERVATION PROGRAMMES
NATIONELLA SKYDDSPROGRAM
KANSALLISET SUOJELUOHJELMAT
OTHER IMPORTANT PROTECTED AREAS
ÖVRIGA VIKTIGA SKYDDSOMRÅDEN
MUUT TÄRKEÄT SUOJELUALUEET
LANDSCAPE AREAS OF NATIONAL INTEREST
LANDSKAPSOMRÅDEN
MAISEMAKOKONAISUUDET
Northern Kvarken
Norra Kvarken
Merenkurkku
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Valsörarna
Valassaaret
8
Björkögrunden
Lapporarna
3
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Mickelsörarna
Mikkelinsaaret
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Utgrynnan
Slättskäret
Rönnskär
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Märaskäret
Rödgrynnorna
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Kaukaluoto
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MAKSAMAA
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Södra Vallgrund
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PROPOSED BORDER OF
WORLD HERITAGE AREA
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RAJAUSEHDOTUS
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NATURA 2000-OMRÅDEN
NATURA 2000 -VERKOSTON KOHTEET
PROPOSED BORDER OF WORLD HERITAGE AREA
FÖRESLAGEN VÄRLDSARVSGRÄNS
MAAILMANPERINTÖKOHTEEN RAJAUSEHDOTUS
BUFFER ZONE
BUFFERTZON
PUSKURIVYÖHYKE
Northern Kvarken
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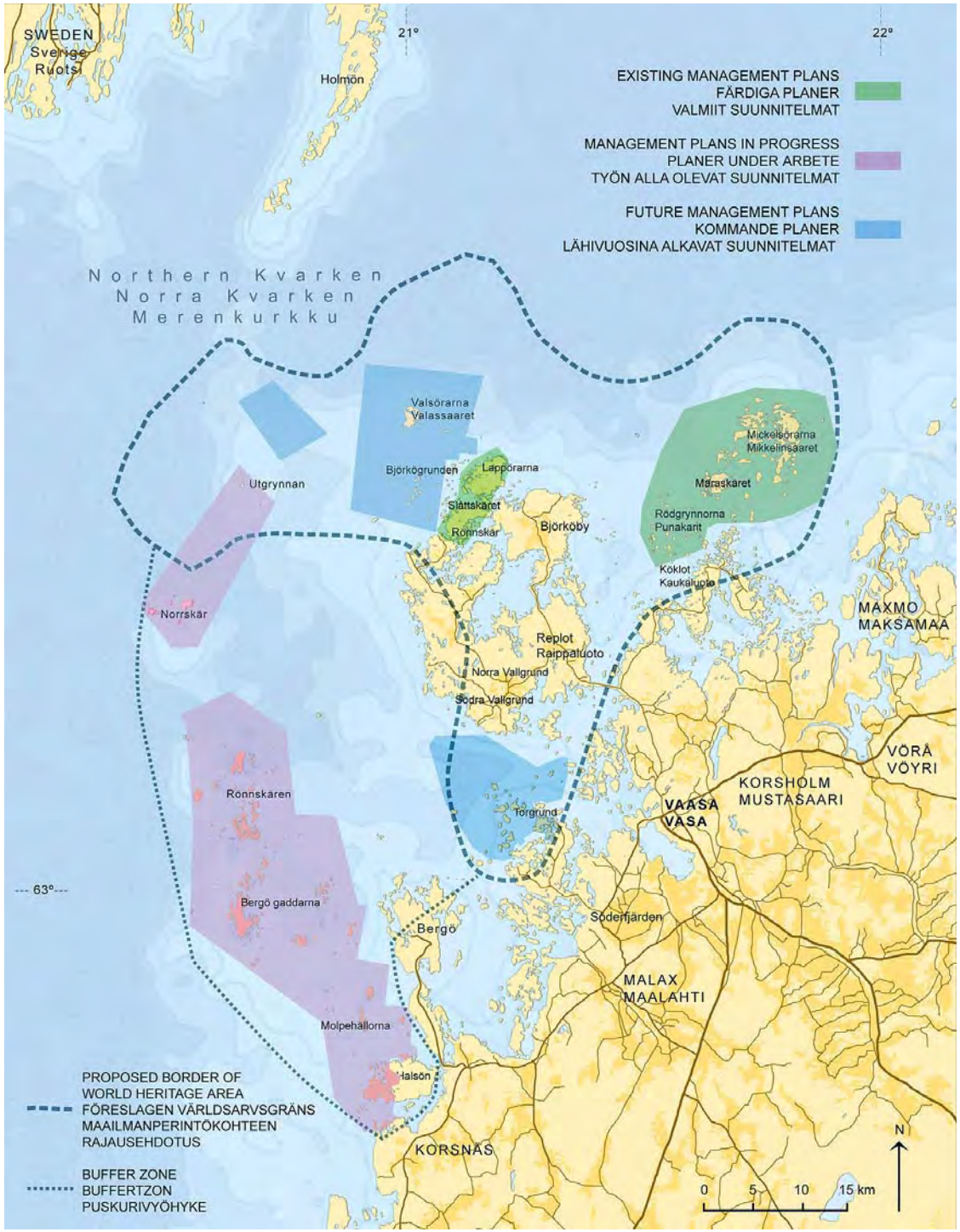
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EXISTING MANAGEMENT PLANS
FÄRDIGA PLANER
VALMIIT SUUNNITELMAT
MANAGEMENT PLANS IN PROGRESS
PLANER UNDER ARBETE
TYÖN ALLA OLEVAT SUUNNITELMAT
FUTURE MANAGEMENT PLANS
KOMMANDE PLANER
LÄHIVUOSINA ALKAVAT SUUNNITELMAT
Northern Kvarken
Norra Kvarken
Merenkurkku
Valsörarna
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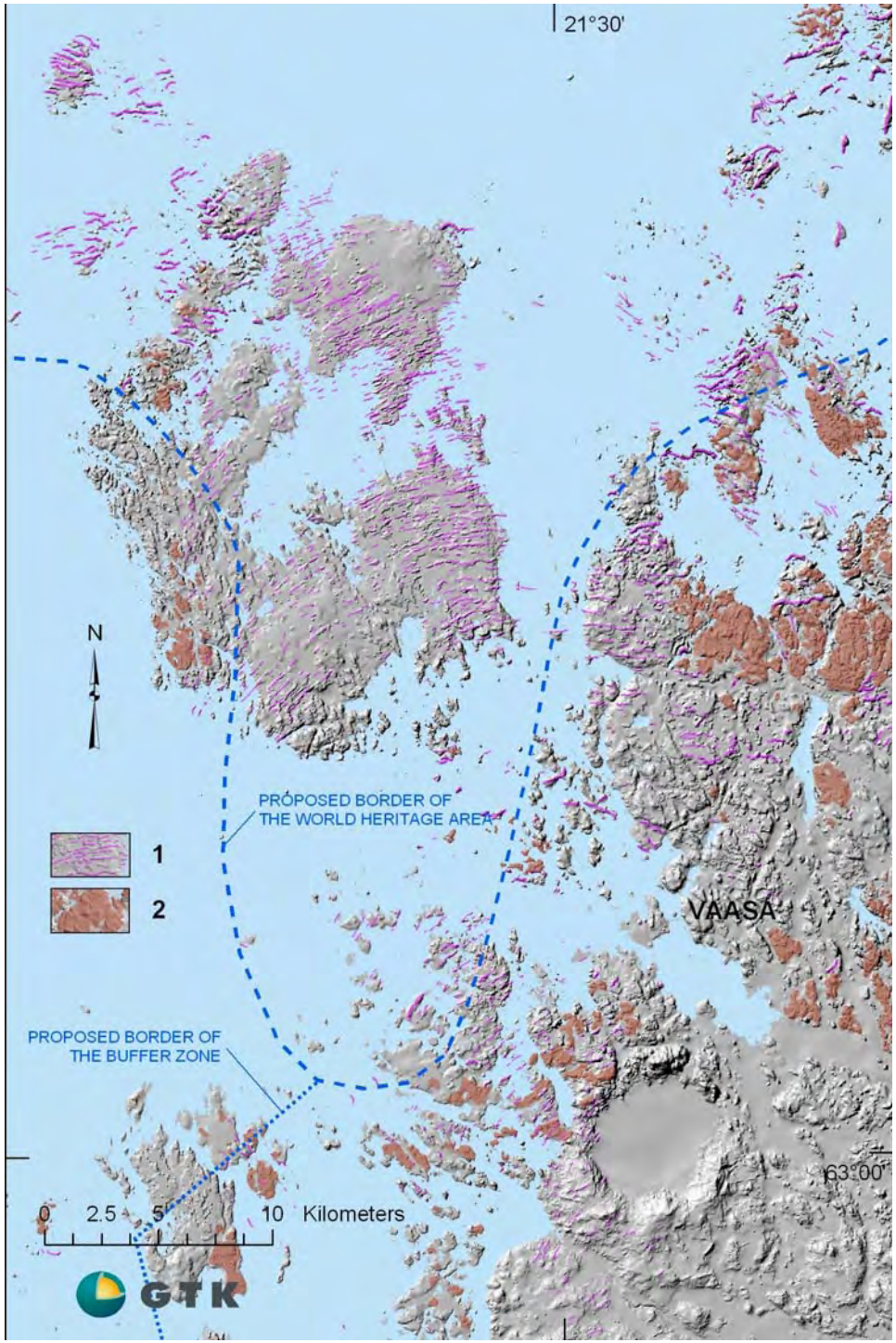
PUSKURIVYÖHYKE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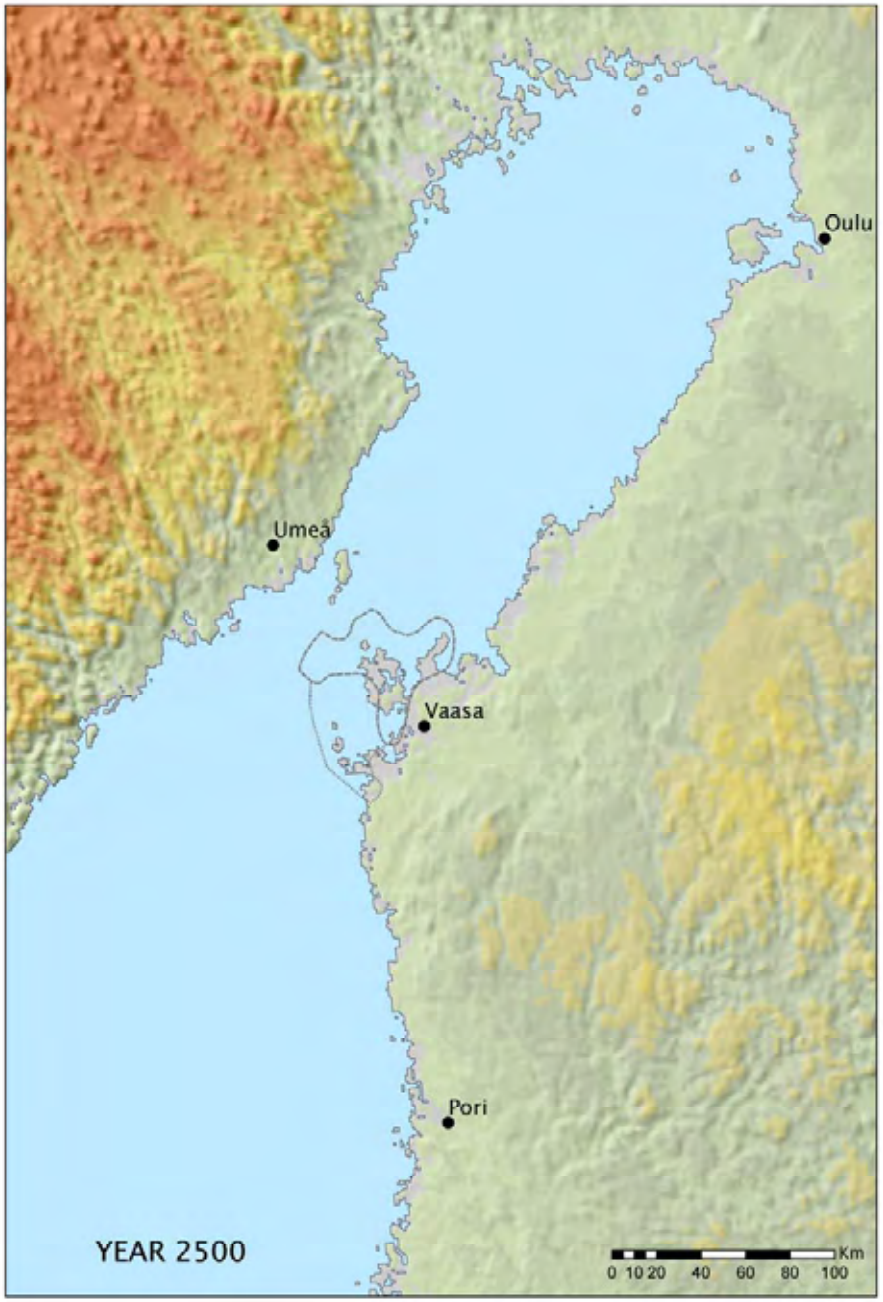
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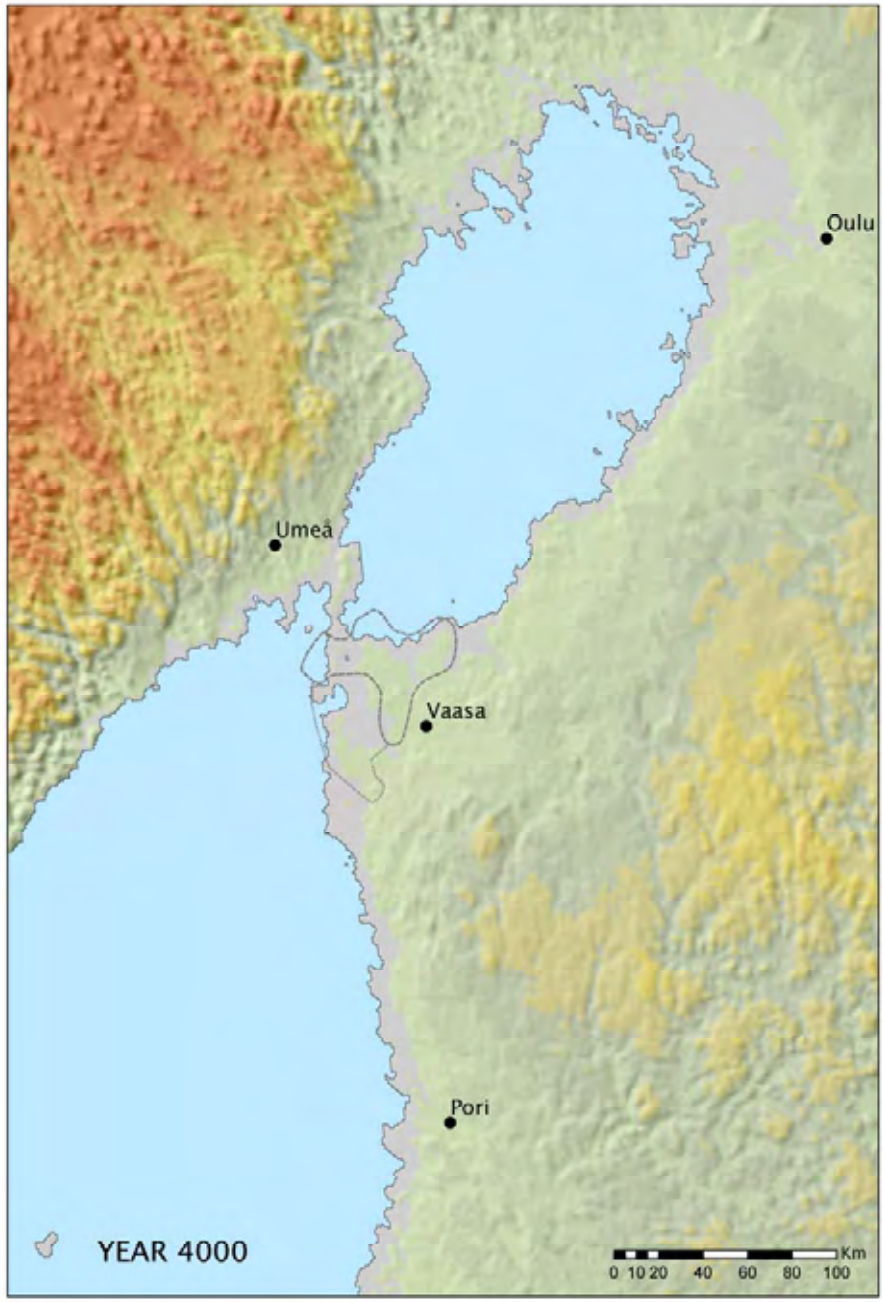
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Österbottens förbund
Pohjanmaan liitto

WHC REGISTRATION
Date 29 09 05
Id N° 898 bis
Copy 1 Item 28

23 September 2005

Director
Francesco Bandarini
World Heritage Center
UNESCO

Ref.: The adjustment of the boundaries of the Kvarken Archipelago World Heritage Nomination and the Regional Plan

During the IUCN field evaluation mission by the IUCN expert Jim Thorsell the need to adjust the boundaries of the Kvarken Archipelago World Heritage Nomination became evident. The Regional Council of Ostrobothnia is according to the Land Use and Building Act responsible for drawing up a regional plan setting out the principles of land use and community structure and will therefore also designate areas reserved for the World Heritage. The Core areas A and B as adjusted in this letter will be included as such with special regulations in the Regional Plan.

As the new proposal regarding the boundaries does not include a buffer zone the Regional Council of Ostrobothnia has considered in the ongoing planning process in Ostrobothnia, that the Regional Plan shall include a special status for the area that was originally nominated as buffer zone of the Kvarken Archipelago World Heritage Nomination with some smaller adjustments of the boundaries of the buffer zone. Thus the buffer zone is connected to the general land use planning in Ostrobothnia and the special geological values will be taken into consideration both in regional development work and when drawing up and amending local master plans and local detailed plans as well as when any other measures are taken to organize land use and off shore acitivities.

Olav Jern
Executive Director
Regional Council of Ostrobothnia
P.O.Box 174
FIN-65280 VAASA
olav.jern@obotnia.fi

THE GOVERNMENT OFFICES OF SWEDEN

U2005/6258/Kr

Ministry of Education, Research and Culture
Minister for Education, Research and Culture

Ministry of the Environment
Jan-Erik Enestam,
Minister of the Environment
P O. Box 35
FIN-00023 GOVERNMENT
FINLAND

Dear Jan-Erik,

Thank you for your letter concerning the proposed name for the World Heritage Site the High Coast/the Kvarken Archipelago

I wish to emphasize that we have no objection to the proposed name the High Coast/the Kvarken Archipelago as a collective name for the future World Heritage Site It is, however, important to us that we retain the separate name the High Coast in Sweden, as the name in question is already well known and well-established as a business name and logotype for the World Heritage Site in question

Naturally, we cannot predict what the Unesco World Heritage Committee (WHC) will decide upon consideration of the proposal

With best regards,
[signed]
Leif Pagrotsky

In Helsinki, Finland
19 9 2005

On behalf of the Finnish State Party of the Convention,

Jukka-Pekka Flander
Senior Adviser

YMPÄRISTÖMINISTERIÖ

APPENDIX 16. Proposal of new boundaries

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1. *Introduction*
2. *Core Area A*
3. *Core Area B*
4. *Conclusions*
5. *Statistics*

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Picture Table 2
Picture Table 3
Picture Table 4

Map of the proposed World Heritage site

1. Introduction

During IUCN expert Jim Thorsell's visit, the need to further focus the size of the proposed area became evident. This focus was necessary to pinpoint the unique and outstanding geologic values, formations and dynamic, ongoing geologic processes within the site. The original proposal contained large marine areas and a buffer zone that has been removed from the new, more focused core areas. From the former buffer zone, a new Core area B was established to include the best examples of geologic formations and processes. The new proposal does not include a buffer zone, but on a national level the areas now left out of the proposal will have buffer zone status in the regional landscape plan (see page 60 of the nomination).

As well, the need for deeper (-20 m) marine areas was reevaluated. The best examples of submarine moraine formations was established according to recent geologic marine surveys and will be situated mostly in the more shallow parts of the submarine sill of the Kvarken strait. In the shallow sea area, there are 5 to 10 meter high moraine formations that will emerge from the sea in the near future due to land uplift (see the sea bed map).

The redesigned site is now 194 400 ha in size, while the initial proposal was 323 200 ha. The proposed World Heritage Site is now 40% smaller. The most superlative terrestrial and shallow water formations are included in the two core areas, along with the bulk of the moraine formations. The new evaluation of the proposal reduced the marine area of the site with 43 % and the land area with 15 % . The land area in the Kvarken Archipelago site is 29 300 hectares compared to the High Coast serial nomination area with 62 500 hectares. Due to the flat topography of the Kvarken Archipelago, the shallow marine areas are larger than in the High Coast World Heritage site with its deeper marine areas, high relief and steeper topography. Rapid isostatic uplift of 8 mm per year increases the land area of the Kvarken Archipelago by 1 km^2/year.

2. Core area A

The Norrskär islands (see Picture Table 1) were included in Core area A because the ongoing and dynamic littoral processes are most prominently demonstrated on these islands. As a result of wave action and littoral sorting, a collection of spectacular uplifted beach ridges and recent barrier beaches are seen. This adds a dynamic explanation for the raised beach formations in the Märäskäret Island in Core area A, where there is an outstanding example of a set of uplifted shore deposits with fossil beach ridges ranging 2000 years back in the land uplift history.

3. Core area B

Core area B includes Halsö- Island, Molpehällorna, Bergögaddarna and Rönnskär islands. These areas define dynamic isostatic uplift with a spectacular boulder field that includes large glacial erratics. On Halsö and Molpehällorna islands (see Picture Table 2) the isolated flada-lagoons and glo-lakes are very shallow, forming a labyrinth of water bodies.

In the Bergögaddarna shoal and rocky islet area (see Picture Table 3), the terrain and seafloor is patterned with large boulders and erratics with an average diameter of 10 m. The isostatic uplift has brought rocks to the surface over the course of decades, thus hampering boating and increasing the mosaic pattern of the area.

The bedrock of the Rönnskär islands(see Picture Table 4) is postorogenic vein rock, a diabase of Post-Jotnian age 1268 +/- 13 Ma. This rock type is susceptible to plastic glacial erosion and thus erosion marks such as glacial striation, grooves and erosion facets are more evident than the country rock locally called Vaasa granite (granodioritic diatextite). A number of crossing striae are found from the islands, explaining the extraordinary ice flow directions and movements of the ice front during deglaciation as well as the complex pattern of the moraine formations.

Core area B also includes moraine formations such as De Geer moraines, moraine ridges parallel or transversal to the last ice flow direction but with more modest dimensions than in Core area A. In contrast to Core area B, core area A has a thicker till cover and thus the moraine formations are greater in dimension, forming dense fields of formations with hundreds of individual ridges.

4. Conclusions

Core area A represents a unique example of land uplift phenomena in a topographically low moraine area with dense fields of moraine formations, where flada-lagoons and glo- lakes are 2-5 m deep basins that are clearly oriented.

Core area B is a unique example of a dynamic land uplift phenomena in a very bouldery and erratic rich, shallow moraine area where the isolating water basins are very shallow and form a labyrinth of water bodies.

5. Statistics

As a result of the redesigned site boundaries, some numbers in the application have been updated. The following is a list of the revised numbers:

The total area of the nominated site:
194 400 ha, of which 15,1 % is land and 84,9 % is shallow sea
Core area A: 160 000 ha, of which 16,6 % is land and 83,4 % is sea
Core area B: 34 400 ha, of which 7,8 % is land and 92,2 % is sea

Numbers of islands: 5600
Shoreline: 2416 km

Different types of nature protection covers 80 % of the site:

Natura 2000:	106 365 ha, of which 9 % is land
National conservation programmes:	85 740 ha, of which 9 % is land (also a part of the Natura 2000)
Nature Conservation areas:	32 890 ha, of which 7% is land (within Natura 2000 and conservation programmes)
Land owned by the state:	1878 ha
Amount of sea owned by the state:	70 212 ha

In the remaining part of the site (20%) the geological values have a sufficient protection by the national legislation (see page 59 and Appendix 12 of the nomination).

PICTURE TABLE 1. The Norrskär Archipelago

Dynamic littoral processes; deposits that origin from hundred of years ago to present time

Photo Arto Hämäläinen,, Korsholm municipailty 1996 ©

Photo Seppo Lammi 2005 ©

Photo Seppo Lammi 2005 ©

Photo Michael Haldin, Metsähallitus,2005 ©

PICTURE TABLE 2. Halsön and Molpehällorna Islands

Mosaic of bays and lakes isolating from the sea in a flat and boulder rich area.

Photo Michael Haldin, Metsähallitus 2005 ©

Photo Seppo Lammi 2005 ©

Photo Juhani Koivusaari 2000 ©

Photo Juhani Koivusaari 2000 ©

PICTURE TABLE 3. Bergögaddarna Islands

Boulder fields and bouldary moraine mosaic emerging from the sea

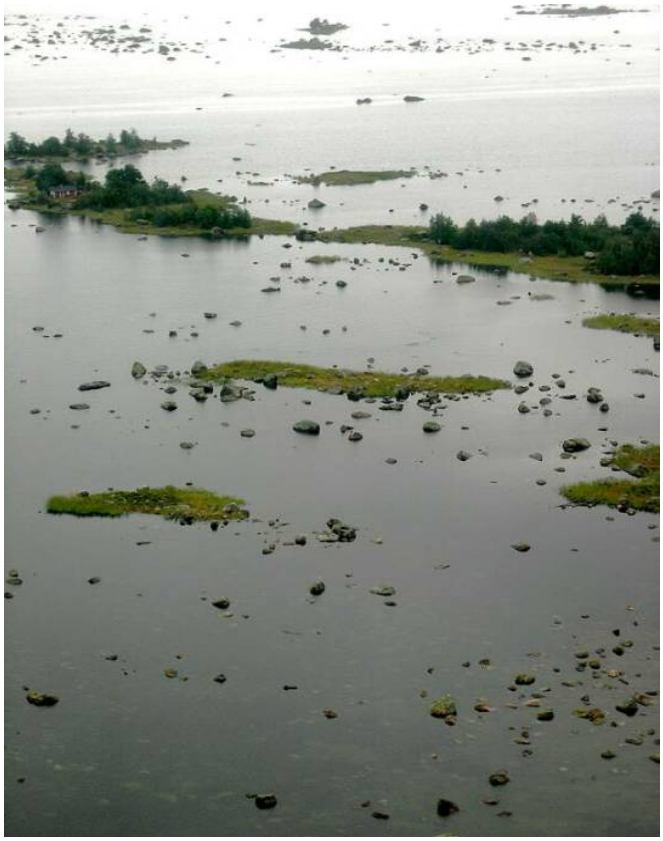


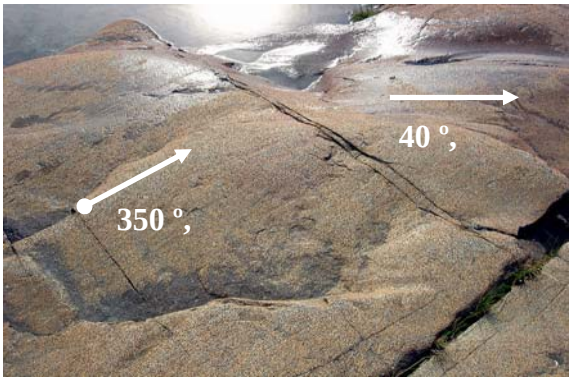
Photo Olli Breilin 2005 ©

Photo Pertti Malinen 2000 ©

Photo Olli Breilin 2000©

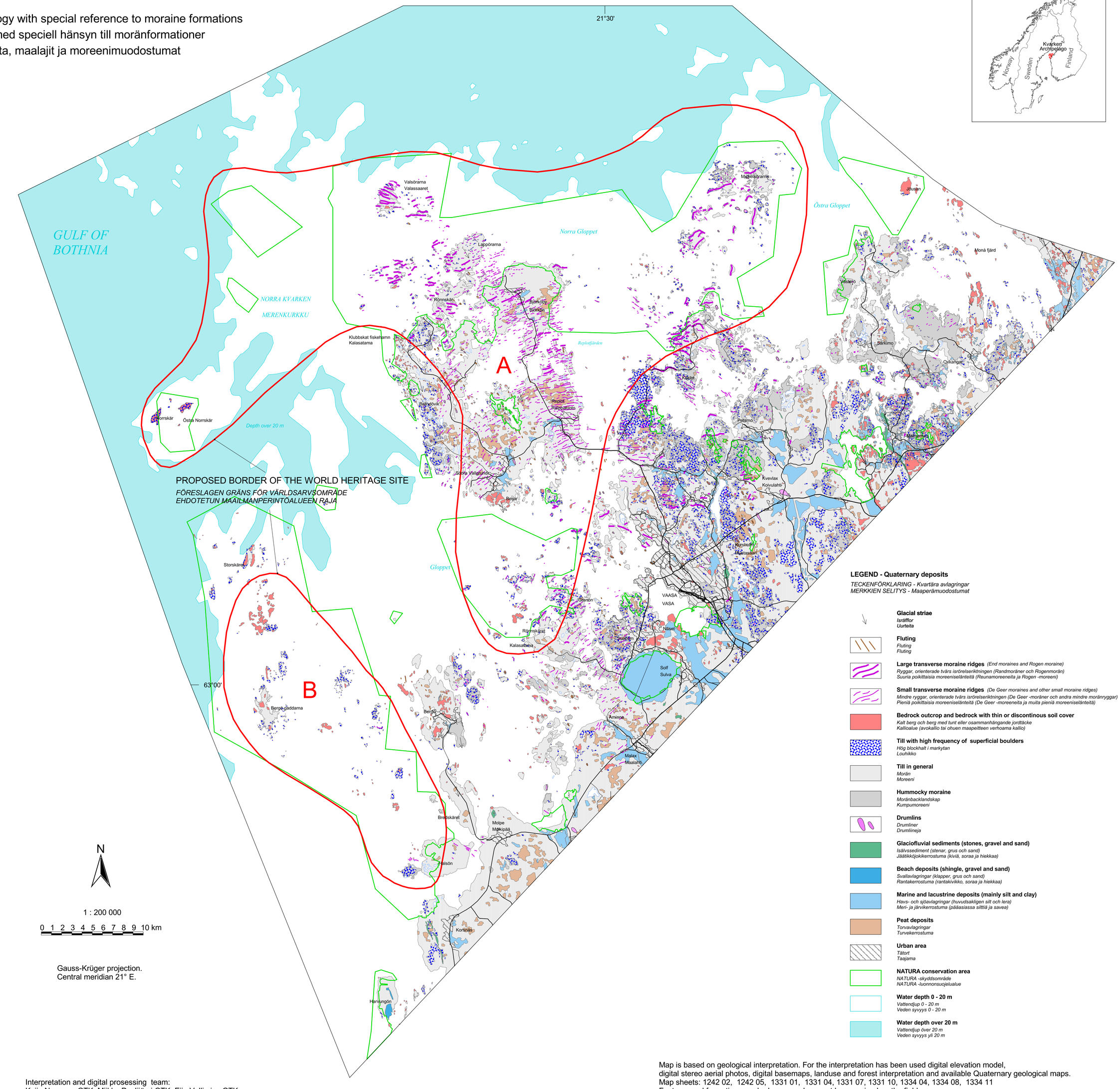
PICTURE TABLE 4. Rönnskär Islands

Diabase bedrock islands with glacial eroded bedroock surfaces and crossing striaes..**Photos Olli Breilin 2005 ©**



GEOLOGY OF THE KVARKEN ARCHIPELAGO

Map of Quaternary geology with special reference to moraine formations
Kvartärgeologisk karta med speciell hänsyn till moränformationer
Maaperägeologinen kartta, maalajit ja moreenimuodostumat



LEGEND - Quaternary deposits
TECKENFÖRKLARING - Kvartära avlagringar
MERKKIEN SELITYS - Maaperämuodostumat

Glacial striae
Isräfflor
Uurteita

Fluting
Fluting
Fluting

Large transverse moraine ridges *(End moraines and Rogen moraine)*
Ryggar, orienterade tvärs isrörelseriktningen (Randmoräner och Rogenmorän)
Suuria poikittaisia moreeniselänteitä (Reunamoreeneita ja Rogen -moreeni)

Small transverse moraine ridges *(De Geer moraines and other small moraine ridges)*
Mindre ryggar, orienterade tvärs isrörelseriktningen (De Geer -moräner och andra mindre moränryggar)
Pieniä poikittaisia moreeniselänteitä (De Geer -moreeneita ja muita pieniä moreeniselänteitä)

Bedrock outcrop and bedrock with thin or discontinous soil cover
Kalt berg och berg med tunt eller osammanhängande jordtäcke
Kallioalue (avokallio tai ohuen maapeitteen verhoama kallio)

Till with high frequency of superficial boulders
Hög blockhalt i markytan
Louhikko

Till in general
Morän
Moreeni

Hummocky moraine
Moränbacklandskap
Kumpumoreeni

Drumlins
Drumliner
Drumlineja

Glaciofluvial sediments (stones, gravel and sand)
Isälvssediment (stenar, grus och sand)
Jäätikköjokikerrostuma (kiviä, soraa ja hiekkaa)

Beach deposits (shingle, gravel and sand)
Svallavlagringar (klapper, grus och sand)
Rantakerrostuma (rantakivikko, soraa ja hiekkaa)

Marine and lacustrine deposits (mainly silt and clay)
Havs- och sjöavlagringar (huvudsakligen silt och lera)
Meri- ja järvikerrostuma (pääasiassa silttiä ja savea)

Peat deposits
Torvavlagringar
Turvekerrostuma

Urban area
Tätort
Taajama

NATURA conservation area
NATURA -skyddsområde
NATURA -luonnonsuojelualue

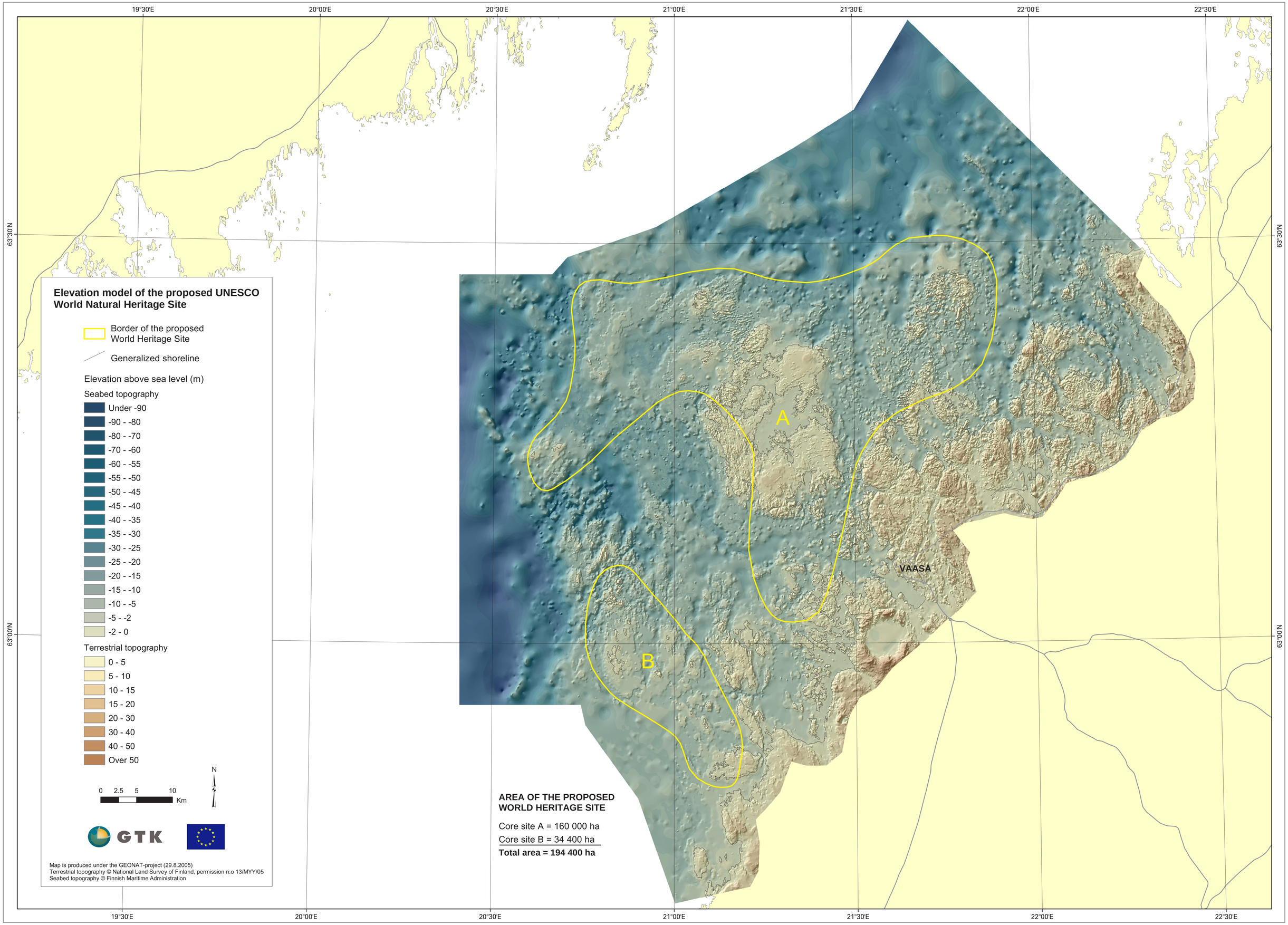
Water depth 0 - 20 m
Vattendjup 0 - 20 m
Veden syvyys 0 - 20 m

Water depth over 20 m
Vattendjup över 20 m
Veden syvyys yli 20 m

GTK

Interpretation and digital prosessing team:
Keijo Nenonen GTK, Miikka Paalijärvi GTK, Eija Vallimies GTK
and Tapio Väänänen GTK. Ver. 06092005

Map is based on geological interpretation. For the interpretation has been used digital elevation model, digital stereo aerial photos, digital basemaps, landuse and forest interpretation and available Quaternary geological maps.
Map sheets: 1242 02, 1242 05, 1331 01, 1331 04, 1331 07, 1331 10, 1334 04, 1334 08, 1334 11
Features and formations marked on maps have not been revised on the field.
Base map (modified) © National Land Survey of Finland


19°30'E
20°00'E
20°30'E
21°00'E
21°30'E
22°00'E
22°30'E
63°30'N
63°00'N
Elevation model of the proposed UNESCO World Natural Heritage Site
Border of the proposed World Heritage Site
Generalized shoreline
Elevation above sea level (m)
Seabed topography
Under -90
-90 - -80
-80 - -70
-70 - -60
-60 - -55
-55 - -50
-50 - -45
-45 - -40
-40 - -35
-35 - -30
-30 - -25
-25 - -20
-20 - -15
-15 - -10
-10 - -5
-5 - -2
-2 - 0
Terrestrial topography
0 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 40
40 - 50
Over 50
0 2.5 5 10 Km
N
GTK
Map is produced under the GEONAT-project (29.8.2005)
Terrestrial topography © National Land Survey of Finland, permission n:o 13/MYY/05
Seabed topography © Finnish Maritime Administration
A
B
VAASA
AREA OF THE PROPOSED WORLD HERITAGE SITE
Core site A = 160 000 ha
Core site B = 34 400 ha
Total area = 194 400 ha

SWEDEN
Sverige
Ruotsi
Holmön
21º
22º
PROPOSED BORDER OF WORLD HERITAGE AREA
FÖRESLAGEN VÄRLDSARVSGRÄNS
MAAILMANPERINTÖKOHTEEN RAJAUSEHDOTUS
Northern Kvarken
Norra Kvarken
Merenkurkku
Valsörarna
Valassaaret
Core Area A
Mickelsörarna
Mikkelinsaaret
Björkögrunden
Lappörarna
Utgrynnan
Märaskäret
Slättskäret
Rödgrynnorna
Punakarit
Rönnskär
Björköby
Köklot
Kaukaluoto
Norrskär
MAXMO
MAKSAMAA
Replot
Raippaluoto
Norra Vallgrund
Södra Vallgrund
VÖRÅ
VÖYRI
KORSHOLM
MUSTASAARI
Rönnskären
VAASA
VASA
Torgrund
63º
Bergö gaddarna
Söderfjärden
Bergö
Core Area B
MALAX
MAALAHTI
Molpehällorna
Hälsön
KORSNÄS
N
0
5
10
15 km

WORLD HERITAGE NOMINATION – IUCN TECHNICAL EVALUATION

THE KVARKEN ARCHIPELAGO (FINLAND) - ID N° 898 Bis

(Proposed extension to The High Coast of Sweden)

Background note: The Kvarken Archipelago is proposed as an extension to the existing World Heritage (WH) property of the High Coast of Sweden, inscribed on the WH List in 2000. The High Coast was inscribed under natural criterion (i) as one of the places in the world that is experiencing isostatic uplift as a result of deglaciation. The Committee was also informed at the time by the delegate of Finland that a nomination (serial transboundary) for the nearby KA area was in preparation.

1. DOCUMENTATION

i) Date nomination received by IUCN: April 2005

ii) Additional information requested from and provided by the State Party: At the conclusion of the IUCN field evaluation in August, 2005, it was decided by the Finnish State Party that a reduction in boundaries of the property was needed to provide a more focused and coherent nomination. Documentation was adjusted and new maps were prepared and sent to the WH Centre and IUCN on 29 September, 2005.

iii) IUCN-WCMC Data Sheet : 7 references

iv) Additional Literature Consulted: Nordic Council of Ministers. 1996. **Nordic World Heritage: Proposals for New Areas for the UNESCO World Heritage List**; Dingwall, P. et al. 2005. **Geological World Heritage: A Global Framework.** Global Theme Study. IUCN; Gilligan, B. et al. 2005. **Management Effectiveness Evaluation of Finland's Protected Areas.** Metsahallitaus, Helsinki; Anon. 2003. **The High Coast – A World Heritage Site.** Vasternorrland County; Lammi, S. and Sevola, P. 2004. **New Land.** Vaasa; Geological Survey of Sweden. 1994. National Atlas of Sweden; Ehlers, J. et al. 1995. **Glacial Deposits in NE Europe.** Rotterdam; Flint, R. 1971. **Glacial and Quaternary Geology.** Wiley; Seppala, M. ed. 2005. **The Physical Geography of Fennoscandia.** Oxford University Press; Larsen, C.F. et al. 2005. Rapid viscoelastic uplift in southeast Alaska caused by post-Little Ice Age glacial retreat, in **Earth and Planetary Science Letters** 23, 548-560.

v) Consultations: 9 external reviewers. Officials from Ministry of Environment, West Finland Natural Heritage, Geological Survey of Finland, West Finland Regional Environment Centre, Regional Council of Ostrobothnia, Municipality mayors.

vi) Field Visit: Jim Thorsell, August, 2005

vii) Date of IUCN approval of this report: 11 April 2006

2. SUMMARY OF NATURAL VALUES

The Kvarken Archipelago (KA) in the Gulf of Bothnia off the west coast of Finland extends over some 70 kilometres from east to west and by 60 kilometres from north to south. The total Archipelago consists of 6,550 islands and islets formed of glacial moraines that are slowly rising from the sea. The nomination consists of two core areas within this region with a total area of 194,400 ha of land (15%) and sea (85%). The KA extension, if approved, would more than double the size of the existing High Coast WH property in Sweden (142,500 ha).

Area of proposed KA extension to High Coast WH property

Core site A:	160,000 ha
Core site B:	34,400 ha
Total area:	**194,400 ha**

The nominated area includes 5600 islands, the highest of which is 20m asl. Landforms in the KA were created mostly by glacial action over a pre-Cambrian peneplain during the last Ice Age, between 10,000 - 24,000 years ago. They are characterised by extensive moraine deposits, a shallow brackish sea of low salinity, and a shoreline 2416 kilometres long. The major geomorphologic feature is the unusual ridged washboard moraines or "De Geer moraines" formed by the melting of the continental ice sheet. Several

formations are represented in the property: mainland, island, coasts and open sea including relatively unaltered underwater geological features. As a consequence of the advancing shoreline, islands appear and unite, peninsulas expand, lakes evolve from bays and develop into marshes and peat fens, resulting in an unusual variety of environmental gradients, both topographic and hydrographic.

The formation of new islands occurs because the property is in the centre of the Fennoscandian land uplift area, which is continually emerging from the sea as a result of isostatic rebound. This occurs when land previously weighed down under the weight of a glacier slowly lifts after the glacier has disappeared. The property complements the High Coast WH property in Sweden, 150 kilometres to the southwest, which is also rising at a similar rate. The last glacier to cover the whole Scandinavian Peninsula drained on the east and south towards the present White Sea, Gulf of Finland and Baltic Sea with the Earth's crust depressed beneath it. The total initial depression is assumed to have been about 900 - 1,000 meters when the Scandinavian Ice Sheet was 3,400m-3,700 meters thick. The land started to lift 20,000 years ago, as de-glaciation began. During the first thousand years of uplift, the rebound rate was up to 100mm per year. The present uplift rate is 8 to 8.5mm per year, increasing the land area of the archipelago by one square kilometre a year. The sea at the Northern Kvarken strait is only 25m deep at a sill across the mouth of the Bay of Bothnia. At the present rate Finland and Sweden will be connected by a land bridge across the strait within 2,500 years, when the Bay will become the largest freshwater lake in Europe. Isostatic rebound is likely to continue for 10,000 - 12,500 years in the Kvarken area and the uplift will probably be between 100 and 125 metres.

The islands are covered by deposits both glacial and post-glacial: drumlins and flute lines parallel to the flow; hummocky, transverse, terminal and de Geer moraines at right angles to it as well as thick till deposits and a great number of boulder fields. The profusion of the De Geer moraines is the most notable feature. The melting and disintegrating ice front reached the Kvarken area 10,600-10,400 years ago when the area was covered by a 250-270m deep glacial lake. A floating and fracturing ice front with calving icebergs was typical of glacial marine conditions during this stage. Varved clay chronology has shown that the annual withdrawal of the ice margin was fast, up to 200-500m per year, leaving the regular ridges of till which reflect the probable positions of the intermittently retreating margin of ice.

The climate is southern boreal, influenced by the sea. Snow and ice cover lasts between 140-150 days a year and rainfall is 400mm. KA is a dynamic landscape, most obvious in flat and shallow areas where uplift is supplemented by sedimentation. The continually emerging shores are colonized by pioneer species which are gradually replaced by a succession of plant communities as the land rises in various ways due to the large number of environmental gradients. Seashore habitats are very heterogeneous and represent several Natura 2000 coastal habitat types. The Archipelago is on an important migratory route and offers excellent breeding habitats for birds. There are important Baltic populations of black guillemot (6,000 pairs, a quarter of the Baltic population) and razorbill (1,000 pairs); also Caspian and Arctic terns, whitetailed eagle (35 pairs), osprey and great scaup. Thousands of roughlegged buzzards and cranes also migrate through. Marine mammals living in the KA are typical for the Baltic region such as grey and ringed seals. As with the plants, the mild climate encourages many southern species of animals which come to their northern limit of distribution here.

3. COMPARISON WITH OTHER AREAS

This section closely follows the text of the IUCN evaluation on the comparison of the High Coast in Sweden as presented to the Committee in 2000.

3.1 Comparison with other World Heritage properties

There are 200 protected areas in the West Eurasian Taiga Biogeographic Province, including one mixed WH property in Sweden (The Laponian Area) and three natural WH properties (the High Coast of Sweden, the Virgin Komi Forest in Russia and the West Norwegian Fjords). Apart from the High Coast (HC), these existing properties are much larger and also display a wide range of geological features. They do not, however, illustrate the isostatic uplift phenomena that occurs in the KA, except, of course, the HC, to which KA is being proposed as an extension.

Many other areas in the Baltic Sea region and Gulf of Bothnia contain archipelagos with moraine landforms which display raised coastlines including several identified in the 1996 Nordic World Heritage report of proposed natural sites. None of these have the geological diversity of the KA nor have the extent of uplift.

There are 71 properties inscribed on the WH List under geological/earth science criteria, many of which contain glacial landforms and several of which have and are experiencing uplift (e.g. Gros Morne, Los Glaciares and Macquarie Island). The only property, however, inscribed under the theme of "Ice Ages" in the Global Geological Theme Study (IUCN, 2005) is the HC in Sweden. There are also 10 natural WH properties under the coastal systems earth sciences theme (IUCN, 2005), some of which (e.g. St. Elias Parks, Henderson Island, Te Wahipounamu - Southwest New Zealand and the Pitons Management Area) illustrate raised coastline phenomenon. Recent research along the coast of southeast Alaska including parts of the St. Elias Parks WH property indicates uplift rates three times that of those found in Fennoscandia (i.e. as high as 32mm per year). Part of this is due to the tectonic setting of coastal Alaska which is fundamentally different than the continental shield of Fennoscandia, but nevertheless, the rate of uplift in Alaska is the highest yet recorded in the world. The distinctiveness of the KA (along with the HC) is that the isostatic uplift is entirely due to the disappearance of a continental ice sheet, the long period of uplift (up to 20,000 years) and the range of coastal and marine landform features displayed as a result.

3.2 Comparison with other areas experiencing isostatic rebound

Another major area with comparable isostatic uplift is found in Richmond Gulf in south-eastern Hudson's Bay (Canada). This area has a similar history of glaciation and uplifted land. Deglaciation occurred about 1,000 years later and the present uplift rate is higher at 11-13 mm per year. It also lies on a Precambrian bedrock peneplain, with deep paleozoic sediments, but unlike the boulder-rich moraine of the archipelago, the moraines of Hudson Bay are boulder-poor, owing to softer rocks. De Geer moraines, drumlin fields, transverse moraines and hummocky moraines occur there but do not form archipelagoes. The wide low-lying western coasts of Hudson Bay area are a wetland-dominated landscape, which is lacking in the Northern Kvarken. The east coasts resemble it more, having a more broken topography and thin stunted forests. But the climatic, topographic, and geomorphological differences are considerable and make the area less nutrient-rich and diverse than the archipelago. The sub-arctic macroclimate of Hudson Bay with permafrost, salt water, strong winds, and a deep, long lasting snow cover affect the structure and dynamics of its coastal ecosystems more than land uplift, the effects of which are more obvious in the Kvarken Archipelago.

Isostatic phenomena are also evident in the northern and western shores of the White Sea on the periphery of the Fennoscandian shield. The land uplift rate is only 1,0-2,5 mm per year. Drumlins, end moraines and De Geer moraines (also called "washboard" moraines) do occur there but do not form archipelagos. The Stockholm Skargard in Sweden is a larger archipelago with some 24,000 islands. It has also experienced some uplift, but is mostly lacking in glacial till deposits which characterize other coastal areas in the Bothnian Sea Region.

In conclusion, the KA and the HC are one of several places in the world that are experiencing uplift as a result of deglaciation. Isostatic rebound is well-illustrated in this area and is among the highest known, although recent data from Alaska suggest that uplift rates are much more rapid there (but over a much shorter period of time). Both the HC and the KA have been well-documented scientifically, and are essentially the "type area" for research on isostacy, the phenomenon having been first recognised and studied there (Flint, 1971).

Other natural values of the KA (wildlife and vegetation succession processes) are also important but relatively common and do not stand out as unique at an international level. Useful information is also provided on the aquatic environment in Appendix 3 of the nomination which indicates the regionally important values of the marine area.

Similarly, the scenic values of the KA, consisting of a blend of farmland, coastline and islands, are harmonious, but typical of much of the rural landscape of northern Europe

3.3 Relation of the Kvarken Area to the High Coast

Unlike the predominantly erosional HC, the KA is a moraine archipelago. Its flat topography comprises glacial till deposited by the melting ice sheet and formed into hummocky moraines and drumlins rising 20-30m above sea level. The archipelagos are mostly less than 1,000 years old. Uplift of the shallow seabed rapidly transforms bays into fladas and glo-lakes (two types of lagoons), then into freshwater lakes, even over the lifetime of a single human generation. Plant succession is equally rapid on the newly created land, displaying marked shoreline zonation. Each phase of uplift has its own characteristic vegetation assemblage, with young marshes of sedges at sea level extending through a series of successional stages to mature spruce forest furthest from the shore.

While the HC and the Kvarken have isostatic rebound in common, they are geologically contrasting areas with marked differences in topography. This in turn has important implications for differences in plant and animal life. The HC has a dramatic land surface of bedrock hills, high islands, steep shores and deep bays and straits -features that do not otherwise occur in the Baltic region. The KA is a low-relief area of extensive archipelagos of till and intervening shallow sea and unique depositional features notable the De Greer (or washboard) moraines. The HC is also much older, revealing 10,000 years of geological evolution, as opposed to the corresponding 2,000-year history of the Kvarken.

The HC is, therefore, a relatively stable biological environment, while the KA, whose low-lying landscape is constantly changing due to rising land, is biologically highly dynamic, with plants and animals continuously colonising newly emergent land surfaces and successional habitats. Thus, the HC and KA areas differ considerably in the ways land uplift processes act on the biota. They are, in fact, complementary in terms of their biophysical evolution. They represent, respectively, the high and low topographical extremes of post-glacial uplifted landscapes in the Baltic.

4. INTEGRITY

4.1 Legal status and ownership

A variety of protective measures cover 80% of the property, including several sites in the Natura 2000 Network (governed by EU Directives on Habitats and Birds and in process of expansion), a RAMSAR site and national measures under the Nature Conservation Act. In the remaining 20% the geological values are also protected under national legislation. As in the HC, there is also a portion of the land area and sea frontage owned privately or by village communities. A much greater extent of land and sea, however, in KA, as compared to the HC, is owned by the State.

4.2 Boundaries

Definition of boundaries of the property went through several iterations and much input from the Geological Survey of Finland. Final deliberations resulted in two core areas of land and sea where the major focus of geological features occurs. Only the most superlative terrestrial formations and formations lying in the shallow

sea are included in the two core areas as well as the majority of the moraine features. While the geological boundaries of the property do not coincide with legal or administrative boundaries, the science behind their selection is justified and IUCN considers that the two core areas incorporate the essence of the KA. A *de facto* buffer zone around the property is provided for in the regional plan for Ostrobothnia, and the geological values will be taken into consideration in local and regional planning.

4.3 Management

The Regional Council of Ostrobothnia promotes the sustainable development and protection of the archipelago and funnels the funds for various EU financed programs. It is also including special status for a buffer zone around the nominated area as part of the regional plan. The main responsibility for nature conservation and environmental protection rests with the Metsähallitus (Forest and Park Service) and the West Finland Regional Environmental Centre which controls most land-uses, regulates and permits small-scale farming, fishing and forestry. The municipalities are responsible for planning and land use within their jurisdictions. Detailed management plans for the area include recent local shore master plans for the Archipelago by the municipalities of Malax, Vaasa and Korsnäs. Cooperation is planned with the Swedish HC property where the geologic processes are complementary. For public presentation there are two nature stations and one museum within the area. A visitor centre ("House of the Sea") is also planned near the road entrance to the property.

4.4 Threats

Although there are some threats to the biological values of the property (e.g. environmental toxins, agricultural runoff and dredging), there are no threats to the geological values of the KA. The resident human population of 2500 in the KA (compared to 4500 in the HC) is engaged in small scale traditional farming, forestry and fishing, all of which have negligible impact on geological values. Tourism pressures are not at a high level (200,000 annually) but will certainly increase in future. Some 600 summer cottages are found throughout the KA but these also pose minimal threats. Both of these issues are adequately addressed in tourism and recreation plans for the property. A long term change in the area may come from the effects of global warming (sea level rise) which may moderate the rate of uplift.

4.5 Serial property

When serial properties, such as this one, are evaluated, IUCN poses a standard set of three questions:

a) **What is the justification for the serial approach?** The nominated property was selected by a panel of experts who determined that two focus areas contained the full range of glacial features that comprise the international values of the property. Each of the two core areas as well as the contrasting site of the HC has a different morphology and geology and displays a different range of geomorphological features. The two parts of the nomination are thus complementary and reinforce the rationale for addition to the existing HC WH property.

b) **Are the separate elements of the property functionally linked?** At their closest point, the two core areas are 7 km apart and are separated only by open sea and a few islands. KA is some 150 km from the HC on the east coast of Sweden. The entire area was covered by the Scandinavian continental ice sheet and its features are derived from the after effects of its retreat.

c) **Is there an overall management framework for all the components?** Under the Regional Environmental Centre two working groups are to be established once the property is included as an extension of the Swedish HC. One to coordinate the land-uses, conservation and management of the existing mix of protected and unprotected private, municipal and state lands. The second will promote sustainable tourist and other enterprises. Both eventually will share common guidelines with their Swedish counterparts. The Kvarken Council is a cross-border association to promote cooperation between Finnish and Swedish municipalities. The entire area on the Finnish side is covered under the regional plan prepared by the Regional council of Ostrobothnia.

5. ADDITIONAL INFORMATION

5.1 Name of property: In a letter from the Swedish Minister for Education, Research and Culture dated 31.01.2005, it was noted that Sweden had "...no objection to the designation of the Kvarken archipelago as a serial nomination to form an international extension of Sweden's High Coast World Heritage site." In a follow-up letter of 19.09.2005, the same office agreed to the name High Coast/Kvarken Archipelago as the collective name for the property.

5.2 Public support: A five year process of consultation was involved in the preparation of this nomination. Also, a "Statement of Intent" regarding future sustainable management for the property has been signed by all the local management authorities and municipalities concerned (Appendix 10 in the nomination). The process is thus both "bottom up" and "top down" and ensures long term cooperation for the KA.

6. APPLICATION OF CRITERIA / STATEMENT OF SIGNIFICANCE

The Kvarken Archipelago has been nominated as a transboundary serial property under natural criterion (i).

Criterion (i): Earth's History and Geological Features

The Kvarken Archipelago, with its 5600 islands and surrounding sea, is of exceptional geological value for two main reasons. First, it is an area of rapid glacio-

isostatic uplift with rates that are among the highest in the world. The uplift has been ongoing for thousands of years and is associated with major changes in the water bodies in post glacial times. The Kvarken, along with the existing High Coast, its Swedish equivalent on the west coast of the Gulf of Bothnia, are key areas for the understanding of the processes of crustal response to the melting of the continental ice sheet. Second, the Kvarken area possesses a distinctive array of glacial depositional landforms, such as De Greer moraines, which add to the variety of glacial landscapes features in the region and reinforce the previous validity of the High Coast inscription. IUCN considers that the nominated property meets this criterion

IUCN also notes that this property has other important and complementary natural values but these are secondary to the criterion used in the nomination. They are, however, being considered in the integrated management of KA region.

7. RECOMMENDATION

IUCN recommends that the Committee **extend** the High Coast World Heritage property (Sweden) to include the Kvarken Archipelago (Finland) on the basis of natural criterion (i).

The property thus becomes a serial transboundary property of both Finland and Sweden with the new name of *High Coast / Kvarken Archipelago* (Sweden/Finland). The total size of the transboundary serial property will be 336,900 ha as detailed below.

Total area of property:

State Party	Property name	Land (ha)	Sea (ha)	Total (ha)
Sweden	High Coast	62,500	80,000	142,500
Finland	Kvarken Archipelago (Core A)	26,560	133,440	160,000
Finland	Kvarken Archipelago (Core B)	2,683.2	31,716.8	34,400
				336,900

Map 1: Location of nominated property

Map 2: Boundaries of nominated property

CANDIDATURE AU PATRIMOINE MONDIAL - ÉVALUATION TECHNIQUE DE L'UICN

ARCHIPEL DE KVARKEN (FINLANDE) ID N° 898 Bis

(Extension proposée à la Haute Côte, Suède)

Note d'information : l'archipel de Kvarken est proposé comme extension au Bien du patrimoine mondial de la Haute Côte de Suède, inscrit sur la Liste du patrimoine mondial en 2000. La Haute Côte a été inscrite, au titre du critère naturel (i), comme l'un des endroits du monde connaissant un relèvement isostatique en conséquence de la fonte des glaces. Le Comité a également été informé, à l'époque, par le délégué de la Finlande, qu'une proposition (sérielle transfrontière) pour la région voisine de l'archipel de Kvarken était en préparation.

1. DOCUMENTATION

i) **Date de réception de la proposition par l'UICN :** avril 2005

ii) **Informations complémentaires demandées puis fournies par l'État partie :** À la fin de l'évaluation réalisée sur le terrain par l'UICN, en août 2005, l'État partie Finlande a décidé de réduire les limites du bien proposé pour fournir une proposition plus recentrée et plus cohérente. Le document a été modifié et de nouvelles cartes ont été préparées et communiquées au Centre du patrimoine mondial et à l'UICN, le 29 septembre 2005.

iii) **Fiches techniques UICN/WCMC :** 7 références.

iv) **Littérature consultée :** Nordic Council of Ministers. 1996. **Nordic World Heritage: Proposals for New Areas for the UNESCO World Heritage List**; Dingwall, P. et al. 2005. **Geological World Heritage: A Global Framework.** Global Theme Study. IUCN; Gilligan, B. et al. 2005. **Management Effectiveness Evaluation of Finland's Protected Areas.** Metsahallitaus, Helsinki; Anon. 2003. **The High Coast – A World Heritage Site.** Vasternorrland County; Lammi, S. and Sevola, P. 2004. **New Land.** Vaasa; Geological Survey of Sweden. 1994. National Atlas of Sweden; Ehlers, J. et al. 1995. **Glacial Deposits in NE Europe.** Rotterdam; Flint, R. 1971. **Glacial and Quaternary Geology.** Wiley; Seppala, M. ed. 2005. **The Physical Geography of Fennoscandia.** Oxford University Press; Larsen, C.F. et al. 2005. Rapid viscoelastic uplift in southeast Alaska caused by post-Little Ice Age glacial retreat, in **Earth and Planetary Science Letters** 23, 548-560.

v) **Consultations**: 9 évaluateurs indépendants. Responsables du ministère de l'Environnement, Patrimoine naturel de Finlande Ouest, Service géologique de Finlande, Centre régional de l'environnement de Finlande Ouest, Conseil régional d'Ostrobotnie, plusieurs maires.

vi) **Visite du bien proposé :** Jim Thorsell, août 2005.

vii) **Date à laquelle l'UICN a approuvé le rapport :** 11 avril 2006.

2. RÉSUMÉ DES CARACTÉRISTIQUES NATURELLES

L'archipel de Kvarken, dans le golfe de Botnie, au large de la côte ouest de la Finlande, s'étend sur plus de 70 km d'est en ouest et 60 km du nord au sud. Il se compose, au total, de 6550 îles et îlots formés de moraines glaciaires qui émergent lentement de la mer. La proposition concerne deux zones centrales de cette région couvrant au total 194 400 ha terrestres (15 %) et marins (85 %). L'extension, si elle est approuvée, ferait plus que doubler la taille du Bien du patrimoine mondial de la Haute Côte de Suède (142 500 ha).

Superficie de l'extension proposée pour le Bien du patrimoine mondial de la Haute Côte :

Zone centrale A : 160 000 ha

Zone centrale B : 34 400 ha

Superficie totale : 194 400 ha

Le bien proposé comprend 5600 îles dont la plus élevée se situe à 20 mètres au-dessus du niveau de la mer. Dans l'archipel de Kvarken, la topographie est essentiellement le résultat de l'action des glaciers sur une pénéplaine précambrienne, durant le dernier âge glaciaire, il y a entre 10 000 et 24 000 ans. Elle se caractérise par d'importants dépôts morainiques, une mer peu profonde et saumâtre à la faible salinité et un littoral de 2416 km de long. La principale caractéristique

géomorphologique est représentée par les curieuses moraines à crête bosselées, dites « moraines de De Geer », formées par la fonte de la nappe de glace continentale. Plusieurs formations sont représentées dans le site : la zone continentale, les îles, les côtes et la haute mer, ainsi que des caractéristiques géologiques sous-marines relativement intactes. À mesure que le littoral avance, des îles apparaissent et s'unissent, des péninsules s'agrandissent, des lacs se forment depuis les baies et deviennent des marais et des fagnes tourbeuses, donnant naissance à une diversité peu courante de gradients environnementaux, à la fois topographiques et hydrographiques.

Si l'on constate la formation de nouvelles îles, c'est parce que le site se trouve au centre de la zone de relèvement fennoscandienne qui émerge continuellement de la mer par suite du relèvement isostatique. Ce phénomène se produit lorsqu'une terre précédemment comprimée sous le poids d'un glacier se relève lentement après la disparition du glacier. Le site complète le Bien du patrimoine mondial de la Haute Côte de Suède qui se trouve à 150 km au sud-ouest et qui se relève également à un rythme semblable. Le dernier glacier qui ait couvert l'ensemble de la péninsule scandinave s'écoulait à l'est et au sud vers la mer Blanche actuelle, le golfe de Finlande et la mer Baltique, la croûte terrestre étant déprimée au-dessous. On estime que la dépression initiale totale était environ de 900 à 1000 mètres lorsque la nappe glaciaire scandinave avait une épaisseur de 3400 à 3700 mètres. La terre a commencé à se relever il y a 20 000 ans, lorsque la fonte des glaciers a commencé. Durant les premiers millénaires, le taux de relèvement atteignait 100 mm par an. Le taux actuel est de 8 à 8,5 mm par an, ce qui entraîne un accroissement de la partie terrestre de l'archipel d'un km² par an. Au nord du détroit de Kvarken, la profondeur de la mer ne dépasse pas 25 mètres au seuil qui se trouve à l'embouchure de la baie de Botnie. Au taux actuel, la Finlande et la Suède seront reliées par un pont terrestre à travers l'estuaire, dans 2500 ans et la baie deviendra le plus grand lac d'eau douce d'Europe. Il est probable que le relèvement isostatique se poursuivra pendant 10 000 à 12 500 ans dans la région de Kvarken et que la surrection atteindra entre 100 et 125 mètres.

Les îles sont couvertes de dépôts glaciaires et post-glaciaires : drumlins et cannelures parallèlement à l'écoulement ; moraines bosselées, transversales, terminales et de De Geer à angle droit de l'écoulement ainsi que dépôts morainiques épais et nombreux champs de blocs rocheux. La profusion des moraines de De Geer est la caractéristique la plus remarquable. Le front de glace, en fondant et en se désintégrant, a atteint la région de Kvarken il y a entre 10 600 et 10 400 ans lorsque la région était couverte par un lac glaciaire profond de 250 à 270 mètres. À cette époque, un front glaciaire flottant et se fracturant, avec des icebergs vêlant, était typique des conditions marines glaciaires. La chronologie des argiles à varves démontre que le retrait annuel de la marge glaciaire était rapide — 200 à 500 mètres par an. Il a laissé des crêtes régulières de dépôts morainiques qui reflètent les différentes positions probables de la marge glaciaire en retraite intermittente.

Le climat sud-boréal est influencé par la mer. Les neiges et les glaces recouvrent la région entre 140 et 150 jours par an et la pluviosité s'élève à 400 mm. L'archipel de Kvarken est un paysage dynamique, ce qui est spécialement évident dans les zones plates et peu profondes où la surrection est complétée par la sédimentation. Le littoral qui émerge constamment est colonisé par des espèces pionnières, progressivement remplacées par une succession de communautés de plantes, à mesure que la terre s'élève de différentes manières, en fonction du grand nombre de gradients environnementaux. Les habitats littoraux sont très hétérogènes et représentent plusieurs types d'habitats côtiers Natura 2000. L'archipel est situé sur une importante voie de migration et offre d'excellents habitats de reproduction aux oiseaux. Il y a d'importantes populations baltiques de guillemots à miroir (6000 couples, un quart de la population baltique) et de petits pingouins (1000 couples) ; ainsi que des sternes caspiennes et arctiques, des pygargues à queue blanche (35 couples), des balbuzards pêcheurs et des grands labbes. On y observe aussi des milliers de buses pattues et de grues en migration. Les mammifères marins qui vivent dans l'archipel de Kvarken sont typiques de la région baltique, en particulier les phoques gris et annelés. Comme pour les plantes, le climat doux encourage la présence de nombreuses espèces animales méridionales qui trouvent ici la limite septentrionale de leur distribution.

3. COMPARAISON AVEC D'AUTRES SITES

Ce paragraphe s'inspire étroitement du texte de l'évaluation de l'UICN concernant la comparaison de la Haute Côte de Suède, présentée au Comité en 2000.

3.1 Comparaison avec d'autres biens du patrimoine mondial

Dans la province biogéographique de la taïga ouest-eurasienne, il y a 200 aires protégées dont un bien mixte en Suède (Laponie) et trois biens naturels (la Haute Côte de Suède, les forêts vierges de Komi, en Russie et les Fjords de l'ouest de la Norvège). Outre la Haute Côte, les biens existants sont beaucoup plus grands et la palette de leurs caractéristiques géologiques est plus vaste. Ils ne présentent cependant pas le phénomène de relèvement isostatique que l'on trouve dans la Haute Côte et dans l'archipel de Kvarken proposé comme extension à cette dernière.

Beaucoup d'autres aires protégées de la région de la mer Baltique et du golfe de Botnie contiennent des archipels à la topographie morainique, qui présentent des littoraux relevés et plusieurs ont été mentionnées dans le rapport de 1996 sur le Patrimoine mondial nordique concernant les sites naturels proposés. Aucune ne possède cependant la diversité géologique de l'archipel de Kvarken ni ne présente un relèvement de la même ampleur.
Sur la Liste du patrimoine mondial, 71 sites sont inscrits sur la base de critères géologiques/sciences de la terre. Beaucoup contiennent des phénomènes géomorphologiques glaciaires et plusieurs ont subi ou subissent une surrection (par exemple, Gros-Morne, Los

Glaciares, l'île Macquarie). Le seul bien, cependant, inscrit sous le thème « âge glaciaire » est la Haute Côte de Suède. Il y a aussi 10 biens naturels du patrimoine mondial inscrits sous le thème des sciences de la terre des systèmes côtiers (UICN, 2005) dont certains (p. ex., les Parcs St. Elias, l'île Henderson, Te Wahipounamu – zone sud-ouest de la Nouvelle-Zélande et la Zone de gestion des Pitons) illustrent le phénomène d'un littoral relevé. De récents travaux de recherche réalisés le long de la côte sud-est de l'Alaska où se trouve une partie du Bien du patrimoine mondial des Parcs St.Elias indiquent un taux de relèvement trois fois supérieur à ceux de Fennoscandie (jusqu'à 32 mm par an).Ceci est dû en partie au cadre tectonique du littoral de l'Alaska qui est fondamentalement différent du bouclier continental de Fennoscandie. Néanmoins, le taux de relèvement de l'Alaska est le plus élevé jamais enregistré au monde. Ce qui distingue l'archipel de Kvarken (ainsi que la Haute Côte de Suède), c'est que le relèvement isostatique est entièrement dû à la disparition d'une nappe de glace continentale, à la longue période de relèvement (jusqu'à 20 000 ans) et à la gamme des caractéristiques topographiques côtières et marines qui en ont résulté.

3.2 Comparaison avec d'autres régions qui connaissent un relèvement isostatique

Un autre site important, présentant un relèvement isostatique comparable, se trouve dans le golfe Richmond, au sud-est de la baie d'Hudson (Canada). Cette région a une histoire de glaciation et de relèvement semblable. La fonte des glaciers s'est produite environ 1000 ans plus tard et le taux de relèvement actuel est supérieur à 11-13 mm par an. Le site se trouve aussi sur une pénéplaine précambrienne à socle rocheux, possède des sédiments paléozoïques profonds mais, à la différence des moraines riches en blocs de pierre de l'archipel de Kvarken, les moraines de la baie d'Hudson sont pauvres en blocs de pierre, en raison de la nature plus tendre des roches. On y trouve des moraines de De Geer, des champs de drumlins, des moraines transversales et des moraines bosselées mais elles ne forment pas des archipels. Les côtes occidentales larges et peu élevées de la région de la baie d'Hudson forment un paysage dominé par les zones humides ce qui fait défaut dans le Kvarken septentrional. La côte orientale lui ressemble davantage car elle a une topographie plus accidentée et porte des forêts clairsemées et rabougries. Cependant les différences climatiques, topographiques et géomorphologiques sont considérables et font que cette région est moins riche en matières nutritives et moins diverse que l'archipel. Le macroclimat arctique de la baie d'Hudson, caractérisé par le permafrost, l'eau salée, des vents violents et une couverture neigeuse épaisse et durable, affecte la structure et les dynamiques des écosystèmes côtiers bien plus que la surrection des terres dont les effets sont plus marqués dans l'archipel de Kvarken.

Les phénomènes isostatiques sont également évidents sur les berges nord et ouest de la mer Blanche, à la périphérie du bouclier fennoscandien. Le taux de relèvement des terres n'y est que de 1 à 2,5 millimètres par an. On y trouve des drumlins, des moraines frontales et des moraines de De Geer (également appelés « moraines bosselées ») mais il n'y a pas formation d'archipel. En Suède, le Stockholm Skargard est un archipel de plus grandes dimensions qui compte quelque 24 000 îles. Il a également subi un certain relèvement mais n'a pratiquement pas les dépôts morainiques glaciaires qui caractérisent les autres régions côtières du golfe de Botnie.

En conclusion, l'archipel de Kvarken et la Haute Côte sont parmi les nombreux sites du monde qui subissent une surrection résultant de la fonte des glaces. Le relèvement isostatique est bien illustré dans cette région et il est parmi les mieux connus bien que des données récentes concernant l'Alaska suggèrent des taux de surrection beaucoup plus rapides (mais sur une période de temps beaucoup plus courte). La Haute Côte et l'archipel de Kvarken sont bien décrits du point de vue scientifique et sont essentiellement la « région type » pour la recherche sur l'isostasie, le phénomène ayant été reconnu et étudié pour la première fois dans cette région (Flint, 1971).

L'archipel de Kvarken a d'autres valeurs naturelles (processus de succession végétale et faune sauvage) qui sont importantes mais relativement communes et ne semblent pas de nature unique au niveau international. Des informations utiles concernent également le milieu aquatique dans l'annexe 3 du dossier de la proposition qui décrit les valeurs importantes, au niveau régional, de la zone marine.

De même, les caractéristiques esthétiques de l'archipel de Kvarken, composé de terres agricoles, de littoraux et d'îles, sont harmonieuses mais typiques de bien des paysages ruraux de l'Europe du Nord.

3.3 Relation entre la région de Kvarken et la Haute Côte

La Haute Côte de Suède est essentiellement d'origine érosive tandis que le Kvarken est un archipel morainique. Sa topographie plate comprend des dépôts morainiques glaciaires laissés par la fonte de la nappe de glace, qui ont formé des moraines bosselées et des drumlins s'élevant de 20 à 30 mètres au-dessus du niveau de la mer. La majeure partie de l'archipel a moins de 1000 ans. La surrection du lit marin peu profond transforme rapidement les baies en « fladas » et « glo-lakes » (deux types de lagunes), puis en lacs d'eau douce, parfois en une seule génération. La succession végétale est également rapide sur les nouvelles terres et présente une zonation de rivage marquée. Chaque phase de surrection a son propre assemblage végétal caractéristique avec de jeunes marais de carex au niveau de la mer qui s'étendent, par une série d'étapes de succession, jusqu'aux forêts adultes d'épicéas en retrait du rivage.

Certes, la Haute Côte et l'archipel de Kvarken ont le phénomène de relèvement isostatique en commun mais ce sont deux régions contrastées sur le plan géologique avec des différences marquées dans leur topographie ce qui a des conséquences importantes du point de vue des différences dans la vie végétale et animale. La Haute Côte présente un paysage spectaculaire de collines sur socle rocheux, de hautes îles, de rivages à pic, de baies et de détroits profonds — que l'on ne trouve nulle part ailleurs dans la région

baltique. L'archipel de Kvarken est une zone au relief bas, de vastes archipels de dépôts morainiques dans une mer peu profonde, qui présente des caractéristiques de déposition uniques, en particulier les moraines de De Geer (ou moraines bosselées). La Haute Côte est beaucoup plus ancienne et révèle une évolution géologique de 10 000 ans tandis que l'histoire correspondante de l'archipel de Kvarken n'en a que 2000.

En conséquence, la Haute Côte est un environnement biologique relativement stable tandis que l'archipel de Kvarken, dont le paysage de basse altitude change constamment en raison de la surrection des terres, est hautement dynamique sur le plan biologique, avec des plantes et des animaux qui colonisent continuellement des superficies émergentes et des habitats de succession. La Haute Côte et l'archipel de Kvarken diffèrent considérablement dans la manière dont les processus de surrection des terres agissent sur le biote. Ils sont en fait complémentaires du point de vue de leur évolution biophysique. Ils représentent, respectivement, les extrêmes topographiques haut et bas des paysages post-glaciaires relevés de la Baltique.

4. INTÉGRITÉ

4.1 Régime de propriété et statut juridique

Le site est couvert, à 80 %, par différentes mesures de protection. Il y a notamment plusieurs sites du réseau Natura 2000 (gouvernés par les directives Habitats et Oiseaux de l'Union européenne) en voie d'expansion, un site Ramsar et des mesures nationales prises au titre de la Loi de conservation de la nature. Dans les 20 % restants, les valeurs géologiques sont également protégées par la législation nationale. Comme dans le cas de la Haute Côte, une portion de la superficie terrestre et du front marin appartient à des particuliers ou à des collectivités locales. L'État possède une superficie beaucoup plus vaste de zones terrestres et marines dans l'archipel de Kvarken que dans la Haute Côte.

4.2 Limites

La définition des limites du bien a fait l'objet de plusieurs tentatives et a bénéficié d'une participation importante du Service géologique de Finlande. Les délibérations finales ont abouti à la création de deux zones centrales terrestre et marine où l'on trouve le principal intérêt géologique. Seule les formations terrestres et les formations de la mer peu profonde les plus exceptionnelles sont incluses dans les deux zones centrales, de même que la majorité des caractéristiques morainiques. Les limites géologiques du bien ne coïncident pas avec les limites juridiques ou administratives mais les raisons scientifiques justifiant ce choix sont valables et l'UICN considère que les deux zones centrales comprennent l'essence de l'archipel de Kvarken. Une zone tampon *de facto*, autour du bien, est prévue dans le plan régional pour l'Ostrobotnie et les valeurs géologiques seront prises en considération dans les plans d'aménagement locaux et régionaux.

4.3 Gestion

Le Conseil régional d'Ostrobotnie encourage le développement durable et la protection de l'archipel et canalise les fonds de différents programmes financés par l'UE. Il accorde également un statut spécial à une zone tampon entourant la partie proposée dans le cadre du plan régional. La protection de l'environnement et la conservation de la nature sont assurées principalement par le Metsähallitus (Service des parcs et des forêts) et le Centre régional pour l'environnement de Finlande Ouest qui contrôle la plupart des modes d'occupation des terres, réglemente l'agriculture, la pêche et la foresterie à petite échelle et accorde les permis. Les municipalités sont responsables de la planification et de l'utilisation des terres placées sous leur juridiction. Il y a des plans de gestion détaillés pour la région qui comprennent des plans magistraux récents pour les rivages locaux de l'archipel établis par les municipalités de Malax, Vaasa et Korsnäs. Il est prévu d'établir des relations de coopération avec le bien de la Haute Côte de Suède dont les processus géologiques sont complémentaires. Il y a deux centres de nature et un musée destinés aux visiteurs et il est prévu de créer un centre d'accueil des visiteurs (« la Maison de la Mer ») près de la route d'accès au bien.

4.4 Menaces

Les valeurs biologiques du site sont soumises à quelques menaces (par exemple toxines environnementales, ruissellement agricole et drainage) mais il n'en va pas de même pour les valeurs géologiques de l'archipel de Kvarken. La population résidente compte 2500 personnes (à comparer avec 4500 dans la Haute Côte) qui pratiquent une agriculture, une pêche et une foresterie traditionnelles à petite échelle, activités qui ont un impact négligeable sur les valeurs géologiques. Les pressions du tourisme ne sont pas élevées (200 000 visiteurs par an) mais augmenteront sans doute à l'avenir. On trouve quelque 600 maisons de villégiature dans tout l'archipel mais les menaces qu'elles exercent sont minimes. Les deux questions sont traitées de manière adéquate dans les plans de tourisme et de loisirs établis pour le bien. Il se peut que des changements à long terme se produisent en raison des effets du réchauffement planétaire (élévation du niveau de la mer) qui pourraient atténuer le taux de relèvement.

4.5 Bien sériel

Lorsque l'UICN évalue un site sériel comme celui-ci, elle se pose trois questions :

a) **Comment l'approche sérielle se justifie-t-elle ?**
Le bien proposé a été choisi par un groupe d'experts qui a déterminé que deux zones particulières contenaient toute la gamme des caractéristiques glaciaires justifiant l'importance internationale du bien. La morphologie et la géologie de chacune des deux zones centrales, de même que du site de la Haute Côte, sont différentes et présentent une gamme différente de caractéristiques géomorphologiques. Les deux parties de la proposition sont donc complémentaires et renforcent

la raison d'ajouter ce site au Bien du patrimoine mondial de la Haute Côte.

b) Les éléments séparés du site sont-ils liés sur le plan fonctionnel?
À l'endroit où elles sont le plus proches, les deux zones centrales sont situées à 7 km de distance et ne sont séparées que par la mer et quelques îles. L'archipel de Kvarken se trouve à environ 150 km de la Haute Côte, sur le littoral oriental de la Suède. Toute la région était couverte par la nappe de glace continentale scandinave et ses caractéristiques proviennent des effets de la retraite des glaces.

c) Existe-t-il un cadre de gestion globale pour toutes les unités?
Sous l'égide du Centre régional de l'environnement, deux groupes de travail seront établis dès que le bien sera inclus en tant qu'extension de la Haute Côte de Suède. Le premier coordonnera les utilisations des terres, la conservation et la gestion du mélange actuel de terres privées, municipales et d'État, protégées et non protégées. Le deuxième encouragera un tourisme durable et d'autres entreprises. Tous deux suivront, en fin de compte, des directives communes avec leurs contreparties suédoises. Le Conseil de Kvarken est une association transfrontière chargée de promouvoir la coopération entre les municipalités finlandaises et suédoises. Toute la région, du côté finlandais, est couverte par un plan régional préparé par le Conseil régional d'Ostrobotnie.

5. AUTRES COMMENTAIRES

5.1 Nom du bien : Dans une lettre du ministre suédois de l'Éducation, de la Recherche et de la Culture, datée du 31 janvier 2005, il est noté que la Suède «... n'a aucune objection à l'inscription de l'archipel de Kvarken en tant que proposition sérielle, en vue de former une extension internationale du Bien du patrimoine mondial de la Haute Côte de Suède. » Dans une autre lettre, datée du 19 septembre 2005, le même ministère accepte le nom de Haute Côte/archipel de Kvarken comme nom collectif pour le bien.

5.2 Appui du public : La préparation de cette proposition a fait l'objet d'un processus de consultation d'une durée de cinq ans. Une « déclaration d'intention » concernant la gestion durable future du bien a été signée par toutes les autorités locales de gestion et municipalités concernées (annexe 10 de la proposition). Il s'agit donc d'un processus « de la base au sommet » et « du sommet à la base » qui garantit une coopération à long terme pour l'archipel de Kvarken.

6. APPLICATION DES CRITÈRES/IMPORTANCE

L'Archipel de Kvarken est proposé en tant que bien sériel transfrontière au titre du critère (i).

Critère (i) : histoire de la terre et processus géologiques

L'archipel de Kvarken avec ses 5600 îles et la mer environnante a une valeur géologique exceptionnelle pour deux raisons principales. Premièrement, c'est une région de relèvement glacio-isostatique rapide avec des taux qui sont parmi les plus élevés du monde. Le relèvement se poursuit depuis des milliers d'années et il est associé à des changements majeurs dans les masses d'eau, à l'époque post-glaciaire. L'archipel de Kvarken et la Haute Côte, son équivalent suédois sur la côte ouest du golfe de Botnie, sont des zones clés pour la compréhension des processus de réponse crustale à la fonte d'une nappe de glace continentale. Deuxièmement, l'archipel de Kvarken possède une gamme distincte de formes topographiques de dépôts glaciaires tels que des moraines de De Geer, qui ajoute à la diversité des caractéristiques paysagères glaciaires de la région et renforce la validité précédente de l'inscription de la Haute Côte. L'UICN considère que le bien proposé remplit ce critère.

L'UICN note également que ce bien possède d'autres valeurs naturelles importantes et complémentaires mais celles-ci sont secondaires pour le critère sur lequel se base la proposition. Elles sont cependant prises en considération dans la gestion intégrée de la région de l'archipel de Kvarken.

7. RECOMMANDATION

L'UICN recommande au Comité du patrimoine mondial **d'étendre** le Bien du patrimoine mondial de la Haute Côte (Suède) pour inclure l'archipel de Kvarken (Finlande) sur la base du critère naturel (i).

En conséquence, le bien devient un bien sériel transfrontière de Finlande et de Suède, portant le nouveau nom de *Haute Côte/archipel de Kvarken* (Suède/Finlande). La superficie totale du bien sériel transfrontière sera de 336 900 hectares selon les détails ci-dessous.

Superficie totale du bien

État partie	Nom du bien	Superficie terrestre (ha)	Superficie marine (ha)	Total (ha)
Suède	Haute Côte	62 500	80 000	142 500
Finlande	Archipel Kvarken (Zone centrale A)	26 560	133 440	160 000
Finlande	Archipel Kvarken (Zone centrale B)	2 683, 2	31 716, 8	34 400
				336 900

Carte 1: Localisation du bien sèriel proposè

Carte 2: Limites du bien sériel proposè