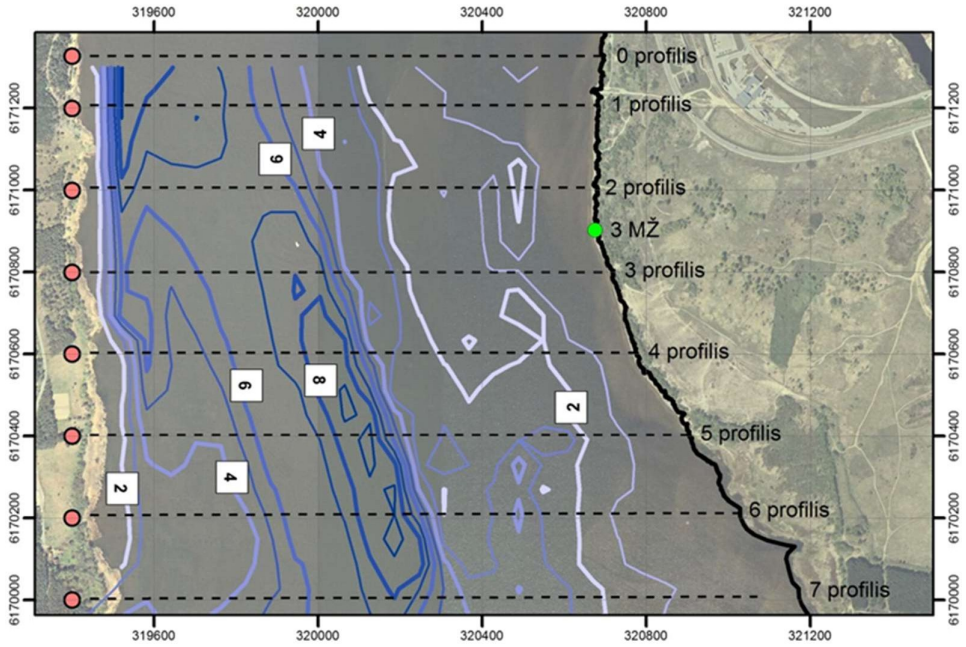


4.6.1.8 Fig. Locations of cross-sectional profiles along the coast of the Smeltė Peninsula. The 2022 shoreline corresponds to the situation shown in the satellite image from March 14, 2022 (Google Earth).

Relatively minor changes to the island's shoreline, mostly caused by ice drift and biogenic processes, have also occurred over the past 50 years. The construction (2014) and operation of the LNG terminal did not have a significant impact on changes in the island's shoreline contour or its morphology (Fig. 4.6.1.9).

Coast of the Curonian Spit Lagoon

Coastal condition. From the start of the distal part of the southern pier (PK10), along a stretch of approximately 8.8 km (up to PK73), the Curonian Spit coast is reinforced with breakwaters of various purposes and types. Therefore, no shoreline changes are occurring in this section. It should be noted, however, that in certain locations along this stretch, where water from the Klaipėda Strait seeps through the breakwater openings and washes away the soil, sinkholes are forming. It should be noted that some of them were filled in after 2018, but south of II Perkėla, three new ones are currently forming, with the following coordinates (LKS-94): 1 – 319701 6175761 (5 m x 1 m), 2 – 319712, 6175743 (5 m x 2 m), 3 – 319709, 6175478 (1 m x 1 m). The southernmost section of the pier (approximately 360 m long) was not fully completed (coordinates of the pier's end in LKS-94: 0319745, 6174630).

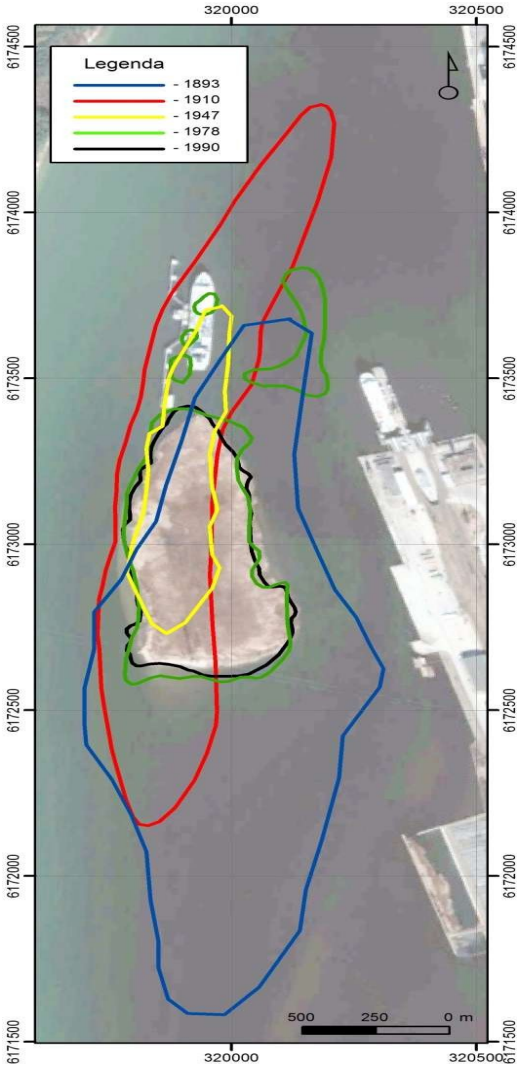
South of the breakwater, along a stretch of approximately 4.6 km along the shoreline (up to the Alksnynė station), there is a section of natural shoreline (Fig. 4.6.1.2). The beaches in this section are narrow and shallow. The beaches widen southward from 7–9 m in the northern part to 15–17 m in the southern part, and near Alksnynė, the beaches, overgrown with reeds, widen to 17–20 m. It should be noted that the position of the shoreline, and consequently the width and height of the beach in this section, vary considerably over time and space. The cause of these changes is frequent, sudden, and relatively large-amplitude fluctuations in water level. They are particularly

significant during the spring flood and ice drift: based on the spread of debris and reed fragments

, as well as marks on tree trunks, it can be concluded that the rise in lagoon water level in this section can reach up to 80 cm.

Along the studied section, the average beach height varies slightly—from 0.8 to 1.2 m. The landscape elements bordering the beach are characterized by much greater diversity. Here, there are steep sand cliffs 3–4 m high, low meadows, and terraces extending high up, in some places even reaching 14 m in height (near Kiaulės Nugaros Island).

The beaches in the study area are composed of sand of varying grain sizes. The average diameter of sand particles increases toward the south, ranging from 0.21 mm in the northern part, 0.28 mm in the central part, to 0.40 mm opposite the southern tip of Kiaulės Nugaros Island. South of Kiaulės Nugaros Island, the sand grains become finer, down to 0.25 mm, and in the southernmost part of the study area, the beaches are covered with silt and organic debris.



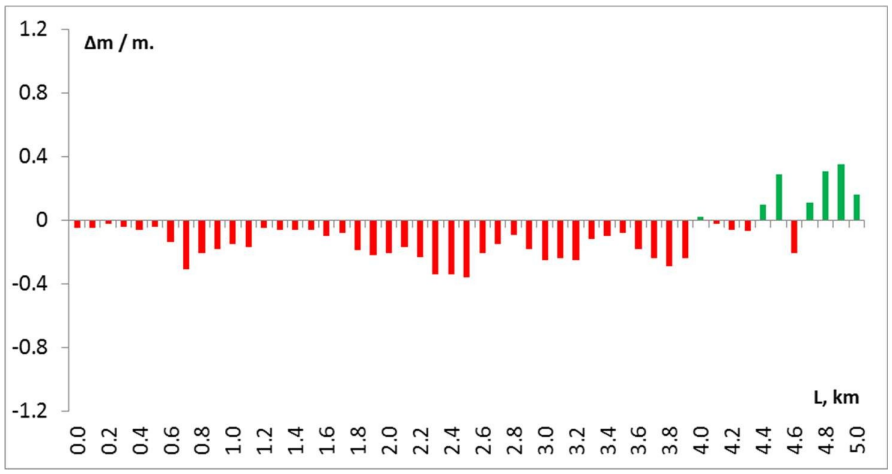
4.6.1.9 Fig. Dynamics of the Kiaulės Nugaros shoal (1893, 1910, and 1947) and the island (1978, 1981, and 2022) over the past 130 years. The 2022 shoreline position corresponds to the situation shown in satellite image from March 14, 2022 (Google Earth).

Geodynamic trends. A comparative analysis of cartographic data from 1910 to 2022 showed that during this period, the shoreline of the analyzed section receded at an average rate of 0.1 to 0.4 m per year (Fig. 4.6.1.10).

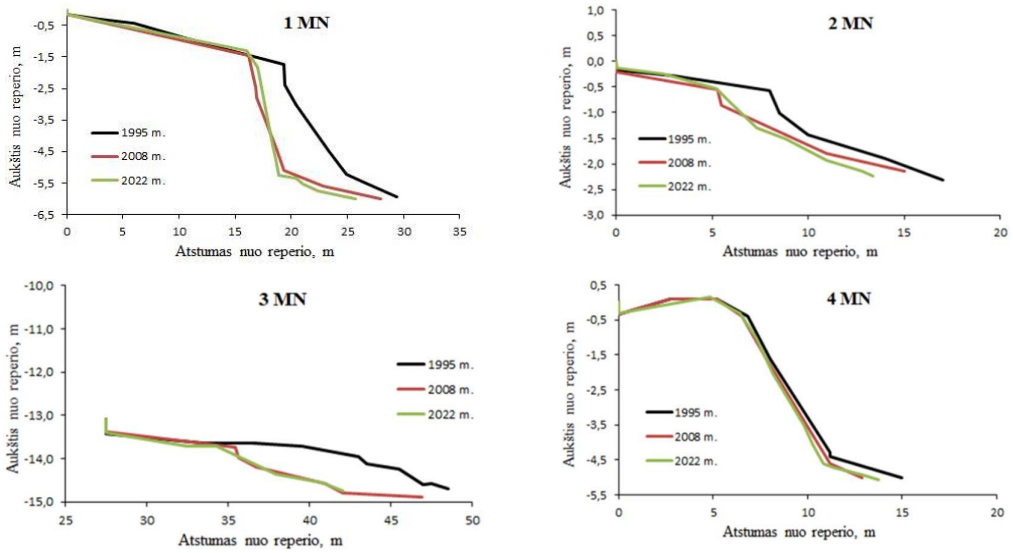
The shoreline dynamics of the past 27 years can be assessed based on KVJU monitoring data (Fig. 4.6.1.11). Summarizing these data, it can be stated that:

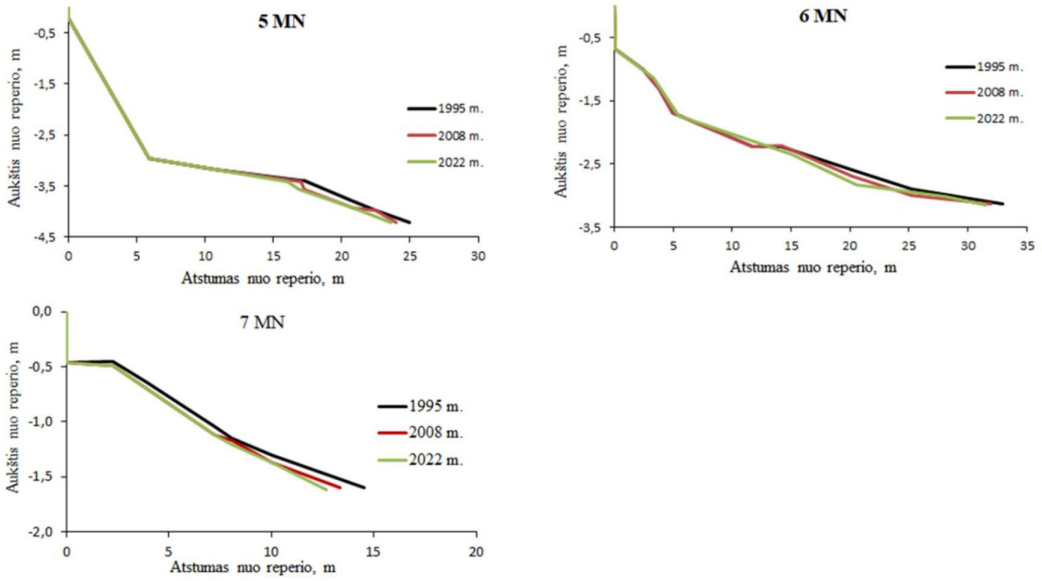
1 – more intense erosion occurred in the northern and central parts of the section; in the southern part of the section, it was negligible (Figs. 4.6.1.12–4.6.1.13),

37. – the period from 1995 to 2008 was characterized by higher erosion intensity; subsequently (2008–2022), it slowed significantly, and in the southern section, erosion has nearly ceased.

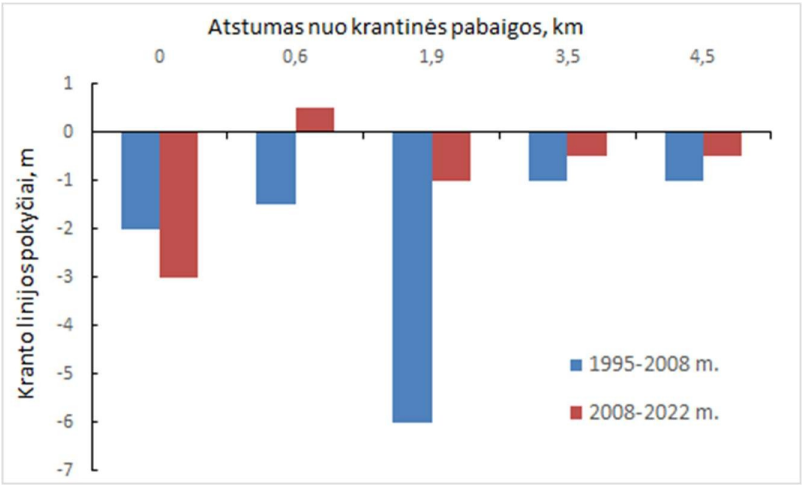


4.6.1.10 Fig. Dynamics of the Curonian Spit shoreline between 1910 and 2022

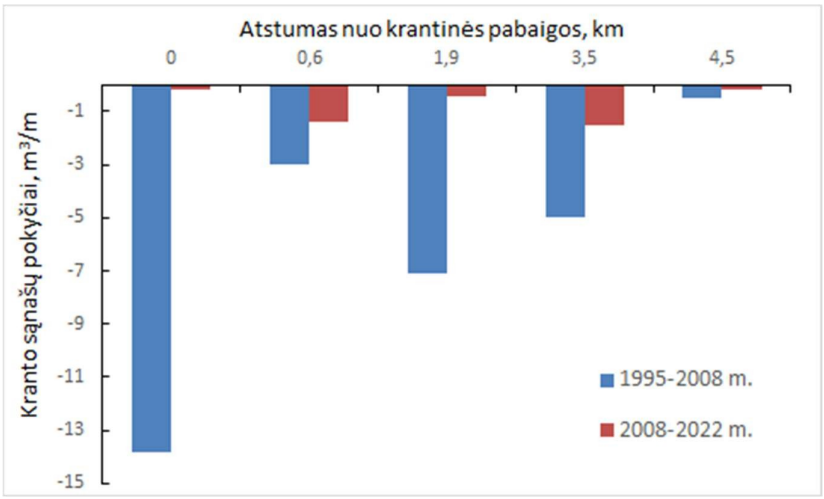




4.6.1.11 Fig. Changes in the Curonian Spit coastline in cross-sectional profiles during the period 1995–2022. Profile locations are shown in Figs. 4.6.1.2 and 4.6.1.16.



4.6.1.12 Fig. Changes in the shoreline between the end of the pier (PK 73) and Alksnynė (PK 117) during the periods 1995–2008 and 2008–2022



4.6.1.13 Fig. Changes in the amount of shoreline sediment in the shoreline section from the end of the pier (PK 73) to Alksnynė (PK 117) during the periods 1995–2008 and 2008–2022

Coastline. While natural processes determined the dynamics of the spit's coastline in the first half of the 20th century, anthropogenic activity caused fundamental changes in the second half of the 20th century. In the first half of the 20th century, due to the accumulation of transit sediments in the Kiaulės Nugaros shoal, intensive accumulation along the coast of the Smeltė Peninsula, and the shallowing of the eastern channel, increasingly larger volumes of water from the Curonian Lagoon were forced to flow through the western channel. This, in turn, accelerated the erosion of the western channel's shoreline and seabed. However, the greatest impact on the shoreline and seabed here was caused by the deepening of the fairway in the 1960s
to 10–11 m (the former Soviet submarine pier was located about 940 m north of the Alksnynė forester's homestead). This pier was burned down around 2001–2004. Significant changes in depth quite quickly led to the erosion of the foreshore slope and, over time, the erosion of the Curonian Spit lagoon shore. Apparently, this prompted the military to construct a continuous stone breakwater at the end of the foreshore, about 25–30 m from the shoreline underwater (at a depth of approximately 1.0 m), which is now about 0.2–0.4 m high, and a base width of about 1.5–2.0 m. However, at present it is nearly continuous only in the northern section of the stretch, while in the southern section only fragments remain, and these are significantly closer to the shore (Fig. 4.6.1.14). It is likely that they ended up here during ice drifts. Unfortunately, no data or information has been found regarding this shoreline reinforcement, its construction date, parameters, shoreline protection effectiveness, etc. It was discovered only this year during measurements of the foreshore depth.

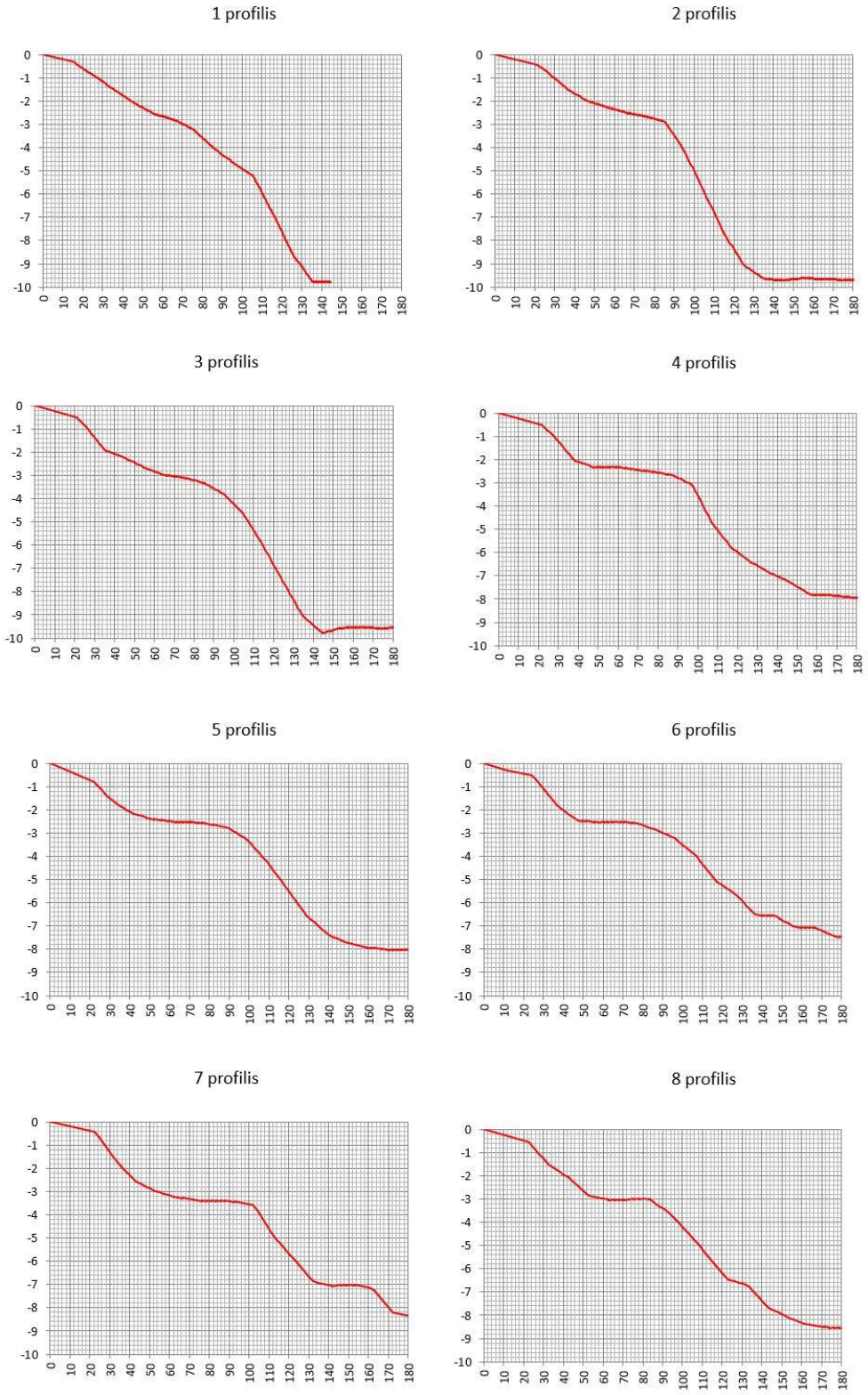
The morphological features of the Curonian Spit lagoon foreshore are reflected in the data presented in Fig. 4.6.1.15. These show that the foreshore of the Curonian Spit is narrow, reaching a width of only 20–30 m in places. Only in the southernmost part, where the dredged channel ends, does the foreshore widen to 40 m (Prof. 22) and 50 m (Prof. 24). The shape of the foreshore slope and its gradient along the coast vary depending on the distance of the channel from the shore. In the northern part of the section, where the channel is 135–145 m from the shore (Prof. 1–3), the foreshore is steep, triangular, with a clearly defined step. Its average gradient is 0.0800 (Profile 1) and 0.0741 (Profile 3). To the south (Prof. 4–9), as the fairway moves even further from the shore (up to 160 m and more), the three-sided shape persists, but the slope gradually flattens as its gradients decrease (from 0.0532 – Prof. 4 to 0.0439 – 9 fathoms), the slope gradually flattens. From depth 9, as the channel approaches the shore again (120 m – depth 10, 85 m – depths 15 and 16), the slope

of the ledge becomes steeper (0.1074 – depth 10, 0.1243 – 16 fathoms), its contour approaches a straight line, and at 16–19 fathoms, it becomes exactly that. At 19 fathoms, as the fairway approaches the shore to 55 m, the steepest slope of the backwater is recorded

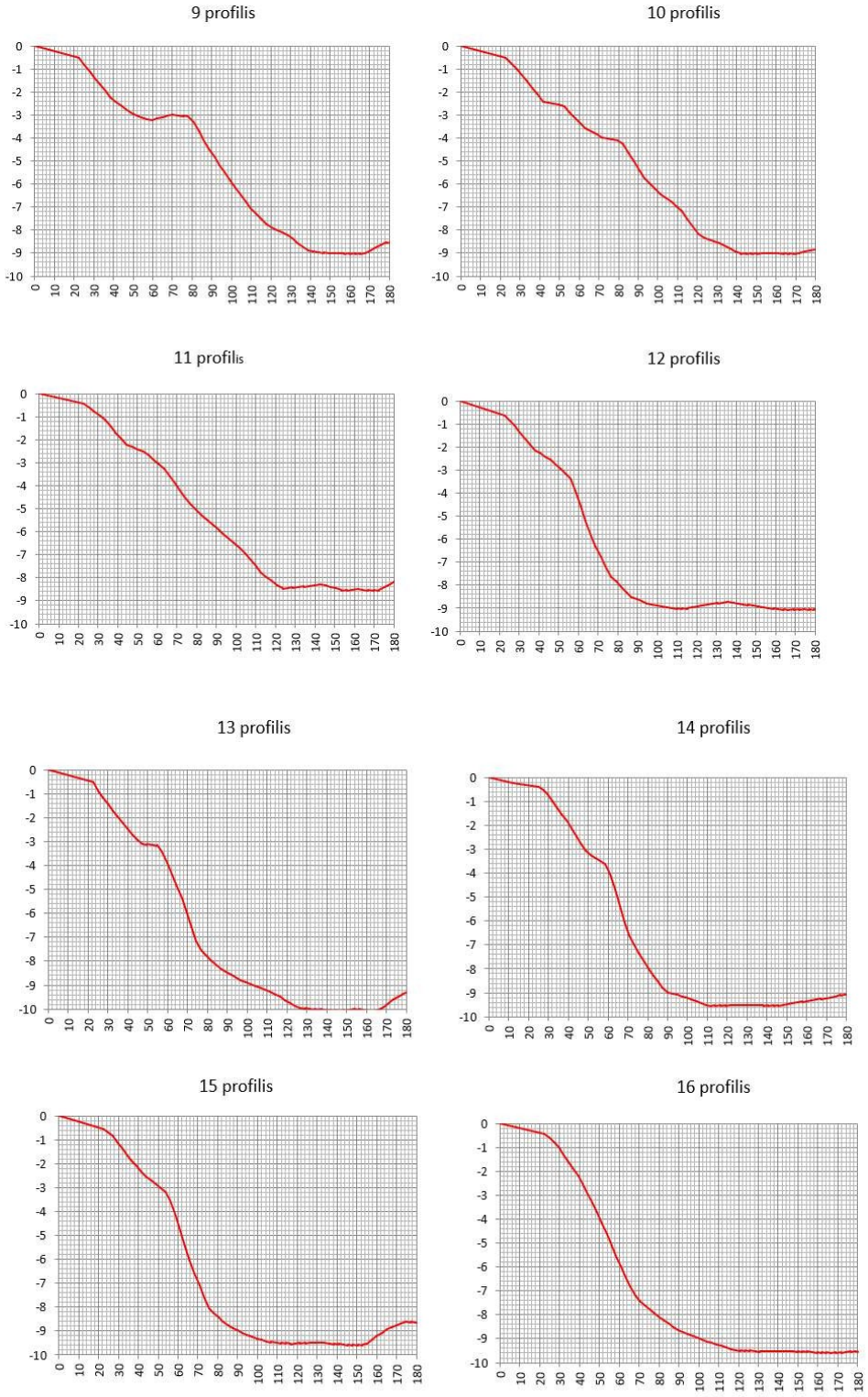
(0.2159) along the entire stretch. Specifically, at depth 19, there was a submarine dock. The channel depths here currently range from 8.5 to 9.0 m. South of the former dock, as the channel moves away from the shore (75 m – depth 20, 135 m – 24 m) and its depth decreasing significantly (6.8 m – 20 m and 3.4 m – 24 m), the slope of the foreshore also flattens significantly (0.1365 – 20 m and 0.0247 – 24 m). The contour of the slope remains nearly straight.



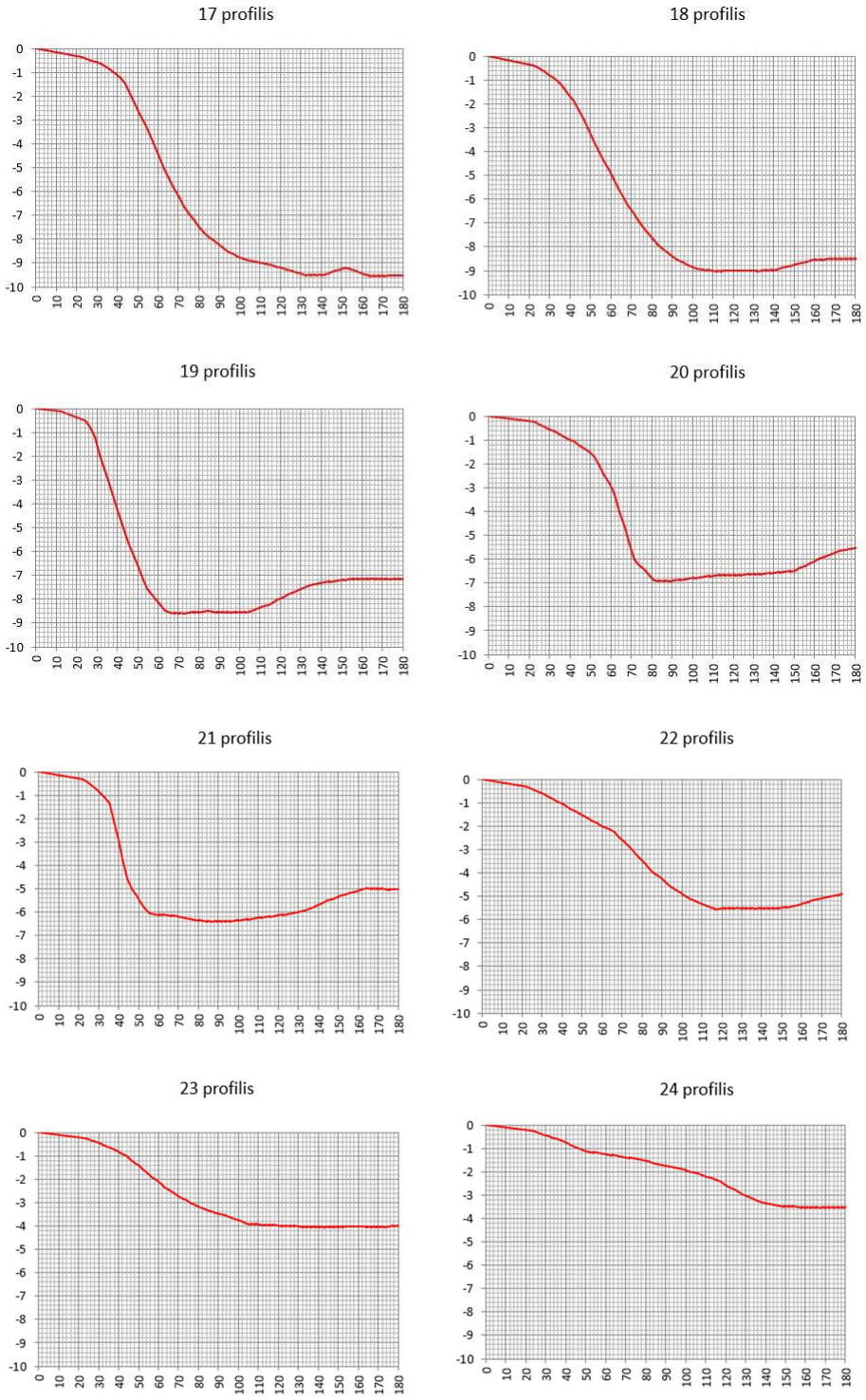
4.6.1.14 Fig. Fragments of annual layers in the foreshore (marked with arrows)



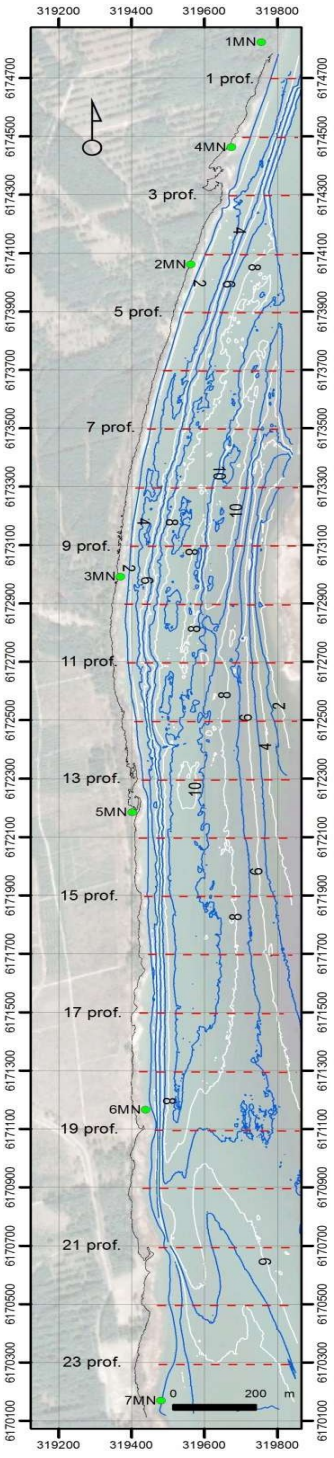
4.6.1.15 Fig. Transverse profiles of the Curonian Spit foreshore (profile locations shown in Fig. 4.6.1.18)



4.6.1.16 Fig. Transverse profiles of the Curonian Spit foreshore (profile locations shown in Fig. 4.6.1.18)



4.6.1.17 Fig. Transverse profiles of the Curonian Spit foreshore (profile locations shown in Fig. 4.6.1.18)



4.6.1.18 Fig. Bathymetry of the Curonian Spit lagoons (September 5, 2022), location of coastal profiles (red dotted line), and locations of shoreline monitoring profiles (green dots). The 2022 shoreline position

corresponds to the situation shown in the satellite image from March 14, 2022 (*Google Earth*).

4.6.2 Significant impact is expected

Impact on Shores During Implementation of the Project Solutions

A detailed description of the solutions is provided in other sections of the EIA report for the PŪV. Therefore, only the most general aspects of the implementation of the PŪV solutions that may affect the condition of the shoreline are mentioned below.

The mainland shore of the Curonian Lagoon (for all project alternatives). During the construction of the southern port gates, the western shore of the Smeltė Peninsula will undergo significant changes: in its northern part (near berths 151–152), the area will be expanded; in the central part, a container terminal area will be established; and in the southern part, a marina will be created following the construction of the southern port gate breakwater (protective dam). Consequently, the spatial position of the shoreline will change; it will be stabilized by the piers and the protective breakwater. There will be no significant damage to the shoreline during the construction process if the construction work is limited to the area behind the structures being built. On the other hand, the shoreline within the project area has already undergone several man-made transformations due to economic activities carried out here in the past and currently underway (see Section 4.6.1).

Kiaulės Nugaros Island*.* During the construction of the southern port gates, it is planned to dredge the majority of Kiaulės Nugaros Island on the eastern and southern sides: approximately 78% for Alternative A2, approximately 76.7% for Alternative A3, and approximately 79% for Alternative A4. Consequently, the length of the island's shoreline will be significantly reduced. Furthermore, it will be straightened on the eastern and southern sides. As a result, the outline of Kiaulės Nugaros Island will change drastically during the implementation of the construction solutions.

The coast of the Curonian Spit (for all PŪV alternatives). During the construction of the southern port gates, several factors may affect the eastern coast of the Curonian Spit: the construction of the Alksnynė dam, the deepening of the water area, and the reduction of water flow (due to the construction of the container terminal and protective dams, and the formation of new land areas). Only the construction of the Alksnynė dam will have a direct impact on the Curonian Spit coast due to changes in sediment flow dynamics caused by altered water currents. During this construction process, damage to the shoreline would also be minimal. Minor shoreline disturbances are associated with the construction of an access road to the construction site and the possible formation of short (up to 10–50 m in length) shoreline segments on both sides of the dam (on both sides of the dam) short (up to 10–50 m in length) sections of the shoreline and direct contact with the lagoon due to the movement of self-propelled machinery (used in construction) and the temporary storage of construction materials on the shoreline. Due to the dredging of the water area and works that reduce water permeability, only an indirect impact on the spit's shoreline is expected. Global practice regarding such works shows that the shoreline's response to these works is typically inert over time (Šuiskyj et al., 1987; Kudale, 2010; Žilinskas et al., 2020). Since the aforementioned works are not directly related to the Curonian Spit shoreline, their impact on the shoreline may manifest not so much during their implementation as after several or even a dozen years.

Impact on the shores following the implementation of the PŪV solutions

The mainland shore of the Curonian Lagoon. The planned construction of the southern port entrance on the Smeltė Peninsula—both north and south of it (in all PŪV alternatives)—will not have a significant negative impact on the adjacent mainland shore of the Curonian Lagoon. The shoreline north of the southern port entrance will be stabilized in time and space by the breakwaters; south of the port entrance, current geodynamic trends will persist. After the construction of the southern protective dike, there is a possibility of even minor accumulation south of it. However, during high-

flow winter-spring floods and spring floods, it is likely that larger areas of the shore will be flooded during the backwaters forming south of the protective dam, and if the ice drift coincides with strong westerly winds, ice floes may damage the shore in local areas.

The coast of the Curonian Spit and Kiaulės Nugaros Island. The PŪV territory of the Southern Gate borders a section of the natural coast of the Curonian Spit Lagoon located between the end of the reinforced shoreline to the north and Alksnynė to the south (PK73–PK117). This stretch of the shoreline may be sensitive to the restructuring of the adjacent water area and the accompanying changes in the natural environment. Therefore, due to reduced water permeability and, consequently, increased flow velocities (especially during high discharge periods), more frequent wave action caused by intensified shipping, increased amplitude of water level fluctuations in the lagoon, the increased frequency of potential ice jam formation, the deepening of the adjacent water area, and the construction of hydraulic structures—the erosion of the lagoon shore and Kiaulės Nugaros Island may intensify. We will briefly discuss the potential impact of these factors on the shore.

Modeling results and a detailed analysis of changes in the Klaipėda Strait's flow capacity, water backwater, flow velocities, and sediment transport following the implementation of the PŪV solutions, along with a detailed analysis thereof, were conducted by staff at the Lithuanian Energy Institute [18] and are presented in the next section of the PŪV EIA and in Textual Appendix 3. Therefore, the subsequent analysis of changes in the coastal zone of the study area is based on the results of the aforementioned studies without repeating them.

Due to the amplitude of water level fluctuations and increased flow velocities, there may be an impact on the spit's shores and Kiaulės Nugaros Island. At the southern gate, the formation of backwaters will become more frequent due to reduced water flow during winter–spring floods or summer–autumn high tides and severe storms. The location of these backwaters (north or south of the gates) will depend on the difference in water levels between the sea and the lagoon. Additionally, their amplitude will increase. As the resulting water level floods the low-lying beaches of the Curonian Spit or the edges of Kiaulės Nugaros Island, wave action will increase, as will shoreline erosion caused by ice drifts and tidal currents. Specifically, the increased frequency of backwaters and the rise in their amplitude will cause changes in current velocity in the area of the southern gates. The results of flow velocity modeling show that, when comparing Alternative "0" with the others, flow velocities will increase in all other PŪV alternatives (only the intensity and location will differ). And although, due to the effect of the "roughness" of the foreshore, changes in current velocity near the spit's shore will be smaller than in the fairway, the narrow foreshore and its relatively steep slope (Figs. 4.6.1.15–4.6.1.17) the increase in velocity will have a negative impact (albeit of varying intensity) on the entire stretch of the spit's shoreline (from the "southern gate" to the start of the pier and Kiaulės Nugaros Island). This is all the more so given that erosion trends currently prevail along most of the spit's shoreline (Figs. 4.6.1.10 and 4.6.1.11).

The potential impact of dredging the water area to a depth of 17 m and the installation of hydraulic structures on the Curonian Spit coastline and Kiaulės Nugaros Island will directly depend on the distance from the 17-meter depth line to the shoreline. The intensity of the dredging works' impact on the shoreline condition will also be significantly influenced by the characteristics of the water area's topography (see Section 4.6.1). The construction of hydraulic structures and the formation of new land areas in the southern gate water area will, in turn, reduce water flow and alter the flow structure. The effects of the aforementioned factors in the case of Project Alternatives 2A, 3A, and 4A, compared to the implementation of Alternative "0," are reflected in the data presented in Figure 4.6.2.2 for cross-sectional profiles of the study area's water body. It should be noted that the locations of the cross-sectional water body profiles (Fig. 4.6.2.2) were not selected sequentially (at equal distances from one another), but rather to reflect the changes in the water body for all project alternatives.

North of PK73, the spit's shore is protected by breakwaters. However, the condition of the breakwaters is currently only satisfactory in some places. Upon completion of the dredging of the inner navigation channel to a depth of 17 meters, the distance between the western 17-meter isobath and the breakwater would be only about 70 meters in some places (for example, at

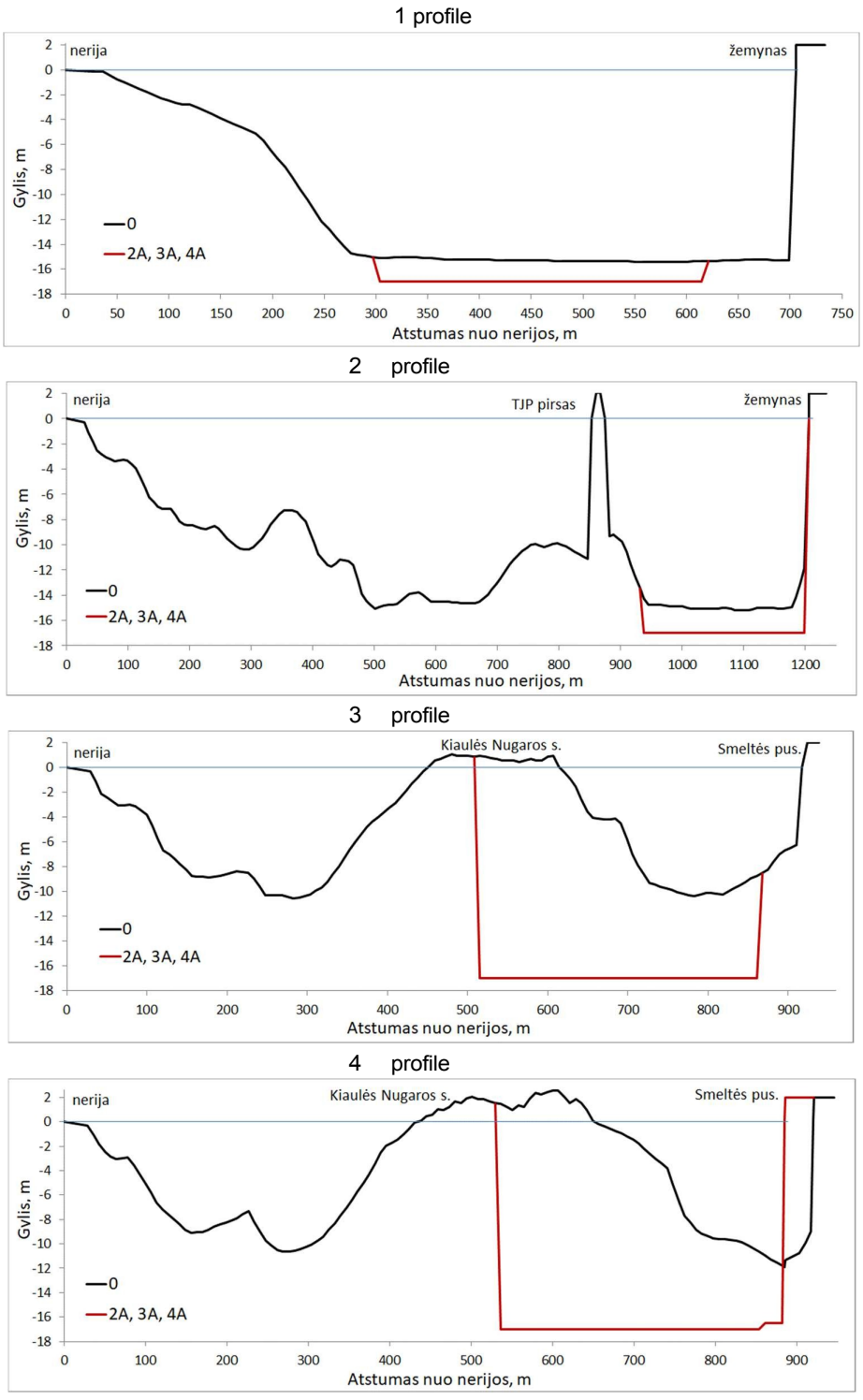
PK62). Therefore, in the future, as the soil at the base of the breakwater erodes and sinkholes form, it will need to be repaired.

Dredging may have a negative impact on the spit's shoreline and the section of the shoreline located south of the end of the quay between PK73 and PK76 (Fig. 1, Profile 1). Although the shoreline here is already about 160–180 m from the 17-meter isobath of the planned dredging area, the already steep slope of the spit's foreshore (Fig. 4.6.1.15, Profiles 1–3) would become even steeper after dredging; consequently, over time, sediment from the foreshore and its slope, dislodged by waves and currents and acted upon by gravitational forces, would move seaward. The foreshore would narrow, which would also accelerate coastal erosion. Moving southward from PK76 to PK85, the distance between the spit's shoreline and the 17-meter isobath increases to approximately 820–850 m at PK84–PK85 (Fig. 4.6.2.2, Prof. 2). At the same time, the slope of the Curonian Spit's foreshore flattens and lengthens accordingly (Figs. 4.6.1.15–4.6.1.16, Profs. 4–9). The slope of the deepened water area here should no longer have direct contact with the foreshore of the Curonian Spit and its slope. On the other hand, the slopes of the water area dredged to a depth of 17 m are planned to be formed as gentle slopes (with a gradient of no less than 1:6), i.e., their slope tg α will be approximately 0.167. Given that fine or silty sands predominate in the study area at the dredging site (Klaipėda State Marine..., 2009), the slopes of the dredged water area would be flatter than their natural angle of repose. Therefore, it is likely that dredging works in the aforementioned section would not have a significant impact on the spit's shoreline. The results of current modeling show that, for various discharge rates as currents flow from the lagoon, the current velocity near the spit's shores in this section would not increase or would increase only slightly for all PŪV alternatives. And in the case of currents from the sea, the current velocity would even decrease.

The changes in the seabed of the water area near Kiaulės Nugaros Island (PK86–PK93) envisaged by the PŪV are reflected in

4.6.2.1 the data presented in Fig. (Profiles 3–5). In the eastern channel near the northern and central parts of the island, changes to the waterway bottom (as well as the dredging of the island) are similar for all PŪV alternatives (Fig. 4.6.2.1, Profiles 3–4). However, the solutions of the PŪV alternatives differ significantly (due to the spatial position of the turning point) in the southern parts of the island and the water area (Fig. 4.6.2.1, Prof. 5). While in the case of Alternative 3A a small part of the island remains after dredging, in the case of Alternatives 2A and 4A, no part of the island remains at this location, and the 17 m isobath approaches (closest in the case of Alternative 4A) the spit's shore (Fig. 4.6.2.1, Profile 5). Therefore, in this location, dredging under Alternative 4A may eventually have a negative impact on the spit's shore as well. Dredging works in the eastern channel will undoubtedly have a significant impact on the Kiaulės Nugaros Island. Moreover, as water flows out of the lagoon, the flow velocity here will increase in all alternatives (only the magnitude of the changes will differ). Similar patterns apply to the section roughly between PK93 and PK96, though here, in the case of Project Alternatives 2A and 4A, the 17-meter isobath will come even closer to the spit's shoreline (Fig. 4.6.2.1, Profile 6) than in the case of Alternative 3A.

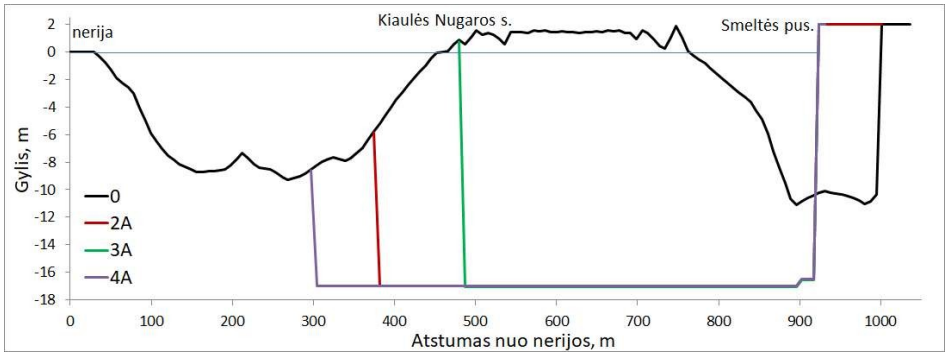
In the section roughly between KP96 and KP110, relatively large differences emerge between the PŪV implementation alternatives not only in terms of dredging but also in the extent of land formation and its spatial location (Fig. 4.6.2.1, Profiles 7–9). Since land reclamation will occur on the eastern side of the lagoon in all PŪV alternatives (only the areas will differ), and quays for various purposes will be constructed along the contact line with the lagoon, the shoreline will not change in this location.



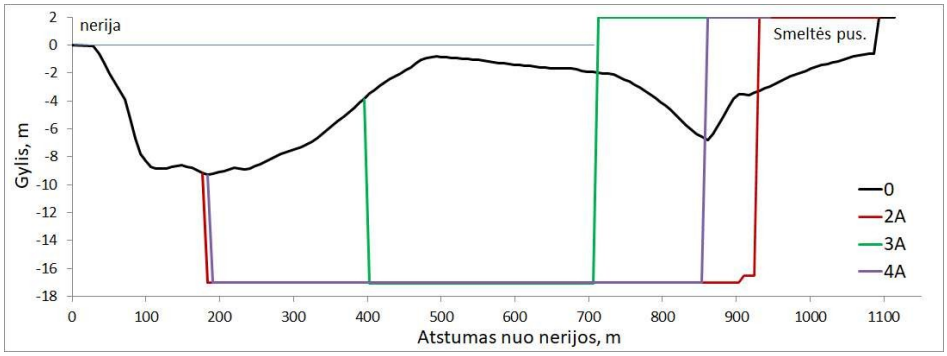
4.6.2.1 Fig. Characteristics of the seabed morphology in the study area (Alternative "0") and their changes in cross-sections following the implementation of PŪV alternatives 2A, 3A, and 4A. Profile locations

are shown in Fig. 4.6.2.2.

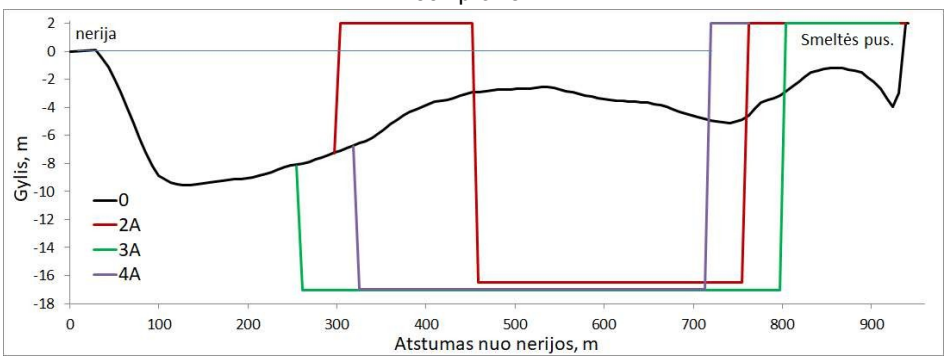
5 Profile



38. profile



39. profile



Profile 8

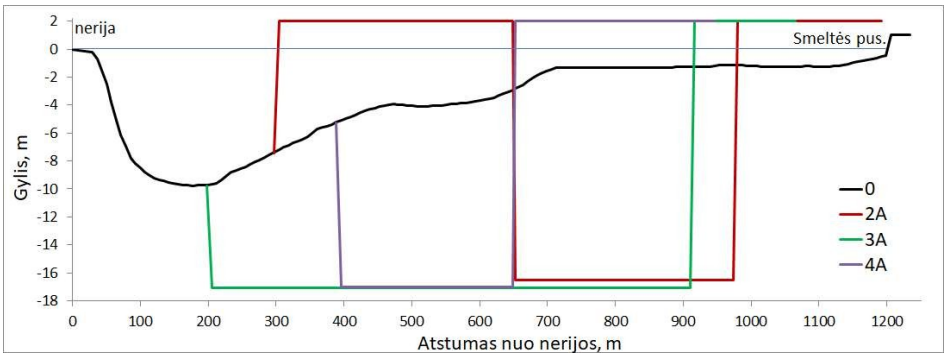
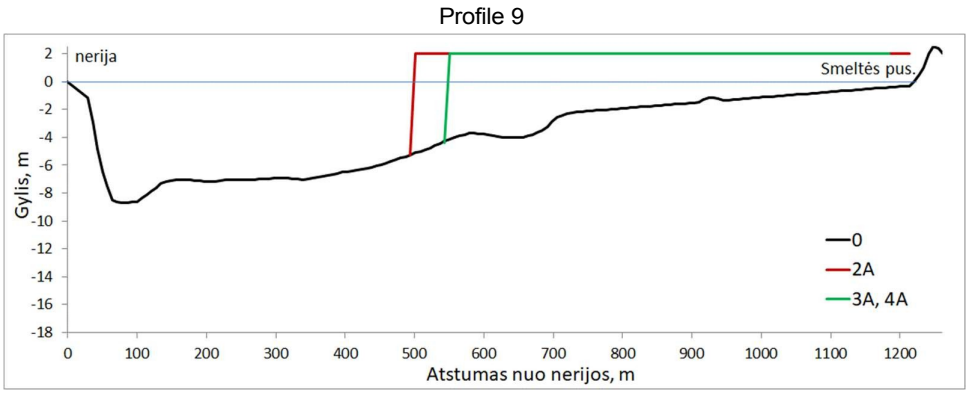
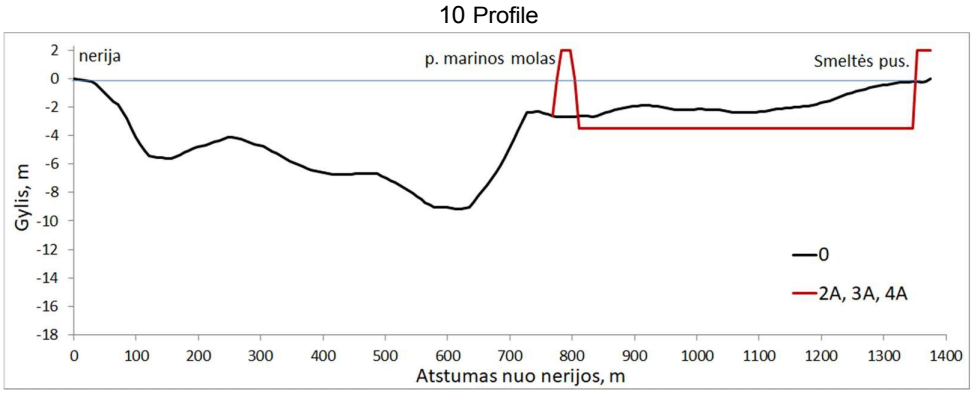


Fig. 4.6.2.1 (continued). Characteristics of the seabed morphology in the study area (Alternative "0") and their changes in cross-sections following the implementation of PŪV alternatives 2A, 3A, and 4A. Profile locations

5 Profile
are shown in Fig. 4.6.2.2.





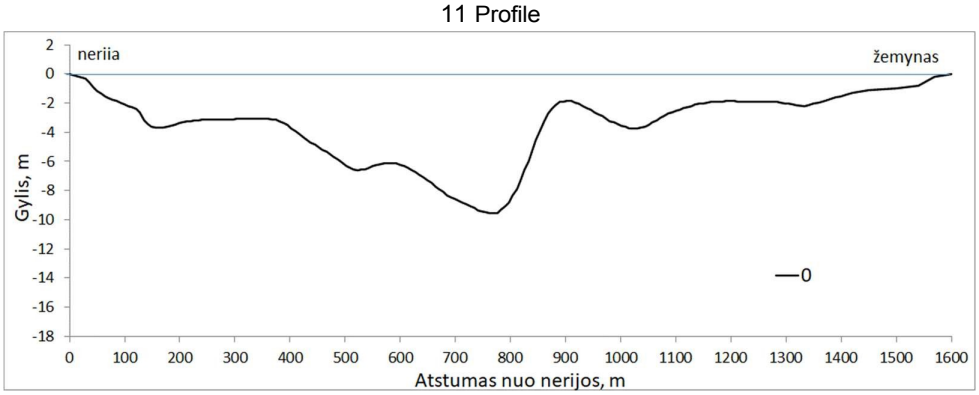


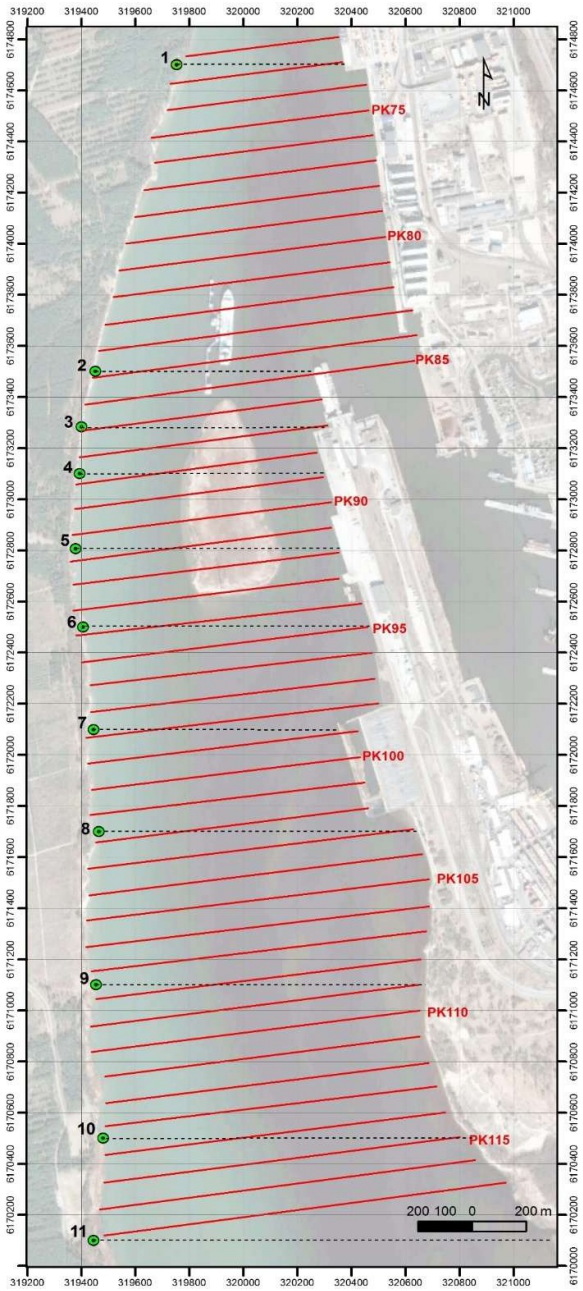
Fig. 4.6.2.1 (continued). Characteristics of the seabed morphology in the study area (Alternative "0") and their changes in cross-sections following the implementation of PŪV alternatives 2A, 3A, and 4A. Profile locations

are shown in Fig. 4.6.2.2.

The 17 m isobath (due to the formation of the turning point) comes closest to the spit's shoreline in the case of Alternative 3A (Fig. 4.6.2.1, Profs. 7–8), and, due to the spatial location of land formation, the western channel will narrow the most in the case of Alternative 2A (Fig. 4.6.2.1, Profiles 7–9). Although in the case of other PŪV alternatives, backwaters will form more frequently and with greater amplitude in this section than in the case of Alternative "0." Therefore, the flow velocity will increase significantly

both as they flow from the lagoon and from the sea. All of this will eventually have a negative impact on the spit's shoreline.

In the southernmost part of the study area (KP 110 – KP 117), dredging works are not planned (Fig. 4.6.2.1, Profile 10). Here, water flow will be reduced only by the marina piers. Dredging the inner marina basin to a depth of 3 m will have no impact on the shores. The characteristics of the seabed relief south of the marina basin are reflected in the data presented in Fig. 4.6.2.1 (Section 11).



4.6.2.2 Fig. Cross-sections in the study area. PK – survey points, 1–11 – profile numbers

It should be noted that the narrowing of the channel at the southern gate is intended to limit the intrusion of saltwater into the lagoon. For this purpose, Alternative 2A, which ensures the lowest water flow, is arguably the most suitable, while Alternative 3A is the least suitable. However, in terms of shoreline stability, the opposite is true: Alternative 2A is the least suitable, while Alternative 3A is the most suitable. Alternative 4A should be considered an intermediate option.

Impact of wave generation by vessels. Upon implementation of the PŪV solutions (new quays, a marina for small and recreational vessels), the movement of various types of watercraft in the southern gate area will increase. Even a simple motorboat can generate a wave of up to 0.5 m, while speedboats can generate waves of 0.75–0.9 m or even higher (Kurennoy, 2009). The increased wave action caused by watercraft will also affect the condition of the shores of the Curonian Spit and Kiaulės Nugaros Island. This is especially true given that the beaches along the Curonian Spit are low and narrow, and the foreshore is narrow as well. For these reasons, in many places along this stretch, waves will reach the shore more frequently than they do now, causing a wave-induced backwater effect. During this effect (as the water level rises), the current will erode the beach.

Summary Conclusions

Negative changes in the condition of the shoreline following the implementation of the PŪV solutions may be caused by reduced water permeability, and, at the same time, an increase in current velocity, an increase in the amplitude of water level fluctuations, a possible increase in the frequency of ice jam formation, and, due to intensified shipping, increased and more frequent wave action.

The mainland shore of the Curonian Lagoon. In all alternative scenarios of the PŪV implementation, the spatial position of the shoreline within the PŪV area will change significantly due to the formation of new land area (this is planned for all PŪV alternatives; only the extent and location will differ). However, both north and south of the PŪV territory, this will have no negative impact on the Curonian Lagoon mainland coast, or the impact will be local and insignificant.

Kiaulės Nugaros Island. Upon implementation of the PŪV solutions, the area of Kiaulės Nugaros Island will decrease by more than three times in all PŪV alternatives due to its dredging. Consequently, the position of the shoreline in space will change significantly; it will shorten and be straightened on the eastern and southern sides.

The coast of the Curonian Spit. Upon implementation of the PŪV solutions, in all PŪV alternatives, the greatest impact on the Curonian Spit coast will be on the northern (due to deepening the channel to 17 m) and southern (due to the reduction of the waterway's width following the formation of new land and the construction of the planned protective breakwaters for the port's southern entrance on the eastern and western (near Alksnynas) shores) sections of the project area's shoreline. It is likely that the impact on the spit's shoreline will be relatively smaller in the central section of the stretch.

The narrowing of the water passage near the planned southern port gates aims to limit the intrusion of saltwater into the lagoon. For this purpose, Alternative 2A is the most suitable (ensuring the smallest water passage), while Alternative 3A is the least suitable. However, in terms of ensuring the stability of the shoreline, the opposite is true: Alternative 2A is the least suitable, while Alternative 3A is the most suitable. Alternative 4A should be considered an intermediate option.

The impact on the shores during the implementation of the solutions should be treated as direct (for the Curonian Lagoon mainland shore—the shoreline is altered) and indirect (for the Curonian Spit shore—), long-term, interactive (may affect other environmental elements, e.g., water), and moderately significant (due to changed hydrodynamic conditions). During the operation of the PŪV facilities, a negative

impact on the subsurface is unlikely. In terms of increasing impact, the PŪV alternatives are ranked as follows: 3A < 4A < 2A. During the construction and operation of the PŪV facilities, it is necessary to implement measures to prevent, reduce, and/or compensate for the negative impact of the PŪV.

4.6.3 Measures to prevent, mitigate, and compensate for significant adverse environmental impacts

General provisions. When proposing measures to prevent, mitigate, or compensate for impacts on shorelines, several aspects must be taken into account. Shoreline erosion is not a continuous process. It intensifies under unfavorable conditions caused by natural (e.g., floods, storms, ice drifts, etc.) or anthropogenic (e.g., construction of hydraulic structures, dredging works, intensive shipping, etc.) factors. The solutions implemented in the PŪV will be long-lasting. Therefore, during their service life, the aforementioned adverse situations will occur many times. For example, it has been calculated that the probability of the maximum (^{4,210}m³/s) discharge when water flows from the Curonian Lagoon into the Baltic Sea is 1 in 4 years. Thus, although at first glance such a situation appears relatively rare, given the long-term nature of the implemented PŪV solutions, it must be treated as relatively frequent (25 occurrences per 100 years), and so on. On the other hand, due to changes caused by climate change, extreme hydrometeorological phenomena will become more frequent in the future. Therefore, when recommending measures to prevent, reduce, or compensate for impacts on the coast, their long-term perspective must be taken into account.

The continental shore of the Curonian Lagoon. It is highly likely that shoreline protection measures will not be necessary in any of the PŪV alternatives. It should be noted that, under the KVU monitoring program, observations of shoreline dynamics have been conducted at Station 3 on the mainland since 1995 (its location is shown in Figure 4.6.1.2). Once the marina for small and recreational vessels is built, it will be located in the middle of the port, and observations at this station will become meaningless. However, observations should not be discontinued until that time. Therefore, if observations are discontinued at its current location, we propose relocating it south of the protective breakwater at the port's southern gate and continuing the observations.

Kiaulės Nugaros Island. Given the extremely drastic transformation of Kiaulės Nugaros Island, we would recommend (for all PŪV alternatives) reinforcing its foreshore with a stabilization wall (similar to Malkų Bay on the Smeltė Peninsula) on all sides. It should be noted that an option to reinforce the area with a stabilizing wall that would protrude above the water should also be considered. In such a case, ships serving the LNG terminal and other vessels could moor alongside it. However, in this case, the space between the wall and the island would need to be filled with soil (the most rational option would be to use dredged sand from the island).

The coast of the Curonian Spit. As mentioned in previous sections, the hydrodynamic regime will significantly intensify after the installation of the southern port gates and a protective breakwater on the Curonian Spit coast. Basic shoreline protection measures (e.g., planting reeds, placing stones, etc.) will not protect the Curonian Spit's shores from erosion in the future. Especially since, even at present, erosion trends prevail in this section. Therefore, along the entire section (in the case of PŪV alternatives 2A and 4A), from the end of the quay to the planned protective dike near Alksnynas (a section of approximately 3,570 m), the lower part of the foreshore should be reinforced at a depth of about 1.0–1.2 m (as this is where the foreshore slope typically begins in this section) with an underwater retaining wall. In the case of Alternative 3A, it is likely that reinforcing the scarp in this manner would suffice for the section from the planned Alksnynė dam to approximately PK85 (in the 2,450 m section). It should be noted that in this case, a local 30–100 m long section of eroded shoreline will form beyond the end of the wall. Therefore, this

section should be reinforced with a stone revetment. Since the wall will be submerged most of the time, its location in the water (for navigation safety) will need to be marked with warning signs.

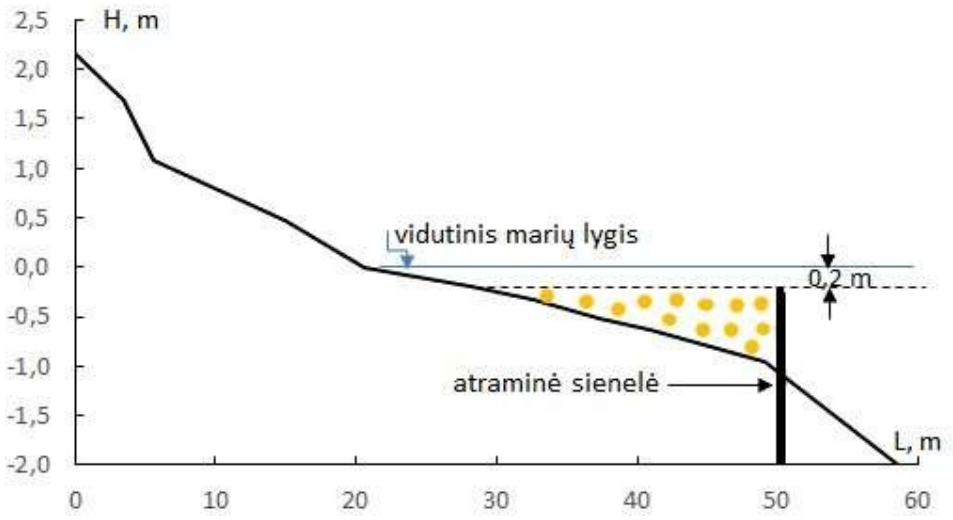
Unlike the underwater retaining wall installed in Malkų Bay, where it is separated from the water surface by about 1.5 m, this difference should be smaller here. In Malkų Bay, only the underwater slope needed to be stabilized, whereas in the case under analysis, the underwater retaining wall should also at least partially dampen the waves caused by wind and increasing shipping traffic, and reduce the impact of rising currents. When determining the optimal height between the water surface and the top of the underwater wall, we face several challenges: highly dynamic changes in water levels over the course of years, seasons, and even individual days; a lack of wave data; and uncertain future climate change projections. Based on data from the Klaipėda Hydrometeorological Station for the most recent thirty-year period (1992–2022), the average annual water level during this period was +10 cm above the station's zero level (the lowest average in 1996 was –9 cm, the highest average in 2022 was +22 cm). The maximum instantaneous water level was reached on December 4, 1999 – +165 cm,
and the minimum instantaneous level on January 28, 2010 – -71 cm.

Taking into account the wishes previously expressed by KNNP specialists, the retaining wall should not rise above the water surface, or this should be only an occasional occurrence. On the other hand, for the wall to at least partially dampen wave action, it needs to be as high as possible. Based on the Mc Cowen criterion (h/H = 0.78), we know that, for example, a 1 m high wave is attenuated at a depth of about 0.80 m. Unfortunately, as already mentioned, there are no comprehensive wave data for the study area. Judging by data from other areas (Kalinauskas, 1995), the largest waves in the study area could reach a height of about 1 m. Taking into account the calculated probabilities of daily water level distribution (Table 4.6.3.1), we believe that the optimal distance from the average long-term lagoon water level surface to the top of the wall would be approximately -20 cm (Fig. 4.6.3.1). In this case, the probability that the wall will rise above the water is only about 6.5%, i.e., only occasionally, and the negative impact of wave action on the shore will be at least partially reduced.

4.6.3.1 Table. Probability distribution of average daily water levels for the period 1992–2022

Water level intervals (cm)	Probability (%)	Probability (times per year)
- 80 – - 70	0.00	0.00
- 70 – - 60	0.01	0.03
- 60 – - 50	0.16	0.58
- 50 – - 40	0.71	2.58
- 40 – - 30	1.19	4.33
- 30 – - 20	4.05	14.79
- 20 – - 10	8.96	32.71
- 10 – 0	17.31	63.19
0 – 10	20.53	74.96
10 – 20	17.66	64.50
20–30	12.78	46.68
30–40	7.70	28.10
40–50	4.47	16.34
50–60	2.87	10.49
60–70	1.10	4.02
70–80	0.31	1.14
80–90	0.11	0.41
90–100	0.03	0.10
100–110	0.01	0.03

To neutralize visual pollution (at least as seen from the shore), sand should be deposited (again, sand dredged during deepening or excavated from Kiaulės Nugaros Island that meets quality requirements could be used) at a distance from the underwater wall, measured from the metal segments of the breakwater (along the wall from the bottom of the ledge to its top), toward the shore, up to the 0.2 m isobath. Approximately 28,500–29,000 m^3 of loose fill would be required for this purpose. This measure would not only neutralize visual pollution but also prevent silt accumulation near the wall and help protect the shore from wave action (Fig. 4.6.3.1).



4.6.3.1 Fig. Schematic diagram of the Curonian Spit shoreline reinforcement with a retaining wall. The yellow dots indicate the area to be filled with sand.

Additionally, to mitigate the impact of waves caused by increasing navigation traffic on the Curonian Spit shoreline, speed limits for vessels should be enforced in the southern entrance to the port.

South of the future protective breakwater, the shoreline is currently stable. It is protected by well-established macrophyte thickets along the shoreline and in the foreshore. However, if, following the planned construction of the southern port gates, coastal erosion processes were to intensify in this section, then the shoreline section from the protective dike at Alksnyne to Alksnių Cape (approximately 600 m) would also need to be reinforced. It is likely that, to reinforce the shore in this section, it would suffice to form a stone revetment along the shoreline.

A stone riprap is a structural element made of stacked stones without binding material, used to reinforce watercourse channels and/or banks, the banks of water bodies, and the slopes of dikes and dams. This bank protection measure has been widely used throughout the world since ancient times. It has been somewhat improved in modern times: geotextile is laid down before the stones are placed to prevent them from “sinking” into the sand. Stone riprap has been used for several centuries not only on the Curonian Spit but also on the mainland shore of the lagoon as a means of stabilizing the lagoon’s banks. Therefore, in part, just like the reinforcement of protective dune ridges with brushwood and wattle fences, it can be classified as an element of cultural heritage. In the landscape of the Curonian Spit, stone embankments have long been a common method of reinforcing lagoon shores (Fig. 4.6.3.2). Stone embankments blend organically into the landscape: vegetation takes root in them, birds nest there, and so on (Fig. 4.6.3.2). A particularly positive feature is that this measure does not hinder the migration of waterfowl, amphibians, reptiles, and others between water and

land or vice versa. The stone embankment is constructed on both sides of the shoreline (above and below the water). Depending on the morphological characteristics and the intensity of shoreline erosion, the width of the stone embankment ranges from a few to several dozen meters.



The shores on the western side of the Curonian Spit are reinforced with a stone



Slope protection along the road to Ventės Ragas using a stone revetment



Stone revetment north of the Juodkrantė pier



Protection of the Nida pier with a stone revetment



revetment blends seamlessly into the landscape



In the cultural landscape of the Curonian Spit, stone revetments have long been a common method of reinforcing lagoon shores

4.6.3.2 Fig. Examples of stone revetments on the Curonian Spit

4.7 Landscape

4.7.1 Description of the current state

Morphological structure of the landscape and features of cultural identity

The morphological structure of the landscape and its territorial characteristics form the fundamental premises for spatial planning. The most important factors that can determine the direction of landscape use and protection are the nature and spatial expression of the relief, the territorial distribution of water bodies and watercourses, and the nature and territorial distribution of forests and other vegetation.

The National Landscape Management Plan (approved by Order No. D1-703 of the Minister of the Environment of the Republic of Lithuania on October 2, 2015) includes a map of landscape management zones (Fig. 4.7.1.1). Part of the PŪV territory in the eastern section falls within the i6P' landscape zone—this zone is characterized by an industrial, technogenic landscape with intensive land use; part of the port's buildings and infrastructure are located within this zone.

To a significant extent, the character of the natural landscape of the inner water area has been fundamentally altered, creating a distinctive spatial landscape complex in which elements of anthropogenic origin occupy a dominant position; therefore, the most appropriate term to describe the local landscape of the PŪV would be *"technogenic landscape*." The least cultivated landscape areas are located to the west (the Curonian Spit), to the north (the Giruliai and other forests), and to the south (the Kliošiai and other forests) of the PŪV territory. On the eastern side, the PŪV site borders the urbanized areas of Klaipėda.

The morphostructure of the coastal region's landscape is characterized by features that are unique not only within the country but also in an international context. Although the PŪV territory occupies only a small part of the coastal region, the landscape's morphological values in the area under consideration are distinguished by zones of varying value (in terms of expressiveness and the preservation of naturalness). The most valuable zone, distinguished by its uniqueness, is the Curonian Spit, which stretches west of the PŪV territory. The narrow Curonian Spit peninsula, located between the Curonian Lagoon and the Baltic Sea, is composed of sand deposited by water currents. Wind-swept dunes, wet depressions (palsas), and beaches—this relatively young landscape is constantly changing. The Curonian Spit's exceptional significance stems from its striking combination of natural and cultural heritage. To preserve, manage, and sustainably use the most valuable natural and cultural landscape complex of the Lithuanian coast—featuring a dune ridge unique in Europe and ethnocultural heritage—*the Curonian Spit National Park* was established (established by Resolution No. I-1244 of the Reconstituted Seimas of the Republic of Lithuania – Reconstituent Seimas on April 23, 1991, Resolution No. I-1244 "On the Establishment of the Dzūkija, Curonian Spit, and Samogitia National Parks, the Trakai Historical National Park, and the Viešvilė State Reserve"). The Curonian Spit, part of which within the territory of the Republic of Lithuania is covered by the Curonian Spit National Park, and part of which within the territory of the Russian Federation is covered by the "Kuršskaja kosa" National Park, was inscribed on the UNESCO and IUCN World Heritage List on December 2, 2002.

The proximity of the Curonian Spit to the planned KVJU territory is linked by direct and indirect connections to the natural and cultural heritage values protected on the Curonian Spit. Currently, this protected area and the restrictions on activities within it do not have a significant impact on the activities carried out in the KVJU territory or on projects already being implemented.

The sandy coastal plain landscape zone, which represents the coastal region's landscape on a national scale, stretches slightly north of the city of Klaipėda. The characteristic features of this landscape complex are the relief sections running parallel to the seashore. Moving eastward from the sea, the landscape first features a beach up to several hundred meters wide, formed from sand. The beach surface is uneven, consisting of three longitudinal sections: a flat embankment, an inner depression, and a higher section. Beyond the beach lies a stretch of coastal dunes, the base of which consists of a ridge washed by waves, eroded by the wind, widened, and raised to a height of 4–6 m. The beach and the stretch of coastal dunes are formations created by the Baltic Sea. Beyond the coastal dunes lies the terraced Litorina Sea plain and its marshy back-dune depression. To the east, the Litorina Sea terraced plain rises and becomes drier. The surface of the terraced plain is hummocky in places, with prominent high dunes or narrow, long dune ridges. In order to preserve the landscape of the Lithuanian coastal mainland with its coastal dune belt, the Great and Small Coastal Cliffs, the marine plain of Lake Placius, the Nemirseta dune ridge formed by the littoral sea, and the coastal continental cliffs, as well as the marine boulder fields and the ethnographic village of Karklė, *the Seaside Regional Park* has been established.

The shallow lagoon landscape zone, located south of the PŪV territory and the only one of its kind in Lithuania, is also classified as having high morphological value. The Curonian Lagoon (formerly known as the Prussian Sea) is a freshwater lagoon-type estuary in the southeastern part of the Baltic Sea, separated from the Baltic Sea by a narrow spit that formed over the last 10,000 years. The lagoon landscape opens up south of Kiaulės Nugaros Island; on the western shore, it borders the Curonian Spit, and on the eastern shore, the landscapes of the Pamario Plain.

Natural framework in the PŪV territory and its immediate surroundings

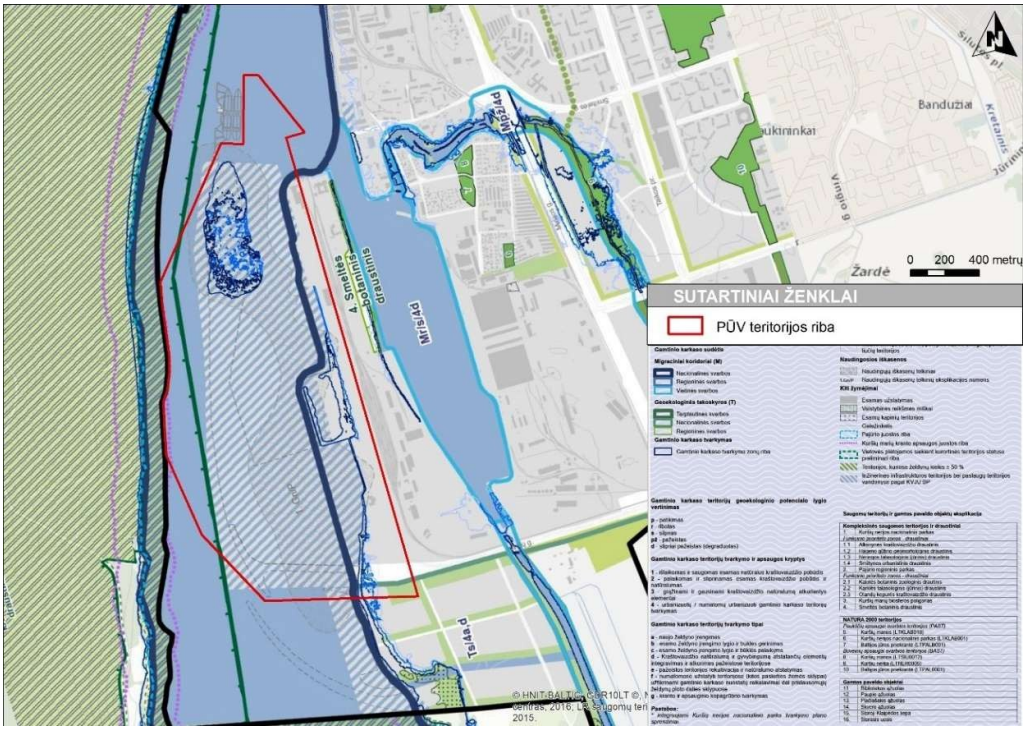
Based on higher-level spatial planning documents, the natural framework in the PŪV area under consideration and its surroundings consists of:

- ***Geoecological corridors***—strips of land connecting areas of particular ecological importance and sensitivity: river headwaters, watersheds, upland lake systems, hill systems, wetlands, coastal zones, and areas of intensive groundwater recharge and karst distribution. They separate large natural geosystems and maintain the overall ecological balance of the natural landscape:
  1. The *Pajūrio* Geoecological Divide of International Importance (covering the coast and coastal zone of the Baltic Sea and the Curonian Lagoon, as well as the entire Curonian Spit);
  2. *The Pamario* Geoecological Divide of national importance.
- ***Migration corridors***—valleys, ravines, and depressions, as well as other low-lying areas where there is an intensive exchange of materials, energy, and natural information, and where plant and animal species migrate:
  1. A section of the *Klaipėda Strait* migration corridor of national importance;
  2. The section of the *Akmena–Danė* migration corridor of regional importance;
  3. The section of the *Smeltalė* migration corridor of local importance;
  4. The section of the *King William's* Canal migration corridor of local importance.

The natural framework areas, as part of the spatial structure, establish the most important territorial priorities for the conservation of the natural landscape, necessary for maintaining the overall ecological balance. It is quite challenging to implement this provision in areas where ecological stabilization (particularly geo-ecological barriers or migration corridors) intersects with urban and economic development zones. The situation of the PŪV territory within the network of natural framework areas is quite complex—it borders on important (of international and national significance) geoecological watersheds to the west, south, and north; the Klaipėda Strait—the port's water area—is a migration corridor, while the sections of migration corridors *(Smeltalė, Akmena–Danė, King Wilhelm Canal)* crossing the urbanized city area are "squeezed" by intensively urbanized territories. Due to the aforementioned overlap between ecological stabilization and urban-economic development areas, some of them have more or less lost their natural landscape structure (areas of the natural framework with *damaged* or *severely damaged* geoecological potential).

The Klaipėda Strait should be highlighted as one of the most problematic natural framework areas in the PŪV environment. The Klaipėda Strait is a waterway approximately 10 km long, stretching from Kiaulės Nugaros Island in the south to the gates of the Klaipėda State Seaport in the north. It is a complex hydrosystem connecting water bodies of different densities: the freshwater Curonian Lagoon and the saline Baltic Sea, each with distinct hydrospheric processes. At the same time, it is a unified system regulating energy flows and the circulation of sediments and biomass between the different bodies of water. The flow rate of water through the strait depends on the difference in water levels between the Curonian Lagoon and the Baltic Sea. When the water levels of the Curonian Lagoon and the Baltic Sea are approximately equal, the denser seawater flows along the bottom of the strait. The less dense water of the Curonian Lagoon flows in the opposite direction along the surface of the sea water. In the southern part of the strait, the sandy, macrophyte-covered Kiaulės Nugaros Island separates it from the northern part of the Curonian Lagoon. *The Klaipėda Strait* belongs to the category of highly altered water bodies. Pollutants enter the Klaipėda Strait not only from companies and ships located in the Port of Klaipėda and from contaminated soil, but also from the city of Klaipėda and the entire large basin of the Nemunas River and the Curonian Lagoon. Currently, the primary ecological significance of the Klaipėda Strait is that it serves as a route through which important and rare fish species migrate to their spawning grounds. Migration occurs throughout the year, but the most critical periods are April–July and October–December.

According to the Klaipėda City Master Plan's landscape protection and management map (Fig. 4.7.1.1), the PŪV territory falls within the Klaipėda Strait migration corridor, a natural framework of national importance. Most of the PŪV territory is classified as engineering infrastructure areas and service areas in water bodies according to the KVJU BP.

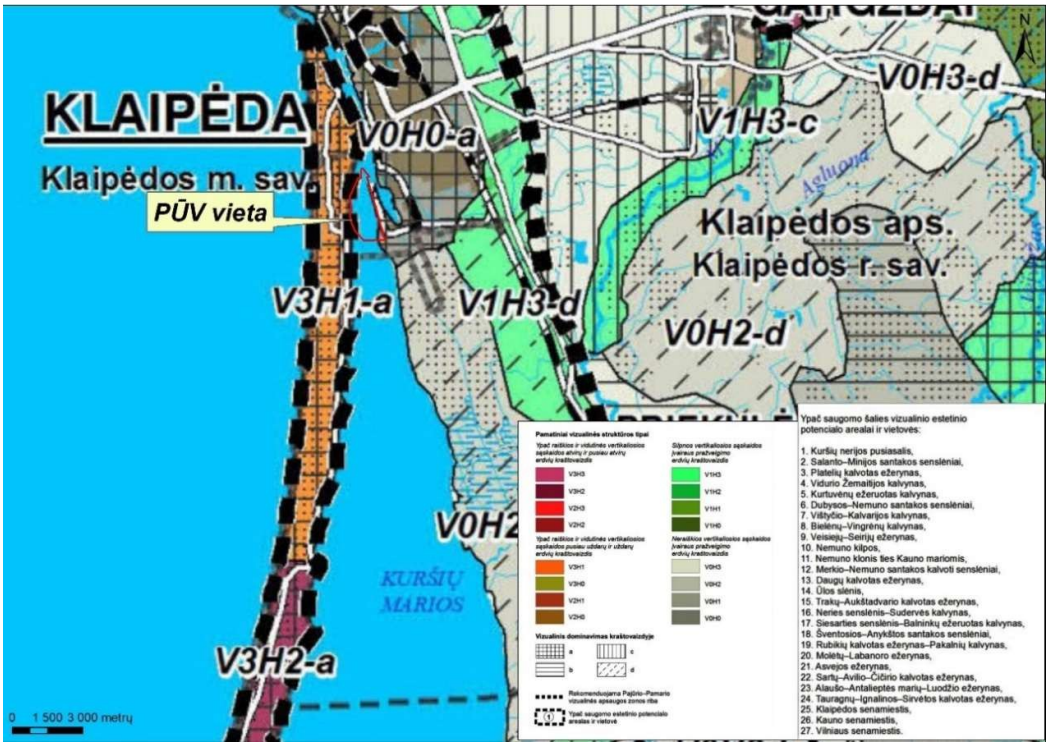


4.7.1.1 Fig. Excerpt from the landscape protection and management plan of the Klaipėda City Master Plan

Visual structure of the landscape

The visual structure of the landscape is assessed based on criteria related to its potential emotional impact on people: vitality, expressiveness, diversity, individuality, compositional harmony, meaningfulness, etc. The most recent national assessment of visual landscape potential is the analysis of the visual structure of the landscape, presented in the report of the National Landscape Management Plan of the Republic of Lithuania.

In accordance with the National Landscape Management Plan, the PŪV territory and its immediate surroundings fall, to a greater or lesser extent, within the boundaries of several types of Lithuanian landscape visual structure or border on them (Table 4.7.1.1). Both within the PŪV area itself and in its immediate surroundings, *the landscape* is dominated by *areas* of low aesthetic potential—*landscapes with indistinct vertical profiles and varying degrees of visibility (V0H0; V0H2) and a landscape of semi-enclosed and enclosed spaces with particularly pronounced and moderate vertical contours (V3H1-a)* (Fig. 4.7.1.2).



4.7.1.2 Fig. Excerpt from the map of the visual structure of the Lithuanian landscape

Landscapes of spaces with varying visibility and *slight vertical relief* (*V1H0; V1H3*), which have somewhat greater aesthetic potential, are located to the north and south of the KVJU territory. *The landscape* with the relatively highest aesthetic potential—characterized by *highly and moderately pronounced vertical divisions in semi-enclosed and enclosed spaces (V3H1)*—is located to the west of the KVJU territory—in the Curonian Spit and its coastal zone.

Table 4.7.1.1. Visual Structure of the Landscape

Visual structure type index	**Vertical visual composition of the landscape (V)**	**Landscape horizontal visual balance (H)**	**Visual dominance in the landscape**
V0H0-a	Indistinct vertical structure (flat landscape with single-level vegetation)	Landscape dominated by enclosed, non-transparent (forested or built-up) spaces	The spatial structure of the landscape features distinct vertical and horizontal dominant complexes
V3H1-a	Particularly pronounced vertical relief (a landscape of steep hills and deep valleys with complexes of four-to-five-level topographic features)	Landscape of predominantly semi-enclosed, partially open spaces	The landscape's spatial structure features distinct vertical and horizontal dominant complexes
V1H0-d	Weak vertical relief (undulating and gently sloping valley landscape with two-levels	Landscape of predominantly enclosed, non-viewable (forested or built-up) spaces	Landscape spatial structure without distinct vertical and horizontal dominant
V1H3-d	Weak vertical relief (undulating and gently sloping valley landscape with levels of video topography	Landscape of predominantly open, well-viewed spaces	Landscape spatial structure without distinct vertical and horizontal dominant

V0H2-d	Indistinct vertical structure (flat landscape with single-level vegetation)	A landscape dominated by semi-open, largely viewable spaces	Spatial structure of the landscape without distinct vertical and horizontal dominant features

The Curonian Spit, adjacent to which the KVJU is located, is one of the areas with the greatest aesthetic potential in Lithuania. This area reflects a landscape formed and still evolving through the interaction of the sea, wind, and human activity. Most of the Curonian Spit (especially the central part) is characterized by a particularly pronounced vertical relief. The northern part of the spit, which is adjacent to KVJU, is characterized by

a “smoothed-out” landscape. Semi-enclosed, partially open spaces predominate. Here, the largest areas are occupied by forests (Scots pine and mountain pine), with elements of development (buildings, infrastructure) interspersed along the coast, including the architectural heritage of the Smiltynė Urban Reserve. From the Old Ferry Terminal at the mouth of the Danė River, a magnificent view of Smiltynė opens up. Here, a visual connection is established between the Curonian Spit, the city, and the port; this location sees a large flow of residents and tourists taking the ferry to the Curonian Spit. It is no wonder that this spot is considered the most beautiful and impressive location in Klaipėda’s Old Town. The New Ferry Terminal offers a similar visual connection, but here the primary focus is on vehicle traffic, so the quays are not designed for recreational use. The best views are primarily accessible from the ferry. The northern pier of the port gate can be identified as a separate vantage point for the Curonian Spit, which is adapted for public access. In all other locations, a view of the Klaipėda Strait, the Curonian Lagoon, and the Curonian Spit is nearly impossible (except for the southern section near Kairių Street). This part of the Curonian Lagoon, currently unused by the Port, is not easily viewed from either the mainland or the Curonian Spit. The eastern coast of the Curonian Spit in this area is difficult to access, with steep shores overgrown with trees and reeds. This part of the Curonian Lagoon (within the PŪV project area) can be viewed from the observation point on the Meškos Galvos dune (Fig. 4.7.1.3), although this observation point is not convenient for tourists and is rarely visited. On the mainland, the PŪV area is accessible via Kairių St., but access is only possible up to Perkėlos St. (beyond which the territory of the stevedoring company KLASCO begins) (Fig. 4.7.1.4).



View from the Curonian Spit toward the PŪV territory (in the central part, the KVJU contaminated soil storage site)



View from the Curonian Spit toward the PŪV site (on the left – Kiaulės Nugaros Island, on the right – KVJU contaminated soil storage site)



View from the Curonian Spit toward the PŪV site (in the southern part – the KVJU contaminated soil storage site)



View from the Curonian Spit toward the PŪV territory (eastern shore of the Curonian Spit)

4.7.1.3 Fig. View from the Curonian Spit toward the PŪV site (photo by L. Stumbrienė)



View from the mainland shore toward the PŪV site (on the right – the location of the wastewater discharge outlet)



View from the mainland shore toward the PŪV site (from the wastewater discharge point)



View from the mainland shore toward the PŪV site (on the right – an abandoned boat dock building)



View from the mainland shore toward the PŪV site (from the abandoned boat dock building)



View from the mainland shore toward the PŪV site (from the entrance to the KVJU contaminated soil storage area)



View from the mainland shore toward the PŪV site (from the KVJU contaminated soil storage area)



View from the mainland shore toward the PŪV site (from the entrance to the KLASCO site)



View from the mainland shore toward the PŪV site (from the entrance to the KLASCO site)

4.7.1.4 Fig. View from Kairių St. in Klaipėda toward the PŪV site

40. Expected significant impact

Impact during the implementation of the PŪV solutions

During the implementation of the PŪV solutions (dredging of water areas and land formation, dredging of part of Kiaulės Nugaros Island, construction of quays, installation of slope stabilization measures, soil transport, etc.) is expected to have a temporary, moderately significant impact on the landscape (due to the visual impact of the equipment used and the changing environment).

A detailed assessment of the impact of the implementation of the PŪV solutions on other environmental elements is presented in other sections of the report.

Impact during the operation of the PŪV facilities

Impact resulting from the implementation of the PŪV solutions

Once the PŪV solutions assessed in this EIA report are implemented in accordance with the selected PŪV alternative, it is likely that the following solutions planned for 2019 will already have been implemented in the Curonian Lagoon water area: – protective dikes and a 190-meter-long shoreline protection dike at

Alksnyne, as well as a marina for small and recreational vessels with infrastructure and urban design characteristic of such facilities, analogous to the ports of Nida and Juodkrantė [19].

The planned PŪV solutions, regardless of the PŪV alternative chosen, would visually alter this water area significantly, i.e., partially transform the local landscape of the eastern water area of the open lagoon into a technogenic landscape characteristic of the port territory. Preliminary visualizations of the PŪV alternative solutions are shown in Figures 4.7.2.1–4.7.2.3.

Upon implementation of the solutions planned for 2019 and these PŪV solutions under any PŪV alternative, the port territory would be fully developed and adapted to port needs, and its approximately 12 km long water area (from the southern port gates to the sea gates) would be used intensively for port operations.

Under Alternative 2A, if most of Kiaulės Nugaros Island in the northern part of the Curonian Lagoon were dredged away, an enclosed land area of approximately 81.7 ha would be formed in the existing open water area, which would extend 340–450 m from the Curonian Spit over a stretch of about 1.3 km. The new land area would be at a similar distance from the Curonian Spit (60.5 ha in Alternative 3A, 83.5 ha in Alternative 4A) in the case of other PŪV alternatives as well, but the zone of the land strip would differ (Fig. 4.7.2.2 – 4. 7.2.4). A similar distance (approximately 350–600 m) between the eastern shore of the Curonian Spit and the western mainland shore exists in the majority of the port area in the Klaipėda Strait. In Alternatives 3A and 4A, a larger open water area remains to the north than in Alternative 2A. The newly formed land areas, which expand the area of the Smeltė Peninsula, will rise approximately 3.0–3.5 m above the existing water surface.

In all PŪV alternatives, the majority of Kiaulės Nugaros Island (about ¾) will be dredged away, thus partially “eliminating” the conditional physical barrier currently separating the Klaipėda Strait and the Curonian Lagoon; and, upon implementation of the previously planned and in this report evaluated PŪV solutions, it
“shift” southward near the planned southern port gates.

Currently, the width of the lagoon’s water area from the eastern shore of the Curonian Spit to the KVJU contaminated soil storage site (the central part of the PŪV territory) and at the southern boundary of Kiaulės Nugaros Island is approximately 1 km, and at the southern boundary of the PŪV territory (near Alksnynas) – approximately 1.2 km. Upon implementation of the PŪV solutions under Alternative 2A, the new port area with its future infrastructure would “approach” the Curonian Spit along a 1.3 km stretch, and in the southern part the minimum distance to the spit’s shore would be approximately 450 m, while in the northern part—approximately 340 m. In the case of Alternative 3A, the minimum distance to the Spit would be in the southern part of the PŪV territory and would be approximately 545 m, while in the northern part—approximately 700 m; and in the case of Alternative 4A, the minimum distance to the Spit would be in the southern part of the PŪV territory and would be approximately 570 m, and in the northern part—about 780 m. Thus, in this regard, the solutions of Alternative 4A would be the farthest from the Curonian Spit.

The solutions for all PŪV alternatives on the southern side border the northern breakwater of the Port’s southern gate, planned for 2019 (Figs. 4.7.2.2–4.7.2.4). The planned southern port gates are not intended for the direct needs of the KVJU (shipping or cargo handling), but serve an environmental function designed to prevent and minimize the potential impact (changes in water permeability and the dispersion of saltwater) and to minimize it as much as possible. In the enclosed water area between the aforementioned breakwaters, a marina for small and recreational vessels is planned, featuring infrastructure and urban design characteristic of such facilities, analogous to the marinas in Nida and Juodkrantė. Taking into account the plans of the Klaipėda City Municipality

Administration to create an attractive recreational area in this part of the city near the Curonian Lagoon

for city residents, the KVJU area would begin and end with areas adapted for and attractive to residents.

The PŪV solutions will not have a significant negative impact on the panoramas of the Curonian Spit (from the port side). The proposed Curonian Spit shoreline management solutions (retaining walls) will be underwater and invisible (for more details, see Section 4.6). Viewed from the Curonian Spit side, the Port's facilities and activities within the PŪV area would "move closer" to the Curonian Spit.

The PŪV solutions would have an impact on the Klaipėda Strait migration corridor, which is of national importance, but this impact would not be significant (see the section on the assessment of impacts on other environmental elements).

Impact on the landscape due to the reconstruction of the 110 EEPOL section

Extending the port's inner navigation channel to the southern part of the port and, for that purpose, dredging a section of Kiaulės Nugaros Island will require the reconstruction of the existing approximately 6.6 km long 110 kV EEPOL Marios – Juodkrantė section, as it will be necessary to dismantle support No. 19 of this line located on the island. The project solutions provide for the dismantling of the 110 kV EEPOL Marios–Juodkrantė section from support No. 12 to support No. 43 (approximately 4.0 km of this EEPOL section is located on the Curonian Spit) and, using a connecting joint, connect via a coupling sleeve and lay a new underground power cable approximately 3.76 km long (of which approximately 1.27 km would run along the bottom of the Curonian Lagoon) to the newly installed Tower No. 43a (or another solution) by connecting to the same 110 kV EEPOL line Marios–Juodkrantė.

Upon decommissioning the approximately 6.6 km 110 kV EEPOL section, 42 towers would be dismantled, 23 of which are located within the KNNP territory. Following the dismantling of the EEPOL section and the removal of restrictions on economic activities related to the AZ within this section, a strip approximately 50 m wide and 6.6 km long (covering a total area of about 3.3 ha, of which about 2 ha is within the KNNP) would be freed up for other activities (industrial within the port area, recreational within the KNNP). The land strip along the underground cable line of the newly laid AZ underground power cable on land would extend one meter on either side of this line, including the water above it and the land beneath this strip [4].

Dismantling the overhead EEPOL towers along a 4 km section on the Curonian Spit would result in a significant positive visual change to the local landscape (Fig. 4.7.2.1).



110 kV EEPOL on the Curonian Spit (Pylon No. 20)



After implementation of the PŪV solutions





110 kV EEPOL on the Curonian Spit



110 kV EEPOL in the Curonian Spit

After implementation of the PŪV solutions



After implementation of the EIA solutions

41. Fig. 110 kV EEPOL in the Curonian Spit; in the photos on the left – current state, on the right – after implementation of the EIA solutions (after dismantling the EEPOL)



4.7.2.2 Fig. Preliminary visualization of the solutions for EIA Alternative 2A and the Port's southern gate planned for 2019



4.7.2.3 Fig. Preliminary visualization of the solutions for Alternative 3A of the PŪV and the southern port gates planned for 2019



4.7.2.4 Fig. Preliminary visualization of PŪV Alternative 4A solutions and the southern port gates planned for 2019

Conclusion: During the implementation of the PŪV solutions (dredging of water areas and land formation, dredging of part of Kiaulės Nugaros Island, construction of quays, installation of slope stabilization measures, soil transport, etc.), a direct (physical work being carried out), interactive (impact on various environmental elements), temporary (only during the implementation of the solutions), and moderately significant negative impacts on the landscape (due to the visual impact of the equipment used and the changing environment).

Upon implementation of the solutions for any of the PŪV alternatives, the water area of the northern part of the Curonian Spit would undergo significant visual changes, i.e., part of the existing open lagoon water area landscape would be replaced by the technogenic landscape of the port's land area with its characteristic infrastructure and superstructure. As the area of the Smeltė Peninsula changes, the port's land area would move closer to the Curonian Spit. The area of Kiaulės Nugaros Island would be reduced by about three-quarters. Secondary solutions related to the PŪV (110 kV EEPOL restructuring) would improve the visual landscape of the Curonian Spit and free up additional land areas for recreational activities. Upon implementation of the PŪV solutions, the PŪV's impact on the landscape would be direct (the appearance of the local environment would change, new land would be formed), long-term and permanent (solutions implemented permanently), interactive (solutions would affect other environmental elements), and moderately significant negative (a large area would be affected). When comparing PŪV alternatives 2A, 3A, and 4A, the implementation of solutions under Alternatives 3A and 4A would have a lesser impact on the landscape. During the construction and operation of the PŪV facilities, it is necessary to apply measures to prevent, reduce, and/or compensate for the negative impacts of the PŪV.

4.7.3 Measures to prevent, mitigate, and compensate for significant adverse environmental impacts

Possible measures to mitigate the impact on the landscape would include:

- harmonious integration of the project's solutions with the existing landscape and utilization of the area to create spaces attractive to the public (e.g., the conversion of the existing 110 kV EEPOL section (dismantling and laying of an underground cable) would improve the visual landscape of the Curonian Spit and free up additional land for recreational activities);
- additional shoreline management measures (underwater retaining walls, beach nourishment with sand) aimed at mitigating the impact on the adjacent Curonian Spit area and its landscape (to ensure shoreline stability by protecting it from erosion, landslides, etc.), compensatory measures aimed at biodiversity conservation (redevelopment of the remaining part of Kiaulės Nugaros Island, creating and maintaining an environment suitable for bird nesting sites, implementation of periodic reed cutting and removal works in the Curonian Lagoon water area, in the lagoon coastal zones agreed upon with the KNPP Directorate, thereby opening up additional feeding areas for birds).

4.8 Protected natural areas

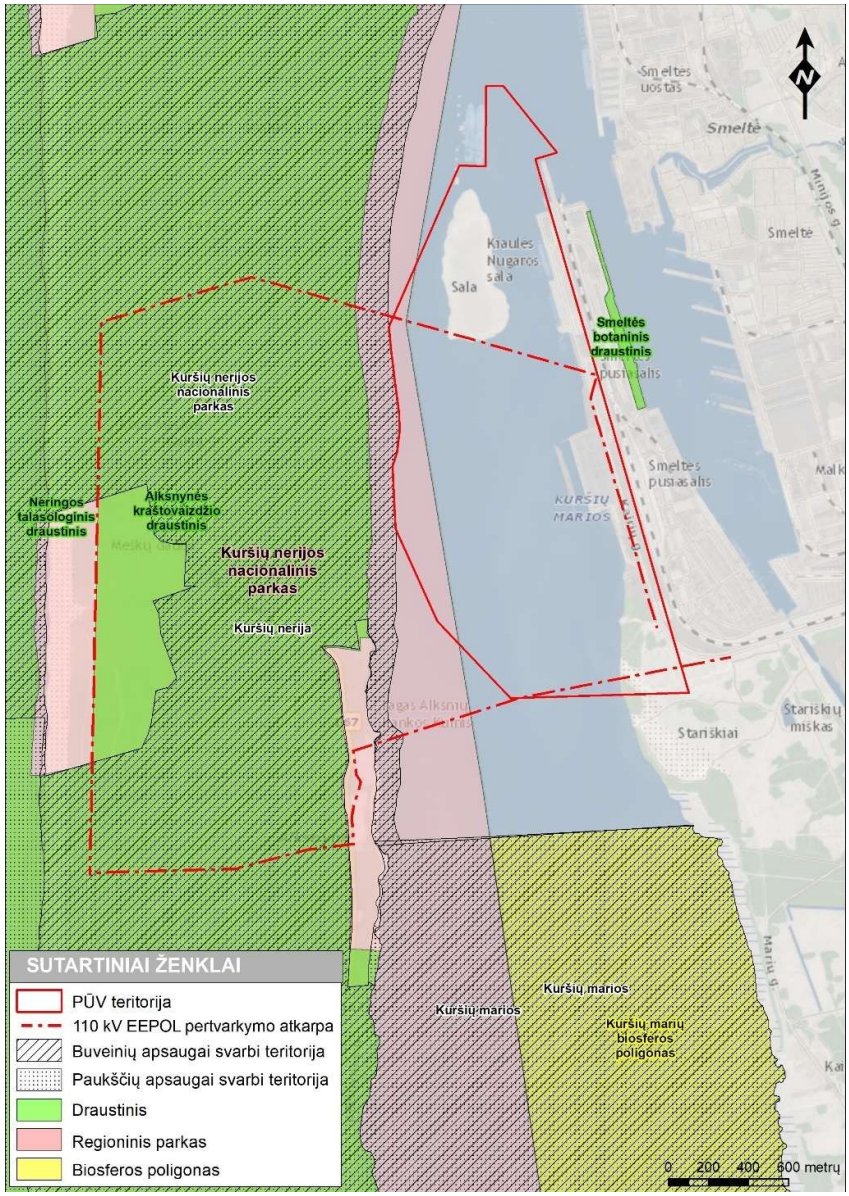
4.8.1 Description of the current situation

Protected natural areas located within or adjacent to the PŪV territory are:

- The Curonian Spit National Park, including its nature reserves and Natura 2000 sites (it borders the KVJU area on the western side, and part of the area falls within the KVJU);
- Smeltė Botanical Reserve (falls within the KVJU territory);

- The Curonian Lagoon Biosphere Reserve (borders the KVJU territory on the south). A more detailed description of the aforementioned protected areas is provided in Table 4.8.1.1.

The KVJU territory borders the Curonian Spit National Park to the west. Part of the boundaries of the protected areas (the Curonian Spit National Park's Natura 2000 PAST sites) overlap with the boundaries of the plot managed by KVJU or fall within the KVJU territory (Smeltė Botanical Reserve). Part of the main project area (in the Curonian Lagoon water area) falls within the boundaries of the Curonian Spit National Park. The planned solutions for the reconstruction of the 110 kV EEPOL Marios–Juodkrantė section fall within the territory of the KNNP and the Alksnynė Landscape and Natura 2000 PAST – Curonian Spit National Park, and BAST – Curonian Spit (Table 4.8.1.1, Fig. 4.8.1.1).



4.8.1.1 Fig. Protected areas and EU Natura 2000 sites in relation to the PŪV area

Table 4.8.1.1. Protected natural areas

No.	Name of protected area/priority zone/ Identification code	Brief description of the protected area	Minimum distance to the PŪV, km
1.	**Curonian Spit National Park** Identification code: 0600000000002	Established in 1991. Area – 27,388 ha. Purpose of establishment: to preserve the most valuable natural and cultural landscape complex of the Lithuanian coast, featuring a dune ridge unique in Europe, as well as ethnocultural heritage values. International importance of the protected area or part thereof: Protection of birds and habitats	Part of the PŪV water area in the V direction falls within the KNNP territory. The planned solutions for the reconstruction of the 110 kV EEPOL section fall within the the KNNP territory.
2.	**Alksnynė Landscape Reserve** Identification code: 0230100000195	Established in 1994. Area – 2,112 ha Purpose of establishment: to preserve the natural complex of the Alksnynė Landscape Reserve, including a vegetated, rolling dune ridge, a dune field with hummocks and hollows in the coastal zone, and a forested coastal plain dune field, a coastal protective dune ridge and sand dunes, sites of plant and animal species listed in the Lithuanian Red Book, and Community	~ 0.01 km east of the main PŪV territory. The planned solutions for the reconstruction of the 110 kV EEPOL section fall within the protected area for all PŪV alternatives.
3.	**Smeltė Botanical Reserve** Identification code: 0210500000011	Established in 1988. Area: 3.6 ha. Purpose of establishment: to preserve the habitats of rare plant species	about 0.14 km in the R direction
4.	**Hageno Hill Geomorphological Reserve** Identification code: 0210200000112	Established in 2011. Area: 159 ha Purpose of establishment: to preserve the geomorphologically valuable, vegetated tip of the Spit's main dune ridge, including Hagen Hill	approximately 1.16 km to the northwest
5.	**Neringa Thalassological Reserve** Identification code: 0211000000003	Established: 2011. Area: 12,537 ha Purpose of establishment: to preserve the ecosystems of the shallow coastal underwater landscape, including habitats of European Community importance	~ approximately 1.74 km in a westerly direction

No.	Protected area/priority Name/Identification code	Brief description of the protected area	Minimum distance to the PŪV, km
6.	**Curonian Lagoon Biosphere Reserve** Identification code: 0900000000028	Established in 2009. Area – 31,138 ha. Purpose of establishment: to preserve the valuable aquatic ecosystem of the Curonian Lagoon. The following functional priority zones have been designated within the biosphere reserve: restoration and water management functional priority zones.	~ 0.67 km in the P direction
Areas of the European ecological network "Natura 2000"			
1.	Areas important for bird conservation **Curonian Spit National Park** Identification code: 1100000000057, Site code LTKLAB001	Established in 2004. Area – 23,859 ha. Purpose of establishment: White-tailed Eagle (*Haliaeetus albicilla*) Woodlark (*Lullula arborea*) Tawny pipit (*Anthus campestris*) Little gull (*Larus minutus*) Common tern (*Sterna hirundo*) Common scoter (*Melanitta fusca*) Razorbill (*Alca torda*), migratory birds	The PŪV water area borders the PAST territory to the east. The planned 110 kV EEPOL line realignment solutions for all PŪV alternatives fall within the PAST territory.
2.	Areas important for habitat protection **Curonian Spit** Identification code: 1000000000215, site code LTNER0005	Established in 2005, area – 9,986 ha. Purpose of establishment: 2110 Embryonic shifting dunes, 2120 White dunes, 2130 Grey dunes, 2140 Dune heaths, 2170 Dune willow thickets, 2180 Wooded coastal dunes, 2190 Wet dune slacks, 2320 Coastal sand dune grasslands, Goldenrod, Sea sandwort, and Sand couch grass.	The PŪV water area borders the BAST territory in the V direction. The planned solutions for the reconstruction of the 110 kV EEPOL section fall within the BAST territory for all PŪV alternatives.

3.	Areas important for habitat protection **Curonian Lagoon** Identification code: 1000000000101, Site code LTSIU0012	Established in 2005. Area – 37,909 ha Purpose of establishment: 1130 River mouths, 1150 Lagoons, Baltic salmon, European chub, European bullhead, European perch, European pike, European burbot	~ 0.67 km in the P direction

No.	Protected area/priority Name of protected area/identification code	Brief description of the protected area	Minimum distance to the PŪV, km
4.	Areas important for bird conservation **Curonian Lagoon** Identification code: 1100000000082 Site code: LTKLAB010	Established in 2010. Area – 6,648 ha. Purpose of establishment: Tundra swan (*Cygnus columbianus*) Northern pintail (*Anas acuta*) Goosander (*Mergus merganser*) Smew (*Mergus albellus*) Little Gull (*Larus minutus*) White-tailed eagle (*Haliaeetus albicilla*)	~ 0.67 km in the P direction

4.8.2 Impact of the PŪV on protected areas

EU Natura 2000 Sites of Community Importance

Curonian Spit (LTNER0005)

The main solutions of the PŪV (dredging of the water area, formation of new land areas) are not planned for the land part of the Curonian Spit in any of the PŪV alternatives. Coastal management solutions (installation of underwater breakwaters and replenishment of the foreshore with sand) would be implemented along the Curonian Spit coastline. The impact on the spit's shores and the lagoon's ichthyofauna is described and assessed in Sections 4.6 and 4.9

On the Curonian Spit, "secondary" project solutions are planned for any project alternative, which are related to the reconstruction of the 110 kV EEPOL Marios–Juodkrantė section (Fig. 4.8.1.1). A detailed description of these solutions is provided in Section 3.3. The impact of these solutions during implementation (during the dismantling of the EEPOL and the laying of the underground power cable) would be temporary and would not have a significant negative impact on the protected values of the Curonian Spit National Park (KNNP) and the Natura 2000 BAST. The implemented solutions (dismantling of approximately 4 km of EEPOL and 23 towers) would have a positive impact on protected areas and the future activities of the KNNP (freeing up areas for potential habitats to establish and/or expand).

Curonian Lagoon (LTSIU0012)

Due to changes in meteorological and hydrodynamic conditions in the relevant area, periodic changes in water chemistry occur, i.e., periodic redistribution of freshwater and hypersaline water zones. The assessment of the impact of all PŪV alternative solutions on hydrodynamic changes in the water and on the ichthyofauna is presented in Sections 4.1.2 and 4.9. The changes in water salinity in the northern part of the Curonian Lagoon (at the boundary of the southern port basin) identified through modeling due to the implementation of the PŪV alternatives would be insignificant at low flow rates (up to 0.32 ‰). At high flow rates (1,725 and ^{3}200 m^3/s), the salinity differences between Alternative 0 and the PŪV alternatives would be up to 0.80‰. Such changes in water salinity would be rare and short-lived (on average 15 days per year) and would not affect the Curonian Lagoon ecosystem.

Areas Important for Bird Conservation

Curonian Spit National Park (LTKLAB001)

Part of the PAST area also covers part of the KVJU area (a strip approximately 16–435 m wide) along the entire eastern boundary of the Curonian Spit National Park up to Kiaulės Nugaros Island. In all cases of implementing the proposed solutions for the PŪV alternatives, there is a potential for short-term negative impacts on migratory and wintering birds due to disturbance caused by dredging of water bodies, land reclamation, and direct shoreline management works. Significant negative impacts can be avoided or mitigated by applying the impact avoidance and mitigation measures listed in Section 4.9.3.

As already mentioned, the "secondary" solutions of the PŪV (reconfiguration of the 110 EEPOL section) will have a positive impact on the protected values of the PAST—birds—in all PŪV alternatives. The dismantling of the approximately 4 km long section of the EEPOL with overhead supports will reduce the risk of birds colliding with these engineering structures during their migration.

Curonian Lagoon (LTKLAB010)

The PŪV solutions for all PŪV alternatives do not fall within the PAST and will have no direct impact. However, the project solutions for all project alternatives involve dredging part of Kiaulės Nugaros Island, which is an important area for the nesting of various bird species (see Section 4.9 for more details). Excavating part of the island would reduce the area of suitable nesting sites, therefore, as a compensatory measure, the LOD ornithologists who conducted the assessment propose considering the creation of a new stationary island of at least 10 ha in the PAST-Curonian Lagoon area, approximately 1.1 km south of the PŪV site near the Stariškiai Shoal (Fig. 4.9.3.1). The aforementioned island would be a new feature in the PAST area, intended to improve the habitat conditions for birds; however, from a legal standpoint, this solution is currently not feasible.

Impact on other protected natural areas

Curonian Spit National Park

The KVJU territory borders the Curonian Spit National Park to the west, which was inscribed on the UNESCO World Heritage List in 2000. Certain parts and areas of the Curonian Spit National Park overlap with the previously described Natura 2000 BAST and PAST sites of the European ecological network. The aforementioned Natura 2000 areas also cover part of the KVJU territory (a strip approximately 16–435 m wide) along the entire eastern boundary of the Curonian Spit National Park up to Kiaulės Nugaros Island and the coastal waters of the Baltic Sea.

The KNNP territory also includes the Alksnynė Landscape Reserve, within which the “secondary” solutions of the PŪV (reconfiguration of the 110 kV EEPOL section) would be implemented (Fig. 4.8.1.1). As described earlier, these solutions may have a temporary, minor impact during their implementation (dismantling of the EEPOL and laying of the underground power cable). In the long term, dismantling the EEPOL section will have a positive impact on the landscape reserve (see Section 4.7 for more details).

When implementing the PŪV solutions (deepening the water areas and creating new land), preventive shoreline stabilization measures will be required in the coastal water area of the Curonian Spit within the KNNP territory for all PŪV alternatives – installing underwater retaining walls. The section for installing such walls from PK83 to Alksnynė was already planned in the 2019 EIA report [19]. In the long term, these solutions would have a positive impact, i.e., they would reliably stabilize the western underwater slope of the Curonian Spit and protect it from the threat of erosion, while also enabling the implementation of the KVJU PŪV solutions.

Smeltė Botanical Reserve

It is located on the Smeltė Peninsula and extends along its eastern boundary. A nature reserve of national importance, established to preserve the habitats of rare plant species. The reserve’s territory is state-owned and managed by the Curonian Spit Nature Reserve. In this reserve, the habitats of rare species are protected within a 3.64-hectare area where no economic activity is permitted. The southern edge of the reserve is bordered by the territory of the container terminal operated by UAB “Konteinerių terminalo grupė.” A small northern section of the reserve (approximately 300 m long and 15 m wide) is located within the territory of the International Ferry Terminal. The western boundary runs along Perkėlos Street, and the eastern boundary along the shore of Malkų Bay. The length of the shoreline along Malkų Bay is 1,534 m; the length of the shoreline relatively untouched by industrialization is 1,162 m. On March 21, 2011, the Nature Management Plan for the Smeltė State Botanical Reserve was approved by Order No. D1-243 of the Minister of the Environment of the Republic of Lithuania [55].

No development is planned in the vicinity of the reserve, and no negative impact on the Smeltė Botanical Reserve is anticipated.

Curonian Lagoon Biosphere Reserve

September 17, 2009 Subsection 5.1.1 of Chapter III of the Regulations of the Curonian Lagoon Biosphere Reserve, approved by Order No. D1-549 of the Minister of the Environment of the Republic of Lithuania, stipulates that it is prohibited to carry out economic or other activities throughout the territory of the Biosphere Reserve if such activities would disrupt the hydrological regime and the chemical composition of the water, or would alter or otherwise significantly degrade the condition of protected natural habitats and species habitats.

The potential impact of the PŪV on this protected area is described in the section on the impact on the EU Natura 2000 site – Curonian Lagoon (LTKLAB010).

Impact during the operation of the PŪV facilities

Areas important for habitat protection

No significant negative impact on the values of the EU Natura 2000 SPA, both on land and in water, is expected upon implementation of the PŪV solutions for any of the PŪV alternatives. The potential impact on biodiversity for individual PŪV alternatives is described in Section 4.9.

Areas important for bird protection

No significant adverse changes are expected in EU Natura 2000 SPA areas following the implementation of any of the PŪV alternatives compared to the current state. Upon completion of the direct KVJU development works, migratory and wintering birds would acclimate and adapt to the new hydraulic structures and the newly formed semi-enclosed water bodies in the Curonian Lagoon.

Impact on other protected natural areas

Curonian Spit National Park

The potential impact for all PŪV alternatives is described above.

Curonian Lagoon Biosphere Reserve

Upon implementation of the PŪV solutions under any PŪV alternative in the southern part of the KVJU, the solutions planned for 2019 would involve the installation of the port's southern gates, designed to reduce water flow and the dispersion of saline water into the lagoon. Modeling has shown that changes in salinity in the northern part of the Curonian Lagoon (at the boundary of the southern port basin) due to the implementation of the PŪV alternatives would be insignificant at low flow rates (up to 0.32 ‰). At high flow rates (1,725 and 3,200 m^3/s), salinity differences between Alternative 0 and the PŪV alternatives would be up to 0.80‰. Such changes in water salinity would be rare and short-lived (on average 15 days per year) and would not affect the Curonian Lagoon ecosystem (see Section 4.2).

Conclusion: None of the main solutions of the PŪV alternatives are planned within the European ecological network Natura 2000 BAST and PAST or other protected areas. "Secondary" solutions of the PŪV are planned within the KNNP and the BAST and PAST areas located therein, as well as within the Alksnynė Landscape Reserve—the reconstruction of the 110 kV EEPOL Marios–Juodkrantė section. These solutions (dismantling the existing approximately 4 km section of the EEPOL line) will have a positive impact on the landscape

landscape and biodiversity. Additionally, to mitigate and compensate for the potential indirect impacts of the project, it is proposed to implement shoreline management measures on the eastern coast of the Curonian Spit (replenishing the foreshore with sand).

The impact of all project alternatives on protected areas would be similar.

4.8.3 Measures to avoid, reduce, and compensate for significant adverse impacts on protected areas

Measures to avoid and mitigate impacts on environmental elements constituting protected areas, such as surface water, shorelines, landscape, and biodiversity, are described in more detail in Sections 4.1, 4.6, 4.7, and 4.9.

4.9 Biodiversity

4.9.1 Description of the current state

Vegetation

Terrestrial vegetation

Terrestrial vegetation in the PŪV area is most often directly related to the distribution of the soil layer; therefore, both low and tall vegetation in the PŪV area is found only in those areas that are not covered by artificial surfaces and where economic activity is not intensive. Such areas within the PŪV territory include:

- the southwestern part of the Smeltė Peninsula;
- Kiaulės Nugaros Island.

The area on the Curonian Spit where “secondary” solutions for the PŪV are planned—the dismantling of the 110 kV EEPOL overhead line and the laying of a new underground power cable (approximately 3.5 ha)—should also be included in these areas.

Southwestern part of the Smeltė Peninsula

The area is overgrown with grass, reeds, and shrubs (common hawthorn, blackthorn, acacia, hawthorn, prickly sea buckthorn, rose hips, etc.) and patches of scattered stands (birch, aspen, black alder, aspen, etc.) (Fig. 4.9.1.1). The total area covered by various vegetation is approximately 11.0 ha.





View to the north from the surface wastewater discharge point into the Curonian Lagoon



View to the north from the surface wastewater discharge point into the Curonian Lagoon



Coastal vegetation



Coastal vegetation



View to the north toward the contaminated soil site (from the abandoned building)

Field paths within the territory

4.9.1.1 Fig. Vegetation in the southwestern part of the Smeltė Peninsula within the PŪV territory

Kiaulės Nugaros Island

Most of the island, covering an area of about 18 ha, is overgrown with reeds, while the remaining part is covered with grass (Fig. 4.9.1.2).



Southern part of Kiaulės Nugaros Island



Central part of Kiaulės Nugaros Island



Northern part of Kiaulės Nugaros Island

4.9.1.2 Fig. Vegetation of Kiaulės Nugaros Island (photos by L. Stumbrienė)

Location of the planned 110 kV underground power cable in the Curonian Spit

Most of the project area is covered with grass or has no vegetation; in the planned cable route and along the existing 110 kV EEPOL line, shrubs grow in some places (Fig. 4.9.1.3).





4.9.1.3 Fig. Planned location of the 110 kV power cable and its vegetation: in the top photo – the planned cable “emergence” point and the location under the lagoon bottom; in the middle photo –

the bend toward the sea near the Alksnynė farmstead; in the bottom photo – the cable route toward the existing 110 kV EEPOL line.

Aquatic vegetation

The lagoon waters near Kiaulės Nugaros Island and the Klaipėda Strait fall within an area subject to intense human activity. Current conditions (water eutrophication, low transparency, and shoreline modification through reinforcement) are unfavorable for aquatic and coastal vegetation. Submerged vegetation in the immediate vicinity of Kiaulės Nugaros Island, and especially to the south of the island, is very poorly developed. Due to low water transparency, plants grow only to a depth of 1 m; only species tolerant or indifferent to low water transparency, pollution, and higher salinity are found: comb-leaved pondweed (*Potamogeton pectinatus*) and perfoliate pondweed *(Potamogeton perfoliatus*), and hornwort (*Ceratophyllum demersum*). Plants of these species typically form only small thickets, which are more common south of the island and along the eastern shore of the lagoon. About 1 km south of Kiaulės Nugaros Island, on the eastern edge of the lagoon near the end of the Smeltė Peninsula, underwater thickets of stoneworts have formed at depths of up to 1 m. These are dominated by rough, globular, and small stoneworts (*Chara aspera, Chara globularis, Chara contraria*); among flowering plants, marsh water-milfoil (*Zannichellia palustris*), water-milfoil, and permautalapė are found. These plant communities are usually covered by filamentous algae of the genus *Cladophora*; *Enteromorpha intestinalis* is found on concrete, boulders, and gravel (Labanauskas, 2000).

The vegetation of shore plants (helophytes) is very poorly developed at the edge of the Smeltė Peninsula, fragmented on the western edge along the Curonian Spit, and most lush at the very

edges of the Kiaulės Nugaros

. The tall helophyte zone is dominated by common reed (*Phragmites australis*), with lake and blue sedges (*Schoenoplectus lacustris, Schoenoplectus tabernaemontani)* and sea club-rush (*Bolboschoenus maritimus*). At the edges of the reed beds, in the zone of water level fluctuations where plant debris accumulates, annual nitrophilic plants grow abundantly—biddens (*Bidens tripartita, B. frondosa, B. cernua*), saltbushes (*Atriplex spp.*), knotweeds (*Persicaria spp.*), and sea sorrel (*Rumex maritimus*). These plants are abundant in the helophyte thickets of Kiaulės Nugaros Island.

The uniqueness of the vegetation in the northern part of the Curonian Lagoon, as a marine lagoon, is highlighted by halophytes—plants adapted to saline habitats. In the underwater vegetation of this part of the lagoon, where species indifferent to salinity predominate, only three halophyte species have been recorded—the Baltic and gray stoneworts (*Chara baltica, Chara canescens*), and the nest-forming stonewort (*Tolypella nidifica*). The main habitats of these algae begin > 2 km south of Kiaulės Nugaros Island, in the shallows along the eastern edge of the Curonian Lagoon near Stariškė. Of the submerged flowering plants common in the lagoon, only the marsh water-crowfoot (*Zannichellia palustris*) is classified as a weak halophyte.

Among the halophytic species in this part of the lagoon, the aforementioned blue sedge (*Shoenoplectus tabernaemontani*) and the sea club-rush (*Bolboschoenus maritimus*) grow in the coastal shallows. They often grow singly or in small, sparse clumps. Blue sedge grows more frequently than sea sedge in areas constantly submerged by water. Sea sedge rarely grows in water and is more commonly found on shores flooded only during high tide or in moist coastal meadows.

Among the halophytes that are not classified as aquatic plants but grow on the shores of lagoons that are periodically flooded and located in the zone of fluctuating water levels, where they are constantly splashed by salty water, the following are worth mentioning: the common aster (*Aster tripolium*), sea milkwort (*Glaux maritima*), and saltmarsh rush (*Juncus gerardii*)—species listed in the Lithuanian Red Book—as well as Baltic rush (*Juncus balticus*). These halophytes occur on the unpaved shores of the Smeltė Peninsula; fragments of milkwort and salt rush communities are found along the entire eastern shore, almost as far as the Tyrų Marsh. Among the annual nitrophiles growing in the helophyte zone, on accumulations of plant debris or in the sandy, hummocky coastal sand, the halophytes include the aforementioned species—sea sorrel (*Rumex maritimus*), arrowhead, and spiny-leaved saltbush (*Atriplex calotheca, Atriplex prostrata*).

All protected aquatic plant species found in the Curonian Lagoon described below are listed in the Lithuanian Red Book and classified as Category 3®—that is, rare species with small populations due to their biological characteristics.

Chara canescens Desv. et Loisel in Loisel. – gray-haired stonewort Submerged algae in the continental water bodies and seas of the Curonian Lagoon. Grows in small or medium-sized clumps. Habitats important for the conservation of this species begin >2 km south of Kiaulės Nugaros Island on the eastern edge of the lagoon near Kairiai. It grows in reed beds protected from strong waves, at a depth of 5–10 cm. It grows sparsely in communities of rough stonewort (*Charetum asperae*) forming in the gaps of reed belts. The reed beds are abundant in filamentous green algae (*Cladophora glomerata*).

Chara baltica (Bruzelius) – Baltic stonewort. Submerged algae of estuarine waters. Grows in tufts 10–35 cm tall. The main habitat is >2 km south of Kiaulės Nugaros Island on the eastern edge of the lagoon near Kliošių Forest. It most commonly grows in shallow waters (up to 10 cm) along

a reed belt, in communities of submerged plants—maurabragis and pondweeds (*Charetum asperae, Potamogetonetum pectinati*). Rarely forms *Charetum balticae* communities or grows singly in communities of sedges and reeds (*Scirpetum tabernaemontani, Phragmitetum australis*).

Tolypella nidifica (O. F. Müll.) A. Braun – nest-forming pondweed. Annual submerged pondweeds of estuarine waters. Forms tufts 5–10 cm tall. The main habitats of this species begin >2 km south of Kiaulės Nugaros Island on the eastern edge of the lagoon near Stariškė. It grows in the shallows of reed beds, at a depth of 5–10 cm, within communities of rough pondweed (*Charetum asperae*) or southern reed (*Phragmitetum australis*).

The port entrance and the Klaipėda Strait, which are used for intensive shipping, do not feature abundant underwater vegetation due to ongoing activities and are currently very poorly developed. The plants do not form large thickets; there are no protected species, and only species tolerant to anthropogenic factors grow there.

Fauna

Benthic habitats

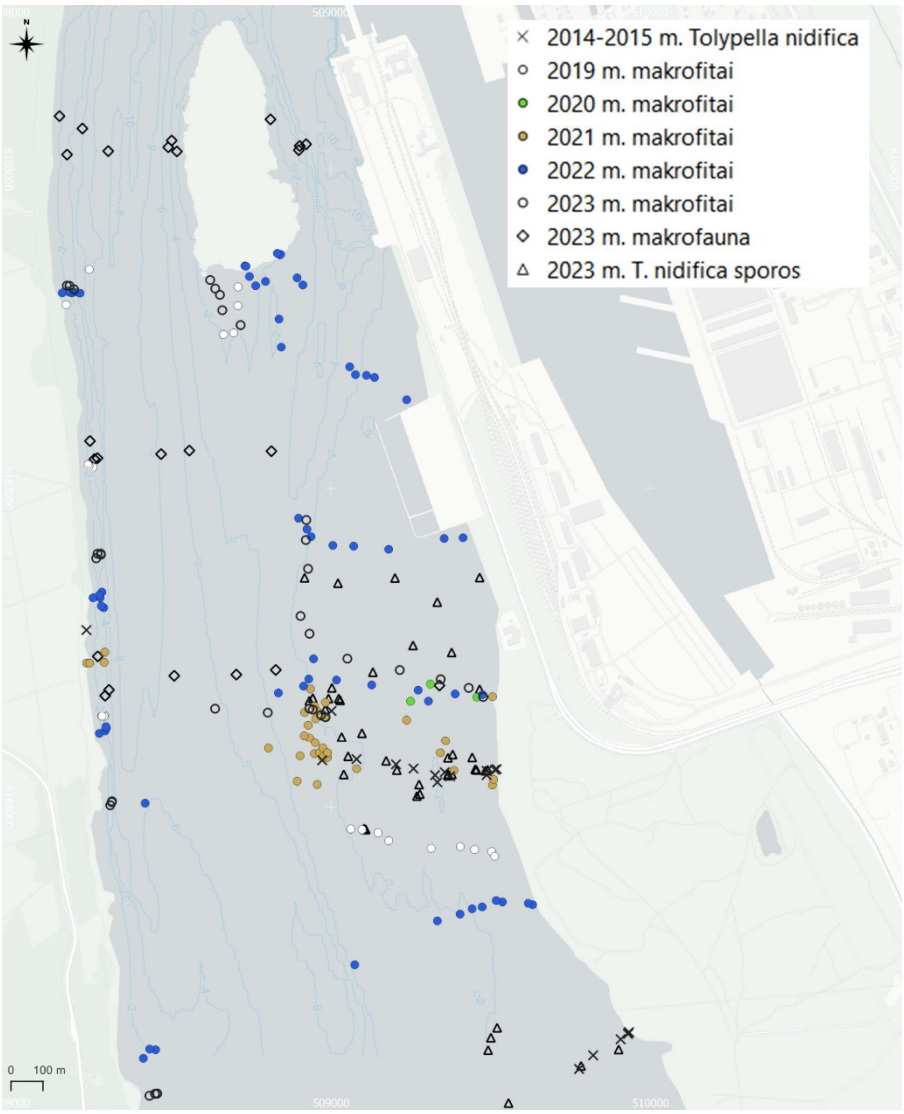
Research and assessment of bottom habitats in the PŪV water area were conducted by KU scientists led by Dr. D. Daunys.

The objective of the seabed habitat survey was to inventory the diversity, structure, and distribution of seabed habitats and biotopes in the project area. The term “habitat” is used in accordance with the concept of the HELCOM underwater biotope and habitat classification system (HELCOM HUB) (HELCOM 2013) and refers to a regularly recurring and structurally recognizable abotic environment on the seabed. A seabed habitat may consist of many biotopes. The term “biotope” refers to an abiotic environment characterized by a distinctive biota (HELCOM 2013). Traditionally, studies of bottom habitats include an inventory of the dominant bottom fauna and underwater vegetation, an assessment of their distribution and abundance, analysis of bathymetric and lithological data, and an evaluation of the diversity and quantitative characteristics of other species or higher-level taxa.

The surveys covered all lithological and bathymetric zones of ecological significance and importance to biodiversity within the PŪV area. Surveys of bottom macrofauna were conducted on May 20, 2023, using standard soft-bottom inventory methods depending on depth: Van Veen (0.025 m², 3.14 L volume) grab samplers at depths greater than 1 m (18 sampling stations), and a pneumatic grab sampler with a 0.1 m diameter at depths up to 1 m (6 sampling stations). In total, surveys were conducted at 24 locations (Table 4.9.1.1 and Fig. 4.9.1.4) [39].
Macrophyte mapping was conducted on June 12, 2023, at 35 sites (Table 4.9.1.1) to assess the distribution of the protected species *Tolypella nidifica*. In subsequent months, this species is subsequently outcompeted by other macrophytes (Steinhardt et al., 2009). The distribution of macrophytes was mapped using a double-sided rake to dredge the bottom (≥ 1 m^2) at different depths. Based on the amount of macrophytes on the rake, bottom coverage by macrophytes was estimated semi-quantitatively (in percentages). Additionally, macrophyte mapping data from the PŪV area in 2014–2015 (only the detection and coverage of *Tolypella nidifica*) and 2019–2022 (Fig. 4.9.1.4) were used, which were collected during scientific projects: Funded by the Lithuanian Council of Science
“MAURAKUMA – Distribution of Maura-bragūnai in the Curonian Lagoon and Analysis of the Impact of Environmental Factors” (MIP-040/2014) and “Assessment of Maura-bragūnai Ecosystem Services and the Impact of Climate Change on Them in a Hypertrophic Lagoon” (S-MIP-19); under a contract with the Environmental Protection Agency

the study “Public Procurement Contract for Services Related to the 2020 Survey of Macrophytes in the Baltic Sea and the Curonian Lagoon” (28T-2021-17/SUT-21P-5).

Due to the spatially uneven distribution of *T. nidifica* habitats, on April 7 and May 12, 2023, 56 bottom sediment samples were collected from different locations and depths (0.3–2.5 m) to assess the oospore bank of the species in and around the PŪV area.



4.9.1.4 Fig. Survey locations for benthic macrofauna, macrophytes, *Tolypella nidifica*, and its spores in 2014–2015 and 2019–2023 within the PŪV area in the Curonian Lagoon. Isobaths—blue dotted lines

[39].

Profiles of the depth distribution of relative coverage of macrophyte species were created for the eastern and western shores and Kiaulės Nugaros Island using the “R” program (R Core Team, 2020) with the “Rstudio” user interface (Rstudio Team, 2020) and the “geometry” (Habel et al. 2019) and “plotrix” (Lemon 2006) packages.

Photic zone habitats were identified based on macrophyte profile data and the following criteria: relative species coverage ≥ 50% and habitat length/width > 10 m. *Cladophora glomerata* was detected as an epiphyte, therefore, this species was not

taken into account. The boundaries of macrophyte communities (habitats) were determined using interpolated bathymetry of the study area. Depths at points were interpolated using the inverse distance method with a distance weight of p = 8 in QGIS (QGIS.org, 2020).

Habitats were identified in accordance with HELCOM HUB (HELCOM) classification criteria by integrating data on benthic fauna, submerged vegetation, surface bottom sediments, and bathymetry. The list of inventoried habitats corresponds to detail levels 5–6 of the HELCOM HUB classification.

4.9.1.1 Table. Sampling stations for 2023.

Benthic macrofauna sampling stations in 2023

Station No.	Length	Latitude	Depth, m
1	21.12993	55.65819	2.9
2	21.13070	55.65893	5.2
3	21.13198	55.65829	8.2
4	21.13496	55.65840	5.0
5	21.13514	55.65859	2.8
6	21.14146	55.65831	2.8
7	21.14150	55.65843	5.0
8	21.14182	55.65847	7.5
9	21.14007	55.64983	3.4
10	21.13599	55.64985	5.2
11	21.13458	55.64975	7.9
12	21.13142	55.64964	5.2
13	21.13126	55.64962	2.9
14	21.14026	55.64367	3.0
15	21.13830	55.64354	5.0
16	21.13521	55.64351	7.8
17	21.13196	55.64312	5.0
18	21.13177	55.64295	3.0
19	21.13539	55.65828	1.0
20	21.12956	55.65928	1.0
21	21.14005	55.65918	1.0
22	21.13104	55.65013	1.0
23	21.13141	55.64406	1.0
24	21.14840	55.64322	1.0

Macrophyte sampling stations in 2023

Station No.	Longitude	Latitude	Depth, m
1	21.14273	55.64233	0.9
2	21.14251	55.64239	2.2
3	21.14210	55.64255	2.9
4	21.14193	55.64258	3.5
5	21.13986	55.64247	4.0
6	21.13200	55.63985	1.0
7	21.13209	55.63997	2.0
8	21.13207	55.63994	1.5
9	21.13429	55.63177	1.5
10	21.13430	55.63177	1.2
11	21.13430	55.63177	1.2
12	21.13419	55.63176	1.3
13	21.13392	55.63170	1.2
14	21.13158	55.64693	1.2
15	21.13157	55.64695	2.5
16	21.13141	55.64695	1.6
17	21.13134	55.64682	0.7
18	21.13027	55.65440	2.2
19	21.13004	55.65450	1.5
20	21.12991	55.65450	0.5
21	21.13704	55.65466	0.3
22	21.13729	55.65441	0.4
23	21.13752	55.65424	0.5
24	21.13764	55.65380	1.1
25	21.13855	55.65338	1.9
26	21.14180	55.64789	2.8
27	21.14177	55.64733	2.0
28	21.14188	55.64652	0.9
29	21.14150	55.64519	0.9
30	21.14194	55.64469	0.9
31	21.14382	55.64398	0.8
32	21.14643	55.64366	1.0
33	21.14846	55.64340	0.6
34	21.14986	55.64315	0.8
35	21.15057	55.64290	0.5

Current status

*Habitat diversity in the PŪV area***.** Based on information collected during the habitat survey in the PŪV area, 9 biotopes were identified (Fig. 4.9.1.4 and Table 4.9.1.2): The 6 biotopes recorded from the shoreline to a depth of 4 m are formed by macrophyte species (47% of the total PŪV area), while the structure of the 3 deeper biotopes is characterized solely by benthic macrofauna species (53%). The distribution of macrophyte habitats across different shoreline profiles and the classification of biotopes by habitat within the photic zone are presented in Appendix 1.

In the photic zone, the biotope of fine sediments with maurabragūnai covers the largest area within the PŪV region (Fig. 4.9.1.5), occupying 0.61 km^2(17% of the total PAV area). This biotope is particularly characteristic of the eastern littoral of the Curonian Lagoon at depths of 2–4 m (Bučas et al., 2019) and is characterized by high biological diversity, primarily consisting of *Chara contraria, Chara aspera, and Chara globularis*. Among the stoneworts, duckweed, water plantain (*Alisma plantago-aquatica*), and spiked water milfoil (*Myriophyllum spicatum*) are frequently found. In this biotope, species listed in the Lithuanian Red Book—Baltic stonewort (*Chara baltica*), grayish stonewort (*Chara canescens*), and *Tolypella nidifica*—were detected in 2014–2015. In 2021 and 2023, only *T. nidifica* sites were found, as the reed beds where other species are most commonly found (Sinkevičienė et al., 2017) were not surveyed. In 2023, new *T. nidifica* sites were found near Kiaulės Nugaros Island and along the western shore, with the highest coverage occurring in the PŪV area at a depth of 0.8–0.9 m (Fig. 4.9.1.6). A relatively higher abundance of *T. nidifica* spores (> 1,000 spores/200 ml of sediment) was observed in the 0.5–2.0 m depth range and overlapped with areas where the species' coverage was > 1%. Spores of this species were also detected along the eastern shore of the lagoon south of the study area, where *T. nidifica* stands were found in 2014–2015 (Sinkevičienė et al., 2017). The relatively high abundance of spores indicates that the *T. nidifica* habitat extends along the eastern shore, likely as far as Dreverna, where salinity is still suitable for this marine species.

The photic zone biotope of fine sediments with floating plants (*Potamogeton, Stuckenia*) covers approximately 0.49 km^2(13% of the total PŪV area). The biotope is dominated by *Potamogeton rutilus, Potamogeton perfoliatus,* and *Stuckenia pectinata*; the latter two are characteristic of the entire Curonian Lagoon, while *P. rutilus* is found only in the northern part, where brackish waters enter (Bučas et al., 2019). Among the floating plants, there are some water milfoils, especially along the eastern shore of the lagoon.

The biotope of fine sediments with water plantain (Alisma) in the photic zone covers approximately 0.4 km^2(11% of the total PAV area) and is characteristic only of the PAV region. The biotope is dominated by a stand of water plantain (*Alisma plantago-aquatica*), which has been present since 2021. Among the water plantains, duckweed and pondweed (up to 7 species) grow, and a dense covering of the epiphyte *Cladophora glomerata* is often observed on the macrophytes.

The photic zone biotope of fine sediments with duckweed and pondweed covers approximately 0.13 km^2(3
% of the total EIA area). The biotope is distributed mainly along the western shore of the lagoon and the Kiaulės Ridge. The diversity of macrophytes in the biotope is not high—up to 8 species.

The biotope of fine sediments with common reed (*Phragmites australis*) in the photic zone covers approximately 0.09 km^2(2% of the total EIA area). The biotope is most developed along the western shore of the lagoon and the Kiaulės Ridge, while there are only a few small stands on the eastern shore. The diversity of macrophytes in the reed beds has not been studied in detail, but common reed dominates; there may be stands of *C. baltica* and *C. canescens* (Sinkevičienė et al., 2017).

The photic zone mixed sediment with green algae (*Ulva*) biotope covers approximately 0.03 km^2(1% of the total EIA area), is most developed along the eastern shore of the lagoon, while on the western shore there are only a few small stands among the reed beds. *Ulva intestinalis* dominates on the

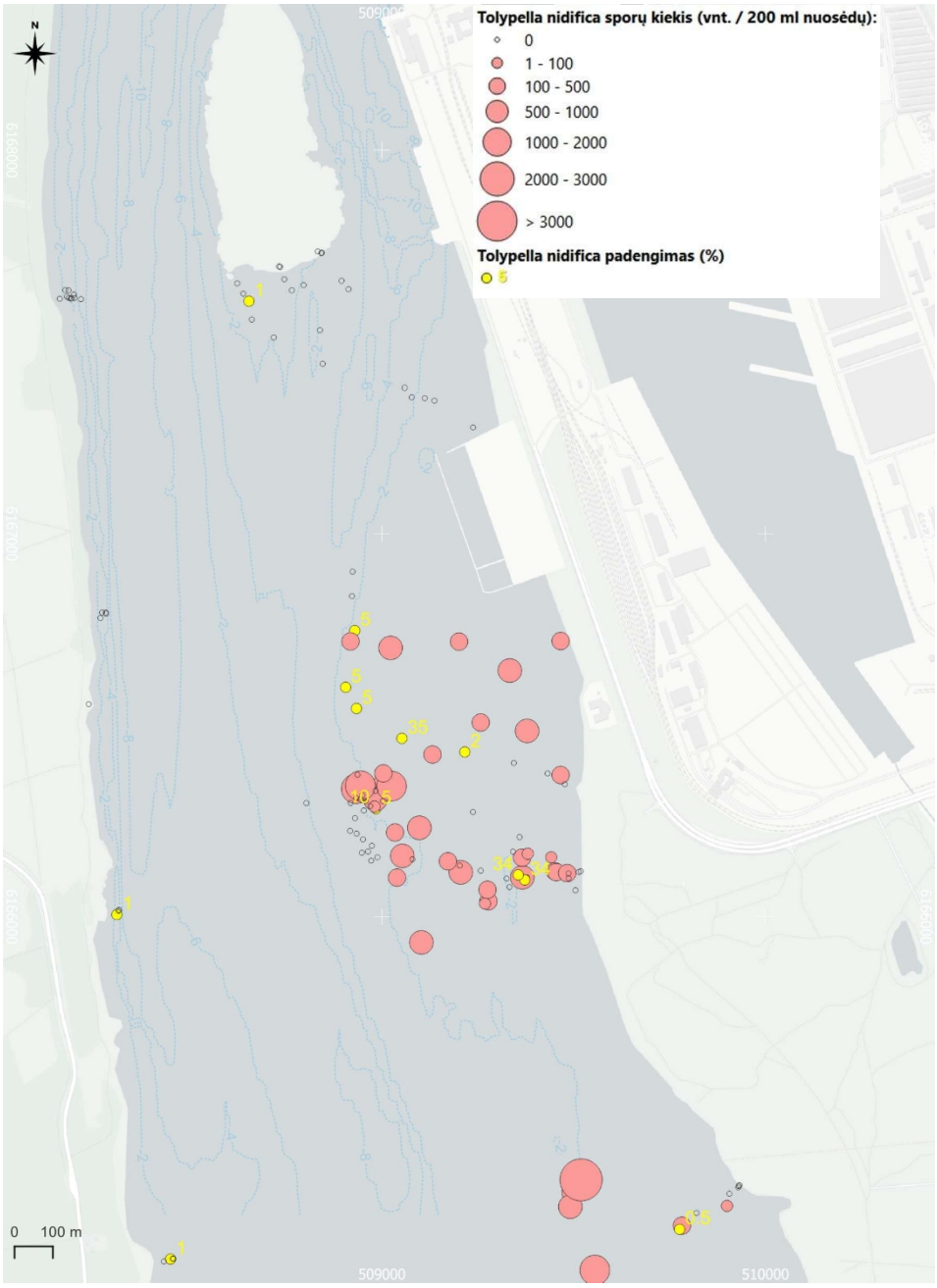
gravel and pebbles, while *Ulva prolifera* dominates as an epiphyte.



Biotopai:

- Afotinės zonos mišrios nuosėdos su įvairia epifauna
- Afotinės zonos smulkios nuosėdos su oportunistinėmis daugiašerėmis kirmėlėms
- Afotinės zonos smulkios nuosėdos su uodų lervomis (Chironomidae)
- Fotinės zonos smulkios nuosėdos su dumblialaiškiais (Alisma)
- Fotinės zonos smulkios nuosėdos su maurabragūnais (Charales)
- Fotinės zonos smulkios nuosėdos su nendrėmis (Phragmites)
- Fotinės zonos smulkios nuosėdos su plūdėmis (Potamogetonaceae)
- Fotinės zonos smulkios nuosėdos su plūdėmis ir maurabragūnais
- Fotinės zonos mišrios nuosėdos su žaliadumbliais (Ulva)

4.9.1.5 Fig. Distribution of bottom habitats in the PŪV area of the Curonian Lagoon [39].



4.9.1.6 Fig. Distribution and relative coverage of the protected species *Tolypella* nidifica (2014–2015, May–July 2021 and 2023)
and spore abundance (2023) in the PŪV area of the Curonian Lagoon [39].

In the aphotic zone, the most common biotope is that of fine sediments with mosquito larvae (Chironomidae), which covers 1.48 km^2(or 39% of the total PŪV area). This biotope is common and found throughout the Curonian Lagoon at depths of 2–3 m; it is characterized by low biological diversity, and the fauna consists primarily of infaunal chironomid larvae and small-mouthed worms.

The biotope of fine sediments in the aphotic zone with opportunistic polychaetes covers 0.28 km^2(i.e., 7% of the total PŪV area). This biotope is characteristic only of the eastern coast of the northern part of the Curonian Lagoon, where regular inflows of brackish water allow the marine polychaete worms *Hediste diversicolor* and *Marenzelleria* sp. to establish themselves.

The biotope of mixed sediments in the aphotic zone with diverse epifauna covers 0.16 km^2(4% of the total PŪV area). To our knowledge, this specific biotope, formed in coarse sand, gravel, and cobble substrates, is found exclusively within the PŪV territory, in the western channel of Kiaulės Nugaros Island at depths greater than 4 m. Coarse soils in the zone of influence of both freshwater and seawater serve as a substrate for various epifaunal species, both marine (e.g., *Amphibalanus improvisus*, *Cordylophora caspia*) and freshwater (e.g., *Dreissena polymorpha*). Due to atypical environmental conditions, this biotope is unique in the Curonian Lagoon.

4.9.1.2 Table. Characteristics of biotopes registered in the PŪV territory and their equivalents in the HELCOM HUB classification.

No.	Habitat name	Habitat area (km^2)	Depth range (m)	Description of habitat structure	HELCOM HUB Code and name in English
1.	Fine sediments in the aphotic zone with mosquito larvae (Chironomidae)	1.46	3–10	This biotope is exclusively found in fine sand–aleurite sediments; its diversity is low—up to 9 taxa are found, but most commonly 4–6 taxa. Macrofauna abundance ranges from 4,000 to 13,000 ind· m^{-2} , but in some locations it can reach up to 50,000 ind· m^{-2} ; biomass – 5–15 g m^{-2} .	AB.H3P1 Baltic aphotic muddy sediment dominated by midge larvae (Chironomidae)
2.	Fine sediments of the aphotic zone with opportunistic polychaetes	0.28	3–6	The biotope is characterized by fine sand and silt, and contains 8 infaunal taxa. The biotope community is stable, formed by a complex of mosquito larvae—small-segmented worms and ostracods (Ostracoda)—common in all lagoons, along with the polychaetes *Marenzelleria* sp. and *Hediste diversicolor*. Due to the latter, the biomass of the macrofauna community is greater than in the first biotope, most often exceeding 50 g m^{-2} .	AB.H3M5 Baltic aphotic muddy sediment characterized by various opportunistic polychaetes
3.	Aphotic zones mixed sediments with diverse epifauna	0.16	4–10	Surface sediments are dominated by washed-out The bottom is characterized by gravel and cobbles, boulders in places. This bottom is unsuitable for the development of infaunal species, so it is dominated by substrate-attached or capable (epifaunal) taxa, among which most found *Amphibalanus improvisus, small Dreissena polymorpha, Potamopyrgus antipodarum, side-swimmers, hydra-like organisms Cardilophora caspia*. The abundance and biomass of macrofauna in this biotope are quite high, ranging from 5,000–7,000 Ind m^{-2} and up to 100 g m^{-2}), and the taxonomic diversity, compared to sand/aleurite biotopes, is also significantly greater, reaching 14 taxa.	AB.M1V Baltic aphotic mixed substrate characterized by mixed epibenthic macrocommunity
4.	Photic zone variety sediments with Alisma (Alisma)	0.16	0.9–2.0	The biotope is widespread in sandy soil. Macrophytes variety of up to 11 taxa, dominated by *Alisma plantago-aquatica*, *Potamogeton perfoliatus, Potamogeton rutilus, Stuckenia pectinata; Chara contraria* and *Chara globularis, Tolypella nidifica, Myriophyllum spicatum, Zannichellia palustris,* and epiphytes (*Cladophora glomerata, Ulva prolifera*). The average and maximum bottom coverage is 25% and 70%, respectively (with epiphytes, it can reach up to 200%).	AA.J1B1/2/4* Baltic photic sand dominated by water-plantain (Alisma)
5.	Photic zone small sediments with sand sedges (Charales)	0.40	0.5–3.5	The biotope is patchy and widespread in sandy soil. Macrophyte diversity up to 11 taxa, of which dominated by *C. Contraria, C. Globularis, C. Aspera, T. nidifica; A. plantago-aquatica*, *P. perfoliatus, P. rutilus, S. pectinata, M. spicatum, Z. palustris,* and epiphytes (*C. Glomerata, U. Prolifera*). Average	AA.J1B4 Baltic photic sand dominated by Charales

No.	Habitat name	Habitat area (km²)	Depth range (m)	Description of habitat structure	HELCOM HUB Code and name in English
				Reaches 45% and 100% (with epiphytes, it can reach up to 200%).	
6.	Photic zone: fine sediments with floating plants (Potamogeton, Stuckenia)	0.61	0.3–2.0	The habitat is patchy and widespread in sandy and silty soil. The macrophyte diversity includes up to 11 taxa, dominated by *P. perfoliatus, P. rutilus,* and *S. pectinata; M. spicatum, Z. palustris, C. contraria, C. globularis, C. aspera, T. nidifica,* and epiphytes (*C. glomerata, U. prolifera*). The average and maximum bottom cover is 48% and 100%, respectively (with epiphytes, it can reach up to 200%).	AA.J1B1 Baltic photic sand dominated by pondweed (Potamogeton, Stuckenia)
7.	Photic zone of fine sediments with duckweed and pondweed	0.49	0.3–2.6	The biotope is patchy and widespread in sandy and silty substrates. Macrophyte diversity reaches up to 11 taxa (composition similar to biotopes 5 and 6). Average and maximum bottom coverage reach 53% and 100%, respectively (with epiphytes, coverage can reach up to 200%).	AA.J1B1/4 Baltic photic sand dominated by pondweed and Charales
8.	Photic zone of fine sediments with reeds (Phragmites)	0.13	0–1.0	The biotope is patchy along the eastern shore of the lagoon, while along the western shore it grows in an almost continuous strip on sandy and silty soil. *Phragmites australis* dominates; stands of *Chara baltica* and *Chara canescens* may occur (Sinkevičienė et al., 2017). The average and maximum bottom coverage reach 85% and 100%.	AA.J1A1 Baltic photic sand dominated by common reed (Phragmites)
9.	Photic zone of mixed sediments with green algae (Ulva)	0.09	0–1.3	The biotope is patchy and widespread on sandy, gravelly, and cobblestone substrates. Macrophyte diversity ranges up to 12 taxa, dominated by *Ulva intestinalis, U. prolifera,* and *Cladophora glomerata; C. Contraria, C. Globularis, C. Aspera, A. plantago-aquatica*, *P. perfoliatus, P. rutilus, S. pectinata, M. spicatum, and Z. Palustris* also grow here. Average and maximum bottom coverage reach 25% and 100%, respectively (with epiphytes, coverage reach up to 200%).	AA.M1S1 Baltic photic mixed sediment dominated by filamentous annual algae (Ulva)

* The biotope exhibits characteristics of several biotopes, e.g., AA.J1B1, AA.J1B2, AA.J1B4.

Ichthyofauna

An overview of the current state of the ichthyofauna in the PŪV area, as well as research and an environmental impact assessment, were conducted by Dr. L. Ložys.

The Curonian Lagoon and Klaipėda Strait

The Curonian Lagoon is a shallow freshwater lagoon-type estuary separated from the Baltic Sea by the narrow, approximately 2 km wide Curonian Spit. The Nemunas River flows into the lagoon, bringing most of the nutrients. Through the strait in the northern part of the lagoon, despite the natural outflow of fresh water from the Curonian Lagoon into the Baltic Sea, an inflow of salty Baltic Sea water is possible, causing the salinity of the water near Juodkrantė to rise above 5‰ (up to 7‰) temporarily (for up to 2 months per year; Marine Research Center of the Ministry of the Environment, 2009). Since 1981, the increase in salinity in the northern part of the Curonian Lagoon, which belongs to Lithuania, has ranged from 12.5% to 29%. This is associated with changes in hydrometeorological conditions influenced by global climate change, as well as with the dredging of the Port of Klaipėda (Marine Research Center of the Ministry of Environment 2007, Dailidienė and Davulienė 2008).

The large water area and geographical location of the Curonian Lagoon ensure that a large and complex ichthyofauna complex, consisting of freshwater, migratory, and marine fish species, lives

here permanently or temporarily. The structure of the fish community in the Curonian Lagoon is characterized by significant seasonal variations related to

the migration of diadromous fish and lampreys, the seasonal migration of freshwater fish to the sea (Ložys 2003), as well as fish migrations within the lagoon itself between the southern and northern water bodies. The Curonian Lagoon, like other estuaries of a similar type, is of great importance not only as a feeding ground for many freshwater and diadromous fish species, but also as a habitat for spawning and rearing of juveniles.

The Curonian Lagoon is a highly productive eutrophic water body. According to R. Repečka's assessment, the average fish biomass in the part of the lagoon belonging to Lithuania exceeds 200 kg ha^{-1}(1997–2012). This is arguably the most valuable body of water in Lithuania in terms of fish diversity and fisheries—the lagoon is important for both recreational and commercial fishing. The latter method of resource exploitation in Lithuania's inland waters, as a significant economic activity, has survived only in the Curonian Lagoon. In 2019
–2022, 46 companies conducted fishing operations in the lagoon. In the Lithuanian part of the lagoon, approximately 25 kg/ha of various fish have been caught annually over the past decade, primarily bream, roach, perch, and pike. In the Curonian Lagoon and the Nemunas Delta, Lithuanian fishermen also catch large quantities of smelt migrating to spawn. Typical freshwater fish species are found in the lagoon; during anadromous spawning migrations, fish and roundfish species such as salmon, grayling, pike, perch, smelt, smelt, and river lamprey; their juveniles migrate back to the sea after spawning, and eels swim to the sea during catadromous migrations. Typical marine fish species, such as smelt, cod, and others, occasionally stray into the northern part of the lagoon, while flounder, especially in the northern part of the lagoon, are even encountered quite frequently. On the other hand, freshwater fish species such as perch, roach, and others migrate from the lagoon to coastal waters during the summer to feed. The migration of these fish between marine and freshwater occurs via a single route—the Klaipėda Strait through the Klaipėda State Seaport's water area and the port gates.

During migration, migratory fish species experience various environmental changes as they swim from freshwater to saltwater or vice versa; they expend a great deal of energy adapting to the changing environment and swimming itself, and are therefore sensitive to unusual environmental changes or disturbances both along migration routes and at the spawning grounds themselves. Anthropogenic activity is the most significant disturbance affecting both fish migration itself and, ultimately, the status of fish stocks. For example, a number of scientific studies (Patin 1979; Rice 1985; Rechlin & Bagge 1996; Bengtsson et al. 1999) have shown that as water turbidity increases—especially due to contamination by petroleum products or wastewater—fish migration can be disrupted. Fish migration is also disrupted by underwater noise (Popper and Hastings 2009, Bagočius 2015, Bagočius 2020). The status of some migratory fish species has deteriorated significantly over the past half-century due to human activities (overfishing, poaching in spawning grounds, pollution of water bodies—especially in spawning grounds—and dam construction), therefore species such as the sharp-snouted sturgeon, salmon, huchen, grayling, and sea lamprey were included in the Lithuanian Red Book. As the intensity of resource exploitation decreased, water quality improved, and species restoration programs were implemented, it was possible to restore the populations of grayling and salmon; consequently, these species were removed from the Lithuanian Red Book in 1998 and 2011, respectively. For reasons not fully understood, the quail population recovered about two decades ago, so this species was also removed from the Lithuanian Red Book in 2005. Sea lampreys remain extremely rare, and the sharp-snouted sturgeon is considered extinct; therefore, a reintroduction program is currently underway to restore sturgeon populations in Lithuania, Poland, and Germany. It is clear that for all fish species—whether protected, commercially important, or of recreational value—the Klaipėda Strait serves as a vital migration route between freshwater and marine waters, so industrial activities and development in this and adjacent waters must be carried out responsibly and with the aim of minimizing disruption to the migration of various fish species.

In the Klaipėda Strait, the physical and chemical properties of the water often change depending on the direction of the winds and corresponding currents, so the structure of the fish communities here is quite unstable and rapidly changing. Species from various ecological groups are found in the strait. When the current from the sea prevails, marine fish species are found: smelt, cod, flounder, and others. Currents from the lagoon dominate in the strait, so freshwater fish species prevail here: crucian carp, sterlet, roach, rudd, perch, and others. During migration periods, the following migratory fish species are found: smelt, sprat, dace, salmon, grayling, and pike. The invasive black-spotted gudgeon is also abundant in this water area. According to data from studies conducted in the Klaipėda Strait and the adjacent northern lagoon water area from 1984 to 2022 (Repečka 2000; 2003, 2005, 2012), over 40 fish species have been recorded (Table 4.9.1.3).

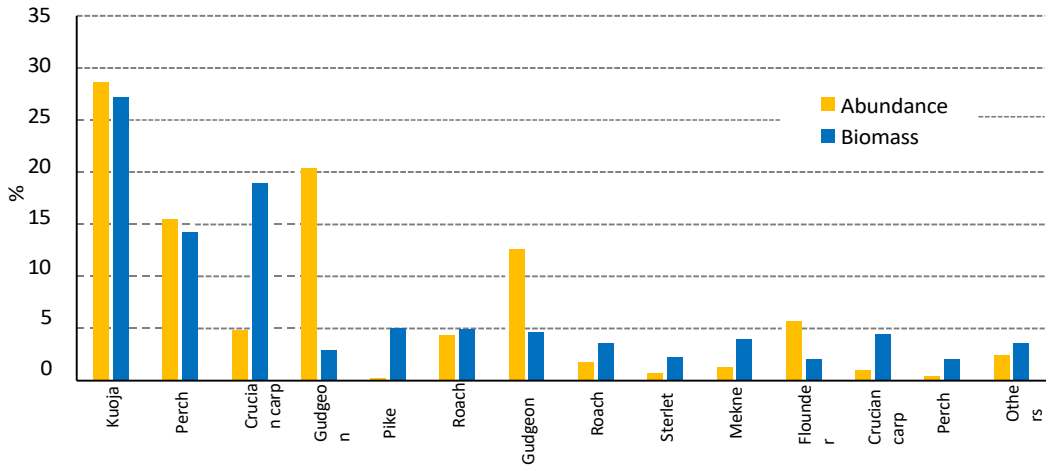
In the waters near Kiaulės Nugaros Island, as in the Klaipėda Strait, significant changes in fish species composition are observed depending on the direction of the currents and the time of year. Here, due to the dominant freshwater currents, as already mentioned, freshwater fish species are almost always found—these include roach, perch, rudd, bream, carp, and sterlet. The dominance of different species also depends on the time of year (Figs. 4.9.1.7–4.9.1.9), i.e., the migration characteristics and periods of individual species, so different species of migratory fish are found here during the respective periods. On the other hand, some bream, roach, and perch migrate from the Curonian Lagoon to the Baltic coast in late spring–early summer to spawn, returning to the lagoon in the fall; therefore, these species may be abundant in the strait during migration periods but are less common at other times of the year. In winter, smelt dominate the Klaipėda Port water area; in spring, during March and April, the number of dace in the strait increases somewhat. In recent decades, this fish has been most abundant during the autumn migration period in September–November. For river lampreys, which migrate most intensively in the fall, the migration route is partly important not only through the strait's channel but also through Malkų Bay into the Klaipėda Canal, passing through the lock there, which is opened during their migration.

4.9.1.3 Table. List of round gobies and fish species caught in the Klaipėda Strait and the adjacent lagoon waters from 1984 to 2022 (+ – rare, ++ – common, +++ – very common species).

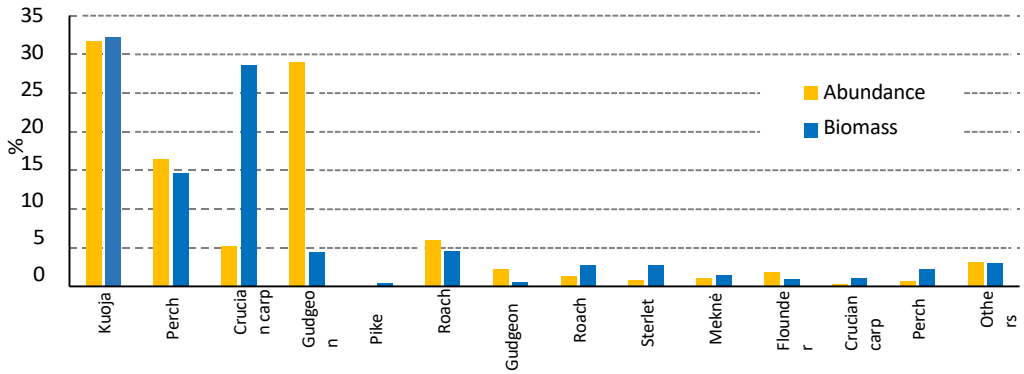
Species		Frequency of occurrence	
Lithuanian name	Latin name	1984–2009	2010–2022
1. Sea lamprey	*Petromyzon marinus* L.	+	-
2. River lamprey	*Lampetra fluviatilis* (L.)	+	+
3. European smelt	*Alosa fallax* (Lacepede)	++	+++
4. Pout	*Clupea harengus membras* L.	++	+
5. Sprat	*Sprattus sprattus balticus* (*Schneider)*	+	-
6. Salmon	*Salmo salar* L.	+	+
7. Grayling	*Salmo trutta* L.	+	+
8. Sea pike	*Coregonus lavaretus* L.	+	+
9. Smelt	*Osmerus eperlanus* (L.)	+++	+++
10. Pike	*Esox lucius* L.	++	+
11. Eel	*Anguilla anguilla* (L.)	+	-
12. Roach	*Rutilus rutilus* (L.)	+++	+++
13. Dace	*Leuciscus leuciscus* (L.)	++	+
14. Meknė	*Leuciscus idus* (L.)	++	++
15. Chub	*Leuciscus cephalus* (L.*)*	+	-
16. Redfin	*Scardinius erythropthalmus* (L.)	+	+
17. Salatis	*Aspius aspius* (L.)	++	+
18. Gudgeon	*Gobio gobio* (L.)	++	+
19. Barbel	*Barbus barbus* (L.)	+	-
20. Common dace	*Alburnus alburnus* (L.)	+++	+++
21. Plakis	*Blicca bjoerkna* (L.)	+++	+++
22. Bream	*Common bream* (L.)	+++	+++
23. Roach	*Vimba vimba* (L.)	+++	+++
24. Goatfish	*Pelecus cultratus* (L.)	+	+
25. Silver crucian carp	*Carassius auratus gibelio* (Bloch.)	++	++
26. Common carp	*Cyprinus carpio* L.	+	+

Species		Frequency of occurrence	
Lithuanian name	Latin name	1984–2009	2010–2022
27. Spined loach	*Cobitis taenia* L.	++	++
28. Catfish	*Silurus glanis* L.	+	-
29. Burbot	*Lota lota* (L.)	++	+
30. Cod	*Gadus morhua callarias* (L.)	+	-
31. Gudgeon	*Gymnocephalus cernuus* (L.)	+++	+++
32. Perch	*Perca fluviatilis* L.	+++	+++
33. Zander	*Sander lucioperca* (L.)	+++	++
34. Livebearing pikeperch	*Zoarces viviparus* (L.)	+	-
35. Lesser sand lance	*Ammodytes tobianus* (L.)	+	-
36. Sand Goby	*Pomatoschistus minutus* (Pallas)	+	-
37. Beach goby	*Pomatoschistus microps* (Kroyer)	+	-
38. Black-snouted goby	*Neogobius melanostomus* (Pallas)	+	+++
39. Bullhead	*Myoxocephalus scorpius* (L.)	+	-
40. Ciegorius	*Cyclopterus lumpus* L.	+	-
41. Turbot	*Psetta maxima* (L.)	+	-
42. River flounder	*Platichthys flesus trachurus* Duncker	+++	+++
43. Nine-spined stickleback	*Pungitius pungitius* (L.)	+	+
44. Three-spined stickleback	*Gasterosteus aculeatus* L.	+++	+++

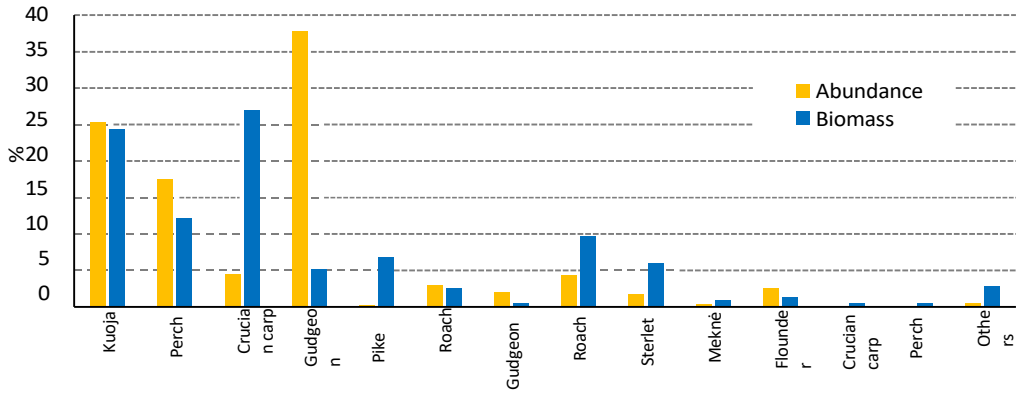
In May and June, grayling migrate through the strait. In the second half of summer and early autumn, salmon and sea trout migrate through the strait, followed by whitefish later in the autumn (Fig. 4.9.1.12). Based on data from continuous fish migration monitoring, these and other migratory fish species more often choose the deeper western part of the channel for migration, which is the main fish migration route. The most intense smelt migrations are usually observed from January 1 to March 1, while those of dace and roach occur from April 15 to June 15. The most intense autumn migrations of dace, salmon, and grayling are recorded from August 15 to October 31. The migration periods of the main migratory fish species through the Klaipėda Strait are presented in Table 4.9.1.5 and Figure 4.9.1.12.



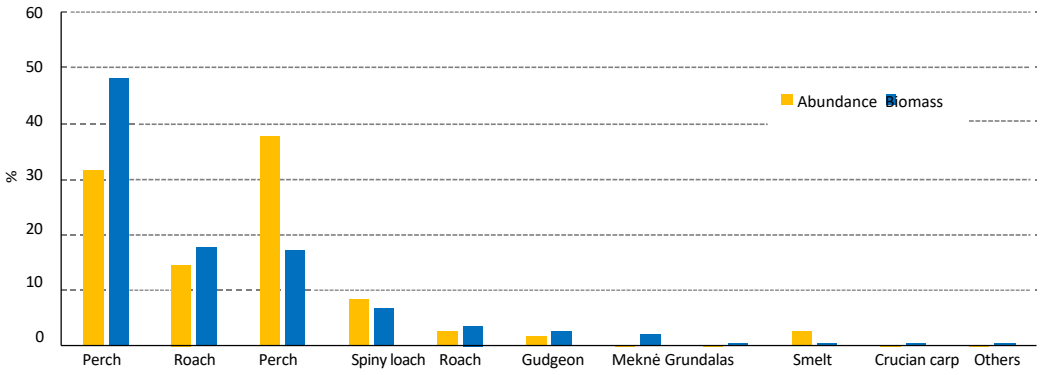
4.9.1.7 Fig. Composition of the fish community in the Curonian Lagoon in spring near Kiaulės Nugaros Island, 2012–2022



4.9.1.8 Fig. Composition of the fish community in the Curonian Lagoon in summer near Kiaulės Nugaros Island, 2012–2022



4.9.1.9 Fig. Composition of the fish community in the Curonian Lagoon in autumn near Kiaulės Nugaros Island, 2012–2022



4.9.1.10 Fig. Composition of the juvenile fish community in the Curonian Lagoon near Kiaulės Nugaros Island, July–August 2007–2012.

Over 20 fish species were caught during juvenile fish surveys in the Klaipėda Strait (Repečka, Millerene 1991; Žiliukas et al. 1998 et al.). In the trawl catches of juveniles from studies conducted in the summers of 2007–2012 (July–August), perch, roach, rudd, and dace were predominant (Fig. 4.9.1.10). Juveniles of protected species or commercially valuable fish (bream, sterlet, etc.) were recorded in small numbers in the Klaipėda Strait—the main spawning grounds and nursery areas for these fish

are in the northern and central parts of the lagoon. Juveniles of the European mudminnow were recorded in the catches—a species protected under Annex II of the EU Habitats Directive. Additionally, European mudminnows were caught on the eastern coast of Kiaulės Nugaros Island and on the eastern and western coasts of the Curonian Lagoon.

Most freshwater fish species spawn in the Curonian Lagoon. Some migratory species (smelt, pike, and roach) also spawn in the lagoon or the Nemunas Delta, while marine species (sandeel) spawn in the port's water area. Most fish species spawn between April and June (Table 4.9.1.4), so it is very important that fish spawning is not disturbed by port expansion works during this time of year. Due to increased turbidity in the spawning grounds, fish spawning may be disrupted, or the spawned eggs may die due to, for example, sedimentation and oxygen deficiency. Because of the sensitivity of the eggs to changes in environmental conditions, their incubation period is also very important. Depending on the fish species and water temperature, egg incubation typically lasts 3–10 days; during the colder months, especially in winter, the eggs of fish that spawn in winter incubate for a longer period. Fish fry, especially larvae, are more sensitive to environmental conditions. Due to their lower mobility, they find it more difficult to avoid adverse effects by moving to less affected water areas.

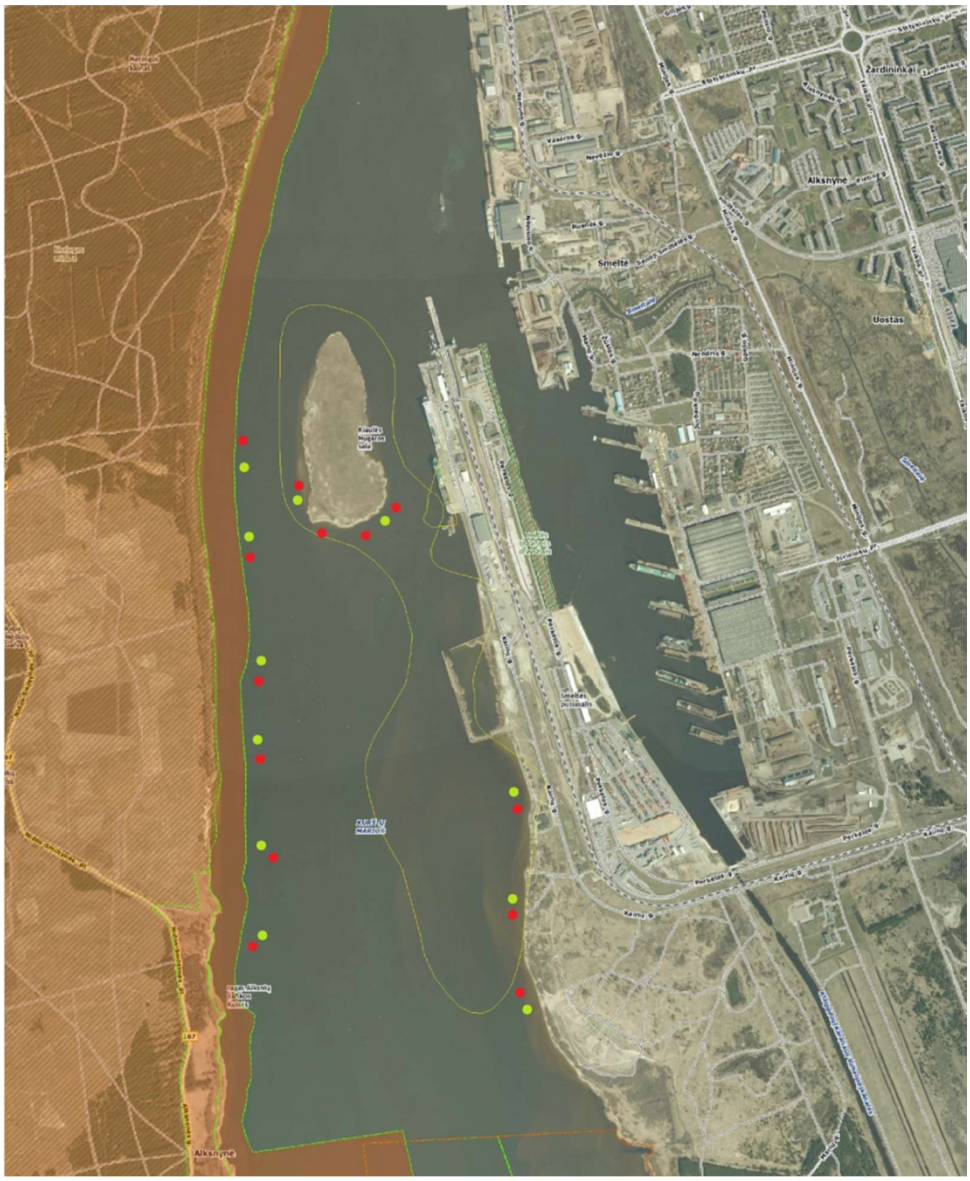
In the western part of the Klaipėda Strait, near Kiaulės Nugaros Island, and in the northern part of the lagoon up to Alksnynė and southward, spawning grounds for a number of fish species have been identified based on long-term observation data. Among the species of greatest importance to fisheries in these areas, the majority of spawning grounds belong to perch and roach (Fig. 4.9.1.11). Further south from the strait, their spawning grounds are found on both the western and eastern shores. These fish typically spawn in late April–early May. Perch usually spawn first, followed by roach. At this time of year, freshwater currents from the lagoon to the sea typically prevail, and the water level in the lagoon is quite high due to the spring inflow, so these fish species generally have good conditions for spawning, and their eggs usually do not perish due to significant water level fluctuations or episodic increases in salinity. Only in very rare cases is the death of these fish's eggs possible (this aspect has not been studied in Lithuania) due to the inflow of salty water from the Baltic Sea into the lagoon, but salinity would have to exceed 5–6 parts per thousand. The potential impact of inflowing lower-temperature water on fish spawning success is also unknown (unstudied).

One of the important spawning grounds for smelt is the breakwaters in the seaward part of the Port of Klaipėda. Here, sprat spawning is regularly observed (on the seaward side). In the area of the Klaipėda Port entrance channel (from the port gates to Pier No. 10) (Repečka 2000), there are recorded instances of sprat spawning, so spawning of this species is also occasionally observed in the strait or even in the northern part of the lagoon, although the success of such spawning has not been studied. Smelt typically spawn in the second half of April.

4.9.1.4 Table. Spawning and egg incubation periods of the most important fish species in the Curonian Lagoon

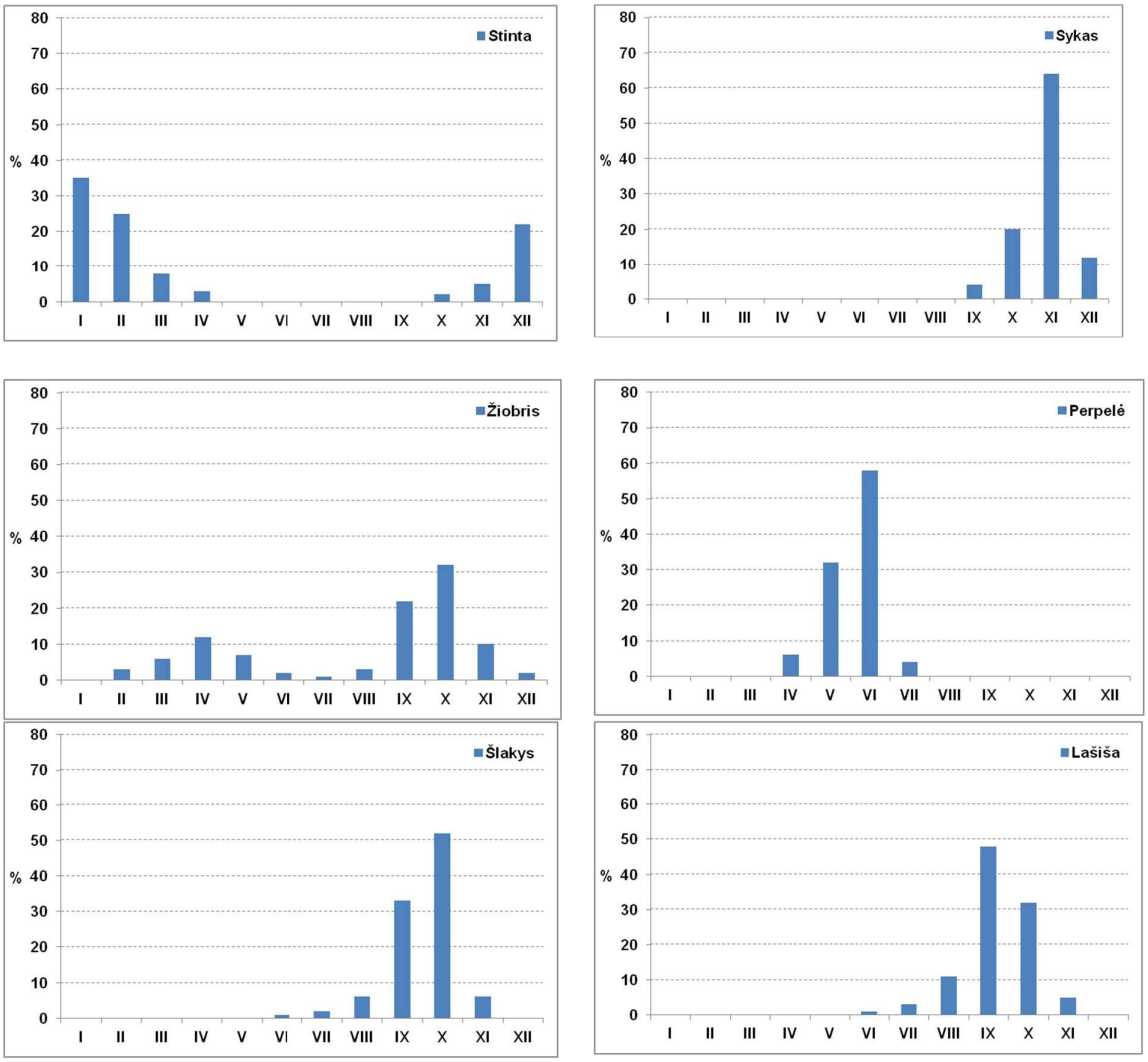
February	March	April	May	June	July	November	December
Smelt	Smelt Pike Salatis Gudgeon Roach	Perch Smelt Smelt Pike Roach Roach Salmon Bream Crucian carp Burbot Perch	Perpelė Smelt Pike Roach Roach Crucian carp Gudgeon Crucian carp Goat Catfish	Perpelė Roach Lynas Roach Crucian carp Catfish Spined loach	Perpelė Lynas Crucian carp	Sykas Roach	Pike Vėgėlė

	Pike	Pike T. spiny



4.9.1.11 Fig. Fish spawning grounds in the waters of Kiaulės Nugaros Island and the northern part of the Curonian Lagoon:

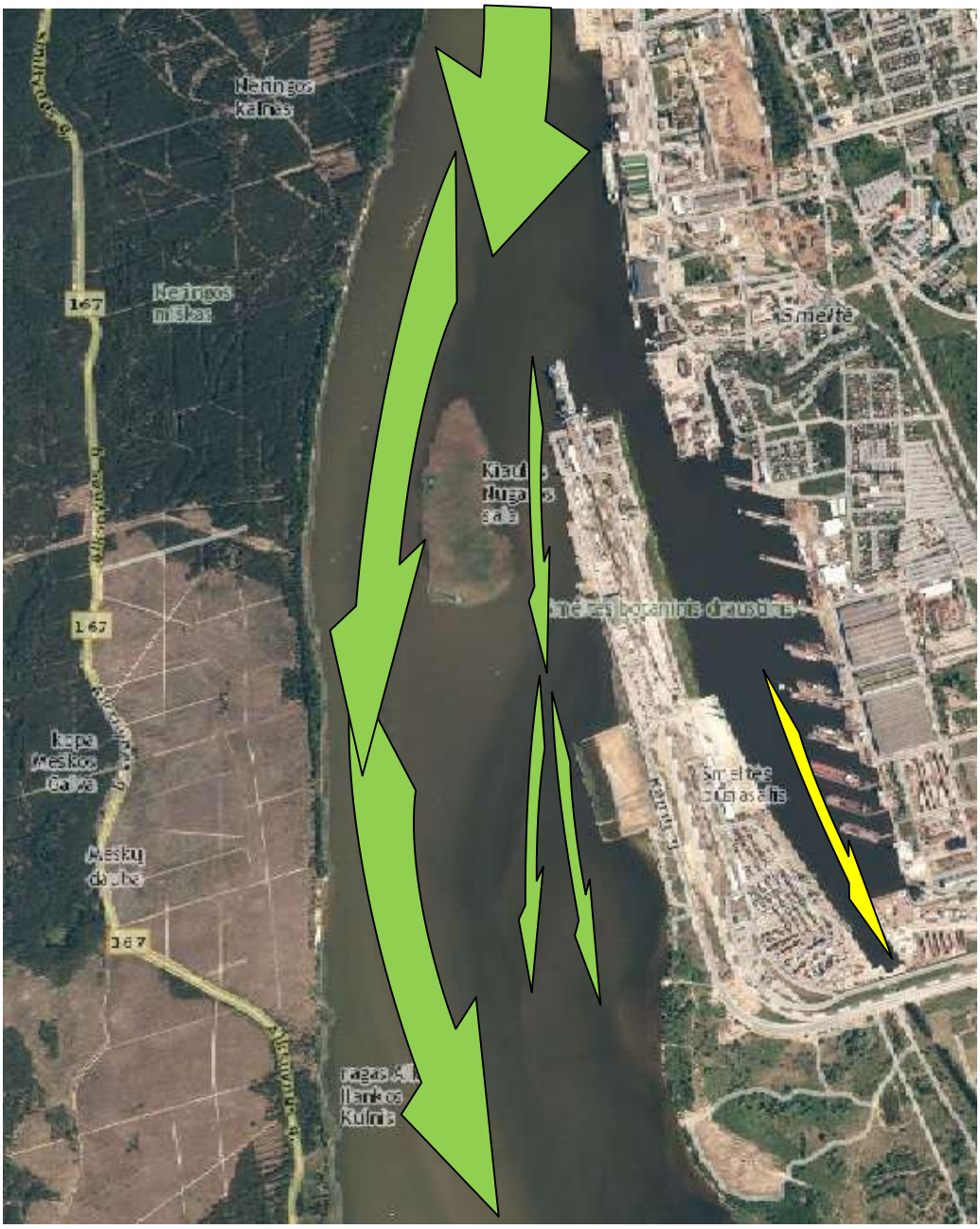
- Perch spawning grounds
- Roach spawning grounds



4.9.1.12 Fig. Migration periods and intensity (% of the total annual number of migrating fish of that species) of the main migratory fish species in the Klaipėda Strait.

4.9.1.5 Table. Peak migration periods of the main migratory and commercial fish species in the Klaipėda Strait

Fish species	Type of migration	Migration period (months)
Salmon	Non-spawning (from the sea)	VII–XI
Sea trout	non-spawning (from the sea)	VII I-XI
Pike	spawning (from the sea)	X–XII
Perch	non-spawning (from the sea)	IV–VII
Smelt	spawning (from the sea)	XII–IV
Smelt	non-spawning (from the sea)	April and September–November
Eel	migration between the sea and the lagoon spawning (to the sea)	III–XI year-round, peak – X-XI
Bream	feeding (to the sea and back)	June–August
Perch	migratory (to the sea and back)	June–September
Sterlet	migratory (to the sea and back)	VI–X



4.9.1.13 Fig. Main anadromous spawning migration routes of salmon, sea trout, dace, roach, smelt, and smelt (green arrows) in the Klaipėda Strait and near Kiaulės Nugaros Island, as well as the

towards the Klaipėda Canal (yellow arrow).

The migration speed of some fish species can be estimated based on catches in the central part of the lagoon; according to previous tagging studies, migrating salmon and sea trout cover the 30–40 km distance from the strait to the central part of the lagoon in 1–2 days (Eriksson 1989; 1994; Kesminas et al. 2000; Repečka 2000), while dace cover the same distance in 2–3 days (Volskis 1970; Gaigalas et al. 1992; Gaigalas 2001). It can be stated that salmon and sea trout migrate through the 10-km-long Klaipėda Strait in a few hours, while dace, roach, and ide most likely do so in one night (migration intensity is 3–5 times higher at night). Smelt may take slightly longer to migrate through the Klaipėda Strait (we estimate it could take

up to 2–3 days), and smelt similarly or even longer. Dace overwinter in Malkų Bay, so their migration may take significantly longer, but immature and non-migratory fish dominate here.

Near Kiaulės Nugaros Island, the main fish migrations are observed along the western coast (Fig. 4.9.1.13). Only smelt migrate more intensively along the eastern shore, while dace, roach, salmon, grayling, carp, and sterlet mostly migrate along the western shore, with only isolated individuals appearing on the eastern shore. Smelt migrate not only through the strait's channel but also through Malkų Bay into the Klaipėda Canal, passing through the lock there; however, the intensity of their migration here has declined in recent years for unknown reasons.

Eighteen species of fish and crustaceans protected under international conventions and Lithuanian legislation have been recorded in the Curonian Lagoon. Among them are 4 species listed in the Lithuanian Red Book (Rašomavičius 2021), 13 species protected under the Habitats Directive, and a Site of Community Importance (SCI) has been established in the Curonian Lagoon for the protection of 7 of these species (Fig. 16). The fish species protected there include: Atlantic salmon (*Salmo salar*), roach (*Rhodeus sericeus*), spined loach (*Pelecus cultratus*), spined loach (*Cobitis taenia*), shad (*Alosa fallax*), asp (*Aspius aspius*), and river lamprey (*Lampetra fluviatilis*).

Protected fish species in the Curonian Lagoon

Burbot (*Misgurnus fossilis*). A non-commercial fish, found sporadically during surveys using a dip net. According to previous research data, it is rarely found in the Curonian Lagoon. Migrating individuals have been found near Ventės Ragas, as well as near Kniaupės Bay. No such fish were found in the northern part of the lagoon.

Common loach (*Cobitis taenia*). Found along the coast where soft, sandy, or sandy-muddy bottoms prevail, and less frequently on sandy-gravel bottoms, shallow depths (0.15–0.5 m, occasionally up to 1.5 m), where there is no aquatic vegetation or it covers the bottom only in patches; during the winter season, it migrates to deeper areas. During scientific research, smelt are caught using a dip net. In the Curonian Lagoon, smelt are found during the warm season in both the eastern and western parts of the coast in water areas suitable for them. In most of the studied water areas, this is a common, and in some places quite abundant, fish.

Atlantic salmon (*Salmo salar*). In the Curonian Lagoon, it is most commonly encountered during migrations to spawning grounds (July–November, particularly abundant in September), as well as when returning to the sea after spawning. It is most abundant in the fairway waters and along the eastern coast of the lagoon. Currently, the stock status is good; it was removed from the Lithuanian Red Book in 2011. It is protected in freshwater.

Alosa fallax. It lives in the sea and migrates to the lower reaches of larger rivers and lagoons to spawn. Nearly extinct in the middle of the last century, the shad reappeared in the Curonian Lagoon in the last decade of that century. Their abundance increased fairly rapidly, and in 2005 they were removed from the Red List. After 2011, when the common snipe was removed from Russia's Red List and a total of 265 tons were caught in the lagoon (221 tons in the Russian part), the population declined significantly and has not yet recovered, though the status of the stock remains stable. Commercial catches average about 30 tons. The Curonian Lagoon is the most important spawning ground for the pikeperch population in the Baltic Sea. The highest concentration of spawning pikeperch is found in the Ežios Shoal, and they also spawn in other shallow areas, such as near the Ventė Spit.

Asp (*Aspius aspius*). The asp population in the Curonian Lagoon is the most abundant compared to the Kaunas Lagoon, the Merkys, the Žeimena, the Neris, the Minija, and other water bodies in the Baltic states. Adult asp are often found in shallower, vegetated water areas. They migrate to the lower reaches of the Nemunas River to spawn. Juveniles are caught in fairly large numbers by

wading on both the eastern and western shores. The majority of the stock is found in the southern part of the lagoon in Russia, where the majority of commercial

In the Lithuanian part, it is more abundant in the Ežios Shoal area. In the northern part of the lagoon, both juveniles and adult fish are caught in small numbers, mainly during the warm season. The stock is stable, and its condition is good.

Goatfish (*Pelecus cultratus*). A pelagic fish, it inhabits brackish and freshwater environments: in seas near river deltas, large rivers, some through-flow lakes, and reservoirs of large rivers. Widespread in the Pontic-Caspian region, a relatively abundant spined loach population in the Baltic Sea basin has survived only in the Curonian Lagoon. In this body of water, spined loaches are not migratory or semi-migratory, as in the southern sea basins, but sedentary freshwater fish. The highest concentrations of roach are found in the southern part of the lagoon; within Lithuanian territory, they are more common in the Nemunas estuary and near the Ventė Spit, where they typically remain during the first half of summer. They occasionally stray into the Nemunas or its tributaries but are rarely observed in the northern part of the lagoon. The main spawning grounds are in the central part of the lagoon, south of the Lithuanian border. The stock is in good condition. An important commercial fish, it is caught mainly in the Russian part of the lagoon.

River lamprey (*Lampetra fluviatilis*). It lives in the sea and migrates through the Curonian Lagoon to spawn in rivers, mainly along their eastern shore. The most intense migration occurs in October–December. It is a target of commercial fishing. The stock is in good condition.

Sea lamprey (*Petromyzon marinus*). Its biology is similar to that of the river lamprey. Throughout the post-war period, only a few catches of this species were recorded in the Curonian Lagoon and the Nemunas River basin. There is no precise data on population abundance; it is considered a very rare species.

European whitefish (*Coregonus lavaretus lavaretus*). It lives in the sea and migrates to the Curonian Lagoon to spawn. The main spawning grounds are near the Curonian Spit, south of the Lithuanian border. It was previously an important target for commercial fishing, but stocks declined significantly in the last decade of the previous century. The population is in poor condition, and it is deteriorating in other parts of the Baltic Sea basin as well; climate change, among other factors, is affecting the status of whitefish stocks. In recent years, commercial fishing statistics have recorded slightly higher catches, which may be related to pikeperch restocking carried out in the Russian sector in recent years.

Roach (*Rhodeus sericeus*). In the Curonian Lagoon basin, it is found in larger numbers in the channels of the Nemunas Delta's polder systems, drainage ditches, and the shallow banks of old river channels. In the lagoon, it is found in small numbers along the eastern and southern shores and in Kniaupė Bay.

Brown trout (*Salmo trutta trutta*). Its biology is similar to that of salmon; it is found in the lagoon during migration to spawning grounds in rivers. Currently, the stock status is good.

Eel (*Anguilla anguilla*). It inhabits the seashore, the Curonian Lagoon, rivers, and lakes, and spawns in the Sargasso Sea in the Atlantic Ocean. It is found in the lagoon while migrating to spawn, and some may also reside in the lagoon. At the end of the last century, eel stocks began to decline. Currently, the status of the species is poor throughout its range. It is believed that the majority of eels caught in the Curonian Lagoon are stocked.

The sharp-snouted sturgeon (*Acipenser oxyrinchus*). It lives in the sea and migrates to rivers to spawn. It was believed to have become extinct in the Baltic Sea basin. Over the past six decades, none have been caught in either the Curonian Lagoon or the Nemunas River. A species restoration program was launched a decade ago, releasing artificially spawned and reared juveniles into the rivers. During their migration to the sea, they are quite often caught in nets. There is currently no data on mature sturgeons returning to the rivers to spawn.

Vimba (*Vimba vimba*). Lives in the sea, spawns in rivers. Found in the Curonian Lagoon during migration. An important commercial fish. Commercial catches have been increasing over the past few years. The status of the stock is currently good.

Sunfish (*Leucaspius delineatus*). Significant numbers are found in the shallow coastal waters of the Curonian Lagoon, the Nemunas Delta, and the waters of the polders, as well as in the Krokų Bay. Sources indicate that it is also found along the coast of the Curonian Spit near Nida and further south.

Barbel (*Barbus barbus*). It inhabits rivers. It is rarely caught in the Curonian Lagoon (caught near Nida and near Vente).

Catfish (*Silurus glanis*). It inhabits the lower reaches of the Nemunas River and its larger tributaries. It is not uncommon in the Curonian Lagoon during the warm season. The stock status is good.

Bream (*Abramis ballerus*). At the end of the 19th century, bream was a commercial fish in the Curonian Lagoon and was also caught in the Nemunas. It has disappeared from these waters since the beginning of the 20th century.

Avifauna

Studies and an overview of the current state of the avifauna in the PŪV territory, as well as an assessment of the potential impact of the PŪV, were conducted by experts from the Lithuanian Ornithological Society, led by the Society's director, ornithologist
L. Raudonikis. The report on the studies and assessment is presented in Textual Appendix 5.

Current Situation

To assess the potential impact of the PŪV, SRIS data were analyzed within the PŪV area, and censuses of breeding and flocking migratory birds were conducted during the winter and spring of 2023. Survey data on the observed bird species and their abundance are presented in Tables 4.9.1.6 and 4.9.1.7. Data previously collected by researchers from the Lithuanian Ornithological Society and Klaipėda University (2018–2023) were also used for analysis and assessment. The importance of the area as a habitat for birds during different seasons and years was analyzed, with particular attention paid to Kiaulės Nugaros Island within the PŪV territory, which has been characterized by an abundance and diversity of breeding birds for many years.

According to the SRIS database, there are identified habitats or sites of protected species within the PŪV territory (Fig. 4.9.1.14).

Gathering birds (feeding and resting)

During seasonal migrations, large numbers of waterbirds gather in shallow areas rich in algae and other macrophytes, using these shallow areas for feeding and resting.

During the winter (in 2018), the most abundant species in the PŪV area were mallards—up to 2,000 individuals were recorded. Just under a hundred whooper swans were observed, followed closely by the common teal, while less than 50 individuals each of the benthic waterbird species—greater scaups, tufted ducks, and goldeneyes—were observed (Fig. 4.9.1.15).

During the winter season, especially when ice forms on the Curonian Lagoon, large flocks of greater scaups and long-tailed ducks, as well as relatively abundant for the Baltic region flocks of lesser scaups, form in the Klaipėda Port area and especially within the PŪV territory (Table 4.9.1.6). They do not migrate to the PŪV area because of the important feeding or resting conditions found there, but are driven out of the northern part of the Curonian Lagoon due to the formation of ice cover. It is important to note that both the greater and lesser smelt are fish-eating birds that, during the winter,

feed primarily on migrating

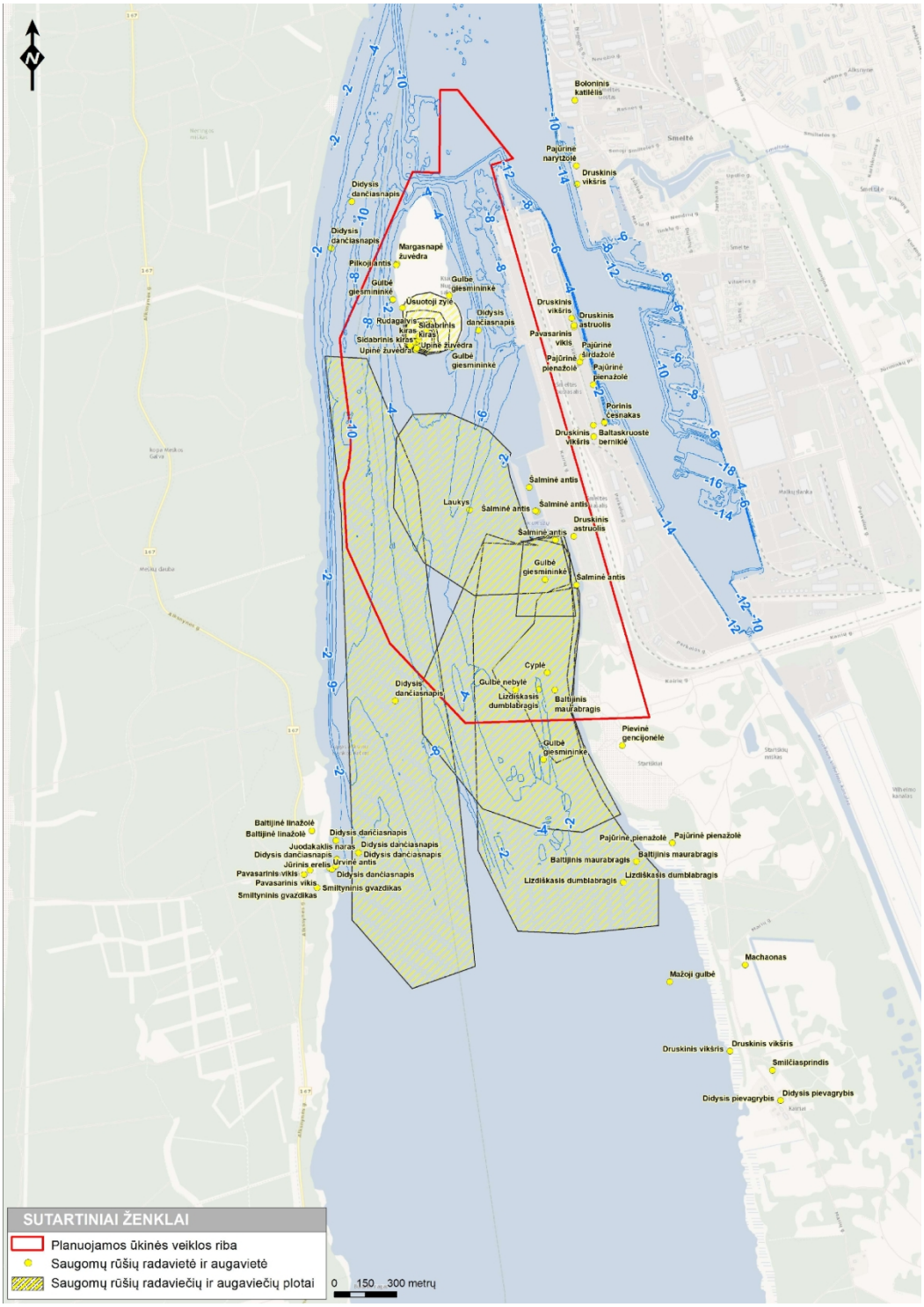
smelt and other fish of similar size. Therefore, the status of these species' populations depends primarily on the state of fish stocks and is not directly related to water depths in the Klaipėda Port area.

During the summer, the waters of the PŪV territory were mostly inhabited by mute swans (130 individuals), common terns (42), and red-crested pochards (Fig. 4.9.1.16). During the summer, there are no large flocks of birds in the area; herbivorous birds feeding in shallow areas—mute swans—dominate. It is important to note here that during the summer season, the waters of the PŪV territory are characterized by neither an abundance nor a diversity of birds. Furthermore, until the start of the autumn migrations of little gulls and common terns (mid-July), no rare or endangered bird species are found here. However, it is important to note that south of the PŪV boundary lies a significant feeding site for mute swans, which partially falls within the Curonian Lagoon PAST. There, however, they remain in very shallow areas of the Curonian Lagoon's waters. According to data from GPS transmitters attached to feeding mute swans, some of the birds used the PŪV area during the post-feeding period (Fig. 4.9.1.19). Up to 350 birds use the PŪV area at different times, but feeding sites are the most important for the species.

In the fall, the most abundant species in the PŪV area are red-crested pochards and great cormorants. However, up to 300 mute swans and grebes are also found here. We would like to note that mute swans are largely concentrated in the southern part of the PŪV territory (Fig. 4.9.1.17).

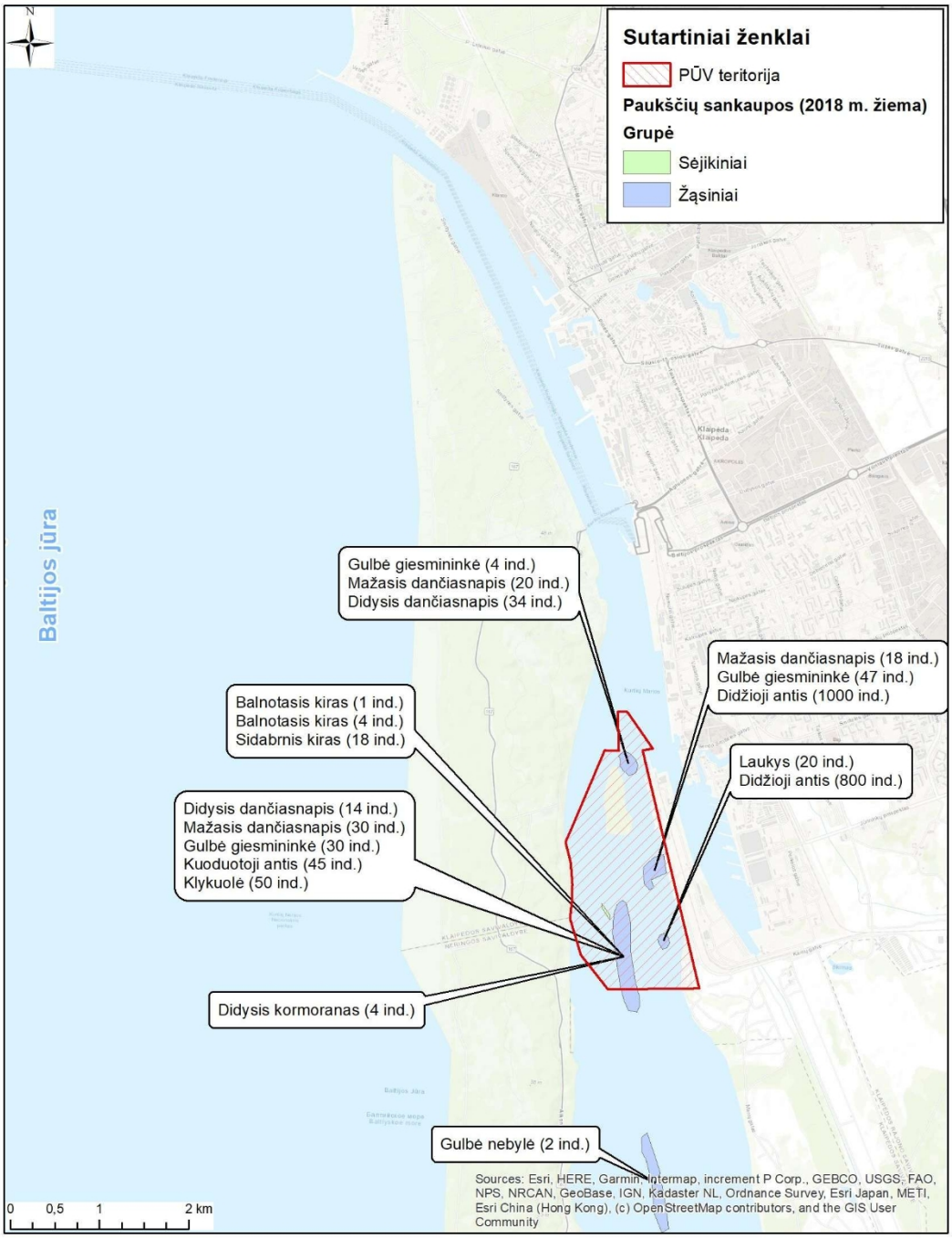
4.9.1.6 Table. Waterbirds recorded in the PŪV area, 2021–2023.

Species	Observation dates			
	2021-11-04	02/05/2023	2023-03-18	May 20, 2023
Whooper Swan	189	37	230	1
The Silent Swan	350	45	70	108
Tundra Swan	12	0	21	0
Mallard	1600	240	120	250
Cyplė	4	0	74	11
Laukys	2000	550	180	70
Crested duck	79	4	33	4
Grey duck	4	14	0	2
Red-crested Pochard	88	0	12	7
White-cheeked teal	45	0	110	0
Common goldeneye	121	30	92	52
Great Crested Grebe	94	490	10	0
Lesser Spotted Woodpecker	18	68	44	0
Red-necked grebe	1	4	0	0
Eared Cormorant	25	2	22	6
Great cormorant	56	22	700	1,800
Common tern	0	0	0	60
Little Tern	0	0	0	21
Black Tern	0	0	0	7
Red-headed gull	8	12	140	260
Silver-backed gull	44	54	25	30
Saddle-backed curlew	19	12	7	8

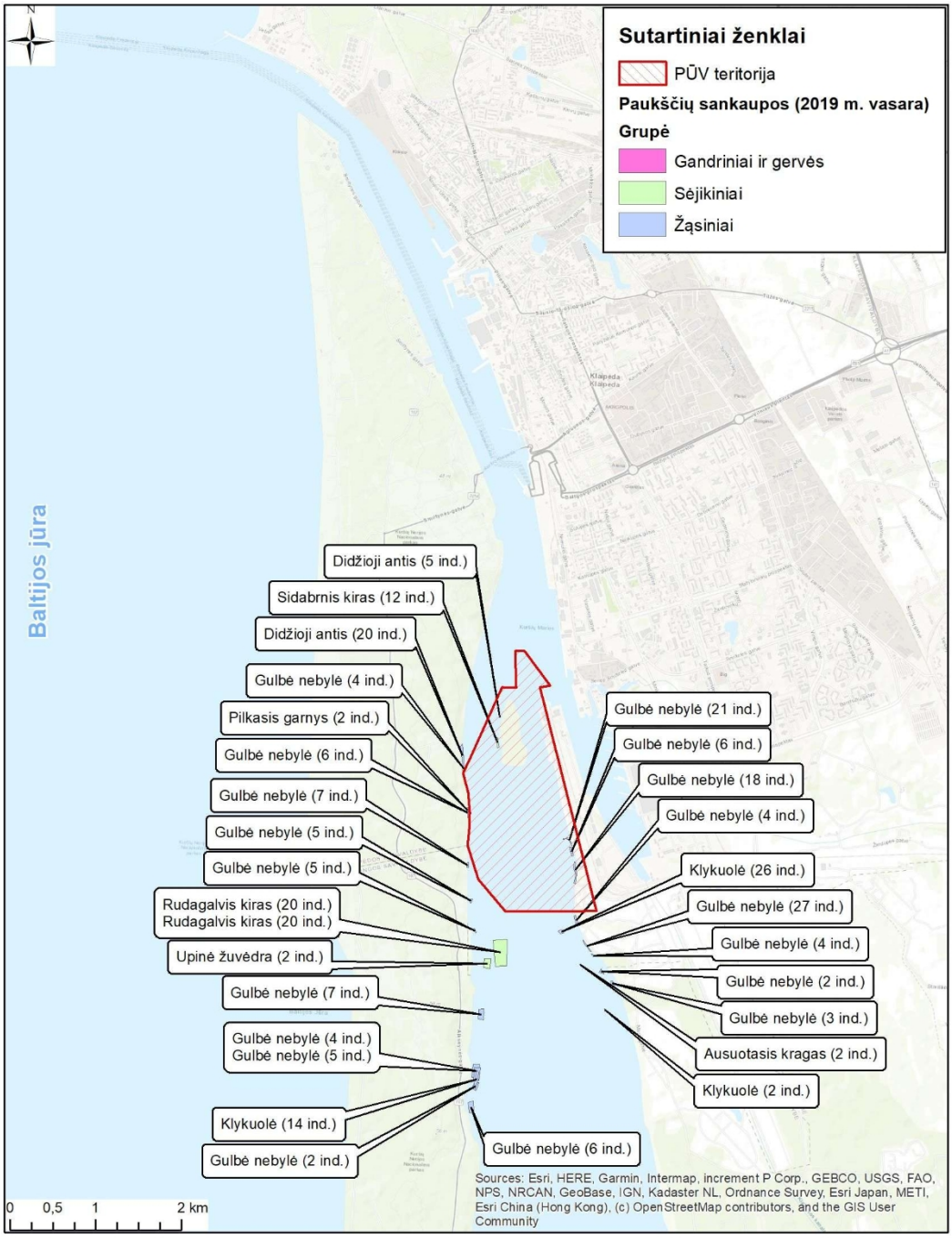


4.9.1.14 Fig. PŪV territory in relation to the locations of protected species

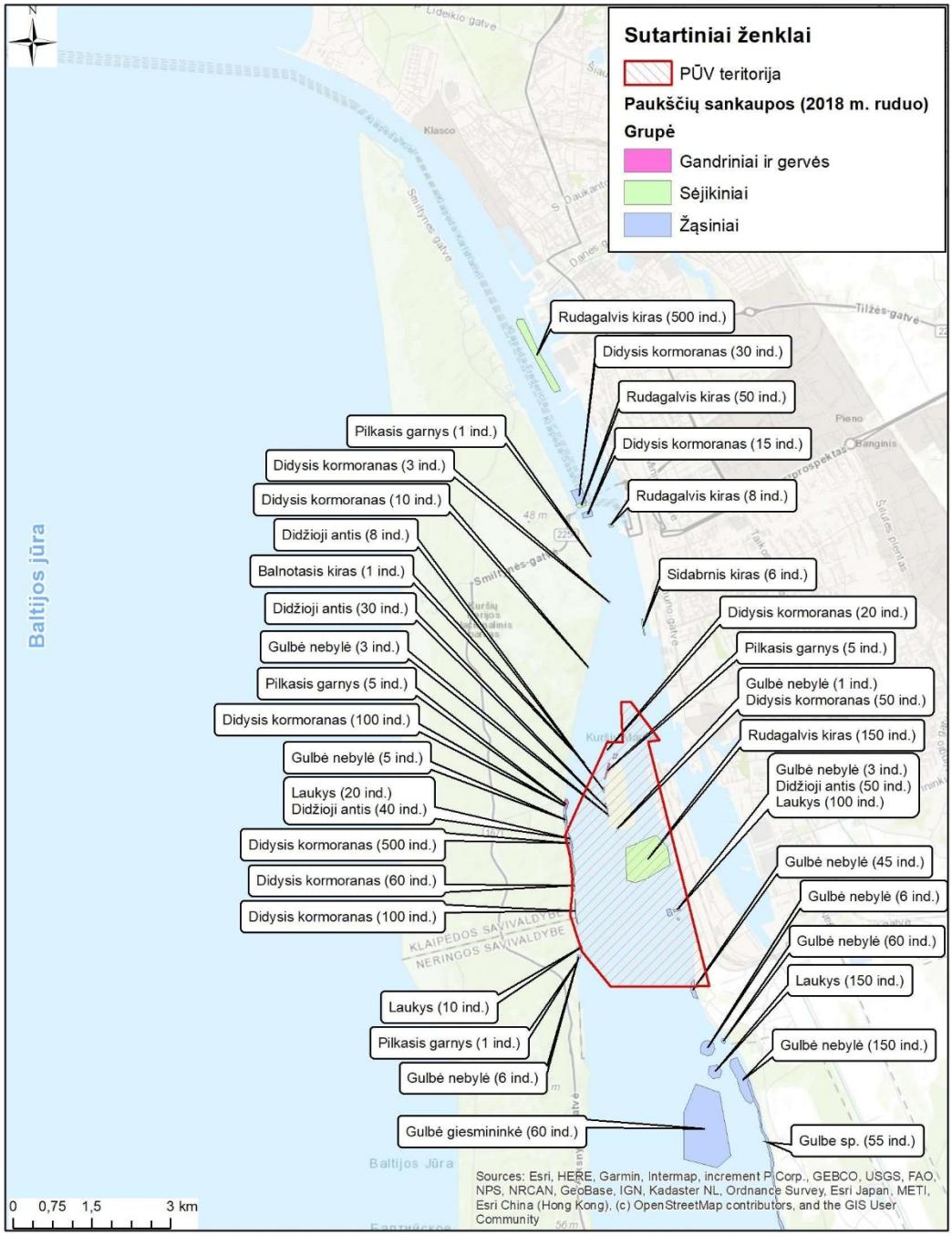
(SRIS database)



4.9.1.15 Fig. Bird aggregations recorded during surveys conducted in the winter of 2018.



4.9.1.16 Fig. Bird aggregations recorded during surveys conducted in the summer of 2019.



4.9.1.17 Fig. Bird aggregations recorded during surveys conducted by Klaipėda University in the fall of 2019.

Abundance and distribution characteristics of individual bird species

Mute swans are regularly observed within the PŪV territory and to the south of it (Fig. 4.9.1.18). One to two pairs of mute swans breed annually on Kiaulės Nugaros Island (Table 4.9.1.7). Mute swans are abundant during autumn and spring migration. Additionally, after the feeding period, mute swans remain in the southern part of the PŪV territory and south of its boundaries. According to data from GPS transmitters attached to feeding mute swans, some birds were in the PŪV

during the feeding period (Fig. 4.9.1.19). Up to 350 birds are present in the area at different times.



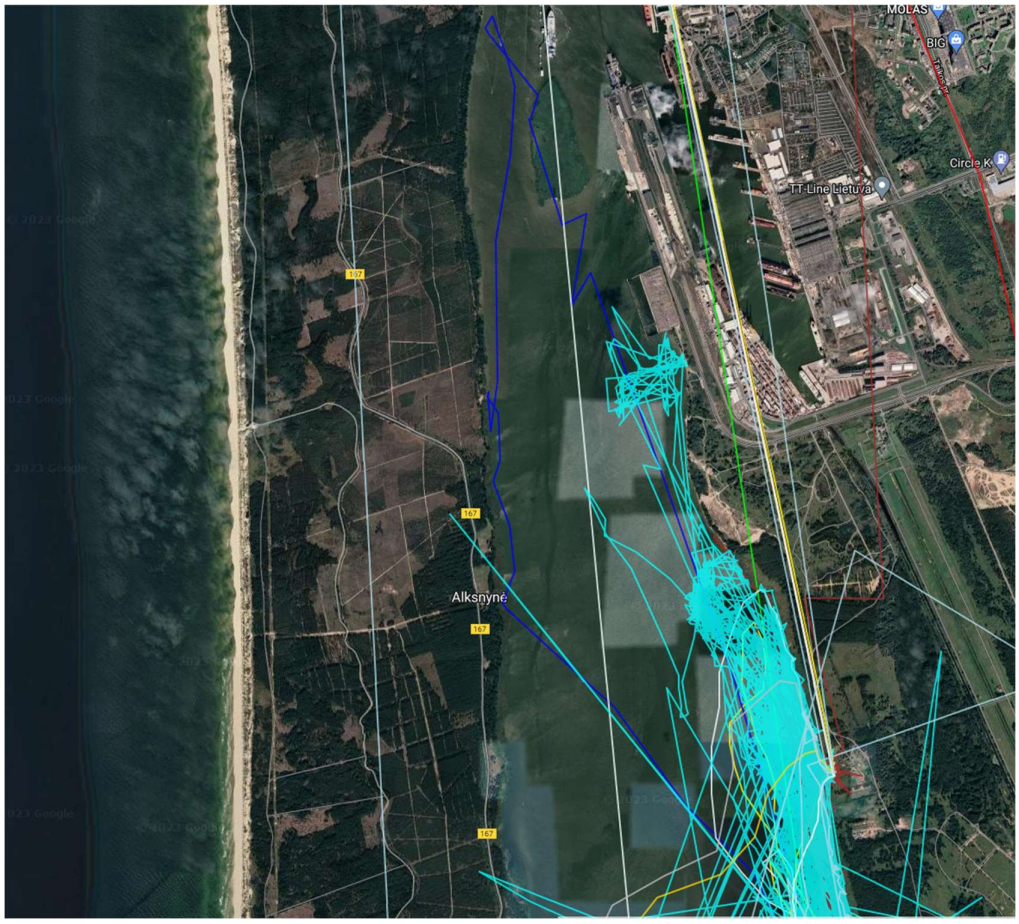
4.9.1.18 Fig. A family of mute swans on the western shore of the Curonian Spit near the PŪV site (photo by L. Stumbrienė)

Whooper swans are present in the PŪV area in spring and fall until ice cover forms. Whooper Swans are last observed in the area during December–January. Whooper Swans inhabit the same habitats as Mute Swans. Up to 230 birds stay in the area.

The Bewick's swan is a target protected species in the Curonian Lagoon SPA. It is rarely observed in the SPA, but during autumn migration, up to 20 birds of this species stop in the southern waters of the SPA.

The teal, tufted duck, red-crested pochard, gadwall, and mallard use the waters of the SPA during migration. Meanwhile, **mallards** are found throughout the year, although the largest concentrations occur in the fall, early winter, and the second half of summer. All of the aforementioned ducks use the SPA for resting and feeding. Diving ducks (tufted, red-crested,

teal, and gadwall) are more abundant in the area during the second half of summer after feeding and in the fall. Tufted ducks are more commonly found in the fall and early winter.



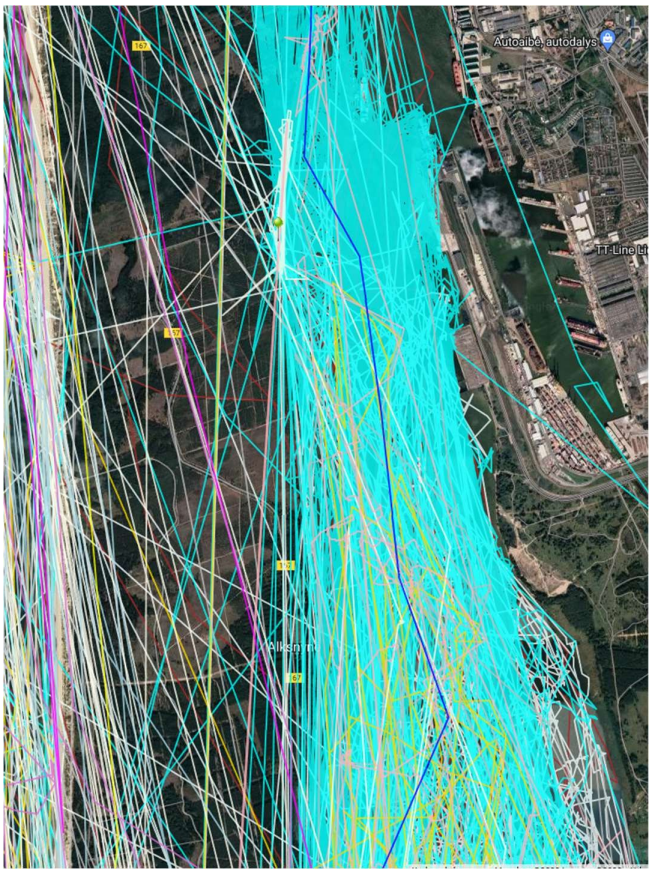
4.9.1.19 Fig. Movement of mute swans with GPS transmitters in the PŪV area in 2020.

The common shelduck is one of the birds forming the largest flocks—after the breeding season, birds gather in flocks in the Curonian Lagoon and remain in shallow areas, including those in the southern part of the PŪV territory, until a permanent ice cover forms. Thus, the southern part of the SPA is very important (as a feeding ground for common goldeneyes) after the breeding season, especially during stormy weather conditions. In some years, when a permanent ice cover does not form, several hundred individuals remain to overwinter here, and at peak times, during the autumn migration period, up to 3,000 long-tailed ducks are found in the area. Long-tailed ducks utilize shallow areas.

The Great Crested Grebe forms fluctuating flocks within the PŪV territory and its immediate surroundings. Here, the size of the flocks typically depends on the ice cover in the surrounding waters. In addition, smews follow migrating fish, and their numbers increase during the migration of smelt or other fish through the PŪV area (into or out of the Curonian Lagoon).

The red-necked grebe, the little grebe, and the horned grebe, like other fish-eating birds, use the PŪV and the areas south of it for feeding and resting. Under favorable environmental conditions, up to several hundred birds may settle in the area. Bird numbers increase during autumn migration or during fish migrations into the Curonian Lagoon. Red-necked grebes only occasionally fly into the PŪV area from the Baltic Sea.

The great cormorant is one of the bird species that uses the PŪV territory the most. It is observed in the area throughout the year. As shown by flight data from GPS-tagged cormorants, cormorants use the area during migration and breeding as a stopover and feeding site (Fig. 4.9.1.20), and Kiaulės Nugaros Island and the shores of the Curonian Spit as a resting site.



4.9.1.20 Fig. Movement of great cormorants with GPS transmitters in the PŪV territory, 2020–2023

The red-breasted goose, white-fronted goose, bean goose, and common tern are regularly present in the PŪV area, resting there during migration and local flyways.

Breeding birds

For breeding birds in the Curonian Lagoon and the PŪV area, Kiaulės Nugaros Island is of paramount importance. In this unique location in the northern part of the Curonian Lagoon, which falls within the territory of the Port of Klaipėda, various species of waterfowl and reed birds breed. Studies have identified the most important bird species that choose this area for breeding (Table 4.9.1.7). Due to the habitats that have formed there, the island has become a breeding ground for both birds that nest in open areas—such as terns and several species of gulls—and reed birds—such as the great bittern, the reed warbler, the bearded reedling, and others. Due to its remoteness and the safety it offers to nesting birds, the abundance and diversity of birds nesting here determine the area's exceptional conservation importance. Under current conditions, their abundance is negatively affected in some years only by terrestrial predators that occasionally wander in—invasive Canadian beavers or foxes. Another unfavorable factor for nesting birds is the ongoing change in habitats on the island—the spread of reed beds, which worsens the condition of the habitats of many protected species (or even leads to their extinction).

Species Overview of Breeding Birds

During surveys, red-headed gulls bred abundantly in the area in different years: at the peak of abundance, up to 4,000 pairs of red-headed gulls bred in the southern part of the island, along with 15–20 herring gulls. After 2020, the population of red-headed gulls on the island declined significantly due to the negative impact of Canadian beavers and other four-legged predators—a large portion of the breeding birds in the colony were killed that year. Apparently for this reason, the number of breeding terns dropped drastically the following year, and their decline continued until 2023, when no breeding birds of this species were detected here. It is important to note that for several consecutive years, Mediterranean gulls (*Larus melanocephalus*)—a species that breeds very rarely in Lithuania and is listed in Annex I of the EU Birds Directive—were observed on Kiaulės Nugaros Island. Most were recorded in 2019 and 2020—at least two pairs, which accounted for nearly half of all these birds breeding in Lithuania.

Gulls choose open areas or those with low vegetation for nesting and do not breed in areas densely overgrown with reeds or shrubs. Therefore, red-headed, herring, and Mediterranean gulls nested in a single colony located in the southern part of the island. In the open, sandy southern parts of the island, the common tern—listed in Annex I of the EU Birds Directive—also nested, and in 2017, for the first time in Lithuania, the black-headed tern. Both tern species built their nests in sandy areas devoid of vegetation, which highlights the exceptional importance of such habitats. We would also like to note that the black-winged terns established themselves, and the river tern population increased, when certain earthworks were carried out on Kiaulės Nugaros Island during the construction of the Klaipėda LNG terminal, resulting in the formation of relatively small areas of open sandy habitats. This is very important when assessing the potential to create suitable and currently lacking breeding habitats for these species.

As for other bird species, the majority of them—the mallard, the gadwall, and the shoveler—also most often breed in the southern part of Kiaulės Nugaros Island. It is important to note that the number of relatively common mallards and grey ducks depends on the abundance of breeding red-crested pochards: when there are more pochards on the island, there are also more breeding ducks. The common pochard breeds on the island regularly, but not always successfully, apparently due to the impact of Canadian beavers and other predators. Additionally, this species requires hiding places where the ducks can settle.

Birds that nest in reed beds, such as the Eurasian bittern, the aquatic warbler, the great reed warbler, and the bearded reedling, breed regularly on the island in the northern and central parts.

4.9.1.7 Table. Breeding bird species in the PŪV territory on Kiaulės Nugaros Island.

Birds	Year, number of pairs						
	2017	2018	2019	2020	2021	2022	2023
Red-headed gull	3,800	4,000	3,000	2,500	100	50	0
Silver Axe	8	9	15	20	8	8	9
Black-headed gull	0	1	2	2	0	0	0
Reed Bunting	1	2	2	2	1	1	1
Bearded Tit	5	8	10	8	8	10	6
Great Crested Grebe	15	15	8	20	14	12	12
Mallard	8	9	16	20	12	15	20
Mallard	5	5	8	9	12	13	14
Cave duck	1	0	1	1	1	0	0
Common tern	12		20	18	5	0	0
Black-headed Gull	10	3	0	0	0	0	0

The Silent Swan	1	1	1	2	2	1	2

Common reed	1	0	0	0	1	0	0
The Great Owl	0	1	1	1	0	0	0

4.9.2 Significant impact expected

Impact during construction of the project

facilities Vegetation

Terrestrial vegetation

Southwestern part of the Smeltė Peninsula

As mentioned in Section 4.9.1, a significant portion of the PŪV territory is currently overgrown with shrubs and scattered groves or their stumps. During the implementation of the PŪV solutions, the aforementioned vegetation would be cleared and removed, and the existing grass cover would be removed along with the displaced soil. In this part of the PŪV area, regardless of the PŪV alternative chosen, shrubs, vegetation, and grass-covered areas cover approximately 11 ha.

There are no valuable or protected plant species identified in this area, except for a recorded site of the saltmarsh aster (SRIS data) on the lagoon shore near the southern boundary of the contaminated soil storage site (Fig. 4.9.1.14).

A permit from the Klaipėda City Municipality must be obtained for tree felling when preparing the technical design.

The reclaimed land area will be covered with artificial surfaces.

Kiaulės Nugaros Island

If the PŪV solutions are implemented, all vegetation in the excavated part of the island will be destroyed for all PŪV alternatives, while in the remaining part of the island, it will be mowed and covered with sand to create open sandy habitats for bird nesting sites. The area of potential impact on vegetation is approximately 18 ha.

Location of the planned 110 kV underground power cable in the Curonian Spit

At the site of direct construction work (during the dismantling of EEPOL towers and the digging of the power cable trench), existing herbaceous vegetation and scattered shrubs will be destroyed. Upon completion of the work, the affected areas must be restored by planting vegetation characteristic of the area.

Once the solutions are implemented and the EEPOL section is dismantled, the area will be available for recreational use and/or reforestation in accordance with the needs and plans of the Curonian Spit National Park.

Aquatic vegetation

Implementation of the PŪV solutions (forming a new land area in the water body and deepening the water body) will destroy the aquatic vegetation in this water body: in the case of PŪV alternative 2A

- in an area of approximately 163.5 ha; in the case of Alternative 3A - in an area of approximately 162.1 ha; and in the case of Alternative 4A -

an area of approximately 164.5 ha.

- In part of the PŪV water area (in the vicinity of the LNG terminal and berths No. 149–151), due to ongoing economic activities (cleaning of the existing navigation channel and sediment removal from the water area), underwater vegetation is periodically removed and is very poorly developed.
- During the operation of the PŪV facilities, the water area used for navigation will be periodically cleared of accumulated sediments, so there will be virtually no opportunity for permanent bottom vegetation to form.

Read more about the potential impact of the PŪV on bottom habitats below.

Bottom habitats

The solutions for the PŪV alternatives are expected to have different impacts depending on the area of habitat destroyed within the PŪV territory (Table 4.9.2.1 and Figure 4.9.2.1). In the aphotic zone, the greatest difference in impact among the PŪV alternatives was identified for the aphotic zone mixed sediment habitat with diverse epifauna. This habitat, which has not been recorded in other areas of the Curonian Lagoon according to our data, would remain undisturbed in the case of Alternative 3A, but would lose approximately 10–12% of its area in the case of the other two PŪV alternatives. Another biotope, characterized by greater diversity—fine sediments in the aphotic zone with opportunistic polychaetes—would also experience the least impact under Alternative 3A compared to the other PŪV alternatives – approximately 68% of the habitat will be destroyed, compared to 82% and 78% for Alternatives 2A and 4A, respectively. For all PŪV alternatives, the biotope of fine sediments with mosquito larvae (*Chironomidae*) in the aphotic zone, which occupies the largest area, will be affected in a very similar manner, and the impact on distribution will account for about one-third of the area occupied by the biotope (32–34%).

When assessing the photic zone, in the case of Alternative 3A, the photic zone fine-sediment habitat with duckweed and water milfoil will be affected the least (19%), and the reed and green algae habitats will also experience a relatively small portion of the impact (<26%). The PŪV alternatives differ little in terms of impact (percentage of habitat destroyed) for three habitats: the photic zone fine-sediment habitat with water-plantain (*Alisma*), charales (*Charales*), and pondweeds (*Potamogeton, Stuckenia*). In the case of any of the PŪV alternatives, the greatest impact would be on the photic zone fine-sediment habitat with water plantain (*Alisma*)—the area of habitat destroyed would be >85%. Although this habitat will be significantly reduced, the likelihood of its extinction is low—according to monitoring data from 1997–2000, small stands *of A. plantago-aquatica* are found in nearly all parts of the lagoon.

A relatively high impact (area of destroyed habitat > 75%) would be felt by the fine-sediment zone with floating plants (*Potamogeton, Stuckenia*) habitat. On the other hand, there are relatively many of these floating-leaved plant communities outside the project area, so the likelihood that the habitat will be significantly reduced in the Curonian Lagoon is low.

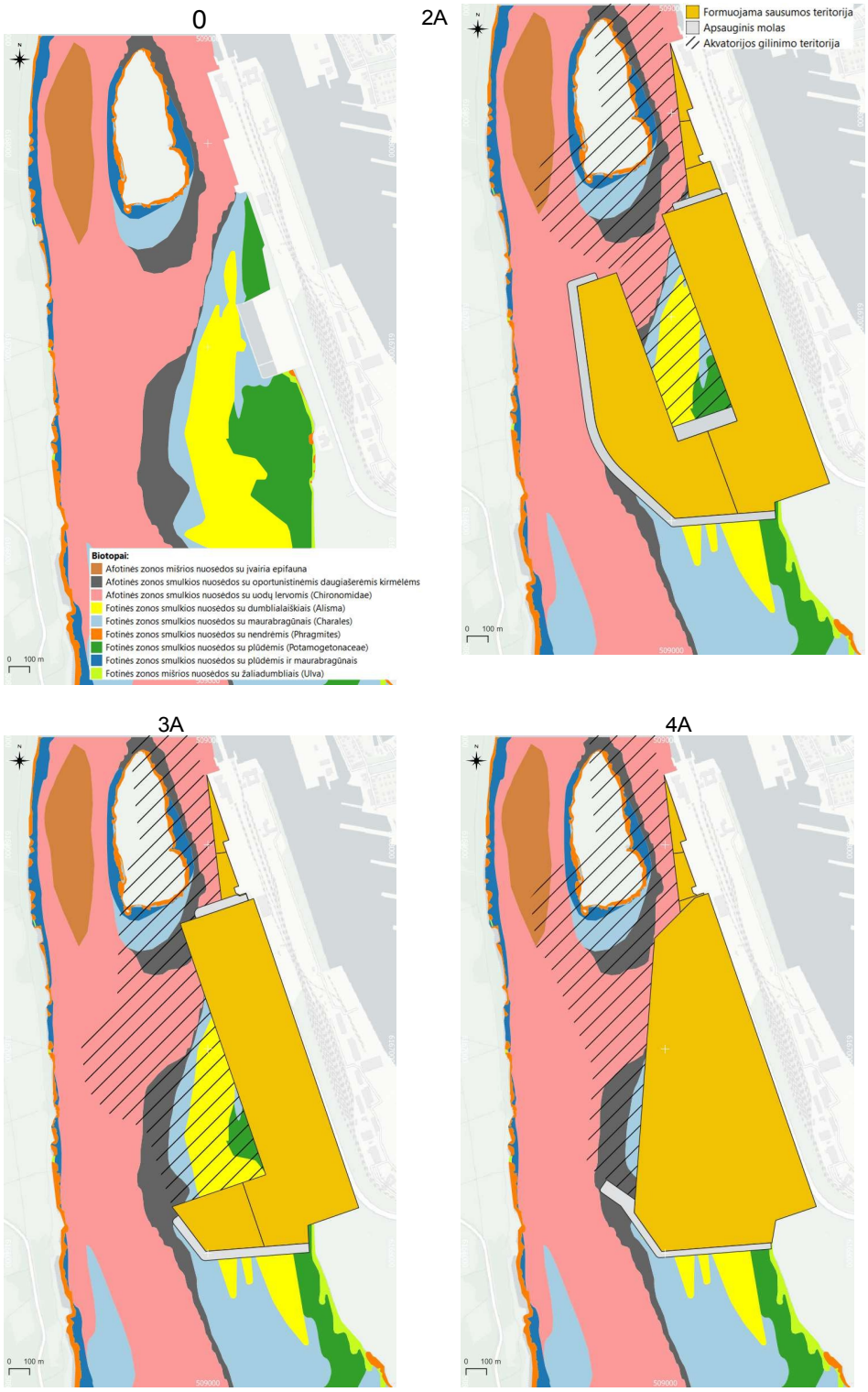
The photic zone fine sediment habitat with charales (Charales) is considered an important biotope, as it contains macrophyte species listed as protected. Development carried out according to Alternatives 3A and 4A would cause the least damage to this biotope.

In summary, regarding the potential impact of the development project on habitats (based on the relative proportion of the area to be destroyed and the rarity of the habitat), Alternative 3A will have the least impact on habitats among the three development project alternatives under consideration. This alternative is also the only one under which the development will have no impact on the rarest habitat, and will have no greater impact on the distribution area of protected habitats within the PŪV territory than the other PŪV alternatives. The order of the PŪV alternatives in terms of increasing impact on habitats is as follows: 3A < 4A < 2A.

42. Table. Habitat area within the project area and the relative proportion of habitat destroyed based on different development alternatives. An important habitat containing macrophyte species listed as protected is highlighted.

		Percentage of habitat destroyed, %		
Habitat	Area, km²	2A	3A	4A
Fine sediments in aphotic zones with mosquito larvae (Chironomidae)	1.46	34	32	32
Fine sediments in the aphotic zone with opportunistic polychaetes	0.28	82	67	78
Mixed sediments in the aphotic zone with diverse epifauna	0.16	10	0	12

Fine sediments of the photic zone with water plantain (*Alisma*)	0.40	81	82	81
Fine sediments in the littoral zone with Charales	0.61	38	37	37
Fine sediments in the photic zone with pondweeds (*Potamogeton, Stuckenia*)	0.49	76	77	76
Fine sediments in the photic zone with floating plants and pondweed	0.13	26	19	27
Fine sediments in the photic zone with reeds (*Phragmites*)	0.09	30	25	30
Mixed sediments in the photic zone with green algae (*Ulva*)	0.03	26	24	28



4.9.2.1 Fig. Distribution of biotopes (A) and loss of biotope areas according to different PŪV alternatives (2A, 3A, 4A) within the PŪV territory.

Conclusions:

- Nine biotopes have been identified in the PŪV area, of which 3 are in the aphotic zone and 6 in the photic zone. In the photic zone, the largest area (17% of the total PŪV territory) is occupied by a habitat of fine sediments with charales (Charales), while in the aphotic zone, the largest area (39%) is occupied by a habitat of fine sediments with mosquito larvae (Chironomidae).
- The PŪV alternatives would have different impacts based on the area of habitat destroyed within the PŪV territory. In the aphotic zone, the greatest difference in impact between the PŪV alternatives was identified for the mixed sediment habitat with diverse epifauna. This biotope, which, according to our data, has not been recorded in other areas of the Curonian Lagoon, would remain intact under Alternative 3A, but would lose approximately 10–12% of its area under the other two project alternatives.
- The biotope of fine sediments in the photic zone with Charales is important because it is home to a species of Charales listed as protected—the nest-forming stonewort (*Tolypella nidifica*). Its primary habitat has been identified in the PŪV area, although it is likely that the habitat extends further south along the eastern shore of the lagoon. Other protected charal species (*Chara baltica*, *Chara canescens*) have not been found, as their habitats are most commonly found among reed beds.
- The greatest impact (area of destroyed habitat > 85%) is likely to be on the photic zone habitat of fine sediments with water plantain (Alisma). On the other hand, the likelihood of this habitat disappearing is low, as small stands *of A. plantago-aquatica* are found in almost all parts of the lagoon. The impact of the different development alternatives on this habitat is similar.
- Development carried out according to Alternatives 3A or 4A would cause the least damage to the important photic zone fine sediment with Charales biotope, although the relative size of the destroyed biotope differs by only 1% from Alternative 2A.
- The only PŪV Alternative 3A will have no impact on the rarest habitat and will also have no greater impact on the area of protected habitats within the PŪV territory compared to other alternatives. The PŪV alternatives are ranked in ascending order of the harm their activities cause to habitats as follows: 3A
  < 4A < 2A.

Ichthyofauna

The expansion and reconstruction works carried out in the port's water area—including the expansion and dredging of the navigation channel and water areas, the reconstruction and construction of quays, and the construction of new hydraulic structures—may have a greater or lesser impact on the ichthyofauna. These activities may have the greatest impact during fish migrations, especially spawning migrations, as the Klaipėda Strait is the only route between the Baltic Sea and most of Lithuania's freshwater bodies. The Klaipėda Strait is of great importance as a waterway for the migration of many passing (migratory) fish and round-mouthed (eel-like) species into the Curonian Lagoon and the Nemunas River basin. River lampreys, smelt, dace, roach, salmon, and pike are the most economically and environmentally significant and the most abundant migratory species. Sea lampreys and smelt also migrate into the Curonian Lagoon, while eels and sturgeons migrate from the lagoon to the sea; however, the abundance of these migratory species is significantly lower than that of the species listed above. Most migratory fish travel through the channel between the western coast of the lagoon and Kiaulės Nugaros Island. In addition, seasonal migrations of freshwater fish, such as sterlets and perch, occur in the Klaipėda Strait between the sea and the lagoon, and the fry of migratory fish that have spawned in the Curonian Lagoon and the Nemunas River basin also migrate to the sea. Based on data regarding the scope of reconstruction, construction, and dredging works at the Port of Klaipėda, the work areas and technologies involved, as well as changes in the natural environment, it can be concluded that these works have both direct

and indirect impacts on fish migration. The main factors that may directly affect the ichthyofauna during the implementation of the southern part of the KVJU expansion are increased water turbidity

and noise. Pelagic fish can avoid these impacts by leaving the affected water area and returning once the disturbance has ended; therefore, the impact of these short-term factors on them is considered negligible. However, it is important to note that disruption of fish spawning migration can have a significant impact on the replenishment of the entire population, so when carrying out works in the port basin during migration that may affect the ichthyofauna, measures must be taken to mitigate the impact. Following the implementation of the port expansion, changes in habitats and alterations in the inflow of saline seawater may have long-term effects on fish communities.

Impact of water turbidity

Water turbidity may increase significantly during dredging and cleaning operations. Experimental studies (Patin 1979; Rice 1985; Rechlin and Bagge 1996; Bengtsson et al. 1999, etc.) have shown that increased water turbidity, especially from suspended sediment particles, impairs fish orientation or disrupts spawning migration. Dredging techniques, and particularly the noise generated by dredges, deter migrating fish, while dredging operations may result in injury or stunning of fish, especially their juveniles. The indirect impact of dredging operations on fish migration results from changes in environmental conditions, primarily turbidity and secondary pollution. It is very difficult to determine the critical thresholds for changes in these parameters due to a lack of data and highly divergent interpretations of the data. Furthermore, there are no regulatory documents specifying threshold turbidity concentrations for migratory fish. Many studies indicate that critical suspension concentrations for fish range from 100 to 300 mg/l. There is data indicating that turbidity concentrations exceeding 35 mg/l reduce fish feeding intensity, 50 mg/l slow their growth rates, and 90 mg/l reduce fish resistance to disease. However, these data were obtained by studying closed water basins, where the effect of turbidity is long-term. At the same time, there are many sources indicating that in some water bodies where suspension concentrations reach 100–400 mg/l, fish stocks were normal, while in others the same suspension concentration severely depletes fish stocks or causes fish mortality. Research by Lithuanian scientists in the Klaipėda Strait (1985–1987) found that concentrations of fine-particle suspensions exceeding 200 mg/l cause fish mortality. When turbidity exceeds 100 mg/l, fish diseases become more frequent, particularly fin saprolegniasis and parasitic diseases. Experimental studies have shown that turbidity levels above 60 mg/l impair certain vital functions in fish. This manifests as respiratory distress, increased fish activity, and, at the same time, an increase in hemoglobin and erythrocyte levels and sedimentation, as well as a decrease in leukocytes in the fish's blood. Turbidity also disrupts the metabolism of lipids, proteins, and salts in the fish's body. About 15 different chemical elements have been found in the sediments of the Klaipėda Strait, which may be dispersed into the water column during dredging operations and, at the same time, enter the food chain as a source of secondary pollution. These substances amplify the negative effects of turbidity on organisms and simultaneously lower the threshold values for suspension concentrations. It has been established that not all fish species react equally to turbidity and secondary pollution. Many literature sources indicate that sterlet and pike are the most sensitive to water turbidity. Salmon and dace are more resistant to it. Meanwhile, for example, eel migration is most intense under conditions of increased water turbidity. Furthermore, it is important to note that many fish species can tolerate turbidity levels of up to several thousand mg/l, but only for a short period of time (1–2 days). Prolonged exposure to increased turbidity negatively affects the vital functions of fish. Furthermore, it has been established that the larger the size of particles in suspensions, the greater the risk they pose to the structure of fish gills. Studies conducted in Malkų Bay at various distances from an operating dredger found that fish abundance near the dredger is significantly lower, particularly for migratory fish species.

In most of the literature (Patin 1979; Rechlin and Bagge 1996, et al.), the prevailing view is that "there are no threshold turbidity concentrations above which fish stocks would be at risk, nor are there any below which fish stocks would be completely safe." Therefore, we propose adopting the view that any increase in turbidity (compared to background levels) will have a negative impact on fish stocks, and as turbidity increases, this negative impact intensifies. There is insufficient data to establish a relationship between turbidity concentrations in water and the consequences for fish stocks, particularly their migrations, not only in Lithuania but also in global practice. Based on existing studies, it is possible to propose classifying turbidity concentrations according to the degree of risk to fish stocks (Birtwell 1999):

- turbidity concentrations below 25 mg/l – no adverse effect on fish stocks,
- turbidity concentrations of 25–80 mg/l – the impact on fish stocks is insignificant or moderate,
- turbidity concentrations of 80–400 mg/l – high probability that the impact on fish stocks is significant,
- turbidity concentrations above 400 mg/l – significant impact on fish stocks.

Although fish can tolerate high turbidity concentrations for a short period of time (several hours or even days), there is a potential for long-term effects on viability. It has been determined that the greatest impact on fish migration is caused by dredging works carried out at the port entrance, in the shipping channel, and along the coast of the Curonian Spit, where the main migration routes of migratory fish pass through. The impact of these works is less significant when carried out in the eastern, most heavily developed part of the estuary, which migratory fish avoid due to constant anthropogenic impact and disturbance. Fish migrations are least affected by dredging works in Malkų Bay, through which some river lampreys migrate to the Vilhelmo Canal in the fall. More migratory fish, especially immature smelt, concentrate here only in the winter. These fish return to the Baltic Sea coast in the spring. Dredging operations in the southern part of the KVJU territory, on the eastern shore of the Curonian Lagoon south of Kiaulės Nugaros Island, are expected to have a similar impact on migration.

Impact of anthropogenic noise

Studies on the impact of anthropogenic noise on fish are scarce, especially for fish living in natural conditions (Popper and Hastings 2009). The effects of noise can manifest as hearing impairment in fish near the sound source, temporary or permanent hearing loss, stress, behavioral changes, and fish may avoid the noise source. It is known that the strongest impact is caused by the sound generated by polyacids, the only known source capable of even killing fish at shorter distances. Fish sensitivity to polyacid sound depends on their anatomy. The most sensitive fish are those whose inner ear is connected to the swim bladder. The inner ear of salmon is not connected to the swim bladder, and they are considered to be moderately sensitive to sound. During the construction of a liquefied natural gas terminal in the Klaipėda Strait, measurements of the sound intensity of the pile-driving showed that the high-risk zone for fatal injuries to salmon extended 27 m from the pile, and for smelt, 80 m from the pile. The high-risk zone for permanent hearing damage for both fish species extended to 160 m, while the zone of temporary hearing sensitivity threshold change reached 450 m; the latter zone may encompass the entire width of the fish migration route (Bagočius 2015, Bagočius 2020). During dredging operations in the port basin, the intensity of noise generated by dredgers or other equipment, and consequently the impact zone, is significantly smaller. The impact of this noise on the ichthyofauna can be considered negligible. For perch, a low-risk zone of reversible damage up to 160 m and a low-risk zone of temporary changes in hearing sensitivity threshold up to 450 m have been identified.

Ichthyofauna in Different KVJU Water Areas

Based on the composition of the ichthyofauna, the KVJU water area can be divided into three parts. In the southern (lagoon) part, south of Kiaulės Nugaros Island, freshwater fish characteristic of the Curonian Lagoon predominate. The northern part of the Baltic Sea coast is characterized by marine fish, as well as some freshwater species that migrate during the warm season. In the Klaipėda Strait, both freshwater and marine fish adapted to variable salinity conditions are found; no significant fish spawning grounds have been identified in this water area. Various species of migratory fish are found in all three parts of the port's waters, depending on the season.

The most common fish species found in the southern part of the KVJU territory near Kiaulės Nugaros Island are carp, sterlet, roach, and perch. Near this island, roach and rudd are also quite abundant, while other species are encountered much less frequently. The impact of the KVJU PŪV on local fish species, especially during the implementation of its solutions, should be less than on migratory species. The abundance and biomass of these fish near Kiaulės Nugaros Island are significantly (2–4 times) lower than in the northern or central parts of the lagoon; when considering the entire Curonian Lagoon, the fish stocks in this water area constitute a small portion of the total lagoon stocks (Repečka and Milerienė 1991). The primary impact on local fish may be due to the loss of spawning grounds and fishing areas resulting from the formation of new land areas and the construction of hydraulic structures. The damage to the ichthyofauna caused by the loss of water area can be calculated according to the methodology established by the Ministry of the Environment (2017). Spawning grounds for roach and perch are recorded near Kiaulės Nugaros Island. Some of these would be lost if the water area were deepened and/or filled with soil. When assessing the impact on the entire roach and perch population in the Curonian Lagoon, it will be insignificant. Spawning grounds may also be affected by increased water turbidity; however, during the spawning season for these fish in April–May, the prevailing currents are typically from the lagoon to the sea, and such an impact would be insignificant. Noise generated during construction activities may also affect local fish species, depending on the nature of the work (pile drivers, dredgers, etc.). Increased water turbidity and noise may also disrupt the seasonal migrations of freshwater fish to and from the sea.

Three main groups of fish are distinguished along the Baltic Sea coast: marine, migratory, and freshwater (Ådjers et al. 2006). Several marine fish species stand out in the Lithuanian economic zone of the Baltic Sea for their high productivity and abundance. These are, first and foremost, sprat, sprat, cod, and flounder. These fish species dominate the waters of the economic zone, but in the coastal waters—defined as waters up to 20 m deep—migratory and freshwater fish species often dominate. According to scientific research data, over 60 fish species have been recorded in the Baltic Sea off the coast of Lithuania (Pūtys 2012, Repečka 2003a; 2005).

The impact on the Baltic Sea ichthyofauna during the implementation period of the various PŪV alternatives is likely to be insignificant. Fish in the water areas adjacent to dredging operations may be affected by increased water turbidity, as well as increased chemical water pollution. During the warm season, a significant portion of the nearshore fish community consists of seasonally migrating freshwater fish from the Curonian Lagoon; these may be disturbed by activities along the migration route (noise, dredging operations).

Impact of seawater inflow into the Curonian Lagoon

The Baltic Sea is a body of water with low salinity, connected to the freshwater Curonian Lagoon via the Klaipėda Strait. Due to occasional inflows of saline water into the Curonian Lagoon, salinity in the northern part of the lagoon sometimes rises to 6‰. Over the past two decades, increasingly frequent inflows of seawater into the Curonian Lagoon have been observed. This is caused by: as in the world's oceans, rising water levels in the Baltic Sea, a decrease in the Nemunas River's discharge, and intensifying and lengthening periods of stormy westerly winds, during which salty Baltic Sea

water is pushed into the lagoon, overcoming the pressure of the freshwater flowing in the opposite direction

water flowing in the opposite direction. As the influx of salty water occurs, a decline in the catches of commercial fishermen is observed in those water bodies into which seawater flows. According to A. Bukančius et al. (2008), the increasing frequency of saltwater inflows into the lagoons can be highly detrimental: plant and animal species adapted to freshwater are displaced by those characteristic of saltwater environments. The authors claim that the impact is evident in the decline of commercial fishing catches, as some freshwater fish species have left the lagoon waters affected by saline water. However, the authors do not provide reliable, research-based data showing that it is specifically water salinity, rather than other factors (e.g., varying water temperatures), affects freshwater fish, and they do not account for the potential consequences of overfishing, even though this is the most common and primary factor driving declining catches in various water bodies worldwide. Experimental laboratory studies (Dainys, 2012) showed that low salinity levels of 3‰ and 6‰ (water of this salinity is closer to the osmotic pressure of fish body fluids and should facilitate osmoregulation, allowing the energy saved to be used for growth), compared to freshwater, does not have a negative effect on the growth of the fish used in the experiments—perch and roach—and a certain, albeit statistically unreliable, acceleration in growth is even observed. This suggests that the brackish water flowing into the Curonian Lagoon from the Baltic Sea, due to its salinity characteristics, cannot have a negative impact on these fish even during prolonged periods of brackish water inflow into the Curonian Lagoon. A positive effect of water salinity on perch growth was observed in the presence of nitrogen compounds—NO2-, NO3-, and NH4+ ions. In this case, perch grew statistically significantly faster in 3‰ and 6‰ water than in fresh water ($p<0.05$). This suggests that, as water quality deteriorates and ammonium compound levels rise, brackish water may have a positive effect on the studied fish by blocking the toxic effects of ammonium compounds. In addition, behavioral experiments (Dainys, 2012) were conducted to simulate natural phenomena occurring in the Curonian Lagoon, where brackish water of varying temperatures flows into the lagoon, and to observe the behavioral responses of model freshwater fish to the effects of such water. A summary of the results of behavioral and growth experiments suggests that the primary cause of the episodic decline in freshwater fish abundance in the northern part of the Curonian Lagoon is the low temperature of the water flowing in from the sea, while water salinity does not have a negative impact on their behavior. Such an effect of seawater should be short-lived, until the temperature of the seawater equalizes with that of the Curonian Lagoon. On the other hand, if the temperature of the inflowing seawater were equal to or higher than that of the lagoon water, the behavioral response of fish in the Curonian Lagoon would not manifest as avoidance of such water. Ultimately, this explains the seasonal migrations of Curonian Lagoon fish to the Baltic Sea coast, which begin in late spring or early summer, when the water along the coast has warmed sufficiently. Another driving force behind these seasonal migrations to the coast may be ammonium compounds forming in the water, which can arise during the summer when massive algal blooms and die-offs occur (various toxins produced by algae may also be released). During such periods, the inflow of clean brackish water into the Curonian Lagoon should be beneficial to the lagoon's ichthyofauna. However, it must be acknowledged that fish in the northern part of the lagoon often retreat southward as colder seawater flows in, resulting in reduced catches for fishermen in the northern part of the lagoon. Furthermore, the impact of brackish water on various species of lagoon invertebrates—which serve as the primary food source for many fish—remains unclear. If the impact on these organisms is significant, fish stocks are consequently affected as well. The impact on fish eggs is also unclear. Laboratory studies conducted in Estonia show that even eggs of the same fish species collected from different water bodies may tolerate water salinity differently (Vetemaa and Saat 1996), so it is evident that different populations of the same species have different adaptations to this factor.

Changes in fish habitats, feeding grounds, and spawning grounds in the Curonian Lagoon

Under all development alternatives for the southern part of the KVJU, part of the Curonian Lagoon water area will be filled in to create new land areas, thereby reducing the area of fish habitats, spawning grounds, and breeding grounds. Additionally, under all PŪV alternatives, part of Kiaulės Nugaros Island will be dredged to extend the inner navigation channel and create a turning basin for ships. The total reduction in the water area will be approximately 93.2 ha for Project Alternative 2A, approximately 64.4 ha for Alternative 3A, and approximately 87.8 ha for Alternative 4A. The reduction in the Curonian Lagoon's water area will constitute a very small portion of the total area of all lagoons, ranging from 0.04 to 0.06% of the total area depending on the PŪV alternative (or approximately 0.17–0.24% of the total area within the territory of the Republic of Lithuania). Fish abundance and biomass near Kiaulės Nugaros Island are about half the average for the Curonian Lagoon (Repečka 2012). Such a loss of water area is likely to have only a negligible impact on fish in the Curonian Lagoon.

No protected fish spawning grounds have been identified in the water area of the planned southern expansion of the KVJU. Spawning grounds for perch and roach have been identified along the southern coast of Kiaulės Nugaros Island, which would be lost if part of the island were dredged and the water area deepened. Spawning grounds for these fish are also located along the western coast of the Curonian Spit and south of the project area (Fig. 4.9.1.11). Some of these may also be lost during the construction of the previously planned coastal protection walls and the southern port gates. Perch and roach are among the most abundant fish in the Curonian Lagoon (Ložys et al. 2022); the lost spawning grounds for these species will constitute a very small portion of the total spawning area for all these fish and will have only a negligible impact.

The expansion of the southern part of the KVJU may also have a positive impact on the fish community. Habitat changes that may have a positive impact include new underwater structures, shelters, and deepened water areas. Some fish may spawn on the created underwater structures. Increased environmental heterogeneity enhances species diversity, including that of fish prey organisms; such habitats are often characterized by higher productivity.

Impact on Fish Migration

The greatest impact on the migration of passing fish may be caused by the large-scale construction and reconstruction works planned under all three alternatives for the development of the southern part of the port, the lengthening and deepening of the port's inner channel, the construction of a turning basin, the reinforcement of the underwater slope of the Curonian Spit and Kiaulės Nugaros Island (installation of retaining walls), and the construction of a coastal protection breakwater near Alksnynas. Work carried out during the peak migration period may have a greater impact in the western part of the channel, where migration is most intense. Work carried out in the eastern channel is expected to have a lesser impact, as the intensity of fish migration along the eastern edge of the Curonian Lagoon is significantly lower than in the western part. The greatest impact on fish migration may be caused by the noise generated by dredgers. Depending on their location, the high-risk zone may cover the entire width of the fish migration route. During dredging works in the port basin, the intensity of noise generated by dredgers or other equipment, and consequently the impact zone, is significantly smaller. The impact of this noise on the ichthyofauna can be considered negligible. Upon implementation of the PŪV solutions under any PŪV alternative, the existing fish migration routes will remain open. During the operation of the deepened port, fish migration may be disrupted by periodic dredging of sediment accumulated in the channel and the restoration of the navigation channel's design parameters (dredging). With the lengthening of the navigation channel, the construction of new berths, and the creation of a turning basin, the scope of these works will increase accordingly, and the potential impact on fish migration may also increase.

Impact due to increased port activity

Upon implementation of the PŪV, the port's cargo handling capacity will increase, and due to the growth in the intensity of port operations, pollution of the port's water area and other disturbances (e.g., noise) may increase, negatively affecting the ichthyofauna.

Impact on ichthyofauna during the implementation of the PŪV solutions

During the implementation of the southern part of the KVJU expansion under all PŪV alternatives (2A, 3A, 4A), the following is planned: extension of the inner navigation channel (approx. 1.7–2.4 km), construction of a 600-meter-diameter turning basin, construction of new quays, formation of new land areas, dredging of part of Kiaulės Nugaros Island, reconstruction of existing quays and deepening of water areas, and relocation of the power transmission line to the Curonian Spit. All of these works may have an impact on the ichthyofauna (Table 4.9.2.1). Port development works may have the greatest impact on fish migration.

During the implementation of the PŪV solutions, increased water turbidity in the port basin resulting from the dredging and widening of the navigation channel, as well as noise generated depending on the technology used, may affect the fish fauna in all PŪV alternatives. Increased water turbidity and high-intensity noise caused by dredging equipment may have a greater impact on fish during the spawning migration period, as the planned works would take place along the migration route. The greatest impact on fish migration may be caused by works carried out closer to the western channel near the coast of the Curonian Spit, where the main migration routes of migratory fish pass. The greatest impact on fish may be caused by noise from pile-driving, especially when work is carried out in water areas closer to the western channel. In this case, the high-risk impact zone may cover the entire or a larger portion of the fish migration route (within a 450-meter radius for salmon and sea trout). The impact would be less significant if work were carried out in the eastern, most heavily developed part of the strait. Significant disruption of migration may have a major impact on the status of migratory fish populations, which may take a long time (up to several generations) to recover, depending on the biological characteristics of the fish species. The impact of the planned port expansion works on local fish populations in the Curonian Lagoon is expected to be minor, as fish can move away from the affected water areas. Possible disruption of spawning in the southern port waters due to increased water turbidity. The impact is expected to be minor, as during the spawning season (April–May) for fish spawning in the northern part of the lagoon, outflows from the lagoon predominate. The impact on the fish fauna during the implementation of the port expansion solutions will depend on the scope of work carried out in the water area; the main factors affecting fish are anthropogenic noise and increased water turbidity. In the case of Alternative 2A, the number of new quays constructed, the area of the water area to be dredged, and the reduction in the water area resulting in the formation of new land areas are similar to those in the case of Alternative 4A. In the latter case, fewer new quays are built than in the other alternatives. In Alternative 3A, the largest area is dredged, but the water area is reduced the least (Table 4.9.2.2).

The impact on the Baltic Sea ichthyofauna during the implementation period is likely to be insignificant. Fish in adjacent water areas may be affected by increased water turbidity and noise, as well as increased chemical water pollution caused by bottom sediments. Disrupted fish migration may also affect coastal fish communities in the Baltic Sea, as a significant portion of the fish communities in this water area consists of diadromous and freshwater fish that migrate seasonally from the Curonian Lagoon.

Similar works are carried out during the implementation of all PŪV alternatives, although the scope of their different parts varies. Summarizing the scope of all activities under the different alternatives, an impact of similar magnitude on the ichthyofauna is expected. By applying appropriate measures, the impact of these factors on fish can be significantly reduced.

4.9.2.2 Table. Scope of KVJU development works under different PŪV alternatives (area of dredged water bodies, new quays to be constructed, change in water body area following the formation of new land areas and the dredging of part of Kiaulės Nugaros Island).

Project alternative	Water area to be dredged, ha	New quays, m	Change in water area, ha
2A	95.2	1803	- 93.2
3A	114.8	1665	- 64.4
4A	96.4	1284	- 87.8

Impact on ichthyofauna following implementation of the PŪV solutions

The main factors that may affect the ichthyofauna following the implementation of the southern section of the KVJU expansion are changes in the inflow of brackish water from the Baltic Sea into the Curonian Lagoon, changes in habitats, spawning grounds, and fishing areas, changes in the scope of navigation channel dredging works, and increased port activity.

After evaluating the project alternatives, it can be concluded that all of them (2A, 3A, 4A) will have an impact on the ichthyofauna upon implementation due to changes in the inflow of seawater into the Curonian Lagoon. All alternatives for the development of the southern part of the KVJU involve dredging part of Kiaulės Nugaros Island, extending, widening, and deepening the shipping channel, deepening the water areas near the existing quays, and constructing a 600-meter-diameter turning basin. All of these solutions will affect the water flow capacity of the port channel and the inflow of seawater into the Curonian Lagoon. Seawater dispersion modeling conducted by the Lithuanian Energy Institute showed that upon implementation of the southern port expansion solutions according to Alternative 2A, water salinity in the lagoon 3 km south of Kiaulės Nugaros Island would decrease by 4.3–2.7% compared to the current situation, depending on the flow rate of water from the Baltic Sea into the Curonian Lagoon; in the case of Alternative 3A, it would increase by 13.7–11.8%; in the case of Alternative 4A, it would increase by 12.4–10.9%; the greatest increase in salinity would occur under Alternative 3A and would amount to 0.32–0.59 ‰ depending on the flow rate. At Juodkrantė, this change would be 0.14–0.56 ‰, respectively (Kriaučiūnienė et al., 2023). The impact of salinity changes on the ichthyofauna following the implementation of PŪV Alternative 2A would be slightly positive. The impact of Alternatives 3A and 4A would be similarly negative, and its severity can be assessed as minor.

When assessing the loss of fish habitats and spawning grounds, the impact would be very similar for PŪV alternatives 2A and 4A, and about one-third lower for alternative 3A (Table 4.9.2.2). The reduction in the Curonian Lagoon's water area will constitute a very small portion of the total area of the lagoon and, depending on the PŪV alternative, will range from 0.04% to 0.06%. Fish abundance and biomass near Kiaulės Nugaros Island are about half the average for the Curonian Lagoon (Repečka, 2012). Such a loss of water area is likely to have a very negligible impact on fish in the Curonian Lagoon.

No protected fish spawning grounds have been identified in the water area of the planned expansion of the southern part of the KVJU. Spawning grounds for perch and roach have been identified along the southern coast of Kiaulės Nugaros Island, which would be lost if part of the water area were dredged. Spawning grounds for these fish have also been identified along the western coast of the Curonian Spit and south of the project area (Fig. 4.9.1.11). Some of these may also be lost due to the installation of protective walls and the southern port gates. Perch and roach are among the most abundant fish in the Curonian Lagoon (Ložys et al., 2022); the lost spawning grounds for these species will constitute a very small portion of the total spawning area for all these fish and should not have a noticeable impact on the status of their populations or stocks.

The development of the southern part of the KVJU may also have a positive impact on the fish

community. Changes that could have a positive impact on habitats include new underwater structures, shelters, and deepened water areas. Some fish may spawn on the installed underwater structures. Increased environmental

increases species diversity, including that of fish prey organisms; such habitats are often characterized by higher productivity.

Upon implementation of the PŪV solutions under any PŪV alternative, the existing fish migration routes will remain open. Following the expansion of the southern part of the port, fish migration may be disrupted during operations by periodic dredging of sediment accumulated in the channel and water area, as well as the restoration (deepening) of the navigation channel's design parameters. As the navigation channel is lengthened and new berths and a turning basin are constructed, the scope of these works will increase accordingly, and the potential impact on fish migration may also increase.

Upon assessing the long-term impact on fish following the implementation of the southern port expansion under all PŪV alternatives, the greatest impact may result from changes in the inflow of brackish water into the Curonian Lagoon. In this regard, Alternative 2A would be the most favorable PŪV option in terms of its impact on fish.

Avifauna

For all of the analyzed PŪV alternatives—2A, 3A, and 4A—three groups of potential negative impacts on breeding and migratory birds are anticipated:

- loss of waterbird breeding areas and the habitats within them during the implementation of the PŪV solutions and, potentially, during the operation of the facilities (a significant impact across the entire coastal region, but without a significant impact on bird species protected in adjacent PAST areas);
- loss of resting and feeding habitats during the implementation of the PŪV solutions (potentially significant at the local/regional level for individual bird species, without a significant impact on protected bird species in adjacent PAST areas);
- Disturbance of birds during the construction and operation of the PŪV facilities (potentially significant at the local/regional level for a substantial portion of the bird population, possibly having a negative impact on the great and little bitterns protected under the PAST in the Curonian Lagoon).

Each group of potential impacts and its presumed level of significance is described in more detail below for the different PŪV alternatives.

1. **Loss of waterbird breeding areas and the habitats within them during the construction and, potentially, operation of the PŪV project facilities**. On the one hand, this is a fairly localized impact, related only to the loss of birds nesting on Kiaulės Nugaros Island and the habitats important to them on this island. The solutions in all PŪV alternatives are similar, so there is no significant difference in the impact they cause. However, the destruction of approximately three-quarters of the island's area will result in the loss of nesting sites for several bird species—red-headed gulls, black-headed gulls, common terns, and sandwich terns. This is linked to the destruction of the breeding grounds of what was once one of the largest colonies of red-headed gulls and the only breeding grounds of the spotted tern (a species listed in Annex I of the EU Birds Directive) and arguably the only relatively stable breeding site for the black-headed gull (a species listed in Annex I of the EU Birds Directive). Therefore, we assess the anticipated negative impact on the populations of these species as potentially significant not only locally but also for the entire coastal region, and in the case of the pied avocet, on a national scale. In fact, this represents the loss of a significant portion of the Curonian Lagoon islands. Separately, we can note that this PŪV would not affect protected bird species in the adjacent PAST—the Curonian Lagoon and Curonian Spit National Park—two of which are found within the PŪV area: the migrating little ringed plover and the migrating common tern.

However, it is also important to note that the impact of the physical destruction (leveling) of part of Kiaulės Nugaros Island on bird nesting sites can be mitigated.

According to SRIS data (Fig. 4.9.1.14), the habitats of birds (red-breasted goose, grey herons, common terns, and others) occupy up to 7 ha (approximately 38.9%) of the current area of Kiaulės Nugaros Island, i.e., the part that is most favorable for their nesting sites (not overgrown with tall grass or covered with reeds and rushes). As shown by monitoring data, the number of breeding red-headed gulls on Kiaulės Nugaros Island has been steadily declining since 2018 (4,000 pairs) for various reasons, and in 2022 numbered only 50 pairs. A similar situation was observed with the common tern (from 20 pairs in 2019 to none recorded in 2022) (Table 4.9.1.7). Upon implementation of the EIA solutions, depending on the selected EIA alternative, approximately 4.4–4.8 ha (in the case of EIA Alternative 4A, which is proposed for implementation – approximately 4.4 ha (about 24.4% of the island's total area)) of the island's area would remain undisturbed, where it is proposed to establish an effective habitat for bird nesting sites by applying the measures proposed in Section 4.9.3 (removal of existing vegetation, raising the surface with a 0.5 m layer of excavated soil, periodic topping/renewal of the surface with sand/gravel, periodic and timely removal of vegetation and loosening of the surface, and control of invasive animals). **It is likely that a habitat of smaller area, but properly managed and maintained, would compensate for the loss/reduction of the current habitat, and perhaps even increase the number of breeding birds** (e.g., the colony of red-headed gulls on the existing island of approximately 0.9 ha in the Krivėnai Reservoir in Babtai Parish, Kaunas District, numbered several thousand breeding pairs). Observation data show that the suitability of a habitat for bird breeding is determined primarily not by its area alone, but by the appropriate environment.

By implementing the proposed appropriate and feasible compensatory and/or mitigation measures, it is possible to create habitats that are important and suitable for the aforementioned bird species in the remaining part of Kiaulės Nugaros Island, which could lead to an improvement in the status of the aforementioned breeding tern and gull populations (see Section 4.9.3). This is also related to the status of other endangered or protected species that breed on Kiaulės Nugaros Island.

2. **Loss of resting and feeding habitats during the implementation of the PŪV solutions**. This relates both to: a) a decrease in the number of the described waterbird species feeding and resting in the PŪV area of the Curonian Lagoon, as it is filled with soil, thereby creating new land areas, and b) the significant deepening of the Curonian Lagoon water area, thereby causing the loss of territories important to certain waterbirds, particularly swans, plant-feeding ducks, and coots. In this case, the significance of the potential impact varies across different PŪV alternatives, depending on both the area of the newly formed land in the current water area (Alternative 0) and the area of the significantly deepened water area. When evaluating the PŪV alternatives, the alternative with the least significant negative impact would be the one involving the smallest area of the water body to be filled with soil. Since the deterioration of waterbird feeding conditions due to the significant deepening of the existing Curonian Lagoon water area will have a negative impact only on some waterbird species—swans, ducks, and coots—furthermore, in the immediate vicinity—the Curonian Lagoon SPA—there are sufficient such habitats, and the aforementioned birds should not experience a shortage of them. Meanwhile, the reduction in the area of open water may significantly worsen the foraging conditions for the great and little crested grebes protected within the Curonian Lagoon SPA during the winter months, when most of the Curonian Lagoon's water area freezes over, and only the part within the KVJU remains open. Furthermore, the PŪV area is often used quite actively by the migratory little gulls protected under the PAST of the Curonian Spit National Park, which settle in relatively large numbers in the KVJU water area during stormy weather. Given that these are species of European Community importance, any potential negative impact, even in the short term,

may be considered significant at the regional level, whereas in the case of other waterbirds, we would assess this only as adverse changes of local significance.

3. **Disturbance of birds during the construction and operation of the PŪV facilities**. In the case of breeding birds, birds nesting on Kiaulės Nugaros Island may be affected if dredging of the island is carried out during the breeding season, i.e., March–July. However, this can be avoided by appropriately scheduling the planned works. During construction, there is also a potential for a fairly significant negative impact on wintering great and little crested grebes, if dredging or landfilling works in the Curonian Lagoon water area within the PŪV territory were carried out during the winter months and when most of the Curonian Lagoon water area is covered by ice. This is because a significant portion of the birds that have settled in the Curonian Lagoon SPA are wintering within the project area at that time. However, even in this case, such an impact can be avoided if the works are planned with due regard for bird conservation needs, particularly given that the proper protection of values within the Natura 2000 site is of international importance and relates to the country's obligations.

Conclusion: The impact on birds during the implementation of the solutions and the operation of the project facilities should be treated as indirect (specific individuals would not be physically destroyed or harmed), long-term, and significantly negative (due to the loss of waterbird breeding areas and the habitats within them, as well as the loss of breeding, resting, and feeding habitats).

In terms of increasing impact, the PŪV alternatives are ranked as follows: 3A < 4A < 2A. During the construction and operation of the PŪV facilities, it is necessary to apply the measures for the prevention, mitigation, and/or compensation of the PŪV's negative impact proposed in Section 4.9.3.

4.9.3 Measures to avoid, mitigate, and compensate for significant adverse environmental impacts

Proposed measures to avoid, mitigate, and compensate for the project's impact on biodiversity:

Vegetation

After completion of the works, the damaged areas in the Curonian Spit must be recultivated by planting vegetation characteristic of the area, with the solutions coordinated with the Curonian Spit National Park Directorate.

Ichthyofauna

The solutions for the development of the southern part of the KVJU under all PŪV alternatives provide for the extension of the internal navigation channel, the creation of a turning basin for ships, the construction of new quays, the formation of new land areas, the dredging of part of Kiaulės Nugaros Island, the reconstruction of existing quays and the deepening of the water area, and the relocation of the power transmission line to the Curonian Spit. During the implementation of all these works, there may be a negative impact on fish that permanently or temporarily inhabit the port's water area, as well as on passing fish, both directly—due to increased water turbidity and noise from the equipment—and indirectly due to increased water pollution. Fish residing in the port basin, especially pelagic species, may actively leave the area affected by the works being carried out in the basin, so the impact on them would be negligible. Meanwhile, the expansion works being carried out in the port may have a significant negative impact on the migration of migratory fish species. In order to reduce the impact of the construction of port hydraulic structures and dredging and deepening works in the water area on the migration of migratory fish species, restrictions on the performance of these works must be established during certain periods of the year. During the main migration periods of migratory fish in the Klaipėda Strait, restrictions on dredging and deepening works must be imposed from January 1 to March 1, from April 15 to June 15, and from August 15 to October 31. On the other hand, due to varying meteorological conditions, the timing of fish migrations may differ from

year to year; therefore, it would be advisable to monitor fish migrations during the implementation of the solutions and to

during the most intense migration periods, which may be shorter than the theoretical periods indicated above. Impulse noise generated by pile drivers can have a significant impact on fish migration. The high-risk zone for disruption may cover the entire width of the fish migration route. Noise generated by the pile drivers can be reduced by applying technical and organizational measures. The noise level and, consequently, the risk zone can be most effectively reduced by using a combination of measures—an air bubble curtain, a foam sleeve, and shortening the duration of the pile driver's hammering sequence (Bagočius, 2020).

Compensation rates for damage to fish stocks and fish migration caused by dredging works at the Port of Klaipėda are calculated based on the section of the port being dredged, in accordance with rates established by the Ministry of the Environment (Ministry of the Environment, 1997) [41]. Compensation rates for the damage caused range from 0.06 to 0.17 EUR per 10 $m^3$of dredged soil; during the period of intensive fish migration (from May 1 to May 31 and from September 5 to October 15), the rates for compensation for damage caused to fish migration are multiplied by a factor of 2. During the implementation of port development projects, the aforementioned restriction periods must also be taken into account. These periods must also be taken into account when carrying out construction work in the water area involving the use of pile-driving equipment.

Following the completion of the port expansion, periodic dredging of sediment accumulated in the channel and restoration of the navigation channel's design parameters (dredging) will be required. When dredging and cleaning the seabed, it is necessary to focus on times of the year when the impact on the migration of both migratory and protected fish species will be minimal. Once the PŪV solutions have been implemented, measures should be applied to reduce pollution caused by port operations.

Avifauna

The following measures to avoid, reduce, and compensate for negative impacts on birds are proposed:

Measures on Kiaulės Nugaros Island

- On the undeveloped part of Kiaulės Nugaros Island, create open sandy habitats by clearing the reed beds and covering the island's surface with a layer of local soil (excavated during the island's development or waterway dredging) at least 0.5 m thick. This would create a breeding habitat of sufficient size for cormorants, terns, and other waterbirds, ensuring the possibility of establishing a large population.
- In the unexcavated part of Kiaulės Nugaros Island, construct at least 5 artificial nesting sites for cave-dwelling ducks using stones.
- Every year in September–October, mow and remove overgrown vegetation on Kiaulės Nugaros Island. Every year, before the bird breeding season (February–March) and after the breeding season (September–October), the island's surface must be raked to maintain an open surface and prevent vegetation from growing.
- At least once every three years, the surface of Kiaulės Nugaros Island must be topped with a layer of sand no less than 10 cm thick.
- Do not carry out dredging work on Kiaulės Nugaros Island during the bird breeding season, i.e., March–July.
- The filling of Kiaulės Nugaros Island with soil and the management of vegetation shall be carried out during the period from August to February, i.e., outside the bird breeding season.
- To protect birds from invasive predators (e.g., Canadian beavers) during the nesting and chick-rearing periods on the island, apply measures to deter and/or neutralize the aforementioned invasive predators

(e.g., traps) to protect birds from these invasive predators. The measures must be selected in accordance with the recommendations of specialists in this field.

- Since part of Kiaulės Nugaros Island falls within the protection zone of the main gas pipeline, all earthworks must be carried out in accordance with the requirements of the Law on Special Land Use Conditions of the Republic of Lithuania and coordinated in advance with the operator of the aforementioned infrastructure;

Measures in the other part of the PŪV territory

- Do not carry out the filling of the Curonian Lagoon water area with soil to form land during the period from December to February, when, after the Curonian Lagoon freezes over, wintering great cormorants and other waterbird species congregate in these areas.
- Select the alternative (3A or 4A) that involves filling a smaller area of the Curonian Lagoon water area within the PŪV territory, resulting in the least reduction (loss) of the current water area.

Compensatory measures

- As a compensatory measure for the reduction in feeding areas for birds that feed on vegetation and benthic biota following the implementation of the PŪV solutions (filling in part of the water area), it is proposed to carry out periodic reed cutting and removal work in the Curonian Lagoon water area, in the lagoon coastal zones agreed upon with the KNPP Directorate, thereby exposing additional feeding areas for the birds. The total area of the managed water area should be approximately 22 ha (corresponding to the area of feeding waters lost), and the specific management sites, timelines, and issues related to the organization and financing of the work should be coordinated by the project organizer with the KNNP Directorate during the technical design phases of the project. Preliminary areas for reed removal in the lagoons are shown in Fig. 4.9.3.1. It is recommended to cut and remove reeds in the selected water areas in the spring and at the end of summer for two consecutive years until their complete eradication and the formation of new feeding areas as well as coastal and shoreline habitats. Repeat management work after 3–5 years, depending on the condition of the managed water area (potential re-overgrowth).
- In addition to the proposed measures to mitigate potential negative impacts on birds, a solution proposed by ornithologists was considered as an additional compensatory measure: the creation of a new artificial stationary island in the northern part of the Curonian Lagoon, south of the project area — within the Curonian Lagoon Natura 2000 site—using dredged material from the project's water area. However, following a detailed analysis of the applicable spatial planning and other documents for this area (the Republic of Lithuania's General Plan, the Klaipėda District Municipality General Plan, the Plan of the Curonian Lagoon Biosphere Reserve and the Boundaries of Its Zones, the Nature Management Plan for a Part of the Curonian Lagoon, etc.) and taking into account the requirements of currently applicable legislation (the Law on Special Conditions for Land Use of the Republic of Lithuania), it must be concluded that such a solution is not provided for therein, and, given the requirements of currently applicable legislation, **it is not possible to implement it** without amending or revising the aforementioned territorial planning documents and the requirements of the aforementioned law. **Article 98(1) of the Law on Special Land Use Conditions of the Republic of Lithuania provides that "it is prohibited to construct islands in surface water bodies, except for islands in artificial, non-flowing surface water bodies."**

Upon implementation of the PŪV solutions for any PŪV alternative, **it is** first **proposed to implement and apply the aforementioned priority measures to mitigate negative impacts in the remaining (non-flooded) part of Kiaulės Nugaros Island** (covering an area of approximately 4.4–4.8 ha, depending on the selected PŪV alternative) and, from the start of the implementation of the solutions, to prepare a monitoring program to monitor breeding birds in that area, in order to assess the actual

impact of the PŪV on birds nesting in this area, as well as the effectiveness of the implemented mitigation measures, and, based on the monitoring results, determine the appropriateness and need for additional mitigation measures.



Fig. 4.9.13.1. Preliminary areas for reed removal in the lagoons

4.10 Material assets

4.10.1 Description of the current situation

The PŪV solutions are planned for the southern part of the Curonian Lagoon (an area of 270 ha), which includes the western part of the Smeltė Peninsula, Kiaulės Nugaros Island, and the port basin in the northern part of the Curonian Lagoon between the Smeltė Peninsula and the Curonian Spit from PK80 to PK111 (Graphical Appendix 1).

The PŪV territory encompasses 5 land parcels or parts thereof (cadastral No. 2101/10:1, cad. No. 2101/10:61, cad. No. 2101/10:62, cad. No. 2101/10:44, cad. No. 2101/10:43). For more information on the intended use of the land parcels, see Section 3.1, *"Brief Description of the Current Condition of the PŪV Territory*." The PŪV territory is owned by the Republic of Lithuania and is managed under a trust agreement by the State Enterprise Klaipėda State Seaport Authority. The quays are leased to stevedoring companies. There is no real estate (land plots or buildings) owned by residents within the PŪV territory. The infrastructure facilities of the Klaipėda State Seaport Authority are state-owned.

Social Infrastructure

There are no social infrastructure[1]facilities within the PŪV territory. Information on the social infrastructure facilities closest to the PŪV territory is provided in Table 4.10.1.1 and Graphic Appendix 3.

43. Table. Social infrastructure (facilities) nearest to the PŪV territory

No.	Social infrastructure facilities, characteristics	Minimum distance to the PŪV territory, km
Cultural heritage sites		
1	Smeltė Primary School (unique code 33607) Address: Nemuno St. 145, Klaipėda Status: protected by the municipality KVR object: 870.00 m² Visual protection zone:[1,]314 m² Value by structure: individual object. Nature of valuable characteristics: architectural (typical, determining significance), historical (typical, determining significance)	740 m in the NW direction
2	Alksnynės Farmstead Building Complex (unique code 2070) Address: Alksnynės St. 1, Neringa. Status: state-protected KVR object: 5074 m² Visual protection zone: 48,086 m² Value by structure: complex. Nature of valuable features: architectural (significant in determining importance), landscape	1,013 m in the PV direction
3	Alksnynės Vitality Complex (unique code 30540) Address: Alksnynės St. 3, Neringa Status: state-protected KVR object: 185,791 m² Value based on structure: complex Nature of the significant attributes: architectural (significant in determining significance), engineering (significant in determining significance), historical (significant in determining significance)	168 m in the V direction
4	King William Canal Complex (unique code 25965) Status: State-protected Value by structure: complex KVR object: 1612783 m² Visual protection zone: 22,396 m²	553 m in the R direction

[1] Social infrastructure – infrastructure comprising cultural, educational, public health, sports and wellness, recreational and tourism, religious, and other public-use facilities.

	Nature of valuable features: architectural (determining significance: rare), engineering (determining significance: unique), historical (determining significance: important), greenery (determining significance: typical)	
Education, sports, and wellness facilities		
1	Klaipėda Judo Club Address: Marių St. 1, Klaipėda	593 m in the R direction
2	Handball Club "Handbalis" Address: Kintų St. 6, Klaipėda	956 m in the R direction
3	Joint-Stock Company VAKARŲ LAIVŲ GAMYKLA Address: Minijos St. 180, Klaipėda	1,036 m in the R direction

Information on the nearest recreational areas and residential buildings, as well as their location relative to the PŪV territory, is provided in Section 4.12 *"Public Health*," Subsection 4.12.1. *"Description of the Current State of Public Health*."

Engineering Infrastructure

The PŪV territory includes KVJU engineering infrastructure[2], which comprises various hydraulic structures, the port's existing quays, as well as transportation routes on the Smeltė Peninsula (access roads, railway spurs), and engineering networks: domestic and surface (storm) wastewater, water supply, gas pipeline, electricity supply, and communications. The KVJU internal navigation channel is also part of the engineering infrastructure.

Part of the PŪV territory (in the KVJU water area) is crossed by the laid "NordBalt" submarine power cable, connecting the Lithuanian and Swedish power grids. Additionally, a portion of the project area (within the KVJU water area, near Kiaulės Nugaros Island) is crossed by the 110 kV Marios–Juodkrantė overhead power transmission line (hereinafter referred to as the 110 kV Marios–Juodkrantė OTL). The following 110 kV Marios–Juodkrantė OTL towers are located within the project area: Nos. 12, 13, 13A, 14, 14A, 15, 15A, 16, 17, 18, 19. A high-pressure main gas pipeline from the LNG terminal to the coastal zone, crossing the Curonian Lagoon at the bend of Kairių St. on the Smeltė Peninsula, has also been laid in the project area. The aforementioned utility networks are shown in Graphic Appendix 3.

There are currently three surface wastewater outfalls within the PŪV territory (outfall code 1210253, in the southern part of the KVJU near the bend of Kairių St.; outfall code 1210171, near Pier No. 152; and an outfall near Pier No. 149).

Additionally, within the PŪV territory, at the site of the former boat marina under construction, there is a location for a contaminated soil storage site (Graphical Appendix 3). Currently, environmental procedures for the construction of a new contaminated soil storage site have also been initiated (the "Environmental Impact Assessment Program for the Construction of a Contaminated Soil Storage Site at the Klaipėda State Seaport, Kairių St. 19, Klaipėda, Environmental Impact Assessment Program," prepared by UAB "Ardynas"). The new contaminated soil storage site, like the existing one, is planned with the possibility of using the site's foundation for the construction of a cargo terminal in the future.

Within the PŪV territory on the Smeltė Peninsula, there is an unfinished and abandoned boat dock building with a pump station and other engineering structures. These buildings belong to AB "Klaipėdos jūrų krovinių kompanija" (Textual Appendix 4).

[2] Engineering infrastructure – facilities in various sectors that serve the economy and residents: utility networks, transportation infrastructure, or facilities necessary for improving environmental quality.

4.10.2 Expected significant impact

The impact of the PŪV on material assets during construction/implementation may be associated with:

- the need for construction raw materials and supplies, as well as transportation and support services;
- impact on existing engineering infrastructure facilities;
- impact on private (residential) or public real estate;
- the impact on urban recreational areas and infrastructure;
- the impact on cultural heritage assets.

Impact of the PŪV during construction

Demand for construction raw materials and supplies, as well as transportation and support services

A significant increase in the demand for relevant construction raw materials and supplies (sand, gravel, stones, concrete products) as well as transportation and maintenance services is projected in the region during the construction period for the implementation of the PŪV solutions (positive impact), this impact is characteristic of all PŪV alternatives. Alternative 4A has the largest area of new land formation in the water area—approximately 83.4 ha (Alternative 2A—81.6 ha, Alternative 3A – 60.5 ha), Alternative 2A features the longest length of quay construction – 1,803 m (Alternative 3A – 1,665 m, Alternative 4A – 1,284 m), while Alternative 3A features the longest extension of the inner navigation channel – 2.4 km (Alternatives 2A and 4A – 1.7 km).

Impact on existing engineering infrastructure facilities

It is planned that, for all PŪV alternatives, during the implementation of the solutions, the 110 kV EEPOL Marios–Juodkrantė section will be reconfigured by dismantling it from support No. 12 to No. 43, and the section itself will be rerouted and connected via a new underground power cable (see Section 3.3.1*, "Description of Project Solutions,"* under the topic *"Redesign of the 110 kV Marios–Juodkrantė Overhead Power Transmission Line Section"* for details). This solution is expected to have a significant positive impact (areas freed up for other activities, a safer supply of electricity to Neringa settlements ensured, and reduced impact on the landscape of the Curonian Spit) for all PŪV alternatives.

In the southern part of the project area, a minimal impact on the surface structure (existing access roads) is possible, due to the use of self-propelled construction equipment (if the entry/exit of self-propelled equipment into the project area is carried out via existing access roads). The implementation of the project solutions will not destroy or damage other infrastructure objects located outside the KVJU territory and unrelated to the project. No significant negative impact on engineering infrastructure unrelated to the project is anticipated for any of the project alternatives.

Surface water outfalls entering the PŪV territory would be modified as part of the reconstruction of quays No. 149–152, while the southern outfall, code 1210253, would require a major reconstruction/relocation of its pipeline across the entire area to be filled. Specific solutions for surface water management and system reconstruction will be determined based on the specific land use and development plans during the technical design phases.

Impact on private or public real estate

In all project alternatives, no additional land or private real estate owned by residents will need to be acquired or purchased during project implementation, with the exception of the unfinished boat dock structures at Perkėlos St. 7, Klaipėda (subject to agreement with the building owner).

During the implementation of all PŪV solutions, it may be necessary to temporarily use additional land areas on state-owned land (not assigned to the port) for the establishment of temporary construction sites. The establishment of temporary sites will need to be coordinated with the land managers to obtain their consent. No significant negative impact is expected provided that the legal requirements governing the establishment and operation of temporary construction sites are complied with.

Impact on recreational areas and infrastructure

For all project alternatives, the entry and exit of equipment to and from the project site during implementation should not have a significant negative impact on the nearest recreational areas; it should also be noted that, for all project alternatives, the majority of the work is planned to be carried out from the port's inner harbor. For all PŪV alternatives, the equipment used for the implementation of the main PŪV solutions (barges—dredgers, suction dredgers, etc.) and their work area will not come into direct contact with recreational areas, therefore, no impact on recreational areas or their infrastructure is anticipated.

Upon implementation of the "secondary" solutions of the PŪV (dismantling a 6.6 km section of the EEPOL and 42 supports, and removing land-use restrictions related to the EEPOL), additional areas within the Port territory would become available—for economic activities, and within the KNNP territory—for the development of potential recreational areas.

Impact on cultural heritage assets

Due to the sufficient and safe distance from the project area to the nearest registered immovable cultural heritage sites, no impact is anticipated during the implementation and operation of the project for all project alternatives. The underground section of the planned new 110 kV EEPOL Marios–Juodkrantė line in Neringa (see Section 3.3.1*, "Description of Project Solutions,"* under the topic *"Rearrangement of the 110 kV Marios–Juodkrantė Overhead Power Transmission Line"*) will run close to the Alksnynė farmstead complex, but this section is planned to be laid alongside the existing NordBalt power cable section, thus avoiding any negative impact on immovable cultural heritage assets. For more information on the anticipated impact on immovable cultural heritage assets, see Section 2.11 *"Immovable Cultural Heritage Assets*."

Impact during the operation of the PŪV facilities

Impact on residents' real estate and the economy

Upon implementation of the PŪV solutions, no new land use restrictions are planned either within the PŪV territory, within the territory assigned to the Port of Klaipėda, or within the water area and its vicinity. Upon implementation of the new 110 kV EEPOL Marios–Juodkrantė section solutions, in accordance with legal provisions, protection zones for the new power cable line section must be established on land plots or parts thereof, and special land use conditions will apply within these zones. Consent/compensation agreements will be concluded with the owners of these land parcels. On the approximately 6.6 km-long section where the EEPOL will be dismantled, the existing land use restrictions associated with it will be lifted.

For all project alternatives, the project's implementation is not expected to cause a decrease in the value of real estate in the surrounding areas.

Upon implementation of the project, an increase in the efficiency, volume, and competitiveness of KVJU operations, as well as the attraction of additional investments to the region, is expected; these positive impacts are characteristic of all project alternatives.

Conclusion: In all project alternatives, infrastructure facilities located outside the KVJU territory and unrelated to the project will not be destroyed or damaged during construction/implementation and operation; no significant negative impact on engineering infrastructure unrelated to the project is anticipated. For all PŪV alternatives, during the implementation and operation of the PŪV, there will be no need to acquire, purchase, or damage residents' private real estate (except for unfinished boat dock structures). In all PŪV alternatives, the equipment used for the main works (dredgers, suction dredgers, etc.) and their work area will not come into direct contact with recreational areas; therefore, no significant impact on recreational areas or their infrastructure is anticipated. Upon implementation of the "secondary" solutions of the PŪV (dismantling a 6.6 km section of the EEPOL and 42 supports, and lifting land-use restrictions related to the EEPOL), additional areas will become available within the Port territory—for economic activities, and within the KNNP territory—for the development of potential recreational areas. During the implementation of the solutions, it may be necessary to temporarily use additional land area(s) on state-owned land to set up temporary construction sites; such use must be coordinated with the land managers and their approval obtained. No new land use restrictions are planned during the project's implementation (except for the protection zone of the new 110 kV power cable line branch and the special land use conditions applicable therein) neither within the PŪV territory, nor within the territory assigned to the Port of Klaipėda, nor within the water area and its vicinity. For all PŪV alternatives, the implementation of the PŪV solutions is not expected to result in a decrease in the value of real estate in the surrounding areas.

The impact on tangible property during the implementation of the solutions should be considered direct and indirect, short-term, and interactive (it may also affect other environmental elements, e.g., the dismantling of the EEPOL section—biodiversity, landscape), and of minor significance. A negative impact on tangible assets during the operation of the PŪV facilities is unlikely. In terms of impact, the PŪV alternatives would be equivalent.

4.10.3 Measures to prevent, reduce, and compensate for significant adverse environmental impacts

Proposed measures to prevent and reduce impacts on tangible property:

- Purchase or compensation in other ways, on mutually acceptable terms with the owners, for real estate located within the project area that hinders the implementation of the project solutions.
- Consent/compensation agreements regarding the establishment of special conditions with landowners whose plots (or parts thereof) will fall within the protection zone of the newly planned 110 kV underground power cable line.
- If violations occur and damage is caused during the implementation of the project (during construction), land plot owners will be compensated for the damage, and the violations will be rectified.
- Solutions for the use and maintenance of the newly formed KVJU territory must be planned, evaluated, and designed so that the development of the territory complies with the solution in row 272 of Table 1 of the Implementation Program for the General Plan of the Territory of the Republic of Lithuania (approved on 20 September 2023, No. 741), namely that "the existing transport network of the city of Klaipėda

transport network is not sufficiently efficient and sustainable, [...], therefore, in conjunction with the port's expansion by 2030, land transport infrastructure should be developed to disperse and redirect freight flows away from the city's territory," and in subsequent design stages, to present possible/planned measures for implementing these solutions, along with their feasibility and timelines.

- All economic activities planned in this newly formed territory of the KVJU must comply with the requirements of valid spatial planning documents and must be assessed and planned in accordance with the requirements of the Law of the Republic of Lithuania on the Environmental Impact Assessment of Planned Economic Activities, i.e., EIA procedures are conducted or not depending on whether the planned activities fall within the lists of activities specified in Annexes 1 and 2 of the aforementioned law, and the provisions of other legal acts regulating the protection of the environment and public health. All future development projects to be implemented in this area must, after assessing their nature, location, and environmental impact, comply with the requirements of legislation on environmental protection, public health, the protection of immovable cultural heritage, fire safety, and civil protection.

4.11 Immovable Cultural Heritage Assets

4.11.1 Description of the current state

Taking into account the PŪV territory (see Section 3.1) and the location of the PŪV solutions, immovable cultural heritage (hereinafter referred to as NKP) objects located within the PŪV territory and its surroundings shall be divided into three conditional groups: Group I – objects on land closest to the PŪV territory, Group II – underwater heritage objects located in the KVJU water area, and Group III – the UNESCO World Natural and Cultural Heritage Site located adjacent to the KVJU – the Curonian Spit.

The objects of the first group of cultural heritage values closest to the PŪV site, registered in the Register of Cultural Heritage, are presented and described in Table 4.11.1.1 and shown in Figure 4.11.1.1 and in Graphic Appendices 1 and 3.

4.11.1.1 Table. Objects of the 1st NKP value group

No.	NKP, Unique code	Brief description of the protected heritage	Minimum distance to the PŪV territory, km
1	Alksnynė Fortification Complex (code 30540)	Address: Neringa Municipality, Neringa City, Alksnynės St. 3. Registered: 2005-04-18. Status: State-protected site. Significance level: Regional. Nature of valuable features: Architectural (significant); Engineering (significant); Historical (significant). Area of the territory: 18.5791 ha	0.168 in the V direction to the territory of the main solutions of the PŪV. The planned solutions for the reconstruction of the 110 kV EEPOL section fall within the KPV territory fall within the KPV territory.

2	Alksnynė Farmstead Building Complex (2070)	Address: Neringa Municipality, Neringa Town. Registered: 06/30/1992. Status: State-protected. Significance level: Regional. Nature of valuable features: Architectural (significant in determining significance); Landscape. Age: 19th century a. Area: KVR site – 0.5074 ha. Visual protection zone: 4.8086 ha.	1.013 km in the toward to the territory of the main solutions of the PŪV. The planned solutions for the reconstruction of the 110 kV EEPOL section fall within the territory of all PŪV alternatives fall within

No.	NKP, Unique code	Brief description of protected values	Minimum distance to the PŪV territory, km
			KPV visual protection zone.
3	Smeltė Elementary School (33607)	Address: Klaipėda City Municipality, Klaipėda City, Nemuno St. 145. Registered: 2010-01-18. Status: Entered in the register (registered), individual object (state-owned). Level of significance: Local. Nature of valuable features: Architectural (determining significance, important), Historical (determining significance, important). Style: A Historicist-style building characterized by elements of Romanticism and Neo-Gothic, details typical of suburban architecture, materiality, scale, and proportions. Year: 1905. Area area: 0.2393 ha.	0.74 in the NW direction
4	King Wilhelm Canal Complex (25965)	Address: Klaipėda District Municipality. Registered: 09/04/2001. Status: State-protected. Significance level: National. Nature of valuable features: Architectural (determining significance: rare); Engineering (determining significance: unique); Historical (determining significance: important); Landscaping (determining significance: typical). Age: built in 1863–1873. Area of the territory: KVR object – 161.2783 ha. Visual protection zone: 2.2396 ha	0.553 in the R direction

Group II of cultural heritage assets consists of underwater cultural heritage assets listed in the Register of Cultural Assets and assets discovered during underwater archaeological surveys conducted as part of this EIA. According to the Cultural Heritage Register, there are no objects registered in the Register of Underwater Immovable Cultural Heritage Assets within the PŪV territory.