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PREHISTORIC SETTLEMENTS AND RIVERS IN THE LITHUANIAN COASTAL AREA IN THE EARLY HOLOCENE

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Keywords

Baltic Sea, Lithuania, flooded landscapes, prehistoric coastal settlements, marine seismic survey, Mesolithic, Neolithic, underwater research

Abstract

The search for sites inhabited by humans of the Late Palaeolithic to Mesolithic period on the coasts of Lithuania is closely related to the coastal and underwater relicts of the Early Holocene and palaeo-watercourses. This article presents the results of coastal, underwater and seismic seabed surveys. The estuaries of the rivers of the Late Mesolithic period could have been at the present seabed level at a depth of 30 m or even deeper. The watercourse sites of the Littorina Sea stage are in shallow coastal waters. At the latitude of Šventoji, Palanga, Klaipėda, Juodkrantė and the area of the Nemunas palaeo-estuary, the seabed was explored with side-scan sonar and by diving. An artefact from the Early Neolithic period has been found in the coastal area next to Klaipėda, and underwater, at a depth of 14.5 m, a relict tree stump has been detected. Two sites at a depth of 10–12 m can be associated with the relict Danė watercourse containing the preserved fragments of relict landscapes. During marine seismic survey, the probable Smeltalė River palaeo-watercourse was detected, and three sites of the former watercourses found to the south of Klaipėda could be the traces of the Dreverna palaeo-river estuary. This area has good prospects as regards the search for Early Mesolithic period settlements. The underwater survey showed no traces of human activity. A further search for the Stone Age sites would be more promising in locations where palaeo-landscapes have survived adjacent to the palaeo-watercourses.

Introduction

The Lithuanian landscape was formed by the forest-tundra during the Holocene, Baltic Sea Yoldia stage (12800–11500 cal BP), and the Palaeolithic period. In Lithuanian coastal areas, Palaeolithic settlements are known only on the former Baltic Ice Lake coasts — in the Lower Danė River area (Bachmann manor site, present-day Klaipėda city) and close to the Minija River (Venckai). The majority of the known Palaeolithic settlements are in the eastern part of Lithuania, to the south of the Nemunas and Neris Rivers (Girininkas and Daugnora 2015, pp. 32–35, 41, 79–81; Rimkus 2020, p. 194).

A few Early Mesolithic or Early Neolithic (Yoldia Sea and Littorina Sea stages) settlements have been discovered in the east Baltic coastal section between the Gulf of Riga and the mouth of the River Vistula. The Early Mesolithic settlements in the territory of Lithuania are found 50 to 80 kilometres from the recent coast of the Baltic Sea (Ostrauskas 1996; Girininkas 2009). From the data available, the impression could be had that during the Mesolithic period, Yoldia–Early Littorina stage, the coastal areas were not yet inhabited, although the Lithuanian coast was densely populated in the Neolithic period (Girininkas and Daugnora 2015, pp. 69, 166, 143, Plate XXII, Fig. 80). This is because the coasts of the Yoldia–Early Littorina stage were flooded by the Baltic Sea. The remains of coastlines were found on the seabed in Lithuanian waters, at a depth of 14.5 m–30 m, from a few to a few tens of kilometres to the west of the present coastline (Žulkus and Girininkas 2020).

The search for prehistoric archaeological sites on the Lithuanian coast is related to the search for the flooded Early Holocene landscape relicts and palaeo-watercourses. The palaeo-watercourses are reliably established in a few places on land based on the archaeological research

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data (Damušytė 2011), but the sites of their watercourses and estuaries on the seabed are frequently just hypothetical (Bitinas and Damušytė 2017). Landscape and river network reconstructions can greatly aid the predictive modelling for the discovery of further submerged sites by locating past shorelines and river mouths (Hansson 2018, p. 40).

Marine seismic surveys were conducted in order to identify the possible palaeo-watercourses during the Yoldia–Early Littorina stages while undertaking the project 'ReCoasts'. The aim was to associate the watercourses with the archaeological find sites on the coast and, on the basis of the data obtained during the seabed investigation, to establish the traces of the relict watercourses on the coastlines presently flooded by the sea. The surviving fragments of the relict Littorina stage landscapes and localised palaeo-watercourses would allow a more reliable exploration of prehistoric settlements on the present seabed.

1. Living on the shores of the sea in prehistoric times and peculiarities of determining the coastline

The main factors which determined the subsistence of the Stone Age people were geographic and climatic conditions. During the Late Palaeolithic period, the forest-tundra dominated in the present territory of Lithuania. It was replaced by forest only at the beginning of the Preboreal. The coasts of the Yoldia Sea were overgrown with pine trees (Girininkas and Daugnora 2015, p. 33; Žulkus and Girininkas 2020). At the end of the Palaeolithic period, people frequently wandered from place to place and were heavily dependent on seasonal sources of nutrition. Opportunities to hunt or to catch fish were also utilised (Girininkas and Daugnora 2015, pp. 34–35, 43), but it is doubtful whether the living conditions in the low areas of the rivers flowing into the sea fully met the needs of the people of that time.

During the Mesolithic period (the Baltic Sea Ancylus and Early Littorina stages), fishing was one of the principal economic branches, in addition to the hunting of large and small animals. In this period and later, people might have chosen to live in the vicinity of rivers inflowing into the sea and their estuaries because of the seals that appeared in the Baltic Sea. The number of their species increased especially when the water became more saline during the Littorina Sea transgression stage, from ca. 4800 BC (Girininkas and Daugnora 2015, pp. 62–64, 296, 297).

During the Neolithic period, at around 5500–2000 cal BC (Girininkas 2009, p. 126), the warm and humid Atlantic climate created favourable conditions in the forest zone for the hunter-gatherer economy to exist and it did not encourage the development of a production economy. Low areas of the rivers flowing into the sea and their estuaries remained favourable areas for people to live. This could be confirmed by the location of the surveyed Šventoji settlements belonging to the end of the Early Neolithic to the Middle Neolithic period adjacent to the former Šventoji watercourse (Girininkas and Daugnora 2015, pp. 87, 92).

During the Late Neolithic period, the nutrition of inhabitants was determined by the ecological effect of sea coasts with more favourable conditions of nutritional supply. Coastal hunter-gatherer economy activities were more varied, as the migration paths of different kinds of animals, birds and fish crossed there. Finds in Palanga show that during the transition period from the Late Neolithic to the Early Bronze Age the inhabitants hunted not only forest fauna but also seals on the coast (Girininkas 2011, pp. 54–55). Seal hunting in Lithuanian coastal settlements may have been responsible for the slower development of stock breeding, as fishing and seal hunting fully met the communities' food needs (Girininkas and Daugnora 2015, pp. 8, 92, 152, 155, 297). Referring to the example of the Užava River in Latvia, it can be maintained that migrating fish such as salmon were an important source of nutrition in the Neolithic period (Bērziņš 2008, p. 349).

Different barriers, the remains of which are found on the seabed, were used for catching marine fish. Later, nets were also employed. The inhabitants of the western coasts of the Baltic Sea (Denmark, Germany) already used dugout logboats for fishing in the Mesolithic period. In Denmark, dugout logboats and paddle blades have been recovered in the settlements of the Ertebølle culture, dated to around 5400–3950 cal BC (about 7400–5900 cal BP), and on the seabed (Bailey et al. 2020, pp. 43, 62). In Šventoji Narva culture settlements, the remains of logboats, their models and paddles were found (Rimantienė 2005, pp. 79–81, 83–84). An oak dugout boat dated to the Early Bronze Age was found in the old watercourse of the Šventoji River (Juškaitis et al. 2016, p. 38). The remains of logboats and paddles from the Middle Neolithic period were recovered at Sārnate in Latvia. There is no doubt that logboats were adapted for marine conditions, thus opening the door for the exploitation of marine resources in the Neolithic period (Bērziņš 2008, pp. 352, 359). No dugout boats have been detected on the seabed of Lithuanian or Latvian waters yet.

The intense exchange of fish, seal meat and fat, wax, and amber allowed the coastal people to use the achievements of the farming economy by means of exchange of their produce and raw materials for livestock or crops (Girininkas and Daugnora 2015, p. 299). During the first Littorina Sea transgression, the rising water started washing away amber-rich layers of sediments in the Sambia Peninsula, therefore amber was already thrown up on the Lithuanian and Latvian coasts in the eastern Baltic region around the end of the Early Neolithic period (Bliujienė 2007, p. 65). The gathering of amber and its exchange with the communities who lived further from the sea had a significant impact on the economy of Lithuanian coastal area inhabitants, especially in the Late Neolithic period (Girininkas and Daugnora 2015, pp. 146–149).

A similar economic system was also evident on the coasts of the Gulf of Gdansk. It has been established that in the Middle Neolithic (^{14}C date: 5520±70 years BP), domestic animal breeding and agriculture were not significant in the economy of coastal dwellers. Research on the ca. 4400–3700 years BP period Rzucewo culture has determined that human economic activity was connected with fishing, seal hunting and amber working and closely related to the rising sea level during the Littorina and post-Littorina stages (Miotk-Szpiganowicz et al. 2010, pp. 5, 11–12).

Using a large number of Stone Age site surveys in the western and southwestern coasts, a model of prehistoric coastal area settlement location was created. A typical Late Mesolithic strategy for locating settlements with immediate access to a large variety of biotopes centres on the mouths of brackish inlets. Such settlements can be said to be located between several environmental elements: sea, brackish inlet, freshwater, open grassland, forest, etc. Many of the sites found on the seabed were related to inland fresh-water or brackish water systems when they were inhabited (Grøn 2012, pp. 180, 185, Fig. 3; 2015, p. 5). A number of settlements were located next to small coastal lakes and swamps as well as small rivers flowing into the sea.

Comparing the distribution of settlements in Lithuanian and Latvian coastal areas in the Mesolithic period, significant differences can be found. In the territory of present-day Latvia, the concentration of find sites of Mesolithic settlements is much higher in the coastal zone, to the north of the Liepaja Lake. Later Neolithic monuments are concentrated in the eastern part of Latvia, and there are only a few of them in the coastal area (Zagorska 2009, pp. 42, 79, 91, 15, 50, Fig. 63; Macāne and Nordqvist 2021, pp. 301–304, Table 1, Fig. 1).

The Lithuanian coast was very sparsely inhabited during the Final Palaeolithic and Mesolithic periods. Only a few sites are known closer to the present coast: Šventoji and Būtingė, Palanga, the former Bachmann manor (in Klaipėda), one adjacent to the Smeltalė River, and Venckai. While the Yoldia Sea was forming and the sea water level had fallen a lot, favourable conditions for human settlement formed in the eastern part of the Aukštumala raised bog (the estuary of the Nemunas), which at that time was quite far from the sea (Rimkus 2020, pp. 194–195, Fig. 2). The Venckai Stone Age find site was discovered during exploration of sites of possible prehistoric settlements next to the former basins of the Minija and its tributaries (Rimkus and Girininkas 2020, p. 404). The only Late Mesolithic site that has been identified so far is in Palanga (Girininkas 2011; Šatavičius 2016, p. 32; Rimkus 2020, p. 194, Fig. 2).

During the Neolithic period, the Lithuanian coastal area was densely inhabited (Girininkas and Daugnora 2015, p. 166, 143, Plate XXII, Fig. 80) and this could indicate that in previous periods people might also have selected living places closer to the sea, in the coastal areas, which were later eroded during the Baltic Sea transgressions, and are presently flooded by sea water.

Depending on sea water level fluctuations, the watercourses of the rivers flowing into the sea changed as well. It can be maintained that prehistoric people who settled next to the estuaries moved to the new estuaries when the water level had risen. No settlements from the Yoldia Sea, or the Ancylus regression, or the Early Littorina stage were found in Lithuanian waters, therefore we cannot confirm any migrations of the inhabitants in the plains of those times during the corresponding transgressions, following the changing watercourses and estuaries.

Surveys in Ventspils Bay, adjacent to the Sise and Užava Rivers showed that such processes also occurred in the eastern Baltic coastal areas. During the later part of the Ancylus Lake stage, which meant re-exposure of the coastal plain, the Rivers Sise and Užava gnawed a deep channel through the Ancylus sediments. Relative water-level rise is once again observed in the Littorina Sea transgression, and at Sise the deeply incised river channel was unfilled. With the formation of a new Ventspils Bay/Lagoon during the Littorina Sea stage, this locality, at or near the Užava mouth, would have regained its special status as a prime fishing location (Bērziņš et al. 2016, p. 1324). Located in this district is the well-known settlement of Sārnate, where people settled in the dry bog of the former lagoon in the coastal area of the Sārnate lagoon in the Middle Neolithic period. Judging by the finds, it was inhabited by hunters, farmers and fishermen (Loze 2009, pp. 79, 80, 88, 436).

Possible human habitation and activity sites of the Late Palaeolithic to Mesolithic period in the relict Lithuanian coastal area are closely related to the relicts of the Early Holocene coasts and landscapes underwater. The location of the watercourses and estuaries of those times is of great importance. The Lithuanian coastal area has been researched intensely by geologists, paying attention to the changes of watercourses during the post-glacial period, but boreholes were limited to the land. Palaeontological and palaeobotanical research, including the spores and pollen analysis, molluscs etc., allowed some coastal palaeo-watercourses in the present coastal area to be located. The locations of the palaeo-watercourses of the Yoldia–Early Littorina stages on the seabed are only hypothetical

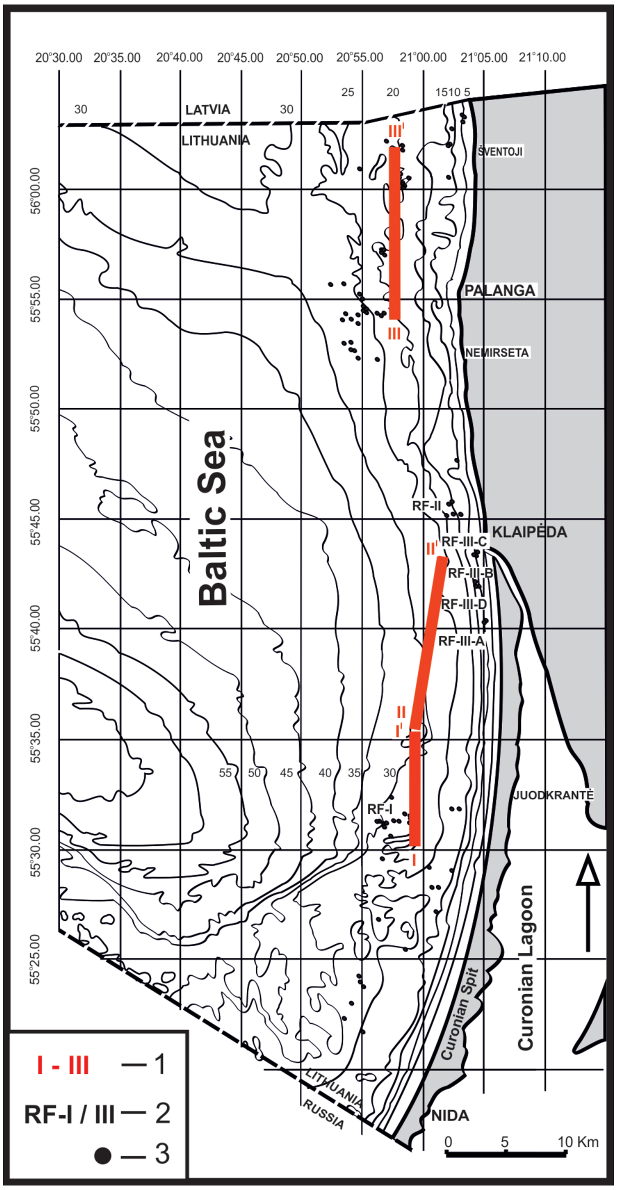

Figure 1. Exploration sites.
1. Seismic cross-sections; 2. Find sites of flooded relict landscapes; 3. Sites inspected during diving sessions ; 4. Borehole Pervalka-18 (drawing by authors).

(Bitinas and Damušytė 2004; Damušytė 2011; Bitinas and Damušytė 2017).

The Yoldia–Littorina stage sea coasts in Lithuanian waters and sea water fluctuations have been specified according to the data of the recent underwater research. Also, fragments of relict landscapes belonging to those periods were detected and surveyed in several sites on the seabed (Žulkus and Girininkas 2020). However, these surviving elements of the prehistoric landscape constitute only a very small part of the former coastal areas. In order to make a search for possible prehistoric settlements flooded by the sea more effective in the environment of the old coastal relicts, part of the underwater research was concentrated on the marine seismic survey for the search for palaeo-watercourses and attempts to relate them to the relict landscapes that have remained underwater (Fig. 1).

1.1. Marine seismic survey methodology

Marine seismic survey has been conducted in the south-eastern Baltic Sea near the coasts of Lithuania to locate buried valleys of palaeo-rivers. Survey lines were chosen according to previous studies of palaeo-rivers and the network of existing rivers, such as the Šventoji, Danė, Smeltalė, Minija and Dreverna, as well as detailed studies of Baltic Sea transgressions and regressions (Damušytė 2011; Bitinas and Damušytė 2017) and new findings of tree trunks on the bottom of the sea (Žulkus and Girininkas 2020). Seismic lines are orientated from south to north. Coordinates of performed survey lines and boreholes used for geological interpretation are presented in Table 1.

Acquisition geometry consisted of one source and one 50 m long streamer with 16 channels (3.33 m between receivers and minimum offset of 26 m). Data processing was done using GLOBE Claritas TM. The processing workflow was minimal and consisted of geometry creation and assignment (bin size is 5 m along the sailing direction), amplitude recovery (t1), stacking velocity analysis, normal moveout (NMO) correction and common mid-point (CMP) stacking, deconvolution to remove reverberation, migration, F-X deconvolution and band pass filter. The main problem in this data set was multiple reflections caused by shallow depths and the hard sea bottom. Attempts to attenuate multiple reflections in this data set were not successful due to the small offset range for move-out discrimination methods, while predictive deconvolution attacked primary reflections.

Table 1. Coordinates of the seismic surveys

Marine seismic survey	Start		End	
Line I – I‘	20° 59’ 13.9607” E	55° 30’ 53.1540” N	20° 59’ 14.2074” E	55° 35’ 14.6813” N
Line II – II‘	20° 59’ 14.5683” E	55° 35’ 20.2541” N	21° 01’ 28.8321” E	55° 43’ 01.1289” N
Line III – III‘	20° 57’ 33.2606” E	55° 54’ 03.9569” N	20° 57’ 31.1222” E	56° 01’ 47.9603” N
Borehole	Easting	Northing		
Pervalka-18	21° 02’ 55.4962” E	55° 23’ 53.0466” N		

1.2. Marine seismic survey results

Marine seismic survey gave promising results. A number of seismic reflections in their shape reminiscent of palaeo-incisions were found in seismic cross-sections I–I‘ and II–II‘ (Fig. 2). Seismic cross-section III–III‘ was collected in shallow waters (Fig. 1), thus the seismic data contains lots of multiples and is hard to interpret.

Geological interpretation of the seismic line I–I’ was performed using borehole Pervalka-18 data and is presented in Figure 3. According to the borehole, Quaternary (Q) deposits are 100 metres thick and are lying on the Upper Cretaceous deposits. The Upper Cretaceous deposits consist of sandstone and aleurolite. The oldest Pleistocene sediments are represented by morainic sandy clay (gIIdn) formed during the Dainava Glaciation (Elsterian), on top is a layer of morainic sandy clay and clay formed during Žeimena (gdIIžm) and Medininkai (gdIImd) glaciations (Saalian complex). The Upper Pleistocene deposits consist of glaciolacustrine sediments of Baltic sub-formation and Baltic Ice Lake glaciolacustrine sediments. Baltic Ice Lake sediments reach 31 m depth. The layer of Littorina Sea sediments (mIVL) consists of fine-grained sand. The bottom of the layer is 27 m below sea level and the top is 9 m below sea level. The recent marine sediments (mIV) were deposited in the Baltic Sea coast during the last 1.0–1.2 thousand years. Pleistocene chronostratigraphical correlations for Lithuania in comparison with the western Europe standard scale is done according to Šeirienė et al. (2015).

Three types of seismic reflection were identified: bottom reflection (blue bold line), the boundary between Quaternary and Cretaceous sediments (yellow bold line) and reflections of three possible palaeo-incisions (I–1, I–2 and I–3) (represented by red bold dashed line). Thin dashed lines represent multiples from the sea bottom (blue thin dashed line) and from the boundary between Quaternary and Cretaceous sediments (yellow thin dashed line). The boundary between Quaternary morainic sandy clay and Cretaceous sandstone sediments provides a strong characteristic reflection and can be also traced in seismic line II–II’. Incision I–1 is approximately 2,107 m wide and 52 m deep. The incision consists of a valley with a terrace on the northern side. Incision I–2 is narrow and shallow — only 771 m wide and 29 m deep. The most peculiar palaeo-incision is I–3, which is approximately 1,350 m wide and 79.5 m deep.

Geological interpretation of the seismic line II–II’ is presented in Figure 4. The same three types of reflections are identified. Unfortunately, the reflection from the boundary between Quaternary and Cretaceous sediments is not observed throughout the whole seismic line — the reflection falls into the zone of multiple reflections from the sea bottom and disappears. Three incisions are observed, with the following main characteristic: II–1 is approximately 3,696 m wide and 32 m deep and consists of three smaller valleys. Incision II–2 is narrow and shallow — 800 m wide and 27 m deep. Incision II–3 is very narrow — approximately 475 m wide and 26.7 m deep.

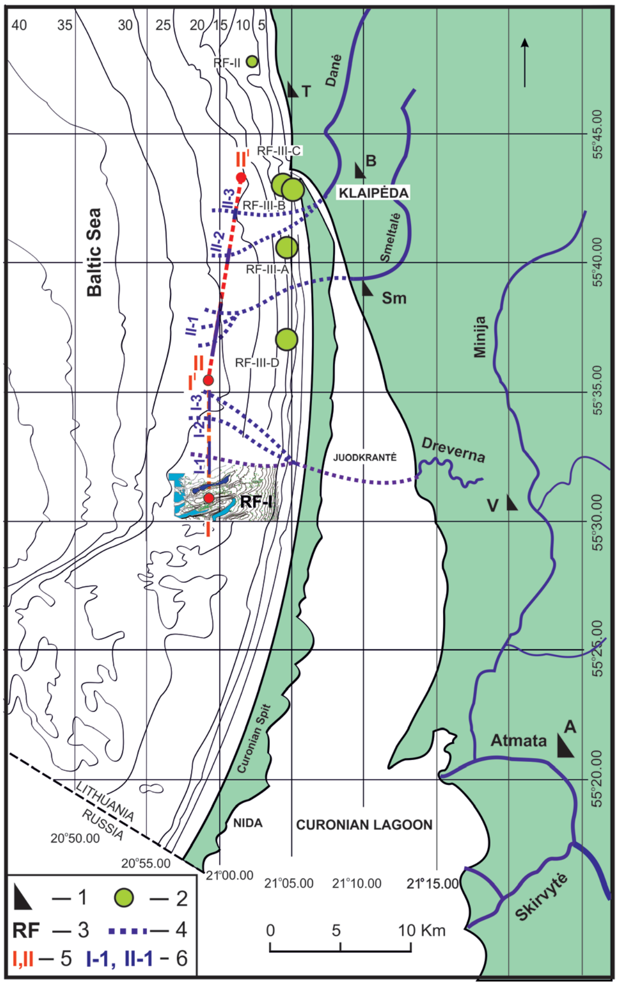

Figure 2. Explorations in the Klaipėda–Juodkrantė area with possible reconstructions of the river valley.
1. Stone Age settlements and find sites (A – Aukštumala; B – Bachmann manor site; Sm – Smeltalė; T – the T-shaped axe find site (Melnragė); V - Venckai; 2. Find sites of flooded relict landscapes; 3. Marking of seabed relict landscapes find sites; 4. Hypothetical relict watercourses; 5. Seismic survey exploration profiles; 6. The sections with the reflections of palaeo-incisions (drawing by authors).

During seismic data analysis, six palaeo-incisions were found in the 22.4 km coastal section with three active rivers (Danė, Smeltalė and Dreverna). Taking into account the maximum depth of the palaeo-incisions and the fact that some palaeo-incisions cross the Quarternary–Cretaceus boundary, the most reasonable scenario is that all of those palaeo-incisions could be the result of glacial activity. However, this does not negate the fact that rivers may have flowed through incisions left by glacial activity.

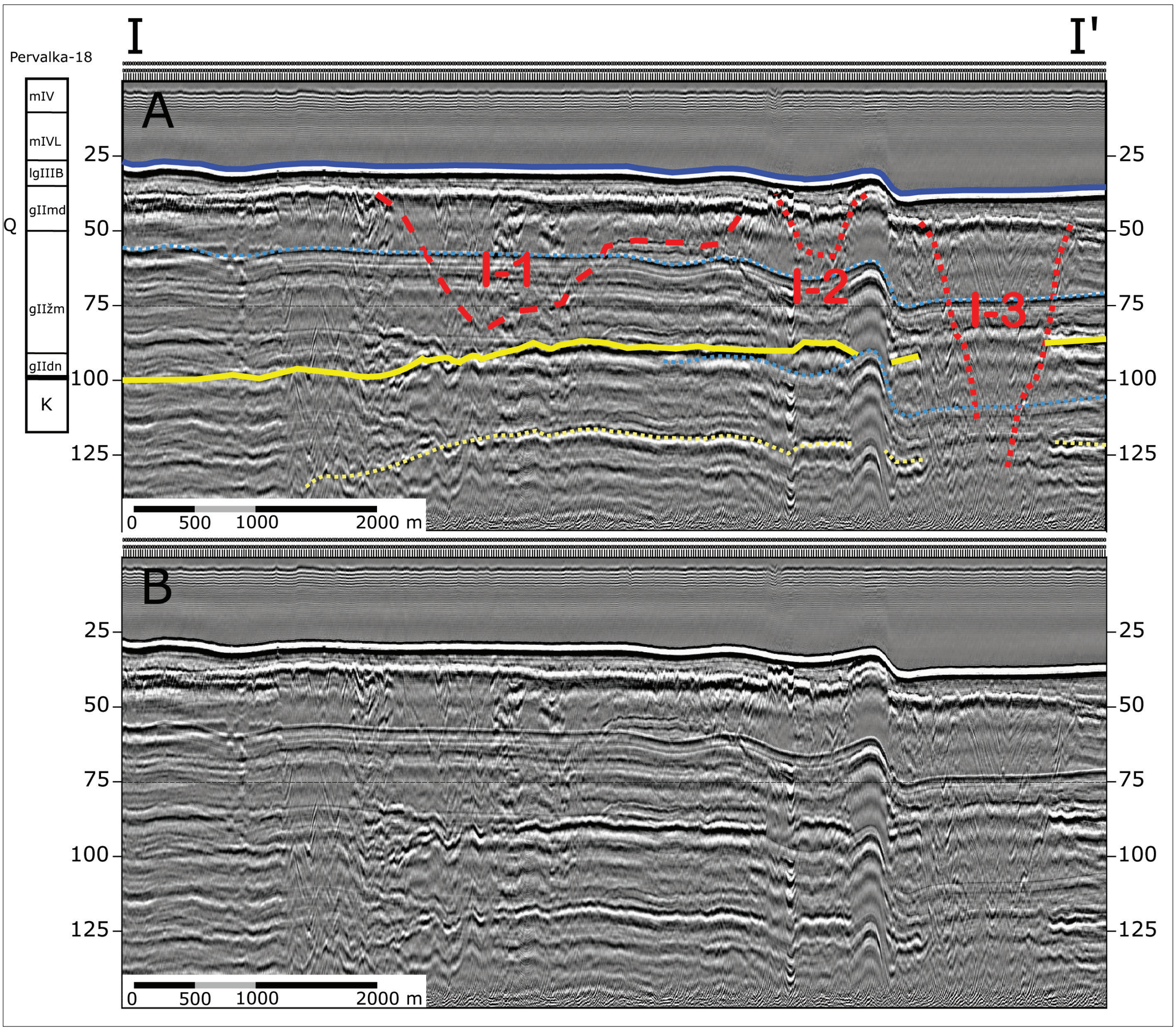

Figure 3. Seismic cross-section I–I'
A) geological interpretation, B) seismic cross-section. Blue bold line – bottom, blue thin line – multiples of bottom, green dashed line silt reflection, yellow bold dashed line – boundary between Quaternary and Cretaceous sediments, yellow thin dashed line – multiple, red bold dashed line – reflections of palaeo-incisions (drawing by N. Dobrotin).

In an attempt to link the discovered palaeo-incisions with the nearest rivers, a map of the possible river valley reconstruction was created (Fig. 5). Near seismic line I–I', currently only one river is found. All three palaeo-incisions (I–1, I–2 and I–3) could at one time have served as a channel for the River Dreverna. The elevation cross-section of the overland Dreverna river valley is presented in Fig. 5C. In the past, the Dreverna River had a wide valley (up to 2 km), similar to located palaeo-incision I–1.

Palaeo-incision II–1 is closest to the Smeltalė River and hence could have served as an initial channel for the river. Palaeo-incision II–1 is almost 3.6 km wide and consists of three narrower incisions. The Smeltalė River valley is narrow (near the lagoon up to 300 m on average, Fig. 5B). Palaeo-incisions II–2 and II–3 are not very deep and approximately 3 km apart. One of those palaeo-incisions probably could have served as a channel to the Danė River. The present valley of the River Danė is on average 500–600 m wide (the elevation cross-section of the overland river valley of the Danė is shown in Fig. 5A) and is associated with palaeo-incisions II–2 and II–3.

2. Coastal area prehistoric settlements and palaeogeography

2.1. Šventoji

In the Lithuanian coastal area, Šventoji is a location where dozens of Stone Age settlements and find sites and their palaeographical environment have been researched. Currently more than 50 Stone Age and Early Bronze Age find sites are known there (Rimantienė 2005; Piličiauskas et al. 2014, pp. 36, 39, Fig. 6). Most of them are linked to the

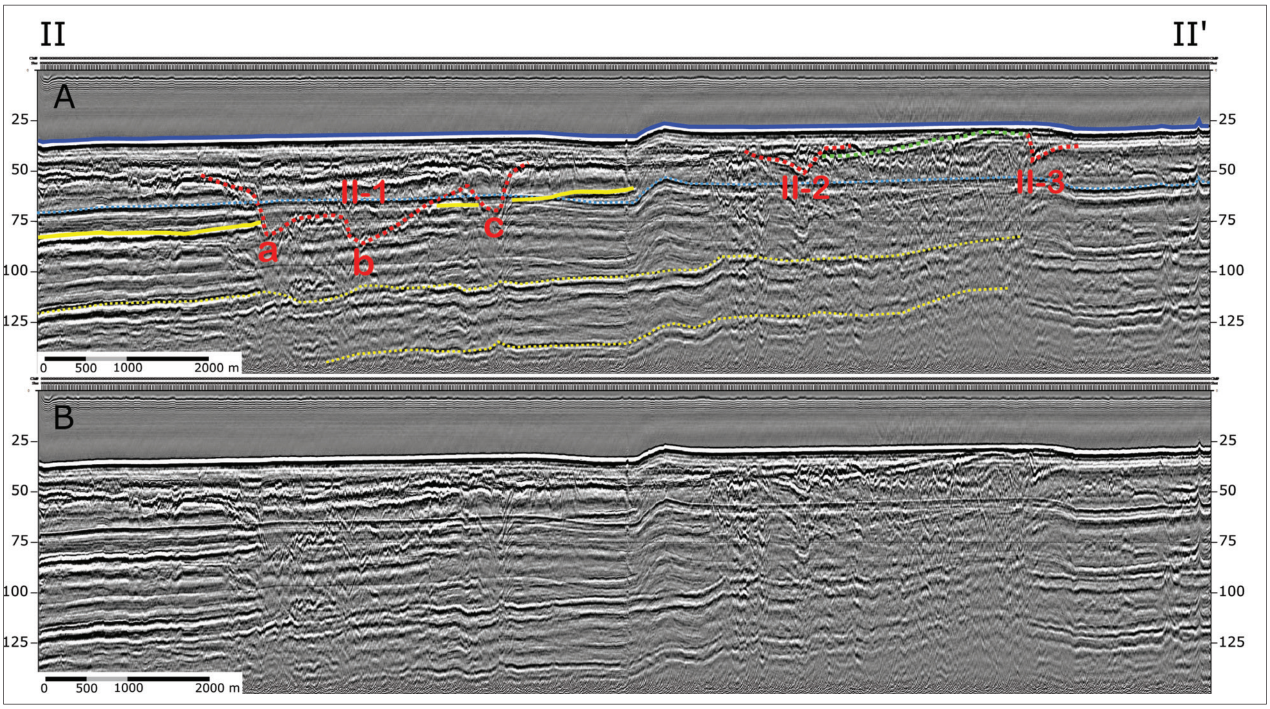

Figure 4. Seismic cross-section II–II'
A) geological interpretation, B) seismic cross-section. Blue bold line – bottom, blue thin line – multiples of bottom, green dashed line silt reflection, yellow bold dashed line – boundary between Quaternary and Cretaceous sediments, yellow thin dashed line – multiple of boundary between Quaternary and Cretaceous sediments, red bold dashed line – reflections of palaeo-incisions (drawing by N. Dobrotin).

lagoon lakes that were present on the Baltic coast during the Littorina Sea stage and the watercourse of the Šventoji, which changed several times. The changes to the Šventoji watercourse are closely related to the transgressions and regressions of the Baltic Sea.

One of the oldest known find sites is Šventoji 40, located next to the present watercourse of the Šventoji River, about 2 km to the east of the present sea coast, being 5 m a.s.l. (Fig. 6.I). It should be noted that it was on the northern coast of the relict lagoon lake (Kunskas 2005, p. 34, Fig. 15). According to the newest data, find site 40 is dated to about 6200–5750 cal BC and is ascribed to the Late Mesolithic period (Piličiauskas 2018, p. 106; Rimkus 2020, p. 194, Fig. 2). This find site is on the Baltic Ice Lake terrace. It is assumed that in prehistoric times the river, the watercourse of which almost coincided with the watercourse of the present Šventoji River, was present next to it (Piličiauskas et al. 2014, p. 35), but the location of that Šventoji watercourse, possibly the oldest one, has not been established precisely. The estuary of the river had to be on the present seabed in an unknown location in the Late Mesolithic period, during the Early Littorina transgression, as the sea coast at that time was at about 32–30 m b.s.l., about 20 km to the west of the present sea coast.

During the Neolithic period, a lagoon-type lake could have existed parallel to the sea coast in the sea coast segment of Šventoji – Monciškės – Būtingė that had been cut off from the sea in the middle of the Littorina Sea stage (Kunskas 2005, p. 24). The traces of this relict cape that separated a lagoon-type lake from the sea were not detected (Piličiauskienė et al. 2015, p. 64). The layers of Neolithic find locations in Šventoji were only about 0.6–0.2 m higher than the present sea level (Rimantienė 2005, p. 272), therefore the emergence of settlements and their disappearance depended greatly on the fluctuations of the sea water level. The newly calibrated dates of the finds show that the settlements existed during two periods. The oldest cultural layer formed at around 5720–5520 cal BP, before the Littorina 3 transgression, while the later one formed after the transgression.

The second, more accurately located, watercourse of the Šventoji River was to the south of the present estuary (Fig. 6.II). The river could have flowed into the sea there in the period between the 6th millennium and 5th millennium BC and its estuary would have been at around 2 m b.s.l. from the present sea level. The watercourse is localised in the environs of the find sites 1, 2/4 and 36. A large batch of radiocarbon dates from the Šventoji 4 find site show that fishermen of the Narva culture attended this site in the period from the end of the 5th millennium BC till the middle of the 3rd millennium BC (Brazaitis 2007, p. 39). Two later horizons with Narva culture pottery and one with Globular Amphora culture pottery were distinguished, both of which date in general to 3400–2500 cal BC (Piličiauskienė et al. 2015, pp. 66–68). The layers of the

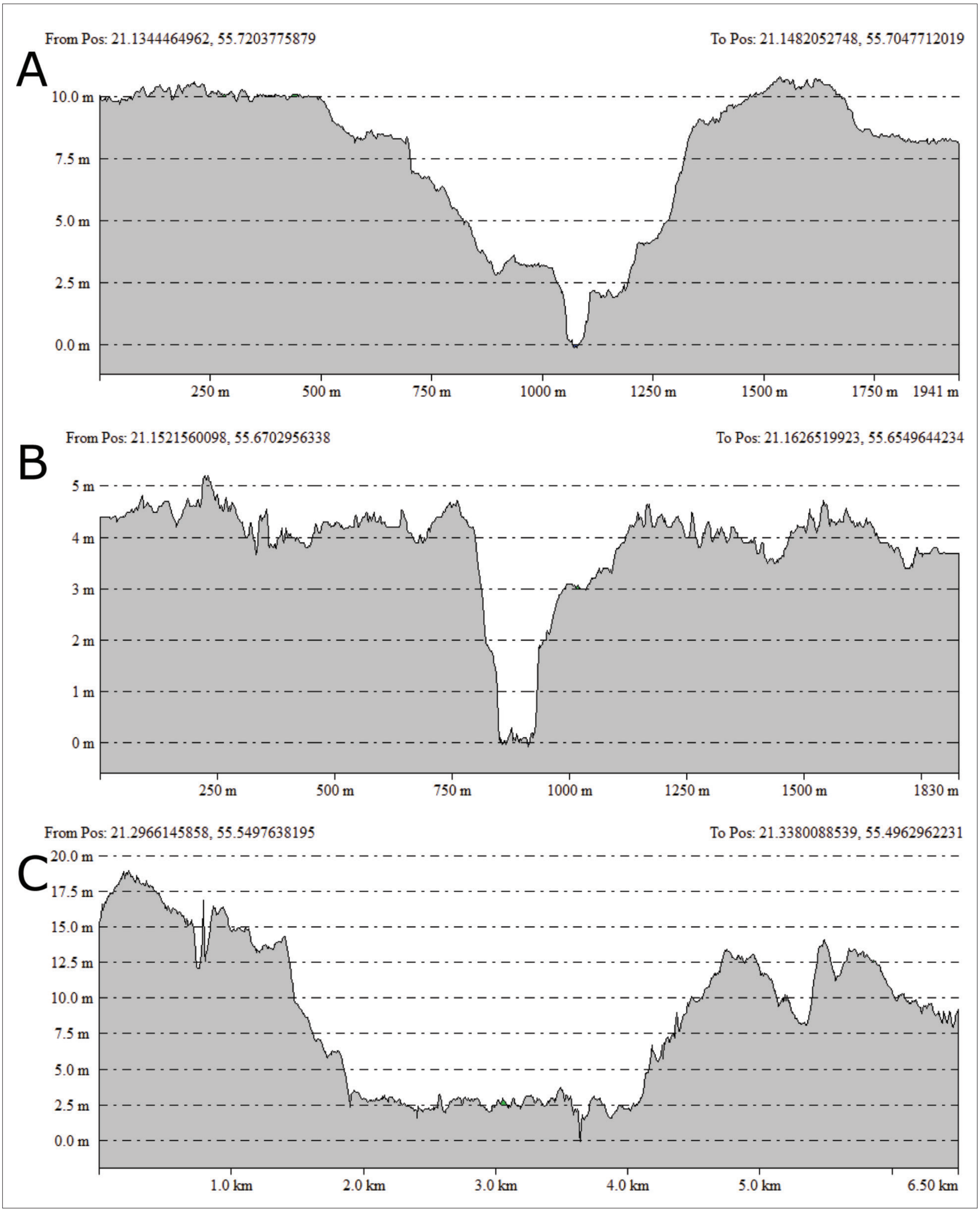

Figure 5. Elevation cross-section of overland river valleys.
A) Danė River, B) Smeltalė River, C) Dreverna River. Y-axis elevation, metres a.m.s.l., X-axis distance (drawing by N. Dobrotin).

Šventoji 2/4 Neolithic settlements from the later period (at around 5140–4610 cal BP) formed during the period of the Littorina 3 regression. They were established on the right bank of the former Šventoji River (Girininkas and Daugnora 2015, Plate XIX, Fig. 75.A).

Later, other watercourses of the Šventoji River were traced in the location of the Monciškiai lagoon-type lake (Fig. 6.III). The Šventoji, having changed its watercourse, started flowing into the sea in this location at around 4500 or around 4300 cal BC (Brazaitis 2007). The Neolithic lake bottom and the Early Bronze Age watercourses in those locations are seen in the GPR radargrams (Juškaitis et al. 2015, p. 40). The Šventoji River flowed 1.5–2 m above the water level of the Baltic Sea in the Middle and Late Neolithic periods (Kunskas 2005, p. 34, Fig. 16; Brazaitis 2007, pp. 35–42). The traces of the Šventoji River estuary of that period should be searched for in the present seabed. The Neolithic Šventoji 47 find site was found in the trough of the relict watercourse (Juškaitis et al. 2015, pp. 35, 43–44). On the northern coast of the former watercourse, the known settlement 9 dated to the Late Neolithic to Bronze Age is located (Rimantienė 2005, p. 208; Girininkas and Daugnora 2015, Plate XIX, Fig. 75.A). It is thought that the Šventoji 9 find site is the location of a Bronze Age (1900–1800 cal BC) fishing place in the Šventoji River (Juškaitis et al. 2016, p. 36–37).

The post-Littorina (Limnean) transgression, during which the sea water level rose above the present one, and the following regression, affected the Šventoji River watercourse once more. At around 4000 cal BP, or slightly later, the regression during which the water level in the Lithuanian coastal area could have dropped to 1.5 metres b.s.l. was already taking place (Damušytė 2011, p. 48, Fig. 10). During this regression, the estuary of the Šventoji River moved to the north of the present one (Fig. 6.IV). At this location the river flowed into the sea till the 18th century. At a depth of 1.5–1 m, the river bank reinforcement poles, which were dated by dendrochoronological methods to 1694, 1696 and 1699 years, have remained in the seabed

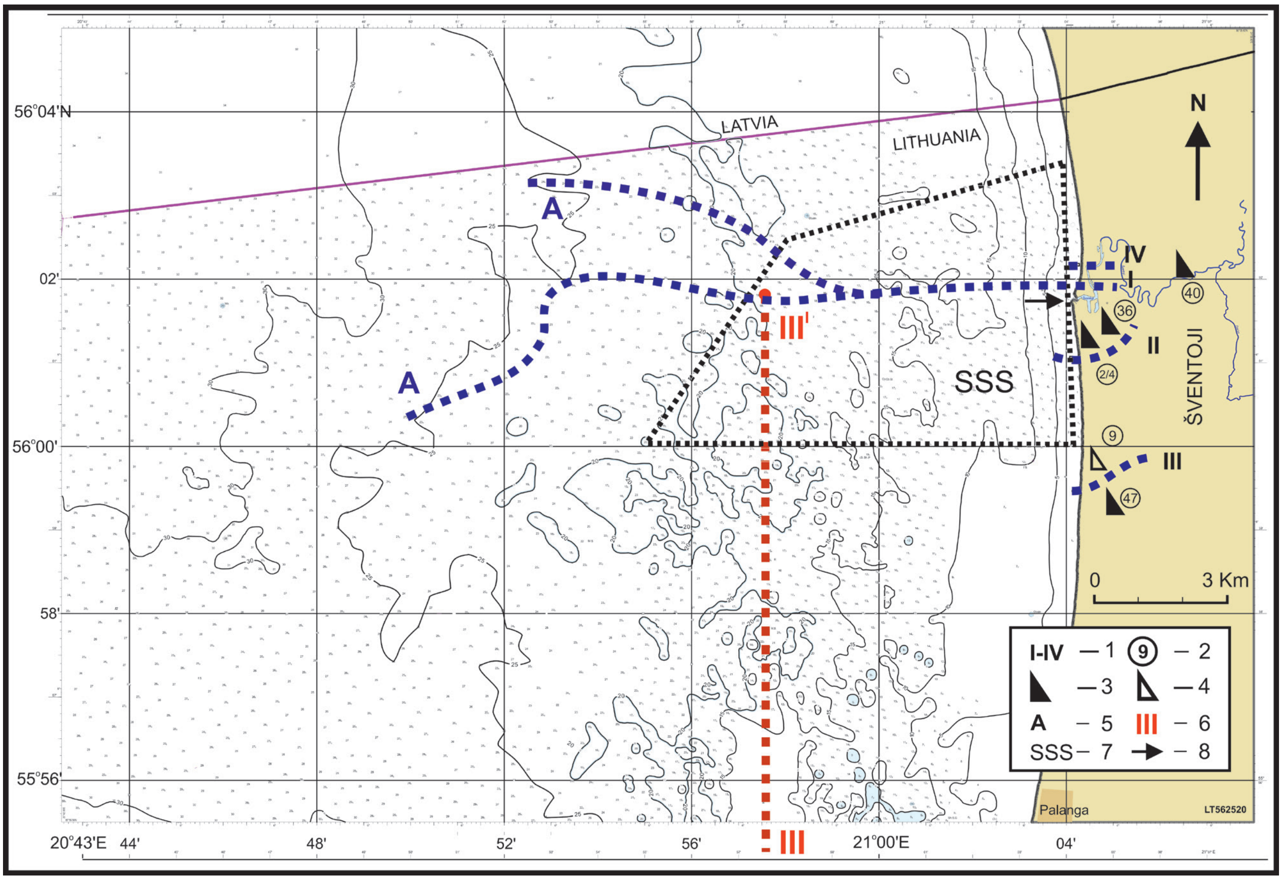

Figure 6. Explorations in the Šventoji area.
1. The locations of the Šventoji relict watercourses according to the archaeological data (I – the presumed watercourse marked in the Late Mesolithic period (at about 6200–5750 cal BC); II – the river watercourse till around 2500 cal BC; III – the Šventoji watercourse recorded since around 2500 cal BC till 2000–1700 cal BC; IV – the watercourse after around 2000–1700 cal BC);
2. Markings of prehistoric settlements and find sites; 3. Stone Age settlements and find sites; 4. Bronze Age settlements and find sites; 5. Presumed Šventoji River watercourses in the Late Mesolithic period, at around 6200–5750 cal BC; 6. Seismic survey exploration profile; 7. Area explored with the side-scan sonar; 8. Present Šventoji River estuary (drawing by authors).

in the location of the former estuary (Žulkus and Springmann 2001, p. 181).

The last change to the Šventoji watercourse occurred in the 18th century. From the 17th century, large sand storms started all along the Lithuanian coast and coastal dunes began to increase. Sand storms reached up to several kilometres off the sea coast to the land (Žulkus 1990, pp. 76–82). Some prehistoric settlements which were located closer to the sea or estuaries of rivers flowing into the sea could have been buried by sand. As a result of sand storms the Šventoji watercourse turned to the south and the present estuary formed (Figs. 6 and 8).

Research has not fully revealed the situation of all Stone Age settlements but it is highly likely that at least some of the settlements that were located next to the Šventoji River and the coastal lagoons depended on the sea water level fluctuations, and the changes in the Šventoji watercourse corresponded to the typical strategy of coastal Stone Age settlement location (Grøn 2012, pp. 180, 185. Fig. 3).

The search for relict watercourses of the Šventoji River from the Late Mesolithic period which hypothetically could have existed around 6200–5750 cal BC (Fig. 6.I) and the possible settlements related to them was carried out underwater. Taking into account relative specified sea water level fluctuations on the eastern Baltic coast (Girininkas and Žulkus 2020, Fig. 4), the Šventoji River estuary of the Late Mesolithic period should be at a depth of 30 m b.s.l. or even deeper. The remains of Šventoji estuaries and archaeological sites, which formed during later periods (Littorina transgressions and regressions), located at shallower depths were not promising for the research because archaeological sites situated on beaches are preserved only when separated from the active zone of beach erosion (Dincause 2006, p. 245).

An area of the seabed sized around 52 km^2 in the external roadstead of the Šventoji port was surveyed by means of side-scan sonar (Žulkus 2009a). In the area surveyed, the formations of the former coast can be seen. A winding incision oriented in the southeast–northwest direction stood out at depths of about 16–21.5 m in the western part of the area. Looking for the possible palaeo-watercourse, the seabed was surveyed by divers (Fig. 7). The width of the watercourse in the southeastern part carved out by the

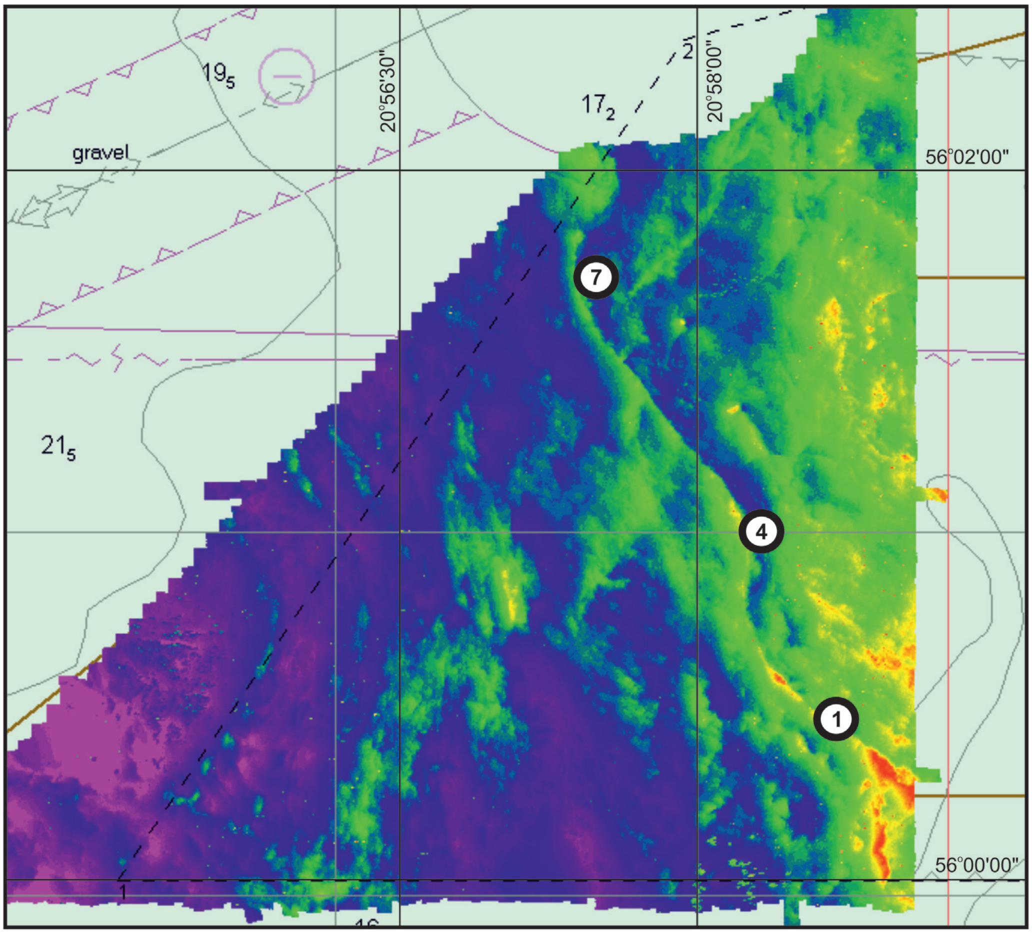

Figure 7. The incision carved by the water currents at depths of 16–21.5 m detected during side-scan sonar surveys. Circles mark the positions on the seabed explored during diving (drawing by authors).

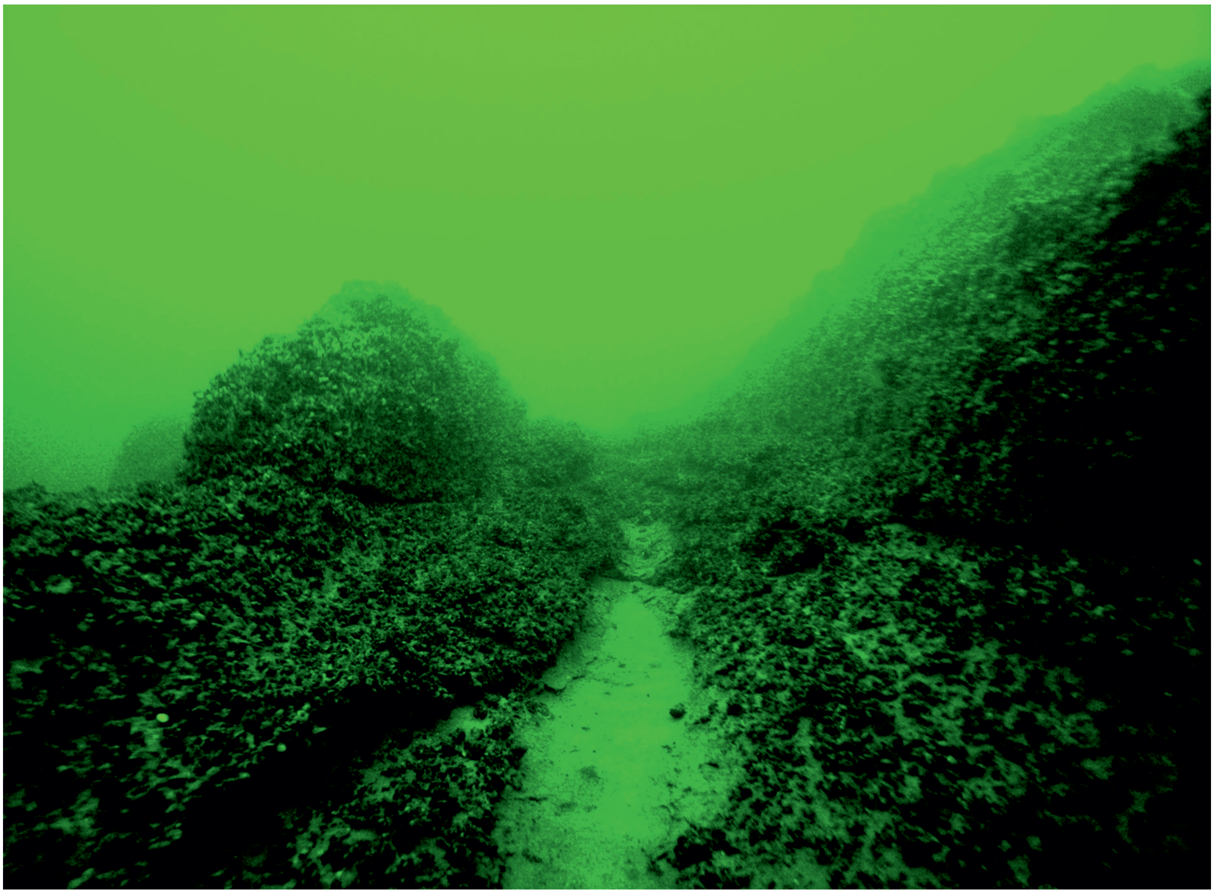

Figure 8. Seabed in the incision site (photo by V. Žulkus).

currents was about 50–60 m at a depth of 16–19 m, the washed boulders were lying on the seabed; between them there was gravel, patches of gritty sand and clay loam with vivid traces of water flows. In the middle of the incision and its northern part there were stony areas with larger or smaller sand patches. This seabed formation is detected in all surveyed sites (Fig. 8). Neither organic sediments nor relict trees were found in any of the explored sites. It was not determined whether the incision detected in the Šventoji watercourse can be related to the Šventoji palaeo-watercourse.

2.2. Palanga

A Stone Age settlement was found in Palanga, next to the Rąžė River, about 0.7 km to the east of the present-day sea coast. The Palanga settlement is attributed to two chronological periods: Late Mesolithic and Late Neolithic to Early Bronze Age. The settlement of the Late Mesolithic Period is situated at the edge of a moraine at the River Rąžė estuary. The settlement had been at the level of about 1 m b.s.l. and the age of bone and antler finds made there is between 6395 and 5735 cal BP (4446–3783 cal BC). Thus the water level must have been no higher than 2–3 m b.s.l around 6400 cal BP. The available archaeological and geological data indicate that in the Late Neolithic to the Bronze Age the settlement existed during the period of the regression of the Limnean Sea, around 4200–4000 BP. This settlement might have been situated at the mouth of the River Rąžė, or not far from it, next to the edge of a moraine hill bordering a small lagoon lake (Girininkas 2011, pp. 49–50, 56; Piličiauskas et al. 2015, pp. 22, 24).

Traces of a prehistoric settlement cultural layer were found at another site in Palanga, about 3 km to the south of the Rąžė River and about 1.5 km off the present sea coast, on the Baltic Ice Lake terrace, at about 14.3 m in absolute height. Quite sparse finds — a flake of flint, fragments of ceramics, natural amber — were dated to about 1500 BC and were assigned to the Bronze Age (Žulkus 2007, pp. 170–173, 183, 234, 373–374).

According to the opinion of the researchers, the River Rąžė flowed into the former lagoon and from there to the sea. The exact site of the estuary from those times is only hypothetical (Girininkas 2011, pp. 48–57). It is possible that the Rąžė River estuary in the periods from the Late Neolithic to the Bronze Age had been to the south of the present one, approximately at the present promenade bridge, where it is shown in the maps of the 17th–19th centuries (Jäger 1982; Vasiliauskas and Zabiela 2013, Fig. 13, Maps III; XII).

The present seabed 30 m isobath shows that at Palanga, during the Early Littorina stage, a narrow cape of 30 km in length could have existed which disappeared when water rose to 25 m b.s.l. (Girininkas and Žulkus 2017, pp. 69–70). The Rąžė River palaeo-estuary should be sought in that area. Stone Age finds might be expected there. At Palanga, the seabed was surveyed in the areas that had previously been investigated by side-scan sonar. The areas previously surveyed with the sonar were from 6 to 12 km off the coast at depths of 20–30 m. In seabed structures, underwater incisions similar to watercourses or estuaries were exposed (Fig. 9). Searching for the traces of palaeo-coasts and the possible Rąžė watercourse during the Early Littorina transgression stage, diving was performed in 26 places. At depths from 15 to 30 m, stone areas with separate 2–3 m sized boulders, up to 3 m high clay ridges were seen, on the almost flat seabed surface. In the northwestern part of the eastern plot, an almost 9 m deep carved out incision was found. It is obvious that coasts which were severely damaged by the sea currents during the Baltic Sea transgressions are present in this location. No traces of ancient trees or other signs of the relict landscapes were found. Also, no signs of human activity or archaeological finds were detected.

2.3. Waters at Klaipėda

The hydrographic network of the continental part of the coast in the segment between Palanga and Klaipėda consists of small rivulets, the watercourses of which are now changed or drained into canals. Earlier, the rivulet Ercininkas flowed to the north of the Klaipėda port lighthouse. A further rivulet watercourse was in the Melnragė II. Three rivulets — the Tydeka, Cypa and Rikinė — flow into the sea to the north of the Olandų kepurė, through Karklė village. The Cypa rivulet earlier started in swampy areas adjacent to the Kalotė Lake, now it flows from the lake itself. The Rikinė rivulet situated to the north of Karklė village is fed with water from swampy Šaipiai meadows and its marsh (Baltrek 2013). Traces of these rivulets were not found underwater on the seabed. According to the data from the side-scan sonar survey, the seabed in coastal waters at Karklė contains bands of boulders and sand extending along the coast to depths of 10 m. At the Cypa rivulet in Karklė, to the south of the Olandų kepurė, 600 m off the present coast, bands of small boulders and sand were found while diving at a depth of 6 m and further approaching the coast, carried by currents from the eroded present-day coast.

There are no known prehistoric monuments or find sites in the environs of these rivulets. There is only one find from this zone — a T-shaped axe from red deer antler, which was found washed up by waves on the Melnragė II beach. The T-shaped axe dates to the Early Neolithic period, its specified date is 7163–6958 cal BP or 5214–5009 cal BC (Rimkus 2018, pp. 151–158; 2019, pp. 8–9). It was washed ashore by the Baltic Sea, almost at the same place where the rooted tree stump RF-II (Fig. 2) dated to the Late Mesolithic to Early Neolithic period (8008–7571 cal BP; 6059–5622 cal BC) was found underwater at a depth of 14.5 m (Žulkus and Girininkas 2020, p. 9). A search was carried out around this relict tree, on the coordinates 55° 45.560‘ N; 021° 03.116‘ E, but no other similar finds or artefacts related to the activities of prehistoric people were found.

The seabed in this site is stony, with small patches of sand between the boulders. The situation in the rooted stump find site RF-II clearly shows that the landscape has changed little since the Late Mesolithic period and coasts were not eroded during the Littorina transgressions. About 8,000 years ago there was a stony coastal plain overgrown with pines. Further to the north, closer to the Cypa rivulet watercourse, two large boulders one next to the other were found on the seabed, at a depth of 9 m, during the survey with the side-scan sonar; one of them is up to 3 m tall. Their environment was explored in greater detail while diving. During the exploratory survey it was not possible to determine whether these two boulders were related to any kind of human activity (Žulkus 2009b, p. 525). At the latitude of the relict stump RF-II, at a depth of 25 m, another unusually big boulder was discovered (4.4 x 3.65 m in size, it rises up to 2.6 m above the seabed). It has quite regular sides, and an even upper surface with strange hollows and splits. In both cases the boulders were not washed up later; they had already dominated in the coastal plain environment, when the territory was overgrown with pines (the site RF-II), at around 7790 cal BP (around 6026 cal BC). The sizes of the boulders and their unusual forms could have attracted the attention of the prehistoric inhabitants, therefore visual underwater survey by diving was carried out. Explorations were conducted in order to find possible traces of human activity, however, they were not found.

2.4. Danė and Smeltalė Rivers

The identification of the Ancylus Lake stage coastal line and reconstruction of the palaeogeographical conditions is problematic. The locations of estuaries of the rivers that flowed into the sea at that time have not been determined precisely yet (Damušytė 2011, p. 57), but it is maintained that during the Holocene period almost all rivers flowing into the sea changed their watercourses, including the Danė and Smeltalė (Bitinas and Damušytė 2017, p. 37).

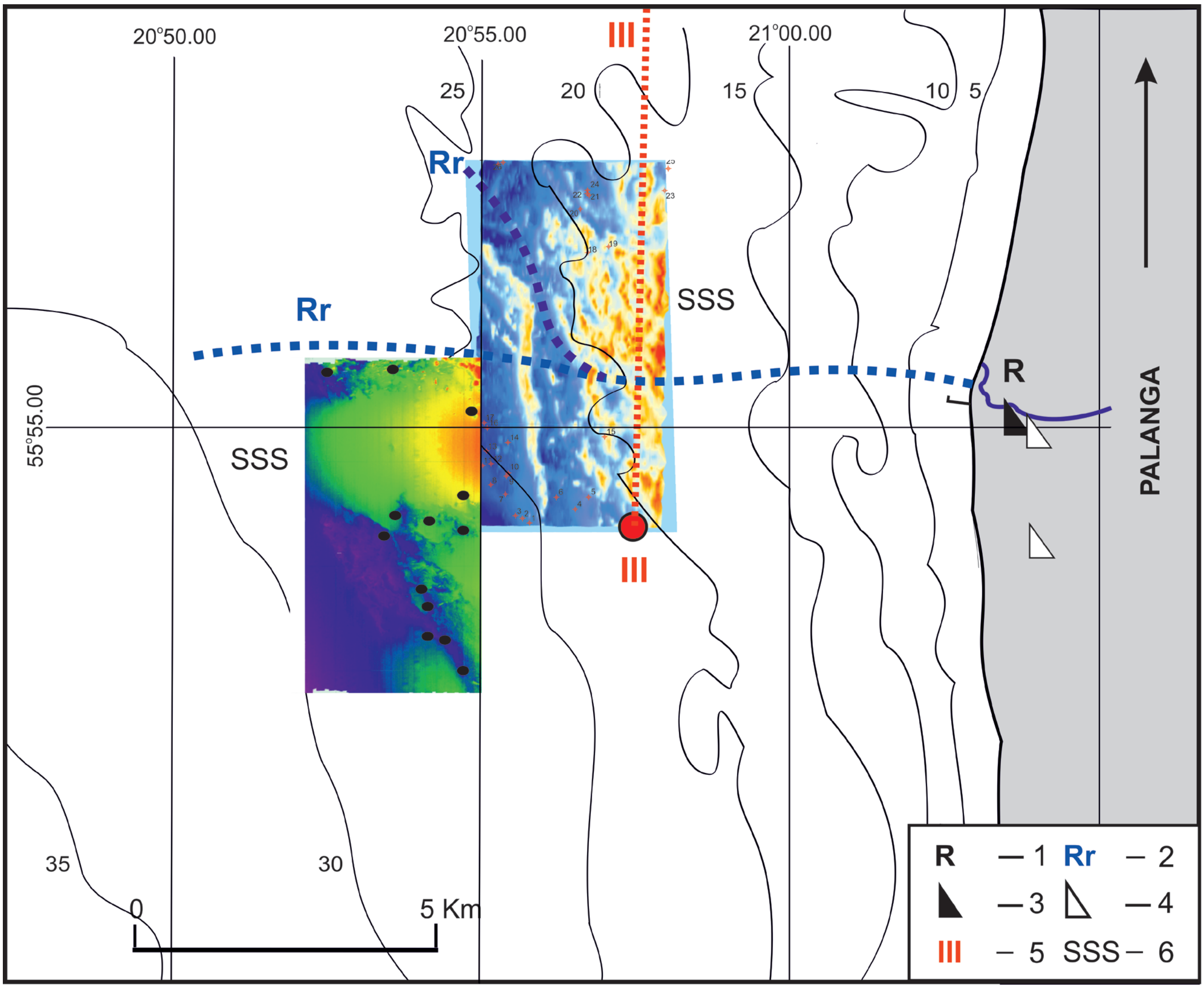

Figure 9. Explorations in the Palanga area.
1. Rąžė River; 2. Supposed Rąžė watercourses during the Early Littorina transgression; 3. Stone Age settlement; 4. Bronze Age settlements and find sites; 5. Seismic survey exploration profile; 6. Areas explored with the side-scan sonar (drawing by authors).

During the Ancylus regression, when around 9200–8500 cal BP the water level dropped from about 18 m b.s.l. to as low as 40 m b.s.l., the rivers flowing into the sea had to make deep incisions into the wide coast. The rivers of that time could have changed the direction of their watercourses depending on the newly exposed relief of the coastal areas. It can be assumed that in the smaller depths, i.e. where the remains of relict landscapes have survived in the sea to the south of Klaipėda at a depth of 10–12 m, the watercourses of the former rivers remained unchanged during the Ancylus regression–Littorina transgression stage.

At a depth of 10–12 m to the south of the Klaipėda port gates, two relict landscape sites flooded by the sea were found (Fig. 2). Their coordinates are 55° 43.511‘N; 021° 04.444‘ E (RF-III-B) and 55° 43,507‘ N; 021° 04,529‘ E (RF-III-C). The find sites are only 50 m away from each other. At these sites, rooted relict trees and washed peat deposits (in RF-III-C) were found in the sandy seabed.

Pine trees and peat deposits in the find sites RF-III-B and RF-III-C are dated to around the range of 9500–8800 cal BP and belong to the period of the maximum transgression of the Ancylus Lake during which the water level must have been lower than 12 metres b.s.l. (Žulkus and Girininkas 2020, Fig. 4). The fragments of the sea flooded and surviving landscape relicts can be related to the presumed relict River Danė estuary.

Despite the fact that the prehistoric landscapes with rooted stumps and peat deposits at Smiltynė and to the south of it have remained in the Klaipėda Strait area[1] and in some sites at the sea (RF-I-III-B; RF-I-III-C; RF-I-III-D[2]), traces of the Danė River watercourse were not detected. Earlier it was thought that some trees at the find site RF-III-B could

[1] The available evidence indicates that small freshwater lakes and peat bogs had been further to the east of the present coasts, from 10700–9000 cal BP (Damušytė 2011, p. 57).

[2] RF-III-D is a newly discovered and not yet surveyed find site of rooted tree stumps at a depth of 10 m, at the coordinates 55° 42,053‘ N; 021° 04,698‘ E.

have been poles left by people, hammered in for fishing barriers located adjacent to the Danė estuary (Žulkus and Girininkas 2020, pp. 2, 13), but later research did not confirm this. Further into the sea at the locations of the relict coasts in the seismic survey profiles made at depths of 20–25 m b.s.l., the detected palaeo-incisions II–2 and II–3 are related to the relict valleys of the Danė River (Figs. 2 and 4). Thus there are two sites for the presumed Danė River watercourse of the Ancylus stage. The Curonian Spit formation that started earlier than 8500–8300 cal BP also could have had an impact on the alteration of the Danė and Smeltalė watercourses during the Ancylus Lake or the first Littorina Sea transgression (L1) stages (Damušytė 2011, p. 68).

In the lower Danė River area, only one find site from prehistoric times is known (Fig. 2). The find is a bone arrow from the former Bachmann manor (now in Klaipėda) (Groß 1939, pp. 65–67). It is not dated very precisely; it is attributed to the Late Palaeolithic period. This period coincides with the Baltic Sea Yoldia–Ancylus stage, when the water level in the sea had not risen above 40 m b.s.l. (Žulkus and Girininkas 2020, Fig. 4). The estuary of the Danė River of that time was far away to the west of the present seacoast. We did not obtain any data about the Stone Age settlements that could have existed on the former coasts, in the lower river areas, which are now flooded by the sea.

Another surveyed site underwater was RF-III-1 (RF-III-A) more than 5 km to the south of the sites RF-III-B and RF-III-C. This site is located at coordinates 55° 41,292‘ N; 021° 04,864‘ E. Rooted stumps of relict pines were found there at a depth of 11 m. The stumps found and dated at this site belong to a slightly later period than the ones at the sites next to Klaipėda port. Average dates for the pine stumps are in the range of 8838–8724 cal. No peat deposits were found there. It is possible that, to the south of this site, between it and the newly discovered site with the surviving tree stumps (RF-III-D), the former palaeo-watercourses of the Smeltalė River, which is situated in the southern part of Klaipėda city, exist. This could be confirmed by the seismic seabed survey results. Palaeo-incision II-1 consists of three narrower incisions (Fig. 2), which should be attributed to the Smeltalė watercourses.

Currently only one find site dated to the Late Mesolithic period is known at the present estuary of the Smeltalė River (Rimkus 2020, p. 194). The statement that the Smeltalė Late Mesolithic to Early Neolithic period settlement could have been on the mouth or estuary of the river flowing into lagoon or the sea (Piličiauskas et al. 2015, p. 22) is true only for the latest period of this settlement's existence as well as for the later Littorina Sea transgressions and regressions, when the sea water level could have fluctuated by only by a few metres higher or lower than the present sea level. The oldest finds next to the Smeltalė are from the end of the Littorina I stage. In the Late Mesolithic, during the Early Littorina Sea transgression stage the sea water level had been at about 30 m b.s.l. (Žulkus and Girininkas 2020, Fig. 4), therefore both the Smeltalė and Danė River estuaries and mouths should be searched at the sea under the seabed sediments. It is likely that people inhabited the estuaries of these rivers in the Mesolithic period, but we do not have any proof of that.

2.5. Minija and Dreverna Rivers

Next to the Minija River, in its low area, next to the high area of the Dreverna River, only one prehistoric find site was found — Venckai (Fig. 2), which is ascribed to the Late Mesolithic period (Rimkus 2020, p. 194, Fig. 2) and is related to the end of the Early Littorina transgression stage. This site is more than 13 km off the western coast of the Curonian Spit. It is likely that in the earlier period, when the sea water level was much lower than at present, people could also have lived on the banks of the Minija River, but those areas are underwater now.

The opinion exists that the Low Minija watercourse could have been in a completely different location compared to the present one because during the Holocene the Minija, as well as the Nemunas, formed new low areas due to the known sea water level fluctuations. The Minija palaeo-watercourse at depths of 25–30 m is seen at the latitude of 55°30‘(Bitinas and Damušytė 2017, p. 37). Situated in the vicinity of the presumed palaeo Minija watercourse, on the seabed, at 25–30 m b.s.l., is site RF-I of the flooded relict coast. Peat samples and relict pine trees from this site are dated to the range of approximately 11600 cal BP and about 8000 cal BP (Žulkus and Girininkas 2020, Tab. 1). The formation of the landscape of that period — the relief, the orientation of the former lakes and peat bogs in the northeast–southwest direction — along the former coast show that there could have been a sea bay in this environment during the Yoldia Sea period. The profiles of the seismic research did not reach the areas to the south of the 55°30‘ meridian. Therefore, we cannot maintain or deny whether palaeo-incisions, related to the palaeo-watercourses, existed there. The palaeo-incisions I–1, I–2 and I–3 are related to the hypothetical watercourses of the Dreverna River (Figs. 2 and 3). However, we cannot reject the assumption that during the Yoldia Sea stage the watercourses of the Minija and Dreverna could have coincided.

The fragments of the relict landscapes on the seabed are found and surveyed in the RF-I site, which is from 3 to 8 km off the present western coast of the Curonian spit. Rooted tree trunks and peat formations in the environment of the relict lakes are known in the area of around 90 km^2 at the following coordinates: latitude between

55° 29,300 and 55° 33,700 N and longitude between 020° 51,900‘ and 021° 04,000‘ E (Project BalticRIM, Lehtimäki et al. 2020). This site is in the latitude of the Dreverna River estuary. The Dreverna River flowed into the lagoon, but its watercourse did not survive when the Wilhelm Canal (now the Klaipėda Canal) was excavated in the second half of the 19th century. The present seabed relief allows for the assumption that the Dreverna palaeo-river could have flowed into the sea at the southern edge of a wide bay during the Yoldia Sea period (Figs. 1 and 2). The remaining palaeo-landscape fragment at the site RF-I could have been on the left bank of the said river. There was a higher location with elongated sandy hills parallel to the sea coast, overgrown with pine forest, and small swampy lakes and lagoons. Relict landscapes in this underwater site were detected in the area of about 90 km^2 (projects Yoldia, BalticRIM and ReCoasts). The oldest rooted trees and peat deposits are dated to the period of more than 11000 years BP and are ascribed to the Yoldia Sea stage, when the sea water level had dropped more than 40 m from the present sea level (Žulkus and Girininkas 2020, Table 1, Fig. 4).

The samples of relict trees and peat deposits were taken for ^{14}C dating, palynological research, chemical research and determination of the tree DNA. During all underwater surveys, traces of human activity were looked for but, despite the fact that diving was undertaken at 18 sites at depths of 15–37.5 m, no prehistoric finds or cultural layers were found. Having carried out the acoustic mapping of the seabed with the side-scan sonar and multibeam echosounder as well as the direct investigations of the seabed during diving, no obvious traces of a relict river were detected. The site RF-I, which existed during the Yoldia Sea stage, in the Late Palaeolithic to Early Mesolithic period, is a promising location for the further search for Early Mesolithic settlements or find sites, which could have been determined next to the Minija or Dreverna palaeo-river during the Yoldia Sea and Early Littorina transgression stages.

It is possible to search for analogues to the typical sea coast population model reconstructed on the basis of the prehistoric settlements researched in the Baltic and North Sea waters. An example of a typical assumption made in these models is that Stone Age settlements were almost always located in the immediate vicinity of water, either on the coast or by inland water systems (Grøn, 2015, pp. 2, 5). For the Early Mesolithic population, the ecological-economic niche of coasts was of great importance. The coastal stretch of the Yoldia Sea was rich in lagoons and bays with inflowing rivers. The conditions for hunting, gathering and fishing to prosper were especially good (Schmölcke 2008; 2013). When the water level dropped, most of the Early Mesolithic population moved from the Baltic Ice Lake coast to the Yoldia Sea coast, which today is 29—30 m b.s.l. (Žulkus and Girininkas 2020, p. 9).

2.6. Nemunas

The earliest Stone Age settlements researched in the Lithuanian coastal area zone dated to the Final Palaeolithic period and assigned to the time lap of the Swiderian culture (about 9800–9300 cal BC) were found in the Low Nemunas area, the Aukštumala peat bog. The emergence of these settlements is related to the fall in the Baltic Ice Lake water level during the formation of the Yoldia Sea (Rimkus and Girininkas 2020, p. 35; Rimkus 2020).

The Nemunas palaeo-watercourse in the low area and the location of its estuary, as well as its transformations, have not been determined. The Nemunas low area that existed during the Middle Holocene is not identified (Bitinas et al. 2002, p. 388). Due to the sea water level fluctuations, the coastal rivers Nemunas and Minija could have formed new low areas during the Holocene period (Bitinas and Damušytė 2017, p. 37).

Traces of the flooded Nemunas palaeo-estuary were detected on the seabed. The traces of the southeastern part of the estuary are identified at depths of 30–40 m where the relicts of the 16.6 km long and 11.2 km wide palaeo-watercourse could have survived. It is maintained that the Nemunas palaeo-estuary as a morphogenetic form started developing at this site during the Preboreal period and finished during the Boreal. The Ancylus (A2) stage regression was identified in the branches of the estuary at a depth of 41.3–39.9 m and dated to 9.31–8.87 ca thousand years BP (Gelumbauskaitė 2010, pp. 109, 110, 115).

At the presumed location of the Nemunas palaeo-estuary and its environs, the seabed was explored by means of side-scan sonar (Navigator XXI 2005; BPATPI 2007; MCOPLIT 97–99). In some places, formations of regular shapes similar to traces possibly left by human activity were detected. Later, the seabed was explored during diving sessions at seven sites at depths of 14–33 m (Fig. 1). The seabed consisted of moraine ridges, boulders and patches of sand at the diving sites. Formations of relict coasts undamaged by the sea currents or rooted relict trees or peat formations were not found.

3. Discussion

Sea coasts at the Lithuanian coastal area during the Yoldia–Ancylus stages were from a few to several dozens of kilometres further to the west of the present sea coast (Šečkus 2009, pp. 22–23; Žulkus and Girininkas 2020). The palaeo-incisions detected during the seismic seabed survey are related to the palaeo-watercourses of the present-day rivers during the Yoldia–Early Littorina Sea stages. The coastal relicts of that period (RF-I and RF-III) show that the then sea coast in the Klaipėda-Juodkrantė segment was low and sandy, overgrown with thin pine forest with small lakes and peat bogs (Žulkus and Girininkas 2020).

Besides the watercourses of larger rivers, there would have been small rivulets still not discovered on the former coasts presently flooded by the sea. Nowadays in Lithuania, small rivulets of 3–10 km in length dominate both in number (around 50%) and general length (Gailiušis et al. 2001, p. 49). Such rivulets that flowed into the sea must have existed in the coastal plains of the Yoldia and Acylus periods. And people could have lived next to them in the Late Palaeolithic to Mesolithic period. The search for those small rivulet watercourses is already a possibility for further research.

The problem remains of how to link the palaeo-incisions found during the geophysical exploration to the present rivers. Do the buried valleys traced during the marine seismic survey belong to these rivers (Danė, Smeltalė, Minija, Dreverna), or are they possibly the traces of separate small rivulets from different periods, which existed in the coastal plain till the flooding of the territory with sea water during the Early Littorina transgression?

During the marine seismic survey of the seabed (Fig. 2), seismic reflections were observed in three locations in the seismic survey cross-section I–I‘, which could be interpreted as traces of relict valleys. Such seabed anomalies were recorded 29–79.5 m deeper than the present seabed. What period do the relict rivers or traces of rivers discovered under the sediments of the seabed belong to? The fact that the detected incisions are not under the RF-I surviving relict landscapes surface and there are no signs that the land surface could have been eroded later in the RF-I site allows the assertion that the adjacent relict rivers existed during the same Yoldia Sea stage.

The palaeo-incisions (Fig. 2) detected at Klaipėda are among the fragments of the coast that existed during the Ancylus transgression (RF-III). This might confirm that the Danė and Smeltalė watercourses were in this location during the Ancylus–Early Littorina stages. Two palaeo-incisions, traced by means of the seismic survey, related to the Danė River, possibly show that the oldest watercourse changed during the Ancylus or Early Littorina stages. The connection of the prehistoric settlements with rivers that flowed into the sea is undoubted. But having not found any prehistoric settlements on the seabed, we cannot determine how this process happened on the Yoldia–Early Littorina coasts in present-day Lithuanian waters. We cannot maintain that in all cases when the sea coasts retreated, people necessarily inhabited the banks of the changing watercourses.

Conclusions

The search for traces of Late Palaeolithic–Mesolithic human subsistence and activity on the relict coasts of the Lithuanian coastal area are closely related to the Early Holocene coastal and landscape relicts underwater. The coasts changed according to the fluctuations of the sea water level; people inhabited the coastal areas which are now flooded.

During marine seismic survey, six palaeo-incisions were found in the coastal section with Rivers Danė, Smeltalė and Dreverna. The results of the research suggest that these rivers in the Early Holocene stage may have flowed through incisions that had been formed earlier by glacial activity.

According to the available data, only a few settlements of the Final Palaeolithic and Mesolithic period are known: Šventoji and Būtingė, the former Bachmann manor (Klaipėda), Venckai and Aukštumala. The low areas of the rivers that flowed into the sea, their estuaries, were the locations with favourable conditions for humans to settle in the Stone Age, but due to the fluctuation of the sea level, the watercourses changed.

The fluctuations of the Yoldia–Littorina stage and the location of the coastline in Lithuanian waters were specified according to the data from underwater research. In some places on the seabed, the fragments of the relict landscapes were surveyed. In order to establish the possible locations of prehistoric settlements on the seabed, a search for the palaeo-watercourses in the environs of palaeo-landscapes remaining on the seabed was conducted. As a result of seabed seismic survey, the seismic reflections, related to the Danė, Smeltalė, Dreverna or Minija palaeo-valleys, were traced.

The Šventoji prehistoric settlements changed location depending on sea water level changes and alterations of the Šventoji watercourse and this coincided with the typical Stone Age coastal settlement location and cost-effective hunter-gatherer economy strategy.

During the Yoldia and Ancylus regressions, in the Late Mesolithic period, the coastal area with possible coastal lakes and lagoons, as well as the Šventoji River estuary, could have been on the present seabed at a depth of about 30 m or even deeper, but they were not located during either the seismic or the underwater diving surveys. The Šventoji River changed its watercourse and estuary locations even further during the Littorina transgressions and regressions, but the estuaries of that period are in shallow coastal waters, under the marine sediments. These locations are not promising for acoustic, seismic and underwater research.

There are two known Late Neolithic–Bronze Age settlements in Palanga, adjacent to the Rąžė River. The present depths of the seabed would indicate that there was a narrow cape at Palanga during the Early Littorina stage, in the environs of which could be the palaeo-estuary of the Rąžė River. In the geographical latitude of the Rąžė River, the seabed was surveyed using side-scan sonar and by diving, but neither remains of the relict landscape nor any traces of human activity were detected at depths of 16–27 m.

At Melnragė next to Klaipėda, in the proximity of the site where the Early Neolithic T-shaped axe made of red deer antler was found, there is the known relict stump RF-II dated to the Late Mesolithic to Early Neolithic period underwater at a depth of 14.5 m. The situation of the stump find site clearly shows that the landscape has been little affected by the fluctuations of the sea water level. The coast in that location was stony, with a thin pine forest. Tall boulders stood out in the environment. The sizes and unusual shapes of some boulders might have attracted the attention of prehistoric people. However, traces of human activity were not found in their environs.

During the Ancylus regression, when the water level fell from about 18 m to about 40 m below the present sea level in the period from about 9200–8500 cal BP, the rivers that flowed into the sea could have changed their watercourse depending on the relief of the newly exposed coastal areas. Two sites at depths of 10–12 m with remaining fragments of the relict landscapes RF-III-B and RF-III-C (about 9500–8800 cal BP) can be related to the presumed relict estuary of the River Danė. Palaeo-incisions II–2 and II–3 detected during the seismic survey are related to the changing watercourse of the Danė River. No archaeological finds were detected during the underwater research. In the present Danė River lowland, only one find site is known so far — the former Bachmann manor, ascribed to the Late Palaeolithic period.

The Smeltė site is known at the present esturary of the Smeltalė River. The palaeo-watercourse and its tributaries related to the Smeltalė River were detected during the seabed seismic survey at the site of palaeo-incision II–1, between underwater sites RF-III-A and RF-III-D.

No finds from the prehistoric period were detected during the underwater research. The estuary of the Dreverna (or Dreverna-Minija) palaeo-river changed its location during the Yoldia–Ancylus stage. During the seismic survey, three sites of the former watercourses (Palaeo-incisions I–1, I–2, I–3) were detected to the south of the site RF-I, where the palaeo-landscape fragments have survived with the former pine forests, swampy lakes and lagoons. This flooded site of the Yoldia Sea stage is promising for the search for Early Mesolithic settlements.

The seabed in the location of the flooded Nemunas palaeo-estuary was surveyed by diving at depths of 14–33 m. The search was carried out in locations where the side-scan sonar survey showed unusual seabed formations. Neither undamaged relict coast formations nor traces of human activity were detected. It is still not known whether people lived only in Aukštumala or also closer to the Nemunas estuary of that time, when the sea coasts presently at a depth of 25–30 m (RF-I) still existed.

The analysis of previous data and our research indicate the directions for further searches in the current and now flooded southeastern shores of the Baltic Sea. The surveys conducted showed that the more promising locations for the future search for Stone Age settlements underwater could be the surviving underwater palaeo-landscapes closer to the palaeo-rivers and estuaries detected using seismic survey.

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Abbreviation

Archaeol. Baltica – Archaeologia Baltica

ATL – Archeologiniai tyrinėjimai Lietuvoje ... metais / Archaeological investigation in Lithuania in .... Vilnius: Lietuvos archeologijos draugija

Hundred Years – G. Zabiela, Z. Baubonis, E. Marcinkevičiūtė eds. *A Hundred Years of Archaeological Discoveries in Lithuania*, Vilnius: Lithuanian Archaeology Society

Lietuvos Arch. – Lietuvos archeologija

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PRIEŠISTORĖS GYVENVIETĖS IR UPĖS LIETUVOS PAJŪRYJE ANKSTYVAJAME HOLOCENE

VLADAS ŽULKUS, NIKITA DOBROTIN

Santrauka

Vėlyvojo paleolito, mezolito ir neolito laikotarpių žmonių gyvenimo vietų paieškos tuometinėse jūros pakrantėse yra tiesiogiai susijusios su ankstyvojo holoceno krantų reliktais ir upių paleovagomis dabartinėse pakrantėse ir po vandeniu. Į jūrą įtekėjusių upių estuarijos ir žiotys akmens amžiuje buvo vietos, palankios žmonėms gyventi, tačiau, svyruojant Baltijos jūros vandens lygiui, keitėsi ir upių vagos, o kartu ir gyvenvietės (2, 6 pav.).

Šiame straipsnyje pajūrio akmens amžiaus gyvenviečių archeologinių tyrimų duomenis siekiama susieti su tyrimais, atliktais po vandeniu, ir seisminių jūros dugno tyrimų rezultatais (1 lentelė, 3–5 pav.). Šventosios akmens amžiaus radavietės yra labai susijusios su besikeičiančiomis Šventosios upės vagomis. Vėlyvojo mezolito laikotarpiu Šventosios upės žiotys galėjo būti dabartiniame jūros dugne apie 30 m gylyje ar dar giliau. Litorinos periodo vagų vietos yra priekrantės vandenyse arba visai arti dabartinių krantų. Šventosios paleovagos buvo ieškota tyrinėjant jūros dugną 16–21,5 m gyliuose. Rąžės upelio (Palanga) žiočių platumoje 17–25 m gyliuose jūros dugnas buvo tyrinėtas šoninės apžvalgos sonaru ir nardant. Melnragėje (prie Klaipėdos), nedidelių pajūrio upelių aplinkoje, rastas ankstyvojo neolito laikotarpio dirbinys, o po vandeniu, 14,5 m gylyje, aptiktas to paties laikotarpio reliktinis kelmas RF-II.

Jūros dugno seisminių tyrimų metu šešiuose profiliuose buvo fiksuoti seisminiai atspindžiai, siejami su Danės, Smeltalės, Drevernos ar Minijos upių paleoslėniais (8 pav.). Reliktinės Danės upės vagos vietos galėjo būti 10–12 m gylyje esančių Anciliaus–Litorinos periodų reliktinių kraštovaizdžių vietovių RF-III-B ir RF-III-C aplinkoje. Seisminių tyrimų metu tikėtina Smeltalės upelio paleovaga buvo aptikta tarp vietovių RF-III-A ir RF-III-D su išlikusiais povandeniniais reliktiniais kraštovaizdžiais. Vykdant seisminius tyrimus, jūros dugne buvo identifikuoti trys paleoįrėžiai, siejami su Joldijos–Anciliaus periodų Drevernos paleoupės pėdsakais. Jie yra į pietus nuo RF-I vietovės su jūros dugne gausiai išlikusiais ir 24–32 m gylyje tyrinėtais paleokraštovaizdžio reliktais. Ši vieta yra perspektyvi ieškant ankstyvojo mezolito radaviečių. Nemuno paleodeltos vietoje jūros dugnas buvo tyrinėtas nardant 14–33 m gylyje, kur žvalgant šoninės apžvalgos sonaru buvo fiksuotos neįprastos dugno formacijos. Nesuardytų reliktinių krantų nebuvo aptikta.

Tyrinėjant jūros dugną, kol kas nerasta priešistorės žmonių veiklos pėdsakų. Tolesnėms akmens amžiaus vietovių paieškoms jūros dugne būtų perspektyvesni arčiau paleoupių vagų esantys rajonai su išlikusiais paleokraštovaizdžiais.