Late Weichselian and Holocene shore displacement history of the Baltic Sea in Finland

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About 62 percent of Finland's current surface area has been covered by the waters of the Baltic basin at some stage. The highest shorelines are located at a present altitude of about 220 metres above sea level in the north and 100 metres above sea level in the south-east. The nature of the Baltic Sea has alternated in the course of its four main postglacial stages between a freshwater lake and a brackish water basin connected to the outside ocean by narrow straits. This article provides a general overview of the principal stages in the history of the Baltic Sea and examines the regional influence of the associated shore displacement phenomena within Finland. The maps depicting the various stages have been generated digitally by GIS techniques.

Following deglaciation, the freshwater Baltic Ice Lake (12,600–10,300 BP) built up against the ice margin to reach a level 25 metres above that of the ocean, with an outflow through the straits of Öresund. At this stage the only substantial land areas in Finland were in the east and south-east. Around 10,300 BP this ice lake discharged through a number of channels that opened up in central Sweden until it reached the ocean level, marking the beginning of the mildly saline Yoldia Sea stage (10,300–9500 BP). As the connecting channels rose above sea level, however, the Baltic Sea became confined once more, to form the Ancylus Lake (9500–8000 BP). During its existence the outflow channel to the ocean shifted to the Straits of Denmark and the major lake systems of central Finland became isolated from the Baltic basin. After the brief Mastogloia transition phase, a greater influx of saline water began to take place through the Straits of Denmark, marking the Litorina Sea stage (7500–4000 BP), to be followed by a somewhat less saline stage known as the Limnea Sea. After a transgressive period early in the Litorina Sea stage, shoreline displacement in Finland has proceeded at a steadily declining rate.

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Introduction

The Baltic Sea has a long and chequered history, in the course of which the area nowadays occupied by Finland has undergone substantial changes. The phenomenon known as land uplift, which still operates in the Baltic region and currently amounts to some eight millimetres per year on the Finnish coast of the northernmost Gulf of Bothnia (Kakkuri 1990; Mäkinen & Saaranen 1998), has had the effect of reducing the sea area over a period of several thousand years and has correspondingly increased the land area of Finland. The present area of the Baltic Sea is about 377,000 square kilometres, and it has a freshwater influx of some 660 cubic kilometres a year from a drainage basin of 1.6 million square kilometres. In addition, some 475 square kilometres of saline water a year flows into the Baltic through the narrow Straits of Denmark. The total outflow of brackish water is of the order of 950 cubic kilometres a year (Björck 1995: 19).

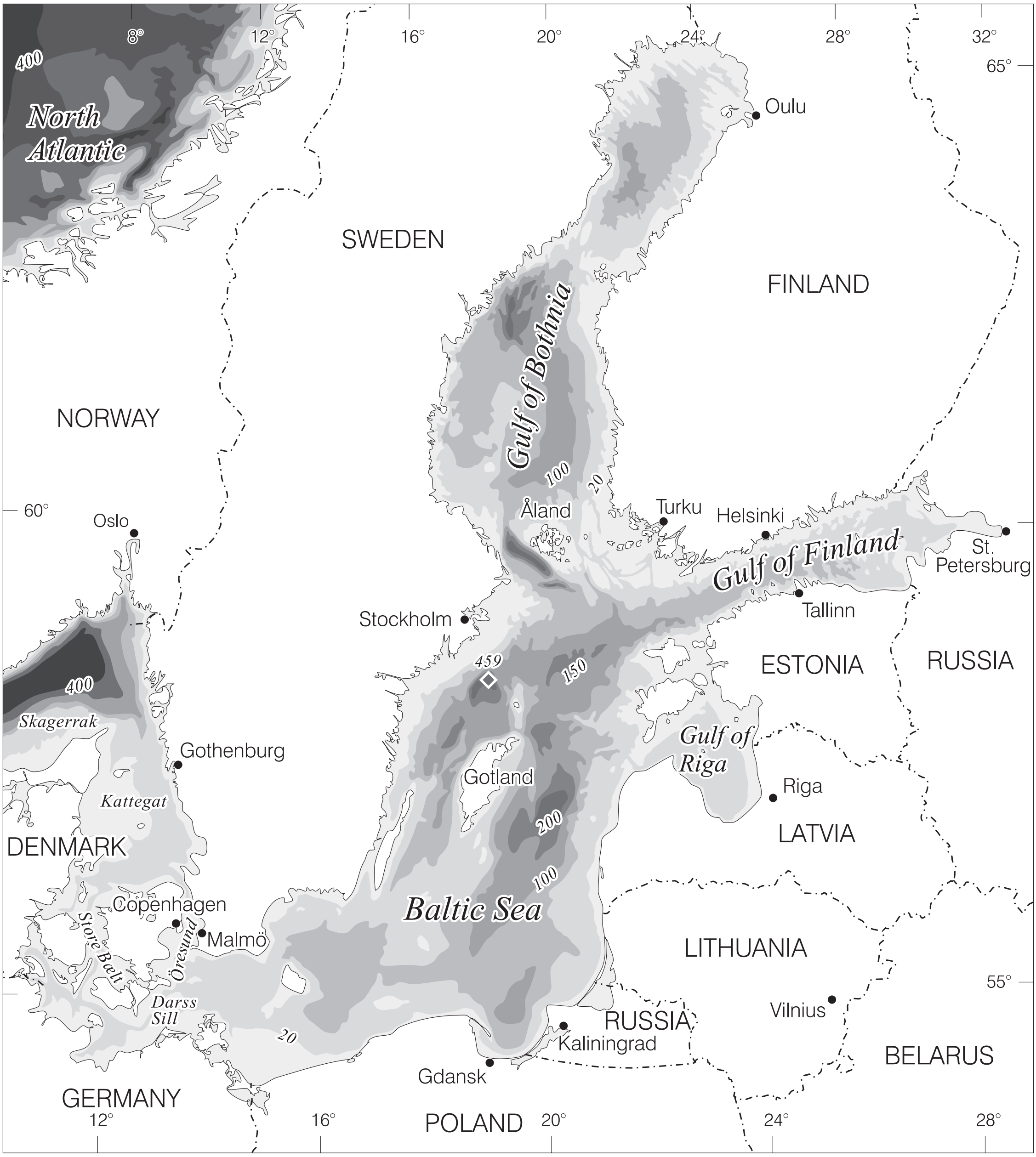

Fig. 1. The Baltic Sea and the surrounding region.

The Baltic Sea is the largest brackish water basin in the world, although it is fairly shallow – its deepest point is only 459 metres. Thresholds divide the basin into a number of separate sections (Fig. 1). The sea's salinity varies from 0.1 percent in the north to 0.6–0.8 percent in the central parts, and can reach as much as 1.5–2.0 percent in the deepest waters (Björck 1995: 20). The salinity has also varied greatly in the course of the history of the basin.

Finland and the whole Baltic basin have been buried beneath the continental ice sheet on several occasions during the Quaternary period (Taipale & Saarnisto 1991: 212). These glaciations have been separated by more favourable climatic periods, during which the Baltic basin has been occupied by water and land uplift has caused progressively greater areas of dry land to emerge on its coasts, in the same manner as during this last postglacial period. During the Eemian interglacial, about 130,000–115,000 BP, the basin contained what is referred to as the Eemian Sea. Its waters were evidently much more saline than those of the Baltic Sea nowadays, as deduced from diatoms recovered from sediments dated to that period. It is possible that there was a connection from the Baltic basin to the Arctic Ocean across Karelia at the beginning of this Eemian Sea stage, although it was closed later due to the effects of land uplift (Björck & Svensson 1994).

The ice sheet associated with the Weichselian glaciation, which followed the Eemian interglacial, reached its maximum extent about 18,000–20,000 BP. It was more than three kilometres thick in the area of Finland, so that it depressed the earth's crust to such a degree that a considerable part of the country's present area lay beneath the waters of the Baltic basin immediately after deglaciation. As the burden of the overlying ice was released, the crust began to rise rapidly, however, so that it is estimated that the total rise up to the present time has been 600–700 metres on the northern coast of the Gulf of Bothnia, 400–500 metres in the middle part of Finland and in central Lapland, and around 300 metres on the coast of the Gulf of Finland and in northern Lapland (Mörner 1980). The majority of this rise nevertheless took place as the ice was melting, before the ground surface became exposed.

Four main stages can be recognized in the history of the Baltic basin since the last glaciation, influenced by a complex interaction between deglaciation, regional differences in land uplift, and eustatic changes in sea level (Tikkanen et al. 1999). The connection with the outside ocean has been located variably in the Straits of Denmark or central Sweden. There is a long tradition of research into the history of the Baltic basin and shore displacement in Finland and the other countries of the Baltic region (see Eronen 1983; Björck 1995; Heinsalu et al. 2000), and the regional changes in shore displacement during the various stages can nowadays be traced fairly accurately by combining the vast amount of data available with altitude data using GIS techniques (Tikkanen & Oksanen 1999).

This article will provide a brief overview of the main stages in the history of the Baltic Sea and their influence on the pattern of shore displacement in Finland. The technique employed for constructing the palaeogeographical maps of Finland is based on a digital elevation model (DEM) for the entire country. The model can be intersected by different surfaces in accordance with the water level that prevailed in the Baltic at each stage. The contour-based DEM was constructed by the National Land Survey, and it has horizontal resolution of 200 metres.

The Baltic Ice Lake (12,600–10,300 BP)

The ice margin began to retreat from the southernmost parts of the Baltic basin around 13,500–13,000 BP, leading to the creation of the first postglacial water bodies in the region (Björck 1995: 21). Deglaciation then proceeded very rapidly, so that the margin was situated close to the south coast of Finland by about 12,000 BP (Niemelä 1971; Saarnisto & Salonen 1995: 10). By that stage the large volumes of meltwater from the ice sheet were able to discharge from the Baltic Ice Lake into the ocean via the Strait of Öresund (Agrell 1976; Björck 1979; Björck 1995) (Fig. 2A).

Before the ice margin had reached the point now marked by the First Salpausselkä moraines, however, the bedrock threshold in the Strait of Öresund had risen above the ocean level and the waters of the Baltic basin had begun to be dammed up to form a freshwater ice lake. Then, around 11,200 BP, a (possibly subglacial) connection to the west opened up north of Mount Billingen in central Sweden. This remained functional for some 400 years, and allowed the water level in the Baltic to return to that of the outside ocean, presumably implying a decline of 5–10 metres (Björck 1995). This has been referred to as the *g-stage*, derived from a now obsolete system of labelling shore levels in the Baltic with letters from a to p (Eronen 1990).

The climate became cooler once more during the Younger Dryas period, causing the ice margin to advance. With the closure of the connection with the ocean around 10,800 BP, the next 600 years proved to be a transgressive period on the shores of the southern parts of the Baltic Ice Lake, its water level gradually rising to about 25 metres above that of the ocean and the outflow channel shifting to the Strait of Öresund once again (Björck 1995). The deltas that developed in connection

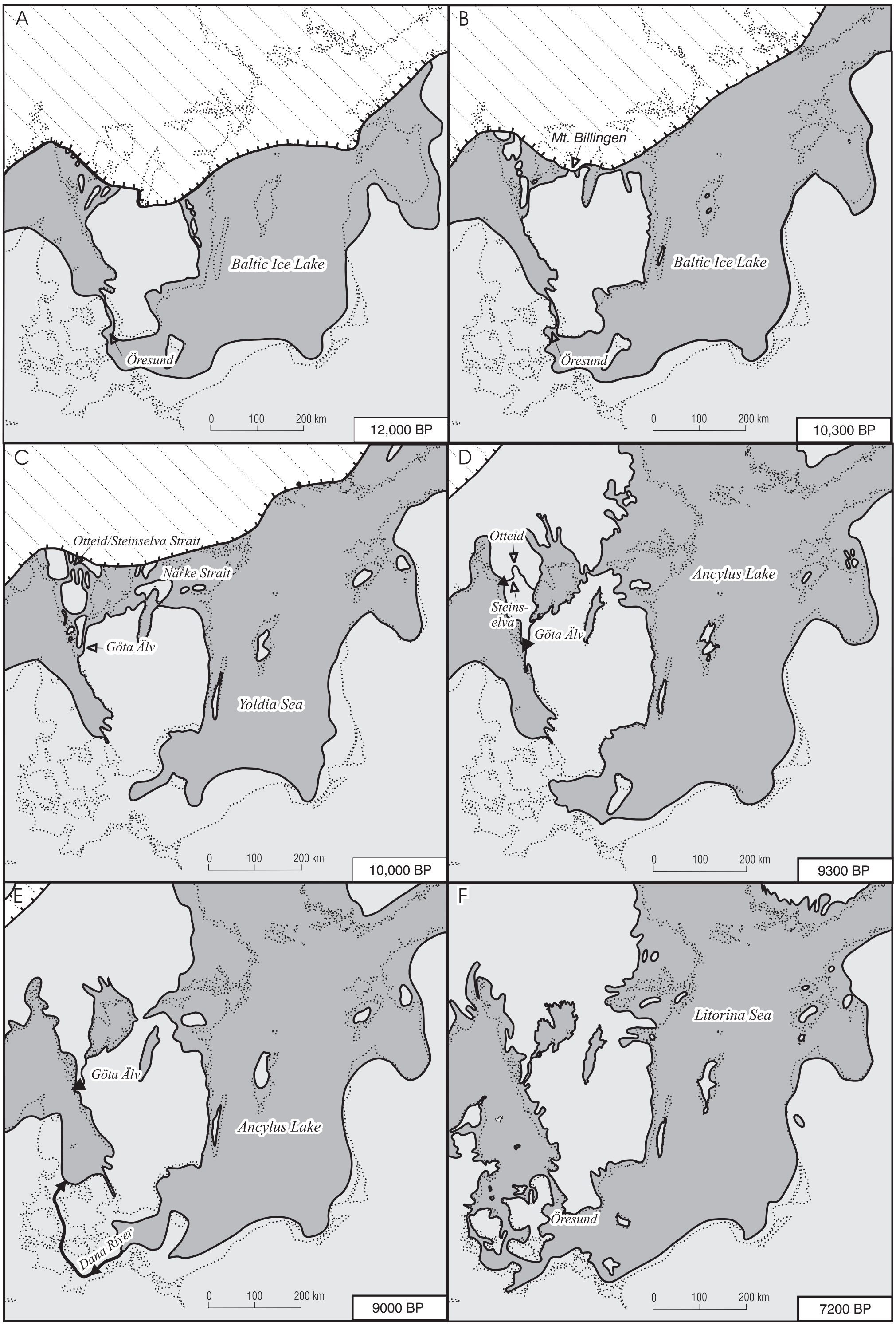

Fig. 2. Subaquatic regions of the Baltic basin and connections from the southern Baltic to the ocean, 12,000–7200 BP (Eronen 1990; Björck 1995).

with the Salpausselkä marginal formations during this period now lie at a level of about 160 metres in the area west of the city of Lahti and at about 100 metres near the south-eastern boundary of Finland. The difference in altitude is due to the differences in the rate of land uplift between these areas.

There were only a few small areas of high ground in southern Finland that projected above the level of the Baltic Ice Lake, together with the Salpausselkä deltas, which were laid down at the water level. The most extensive areas of dry land were to be found close to the eastern and south-eastern boundaries, in the present-day districts of Ilomantsi–Tuupovaara and Ruokolahti–Rautajärvi (Tikkanen & Oksanen 1999: 34) (Fig. 3 & CD-Fig. 1).

Towards the end of the Baltic Ice Lake period (stage BIII) the depth of water at the point of the present shoreline at Hanko was about 130 metres, that at Helsinki, 115 metres, and that at the south-eastern boundary of Finland, 80 metres (Svensson 1989: 159). By that time the delta surfaces associated with the First Salpausselkä, representing the BI stage, had risen to a level of ten metres above the Baltic Ice Lake level.

By the time the Younger Dryas cold phase came to an end, the Second Salpausselkä marginal formation was also in existence, and the sharp warming of the climate around 10,500 BP then caused the ice margin to retreat rapidly (Björck 1995). As a consequence, the Billingen 'gateway' opened up again around 10,300 BP and the waters of the Baltic Ice Lake once more began to discharge into the ocean through central Sweden (Fig. 2B). This dropped the water level in the Baltic basin by 25–28 metres within a few years, regaining the level of the outside ocean.

The Yoldia Sea (10,300–9500 BP)

The new warming of the climate finally brought the Ice Age to an end. The reopening of the Billingen channel and the drop in the level of the Baltic Ice Lake also marked the end of glacial conditions in the Baltic basin. The next stage in the history of the basin is referred to as the Yoldia Sea, after the bivalve *Portlandia (Yoldia) arctica*, typical of cold, saline water and found in sediments of this age in the Stockholm area (De Geer 1913). As the ice margin retreated further, the Närke Strait in the lowlands of central Sweden north of Billingen opened up about 10,000 BP, allowing saline water from the ocean to flow into the Baltic basin (Eronen 1990; Björck 1995) (Fig. 2C). This weakly saline brackish water phase remained relatively short, however, and within 100–200 years the salinity of the Baltic began to decline again. The saline effect reached the area of Finland with a delay. The Yoldia stage was evidently characterised by freshwater conditions throughout in the present-day inland areas, on account of the large volumes of meltwater (Taipale & Saarnisto 1991). Brackish water species have been identified in the diatom stratigraphy for this period in some places on the Karelian Isthmus, however (Arslanov et al. 1996; Saarnisto et al. 2000).

Ocean levels rose at a rate of more than a metre per century around 10,000 BP, but the water level was still 30 metres below what it is today (Taipale & Saarnisto 1991: 237) and shore displacement continued at a considerable rate in Finland on account of the pronounced land uplift. Current altitudes of the Yoldia shoreline in Finland vary in the range of 120–185 metres (Saarnisto 2000: 27), and the delta surfaces laid down in connection with ice margin formations in the interior of the country tend to lie at current levels of 140–160 metres above sea level. In the southern parts of the Baltic basin, in turn, the Yoldia shoreline is located some 50 metres below current sea level, and Björk (1995) claims that southern Sweden was joined to the continent of Europe by an isthmus some ten kilometres wide at that time (Fig. 2C).

The land area in what is now Finland expanded greatly during the Yoldia Sea stage. The drop in water level that marked the end of the Baltic Ice Lake caused land to be exposed very suddenly. A zone ranging between 10 and 100 kilometres in width along the present boundary of Finland in the east and south-east had become isolated from the Baltic by just over 10,000 BP (Fig. 3 & CD-Fig. 2), although a local ice lake covered part of this area at first (Hellaakoski 1934). There were also extensive islands in the present-day Lahti and Hyvinkää areas, and an archipelago emerged in the interior of Finland almost as soon as the ice had retreated (see Tikkanen & Oksanen 1999).

The Ancylus Lake (9500–8000 BP)

As the rate of land uplift in central Sweden was faster than the rise in ocean level, the thresholds in the connecting straits began to approach the

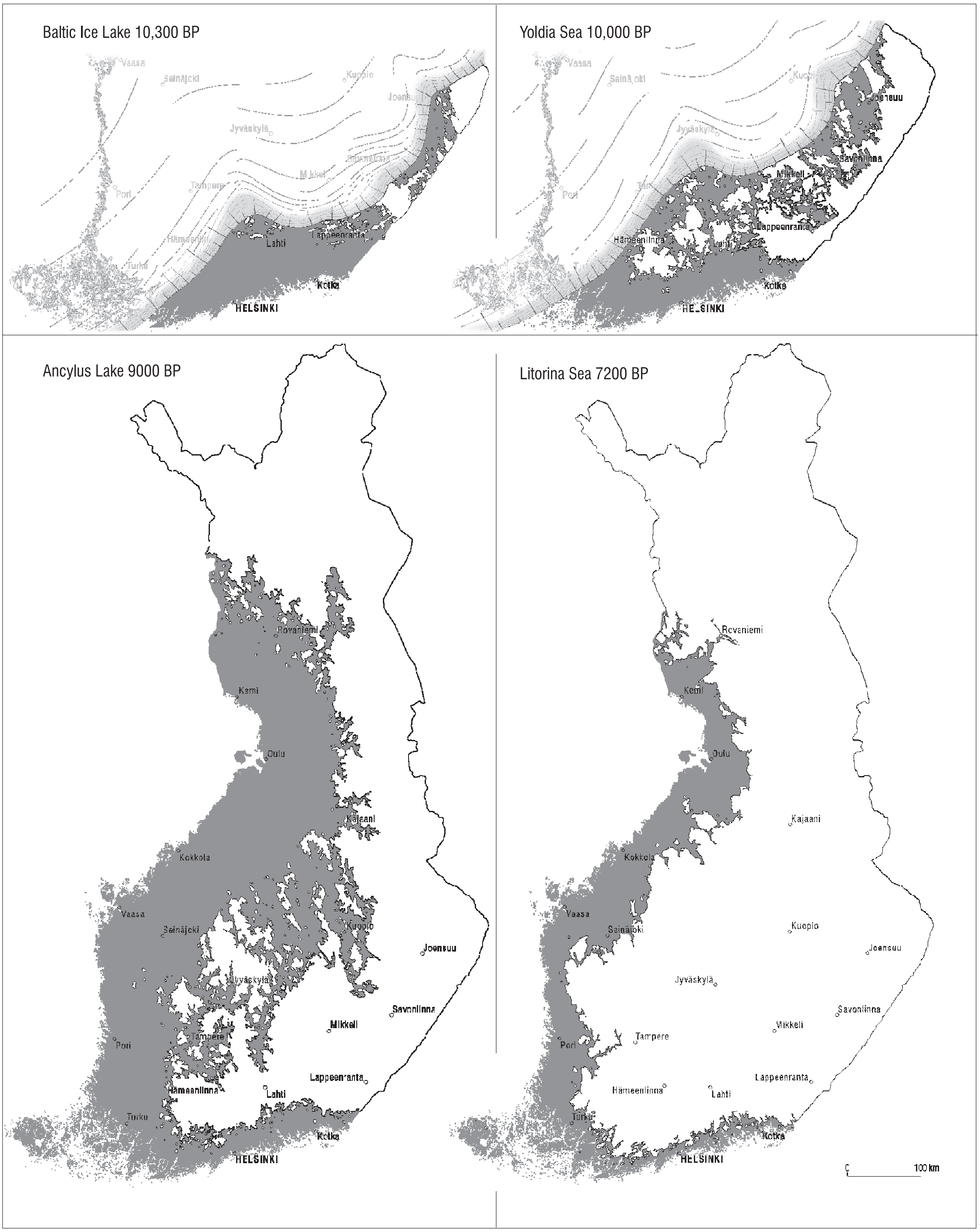

Fig. 3. Shore displacement in Finland at different stages in the history of the Baltic. For more details, see CD-Fig. 1–4.

latter level around 9500 BP. This meant that the Baltic basin was once more isolated to form a freshwater lake, which De Geer (1890) named the Ancylus Lake after the gastropod *Ancylus fluviatilis*, characteristic of its sediments (Munthe 1887). It was thought earlier that the outflow channel from the Ancylus Lake had been located at the watershed between the Baltic Sea and the Atlantic Ocean in the Degerfors area, the flow across which was referred to as the "Svea River" (von Post 1927). Recent research has nevertheless shown that there was a connection from Lake Vänern to the Baltic through the Närke-Degerfors Strait and that the outflow threshold was located west of Lake Vänern (Björck 1995). The channels concerned were formed by the rocky beds of the present-day rivers Göta and Steinselva (Fredén 1982), but these were so narrow that hydraulic dams developed, allowing the surface of the Ancylus Lake to rise above the ocean level (Björck 1986, 1987, 1995) (Fig. 2D).

This marked the beginning of the Ancylus transgression, which lasted about 300 years (9500–9200 BP). During this time, the rising water level caused extensive areas of land to be inundated once more, especially on the south coast of the Baltic, where practically no land uplift took place. The water was rising at a rate of 5–10 centimetres a year, and the transgression as a whole is estimated to have been of the order of 15–25 metres (Eronen 1990; Björck 1995). This was also felt on the south coast of Finland, in the form of a rise of a few metres in water level, causing the creation of clearly defined ancient shorelines. In the Gulf of Bothnia, the rate of land uplift consistently exceeded the rise, so that a certain amount of new land emerged even during this transgressive period. The uppermost shoreline of the Ancylus Lake in the Helsinki area is located at about 60 metres above sea level (Eronen & Haila 1982: 123). There are many places around the northern part of the Gulf of Bothnia where it is close to 200 metres or even slightly over this (Saarnisto 1981).

The rising waters of the Ancylus Lake eventually exceeded the threshold known as the Darss Sill in the south-western part of the Baltic basin and water began to flow out through the Dana River, at the site of the present-day Great Belt (Store Bælt), around 9200 BP (Fig. 2E). This brought the Ancylus transgression to a close and severed the land connection between Sweden and Denmark at the same time. For a time the channels across central Sweden functioned alongside the Dana River, but the rapid regression of the Ancylus Lake, combined with land uplift, soon caused these channels to dry up (Björck 1995).

The surface of the Ancylus Lake was at least ten metres above the ocean level at the time when the Dana River arose, but as the till of the Darss Sill was not especially susceptible to erosion, the deepening of the Dana River and lowering of the Ancylus Lake level did not take place very suddenly (Kolp 1990). The drop in water level lasted altogether some 200 years, so that the Ancylus Lake reached the level of the outside ocean around 9000 BP. This did not mean any influx of saline water into the Baltic basin, however, as the Dana River, being narrow and more than 100 kilometres long, remained the only connection for a long time (Björck 1995).

Large expanses of dry land emerged in the area of Finland during the Ancylus regression. The great lake basins of the interior of the country were separated from the Baltic at this time (Saarnisto 1971, 2000; Tikkanen 1990). On the other hand, when the last of the ice disappeared from the Tornionjoki valley around 9000 BP, the outermost islands in the Gulf of Bothnia were still more than 100 kilometres away from the present shoreline, which in the northern part of the Gulf was still covered by more than 200 metres of water (Eronen 1990; Tikkanen & Oksanen 1999). In the south, the Vuoksi, Kymijoki, and Kokemäenjoki watercourses were marked by bays of the Ancylus Lake stretching far into the interior, and narrow sounds divided the uplands of that area into a labyrinth of islands.

The waters of the lake extended up the great river valleys of the north as far as the southern boundaries of Pelkosenniemi, Kittilä, and Muonio (Fig. 3 & CD-Fig. 3), but the shoreline of the Gulf of Finland was very much closer to its present position, extending to the First Salpausselkä in places. There were also innumerable islands throughout the area. The shoreline was highly irregular on account of the location of the coastal zone in an area of bedrock faults in which the surficial deposits played little part in levelling out the topography (Tikkanen & Oksanen 1999).

The Litorina Sea (7500–4000 BP)

As ocean levels were still rising by more than one centimetre per year (Fairbanks 1989), saline water eventually rose above the threshold in the Straits of Denmark and began to enter the Baltic basin, perhaps around 8400–8300 BP, although the Darss Sill prevented it from spreading to the area in any great quantity at first (Eronen 1990). The effects of this saline addition began to be felt more clearly around 8200 BP (Berglund 1964; Björck 1995). The transition period known as the Mastogloia Sea is deemed to have begun at this time (the name comes from a similarly-named diatom that favours slightly brackish water) (Eronen 1974, 1983; Taipale & Saarnisto 1991). More and more saline water entered the basin as the connecting channels became broader, and by around 7500 BP the Litorina Sea (named after the gastropod *Littorina littorea*) may be regarded as having reached the south coast of Finland (Eronen 1974; Björck & Svensson 1994). It took somewhat longer for the saline effect to reach the head of the Gulf of Bothnia: the Litorina Sea is deemed to have commenced in that area around 7000 BP (Eronen 1974) (Fig. 2F). In the early part of the Litorina Sea stage, salinity was about 0.8 percent in the northern end of the Gulf of Bothnia and 1.3 percent in the central Baltic (Taipale & Saarnisto 1991: 276), i.e., the water was a good deal more saline than nowadays (0.2% and 0.7%).

The eustatic rise in ocean levels led to a transgression at the beginning of the Litorina Sea stage. As a result, water levels on the south-east coast of Finland rose by a few metres and a slight rise was recorded in the Helsinki area (Eronen 1990). Little or no land uplift from the sea was recorded in south-western Finland (Glückert 1991), and a distinct belt of ancient shorelines was created, in the same manner as on the south coast. On the other hand, the Litorina Sea remained regressive throughout on the coast of the Gulf of Bothnia, i.e., new areas of dry land were being created constantly as a consequence of the high rate of land uplift.

When the rise in ocean levels came to an end between 6000 and 5000 BP, the transgressive phase of the Litorina Sea also finished (Eronen 1990). Since that time the Litorina Sea has continued to develop without any marked changes up to the present and new land has been laid bare on the coasts of Finland at a steadily declining rate. No biostratigraphic evidence has yet been found in Finland for the later transgressions identified in the southern parts of the Baltic (Seppä & Tikkanen 1998; Seppä et al. 2000). At the same time salinity has been declining slightly as the Straits of Denmark have become gradually narrower and shallower. It has thus become common to refer to the period since around 4000 BP, when the Baltic Sea has been more or less at its present level of salinity, as the Limnea Sea (Hyvärinen et al. 1988; Heinsalu et al. 2000). The current altitude of the highest Litorina Sea shoreline is around 20 metres near the border in the south-east of Finland and just over 100 metres around the northern part of the Gulf of Bothnia (Hyyppä 1960: 9; Eronen 1974: 158).

The shoreline still lay about 100 kilometres inland of its present location in the river valleys of the Gulf of Bothnia coast at the beginning of the Litorina Sea stage (Fig. 3 & CD-Fig. 4), but it was considerably smoother than at the start of the Ancylus Lake stage. The coastal areas in the south and south-west were at least as fragmented as at that earlier stage and have retained such an aspect more or less up to the present. There were a few large islands on the Gulf of Bothnia coast at the beginning of the Litorina Sea stage, and the ring encircling the ancient meteorite crater that now makes up Lake Lappajärvi stood out close to the shoreline (Tikkanen & Oksanen 1999: 37).

The highest shoreline of the Baltic in Finland

The highest shoreline at a particular point is the uppermost level to which the waters of the Baltic basin have reached. It marks the dividing line between supra-aquatic and subaquatic terrain. It is usually represented in the landscape by belts of washed rocks or stones (Fig. 4), and the vegetation is frequently much lusher on the slopes above this point than below it. The highest shoreline is a metachronic feature, and will have arisen as the ice margin retreated, i.e., within the period 11,000–9000 BP (Taipale & Saarnisto 1991: 268). As far north as the Salpausselkä zone, the highest shoreline will mark the level of the Baltic Ice Lake, as reflected by the delta surfaces on the Salpausselkä formations. Elsewhere in the southern and middle parts of the country, it will have arisen during the Yoldia Sea stage, and further north, in Ostrobothnia, central Finland, and Peräpohjola, similar shore markers will have been laid down by the Ancylus Lake (Eronen 1990). According to Saarnisto (2000: 26–27), the dividing line between the Yoldia Sea and Ancylus lake shorelines run from Pori through Jyväskylä to Kajaani (Fig. 5).

About 62 percent of the surface area of Finland

Fig. 4. An exposed boulder field created by littoral forces on the slope of Lauhanvuori in South Ostrobothnia. The top of this hill lies slightly above the level of the highest shoreline of the Baltic. (Photo: Matti Tikkanen, 07/95)

has been beneath the waters of the Baltic at some stage. The only parts of the country where there are extensive supra-aquatic areas are Lapland and eastern Finland, and even here local ice lakes have covered many places for brief periods. One outstanding supra-aquatic area in the interior of the country consists of the extensive Central Finland Uplands north-west of Jyväskylä, while other such areas further south are the Tammela Uplands in the south-west and the Rautavesi–Ruoholahti area between the Salpausselkä formations in the south-east (Tikkanen & Oksanen 1999: 39). The Gulf of Bothnia, in particular, is lined by a continuous subaquatic zone some 100 kilometres wide, punctuated only by the hill of Lauhanvuori, the top of which extended above the highest shore level to form a tiny island (Fig. 3 & CD-Fig. 4).

The oldest shorelines of southern Finland have been subject to the effects of land uplift for the longest time, but the highest current altitudes for ancient shorelines are to be found north of the Gulf of Bothnia coast, as it is here that the rate of land uplift has been greatest. The highest known ancient shore marker in Finland, at a current altitude of 220 metres, is located on the slope of Vammavaara, south of Rovaniemi. It was created by the waters of the Ancylus Lake. By comparison, the highest Ancylus shore markers in Sweden, in the area west of the Gulf of Bothnia, are to be found at 285 metres. The highest markers of the Baltic Ice Lake in the area near the border in the south-east of Finland lie at about 100 metres.

There are also numerous stone belts indicative of shorelines and deposits laid down in water that are to be found well above the uppermost shore of the Baltic in eastern and northern Finland. These are the work of local ice lakes which developed in front of the ice margin in places where this prevented the water from draining into the Baltic basin. These lakes were short-lived and drained as soon as a suitable route emerged from beneath the ice. Their areas and water levels varied according to the location of the outflow channel at a particular point in time.

One of the largest of these water bodies was the Sotkamo Ice Lake, which discharged its water southwards through the Hiidenportti channel in Sotkamo and the Kattilamäki channel in Kajaani (Saarelainen & Vanne 1997). The level reached by the Ilomantsi Ice Lake in the extreme east of the country is marked by the Selkäkangas ice margin formation, which is regarded as a continuation of the Second Salpausselkä (Taipale & Saarnisto 1991). There were also extensive ice lakes in the headwaters of the Kemijoki River and its tributaries in Lapland (Johansson 1995). The easternmost of the Lapland ice lakes evidently drained to the east, over the Maanselkä watershed, until such time as the channels leading to the Kemijoki valley were free of ice.

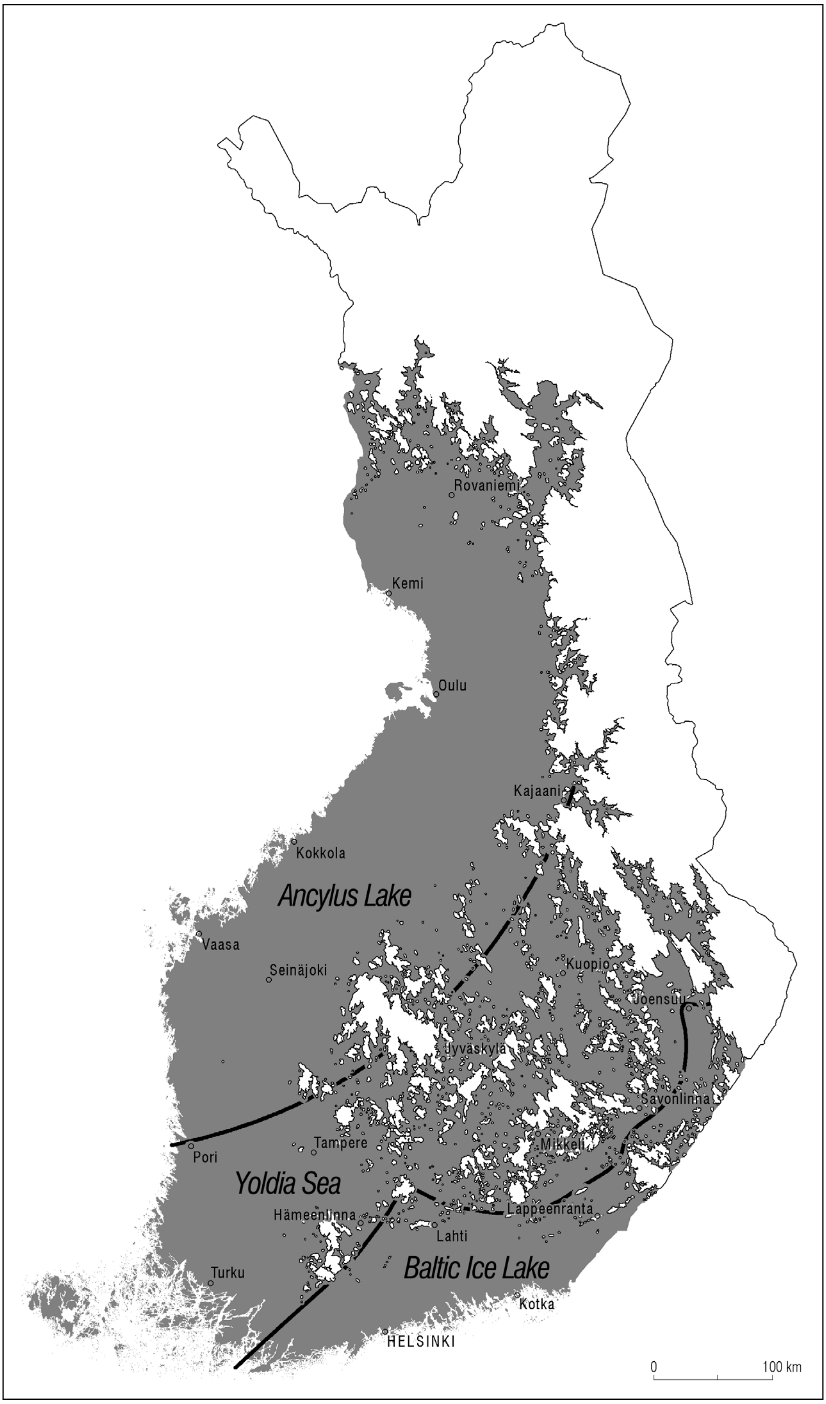

Fig. 5. The highest shoreline: supra-aquatic and subaquatic areas of Finland. The areas in which the uppermost shoreline dates from the Baltic Ice Lake, Yoldia Sea, or Ancylus Lake are marked separately. The boundaries between these areas are after Saarnisto (2000: 27).

Recent and future shoreline changes

The shore displacement curves compiled on the basis of the dated isolation basins in Finland indicate that since the clear Litorina transgression at 7500–6500 BP, no transgressions have taken place but that the shore displacement has been a stable, gradually slowing process (Tikkanen et al.

1999; Seppä et al. 2000; Eronen et al. 2001). The present land uplift rate of the order of two millimetres per year on the south-eastern coast of Gulf of Finland and eight millimetres per year on the Finnish coast of the Gulf of Bothnia's northern part means that shore displacement continues. Finland's area is increasing every one hundred years by about 1,000 square kilometres, of which two-thirds can be attributed to land uplift and the remainder to sedimentation and colonization by vegetation (Jones 1977: 14–15). During few decades new islands emerge from water and then gradually merge together or with the continent in the archipelago off Vaasa, for example. Due to the land uplift many harbours and towns have been moved and re-established on the rapidly uplifting coast of the Gulf of Bothnia (Palomäki 1987; Ristaniemi et al. 1997).

The geophysical data indicate that glacio-isostatic rebound will continue for several thousands of years, even though there are uncertainties in the numerical calculation of the remaining land uplift (Eronen et al. 2001). The most recent calculation suggests an amount of circa 90 metres for residual uplift (Ekman & Mäkinen 1996). If the land uplift continues in the same manner as in the past, the northern part of the Gulf of Bothnia will be cut off to form an inland lake of its own after the next 2,000 years (Kukkamäki 1956; Ristaniemi et al. 1997). The present human impact, however, can cause perturbations in the natural development, and there are very widely differing estimates on the future sea level rise caused by the predicted greenhouse warming. The recent estimates suggest an average sea level rise of about five millimetres per year over the next century, within a range of uncertainty of 2–9 millimetres per year (Wigley & Raper 1992). According to Watson et al. (1996), this will produce a total increase of about 50 centimetres by the year 2100, and means that sea level will rise two to five times faster than over the last one hundred years. Anyhow, the land uplift will then cancel out most of the eustatic rise, and changes on the Finnish coastal area will be less dramatic.

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