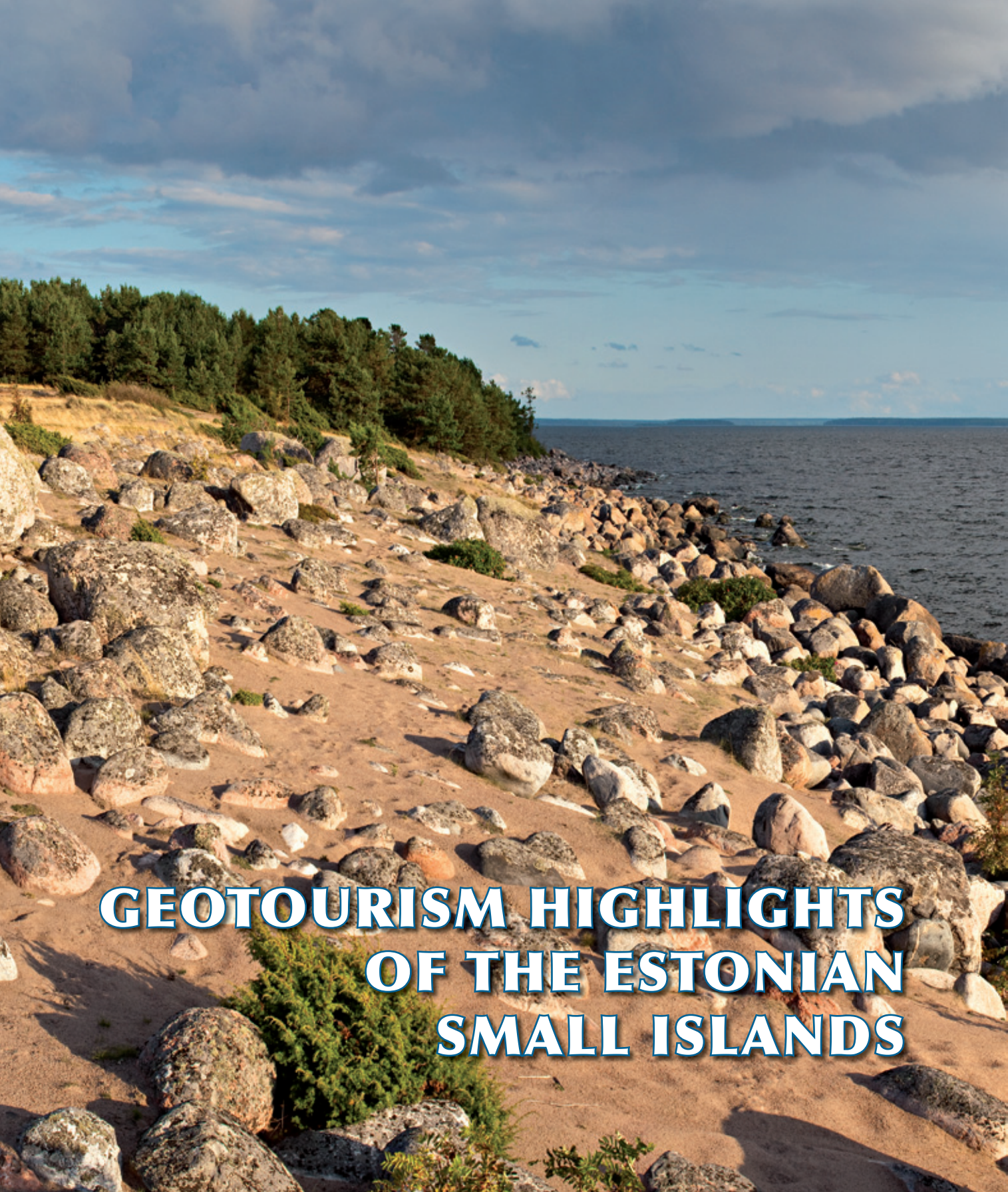

GEOTOURISM HIGHLIGHTS OF THE ESTONIAN SMALL ISLANDS

NGO GEOGUIDE BALTOSCANDIA
DEPARTMENT OF EARTH SCIENCES,
UPPSALA UNIVERSITY

GEOTOURISM HIGHLIGHTS OF THE ESTONIAN SMALL ISLANDS

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Compiled by:	Elle Puurmann Urve Ratas Anto Raukas Heikki Bauert Sebastian Willman
Translation into English:	Saima Peetermann, Heikki Bauert
Proof-reading:	Graham E. Budd
Layout:	Heikki Bauert
Photos & Illustrations:	Heikki Bauert, if not otherwise stated
Cover photo:	The western coast of Mohni island, Gulf of Finland

E-mail: baltoscandia@yahoo.com

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ENVIRONMENTAL INVESTMENT
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CONTENTS

Introduction

Estonia is a small country (45 215 km^2) with a great number of islands. The three largest islands in its coastal waters are Saaremaa (2671 km^2), Hiiumaa (989 km^2), and Muhumaa (198 km^2). All the other islands have an area of less than 100 square kilometres and these are considered small islands and islets. The largest (93 km^2) amongst the small islands is Vormsi island in western Estonia.

There are over 1500 small islands and islets in the coastal sea of Estonia and in all they make up almost 9% of the territory of the country. Most of these land patches are tiny – more than a thousand of the islets are less than a hectare. The length of the coastline of Estonian islands is 2552 km and the total length of the Estonian coastline is over 3974 km. Such an abundance of islands in Estonia sharply contrasts with Latvia, the neighbour to the south, that has no islands.

The small islands are located rather irregularly in the Estonian coastal waters. Their presence is determined by the pre-glacial topography as well as by glacial

landforms. To a great extent, however, the emergence of the islands from the sea was caused by the uplift of the land after the ice melted at the end of the last age, something that has proceeded at different speeds in different coastal regions. The highest rate of land uplift at the present time is about 3 mm per year, in northwest Estonia, but in the past this rate was much higher.

In the region of the Gulf of Finland, Estonia has some hundred small islands and islets – most of them are located in Kolga and Tallinn bays. But the Väinameri sea, up to 22 m deep, which lies between the mainland and Hiiumaa and Saaremaa, hosts the highest number of islands and islets. Numerous small islands and islets occur also along the southeastern and western coasts of Saaremaa. Kihnu (16.4 km^2), with its surrounding small islands and islets, forms the largest group of islands in the Gulf of Riga (known historically also as the Gulf of Livonia). At the same time, there are no islets in those coastal areas where the post-glacial uplift has been rather insignificant (e.g. the region of Narva bay or the southern part of the Gulf of Riga).

The northern- and westernmost land points of Estonia are also located on small islands. The northernmost patch of dry land is Vaindloo island (59°49′03″ N, 26°21′36″ E) in the Gulf of Finland, not far from the major freight ship route to St. Petersburg. For many centuries this island has been an important landmark for sailors known as Stenskär (stone skerry). The westernmost island is the tiny Nootamaa islet (58°19′22″ N, 21°45′59″ E), consisting of shingle beach ridges made up of carbonate rocks.

Sometimes the natural peculiarities of small islands can be reflected in their names. In the Estonian language various terms are used to designate the tiny primary islets emerging from the sea. In the West Estonian Archipelago, the word *laid* is used for bigger islets (usually up to 4 km^2 in area) with a well-developed plant cover. The tiny, mostly barren islets in this region are called *kare*, *rahu*, *nasv* etc. In northern Estonia however, *loo* or *kari*, as well as *maa*, are often used for such islets. The coastal regions and many small islands in western and northwestern Estonia were inhabited by Swedes for centuries, and thus quite a number of small islets around Vormsi island still have Swedish names (e.g. Gutagrunne, Norrsanken). The islets' names may also derive from their position (e.g. Esirahu – Front islet, Tagarahu – Back islet), usage (e.g. Heinlaid – Hay islet, Külalaid – Village islet), dimensions or shape (e.g. Kõrgelaid – High islet, Harilaid – Ridge islet, Suurlaid – Big islet, Sipelgarahu – Ant islet), or from some landscape-specific element (e.g. Pihlalaid – Rowan islet, Kadakalaid – Juniper islet) etc. Many islands also have Swedish and German names in parallel to their Estonian counterparts – these names exist in a great variety of forms on old maps and in ancient documents. Many Estonian islands are internationally even better known under their foreign names: Naissaar is known as *Nargö* (Swedish) or *Nargen* (German), Aegna as *Wulf* (German), Kessulaid or Kesselaid as *Schildau* (German), Osmussaar as *Odensholm* (Swedish), and Vaindloo as *Stenskär* (Swedish). Viirelaid islet, located on a shipping lane with many shallows, even has the Latin name of *Paternoster* on old maps, presumably because of the fervent praying by sailors passing through this hazardous area.

The distinctive and unique nature of the Estonian small islands is reflected primarily in their diverse landscapes. These islands often serve as nesting grounds for an abundant and species-rich bird fauna. Several islands in Estonian coastal sea are thus inter-

Excerpt from the map *Nova Descriptio Insulae Oseliae*, 1770 showing environs of Muhu island

nationally recognized bird breeding sites. Furthermore, the West Estonian Archipelago is located on the main East-Atlantic migratory path of the Arctic waterfowl, passed by about a million migratory birds each spring and autumn. The coastal seas around the small islands are inhabited by several thousand ringed and grey seals – for them the small islets are important places for giving birth to pups.

Human settlement has over time changed the landscapes of islands. Owing to the former active use of

islands as pastures and hayfields, they have not been overgrown with bushes. Small strips of fields and farm buildings have contributed to landscape diversity as well. In addition, most Estonian lighthouses are situated on small islands, although because of the application of modern navigation systems on ships many of them are not in operation any more.

The small islands have played an important role in defending Estonia from invaders and many of them have hosted military bases for several decades. The largest military facilities built here are the marine fortifications of Peter I the Great, erected during World War I. This system of land fortifications was built in the environs of Tallinn, Estonia and Porkkala, Finland as well as on the islands between them, in the years of 1912 – 1918. The aim of this fortification system was to protect St. Petersburg, the capital of the Russian Empire, from invaders from the sea. The structures of the marine fortifications in Estonia were made protected sites in the early 1990s and many of them are now tourist attractions.

Considerable changes in the life on the islands took place during World War II and with the following Soviet occupation. The strict border zone regime established by the Soviet Union led to the perishing of the traditional way of life that had continued for centuries. In addition, people were forced to abandon their homes and to leave several small islands.

Smuggling, mostly the contraband traffic of spirits, was an important way to earn a living for many inhabitants on the small islands in the Gulf of Finland before World War II. This was primarily related to the "dry law" that prohibited alcohol in Finland in the years 1919 – 1932. In these times a network of taverns was constructed in the North Estonian coastal area and on islands, through which the trafficking of spirit mostly occurred. Oskar Kallas, the Ambassador of Estonia in Finland at that time, warned that smuggling would put a strain on Estonian-Finnish relations, and the government of Finland accused Estonia of demoralizing the Finnish people. However, smuggling of spirits had occurred already before that – there is written evidence confirming that in 1850 one third of the spirit produced in Estonia was sent to Finland. Still earlier, smuggling was related mainly to the transport of salt from Finland and Sweden to Estonia, as salt was much cheaper in those countries. In these years smuggling occurred mainly as compensation trading, e.g. salt was traded mainly for grain. In addition, fruits, coffee and all kinds of bric-a-brac were smuggled in. In addition to spirit, inhabitants of the Vormsi island smuggled duty-free thread, clothes and even door hinges, i.e. various household goods, from Sweden.

The inhabitants of the islands have remarkably broadened the cultural history of Estonia, and the Swedes who lived on small islands in western and northwestern Estonia for many centuries have played the most important role. In the past centuries, the majority of the inhabitants on Vormsi, Ruhnu, Osmussaar and Pakri islands were Swedes. Unfortunately, most small islands are today uninhabited or the make-up of their inhabitants has considerably changed. Native inhabitants are still living on just a few islands. In this sense the folk culture of Kihnu is clearly distinguished, being a peculiar fusion of the past and present. Together with the Baltic song festival tradition, the folk culture of Kihnu has been included in the UNESCO World Heritage List.

Estonian small islands are important targets for local as well as foreign tourists. Main tourist destinations are easily accessible islands with a regular boat service, e.g. Vormsi, Kihnu, Aegna and Naissaar. Many

other small islands can be visited with the assistance of local fishermen or boat owners, or by private speedboats or sailboats. In recent years kayak and boat trips to small islands have also become popular. However, tourists should bear in mind that many small islands are wildlife reserves and when visiting them, the established environmental rules should be followed.

A busy lifestyle have taught people to value peace and stillness. Thus, a popular tendency for holidays is to leave the towns and proceed instead to nature. One option then is visiting the diverse small islands in Estonian coastal sea that offers unforgettable memories.

1. A short review of the geological history of the northern Baltic Sea area

1.1 Travelling back into distant geological history

The contemporary Baltic Sea is located in an old depression on the crystalline basement, where the first known sedimentation underwater took place in Ediacaran time almost 600 million years ago. The Estonian territory is located on the southern slope of the Fennoscandian Shield that is made up by Proterozoic crystalline rocks. The rocks dip slightly southwards – about 3 metres per kilometre. From borehole data and geophysical evidence, the Proterozoic crystalline rocks are known to occur at a depth of a few hundred metres in the Gulf of Finland region, but on Ruhnu island in the Gulf of Riga the top of the crystalline basement lies at a depth of over 778 metres. These Proterozoic rocks are represented by different magmatic and metamorphic rocks formed 1.9–1.6 billion years ago.

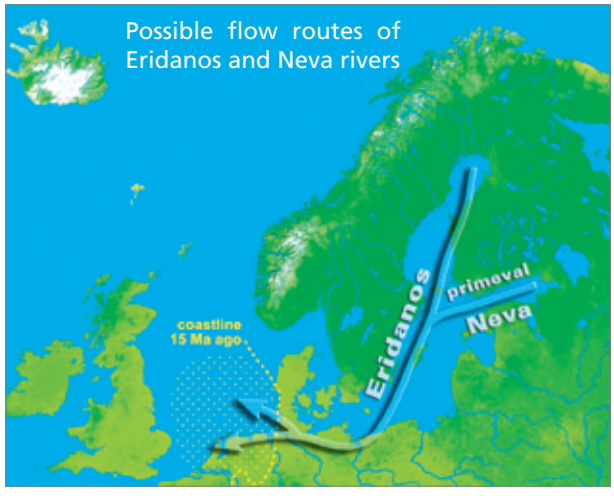
This folded Precambrian crystalline basement in Estonia is overlain by sedimentary rocks of Early Palaeozoic age. The oldest sedimentary rocks are Ediacaran and Cambrian sandstones, siltstones and clays, which in turn are overlain by Ordovician and Silurian rocks that are mostly carbonates (limestones, dolostones and marls). This carbonate sequence is covered by terrigenous rocks (sandstones, siltstones and clays) of Devonian age in southern Estonia as well as in the south-western coast of Estonia. The sedimentary rock cover is relatively thin in northern Estonia and thickens southwards. Like the upper surface of the crystalline basement, all sedimentary bedrock strata have a gentle southward inclination.

Along the southern coast of the Gulf of Finland, where most of the North Estonian islands are located, Cambrian clays are common below the Quaternary deposits. These clays occasionally also crop out at sea level along the coast.

The northwestern Estonian islands – Osmussaar and the Pakri islands, consist mainly of Lower to Middle Ordovician limestones and are in essence part of the North Estonian Plateau, separated from the mainland by Paldiski bay and Kurkse strait. Here the most interesting landscape form is the magnificent escarpment of the North Estonian klint. This North Estonian klint is actually the middle section of the extensive Baltic klint, which spans from Öland island offshore Sweden to Lake Ladoga in northwestern Russia.

In the northern part of the Western Estonia Archipelago, the Upper Ordovician and Lower Silurian calcareous rocks form the core of islands. The bedrock of Saaremaa and Muhu and adjacent small islands consists of Lower and Upper Silurian limestones, dolostones and marls. Here the most outstanding landscape feature is the Silurian (also known as the West Estonian) klint, a patchy coastal escarpment that runs along the northern coast of the Saaremaa and Muhu islands. These coastal cliffs owe their existence to the hard, reef limestone of the Jaagarahu Stage that tops the cliff sequence. Further southwards, in the Gulf of Riga area, Middle Devonian silt- and sandstones form the bedrock.

Some 30 million years ago, in the Late Paleogene, the sea-level was considerably lower than today – for example France and England were united by dry land. The Baltic Sea depression was also dry land, covered by a complex river system. Geologists suggest that at



this time the wide so-called "Eridanos river", much bigger than the modern Amazon river, flowed southwards towards the Danish straits along the present-day Baltic Sea depression. One of its main tributaries was the ancient Neva river, carrying its waters to the Eridanos river along the present-day Gulf of Finland area.

Geological studies have revealed that in the Baltic area, many deep valley-like incisions exist (some of them may reach down several hundred metres). These deep valleys, now filled with glacial deposits, originally formed by erosion of preglacial rivers. At a later stage of development, these valleys may have been over-deepened by interglacial rivers, subglacial meltwaters and glaciers. Modern river drainage in Estonia is in most cases inherited from the pre-Quaternary fluvial systems.

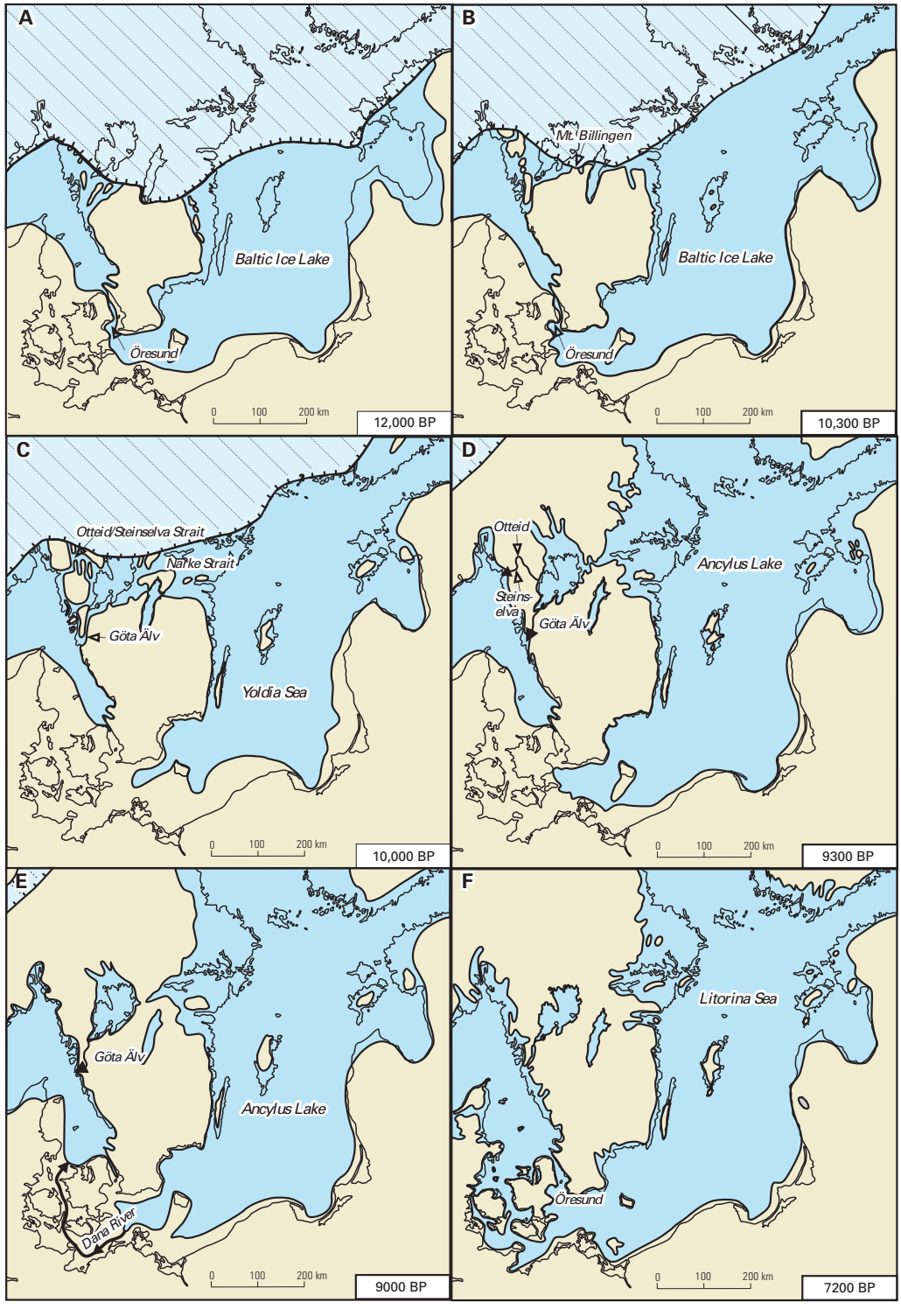
1.2 The time of the great ice ages

The Quaternary era, which started some 2 million years ago, has been climatically rather unstable, with long-lasting ice ages repeatedly alternating with warmer intervals called interglacials. There is clear evidence available for the existence of the last three glaciations in the northern and central Baltic: the Elsterian (600 000–380 000 years ago), Saalian (240 000–130 000 years ago) and Weichselian (90 000–10 000 years ago) glaciations, as well as for two interglacials in between: the Holsteinian (380 000–240 000 years ago) and Eemian (125 000–90 000 years ago). A date of 10 000 ^{14}C years or 11 700 calibrated years marks the Pleistocene–Holocene geochronological boundary.

During these ice ages, the continental ice-sheets moved in a south-east direction to the Estonian region from the Scandinavian mountains, forming large drumlin- and valley-like landscape forms. Many elongated islands in the Gulf of Finland have inherited their morphology owing to reshaping action of these continental glaciers.

The first evidence of seawater filling the Baltic Sea depression in the Quaternary derives from the Holsteinian interglacial – although the resulting sea was much smaller in area than the modern Baltic Sea and existed only in the southern part of the depression. During the following Eemian interglacial, however, the sea was much larger than today. Probably the sea basin was then connected to the North Sea via the Danish straits, through the present lake system of Vänern and Mälaren in central Sweden and through the area of the current Kiel canal on the Jutland peninsula. In the northeast, the connection between the Eemian and White Sea basins was through a system of shallow sounds and through the lakes Onega and Ladoga.

The Eemian interglacial was the warmest of the interglacials. Palaeogeographic reconstructions provide evidence that during the Eemian interglacial the mean July temperature over the Baltic was much the same as the present, but in January it was even 4–8 °C



Subaquatic regions of the Baltic basin and connections to the ocean, 12000–7200 BP (modified after M. Tikkanen and J. Oksanen, 2002)

warmer. The climate was more humid, with a mean annual precipitation over the southern part approximately 100 mm higher than at present. One of the best Eemian interglacial sediment sections is known from cores drilled in Prangli island. Interglacial deposits, composed of greenish-grey silts containing some vivianite and with mollusc and plant remains, were encountered at a depth of 61–75 metres. The interglacial deposits have varying thicknesses and are underlain by glacioaquatic deposits and by two different till beds, and are overlain by four other till beds, showing a complicated geological history in this area.

On several North Estonian islands the former glacial period is recorded by the Saalian till (locally called as the Ugandi till), which is covered by interglacial deposits of the Prangli Formation. The deposits of the last Weichselian glacial period are represented by the Järva till, covered occasionally with late- and postglacial glaciolacustrine and lacustrine clays. The glacial deposits on the West Estonian small islands are rather thin and usually represented by Järva glacigenic deposits only. The retreating continental ice sheets are marked in the landscape of western Estonia by two distinct ice marginal formations: the Pandivere (older) and Palivere stages. Immediately after retreating, vast areas of coastal Estonia were covered with large ice-dammed lakes, where varved clays accumulated.

1.3 Formation of the contemporary Baltic Sea

The Baltic Sea is a young water body which formed only some 12 000 radiocarbon years ago after the retreat of the glacier margin from the northern slope of the Pandivere Upland in North Estonia. As a result of this retreat, the existing isolated large ice-dammed basins located westward and eastward of the Pandivere Upland were able to join up.

The **Baltic Ice Lake**, the first phase in the history of the Baltic Sea, can be recognized in nature by coastal formations formed at five different altitudes. This dammed ice-lake came to a rather rapid end when the retreat of the continental ice cover near the Billingen mountain in central Sweden opened a connection between the Baltic Ice Lake and the ocean farther to the west, causing a rapid lake level drop. This fast water level drop is estimated to be in the range of about 25–30 metres near Pärnu in southwestern Estonia. This event occurred some 10 300 radiocarbon years BP.

After the rapid drainage of the Baltic Ice Lake, slightly saline conditions could have existed in the so-called Preboreal **Yoldia Sea** near the Swedish coast, but not in the open off-shore waters and in the eastern Baltic. In terms of shore displacement, the Yoldia Sea in Estonia was regressive owing to rapid crustal uplift. Owing to its limited connection with the ocean, and abundant meltwater supplied from the nearby ice sheet, the salinity of the Yoldia Sea was low, and the brackish-water malacofauna, including rare dwarf forms of benthic bivalve molluscs *Portlandia* (*Yoldia*) *arctica*, was preserved in a rather small western part of the Baltic Sea.

Crustal uplift, being more rapid than the eustatic sea-level rise, closed the connection between the Yoldia Sea and the ocean, giving the birth to the **Ancylus Lake**. Opinions about the timing of this event vary, but most probably it occurred about 9600 BP. Although the ice sheet had already strongly receded by that time, its influence on the rapid Ancylus Lake transgression was still considerable. The transgression maximum was asynchronous in different regions and in the Estonian coastal waters it culminated about 9200–9000 radiocarbon years or some 10 200–10 300 years ago. The name of the Ancylus stage comes from the fresh-water snail *Ancylus fluvia-*

tilis. According to various data, the water salinity of Ancylus Lake offshore Estonia coast did not exceed 3‰, because *Ancylus fluviatilis* does not tolerate salinity over 2–3‰. The Ancylus transgression was in the order of 10–15 m in the Gulf of Finland area, but in the southern Baltic its range was even larger.

Owing to a strong erosion of the new outlet channel through the Danish Straits, a rapid regression occurred over the whole area of the Ancylus Lake. After a few hundred years of lake level lowering, about 8500 radiocarbon years ago, the rising ocean level reached equilibrium with the level of the Ancylus Lake. The formation of a sound connection between the two large bodies of water concluded the end of the Ancylus Lake stage.

The following **Litorina Sea** is named after the gastropod genus *Littorina*. According to the diatom flora and mollusc fauna, the salinity rise in the Litorina Sea was quite modest. So in the Arcona depression in the southern Baltic Sea, the saline conditions were established at about 8000 years BP, but on the southwestern coast of Finland at about 7400–7300 BP, and at the head of the Gulf of Bothnia only at about 7000 years BP. The regression following the maximum of the Ancylus transgression was rather rapid and the water level on Hiiumaa island dropped about 20 metres.

The final stage in the history of the Baltic is the **Limnea Sea**, named on the basis of the introduction to the Baltic Sea of the fresh-water mollusc *Lymnaea baltica*. The transition from the Litorina Sea to the Limnea Sea was gradual and occurred about 4000 radiocarbon years BP or 4500 calendar years ago. The Limnea shorelines are regressive.

The changing water level of the Baltic Sea has played an important role in the development of the small islands. The ancient coastal forms left behind by different development stages of the Baltic Sea are located at different heights. As a rule, the younger beach deposits (Litorina Sea and Limnea Sea ones) are more fine-grained than those formed during earlier stages (e.g. in the Baltic Ice Lake and Ancylus Lake stages).

1.4 Land uplift and the formation of small islands

Among the small islands offshore from Estonia, the oldest one is Ruhnu, which started to emerge from the sea waters at the initial stage of the Ancylus regression about 9000 radiocarbon years or 10 250 calendar years ago. Consequently the Ruhnu island is just slightly younger than the Hiiumaa and Saaremaa islands. This evidence is derived from the finding of the Ancylus Lake mollusc fauna in the deposits of ancient beach ridges near the Ruhnu lighthouse. The oldest island in the Gulf of Finland region is Naissaar, where the first patches of land also emerged from water during the Ancylus Lake regression about 8500 radiocarbon years ago. In the Western Estonia Archipelago, the Kesselaid islet is the oldest one. It started to rise above sea level at the end of the Litorina Sea approximately 5000 radiocarbon years ago. A great number of small islands have emerged from the sea during the Limnea Stage and this process still continues in today.

New islets can be observed emerging from the sea in the Western Estonia Archipelago area owing to glacioisostatical uplift of the Earth crust, the speed of which is highest in northwestern Estonia (up to 3 mm/year). Also this number may look quite negligible, it will cause the Väinameri sea to vanish in the future.

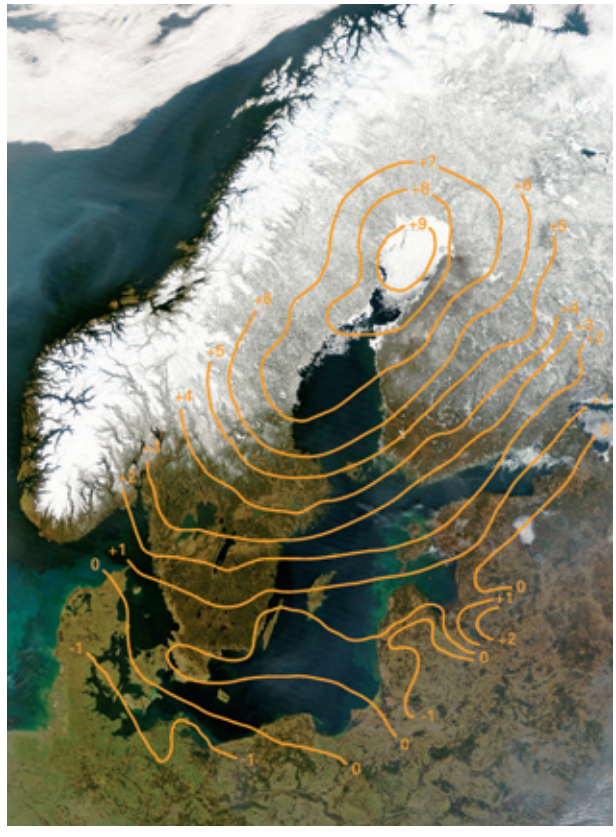
Therefore, in about 3000 years from now, the western Estonia map will look completely different from the present-day one, as mainland Estonia will be united with the Saaremaa and Hiiumaa islands.

2 Insular landscapes and their formation

The landscapes of the islands in the Estonian coastal sea exhibit a wide diversity, which is because of their geological setting as well as their exposure to winds and storm waves. In addition, the development of the landscapes of the islands is affected by the composition of Quaternary deposits that form the basis for the formation of different soil types. Soils in turn influence the genesis of vegetation with differing species associations.

Because of the uplift of the land, the Estonian islands differ not only in age, but are also in different development stages. The rule of thumb is that the higher the island from sea level at present, the earlier its development started. This general development trend might be disturbed by severe storms with high sea level stands. Thus, a fierce autumn storm may transport coastal deposits further inland and thus form a coastal ridge much higher and farther away from the coastline than the previous one. Such severe storms may also abrade high coastal scarps and carry the abraded sediments for a distance of several hundreds of metres.

In the initial development of islands, during the so-called abiotic stage, at first the highest parts of a seafloor emerged from the sea – either bedrock elevations or moraine hills as eskers, kames and drumlins that accumulated during the last glaciation. Small islands are frequently a continuation of capes jutting out from the mainland or extensions of major landforms from neighbouring islands.



Isolines of present land uplift (mm/year). Background image: courtesy of MODIS Rapid Response Project at NASA/GSFC

The beach ridges and abrasion scarps on islands may be located at different distances and heights in regard to the present shoreline – this is a result of the land uplift combined with sediment transportation by storms. The islands along the coast of Estonia display a variety of shore types: cliffed shores, rapidly changing gravel-pebbly shores, scenic sandy shores and finally, sodded silty shores in bays protected from strong winds.

As was mentioned before, terrigenous deposits play an important role in the formation of landscapes of small islands. The bedrock here is often covered by tills of the last Ice Age. These areas are characterised

by an abundance of crystalline cobbles and boulders washed out from glacial deposits. Many large erratic boulders stand out from the water in shallow coastal seas. Often the waves have washed away the tops of the eskers providing abundant pebbly, terrigenous material to the surroundings. Shingle beaches, made up of accumulations of angular limestone pebbles, abound in the environs of the Ordovician and Silurian coastal cliffs. These limestone pebbles, abraded from cliff faces, are often piled into beach ridges up to some metres high. Outstanding shingle beach ridges, rising three or more metres in height, can be seen on Osmussaar as well as on Pakri islands. If sand abounds in the Quaternary cover on the shores (e.g. on Naissaar and Aegna), wind-drift dunes are accumulated.

When a small island grows higher and its area expands, primary vegetation is formed; the latter in turn creates a basis for the formation of soil cover. This introduces a new, biotic stage in the development of islands. In the long run, higher parts of the island become covered with vegetation. The vegetation on low small islands and islets is normally characterised by species-specific zonation reflecting the influence of sea-water, as the lowland shore areas can be repeatedly flooded. Coupled with the rise in the level of the land, the direct influence of seawater on the vegetation substantially decreases towards the island's central parts, leading to the changes in vegetation. Vegetation cover forms earlier on land patches located on shallow leeward coasts, the area which is protected from heavy wave action. In addition, the varieties of vegetation and soils greatly depend on the surface sediments. The vegetation formed on the carbonate rocks in the West Estonian Archipelago contrasts distinctively with the vegetation in northern Estonia that mainly grows on sandy or gravelly deposits. Coastal meadows are widespread on small islands with slightly sloping topography in western Estonia, whereas juniper shrubbery and groves of pine or birch trees grow in their central parts. Broad-leaved and spruce forests occur only on a few islets. Alvars with thin Quaternary cover are common in this region, too. On the other hand, the major islands

Large shingle beaches border the western and southeastern coasts of Osmussaar island. Photo: T. Bauert

Coastal meadows with juniper thickets at Rumpo, Vormsi

in the North Estonian coastal lowland region are densely forested. Spruce is common in addition to pine amongst coniferous trees, whereas juniper thickets and coastal meadows spread only in narrow strips. Crowberry heaths are also characteristic of some of the smaller islands in the Gulf of Finland.

Climate is a substantial factor influencing the formation of the biota on the islands. Compared to mainland Estonia, the climate of the islands is milder, but the number of days with snow cover, as well as the wind speed and precipitation may considerably vary among islands in the coastal seas of Estonia. The vegetation of small islands is influenced by frequent strong winds that impede the rooting of plants in sandy areas, and also shape the trees and bushes growing there. In addition, the average annual number of stormy days (when average wind speed exceeds 15 m/s) is much higher on the islands as compared to the mainland. Severe storms occur mainly in the autumn. Such storms may be accompanied by a wind-blown tide, especially with a west wind.

3 Human impact on the nature of small islands

The development of the landscape of the small islands has been strongly influenced by human activity. Human activities mainly modify the pattern of vegetation. The capacity of small islands to sustain human activities depends on their landscape diversity and size.

Several very small islands have never been used by man – these were and still are major nesting sites for birds as well as resting grounds for migratory birds. Larger islands with extensive meadows have been used as hayfields and pastures, and some islands with more fertile soils as arable land. The islands that were less suitable for agriculture, e.g. the sandy Naissaar, have been covered with forests through the centuries. The forested islands provided firewood as well as timber for shipbuilding. The economic use of the islands by man has resulted in diverse landscapes, and it has also enabled the open landscapes to be preserved.

During the second half of the 20th century traditional agricultural usage diminished and the small islands were used mainly as pastures for young animals. The strips of fields disappeared, the hayfields and pastures became covered with coppice, and the coastal areas were overgrown with reed.

Permanent residents already inhabited several small islands in the 13th – 14th century. The first residents on such islands were often nominated as guards of hayfields by the owners of manors, but their responsibility was also to provide fish for the manors. In addition to fishing, the inhabitants of small islands were engaged in seal hunting.

Most Estonian small islands were inhabited by just a few families, and they took great care of the nature on them. However, on the larger islands, e.g. Prangli, Naissaar, Suur- and Väike-Pakri, Kihnu and Ruhnu, there were several villages. The architecture of farm buildings on the islands was rather distinctive compared to the mainland, since there were very specific requirements for the dwellings, storehouses, saunas and even fences. All these building traditions were maintained by several generations over centuries.

Several small islands were inhabited by Swedes for centuries, who moved over there in the 13th – 14th century. Before World War II there were about 8000 Swedes living along the coasts of Estonia. During the war most of them left for Sweden, and after that the islands remained either uninhabited, or people moved there from elsewhere. However, the population of the small islands has changed before as well. One of the longest periods of continuous population of the small islands began after the last great plague epidemic in 1712, and lasted until the end of World War II. Everyday life on the islands was closely connected with the sea, but since there were not always jobs available, many men left the islands to work on ships worldwide.

For centuries during the medieval period, important sailing fairways from Western Europe to Russia passed in the vicinity of the northern coast of Estonia. As a result, the island silhouettes were important landmarks for sailors and logging was thus strictly prohibited on several islands. Later on, when building of lighthouses started to ensure safer marine navigation offshore the small islands, the lighthouse keepers and their families settled down on the islands.

In winter, the only connection of islanders with the mainland were ice-roads across the sea. In cases of emergency, islanders had to cross the sea even under conditions of very thin ice. Small horses living on the islands were courageous on the ice, skillfully crossing the fractures in it. There were taverns for resting the horses and offering shelter for stormy weather established on several small islands. Already during the Swedish time, tavern-keeping became an important income source for local landlords. Today, crossing the frozen sea with horses is history, but even nowadays besides ferry service marked ice-roads across the sea are built for cars on cold winters.

The location of Estonia at the northwestern border of the Russian Empire and the Soviet Union considerably increased the importance of the islands, as part of military defense systems. In the first half of the 20th century, various fortification facilities were established on the islands. After being incorporated into the Soviet Union, the border security zone was established on all the islands as well as along the coastal region of mainland Estonia, and people who did not permanently live there needed special permits to visit this area.

Excerpt from the *Charta Öfver FINSKAVIKEN Med Däromkring Belägne Provincier*, Stockholm 1788


HELSINGFORS
REVEL
HAPSAL
DAGÖ
Nargö
Wormsö
Odensholm
F I N S K A
E S T

The military importance of Naissaar and Aegna islands was greatest at the beginning of the 20th century when a system of marine fortifications for protecting St. Petersburg was established there. The military history of Pakri islands began in the years of the reign of Peter I the Great, Tsar of Russia. According to the agreement about military bases imposed upon Estonia by the Soviet Union in late 1930s, Naissaar, Pakri islands and Osmussaar passed into the possession of the Soviet armed forces and for almost a half of century remained closed to the residents of Estonia.

Several nature protection measures in Estonia were initiated on the small islands. The oldest of these dates back to 1297 when Erik VI Menved, King of Denmark, endorsed a document assembled in Roskilde, which limited the use of forests on Naissaar and Aegna islands, and on Paljassaar cape. Since 1765 the seaside forests were treated as daytime seamarks and to guarantee safe navigation they had to remain unchanged – therefore in a distance of 50 fathoms from the coast the cutting of forest was forbidden. In late 18th century the authorities came to understand that it was not necessary to enforce total forest protection to prevent the destruction of forests, but to apply economic and timely management of forests. The first forest management rules were introduced on the small islands at the beginning of the 19th century.

Classical nature protection started on the Estonian small as well. An important milestone was the establishment of the first nature reserve in the Baltic Governments on six small Vaika islets in 1910. In the late 1930s, several protected regions were established on Abruka island and on Sala islet. Nature protection substantially expanded to the small islands in 1957 when the Matsalu State Nature Reserve and Virtsu-Laelatu-Puhtu botanical-zoological reserve were established. In the beginning of the 1970s, more islands were taken under protection in connection with the founding of the Lahemaa National Park, Vilsandi Nature Reserve and Landscape Reserve of the

Hiiumaa islets. In the mid-1990s nature reserves were created on Naissaar, Pakri islands and Osmussaar, which for almost half a century were closed areas because of the presence of Soviet military bases.

The European Union is seeking to ensure biodiversity by conserving natural habitats and wild fauna and flora in the territory of the Member States. An ecological network of special protected areas, known as "Natura 2000", was set up for this purpose. Natura 2000 inventories have revealed the nature values of many islands and emphasized the need for protection in order to preserve important natural habitat types within their natural area of distribution. Firstly the local wetlands and trampling-prone dune landscapes needed protection. Several islets and their environs are valued as bird protection areas. The aim of the reserves is to preserve and protect the forest and coastal landscapes, nature and cultural heritage characteristic of the islands.

In the last decade, however, more attention has been paid to the recreational values of the islands. Nowadays the following Estonian small islands are inhabited all the year round: Abruka, Kihnu, Kesselaid, Kõinastu, Manija, Naissaar, Osmussaar, Prangli, Ruhnu, Vilsandi, Väike-Pakri and Vormsi. In order to better organize everyday life on the islands, a Permanently Inhabited Small Islands Act was adopted in Estonia in 2004. It formalizes the aims and tasks of central as well as local government in managing the small islands with a permanent population. Among these tasks, the most substantial are sustaining the permanent population and supporting the capacity for development, maintaining the insular specific lifestyle and continuity of local folk culture, preserving and protecting the landscapes and environment characteristic the small islands and relating the activity and interests of permanent residents to the public need for protection of territorial waters and the frontier, as well as environmental protection.

Tourists wading through the sea to Vilsandi

4. Estonian small islands

4.1 North Estonian islands

Most North Estonian small islands are located close to the Estonian coast, in the southern reaches of the Gulf of Finland. Here, the landscapes of the islands have been considerably shaped by both the abrasive and accumulative processes of the continental glaciers. Many islands present the topmost parts of large drumlin-like landforms that have been reshaped to a large extent by wave activity. Their height from seafloor to their highest parts may be over 100 metres. Presently, landforms of such great height above sea level do not occur on mainland Estonia. The bedrock of these islands is composed of Cambrian and Ediacaran rocks that are overlain by Quaternary deposits. However, on Prangli island the Quaternary deposits lie directly on the crystalline basement. Geological investigations carried out on Prangli and Keri islands have revealed interglacial deposits to which are related natural gas occurrences, consisting mainly of methane. The prevalent landforms on the islands are plains, beach ridges, scarps and dunes.

4.1.1 Vaindloo

The island of Vaindloo in the eastern Gulf of Finland (*Stenskär* in Swedish) is the northernmost island of Estonia. Its area is some 6 hectares and it is located at about 35 km from the mainland. The core of the island is a glacial ridge, the topmost part of which has been reshaped by the waves, and it rises up to 4 m above sea level. There is an active pebble beach in the eastern part of the island, whilst the western shore is more gently sloping with a boulder pavement. There is a small overgrown water body close to the shore in the eastern part of the island which was already depicted on a map from the 17th cen-

Map of North Estonian islands in the Gulf of Finland

tury. The Vaindloo giant rapakivi erratic boulder lies at the water's edge on the east coast of the island. By volume (480 m^3), this is the fourth largest such boulder in Estonia (length – 15.3 m, width – 10.1 m and height – 7.7 m).

The island and the surrounding sea area belong to the Vaindloo Conservation Area that is intended primarily for birdlife protection. The protected species are ruddy turnstone (*Arenaria interpres*), short-eared owl (*Asio flammeus*), lesser black-backed gull (*Larus fuscus*), common tern (*Sterna hirundo*) and arctic tern (*Sterna paradisaea*).

An important sight is the cast iron lighthouse built in 1871 with a fog bell, weighing about 328 kg, that was used to guide sailors when the lighthouse fire was not visible. Some seamarks for safe navigation were already established here before the lighthouse was built. There is also a memorial stone to four British sailors, who perished in 1721 during the Great Northern War as allies of Sweden. During the Soviet occupation the memorial was destroyed, but it was restored in 1996. Since 1994, there is an Estonian border guard station with radar and 50 m high observation tower.

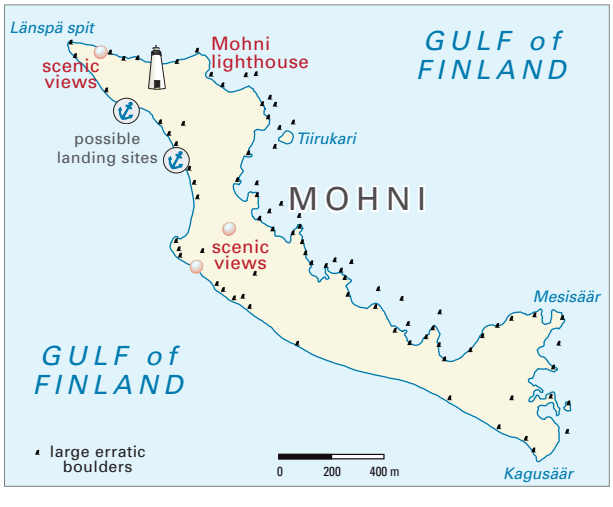
South of Vainloo, the Uhtju islets are situated on a common northwest-southeast ridge. The largest is the northern one – Põhja-Uhtju (area – 10.1 ha). The northern extension of this islet is called Hallisäär, which may join with Põhja-Uhtju islet during low-water stands. Hallisäär is an important place where seals give birth to their pups. The southern island is called either Lõuna-Uhtju or Sala. A nature reserve was already established in 1938 to protect vegetation and birdlife. This islet is known as the only habitat of the white sticky catchfly (*Silene viscose*) in Estonia. The islands of Uhtju together with the surrounding

Vaindloo giant rapakivi erratic boulder. Photo: R. Urb

sea area make up the Uhtju Nature Reserve, with the main aim of protecting the habitat of grey and striped seals.

4.1.2 Mohni

Mohni island (Swedish *Ekholm*, German *Eckholm*) has an area of 62.5 ha and is separated from the Pärispea cape by a 5 km wide strait, where the water depth may reach 80 metres in places. Mohni is the northern part of an underwater drumlin-like elevation from the northwest of Käsmu peninsula. The island formed by several adjacent islets becoming joined



Views of Mohni island. Photos: T. Bauert

together, a history that can be vaguely distinguished in the present topography as well. The east-west cross section of this elongated island is asymmetric, with a much steeper western slope. The island has a till core that is overlain by younger marine sediments, and in places dune sand occurs. The island also hosts many erratic boulders – the largest among them is Mohni boulder (7 x 6 x 5.2 m). Abundant erratic boulders border the coast line – the best-known is Elukivi (Life boulder), marking a shipwreck.

A sandy plain covered in places with crowberry heath spreads within the central part of the island. The shores of the island are diverse – reed-covered sections alternate with coast strips exposed to wave activity covered by abundant boulders. The most outstanding tree on island is an old linden (*Tilia cordata*) – although it is only 12 m high, the trunk circumference is as much as 328 cm. Local residents consider this tree to be a relict of a linden-oak forest that formerly grew here, but which perished in a fire. The Swedish name of Mohni is *Ekholm* ("island of oaks"), which supports this legend. The current name Mohni is probably derived from the German name *Mönchsinsel* ("island of monks"), because up to the 16th century the island belonged to a monastery located on Gotland, Sweden.

For many centuries the island has been a shelter for the shipwrecked, fishermen and seal hunters. The first seamark built on the 19th century was made of wood, and the current lighthouse was built in 1871. Mohni belongs to Lahemaa National Park and boat trips to Mohni can be arranged from the Viinistu harbour which also hosts a local art museum, hotel and conference centre.

4.2 KOLGA BAY ISLANDS

4.2.1 Pedassaar, Koipsi and Rammu

The Kolga bay islands are the largest group of islands in the North Estonian coastal sea (for locations see map on page 22). Their landscapes differ considerably because of the great variation in their main features: their areas range between 0.2 – 102.6 ha; the maximum elevations above sea level are between 1 – 13 metres, and openness to the winds and wave activity, as well as the topography, all vary considerably. All these islands are quite young as they rose from the Baltic Sea during the Limnea stage – the oldest is Pedassaar (area – 90.5 ha, max. elevation is 13 metres above sea level).

In terms of geological setting, the Kolga bay islands are similar to the peninsulas of northern Estonia – actually they are just extensions of capes on the mainland. The bedrock lies deep here and therefore the total thickness of the Quaternary cover is great – e.g. 62 metres on Rammu island. Several till beds have been recorded in the geological succession of the Quaternary sediments from the drill core material. The glacial deposits are usually covered by marine deposits. Erratic boulders abound on the islands as well as in the shallow nearshore sea – of these the largest is Malusi boulder on Lõuna-Malusi island (8.7 x 7.6 x 4.0 metres, circumference – 24.3 metres).

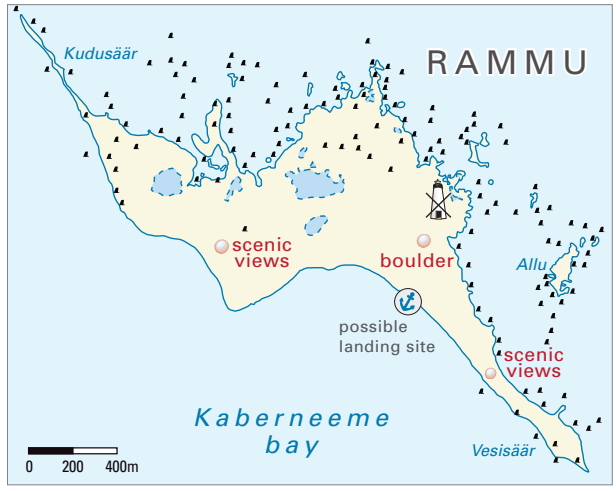
Beach ridges are common landforms on the Kolga bay islands. Coastal scarps are infrequent – among them the most conspicuous is the up to 10 metres high Lant(d)vaotsa on Pedassaar island. On these islands one can also encounter low dunes and small paludified hollows. The freshwater pond-like body of

Extensive sandy beaches spread on the southeastern coast. Photo: T. Bauert

Pedassaar from air. Photo: T. Bauert

water called Leetseljajärv exists in the central part of Rammu island, but this is gradually being overgrown to become a mire. Several shallow lakelets with brackish water (e.g. Maalaht, Lake Loodeotsa) can be seen in the northern part of the island – these are former bays that have been only recently separated from the sea. The gravel-pebble and sandy shores dominate the shore types here, whereas till shore is infrequent. Both Rammu and Koipsi are enlivened by long spits reaching far into the sea.

The topsoil of the islands lies thinly over marine sands and is nutrient-poor. Nevertheless, the vegetation here is rich in species. In the environs of Lake Leetseljajärv on Rammu island hikers can appreciate dwarf cornel (*Cornus suecica*) with white and purple blooms and bright-red berries, while sea thrift (*Armeria elongata*) blossoms on the meadows in the western part of the island, and beach pea with pink blossoms (*Lathyrus*



View to Rammu island from west (top right). Photo: E. Lepik

Crowberry (*Empetrum nigrum*) close-up (middle right)

Large erratic boulder on Rammu island (bottom right)

Dwarf cornel (*Cornus suecica*) with bright-red berries (below)

japonicus) can be spotted on sandy beaches. All three are protected species in Estonia. On these islands one can also find many moss and lichen species. Of forest types, the trampling-prone heath pine groves dominate. The crowberry heaths on Koipsi and Rammu islands occur close to the southern distribution limit of this habitat type, and make a remarkably distinctive landscape element here. In 1980s numerous pine trees were planted on these islands, which resulted in a considerable shrinkage of the distribution area of crowberry heaths. On Koipsi, one can find also juniper coppices that are normally not common on the North Estonian islands. In the northern part of Rammu however, coastal meadows cover extensive areas. The smaller islets in Kolga bay are often covered by meadows, but some of them may lack covering vegetation at all. These small islets here are important nesting grounds for seabirds. The environs of Malusi islands

Crowberry heath on Koipsi

Koipsi from air. Photo: T. Bauert

are inhabited by a colony of grey seals (*Halichoerus grypus*) and these islands are their major breeding-ground.

A landscape reserve was established on the Kolga bay islands in 1999 to preserve these landscapes, plant communities and avifauna characteristic of the North Estonian small islands. Habitat types of all-European importance on these islands are coastal lagoons and lakes, coastal meadows and sandy plains covered by crowberry.

In past centuries the nature of these islands was considerably influenced by human activity. The main fields of activity were related to fishing, accompanied by bird and seal hunting and by boatbuilding. Owing to a dense population there was a shortage of firewood and it had to be transported from the mainland. Low farm buildings were common on the inhabited islands of Kolga bay, but by today only a few foundations, former wells and low stone fences remain of them. Previously the small islands of Kolga bay were important for the trafficking of spirits, and the tavern established on Lõuna-Malusi island was an important meeting point of the Estonian and Finnish alcohol smugglers in the 19th century.

The Soviet occupation drastically changed the life of local inhabitants. The occupation regime established strict border protection zones along the coast of Estonia. As a result, the local residents were forced to leave their homes and move to the mainland. Later they were allowed to visit their home islands only on rare occasions when in possession of special permits.

Western coast of Prangli (view from south) with a white church visible on a foreground. Photo: T. Bauert

When Estonia regained her independence, land was given back to the successors of former landowners, and today several summer cottages have been built on Rammu and Koipsi.

Owing to the fast development of nature tourism in the last decade, the number of visits to the islands of Kolga bay has increased considerably. People can get to these islands by private boats, but several tourist firms also arrange trips to these islands. On Pedassaar, visitors can rent a log-house with a sauna for overnight stays through the web page of the State Forest Management Centre. In addition, there is a marked nature trail and fire- and camping ground on this island.

4.2.2 PRANGLI, AKSI AND KERI

The island of **Prangli** (area – 6.4 km^2, Swedish *Wrangö*, German *Wrangelsholm*) is located 9 km northeast of Viimsi peninsula. The island, with a highly rugged coastline, is almost triangular by shape. Several tiny islets occur in its western nearshore sea (Seinakari, Tiirloo, etc.). There is a passenger boat connection between the Kelnase harbour on the island with the Leppneeme harbour on mainland – the waterway between these harbours is 18 km.

Prangli, together with Aksi island and Nygrund bank northwest of Prangli, is situated on a northwest-southeast ridge of Quaternary deposits. The highest parts of

Large Punakivi erratic boulder

The southern coast of Prangli (right). Photo: T. Bauert

the island rose from the sea about 3500 years ago. In the northern part of the island, the sedimentary bedrock is missing, and Quaternary sediments lie directly on igneous and metamorphic rocks of the crystalline basement. Drilling carried out within geological investigations has identified, besides the glacial and glaciofluvial deposits, some interglacial deposits that lie between the till beds of different age, composition and colour. The Prangli (Eemian) interglacial was the warmest time in the Pleistocene. The occurrences of natural gas on Prangli (discovered in 1924) are related to these interglacial deposits.

Geomorphologically, the western part of Prangli is low and flat, but its eastern part is dissected by shallow coastal ridges and dune chains. Shore types include stony, non-vegetated till shore alternating with a turfed till shore on the western coast, and with sandy beaches in the east and south. The dry pine forests dominate in eastern Prangli. In the western parts of the island shrubs and grasslands grow. The coastal meadows in western Prangli are the largest on the North Estonian islands, but these have currently been overgrown with reed. Sandy areas with herbaceous vegetation spread in northeastern Prangli, while in southeast, developing crowberry heaths can occasionally be found.

Prangli was supposedly inhabited already by the 13-14th century. From historical documents it is known that 16 households lived on the island in the first half of the 18th century. Their dwellings stood mostly side-by-side along the narrow dirt road passing through the island. There are three villages on the island: Lääneotsa, Idaotsa and Kelnase. When agricultural collective farms were formed on mainland Esto-

Prangli church of Laurentius

nia in the 1950s, the permanent residents were forced to leave most of the small islands, but on Prangli they were allowed to stay at home on the island. Instead a collective farm was instituted here with a major focus on fishery, as the scattered plots of arable land on the island were not suitable for large-scale farming. Therefore, the traditional insular landscape was preserved until the late 20th century. In 1962, altogether 83 families with 296 people lived on the island – today the number of inhabitants of Prangli is just 130.

The main cultural heritage sites are the Laurentius Chapel built in 1848 in the southern part of the island, and the local graveyard. The burial ground of those who perished in the bombing of the steamboat "Eestirand" during World War II is situated in eastern Prangli – this site is marked by a simple wooden cross 4 m high. On 24 August 1941, "Eestirand", carrying some 4000 soldiers mobilised to Soviet Army, was headed to Leningrad from Tallinn. Near Keri island, the ship was hit by bombs dropped by German bombers, but the captain managed to take the sinking ship to the shore of Prangli.

Aksi island (known also as Väike Prangli or Äksi or *Lilla Wrangelsö* in Swedish or *Klein-Wrangelsholm* in German) is situated southeast of Prangli. This island, with an area of 59 ha, is separated from Prangli by

Aksi island (view from southwest). Photo: E. Lepik

Scenic views on Aksi island: east coast (top left), west coast (top right) and the northernmost tip

the some 2.5 km wide Aksi strait. The ridge forming the island emerges steeply from the seabed. The characteristic landforms on the island are pebbly-gravelly beach ridges covered by juniper shrubs. Between the beach ridges there is lowland with many small lakelets in the central part of the island, where white water lilies (*Nymphaea alba*) blossom in the second half of summer.

Vegetation is either entirely missing or is rather stunted on the shores of Aksi, and particularly in its northernmost top. The steep shore slope is often covered by numerous erratic boulders, occasionally forming a dense boulder pavement. Crystalline cobblestones from Aksi island were delivered to Tallinn for paving the streets in the old town area.

Aksi island was inhabited in the late 18th century. Most of its residents belonged to the Aksberg family, a majority of which left for Sweden during World War II. The last inhabitants left the island in 1952. A noteworthy tourist attraction is a monument in the southeastern part of the island – a stone labyrinth some 10 metres in diameter, created in 1849. In Estonian coastal areas inhabited by Swedes, similar stone labyrinths are also known on Aegna island as well as at Kootsaar in northern Hiiumaa. In connection with establishing the Port of Muuga in 1986, a lighthouse was built on the southern tip of Aksi.

Prangli Landscape Reserve (established in 2000) includes Aksi island and the southeastern part of Prangli. The near-shore sea west of Prangli with its local shallows and the sea around Aksi, belong to a conservation area established in 2005.

North of Prangli lies the tiny **Keri** island (area – 3.1 ha, *Kokskär* in Swedish). The island's ground is mostly covered by pebbly gravel with numerous erratic boulders, while some small patches of grasslands exist in the central part.

Keri island was described for the first time in 1623, and it has throughout the centuries been considered as an important navigation mark for sailors. Nowadays, sailors can easily recognize Keri by its distinctively-shaped lighthouse, which is one of the oldest

lighthouses in the Gulf of Finland. As early as 1718, according to the order of Peter I the Great, a 15 m high stone deck was erected on Keri island, on which a fire was made to warn sailors in the dark. Some years later a permanently operated wooden lighthouse was built. The distinctively shaped, wide at the base but narrowing upwards, stony lighthouse building, topped by an 24 m high wooden tower with lantern room, was erected here at the beginning of the 19th century. This eye-catching lighthouse still stands on the island today. The lighthouse beacon, with oil lamps and copper reflectors, incorporated the most outstanding technology of the time. In 1858 the primary wooden tower was replaced by a metal cylinder-shaped tower.

It is interesting to note that between 1906 – 1912, natural gas was used for lighting the beacon and for heating the lighthouse guard housing. The natural gas was found there during drilling in 1902, but as the result of strong explosive eruptions in the spring of year 1912 the extraction of gas stopped. At present, power to the lighthouse is provided by a wind generator and by solar cells.

The Keri lighthouse has been taken under the protection of national heritage and is included in the IALA's (International Association of Marine Aids to Navigation and Lighthouse Authorities) list of a hundred most prominent lighthouses in the World. In 1937 the strongly-deformed stony walls of the lighthouse were reinforced by four concrete collars, but the lighthouse still needs extensive repairs. Through time the island has been permanently inhabited only by the lighthouse keepers and their families – the last keeper left the island in 2002.

Another noteworthy site on Keri island is the memorial established on the island in 1993 to commemorate the loss of the passenger plane Kaleva that was shot down north of Keri by the Russians in 1940. The erection of this monument was supported financially by Finnair.

Keri island

4.3 ISLANDS IN TALLINN BAY

The most frequently visited islands of northern Estonia are two densely forested islands in the mouth of Tallinn bay – Naissaar (Swedish *Nargö*; German *Nargen*) and Aegna (Swedish *Ulfsö*; German *Wulf*). Their landscapes exhibit numerous coastal formations, including dunes and large erratic boulders. Owing to their geographical position both islands have been important seamarks for navigation. In 1470 the fairway between Naissaar island and Paljassaar cape on mainland was marked by two drifting light beacons. Wooden lighthouses were built on the northern- and southernmost tips of Naissaar in 1788 to ensure safe passage of ships into the Port of Tallinn in any weather. Currently, the 45 m high Naissaar lighthouse, built in 1960, stands on the northern tip of the island.

4.3.1 Naissaar

Naissaar (area – 18.6 km^2) is the largest and oldest island in the North Estonian coastal sea. Its high central part (up to 27 metres above sea level) began to emerge from the sea in the Ancylus Lake stage. Considerable parts of the island are occupied by abrasion-accumulation plains that are dissected by beach ridges and scarps. Between the coastal formations, peaty hollows occur. Here one can find Estonia's northernmost mires – Kunila, Kullkrooni, Bletkärri, Sinkarka and Storkärri. There are several lovely dune fields covered by wooded heaths. The highest dunes – Suurmäed and Kunilamägi – are located in the central part of the island. The dunes on the northwestern coast of Naissaar exhibit a scattered, weakly-developed plant cover and thus extensive trampling may easily lead to the formation of drifting sands.

The crystalline basement lies here at a depth of about 130 metres. This is overlain by 80 metres of Ediacaran and Cambrian clastic rocks, and these in turn are covered by the Cambrian blue clay belonging to the Lontova Formation. The Quaternary cover is represented by till beds that alternate with glaciofluvial deposits. The glacial deposits are covered by some 10 metres of younger marine and aeolian deposits. Numerous large erratic boulders, consisting mainly of rapakivi granites, can be seen on the island and in the nearshore sea.

Two large erratic boulders – Lehtmetsa and Männiku boulders can be visited in the eastern part of the island, but the largest one is the Põlendiku erratic boulder (10.6 x 7. 6 x 7.0 m, circumference 28.8 m) in the central part of the island. The name "Põlendiku" supposedly originates from the years of the

Aerial view at Naissaar from south. Photo: T. Bauert


Virbi point
lighthouse
coastal escarpment
Savikallas
GULF of FINLAND
Haldja
Suursoo mire
Põhjaküla
Tallinn bay
30
Kunila hill
Kunila mire
garden of the Danish King
NAISSAAR
Kullkrooni mire
Tümasoo mire
Sinikarka mire
25
20
15
10
nature park centre
Naissaare moorage
Põlendiku boulder
mine depot
Storkärri
Mädasadam
Noodamaja-rand
Väikeheinamaa village
Männiku village
church
Omar's barn
Hülkari point
Lõunaküla
Küla-sadam
railway
northern trail
central trail
southern trail
landing site
0
250
500 m

The large Põlendiku erratic boulder rests on the western edge of sea mine depot

Crimean War in the mid-19th century when the forest around the boulder was burnt. Numerous smaller erratic boulders were blasted in the beginning of the 20th century to obtain building materials for military structures.

The coastline of Naissaar island (24.2 km) is poorly dissected. Sandy shores dominate, but in the southern and southwestern parts of the island silty shores also occur, and in some stretches a pebble-rich or scarp shore can be found. The most considerable

Road from the Naissaar moorage to the music events site at the Omar's Barn passes through Männiku village

coastal scarp is the up to 7 metres high Savikallas in the northeastern part. Natural lakes and permanent watercourses are lacking here. Forests cover over 80% of the total area of Naissaar island. The majority of the forest types present in Estonia can be found here – from dry heath pinewoods to peaty forests. As a rule, various pinewoods dominate, but spruce forests are present as well. A distinctive deciduous broad-leaved forest with abundant undergrowth known as the Danish King's Garden occurs in the eastern part of the island. After recent management works, a large part of this forest has regained the appearance of wooded meadow, where lime trees, together with maples, oaks and ash trees all occur in the treeline. The most unusual species in the undergrowth is coral root (*Cardamine bulbifera*).

Many natural habitat types of Natura 2000, an ecological network of protected areas, are found on Naissaar: forested dunes, transitional mire and bog forests, and habitats connected with sandy shores and dunes. The protected species are represented by the European crab apple (*Malus sylvestris*), wolf's-foot clubmoss (*Lycopodium clavatum*), beach pea (*Lathyrus japonicus*) and several orchids.

The oldest records about Naissaar date back to the 11th century, while the first notes available about permanent residents are from 1469. Through time, four villages are known to have existed on the island – Põhjaküla, Lõunaküla, Tagaküla and Väikeheinamaa.

Naissaar is the island with the longest military history in the Estonian near-shore sea. The first known military structure on the island was the shore defense battery established by the Swedes in 1705. During the Great Northern War a powerful earth fortification (Sternschanz) was established in the same location, on the lands of the village of Lõunaküla. At the beginning of the 20th century Naissaar was included in the main positions of the St. Petersburg marine fortifica-

One of main attractions on Naissaar is the possibility to have an exotic train ride. Photo: T. Bauert

tions, which owing to its position in the narrowest part of the Gulf of Finland was suitable for the bases in every way. In May 1914, a complete militarization was announced and the inhabitants were forced to leave. In addition to eight air defense batteries, detachment points and other military facilities, 37.7 km of narrow-gauge railway were built on the island for transporting building materials and ammunition. Most preserved military structures are currently protected as historical monuments.

An interesting moment in the history of Naissaar was the proclamation of an independent Soviet Republic in December 1917 by some 90 Bolshevist Russian sailors. This local, unofficial republic existed on the island until February 1918.

When the Republic of Estonia was established, only four shore defense batteries remained on the island and the island became permanently inhabited again. In 1940, in connection with the establishment of Soviet military bases in Estonia, all residents were once again forced to leave the island. In 1941, in the southern and western parts of the island, Russian batteries were set up, with the aim of blocking the penetration of the German Navy. After World War II, the storehouse of sea-mines of the Baltic Navy and the mine-manufacturing department have remained in the central part of the island. In conjunction with this, the railway that connected the northern and southern part of the island with the mine storehouse was renovated in 1958. A frontier guard post with an

air defense missile division was situated in northern Naissaar at this time too.

Life on Naissaar changed when Estonia regained independence. Alien military forces left and Naissaar became a part of Viimsi Parish. In 1995 the Naissaar Nature Park was founded, with the aim of protecting the valuable local landscapes and cultural heritage.

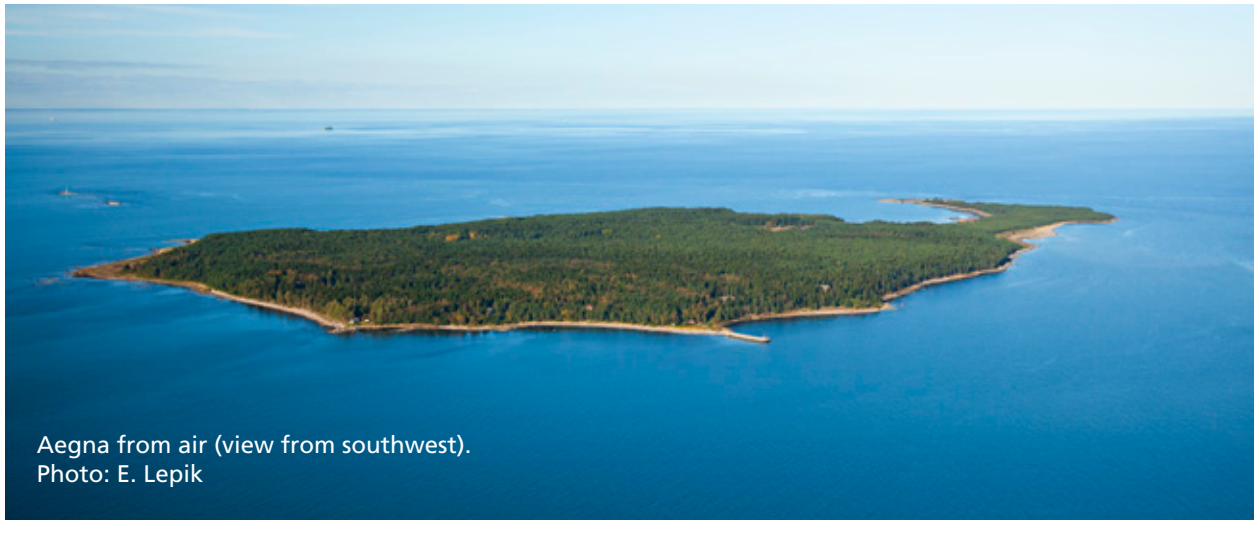
The Naissaar Nature Centre organizes walking tours and offers accommodation for those visiting the island. Three nature trails on Naissaar introduce the island's nature and cultural life as well as its military past. Renowned choir leader and conductor Tõnu Kaljuste has built one of the most exotic concert houses in Nordic countries – the Omar's Barn in Lõunaküla village. This concert house is located in the lands of the former farm where Bernhard Schmidt (1879–1935) – a great astronomical optical engineer of the twentieth century was born.

A music event – the Nargen Festival – was initiated on Naissaar and by now is becoming one of the most prominent musical undertakings of the whole Baltic Sea region. In the summer people can reach Naissaar by the passenger boat Monica from Tallinn harbour.

4.3.2 Aegna

The small Aegna island (area – 2.9 km^2, highest point 12.8 metres above sea level) is situated in the north-eastern Tallinn bay, not far from Viimsi peninsula. Its neighbouring islands are the small Kräsuli (0.17 km^2) and Kumbli (0.02 km^2) islets. Aegna emerged from the sea during the Limnea stage, at first as a small patch of land, while the Lemmiku cape (that forms the eastern part of the present Aegna island) emerged as a tiny islet on the east. When the sea level dropped, both islands were uniting, forming the present day Aegna.

The generally flat relief of the island is enlivened by coastal formations and dunes that are highest and most easily observed in northern part of the island. Between the coastal formations and dunes spread small mires influenced by human activity (Järvsoo, Samblikusoo, Talneemesoo, Krõnka, Juhani, Abneeme mires, etc.), where the peat thickness is less than a metre. The island has an about 10 km long rugged coastline, represented by sandy, gravelly-pebble, till and silty shores. Up to some metres high coastal scarps occur on the northeastern, eastern and south-eastern coasts.



Aegna from air (view from southwest).
Photo: E. Lepik

A historical stone maze on Aegna which was recently excavated and cleaned up

Aegna from boat (view from southeast)

The Lemmikneeme (Lemmiku) boulder field. Photo: T. Bauert

The upper part of the Quaternary cover is dominated by till, which is overlain by sand with abundant pebbles and gravel. Numerous erratic boulders are scattered around the island as well as in the surrounding sea. The most prominent pile of boulders is called the Lemmikneeme (Lemmiku) boulder field in southeastern part of the island. Here are counted 23 large erratic boulders and about ten smaller ones. The largest and best known among these erratic boulders is the Tulekivi (known also as Sihi Suurkivi) rapakivi boulder (11.5 x 11.3 x 3.8 m, circumference 35.5 m), which has been under protection since 1939.

Another large boulder – the Eerikukivi boulder (circumference 23 m, height 4 m) rests in the northeastern part of Aegna. Not far away from the latter is a stone labyrinth, discovered 1930, located. After World War II, when the island was closed to visitors, the stone labyrinth became overgrown by grass and buried by the topsoil. It was excavated and restored by archaeologists again in 2009. The diameter of the 10-circled stone maze is 10 metres. It was made with regard to the movement of celestial bodies and its entrance is headed towards the midsummer sundown. The labyrinth was supposedly established in the 17th century.

The earliest data about the settlement on Aegna are known from the year 1460. Swedes were obviously the first residents here. In late 17th century there were

10 farmsteads on the island, but the number of residents decreased after the Great Northern War. At the beginning of the 20th century there were 7 farms on Aegna, when the main fields of activity were fishing and seal hunting.

Aegna island was one of the main footholds of the former Peter I the Great marine fortifications system. Therefore, in the early 20th century several military structures were built on the island. For military purposes a 3 km long narrow-gauge railway was also built here and operated between 1914–1944. The military importance of the island also persisted during the Soviet Estonia, when another air defense battery was built in the northwestern part of the island. In 1940 the island was put at the disposal of the Soviet military forces and the residents were forced to leave. After the war, a boarder guard unit was situated on the island. Since 1975, the island has been an administrative unit of Tallinn. Presently most of the island is private property and a permanent population is growing here.

For centuries Aegna has been covered by forests, where various pine forests alternating with old spruce forests dominate. The majority of the forests on the island are valued as Natura 2000 habitats. Here and there small patches of meadows occur. On the coast one can find magnificent areas where Japanese rose (*Rosa rugosa*) grow. To ensure preservation of the diverse nature of the island, the Aegna Landscape Reserve was established in 1991. In recent years a Nature Centre has been built on the island, which is administered by Tallinn city. In the summer people can reach here by passenger boat from the Kalasadam harbour, Tallinn.

4.4 ISLANDS OFFSHORE NORTHWEST ESTONIA

The Suur- and Väike-Pakri and Osmussaar islands are geomorphologically closely related to the North Estonian Plateau and North Estonian klint. The islands are located in the outcrop area of limestone, therefore their landscape is dissected mainly by the beach ridges made of limestone shingle with shallow hollows between them. The northern coasts of these islands are bordered by majestic, abrupt cliffs abraded by storm waves.

The small bay Pardilõugas in northeastern Aegna

4.4.1 Suur- and Väike-Pakri

The Suur-Pakri (area – 11.6 km^2) and Väike-Pakri (area – 12.8 km^2) islands are administratively part of Paldiski town, although being separated from mainland by the approximately 2 km wide Paldiski bay. The geological and natural value of the Pakri islands is greatly related to the striking coastal escarpment and its fine exposure. The local cliffs exhibit a sequence of Lower to Middle Ordovician (Pakerort to Uhaku Stages) hard limestones with abundant faunal remains.

These coastal cliffs on the Pakri islands are subject to intensive sea abrasion. On Suur-Pakri the 3 kilometres long and 1–5 metres high escarpment is composed entirely of limestones and it exposes only the central and upper part of the bed sequence compared to the cliff on the neighbouring Väike-Pakri island. South of the escarpment continues the klint plateau, the flat surface of which is in places slightly undulating owing to the presence of low beach ridges.

The eastern and northern coasts of Väike-Pakri are bordered by an about 7 kilometres long klint escarpment with a maximum height of 14 metres in its northernmost part. Here one can see huge limestone slabs, several tens of square metres in area, that have fallen down from the upper edge of the escarpment and are now leaning against it. Other remarkable features are up to several metres deep large notches cut by storm waves into a soft glauconite sandstone at the base of the cliff. Owing to the southward inclination of Ordovician sedimentary rocks, the oldest exposed rocks are observed only in the northern part of Väike-Pakri, and the youngest in the western part of the cliff.

Continental glaciers have dropped abundant erratic boulders on the land of the Pakri islands, which mainly consist of coarse crystalline rapakivi granite. The largest among these is Suurkivi (8.7 x 6.7 x 4.0 m; circumference 22.6 m) in northern Suur-Pakri. Limestone plains are the major landscape feature on these islands, being dissected by ancient shingle beach ridges. Such large, poorly-vegetated shingle ridges are found in northwestern and northeastern Suur-Pakri, as well as in southeastern Väike-Pakri. The only mire (Djupmosan) with a thin peat layer is situated


BALTIC SEA
Pliiku point
coastal cliff
scenic views
coastal cliff
scenic views
coastal cliff
1,8 km
1,6 km
1,5 km
0,9 km
limestone quarry
0,8 km
Väikeküla
Lillby
VÄIKE-PAKRI
LILLA-RÅGÖ
shipwreck
1 km
1,8 km
0,6 km
1,3 km
Suurküla
Storby
church &
cemetery
0,7 km
Kappa
Lihl-träske
Stor-träske
1,4 km
Kurkse strait
Bodän
coastal cliff
1,6 km
scenic view –
alvar meadow
Lihl-viki
0,9 km
1,6 km
2,3 km
3 km
SUUR-PAKRI
STORA-RÅGÖ
Lepikuküla
Bisagidby
Rannaküla
Åsby
1 km
Suurküla
Storby
1 km
church &
cemetery
landing site
0
500
1000 m

Väike-Pakri from air (view from south).
Photo: E. Lepik

The large alvar on Suur-Pakri is a former military bombardment and navy artillery target ground

in northern Väike-Pakri. Small shallow, temporary water bodies that dry up in summers can be seen in northern Suur-Pakri as well as in southern Väike-Pakri. Because the limestone plateaus on the islands are strongly fractured, the rainwater easily percolates into the ground and seeps out through numerous springs on shore slopes.

The vegetation of Pakri islands is dominated by calciphilous plants. There are more than 30 protected vascular plants that mostly grow in the northern parts of these islands. Among mosses, the most interesting are the arctic species growing there. When compared to that of the first decades of the past century, the vegetation patterns on these islands have changed considerably. Then the land was cultivated, hay was made and cattle raised. By today, however, these former fields have turned to grasslands, former pastures and hayfields are overgrown by shrubs, and coastal meadows are covered with reed. Fortunately, the majority of alvars are still preserved as open areas, mainly because the Soviet army used Suur-Pakri as a target area for military exercises including bombing from planes as well as a navy artillery target ground. All this often led to frequent fires that kept the area clean from bushes and preserved alvar grasslands.

The about 5 km^2 meadow alvar in northern Suur-Pakri is one of the largest open alvars in Estonia. The plant associations on alvars are diverse, where in places abundant sand pink (*Dianthus arenarius*) can be found blossoming. Deciduous forest is widespread on the islands, including a remarkable lime tree grove in northern Väike-Pakri. The sea between islands and around them is one of the most important bird-protected areas in Estonia. It is widely used as a resting area for waterfowls during their migration periods. The Pakri Landscape Reserve (comprising part of Pakri islands and a coastal area of Pakri cape on mainland) was founded in 1998 to protect rare and scientifically valuable geological features (bedrock outcrops, beach ridges, erratic boulders) as well as wildlife associations. Since 2005, the Pakri islands as a whole are incorporated into Natura 2000 areas.

It is not exactly known yet how and when the first Swedes arrived on the Pakri islands. The first written records of the Swedish name for Pakri islands, *Rogoy*, date back to 1283. In all likelihood the islands were inhabited at least by the 14th century. During the centuries a distinctive folk culture and a specific local language dialect developed. It is known that there were five villages with 119 farmsteads and a total of 354 residents on both islands in 1934. Both islands also had a school, church and cemetery. Because of a shortage of arable land with good natural fertility and sufficient moisture in the topsoil, the same plots were cultivated over again on the Pakri islands for centuries. The other Swedish name used for the islands – *Rågöarna* ("rye islands") refers to land suitable for growing cereals here. During World War II most permanent residents fled to Sweden and therefore the local agricultural landscapes began to perish. Directly after World War II some twenty residents still lived on Väike-Pakri, but in 1965 the last two families left the island.

The islands of Pakri together with a cape of the same name on the mainland already had considerable military importance some centuries ago. This was owing to their strategic position in the mouth of the Gulf of Finland as well as the presence of the deep Paldiski bay that offered a good shelter for ships against fierce storms. In the 18th century Peter I the Great initiated construction of a military port in Paldiski bay. For this port, building material was partly broken from the limestone escarpment on the eastern coast of Väike-Pakri. The quarry walls expose a building limestone sequence of the Väo Formation (Uhaku Stage) and it is considered to be a geological monument of national importance.

The building of defense fortifications was started during World War I, both on Pakri cape and on the Pakri islands, with the aim of guarding the Paldiski roadstead. The Pakri islands were handed over to Soviet military forces and they became inaccessible to civilians for about half a century after 1939. As a result, numerous military structures were built on both islands in the 1950s and 1960s and covered more than a half of the territory of Suur-Pakri, and some tenth of the area of Väike-Pakri. In these years a shooting target ground was also prepared on the islands – firstly it was used mainly by artillery, later on for bombardment from military planes.

In early 1990s, the former legal private land-owners or their heirs regained the land ownership through the Land Reform Act. As a result, the successors of the former community on the islands started to implement plans of restoring and exhibiting the local cultural heritage. The preserved tower of the Väike-Pakri chapel was newly consecrated in July 2010. A dona-

Tower of the Väike-Pakri church (top right). A limestone slab pavement leads from the sea coast to the church (bottom right). Photos: T. Bauert

Huge limestone slabs lean against the cliff wall at Väike-Pakri

tion for renovating the latter was also made by the King of Sweden. Conservation of Suur-Pakri church has also begun.

Väike-Pakri island is currently inhabited year-round by four families – some of them are engaged in sheep and beef cattle breeding. Presently the Pakri islands can be reached from the harbours of Paldiski and Kurkse. Owing to its good logistic position and the scarce population of the island, the state enterprise Eesti Energia is currently carrying out feasibility studies about building a nuclear power plant on Suur-Pakri.

4.4.2 Osmussaar

Osmussaar emerged first from the sea some 3000 years ago and by now the highest areas are up to 6 metres above sea level. It is surrounded in the east and west by an up to 200 metres wide underwater limestone plateau that is bordered by a steep underwater slope. Because Osmussaar is located in an area with the most intense post-glacial land uplift, the island is still noticeably emerging from the sea, while at the same time the cliff walls along the northwestern and northern coasts are being intensely abraded by sea waves. The abraded limestone shingle is carried on along the coast southwards, making the island's outline longer and narrower.

The approximately 5 kilometres long and up to 6 metres high coastal escarpment is the main geological highlight on Osmussaar. It is the westernmost outcrop of the North Estonian klint, because further southwestward the klint escarpment continues under the waters of the Baltic Sea until emerging again on the island of Öland in the coastal waters of Sweden.

Most of the geological sequence of this coastal cliff on Osmussaar is represented by the Middle Ordovician Väo Formation (Lasnamägi Stage). However, the most intriguing part of the Osmussaar bedrock sequence is related to the 1.0–1.5 m thick layer of

The limestone cliff at the northernmost tip on Osmussaar


BALTIC SEA
OSMUSSAAR
ODENSHOLM
Norda sia
Västa sia
Sånna sia
megabreccia occurrences
lighthouse
coastal cliff
scenic shingle ridges
shipwreck
Neugrund-breccia boulders "Twins"
Kappelkärre
chapel ruins
Lihlhamne
Skanvike
Neugrund-breccia boulder "Skarvan"
Inahamne
Storhamne
Lõunalaht
open areas / alvars
shrubs / juniper thickets
tree groves / forest
marshy areas
shingle ridges
landing site
0
250
500 m

rocks of the Billingen, Volkhov and Kunda stages at the foot of the coastal escarpment, where the limestones are penetrated by veins and larger bodies of strongly cemented breccia-like limey sandstones. This rock unit, known as the Middle Ordovician Osmussaar megabreccia, formed about 466 Ma ago. It should be noted that the rocks above (limestones of the Lasnamägi Stage) and below this level (glauconitic sandstones of the Hunneberg Stage) are completely in undisturbed state.

Since the middle of the 19th century, several hypotheses concerning the origin of this megabreccia sequence have been proposed. The most plausible explanation involved formation and filling of the cracks due to nearby earthquakes. However quite recently (in 1996) the Neugrund shoal, located less than 10 kilometres off Osmussaar island, was identified as a large meteorite impact structure. This Neugrund impact was proposed to have occurred in Early Cambrian time, about 535 Ma, by geologists Kalle and Sten Suuroja (Geological Survey of Estonia) in 2004. Although shocked quartz grains, which have been considered to be a reliable indicator of meteorite impacts, had already been recorded from the Osmussaar breccias by this time, they argued that these grains were redeposited by an earthquake in Middle Ordovician from the nearby 535 Ma Neugrund crater. However, recent studies have demonstrated a high concentration of angular chromite grains of extraterrestrial origin as well as shocked quartz grains in the Osmussaar breccia. The angularity of these chromite grains excluded the possibility of them being subjected to any extensive re-deposition from Neugrund crater. Thus, in the light of this new information, the most plausible explanation for the creation of the Osmussaar breccia is an impactor that about 466 Ma created this brecciation and caused the injection of sandstone veins into the Lower Ordovician carbonate sequence by nearby impact. This in turn points out the need for drilling through the central cap of the Neugrund impact structure to convincingly confirm the age of this structure.

Osmussaar from air (view from north). Photo: E. Lepik

Sandstone vein (thickness ca 3 cm) injected into Lower Ordovician limestone

Extensive beach ridges border the southeastern coast of Osmussaar (above). The bedding plane of fossiliferous Kunda limestone in northeastern island (bottom right)

The Neugrund impact fused together various crystalline basement rocks during the cratering process to form what is now known as the Neugrund breccia. These Neugrund breccia boulders of various sizes have been transported by continental glaciers tens of kilometres to the south and southeast of the crater. The two largest Neugrund breccia boulders laid down on Osmussaar are known as the Twins (Kagronsstaina), while a giant boulder named Skarvan lies in the sea near the island's western coast.

The landscapes of Osmussaar are characterised by shingle beach ridges that form extensive beach ridge systems in the northwestern and southeastern parts. Owing to fast postglacial uplift (2–3 mm per year), the beach ridges formed earlier are located farther inland from the present coastline. Between these beach ridge systems, flat peaty areas and fresh or brackish water lakelets occur. Alvars covered by juniper thickets are the prevailing landscape type on this island.

Osmussaar island is situated on the major East Atlantic waterfowl migration route, connecting nesting areas on the shores of the Arctic Ocean to the wintering areas in southern Europe and Africa. The number of birds passing by during the spring migration season may reach as much as million on the best days. As a hatching site, Osmussaar is important for the red-breasted merganser (*Mergus serrator*), ruddy turnstone (*Arenaria interpres*), velvet scoter (*Melanitta fusca*) and little tern (*Sterna albifrons*).

Considering the name of Osmussaar in Swedish *Odensholm* – one may assume that this island was already known in the Viking era. First and foremost this name is connected with Odin, the major god of the Vikings who, as the legend goes, is buried on the island. Once the island became inhabited by Swedes, everyday life there was regulated by the so-called

Swedish settlement rights (*besittningsrätt*). Before 1940, when all the inhabitants were deported, over 130 residents lived on the island. All of them, except the lighthouse keeper, were Swedes. The main source of living here has been fishing and working on ships.

After the deportation of local residents in the summer of 1940, the establishment of a fortified naval base began on the basis of the Estonian-Russian agreement about military bases. The ruins of some military facilities can still be observed on the island today. The most prominent of these military facilities are the remains of the gunfire control centre and the positions of two large-calibre (180 mm) long-range cannons that were blasted by the Russians in December 1941 while retreating from the invading German troops. It should be noted that Osmussaar was the last foothold of the Red Army in Estonia that was ceded to the German military forces. The naval military base on Osmussaar was liquidated in 1947 and after that just a small Soviet naval unit and the lighthouse keepers remained on the island.

A historical sightseeing and cultural heritage site on this island is the ruin of the chapel (consecrated in 1766) with a statue of Martin Luther on the chapel-yard gate. The above statue originates from a ship that wrecked near the island in 1852. There is a lighthouse in the northernmost tip of Osmussaar, which was built in 1952. The island was inhabited once again in 2001. Currently there lives a family engaged in sheep- and cattle-breeding and an island warden is employed as well. Presently the whole island is situated on the territory of the Osmussaar Landscape Reserve that was instituted to protect the local geological heritage. During summers numerous people visit the island – for them a nature trail has been marked up and camping facilities have been established. However, Osmussaar has no regular boat connection to the Estonian mainland. The starting point for most boat trips to the island is Dirhami harbour on the adjacent mainland, but trips to the island have to be agreed beforehand with a local boatman.

4.5. WEST ESTONIAN SMALL ISLANDS

The majority of the Estonian small islands and islets are located in the Western Estonia Archipelago area, where the Väinameri sea between the major islands of Saaremaa, Hiiumaa, Vormsi and the mainland abounds with small islets. This is the area where Ordovician and Silurian carbonate rocks crop out. Therefore, when compared to the North Estonian islands, the Western Estonia Archipelago islands and islets have more uniform, slightly sloping landscapes, and the surrounding sea is usually shallower and with numerous shoals. Many islands here have a limestone bedrock core with thin cover of Quaternary sediments. The oldest beds in the Quaternary cover consist of grey-yellowish till with abundant angular clasts of carbonate rocks. These are commonly overlain by marine deposits. Erratic boulders are abundant on the West Estonian small islands – these have usually been washed out from glacial deposits in zones of intensive wave activity. Later on, these erratic boulders may have been relocated by packed ice.

The main landforms on these islands are coastal scarps and beach ridges with shallow depressions between them. Most widespread shore types are till, pebble and silty shores; cliff shores are few.

The carbonate bedrock, which lies close to the surface, have a direct influence on the development of soils and vegetation. The juniper bushes, often forming thickets, dominate the vegetation on most larger and higher islands. The other landscape type common on the islands is meadow. Among them, alvars and coastal meadows are the most distinctive, as their preservation requires constant human involvement. The grasslands here provide suitable habitats for many unique plant and animal species. The West Estonian small islands have always been characterised by extensive coastal meadows; but when cattle grazing ceases, they will be overgrown with reed. These areas are also habitats for many bird species. The natterjack toad (*Bufo calamita*), a threatened amphibian species in Estonia, may also be spotted on well-maintained coastal meadows. The deciduous and pine forests are most characteristic of the West Estonian small islands. In 1998, the West Estonian Archipelago Biosphere Reserve was instituted, which comprises the West Estonian islands and surrounding sea areas.

4.5.1 VORMSI

Vormsi (Swedish *Ormsö*), with an area of 93 km^2, is the largest among the inhabited small islands in Estonia. The generally flat landscape on Vormsi is dissected by a few beach ridges and by northwest-southeast oriented eskers, with the overgrown coastal lakes and paludified areas spreading between them. The western part of island is characterised by spruce forests, alvars and juniper thickets, while the eastern part is lower and wetter. More than half of the island is covered by forests, while coastal pastures with juniper shrubs spread on the remaining part. The meadows and arable land strips have formed here as a result of human activity. This abundance of different habitats creates good preconditions for a variety of plant and animal species.

The oldest parts of the island first emerged from the sea some 3000 years ago and by now the highest point of Vormsi is 13 metres above sea level. The bedrock core of Vormsi is represented by limestones of uppermost Ordovician age. The Huitberg bioherm hummock, located in the western part of island, is one of the oldest coral reefs in the Estonian geological succession. This oval bioherm body covers about


Austurgrunne
Kersli point
scenic views
Kjursgrunne
Suur-Tjuka
Väike-Tjuka
lighthouse
Kersleti
Saxby
Kakralaid
Rälby cape
scenic views
Borrby
Paslepa
Diby
Seasaar
Rälby
Norrby
Noarootsi cape
Huitberg
Fällarna
Förby
springs
VORMSI
Söderby
church
HULLO
Suuremõisa
Lake Prästvike
Einbi
Sääre point
Kadakalaid
Hosby
Uusmere islet
Bussby
Sviby
Harilaid
Rumpo
Obholmen
Mõisaholm
Hullo Bay
Sviby harbour
Rumpo cape
scenic views
Mõisanina
Hobulaid
HARI KURK STRAIT
Hellamaa
Telmen
Pullapää point
Uuemaa
Hellamaa
Nõmme
Värssu
Vohilaid
Eeriku
Rukkirahu
Hõralaid
HIIUMAA
Vahtrepa
Rohuküla harbour
ferry connections
Pusku
PÜHALEPA
Hilleste
Sepaküla
Heltermaa harbour
Tanska
Kuivarahu
Aruküla
Valjpe
VÄINAMERI SEA
Soonlepa
Sõmeri
Heinlaid
Sarve cape
Salinõmme
Liialaid
Tauksi
Oakse
Salinõmme moorage
Mustarahu
Saarnaki
Kaevatsi
Tagarahu
Esirahu
Langekare
Valgerahu
Valgerahu
Puise
Hanikatsi
Tondirahu
Vareslaid
Kumari
Puise moorage
Kõverlaid
Kõrgelaid
Sipelgarahu
Hanerahu
Ahelaid
0
2
4 km

Limestones of the Vormsi Stage are exposed next to Saxby lighthouse. Photo: T. Bauert

500 m^2, is up to 2.5 m high and consists of whitish-grey, fine-grained limestone of the Pirgu Stage. In places not covered with mosses, one can admire abundant casts of marine organisms that lived in a shallow Ordovician sea over 400 million years ago. In grooves within the bioherm, a protected wall-rue (*Asplenium ruta-muraria*) and maidenhair spleenwort (*Asplenium trichomanes*) have made their habitats.

An almost 2 km long shore section exposes the limestones of the Vormsi Stage of Late Ordovician age near the Saxby lighthouse on the western coast of Vormsi. This whitish-grey to bluish-grey, slightly argillaceous limestone contains abundant fossilized remains of organisms that inhabited the shallow tropical sea. Numerous erratic boulders have also been pushed to the shore here by sea ice and now stand on a narrow limestone plateau exposed along the waterline near the Saxby lighthouse. Comparing the

Red helleborine (*Cephalanthera rubra*) grows in the spruce forest at Fällarna. Photo: G. Bauert

View at the Hullo bay, Rumpo. Photo: T. Bauert

Kirikukivi lies at the shallow sea
off northeastern coast of Vormsi

present-day view with photos taken several decades ago, one can clearly see how part of the cliff has been eroded away by sea-waves and that waterline has approached the lighthouse. The material abraded away by storms accumulates mainly to the north of the lighthouse, forming new shingle ridges. An extensive area of up to 2.5 metres high ancient shingle beach ridges can be observed for almost a half kilometre towards the inland.

Various development stages of vegetation can be seen on these shingle ridges, but further inland mostly spruce forest grows on ancient beach ridges. Those areas where carbonate bedrock occurs close to the surface and where the soil horizon is rather thin are a favored habitat for various orchids.

Fossiliferous limestones of the Upper Ordovician Moe Formation (Pirgu Stage) are exposed in the southernmost part of the Saxby coast. These brownish limestones contain abundant remains of tubular calcareous algae, some millimetres in diameter. Still further southward, an about 300 metres long outcrop of the fossiliferous Adila Formation carbonates (Pirgu Stage) can be seen on the southwestern shore of Mõisaholm. The only known outcrop of the Upper Ordovician Nabala Stage is located north of Kärrslätti village on the Kerslinina shore, where very fine-grained limestones of the Saunja Formation are exposed during low sea level stands.

The largest erratic boulders on Vormsi are: Smen or Sepakivi, Kirikukivi, Skärestain, Vargstain or Hundikivi, and Parunikivi. All these have been taken under nature protection.

One of the best-known nature objects on Vormsi island is the Suurallikas spring on the northwestern shore of the reed-overgrown Lake Prästvike, west of Hullo village. Its discharge may amount to some 10

The Suurallikas spring forms a shallow lakelet

liters per second in summers, forming a shallow outflow lakelet. Several smaller springs are also situated on the northern shore of Lake Prästvike. Among them, the Lubjakünka or Raviallikas spring is the most distinctive, as it flows out from a lime hummock about 0.5 m high. The name of this (Lime Hill spring or Healing spring) refers to the high lime and iron content of its water.

Tourists visiting Vormsi island can enjoy the most outstanding landscape scenery on Rumpo cape, which stretches far out to sea at the island's southern shore. To get acquainted with this area, they can use the roughly 3 km long hiking trail along the Hullo esker that leads from Rumpo village to the southern tip of the cape. Dense juniper thickets and a few pine groves growing here give the landscape of this narrow cape a memorable aspect. This area with thin soil layer is called an alvar. At the southernmost tip of the cape, lichen communities that are rare for Estonia, but similar to those of the Arctic tundra, grow.

Numerous tiny islands and islets enliven the view to the Hullo bay that borders the Rumpo cape from the west. The islets in this shallow bay form an important nesting ground for mute swan (*Cygnus olor*), greylag goose (*Anser anser*), common eider (*Somateria mollissima*), ducks, sea gulls and terns. White-tailed eagle (*Haliaeetus albicilla*) can often be seen gliding above the islets. The Hullo bay also serves as a major resting place for waterfowl on their Atlantic-Arctic migration route.

The highly rugged northern and northeastern coastline of Vormsi offers lots of sightseeing sites too – the long and narrow Åusturgrunne spit reaching far into the sea is one of them. In late spring, numerous orchids blossom on the diverse landscapes of the Diby cape.

Vormsi is a historical settlement area of Swedes who most likely migrated to the island during the 13th – 14th century. However, Vormsi might have already been sparsely populated before that. The main historical monuments on the island are the Vormsi church built in the 14th century and over 300 wheel-shaped stone grave crosses on the graveyard next to the church.

Before World War II more than 2500 people lived on Vormsi – the men were mostly sailors and fishermen, while women were engaged in farming. The apples, potatoes and dry-cured mutton produced in Vormsi were also valued abroad. The 700-year settlement by the Swedes ceased in 1943 – 1944 when in the fear of the Russian troops, the islanders fled mostly to Sweden.

During the Soviet occupation, Vormsi island was a restricted frontier zone that could be only visited by people from mainland Estonia with special permits. In these years the local residents were engaged mainly in grain and potato growing, as well as cattle, sheep and pig breeding and forest management. Bread and butter made on Vormsi were famous and highly prized also on the mainland. Presently some 300 inhabitants live on the island – the main fields of activity are tourism, agriculture and forestry, with fishing being mainly just for personal needs.

Following long experience, traditional wooden boats are built in Vormsi even today, reed roofs are made to cover housings and a traditional musical instrument *talharpa* (a four-stringed bowed lyre as known in northern Europe) is played.

Vormsi church (p. 74 top) and its interior (p. 74 bottom); wheel-shaped stone grave crosses at the graveyard (p. 75 top); a graceful statue of St. Olaf above the main church entrance (p.75 bottom). Photos: T. Bauert

Since 1989, Vormsi and the surrounding sea belongs to the West Estonia Archipelago Biosphere Reserve. In 2000, the Vormsi Landscape Reserve was founded to protect the distinctive natural landscapes, cultural landscape heritage as well as habitats and natural sites of endangered species. In 2007, the valued coastal habitats were incorporated into the Natura 2000 Väinameri habitat as important bird area.

There is a year-round regular ferry connection between Sviby harbour on Vormsi and the Rohuküla one on mainland, allowing visits to the island by cars and busses.

Several tiny islands and islets surround the island of Vormsi, most of which are concentrated in the Hullo bay on the southern coast of Vormsi. Near its northern coast, however, are located the tiny islands of Suur-Tjuka (0.4 km^2) and Väike-Tjuka (0.1 km^2) – the latter has almost joined up with the cape in northeast Vormsi.

East of the Sviby-Rohuküla fairway lies the elongated scenic islet of Hobulaid (0.7 km^2) together with the small Hülgerahu shoals. Hobulaid (Swedish *Hästholm* or "horse islet") used to be inhabited, but presently just a few people live there during the summers. It is situated on an esker and is covered by thick deciduous forest and juniper thickets. It is believed that the Hobulaid islet was named this way because horses of the Haapsalu Bishop Castle were pastured on this islet in medieval time.

Geese are taking a feeding rest at a shallow Hullo bay on their way back to the south

4.6 SMALL ISLANDS IN VÄINAMERI

4.6.1 Small islands near the eastern coast of Hiiumaa

There are altogether more than 200 small islands and islets in the coastal sea around Hiiumaa island. Such a large number was inherited from the strongly dissected seafloor topography in the region that mainly developed during the last ice ages, when continental glaciers reshaped the bedrock and relocated terrigenous deposits. As a result, the northwest-southeast oriented landscape elements, corresponding to the glacier movement direction, developed in this area. The small islands and islets here are often connected to each other by underwater shoals.

Many local tiny islets barely emerge above the sea, and sea waves of severe storms may thus run over their surface. Some islets abound with erratic boulders – particularly large numbers of them have piled up on about half a kilometre long Selgrahu (1.6 ha; 0.6 m above sea level) and on tiny Pujurderahu (1.2 ha; 0.7 m asl).

Most small islands and islets offshore from eastern Hiiumaa are situated on an outcrop area of limestones of the Upper Ordovician Vormsi, Pirgu and Porkuni stages. The limestone cores of the larger islets, e.g. Vohilaid (3.9 km^2; 10.2 m asl) and Kadakalaid (18.7 ha; 9.3 m asl) may rise several metres above sea level, but they actually crop out only on a few islands. Among these, most noteworthy is the outcrop of Vormsi Stage limestones on the Kadakalaid islet in the Hari kurk strait close to Hiiumaa. The carbonate bedrock is commonly covered by a thin layer of Quaternary sediments. This Quaternary cover is represented by till of the last glaciation as well as by younger marine and beach deposits. Low beach ridges consisting of limestone shingle are observed on several small islands, e.g. on Eerikulaid islet (3.9 ha; 0.9 m asl). In addition, coastal scarps abraded from ancient sedimentary deposits occur on the islands. The largest of coastal scarps is the up to 3.5 metres high Kõrgekallas in the eastern part of Vohilaid islet, but up to two metres high scarps occur also in the eastern part of Kadakalaid and in the northern part of Harilaid.

The sea around eastern Hiiumaa is quite shallow and large waves vanish far away, before reaching the shore. Therefore, the shores of most small islands are covered with seashore meadows often overgrown with reed. However, in zones of high wave activity, mostly pebble shores are formed. Juniper thickets and meadows spread on the higher central parts of islets, whereas on Kadakalaid, Vohilaid, Hõralaid (20.3 ha; 3.6 m asl) and Heinlaid (162,2 ha; ca 2 m asl) some coppices also occur. Harilaid and Vohilaid are the most often visited among the small islands and islets off eastern Hiiumaa.

4.6.1.1 Harilaid

Harilaid (14.6 ha; 5,4 m asl) is a small island of elongated shape situated in the Hari kurk strait between Hiiumaa and Vormsi islands. The island has developed on a steep-sloped underwater ridge. At earlier times, two separate islands existed here and even today during periods of high sea level stand, the island may be split into two parts. The northern part is older and higher, reaching more than 5 m above sea level. This is Kõrg-Hari (*High-Hari*), a northeast-southwest oriented till ridge, descending stepwise towards the northern as well as towards the southern shores. The Madal-Hari (*Low-Hari*) forms the island's southern part where the maximum ground elevation is only 2.8 metres near the lighthouse. Meadows and juniper thickets dominate the vegetation.

Historical records show that Harilaid was inhabited by 1840. The first light beacon was built on the island in 1849 and the present reinforced concrete lighthouse in 1940. The people living on the island were the innkeeper-lighthouse keeper and his family. One of the major ice-roads from Hiiumaa to Vormsi passed across Harilaid, and the latter was therefore an important resting place for travellers. In summers, when strong northwesterly winds did not allow sailing to the Baltic Sea from the narrow Hari kurk strait, sailing ships took shelter here. In such cases the local vodka and beer sold well. When steamboats started to operate between St. Petersburg and Riga, they also stopped at Harilaid – to take aboard new passengers or to let off others to continue their travel to Haapsalu on the mainland.

All local residents were forced to leave the island in 1939. A military radar station was built on Harilaid by the Soviet border guard in the early 1950s – this allegedly enabled monitoring of ship traffic as far as the coast of Sweden. Also, a peculiar pier using old shipwrecks was built here – at present this is largely tumbledown. The Soviet military unit left the island in 1992.

4.6.1.2 Vohilaid

Vohilaid (3.9 km^2; 10.2 m asl) is the oldest and largest among the islands near the eastern coast of Hiiumaa. It began to emerge from the sea some 3500 years ago and nowadays reaches over 10 metres above sea level. Vohilaid formed as a result of merging several smaller land patches as can be clearly seen on a map drawn in 1878. The landscape of this island is diverse: a limestone alvar with juniper thickets dominates in the eastern part, while the western part is low and sandy. The shores of Vohilaid are often overgrown with reed.

People already used to live on Vohilaid in times when the present-day island consisted of isolated smaller islets. From church registers it is possible to see that the island was inhabited in the 18th century. The historical records also mention that owing to the famine in 1740, the tenant of the Suuremõisa manor had a part of Vohilaid ploughed and grain cultivated there. Before World War II, there were four farmsteads on Vohilaid and its northern part belonged to the Estonian Native Horse Society. In the Soviet period, the island was used mainly for pasturing young animals and sheep. The inhabitants left Vohilaid in 1956. One can get to the island not only by sea, but it is also possible to wade there through a narrow, shallow sound between Vohilaid and Hiiumaa.

4.6.2 Small islands near the southeastern coast of Hiiumaa

The Palivere marginal glacier formation belt submerging into the Väinameri sea from the Puise spit on the northwestern coast of Matsalu bay is responsible for a chain of islets extending in a bow-shaped manner across Väinameri to Salinõmme cape on southeastern Hiiumaa island.

The Kumari islets – a group of islets that together with Sipelgarahu and Tondirahu shoals belong to the Matsalu National Park, form the eastern part of this islet chain. The western parts of the islet chain are, however, known as the Hiiumaa islets and they belong to the Hiiumaa Islets Landscape Reserve.

Among these, **Saarnaki** (136 ha; 9 m asl) and **Hanikatsi** (85 ha; 7 m asl) are the biggest and highest – they emerged from the sea some 2000 years ago. These oblonged islets are characterised by the presence of beach ridges and shallow depressions between them. Several shore types can be seen on Hiiumaa islets: pebble, till and silty beaches. Mead-

ows have formed in older and higher areas, but some coppices are found as well. A distinctive, natural broad-leaved forest occurs on Hanikatsi with oak, lime and maple trees growing here. The Saarnaki islet is characterised mainly by juniper thickets and coastal meadows. A noteworthy landscape element on Saarnaki is an up to 5 m high coastal scarp with old lime trees growing on top.

The islets in Väinameri with their surrounding sea serve as a resting place for almost 200 migrating bird species, and as a nesting ground for about 110 species. The most numerous sea birds nesting here are common eider (*Somateria mollissima*), herring gull (*Larus argentatus*) and great black-backed gull (*Larus marinus*); among waders, the most common are oystercatcher (*Haematopus ostralegus*), common redshank (*Tringa totanus*) and ringed plover (*Charadrius hiaticula*). The most common transmigratory birds are barnacle goose (*Branta leucopsis*), common goldeneye (*Bucephala clangula*), swans, scoters and several waders. Ringed seals can be seen swimming and resting on boulders near Ahelaid and Kõverlaid islets, while grey seals are less common.

The largest islets of southeastern Hiiumaa have been inhabited for several centuries (first records about Saarnaki date back to 1564 and about Hanikatsi to 1623). In the past centuries, ice roads were used in winters to travel along this islet chain from Hiiumaa to Muhu and farther to mainland – inns were set up for travellers on these islets.

Since 1973 there has been no permanent settlement on the islets. For visitors however, 1.5 km of nature trail have been marked up on Saarnaki, introducing the highlights of this islet. Because these islets belong to the Hiiumaa Islets Landscape Reserve, visits to the islets must be approved in advance with officials at the local environmental board.

4.6.3 Small islands within the territory of the Matsalu National Park

More than 40 small islands and islets are situated within the territory of the Matsalu National Park. Most of them are rich in birds, including mute swans, mergansers, scoters, cormorants, several sea gulls and ducks. In addition, several common coastal birds live and nest here. In the best hatching areas, even more than a thousand couples may be counted in one hectare. These islands are a part of the Matsalu wetlands, one of the most important bird areas in western Europe.

Most islands within the territory of the Matsalu National Park are located in the park's northwestern corner – north of the Puise spit. Among these, the largest is **Tauksi** island (2.5 km^2; ca 3 m asl), which was first mentioned in historical records in 1526. There have been a few farmsteads on this island and until late 19th century there was also a tavern.

Formerly there were mostly hayfields on Tauksi, but presently the island has developed into forest. Alder groves grow on former hayfields in its lower eastern part, while the beach ridges in western part are covered with pine forest. Juniper thickets also occur. Northwest of Tauksi are situated Sõmeri islet – a bedrock elevation covered with junipers and Liialaid islet, with a pine grove. Both islets have been used formerly as hayfields and pastures. The other tiny islets in this area are mostly grass-covered, however now the coastal meadows here are overgrown with reed. These islets form a heaven for seabirds.

The **Kumari** islets is a group of islets in the central part of Väinameri. The oldest and largest of them is Kumari islet (14.8 ha; 6.8 m asl), where at the beginning of the last century a tavern was opened, as the ice-road from Muhumaa to Haapsalu town on mainland

passed by. By now, Kumari islet is mainly overgrown with juniper thickets, but pines and birches still exist in its southern lower and wetter area. A small lime tree grove growing on this island is remarkable too. In the last few years some maintenance work has been carried out on Kumari islet – juniper thickets have been trimmed and habitats for the natterjack toad (*Bufo calamita*) have been cleaned.

The vegetation of the formerly picturesque Tondirahu islet (just north of Kumari islet) where groves of rowan trees and junipers used to grow, has been completely devastated by the waste of cormorants (*Phalacrocorax carbo*) since they established here a colony in 1980s.

Two small bedrock islets – Papirahu and Papilaid - occur in southern Väinameri sea, close to the south-western border of the Matsalu National Park. Papirahu is a low-lying bird island where vegetation is still in its initial development stage. Papilaid however rises almost 6 metres above sea level – it has a rugged shoreline and is covered by meadows. A low escarpment exposing argillaceous sedimentary rocks with pyrite concretions of the Jaani Stage can be seen in the western part of the islet.

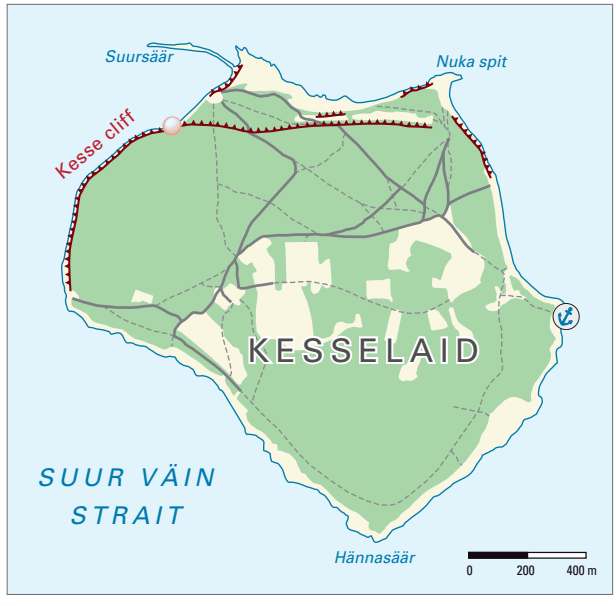
Most small islands and islets belonging to the Matsalu National Park are closed for visitors to avoid disturbing the birds. Those wishing to reach these islands and islets should request a permit from a local environmental board office.

4.7 Small islands in the environs of Muhumaa

4.7.1 Kesselaid

Kesselaid or Kessulaid (German *Schildau*; Swedish *Sköld*, *Skölldo*) is the oldest and largest (1.7 km^2; 15.6 m asl) island in Väinameri sea. It is situated between Muhumaa and the mainland, about in the middle of the Suur väin strait. Close to this islet is also located the deepest point of Väinameri sea – 22 metres. The first parts of Kesselaid islet emerged from the sea in the late Litorina Sea stage about 5000 years ago.

An approximately 3 kilometres long and up to 8.5 metres high coastal cliff in the form of several descending steps borders the island's northwest coast. The Kesse cliff is part of the West Estonian klint




Kesse cliff. Photo: I. Tuuling

(otherwise known as the Silurian klint) and exposes Lower Silurian sedimentary rocks that formed some 450 million years ago, from the calcareous shells of organisms that inhabited the tropical sea of that time. The platy dolostones of the Jaagarahu Stage, with abundant large, dark-brown pyrite concretions, can be observed in the northern part of the Kesse cliff wall. These dolostones are underlain by highly argillaceous dolomitic marls of the Paramaja Formation (Jaani Stage). The topmost 5 metres of the cliff consist of hard biohermal dolostone.

The scenic Kesse cliff and some 60 hectares of the surrounding area were already taken under protection in 1938. It was forbidden by law to excavate limestone in the cliff area, to erect buildings here, as well as to change the local landscape in any way. To further protect the entire island, the Kesselaid Landscape Reserve was founded in 2004.

The vegetation on Kesselaid island is variable. Various orchids have been found growing here – altogether 17 species. Owing to insufficient human activity, the former fields, hayfields and pastures are vanishing in the landscape. The major area of juniper thickets can be seen in the northern part of the islet. A specific forest type, uncommon elsewhere in West Estonian islands is the spruce forest (so-called Panga forest) growing on alvar in the western end of island. Broad-leaved trees with ash and lime can be seen in the island's southern part; the circumference of large lime trees may reach 4 metres here.

The islet is mentioned for the first time in historic records in the late 17th century. In the mid-19th century more than 40 people lived on Kesselaid and at the beginning of the same century a large dairy farm was established here. In the early 20th century, there were plans to establish a limestone quarry and a hard-labor prison on the island, but luckily this plan was not executed. Before World War II, there was a small village with six farmsteads in the eastern part of Kesselaid. Most people had left the island by 1963 and only the lighthouse keeper´s family remained to live there. Presently two people permanently live in this lighthouse keeper's house.

The island has been an important reference point for sailors throughout several centuries. The first seamark was erected on Kesselaid in 1879, and light beacons in 1885. Since 1994 the beacons have been automatized and operate using solar energy. In mild winters when the sea does not freeze completely, the islanders may find themselves in isolation from the mainland for quite a while.

Kesselaid island is of great interest for nature tourists and a hiking trail has been marked out here. The island can be reached by boat from Virtsu harbour on the mainland as well as from the small Lalli harbour on Muhu. The landing site is located on the island's eastern shore.

4.7.2 Kõinastu

Kõinastu islet (area – 2.6 km^2; ca 7 m asl) is located near the northwestern coast of Muhu island and rises up to 7 metres above sea level. The islet can be reached by sea from Koguva on Muhu or from Orissaare on Saaremaa. However, it can be reached also by wading through shallow waters from Sääreotsa spit near Koguva village on Muhu island. The almost 3 kilometres long path follows a row of sandbanks – these are usually covered by coastal meadows separated by water strips. The carbonate bedrock of Kõinastu islet is made of Silurian Jaani Stage limestones.

These carbonate rocks are exposed as a roughly 20 metres long escarpment, known as Esimene pank

(*First cliff*) or Suur pank (*Large cliff*) in the northern part of Kõinastu. The western coast of Kõinastu islet displays high shingle ridges in which an up to 4 metres scarp has been abraded by the sea – this shore section is known as Vesiru.

The dominant landforms on the islet are till plains. Agricultural plots were formerly located on these plains, but presently the plains are used mainly as hayfields and pastures. Even so, part of them is already being overgrown by juniper thickets.

Broad-leaved forest grows in the eastern part of Kõinastu, while partly reed-covered coastal meadows spread in the southeast of the islet. Juniper thickets and pine groves are common on old beach ridges. In these different habitats, 369 plant species have been recorded altogether on the islet – among these, 16 are protected species. The eastern coast of Kõinastu together with its surrounding shallow waters is a well-known resting place for geese and waders on their East Atlantic-Arctic migration route. The Väike väin (*Väike strait*) protected area helps to preserve these local nature values.

Kõinastu islet has been historically tightly connected with Saaremaa. It is known that the Kõinastu islet (*Drotzenholm*) belonged to the Maasilinn settlement in medieval times. The number of inhabitants on the islet was highest in the mid-19th century – 73. The village on islet was destroyed during World War II, but new houses were built up and life continued. As a result of people being forced to join collective agricultural farms, the permanent settlement vanished and the last residents left the islet in 1965. The former landowners and their successors have built summer cottages on Kõinastu in recent decades, but some permanent residents engaged in cattle breeding also live there.

4.7.3 Viirelaid

Viirelaid (area – 0.8 km^2; ca 4.5 asl) is a flat islet near the southeastern coast of Muhu where just a few trees grow. Formerly, Viirelaid was used mainly as a hayfield region for people from the adjacent Muhu island. This islet has been an important landmark for sailors for centuries. The local lighthouse directs those approaching from the south to the Suur väin (*Suur strait*) between Muhu and the mainland. Until the beginning of the 19th century, the shortest fairway between Riga and Tallinn passed here. In these times, Viirelaid islet was known under the name *Paternoster*. The only 11 metres high lighthouse is the oldest one in Estonia and was built from iron plates (completed by 1881).

4.7.4 Suurlaid

Suurlaid (area – 1.9 km^2; 2.1 m asl) is located near the southern coast of Muhu island and has presently almost joined up with Ahenda cape on Muhu. This low and flat islet is mostly covered by till on carbonate bedrock. Formerly the islet was used mainly for hayfields, but in present times the meadows and wooded meadows have grown over with forest. Small islets around Suurlaid are nesting grounds for many seabirds. During the spring and autumn migration periods, large flocks of birds take short rests here. In the 19th century, Suurlaid belonged to Suuremõisa manor on Muhu and the manor's salt storage was located here. During the Soviet period the island was mostly used as pasture for young cattle.

4.8 Small islands west of Saaremaa

4.8.1 Vilsandi

Vilsandi island (area – 8.8 km^2; ca 7 m asl) is situated near the western coast of Saaremaa and was formed

by was formed by joining the western Suur-Vilsandi and the eastern Väike-Vilsandi islets during the past century. The low land strip between those islets is called Vahemeri. This name, meaning "the sea in between", derives from the fact that even 120 years ago only a boat connection was possible between the two islets.

The island has emerged from the sea during the last 3000 years. Carbonate bedrock has played an important role in the formation of its contemporary topography. Porous biohermal dolostones of the Silurian Jaagarahu Stage are exposed along the western and northern coasts of Suur-Vilsandi, on the northeastern coast of Väike-Vilsandi as well as on the Vaika islands.

The rough surface of the exposed sedimentary rocks (formed some 400 million years ago) is because of karstification, which has led to the formation of fre-

Rocky shore at western Vilsandi

quent small-scale (depth 2 – 5 cm), rounded hollows and furrow-like grooves up to half a metre in depth on the bedrock surface. The local landscape with karst phenomena is unique compared to other islands in Estonia.

The bedrock core of the southern part of Vilsandi is covered by thin Quaternary sediments. Here the east-west oriented ridge is the most prominent landform element, where, owing to the marine climate and the thin alvar soils, a distinctive vegetation pattern has formed. Most rare plants growing here belong to calci- or halophilous communities, including Danish scurvy-grass (*Cochlearia danica*), sea wormwood (*Artemisia maritima*), green-winged orchid (*Orchis morio*), beach pea (*Lathyrus japonicus*) etc.

Alvars with a thin Quaternary cover spread in the northern and western parts of Vilsandi. Here, the vegetation is dominated by juniper thickets, while pine forest grows in the central part of Suur-Vilsandi. Fields of arable land were concentrated in the southern part of island, but agricultural activity here has almost ceased after World War II. Therefore former meadows have been partly overgrown with junipers, and local coastal meadows with reed. The land cover maps compiled at different times provide clear evidence for the changes in vegetation patterns – major tendencies observed are the decrease of arable land and the development of shrubs on former natural grasslands.

Vilsandi island was inhabited in the early 18th century. At least 30 households with almost 200 people

Beach pea (*Lathyrus japonicus*). Photo: G. Bauert

Excerpt from the map *Nova Descriptio Insulae Oseliae*, 1770 showing environs of northwestern Saaremaa

lived on the island at the beginning of the 20th century. For children there was also a school. Most local men found work on ships – many of them became captains who sailed on the oceans of the world. The people of Vilsandi were also famous as skilled boat and ship builders. After World War II, life on the island changed beyond recognition – most people had fled the island by the end of the war. The few residents who still lived on Vilsandi were forced to establish a small collective fishery farm in 1949. There-

fore, during the following decades, Vilsandi mostly became a place for Soviet frontier guards.

Vilsandi lighthouse (built in 1806) is the oldest lighthouse in Saare County. In the mid-19th century, a maritime rescue station was founded here to rescue people from shipwrecks. This station operated until World War II.

Nowadays, Vilsandi is inhabited mostly by summer residents, but in winter a few people live there, including the island's ranger. Through long-term settlement on the island, the distinctive landscape heritage has come into being, characterised by long dry-wall fences and windmills. Those interested in learning about local nature can hike along two nature trails. Those interested in the island's history can get acquainted with the earlier years of nature protection on Vilsandi through a permanent exhibition in the Mändre farmhouse.

Vilsandi is surrounded by more than a hundred small islets and dry land spots, which all belong to the Vilsandi National Park. These tiny land areas differ by age, geological-geomorphological settings as well as by vegetation types. The best known among these islets are the rocky Vaika islands – a heaven for sea birds. The largest among the small islands are Loonalaid (1.1 km^2; ca 5 m asl) southeast of Vilsandi, and Vesiloo (14 ha; ca 3 m asl) with characteristic shingle ridges. The vegetation of these local small islands is diverse, but first and foremost the small islands of Vilsandi National Park are famous for various bird faunas. Altogether 247 bird species have been recorded, among them 114 are nesting species.

It has been estimated that about 7000–8000 seabird couples breed in the colonies on the islands of the Vilsandi National Park – particularly numerous are sea gulls and terns, but also common eider (*Somateria mollissima*), greylag goose (*Anser anser*), goosander (*Mergus merganser*), red-breasted merganser (*Mergus serrator*), and tufted duck (*Aythya fuligula*). In the spring and autumn migration periods, hundreds of thousands of birds migrate across Vilsandi National Park and stop here for rest and feeding. Some species, returning from the Arctic hatching grounds in the autumn, may stay here for over-wintering, feeding in adjacent ice-free waters. Numerous grey seals live in the surrounding seas, giving birth to their pups on local small islets – these are the largest breeding grounds for grey seal in the Baltic Sea.

Vilsandi National Park is the oldest nature reserve in the Baltic States. Artur Toom – the keeper of Vilsandi lighthouse, began to protect birds on six rocky islands already in 1906. The first nature reserve was founded here in Estonia in 1910, which has now developed into the Vilsandi National Park (instituted in 1993). This national park has been included in the list of Ramsar areas – a list of wetlands with international importance. Visitors can reach Vilsandi by boat from Papisaare harbour near Kihelkonna village on Saaremaa. Another way of getting there is by wading several kilometres through the shallow sea, starting from the tip of the Kuusnõmme cape.

4.9 Small islands in the Gulf of Riga

Most small islands in the Gulf of Riga are located near the southern coast of Saaremaa island and next to the southwestern coast of the mainland. As an exception, Ruhnu island is located in almost the centre of the Gulf. The islands offshore the southern coast of Saaremaa have a core of Silurian age carbonate rocks, while Ruhnu as well as Kihnu and Manilaid islands together with their adjacent islets have formed on a core of Devonian sandstones.

4.9.1 Abruka

Abruka island (area – 8.8 km^2) with the adjacent Vahase and Kasselaid islets lies offshore the southern coast of Saaremaa. This island emerges from the sea as a till hillock rising as high as 9 metres above sea level. Characteristic to the island are not only coastal meadows and juniper thickets, but the forests are spread over more than a half of its territory.

A distinctive broad-leaved forest type grows on the island where lime, together with maple, elm and ash dominate, but birch, aspen, spruce and oak also rarely occur. Hazel dominates in the undergrowth. The forest ground vegetation is characterised by a lush and species-rich cover of grass. In 1937, on the proposal of Teodor Lippmaa, a renowned botanist of the University of Tartu, the unique species-rich forest of Abruka was taken under environmental protection.

The coastal meadows of Abruka are nesting grounds for many bird species, including ruddy turnstone (*Arenaria interpres*), pied avocet (*Recurvirostra avosetta*) and Baltic dunlin (*Calidris alpina schinzii*). The island was used as hayfields and pasture in the Middle Ages – horses were transported to the island with large boats during this period, and some shelters for herdsmen were built on the island.

Abruka has only been permanently inhabited since the 18th century. In the 1920s, 150 people lived on the island, but since then their number has constantly decreased. A school was also operating there during the years 1883–1972. In recent decades Abruka has become a popular place for summer residents, but about ten permanent residents (including the island ranger) still live on the island all year round.

Today Abruka's silhouette is enlivened by a 36 m high reinforced concrete lighthouse, the predecessor of which was a wooden lighthouse built in 1897.

The latter was established to safeguard the steamboat traffic between Riga and St. Petersburg that started in 1845. Another tourist attraction on the island is the Abruka windmill, restored in 2001. A small exhibition in the House of Abruka at the harbour introduces visitors to the history of the island. Visitors can reach Abruka by postal boat from Roomassaare harbour on Saaremaa and they are all warmly welcomed at tour-

Broad-leaved forest and a windmill on Abruka.
Photos: K. Kikkas

ist farms around the island. People wishing to stay in touch with the rest of the world can use Wifi internet at the tourist information office located in the harbour. There is also a marked nature trail that leads to the most interesting nature sites.

West of Abruka lies the small Vahase island, with two giant erratic boulders as the main geotourism highlight. The larger boulder is 5.1 metres high. Vahase together with Abruka is located within the territory of the Abruka protected area.

4.9.2 Kihnu

Kihnu (area – 16.6 km^2) is the largest island in the Gulf of Riga. The sea around Kihnu is shallow, with numerous erratics resting on the sea bottom. The island is surrounded by numerous small islets (*suardu* in Kihnu dialect) and underwater shoals (*lied* in local dialect). The shoreline is very rugged with numerous tiny islets and shoals offshore the western and northern coasts of the island. The largest islets are Sangelaid (0.05 km^2) and Umalalaid (0.023 km^2), consisting mostly of gravel and sand.

The landscape of Kihnu island is relatively low and flat, reaching up to 8.5 m above sea level. The low ridge passing along the island and the sand plain west of it, are covered by a dry pine forest, which actually more resembles a well maintained park than a forest. Large parts of this forest have been planted during previous generations for stabilizing drifting sands.

The meadows and wooded meadows, both diverse in species, are the most common landscape types in Kihnu. Major coastal meadows (160 hectares) occur at Linaküla-Sääre in the northwestern part of Kihnu, at Tapurand near Lemsi village and at Rootsiküla is the Ristinä coastal meadow. These species-rich coastal meadows are elements of cultural heritage landscapes

and thus deserve to be protected. Coastal grasslands of Kihnu are often used as pastures. Juniper shrubs are common here, particularly in southern Kihnu and on the northwestern coast, near Linaküla village.

Sea-holly (*Eryngium maritimum*) and ray's knotgrass (*Polygonum oxyspermum*) that are unique in Estonia grow on sandy beach ridges, while early marsh orchid (*Dactylorhiza incarnata*), spiny plumeless thistle (*Carduus acanthoides*) and angelica (*Angelica palustris*) grow on the Sääre coastal meadow.

In ancient written records, Kihnu was first mentioned under the name of *Kyne* in 1386, but the first notes about human settlement on the island date back to 1518. In addition to traditional fishing, inhabitants of Kihnu were known also as seal hunters – both striped and grey seals were hunted. The area of tiny islets northwest of Kihnu is an important breeding ground of grey and striped seals. The striped seals in particular tend to come here to give birth to their pups on hummocky ice in winter, and to shed hair in spring. The environs of Sangelaid islet is the most favorable area for striped seals gathering here in April and May – the highest number of them in the whole Baltic Sea has been counted here.

Through time, the men of Kihnu have worked not only as sailors on ships, but they also built sailing ships on the island. Today, the main activities are fishing and farming for personal needs, but one of the most important sources for income is tourism.

During the recent centuries, the men of Kihnu have spent most of their time at sea and have thus left other activities on the island for women. The women of Kihnu have thus become the protectors and carriers of cultural heritage – including local handicraft, folk dances and folk music. Inhabitants of Kihnu have preserved their local dialect, which differs noticeably from that of mainland Estonian. Even today, the distinctive striped skirt of the folk costume (called *kört*) is a common everyday clothing on the island. A woman dressed in striped skirts and driving a motorbike or even a tractor is thus a quite common sight here. Handicraft and many community traditions are honored in Kihnu to this day. To preserve the distinctive culture of Kihnu, this local cultural space has been included in the UNESCO List of the Intangible Cultural Heritage of Humanity.

Today Kihnu is a peculiar fusion of present and past – people here use the wisdom, traditions, and tools passed down through several generations in combination with modern technology. Its strong community spirit with firm ties to ancestral traditions as well as its geographical isolation as a small island are the reasons that Kihnu island has preserved its unique identity. Altogether, about 600 people live on the island today.

The Kihnu museum was instituted in 1974, enabling visitors to obtain a glimpse of the island's history; the life of a famous local captain Kihnu Jõnn, and to

The coast at Linaküla, western Kihnu. Photo: T. Bauert

The southern coast of Kihnu. Photo: T. Bauert

admire the paintings by local artist Jaan Oad. Kihnu church (built in 1784) is one of the few orthodox churches in Estonia; it as adapted for this religion from a formerly Lutheran sacred building. Almost all residents of Kihnu changed their faith and became orthodox in the years 1846–1847. Therefore by the order of Russian Tsar Nikolai I the church was handed over to the orthodox congregation and the church tower got an onion-shaped dome. This church exhibits a simple but beautiful iconostasis. The 28 metres high lighthouse on Pitkänä cape in the southernmost part of the island is one of the few cast-iron lighthouses preserved on Estonian shores. It was put together from components made in England in 1864.

In order to learn about the local traditions of Kihnu, it is better for travellers to plan their visits to the island to coincide with major folk or church holidays, e.g. Christmas, Midsummer Day or St Catherine's Day (*kadripäev*). Kihnu is a perfect place for those loving walking, fishing, cycling or just meeting the friendly local people.

There is a regular ferry connection between Kihnu and the mainland from Munalaid harbour as well as from Pärnu. Additional options are using a plane connection from Pärnu, but the most unforgettable is certainly driving over to the island by ice road in cold winters. There are several camping sites as well as tourist accommodation in local farms available on the island.

4.9.3 Manilaid

The small Manilaid (also known as Manija) island (length ca 4.5 kilometres, width < 1 kilometre) is situated in the mouth of Pärnu bay, separated from the mainland by a narrow, less than a kilometre wide strait. The most clearly observable landscape element on the island is the ridge (rising up to 5 metres above sea level) that runs along the island's long axis. It is composed of gravel and sand, with numerous scattered erratic boulders sitting on top of it. Here one can see Kokkõkivi (height 3.4 m, circumference 15.1 m) – the largest erratic boulder in Pärnu County.

The landscapes of Manilaid have been considerably reshaped by man. By now most of the island is occupied by coastal meadows – a hatching site for several bird species, and where it is also possible to spot the protected natterjack toad (*Bufo calamita*).

In former times, Manilaid was used mainly as hayfields. But in the mid-1930s, the island's land area was split into small fishermen farmsteads, where 79 people settled down from the heavily overpopulated Kihnu island. The women were engaged mainly in farm work, tillage and cattle breeding on Manilaid, while men were mainly sailors. Because of the numerous livestock on the island, there was a shortage of hay for feeding the cattle in winters. Therefore, additional hay had to be made on the mainland and brought over by boats. Presently 47 people live on

The southeastern coast of Manilaid

Manija. The island can be reached both by boat or ferry from the nearby Munalaid harbour.

4.9.4 Ruhnu

Ruhnu (area – 11.4 km^2) in the central part of Gulf of Riga is the oldest small island in the Estonian coastal sea. It lies on the top of a bedrock ridge shaped by the continental ice sheet. The bedrock of the island is composed of sandstones of Devonian age, while loose sands dominate in the Quaternary cover. The highest part of the primeval Ruhnu island rose above sea level more than 10 000 years ago.

The present topography of Ruhnu has been formed jointly by coastal processes and by wind action. The island can be divided into a low and flat western part, and a higher eastern part with dunes. The highest point of the island is the Haubjerre hill (reaching ca 30 metres above sea level), which is situated in the island's eastern part. This dune landscape, including well-developed foredunes, is the most distinctive nature highlight on the island. There are places where the dune field rises steeply up to some 10 m above sea level in close proximity to the present shoreline. Sandy beaches are the dominating shore type here, including the rare phenomenon of "singing sands" on Limo shore.

There are no natural watercourses on the island as the brook that previously ran in the middle part of the island has dried up. A peaty hollow surrounded by beach ridges and dunes is located in the eastern part of Ruhnu. Here is located the island's largest mire – Haubjerre, which is a former sea bay. The deepest borehole in Estonia (787.4 metres) has also been drilled on Ruhnu. The water flowing out from the borehole is well mineralized and thus has some curative properties. Almost half of Ruhnu is covered by forests, mostly by dry pine forests. Coppices of

common alder spread mainly in areas of former fields in the low and flat western part of island.

The first data about people living on Ruhnu date back to 1341. The community of coast-dwelling Swedes has been living here for more than six centuries. The number of inhabitants was the greatest in the middle of the 19th century, when it reached almost 400. Since then, the population of Ruhnu has continuously decreased. Most of the people fled to Sweden in the face of the threat of invading Soviet troops before the end of World War II, with the exception of only two families who remained on the island. Nevertheless, Ruhnu was not totally abandoned by people as new settlers came in, mostly from Kihnu and Saaremaa. The island's history can be learned about at the local Ruhnu museum.

One of the cultural heritage highlights on the island is the Ruhnu St. Magdalene's church, which dates from

Ruhnu churches. Photo: L. Laja

1644 and is thus one of the oldest remaining wooden churches in Europe. The collection of window paintings of this church (the originals are stored in Stockholm) is the oldest example of Estonian glass paintings. By the side of the old wooden church stands a stone church (built in 1912) – its walls are made of carefully selected erratic boulders trimmed to size on the site.

The Ruhnu lighthouse is truly remarkable in architectural significance as this is one of few quadruped lighthouses (having four supporting legs). Assembly of the 40 metres tall lighthouse on Ruhnu was completed in 1877.

Presently the residents of Ruhnu are engaged mainly in fishing and agriculture as well as in tourism – various services to visitors are offered by local bed and breakfast properties. Today there are almost 30 households on the island with 72 people living there.

The current book, intended for people interested in geotourism, provides a short review of most Estonian small islands, which remarkably differ both in their nature and landscape. Many of these islands belong to the naturally valuable landscapes of Estonia, being attractive geotourism destinations because of their unique landscapes as well as the presence of an abundant historical and cultural heritage. Visiting Estonian small islands makes travellers feel that human beings are still part of nature, united mentally with land and sea. The small islands, together with the mainland landscapes – characterised by a rugged shoreline, diverse landforms, numerous lakes and rivers and unforgettable scenic views – together make up Estonia. It is for sure that the Estonian small islands can offer the joy of discovery to people of all ages.

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