LEI

Laboratory of Hydrology

ENVIRONMENTAL IMPACT ASSESSMENT OF ŠVENTOJI PORT RECONSTRUCTION

Summary of the EIA Report

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CONTENT

1. The purpose of the port. The Governmental decisions

Šventoji has been an old fishermen settlement, situated on the river mouth. The first records about the port on the mouth of the Šventoji River (then called Heligaw or Heiligen) in the written sources were dated to XVI-XVII centuries.

The port that operated in Šventoji up to the 18th century successfully competed with other ports of the Baltic Sea (Fig. 1). However, the current condition of Šventoji port requires major reconstruction.

Fig. 1. Location of the Šventoji borough

Restoration of the port would accommodate small leisure boats and yachts, thereby giving a boost to tourism development in Šventoji. The port will also be used by local fishermen; it will have quays for specialized vessels: rescue, oil spillage containment, fire-fighting, marine environment, fish breeding, state border guard service.

In 2003 prof. Smailys [1] elaborated Feasibility Study of Šventoji Seaport reconstruction. He pointed out the necessity to rebuild the port.

The Government of Republic of Lithuania decided to establish the national port of Šventoji, approved regulations of the port and defined the land and water areas allocated for the port and their boundaries by decree No 1469.

In 2006 the Parliament of the Republic of Lithuania adopted the Law on Šventoji State Sea Port (Official Journal of 5 December 2006, No 132-4987), on the basis of which it was intended to restore Šventoji Port. Šventoji State Sea Port is a property of the Republic of Lithuania and the Government of the Republic of Lithuania is the founder of the port. On 3 October 2009 by issuing the Government's resolution (Official Journal on 3 October 2009, No 118-5074) functions of Šventoji State Seaport Authority (before its establishment) were assigned to State Enterprise Klaipėda State Seaport Authority.

Port operation purpose blueprinted in the Law:

- attend recreational, small and sports boats;
- attend fishing boats;
- attend small sea cruise and ro-ro passenger vessels;
- attend vessels of State Border Guard Service of the Republic of Lithuania as well as the vessels of rescue, spilled oil collection, fire fighting and sea environment protection, shipping and fishery control and other state entities;
  - attend Būtingė oil terminal ancillary fleet and accident liquidation measures;
  - perform initial fish processing, develop trade.

By assessing the blueprinted port infrastructure and navigation purpose, Šventoji Port has been allocated to a port type for small recreational boats. The major and the most important services for small recreational boats at harbours are boat and crew's attendance.

Šventoji port would have a considerable significance in the national context. Construction of a new state-off-the-art port with capabilities to develop all mandatory and additional services (what has been quite often a complicated business in the existing harbours), first of all, would be significant by improving infrastructure for recreational navigation (quantitatively and qualitatively) in the country. Besides, the construction of such a unique and specific facility may, in essence, change Šventoji nature and image as a resort. As recreational navigation has been prestigious, a lot of investment requiring hobby, the major port contingent would become well-off people. However, it would mean higher requirements for infrastructure of services/entertainment. Therefore, in order to take advantage of opened opportunities it is mandatory to improve a level of accommodation, entertainment and other services in Šventoji or, at least, to ensure good communication infrastructure with larger tourism centres such as Palanga and Klaipėda.

The significance of Šventoji port has also been of utmost importance to a network of recreational boats in the Baltic region. Pursuant to the EU requirements, the Baltic and Nordic Sea states must capacitate recreational boats to hide near the coast from storms at the distance of 50 nautical miles (about 100 km). Currently Lithuania has not met the above-mentioned requirement. However after the construction of Šventoji port this requirement would be executed. Besides, Šventoji port would be more convenient to inbound small boats than Klaipėda Seaport, where navigation of small recreational boats has been highly restricted due to intensive traffic, what would be avoided in Šventoji.

In 2010 Spanish engineering, consulting and architecture company "Alatec" prepared the new feasibility study of Šventoji Seaport reconstruction [2]. On 5 May five potential options of Šventoji port reconstruction were presented at the meeting of the Technical Board held in the Port Authority. "2B" option was selected as the optimal one.

The main objective of the planned EIA is to evaluate the possible environmental impact, to mitigate the impact on the environment components, as well as on public health, and to justify environmental protection measures.

2. The location

Šventoji State Sea Port is situated in the delta of the Šventoji River near the Lithuanian northern state border with Latvia (the distance to the Latvian border is 4.4 km; Fig. 1). The Šventoji (the catchment area is 471.9 km^2) is flowing through the water territory of Šventoji Sea port. The mean annual discharge in the river mouth is 5.38 m^3/s.

In 1973 Šventoji became a part of Palanga. The recreation zone of Šventoji and Palanga has a real potential to rapidly develop a popular in the Baltic States water sport.

The detailed plan was approved by Palanga town Municipality Council solution No.T2-315 as of 5 December 2008. The limits and size of Šventoji State Sea Port have been specified: 15.3 ha state land has been allocated to the internal waters lot and 209.6 ha have been allocated to the external waters lot.

3. The port restoration activities

The port restoration works are planned for the period of 2012-2015; the expected exploitation period is 50 years.

3.1. Activities during port reconstruction

In the EIA programme of Šventoji State Sea Port and the new feasibility study of Šventoji Seaport reconstruction prepared by Spanish engineering, consulting and architecture company "Alatec" [2] three port alternatives have been analysed. On 25 May at the meeting of the Technical Board of the Klaipėda State Sea Port the final report of the mentioned study was accepted and "2B" option (Table 1) of the Šventoji Sea Port reconstruction was selected as the most beneficial for the user (Fig. 2-4).

Table 1. The options of Šventoji Sea Port

Alternatives, options, figures	Length of breakwater, m		The port depth, m	The entrance channel depth, m	The number of quays	Option in EIA program
	S	N				
2A (3a)	400	500	6	7	404	small port
2B (3b)	400+245	426	6	7	474	small port with NW entrance
2C (3c)	400	500	6	7	494	small port with sea dredging
3D (4a)	800+242	790	6	8	805	avanport with NW entrance
3E (4b)	800+242	790	7	9.5	805	avanport with increased depth

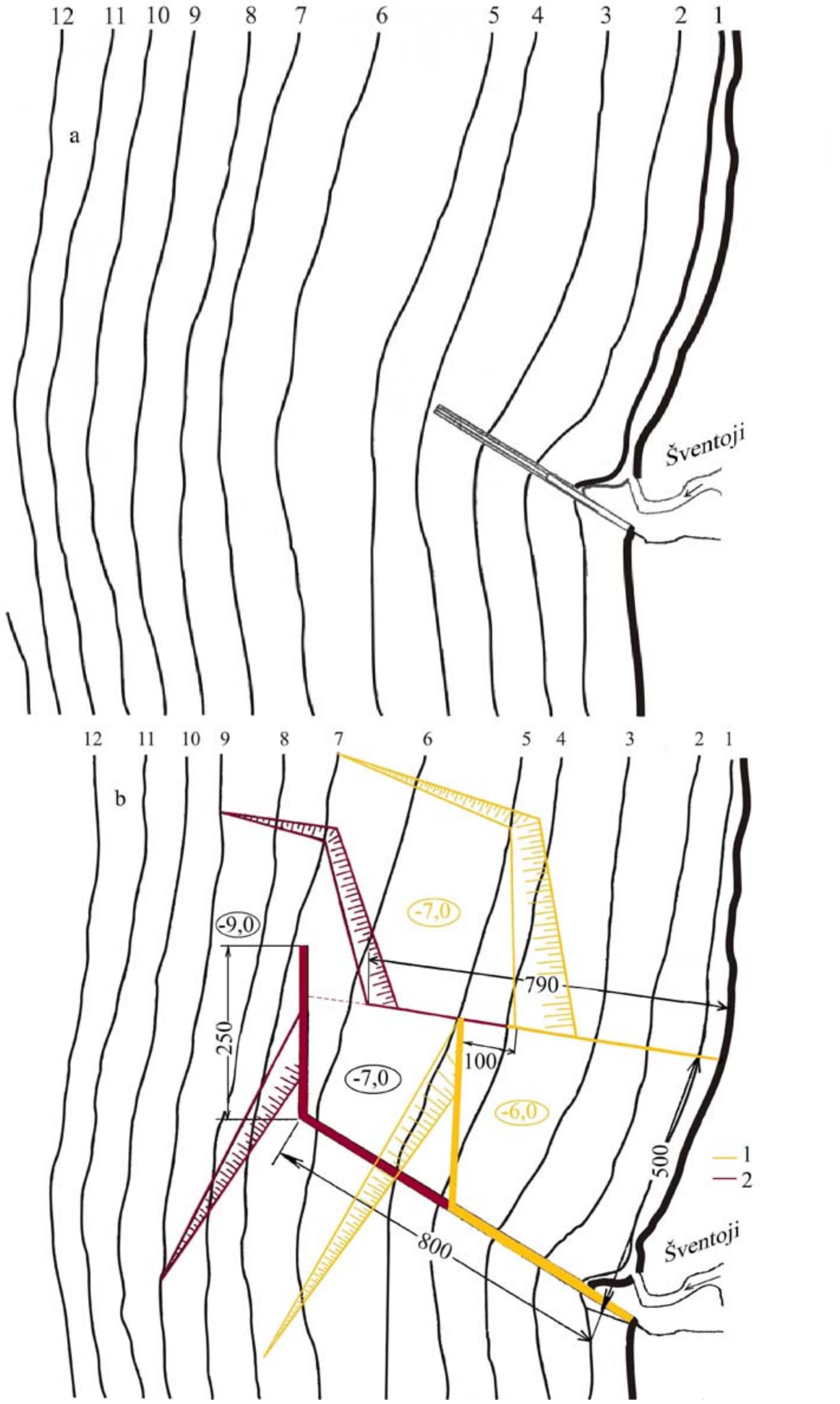


Fig. 2. Zero alternative of the Šventoji State Sea Port reconstruction (a) and option “2B” (b) with opportunity to extend breakwaters and to deepen the entrance channel according to option “3E”. 1 – option “2B”, 2 – option “3E”

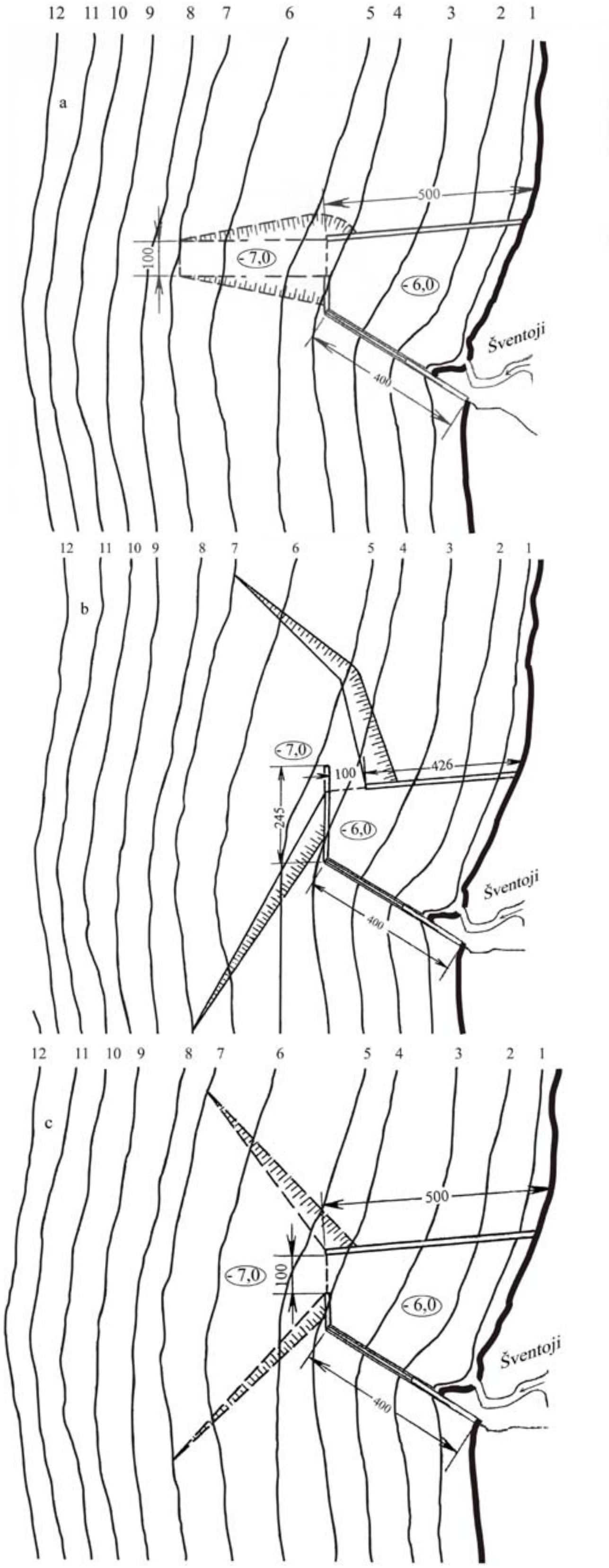


Fig. 3. The options “2A” (a), “2B” (b) and “2C” (c) of the Šventoji State Sea Port reconstruction

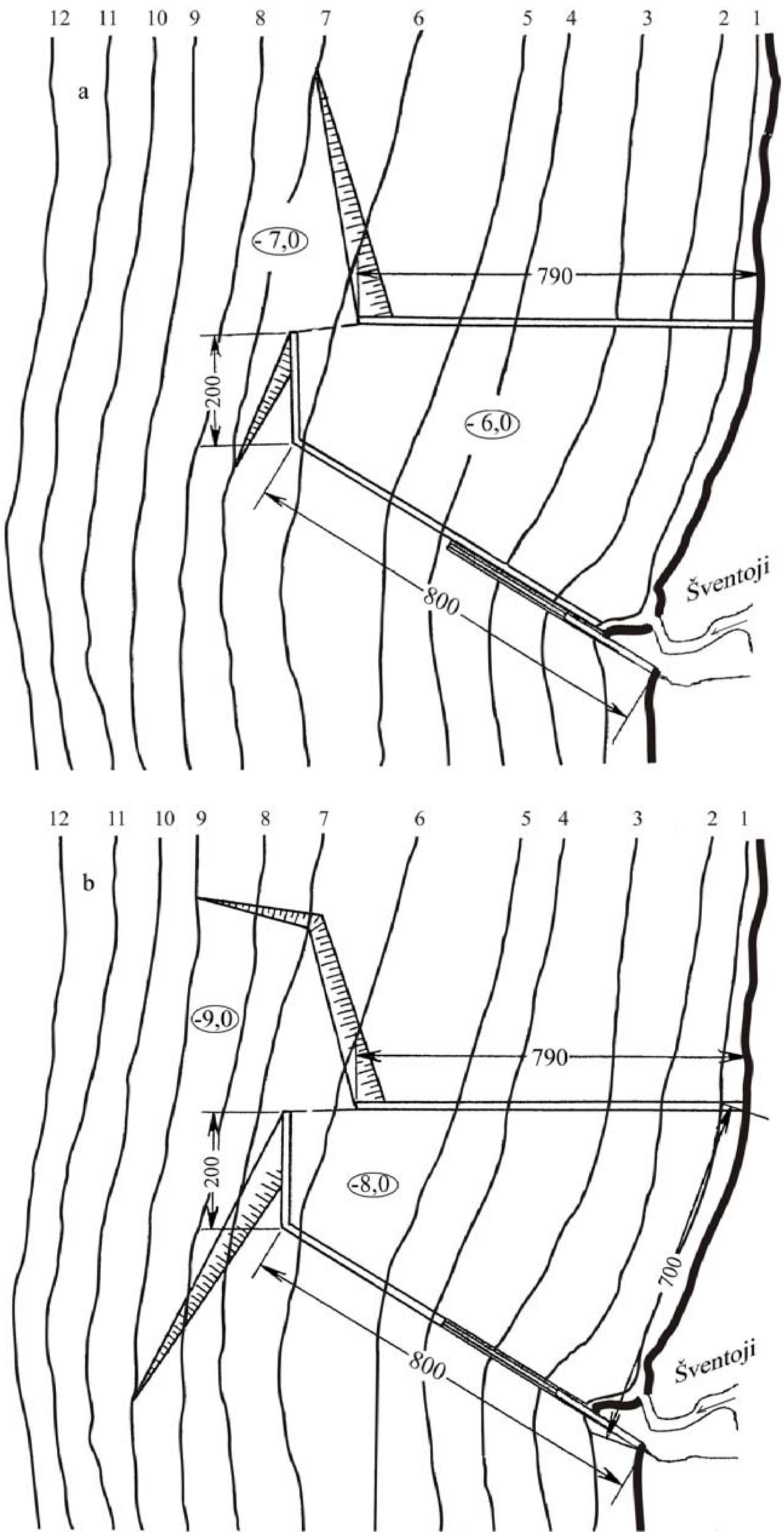


Fig. 4. The options “3D” (a) and “3E” (b) of the Šventoji State Sea Port reconstruction

"2B" option has been developed within the limits of the port. The area of shielded water obtained is of about 171,000 m^2. The breakwater has a length of approximately 645 metres in two alignments. The first alignment departs from the coast in a North-Westerly direction and has an approximate length of 400 metres. The second forms a 126º angle in relation to the previous one, and has a length of 245 metres in a Northerly direction.

The counter-breakwater is of single alignment and departs from the coast in a Westerly direction and is 426 metres long. The structural typology, like the dyke, is sloping with protective rock layers.

The depth in the inner harbour part up to shoreline is suggested to be 3-4 m, in the outer harbour – 6 m, and in the entrance channel – 7 m.

In 2011-09-06 by the document No. UD-9.6.3.3650 Klaipėda State Sea Port authority informed EIA organizer, that the tugboat with 5.5 m draught from SC "Orlen Lietuva" of the Būtingė Oil Terminal requires the entrance channel of 9.5 m depth and the water territory of 7.0 m depth for mooring. Therefore the port option, where breakwaters are constructed further in the sea was discussed. That is alternative "3" of the "Alatec" feasibility study, demanding two times bigger investments and much longer construction period. It is advisable to plan and implement the whole Seaport reconstruction in two stages:

- the first: to implement minimal objectives according to "2B" option proposed by "Alatec", i.e. the entrance channel of 7.0 m depth and short (about 400 m long) breakwaters;
- the second: to extend the breakwaters and to improve the depth of the entrance channel to 9.5 m (alternative "3" according to "Alatec" feasibility study).

During the port reconstruction period the following large-scale works are going to be accomplished:

- destruction of the old port quays,
- construction of new breakwaters from stones and boulders,
- construction of new quays and berths (about 1000 m^3 of concrete),
- earthwork:
  - dredging of the sea part of the harbour (600 thousand m^3),
  - dredging of the inner water territory (80 thousand m^3),
  - forming of the new land territories (34 thousand m^3).

During the construction of the port facilities, mobile sources, i.e. dredgers and other techniques will raise noise level in the surrounding areas, however this impact can be characterized like local and temporary and will take place only during the construction works.

3.2. Activities during the port exploitation (vessel number, buildings, depths, and scheme)

According to option "2B" total number of craft is planned to be 655 (495 afloat and 160 on land). A place for one small up to 70 m long sea cruise vessel is projected as well.

The road to the port at the quays could be located only near the southern breakwater. Whereas the reserved land area is not sufficient for the port infrastructure and the old port is intended for small vessels, all port functions lay on a newly formed territory of the southern breakwater. The quays for ships are located close to this territory. According to the approved Detailed Plan of

Šventoji, no port activity related to infrastructure (road and streets, quays, bridge) is planned in the territory between the port breakwaters.

Depending of this situation the inner port water territory is divided to these zones:

1. Inner entrance channel (from the harbour gates to ship turning basin). The channel depth is accepted the same as for sea entrance channel.
2. Ship turning basin. Its diameter (if tugboats are not used) has to be not less than 3.4-4.0 of the largest ship length or 136-160 m; and the depth – 6.0 m.
3. Quay zone for larger ships (fire rescue vessels and tugboats) with a draught of 4.0-5.0 m. at the end of the southern breakwater.
4. Zone for small vessels and yachts, where the depth is 4.0 m.
5. Inner basins for fishing vessels, where the depth is 3.0 m.

4. Environmental impact

4.1. Impact on the sediment transport and accumulation in the nearshore of the Baltic Sea

The planned economic activity – reconstruction of Šventoji State Sea Port – is going to be implemented in the territory, near the Lithuanian northern state border with Latvia (the distance to the Latvian border is 4.4 km). Because of the port hydrotechnical structures (breakwaters) the Baltic Sea environment will experience an impact on the shore nourishment conditions. The sediment transport (accumulation and erosion) is the one that can make transboundary impact.

According to the results of the cartographic material analysis and the monitoring data of the coastline dynamics, an assessment of the old Šventoji Sea Port impact on the shore state was performed. It was determined that the southern breakwater constructed in 1939 has caused an intense sediment accumulation at the port gate and southwards. Meanwhile, the coastline erosion processes have become intense northwards of the formed cape to the Latvian border. Thus, over the years, the breakwater has shortened because of the lack of care and reconstruction. The monitoring data collected during the last 17 years shows sediment volume stabilization on the northern side of Šventoji Sea Port and the beginning of a slight sediment accumulation at 1.5 km distance from the breakwater.

Geodynamic tendencies. The old port construction in 1925-1939 has changed coastline processes, including the coast state between the Ošupis stream and the Latvian border. In the beginning of the 20th century this coastline was “slightly” convex. Although the port construction had not been finished, the constructed breakwaters changed the coastline configuration significantly: intense sediment accumulation took place on the southern side of the port and the coastline moved closer to the sea, on the northern side – erosion occurred and the coastline shrank. Summarised data reflecting the impact of Šventoji Sea Port on the coastline dynamics in the neighbouring areas during the time period from 1910 to 2010 is presented in Figure 5.

Fig. 5. Coastline changes in the analysed area during the time period from 1910 to 2010

As Figure 6 shows, the zone of accumulation southward of Šventoji southern breakwater (from 1910 to 2010) covered 4.6 km long coast section. Especially intense accumulation took place in 1.5 km long section close to the southern breakwater. During the period of 1910-2010 the land area in this section increased by 38.4 ha. Northward of the southern breakwater, in 800 m long section, accumulation process also took place. Figure 6 shows that the land area here increased by 6.5 ha in the period of 1910-2010. Although northward of this section up to the Latvian border (and further) the coast was intensively washing-out (the maximum coastline shrinkage reached 120 m). Approx. 38.4 ha area of land has been washed-out in this section. According to local residents, since the day the port construction was finished, the sea has taken about 19 residential buildings and outhouses in the above mentioned coastline section.

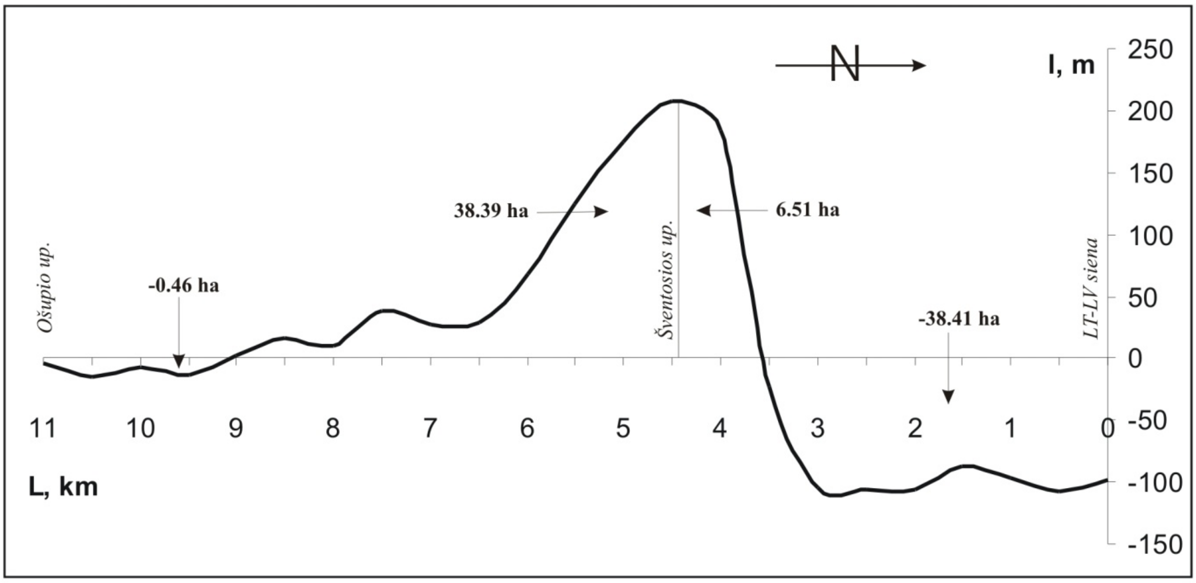


Fig. 6. Coastline changes in the area of Šventoji port from 1910 to 2010. 0 of X-axis identifies the coastline condition in 1910

During the last 15 years tendencies of the coastline dynamics in the southern part of the breakwater remained almost unchanged (Fig. 7). In the northern part of the breakwater situation partially changed: erosion in the section nearest to the breakwater and slight accumulation at 1.5 km distance from the breakwater began.

Changes of the protection beach head practically reflected tendencies of the coastline variation, except in the section at 1.5 km distance northward of the breakwater (Fig. 8).

During the last quarter of the century the non-repaired port breakwater has been shortening and decomposing rapidly, and became more and more pervious to sediments. That's why recently sediment accumulation takes place not only on the southern side of the port breakwater, but also on the northern side (Fig. 9).

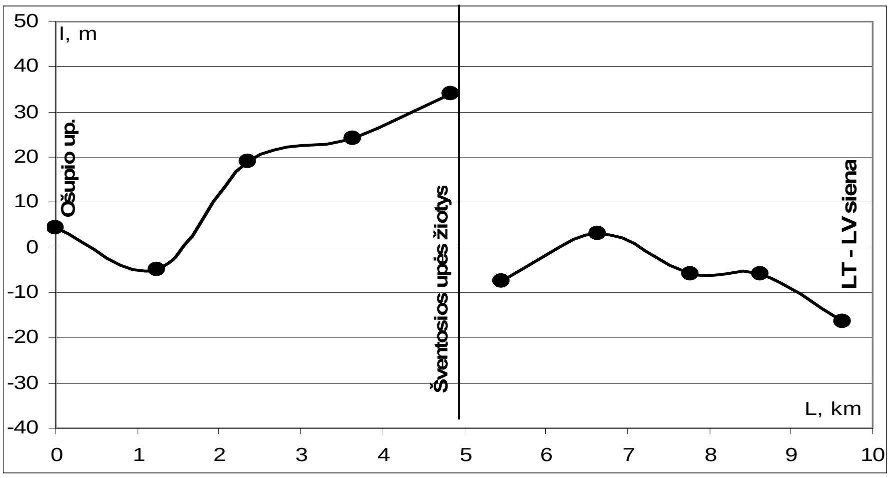


Fig. 7. Changes of the coastline (m) in the section between the Ošupis stream and the Latvian border from 1995 to 2010

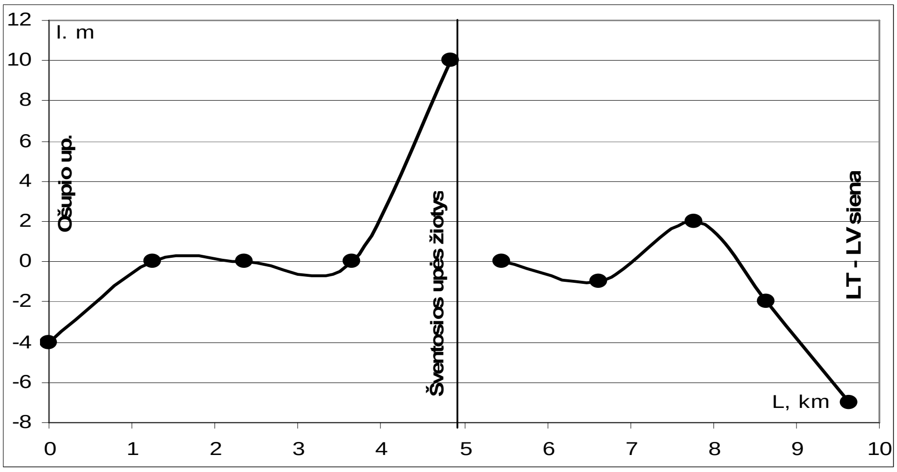


Fig. 8. Changes (m) of the protection beach dune crest and the coast dune crests in the section between the Ošupis stream and the Latvian border from 1995 to 2010

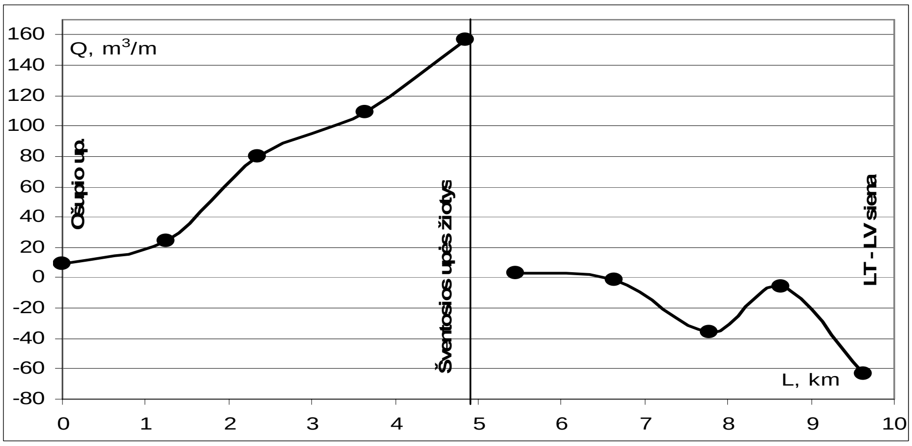


Fig. 9. Sediment changes (m^3/year) in the coastline section between the Ošupis stream and the Latvian border from 1995 to 2010

Analysis of impact of the port breakwater length. The impact of the port breakwater length on hydrodynamic and sediment transport processes of the Baltic Sea nearshore was analysed comparing options "2B" and "3D" with zero alternative (Fig. 2 and 4). The length of the port southern breakwater according to option "2B" is 400 + 245 m, and 800 + 242 m long according to option "3D".

Nearshore flow structures were modelled for the mentioned above options for the wind speed of 20 m/s and different directions: W (Fig. 10-11), SW (Fig. 12-13) and NW winds (Fig. 14-15). The flow speeds were compared in cross-sections on the southern and northern sides of the port – in the area where hydrodynamic regime was changed most. The beginning of the sections was in the open sea, and the end – at the coastal line. Flow speed comparison was made for W wind in 6 cross-sections (Fig. 10, 16-17), for SW – in 3 cross-sections (Fig. 12, 18) and for NW – also in 3 cross-sections (Fig. 14, 19).

Under the influence of W wind the port breakwaters (option "3D") form erosion zone 200-400 m away from the northern breakwater (Fig. 11). The flow speeds in nearshore (Fig. 17a, cross-section 4) increased from 0.07 m/s (zero alternative) to 0.48 m/s (option "3D"). Whereas the shorter breakwaters of option "2B" raised flow speeds from 0.02 m/s to 0.34 m/s (Fig. 16c, cross-section 3). Beginning from cross-section 3 800 m northwards from the coast in the sea the decrease of the flow speeds is observed for both "2B" and "3D" options.

Under the influence of SW wind (Fig. 13) changes of hydrodynamic regime northward of the port breakwaters (option “3D”) take place: in a big area of nearshore flow speeds decrease to 0.02-0.04 m/s (Fig. 18). In this sea area (zero alterative and “2B” option) flow speeds are the same and equal to 0.4-0.7 m/s. Therefore SW winds will likely generate sediment accumulation in this area according to option “3D”.

When NW wind is blowing (Fig. 14) the erosion zone is formed on the southern side of the port. In this area flow speeds increase to 0.4-0.5 m/s (Fig. 19b) for options “2B” and “3D”, whereas flow speeds according to zero alternative are 0.2-0.3 m/s.

The reconstruction of Šventoji port according to option “2B” (short port breakwaters) answers the minimal requirements of the port and makes the least impact on the hydrodynamic and lithodynamic processes in the Baltic Sea nearshore. The port reconstruction option “3D” (long breakwaters) will cause coast erosion both on the southern and northern sides of the port.

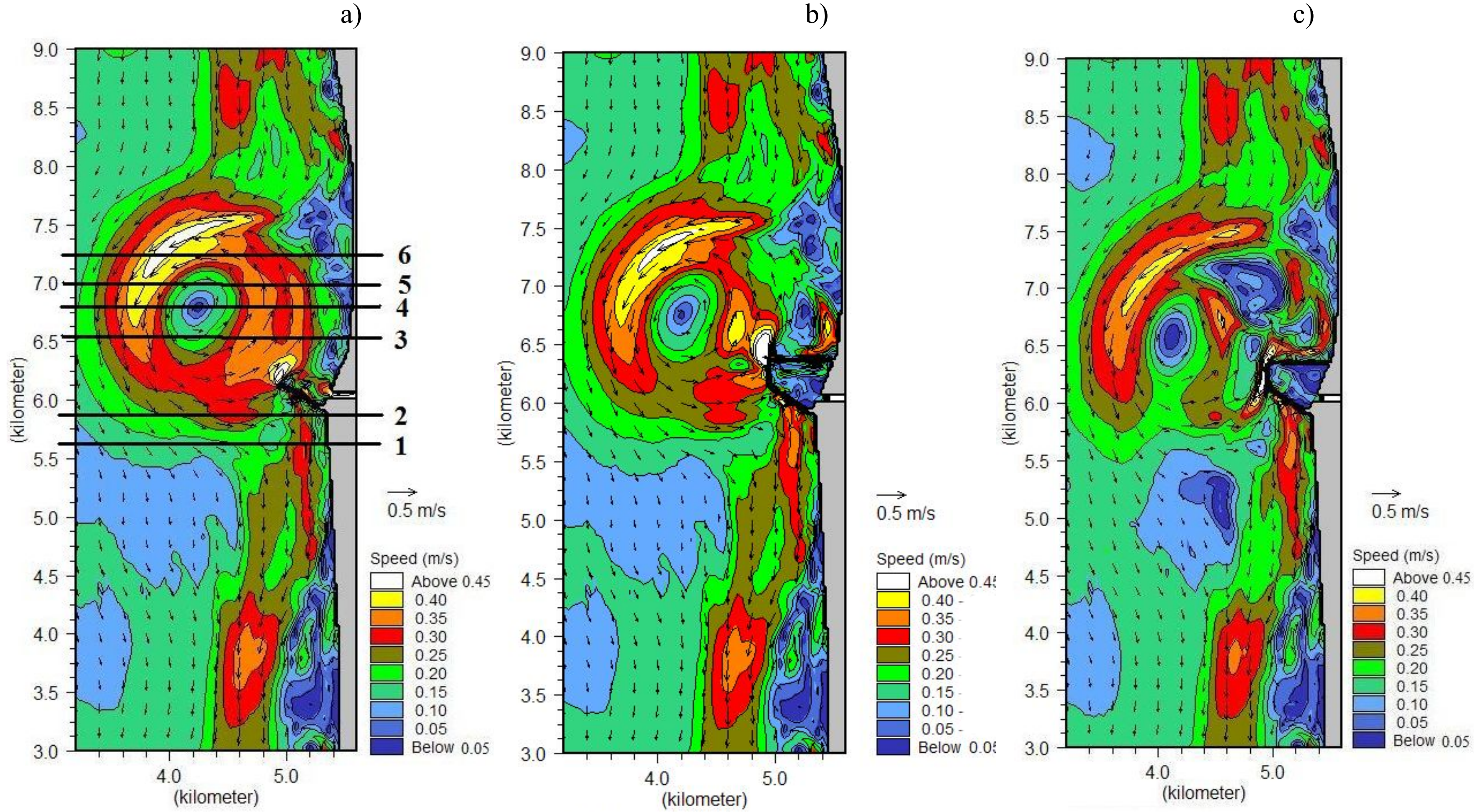


Fig. 10. The flow structure, when W wind of 20 m/s speed is blowing: zero alternative (a), “2A“ (b) and “2B“ (c) options

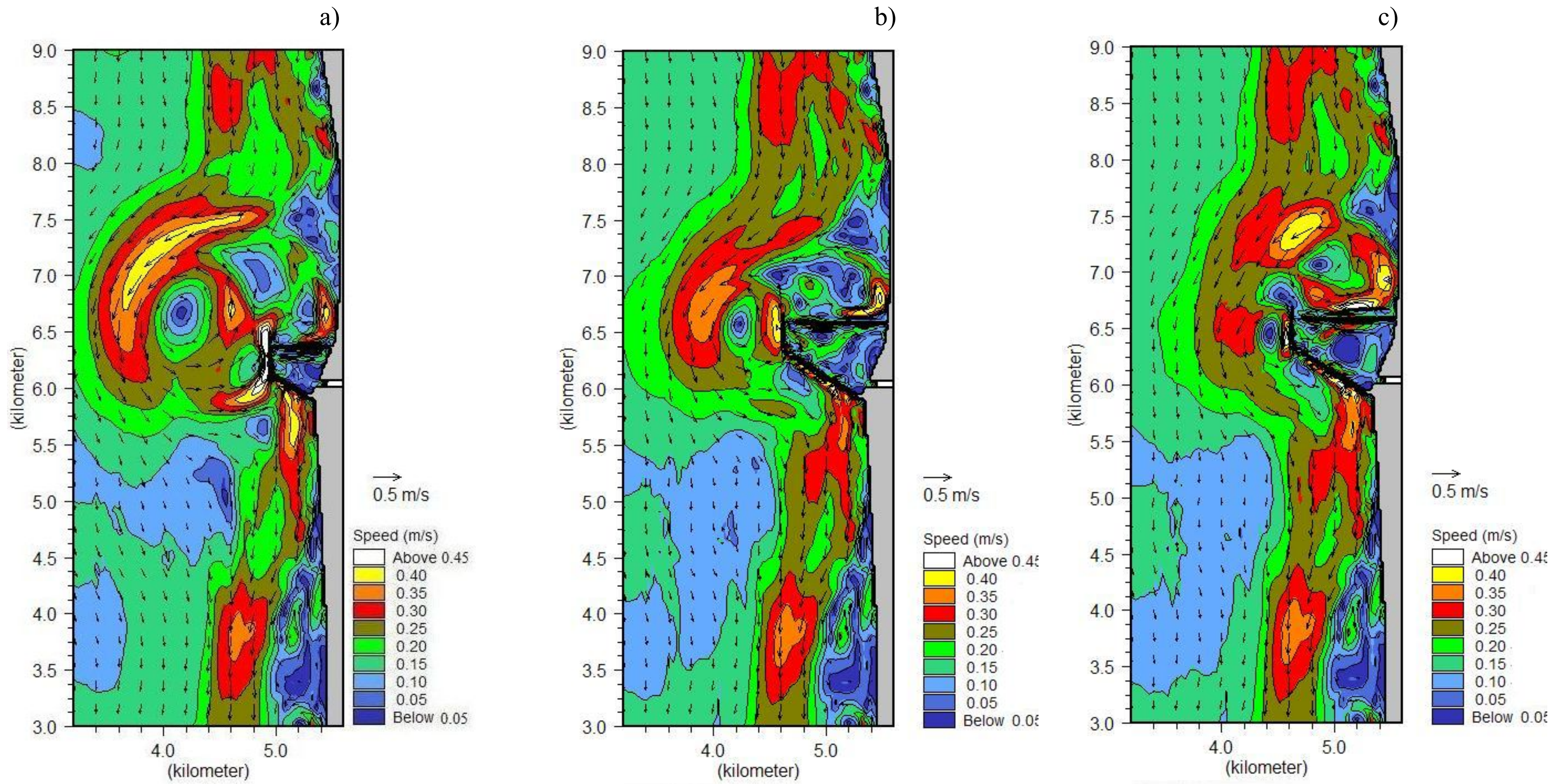


Fig. 11. The flow structure, when W wind of 20 m/s speed is blowing: "2C" (a), "3D" (b) and "3E" (c) options

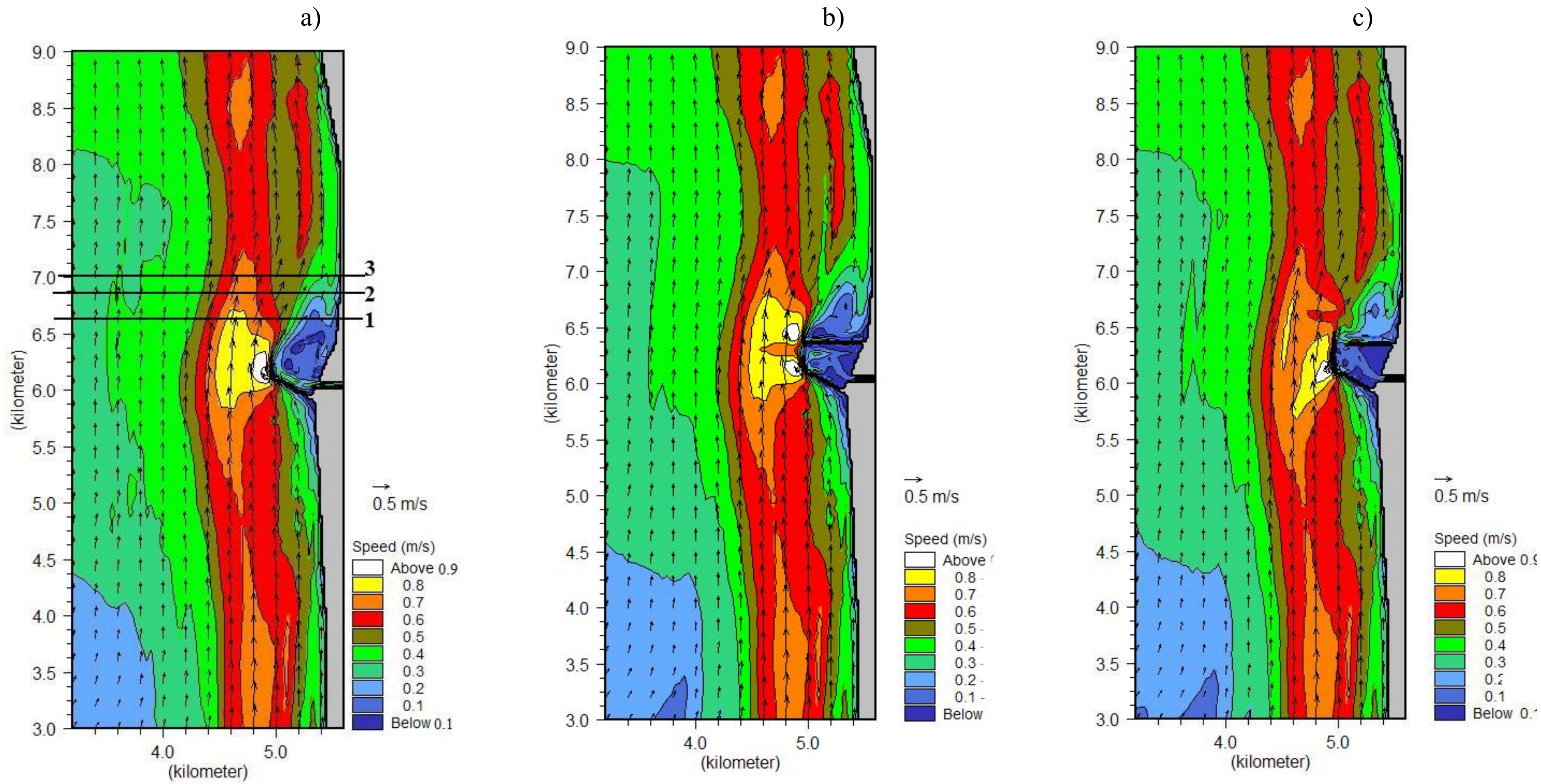


Fig. 12. The flow structure, when SW wind of 20 m/s speed is blowing: zero alternative (a), “2A“ (b) and “2B“ (c) options

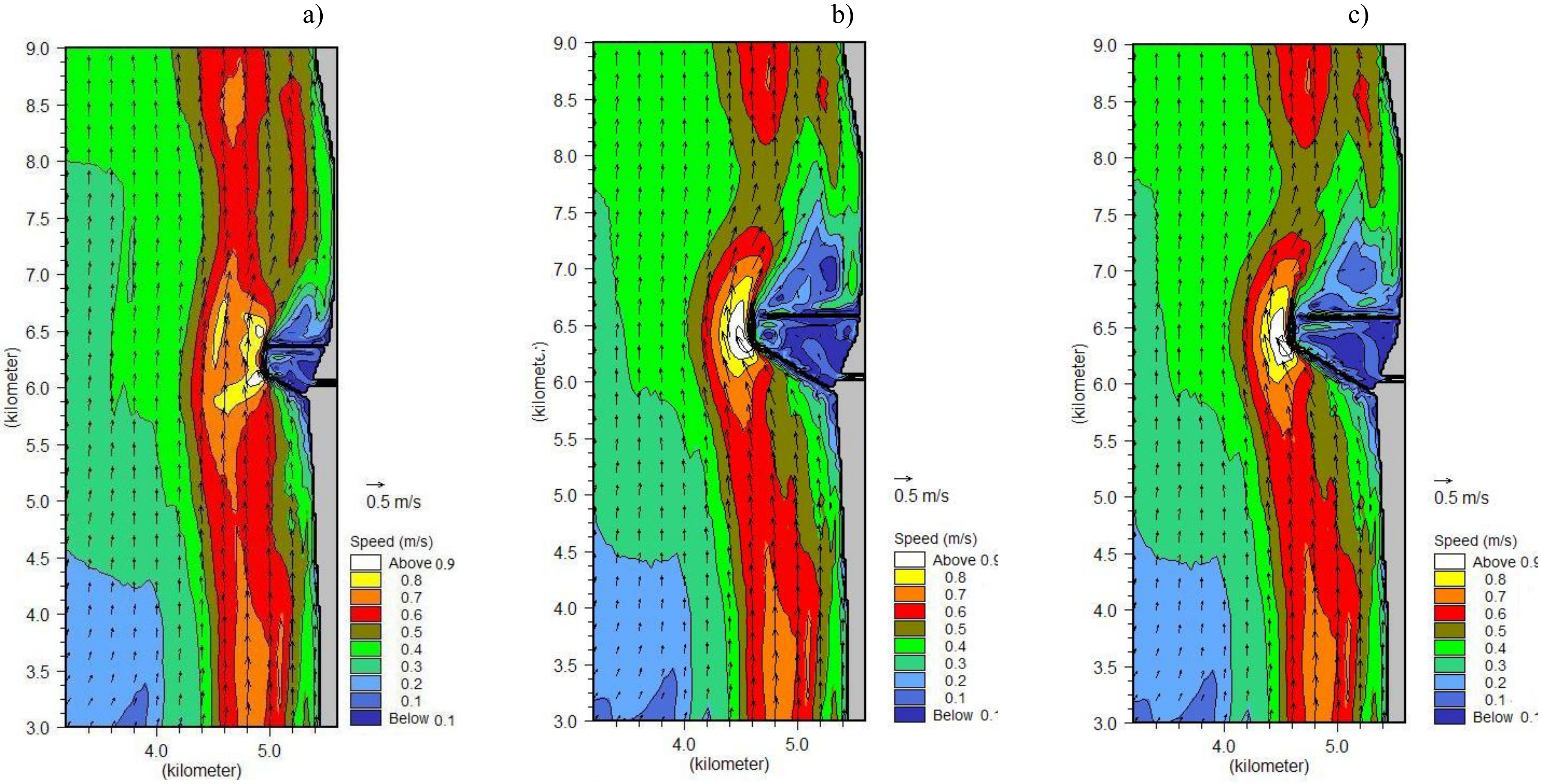


Fig. 13. The flow structure, when SW wind of 20 m/s speed is blowing: “2C“ (a), “3D“ (b) and “3E“ (c) options

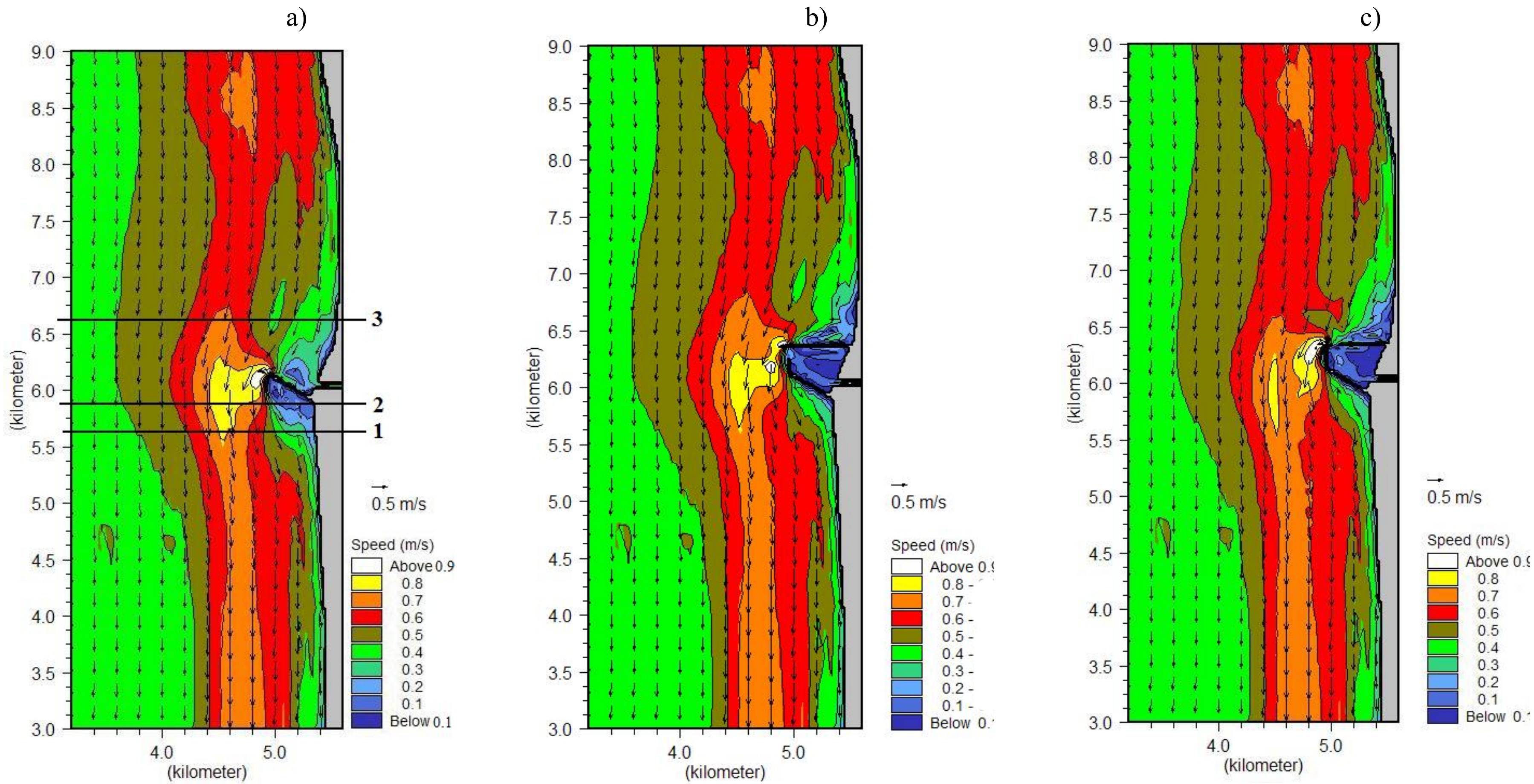


Fig. 14. The flow structure, when NW wind of 20 m/s speed is blowing: zero alternative (a), “2A“ (b) and “2B“ (c) options

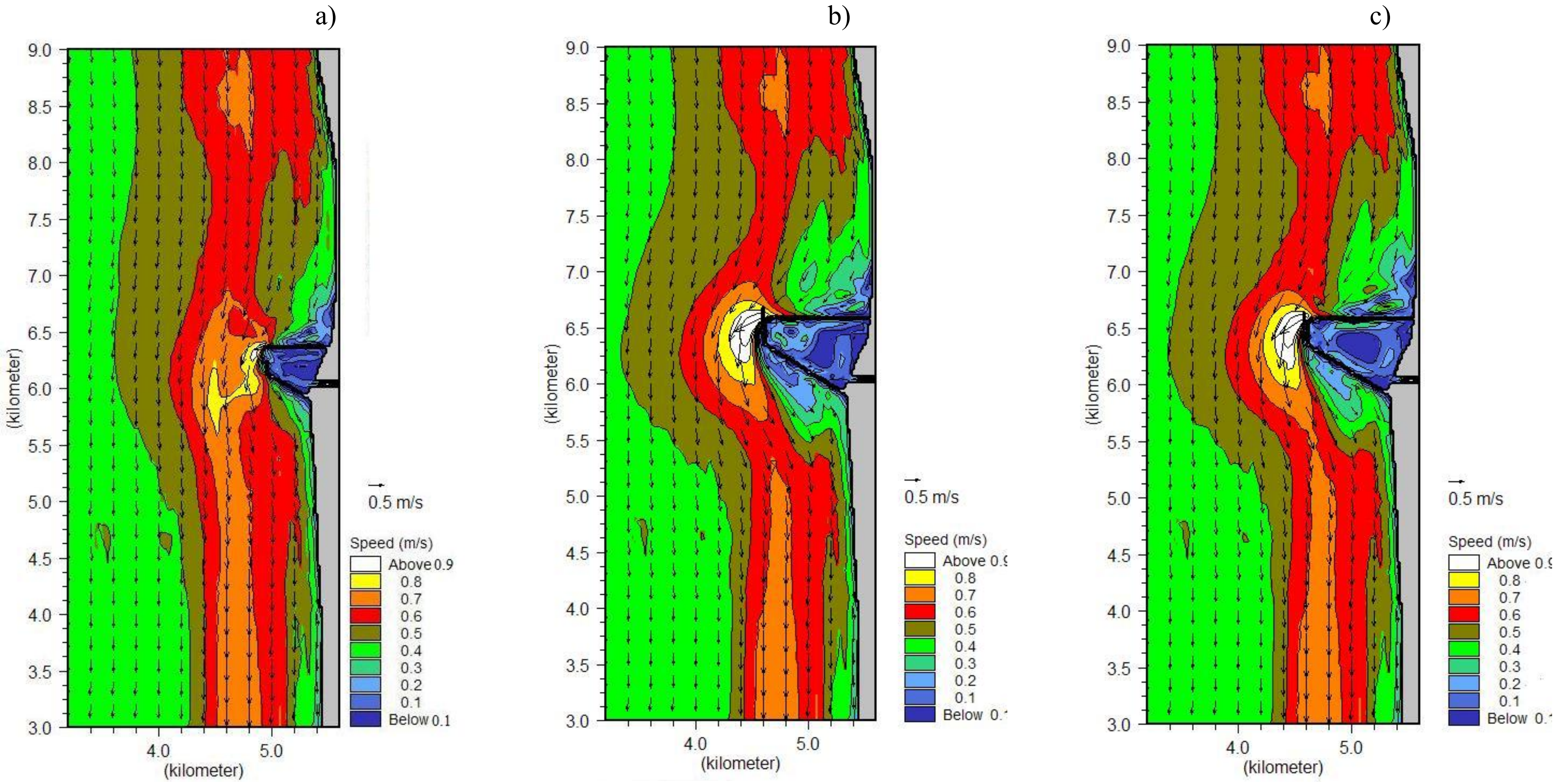


Fig. 15. The flow structure, when NW wind of 20 m/s speed is blowing: “2C“ (a), “3D“ (b) and “3E“ (c) options

a)

b)

c)

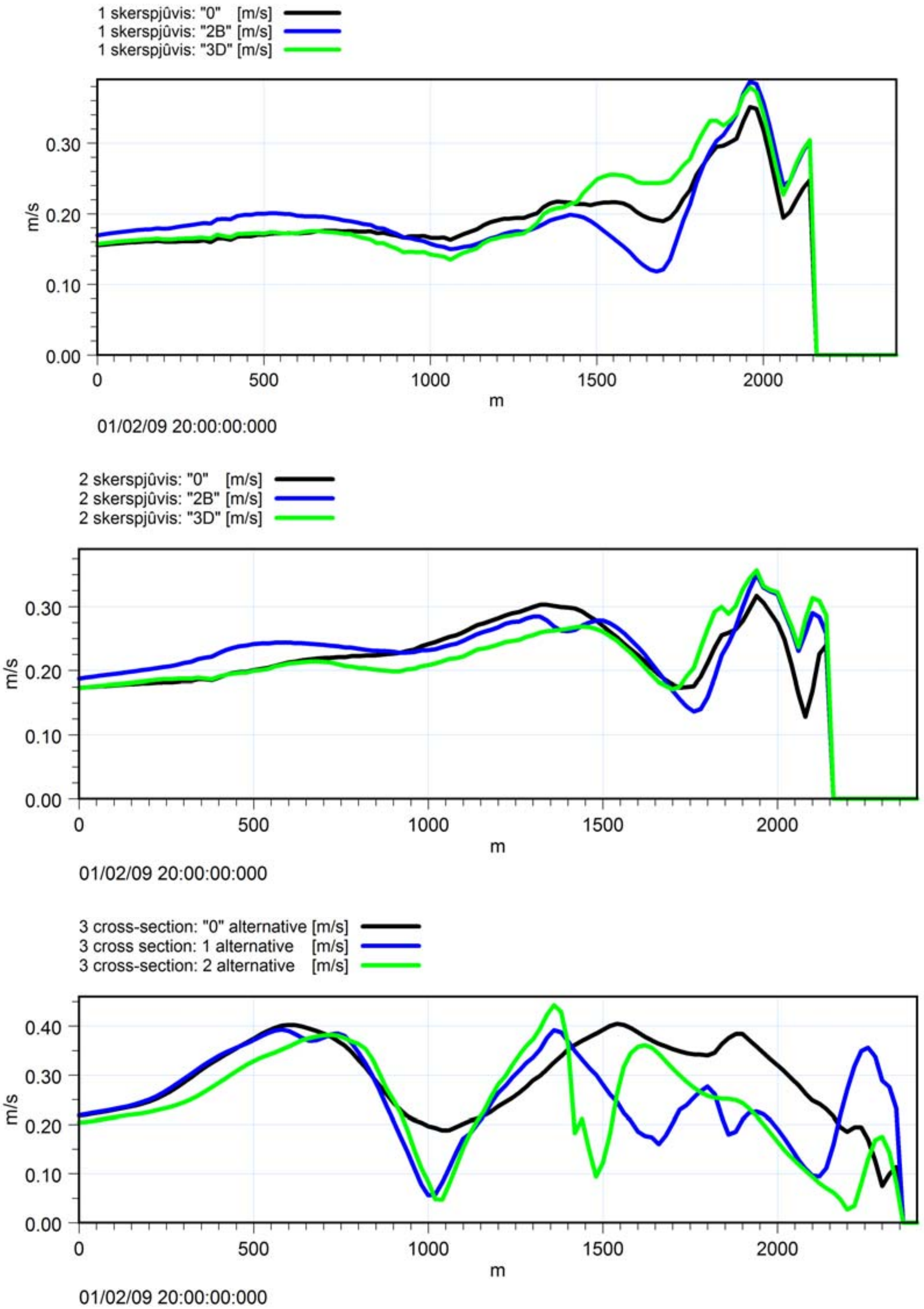
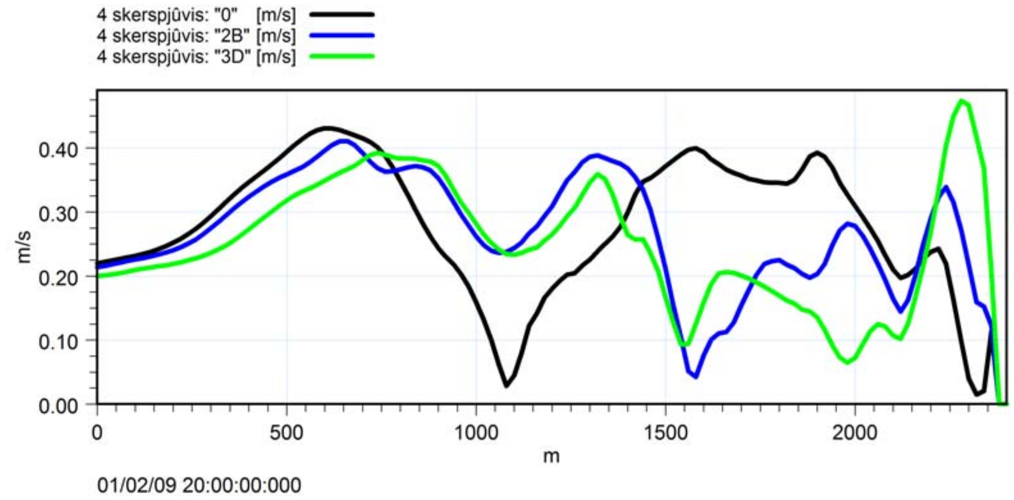
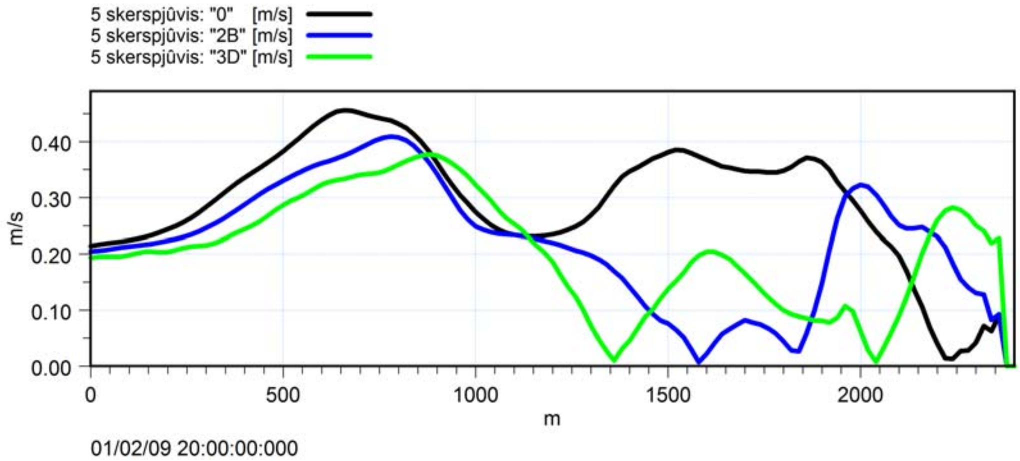


Fig. 16. The flow speeds for zero alternative, “2B” and “3D” options in 3 cross-sections (Fig.10), when W wind is blowing: 1 (a), 2 (b) and 3 (c) cross-section

a)



b)



c)

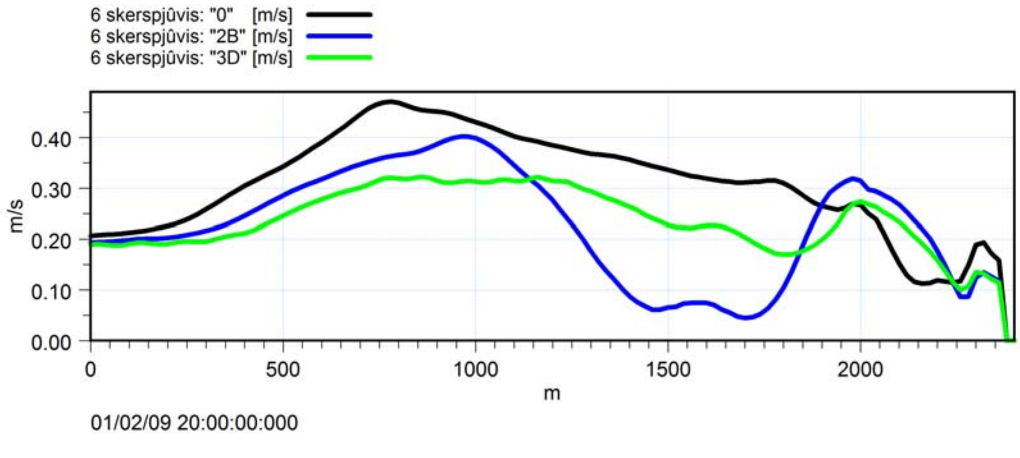
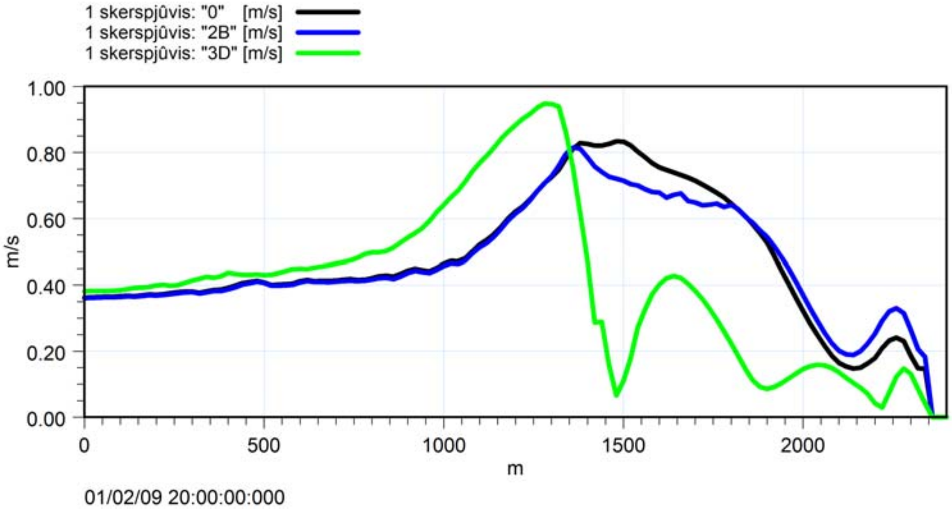


Fig. 17. The flow speeds for zero alternative, “2B” and “3D” options in 3 cross-sections (Fig. 10), when W wind is blowing: 4 (a), 5 (b) and 6 (c) cross-section

a)



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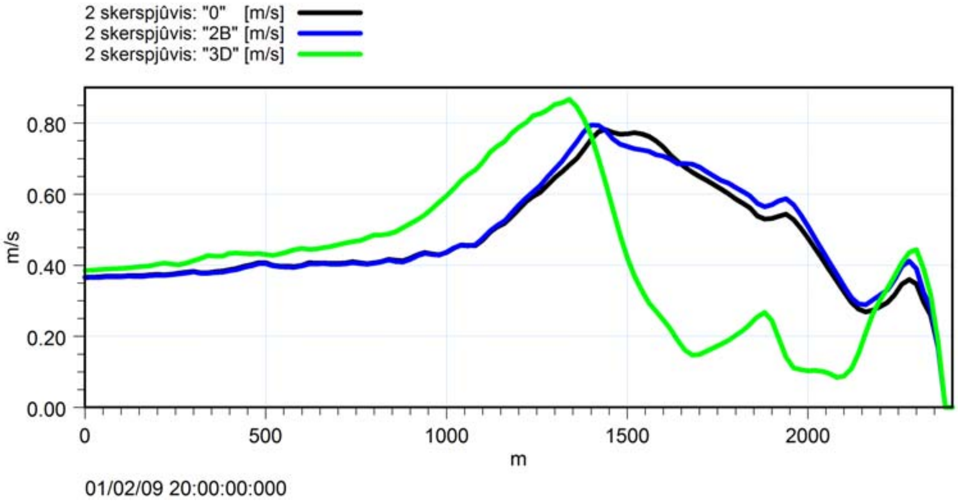

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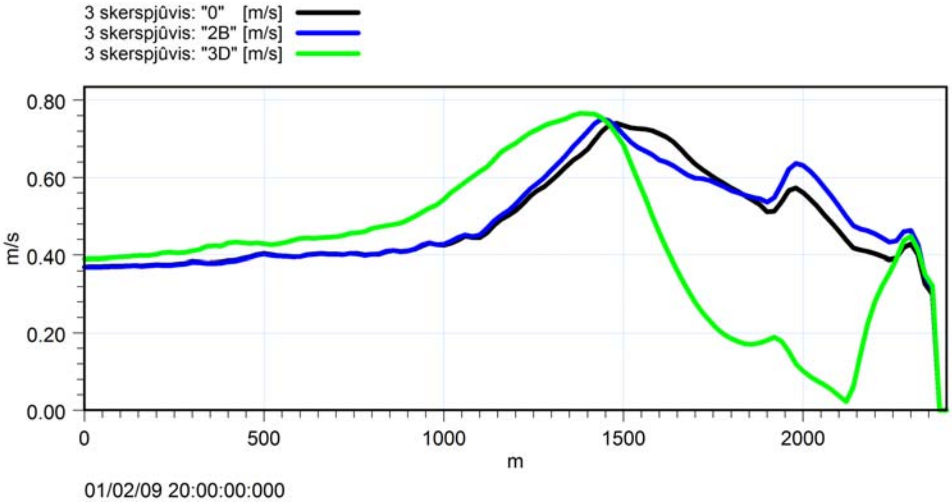
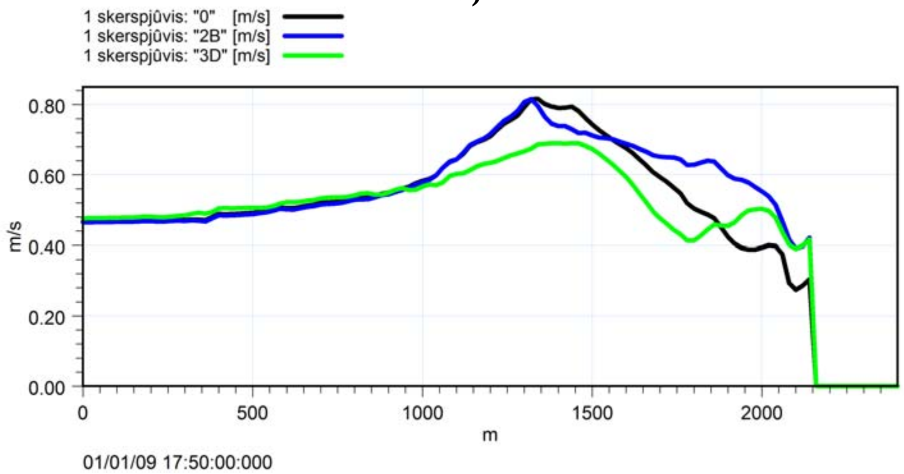
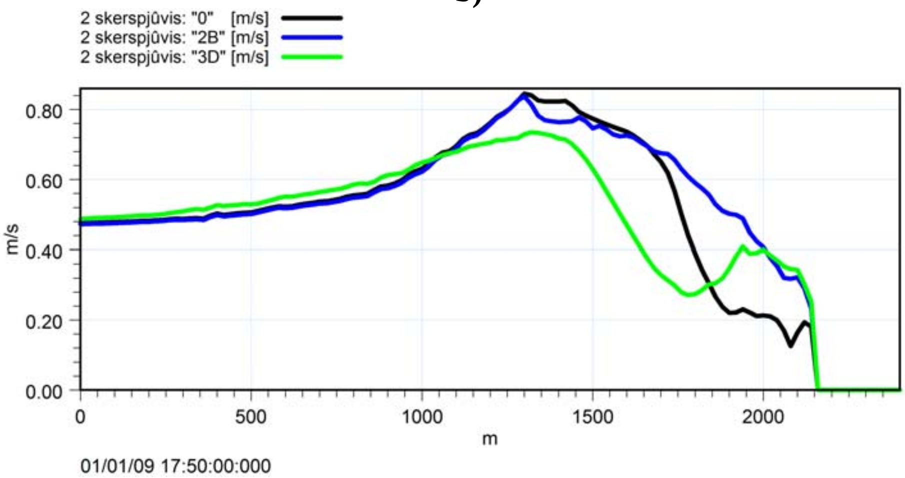


Fig. 18. The flow speeds for zero alternative, “2B” and “3D” options in 3 cross-sections (Fig. 12), when SW wind is blowing: 1 (a), 2 (b) and 3 (c) cross-section

a)



b)



c)

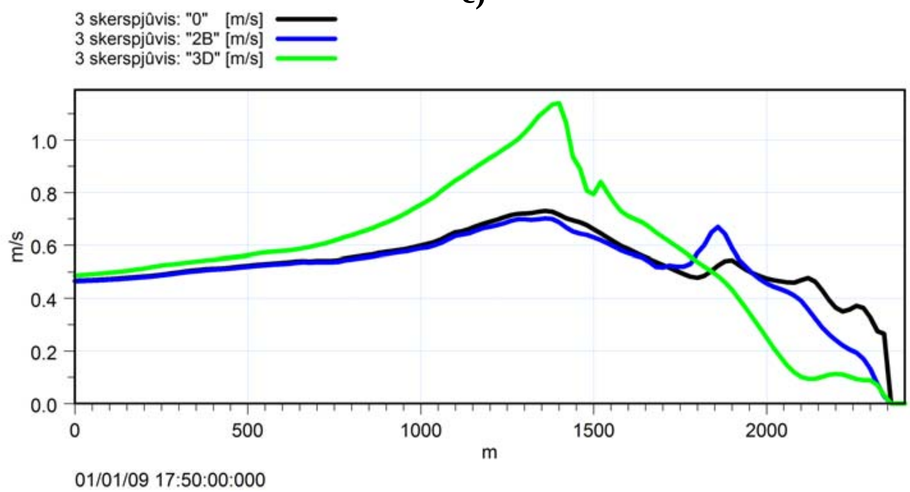


Fig. 19. The flow speeds for zero alternative, “2B” and “3D” options in 3 cross-sections (Fig. 14), when NW wind is blowing: 1 (a), 2 (b) and 3 (c) cross-section

Analysis of environmental impact of the port depth, entrance channel direction and width. Flow speed and direction in the surrounding water territories of Šventoji Sea Port were determined using two-dimensional modelling system MIKE 21 and its hydrodynamic model (HD) [3]. The entrance channel of western direction (option "2A", Fig. 3a) is especially unfavourable when the wind of NW and SW directions is blowing. Vessels that are entering or leaving the port gate cross these wind directions, while the waves generated by W winds get farthest to the port inner water territory. Therefore from the navigation approach the gate position, when the entrance channel axis has northern direction (option "2B", Fig. 3b), is much more favourable. However northward of the Šventoji Port the reserved port water territory is located where the opportunity to construct a deep-water port is discussed. That's why the entrance channel has 90º turn to the west.

Comparison of the port options "3D" and "3E" with zero alternative was made in order to assess the influence of Šventoji port depth on mortholitodynamic processes. According to option "3D" the port depth is 6 m, and according to "3E" – 8 m (Fig. 2-4), the depth of the entrance channel is respectively 7 and 9 m.

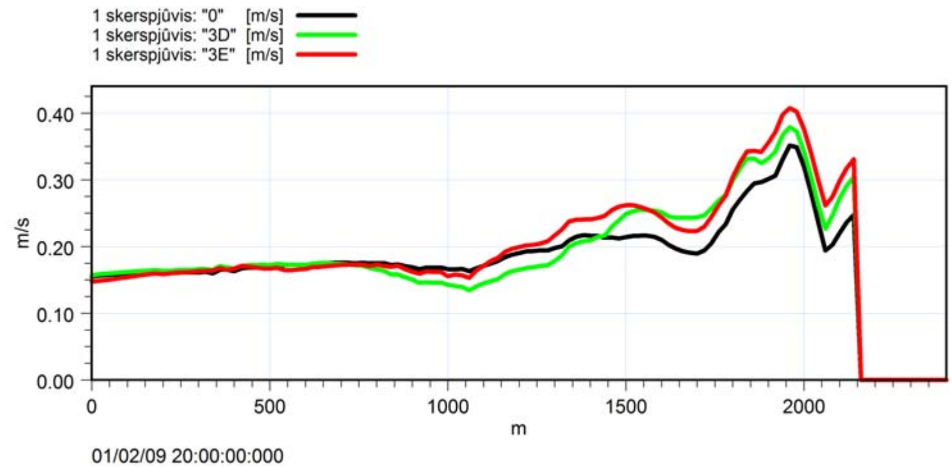
Under influence of W wind the impact on the coastline condition is made by the port option "3E", when erosion zone forms northward of the port (Fig. 11c). The impact of the breakwaters of option "3D" is much less and covers smaller area. Northwards of the port breakwaters flow speed increases to 0.43 m/s (option "3E") and to 0.47 m/s (option "3D"), whereas speeds for zero alternative are 0.02 m/s (Fig. 21).

SW winds generate the highest flow speed changes northward of the port breakwaters (Fig. 13), when comparing options "3D" and "3E" with zero alternative. In the 1st (from the port breakwaters) cross-section estimated the increase of flow speed to 0.4 m/s according to option "3E" (Fig. 22a). Also flow speed decrease to 0.2 m/s (Fig. 22b and c) is observed in a big nearshore area comparing to zero alternative (0.4-0.6 m/s).

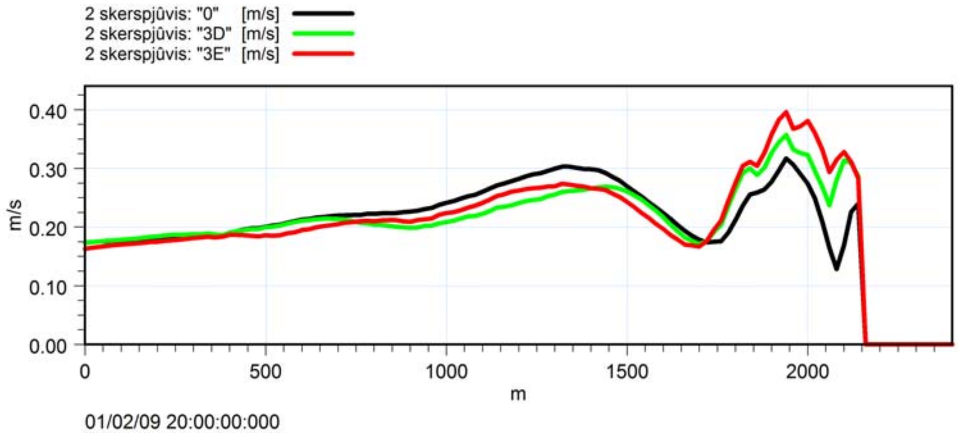
When NW wind is blowing the maximum flow speed is defined southward of the port breakwaters (Fig. 15). In the cross-section away from the southern breakwater (Fig. 23b) flow speed will increase near the coastline comparing options "3D" and "3E" with zero alternative. In the next cross-section (southwards) (Fig. 23c) flow speeds at the coastline are going to be higher according to option "3E" in comparison to option "3D". For wind of NW direction, flow speed differences comparing option "3E" with option "3D" are small.

The port deepening (option "3E") up to 8 m will have greater influence on hydrolitodynamic processes, because W wind generates erosion zone northward of the port (the greater coast erosion is possible). The smaller port depth of 6 m (option "3D") would be more favourable for litodynamic processes in Šventoji Port water territory.

a)



b)



c)

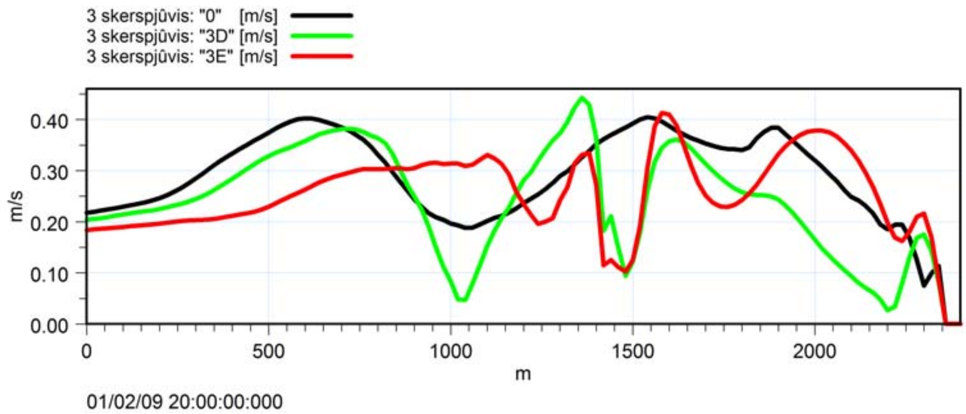
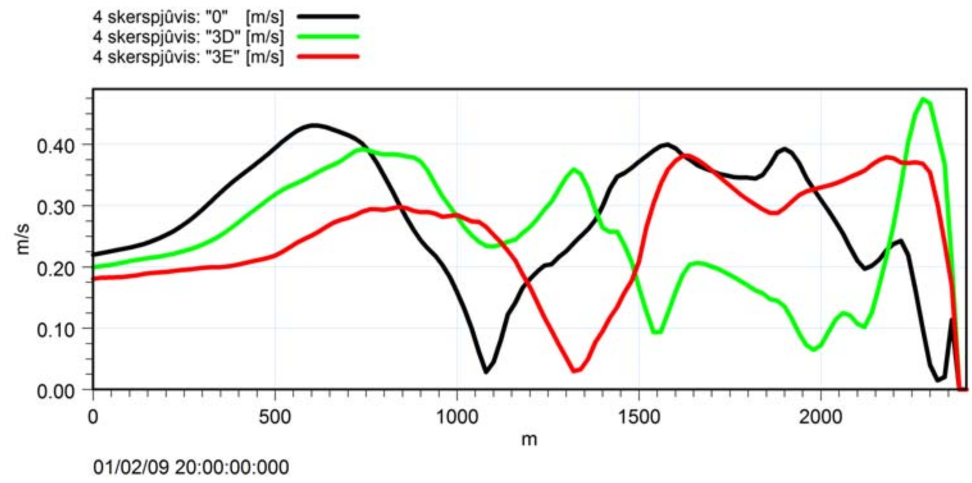
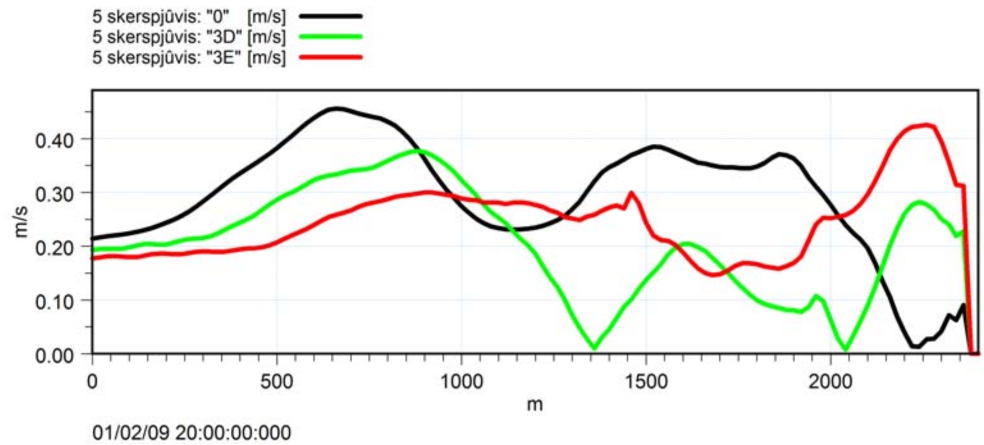


Fig. 20. Flow speeds for zero alternative, “3D” and “3E” options (Fig. 10). The blowing wind direction W: 1 (a), 2 (b) and 3 (c) cross-section

a)



b)



c)

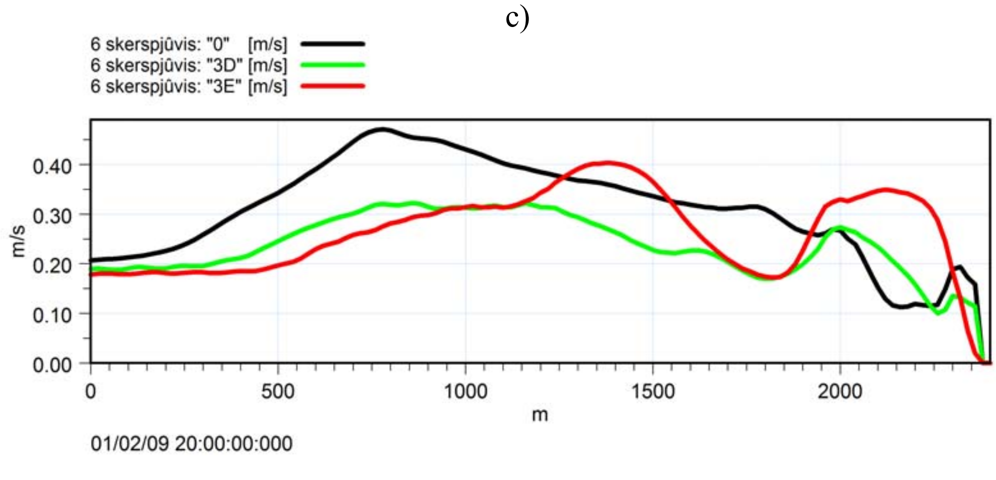
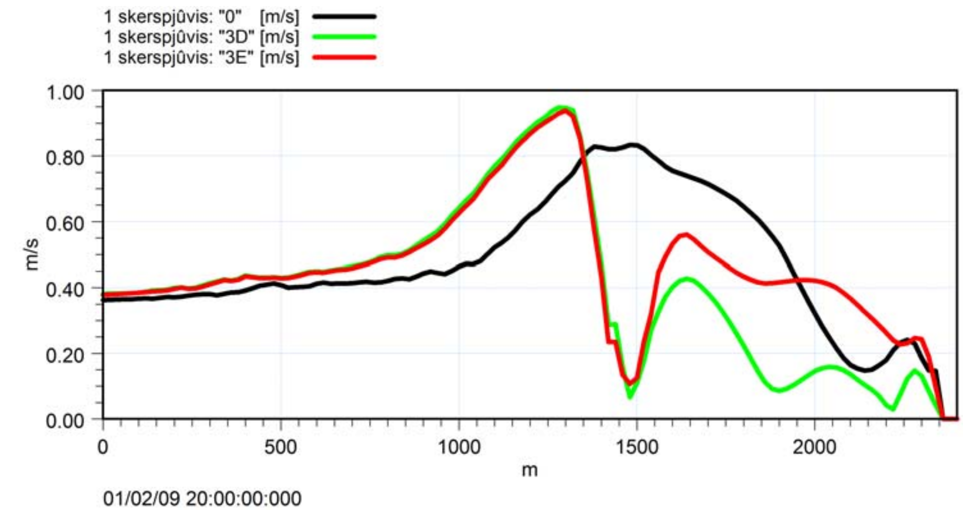
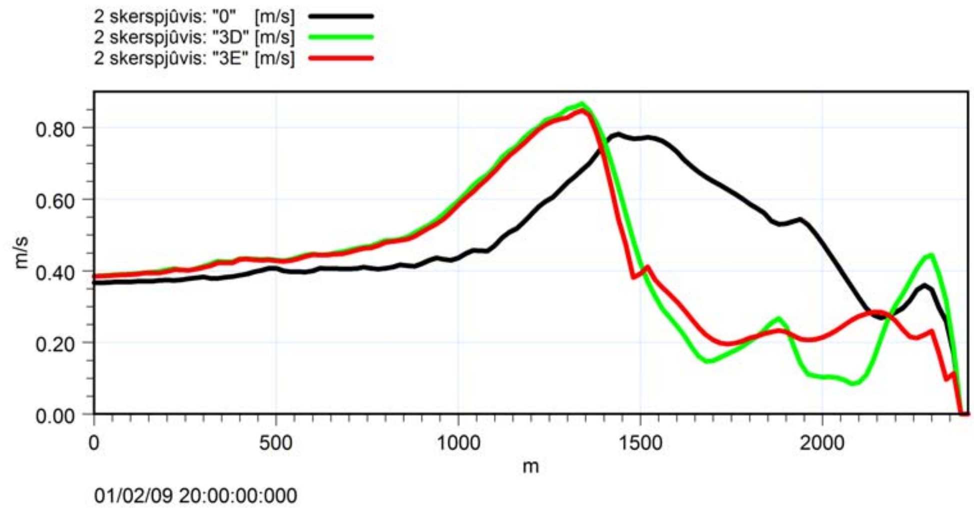


Fig. 21. Flow speeds for zero alternative, "3D" and "3E" options for the three cross-sections (Fig. 10). The blowing wind direction W: 4 (a), 5 (b) and 6 (c) cross-section

a)



b)



c)

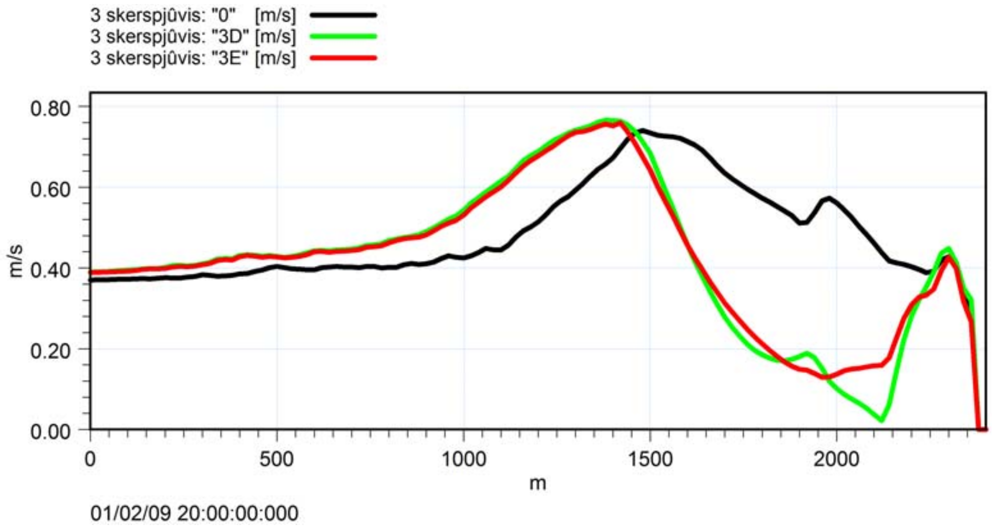
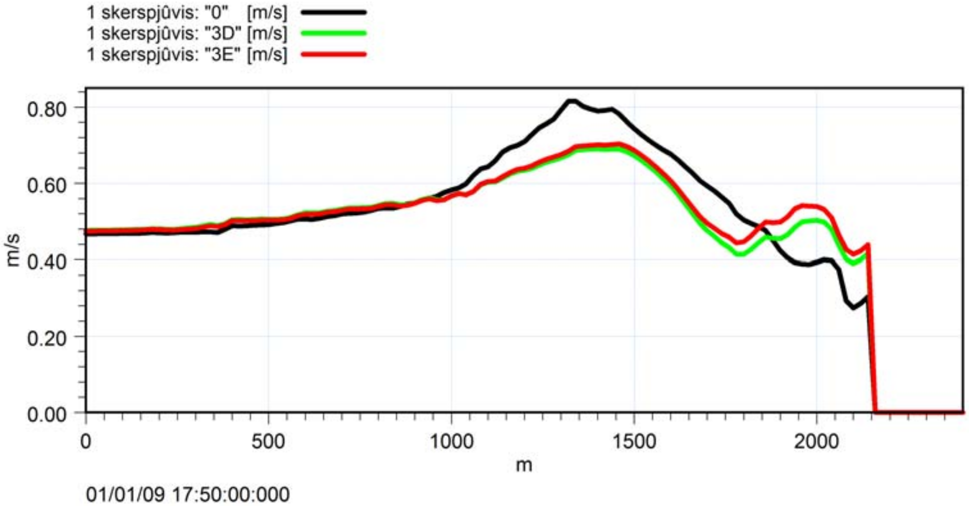
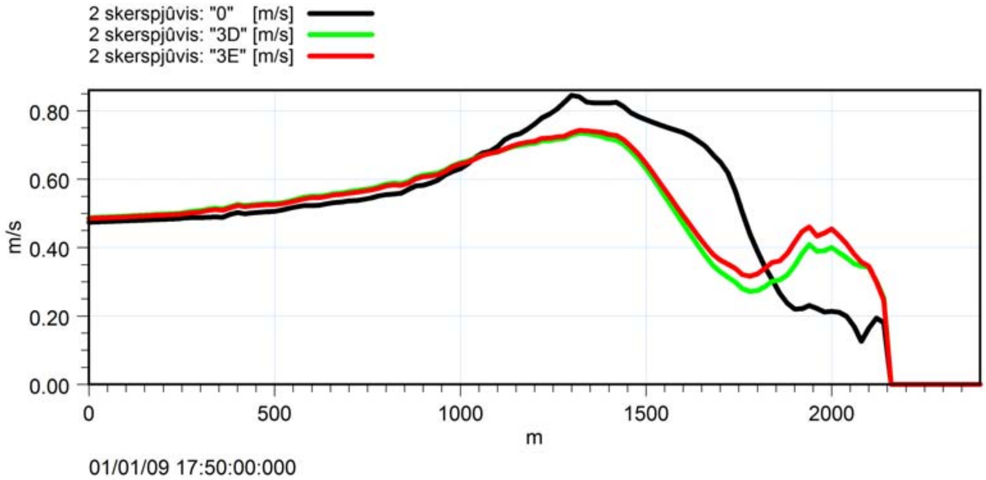


Fig. 22. Flow speeds for zero alternative, “3D” and “3E” options for the three cross-sections (Fig. 12). The blowing wind direction SW: 1 (a), 2 (b) and 3 (c) cross-section

a)



b)



c)

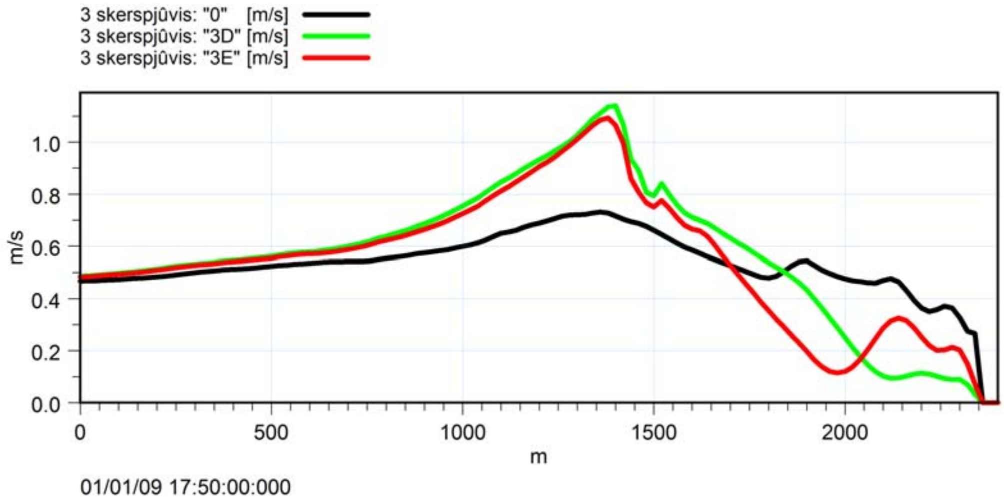


Fig. 23. Flow speeds for zero alternative, "3D" and "3E" options for the three cross-sections (Fig. 14). The blowing wind direction NW: 1 (a), 2 (b) and 3 (c) cross-section

One-sided entrance channel width and gate width are selected according to the maximum vessel width d = 20.0. Entrance conditions of the Šventoji Seaport are very difficult, because vessels have sudden bends before entering and leaving the port, and the channel axis crosses the main directions of the wind and flow. Channel width accepted with maximum reserve. The vessel manoeuvring band is 2d and coastal margin – 2d according to C.A. Thoresen [4]. Manoeuvring band has to be widening by one vessel width, if vessel can deviate from the direction because of cross-flows and winds. According [4], width of the entrance channel is 5d = 100.0 m.

According to [5], entrance channel width of the Šventoji Port is calculated as follows (in % of vessel width):

- vessel manoeuvring band – 200%,
- vessel reserve – 160%,
- shore reserve – 120%.

This composes 480% of vessel width or 96.0 m and coincides with value of the channel width according by the [4].

Bandwidth of vessel manoeuvring has to be significantly increased before and after the bend of the channel. Radius of the bend curve shall be like 10 lengths of the biggest vessels, i.e. 700 m, when bend angle exceeds 35 degrees. There must be dredging water territory with width of less than 350-370 m before the port gates, because the biggest vessel length is L = 70.0 m. Hereby water territory should be dredged before port gates not only for the vessel manoeuvring, but for the removal of sand collections, which is the source of the port silt as well.

Swell of the port entrance channel will be bigger; accordingly, the channel depth has to be increased by the depth of reserves, which is equal to 50-100% of the maximum wave height depending on vessel length.

In the absence of monitoring data, wave height at the beginning of the entrance channel obtained by simulation of the wave field using MIKE 21 NSW model [6], when wind of NW, W and SW directions is blowing and has speed of 20 m/s (Table 2).

Table 2. Wave height (m) at the beginning of the entrance channel

Wind direction	Port options	
	2A, 2B, 2C	3D, 3E
NW	2.9	3.2
W	3.1	3.4
SW	2.9	3.2

Depth calculation of the port entrance channel is described in Table 3.

Table 3. Depth of the port entrance channel

Components of the entrance channel depth	Factors affecting the depth	depth, m
Vessel draught	Draught of the largest (L = 70.0 m) selected vessel	4.50–5.50
Water level	Low water level with 95% probability, calculated from the average mean of the sea water level	0.44
Reserve of the wave height at the beginning of the entrance channel	Half of the maximum size of the estimated wave	1.60–1.70
Reserve under of the vessel's keel	The bottom sandy soils	0.40–0.50

Entrance channel of the port needs 7.0 m depth according to options "2B" and "3D", and 8.20 m according to option "3E"; it is necessary to have 9.5 m depth of the entrance channel for towboat exploitation especially in difficult storm conditions (the official report of the SE Klaipėda State Seaport Captain of 2011-07-29 and 2011-08-04 letter No. UD-9.6.5-3262).

The port entrance channel direction impact on the lithodynamical processes of the sea bottom and shores was studied in relation between “2B” (the entrance from the north) and “2C” (Fig. 11) options, where entrance channel has western direction. This comparison (Fig. 10-15) shows that there are no large differences of the littoral hydrodynamic regime between these options for the winds of various directions.

Larger changes of flow speed were observed only for W wind according to option "2C" in the sea part at the distance of 500-600 m.

Direction of the entrance channel crosses sediment flows directed along the shore. Impacts of narrow (100 m width) entrance channel ("2A" option, Fig. 3a) and wide entrance channel ("2C" option) on the littoral hydrodynamic regime were compared. Such dredging impact on littoral hydrodynamic regime is shown in Figures 10-15. The difference between “2A” and “2C” options is minor for SW and NW winds. However, wide dredging of marine water territory (option “2C”) significantly increases flow speeds northward of the port breakwaters (from 0.02 m/s for the zero alternative to 0.20 m/s for option "2C" (cross-section no. 5, Fig. 27)) in the littoral for W wind. Meanwhile, the port option “2A” has a smaller impact on the littoral hydrodynamic regime. Narrow (100 m wide) channel shores (option “2A”), consisting of sands, are not stable. It would be appropriate to widen the sea water territory before the port gates (“2C” and “3E” options).

Reasoning of the port depth and area (water territory size). Main parameters of the port are determined by the maximum possible ferryboat (length L = 70.0 m, width d = 20.0 m and draught H = 5.0 m) and a one meter reserve by the shores is sufficient. Port depth (6 m), proposed by option “3D”, would be sufficient for the port reconstruction in the first stage of the port restoration. On the second stage, when by the shore near the port gates will be located tugboat SC “Orlen Lithuania”, the depth of the 8 m will be necessary, because the vessel draught is 5.5 m and this tugboat will be used under extreme conditions, when the waves are higher than 3.4 m.

Table 4. Water levels of the Baltic sea by the data of the Pioniersk water level measurement station

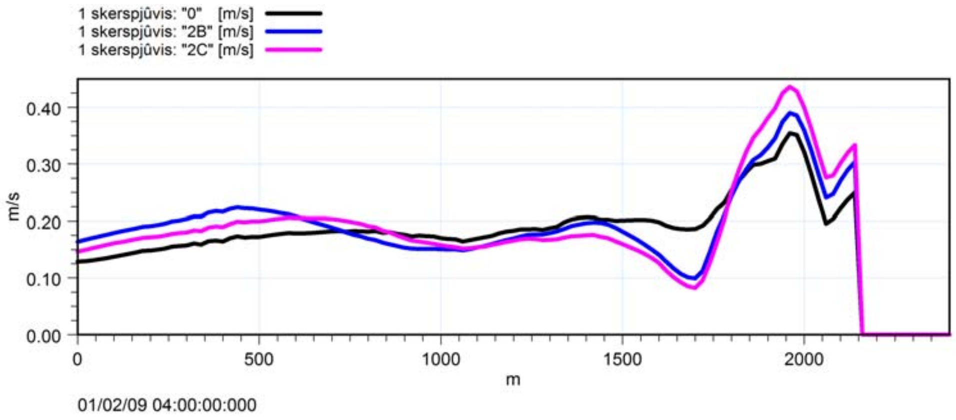
Probability, %	50	20	10	5	2
Recurrence of 1 time per n year	2	5	10	20	50
Maximum level, cm	80	100	115	122	126
Minimum level, cm	−20	−26	−41	−44	−58

It is necessary to take into account the following factors during the restoration of the Šventoji port and validate size of the water territory:

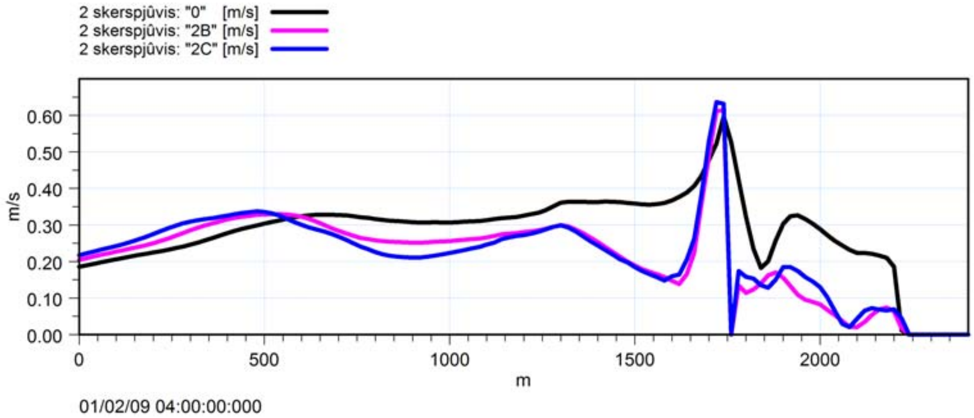
– shore length, depending on the port according to the Šventoji Detailed plan;
– purposive destination of the land and possibility of the land transport to get to the port shores. Only one possible way to the shores can be on the left side of the Šventoji River according to Detailed plan of the Šventoji Seaport. Right side of the Šventoji shore and about 400 m long section (from the river mouth to the north) of the shore cannot be used for the infrastructure of the port restoration;
– the need to install the turning basin for the vessels, which diameter equals from 3.4 to 4.0 of the overall vessel length (about 240-280 m);
– to leave south breakwater of the old Šventoji port as a cultural heritage object and to make possibility to visit it and view.

"2B" option of the port, based on the length of the port breakwaters and destinations of the land use, answers the minimum requirements by number of small vessels. Another option of the port ("3E") is valuing bigger requirements by the number of vessels and supplies tugboat, operated under difficult weather conditions, needs.

a)



b)



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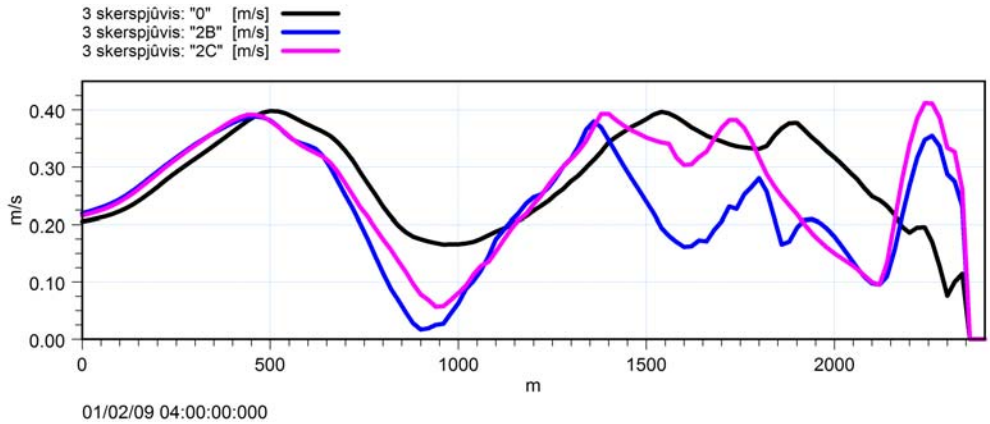


Fig. 24. Flow speeds for zero alternative, "2B" and "2C" options in the three cross-sections (Fig. 10). The blowing wind direction W: 1 (a), 2 (b) and 3 (c) cross-section

a)

b)

c)

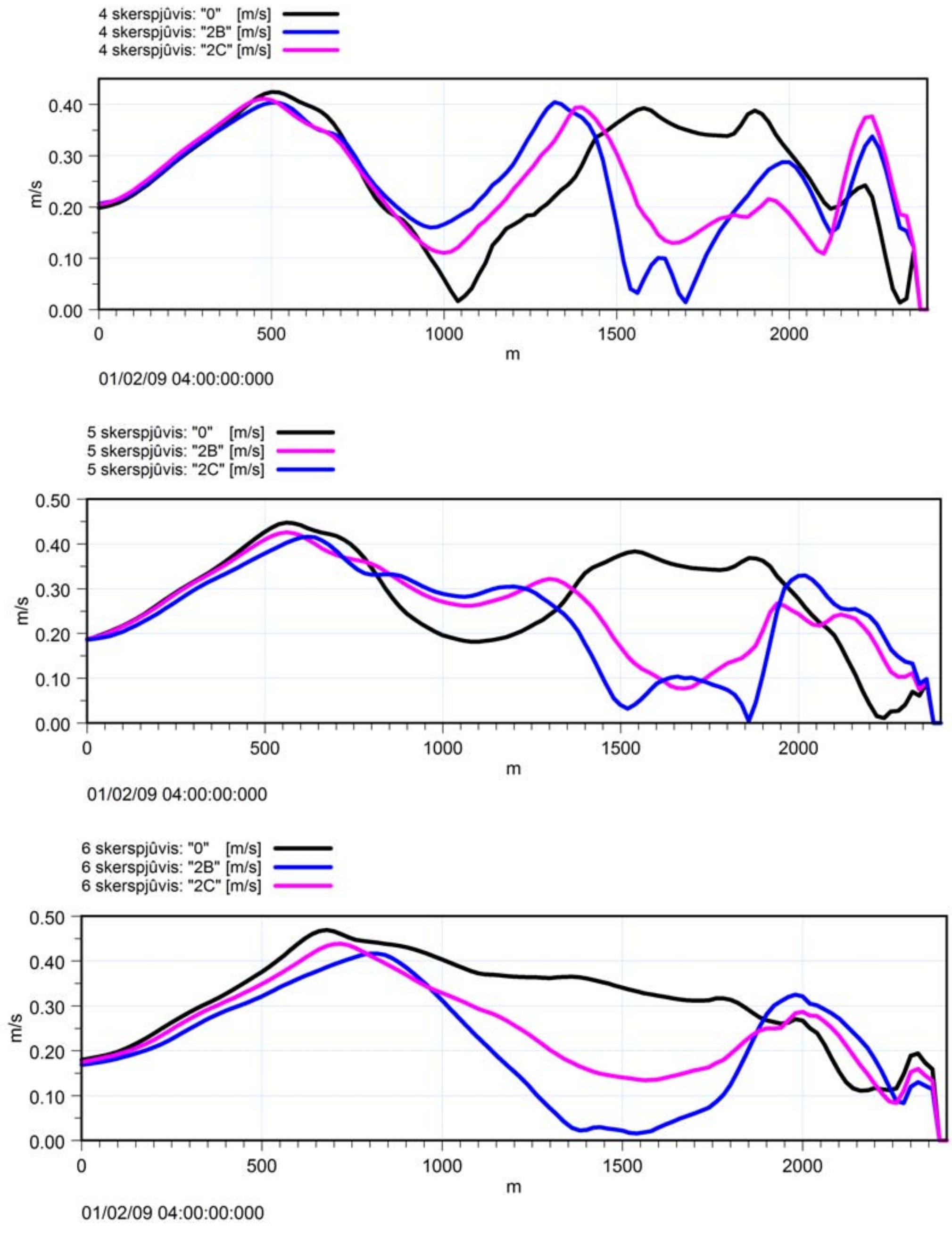


Fig. 25. Flow speeds for zero alternative, “2B” and “2C” options in the three cross-sections (Fig. 10). The blowing wind direction W: 4 (a), 5 (b) and 6 (c) cross-sections

a)

b)

c)

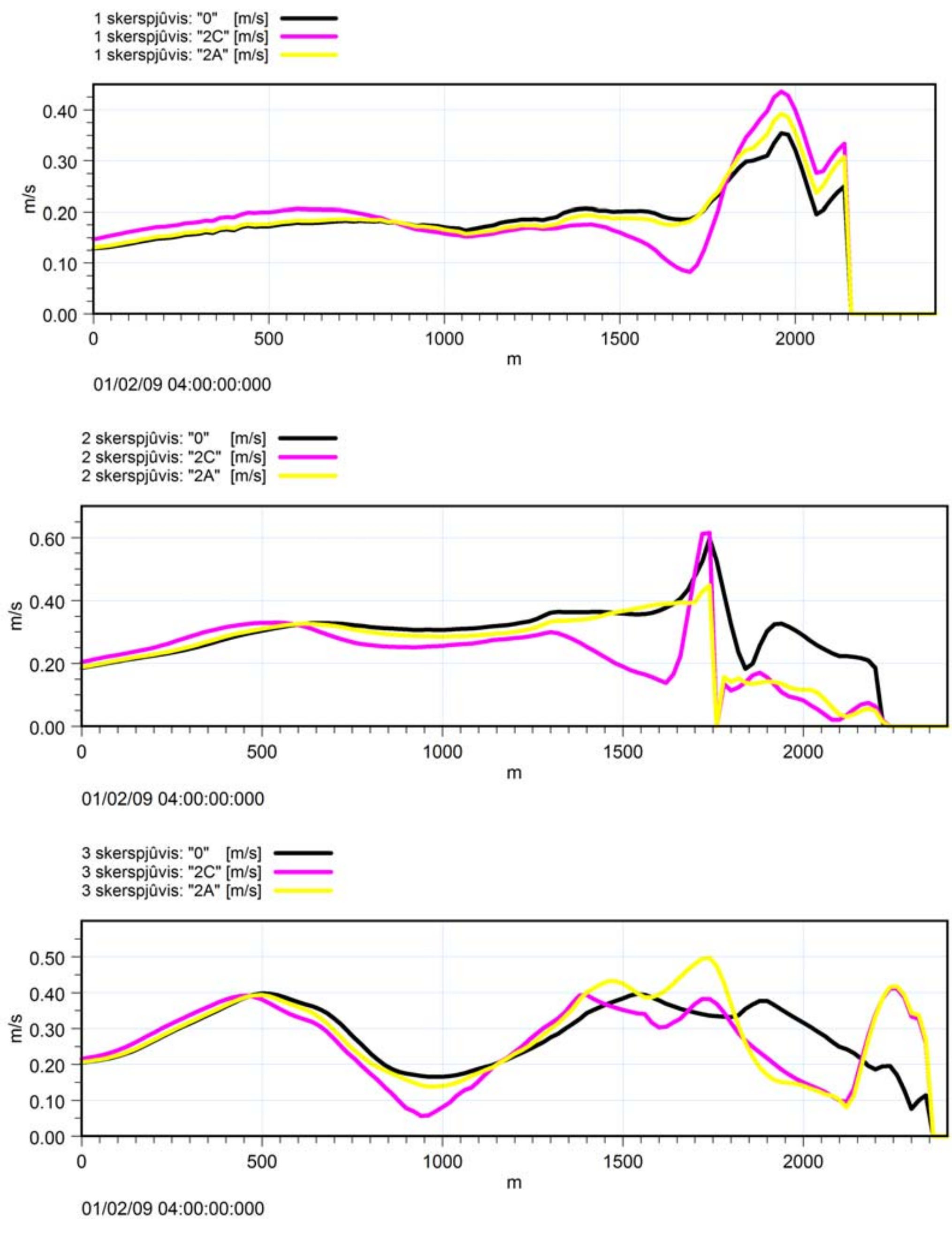
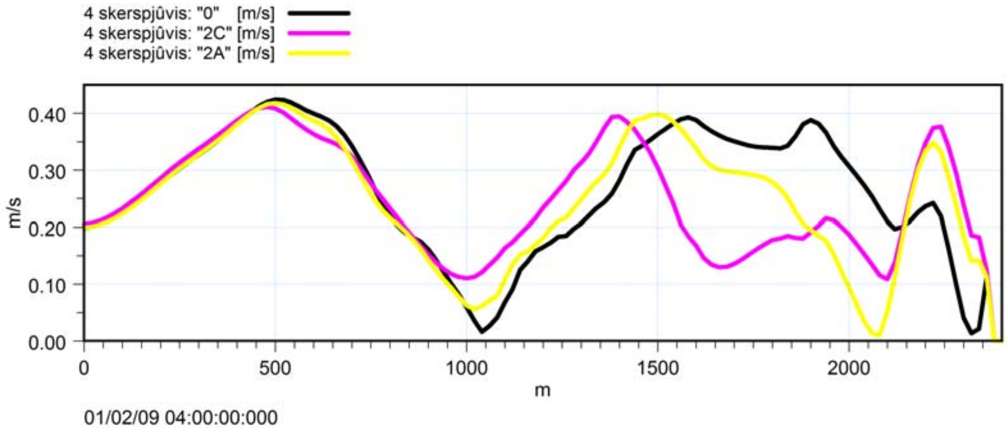
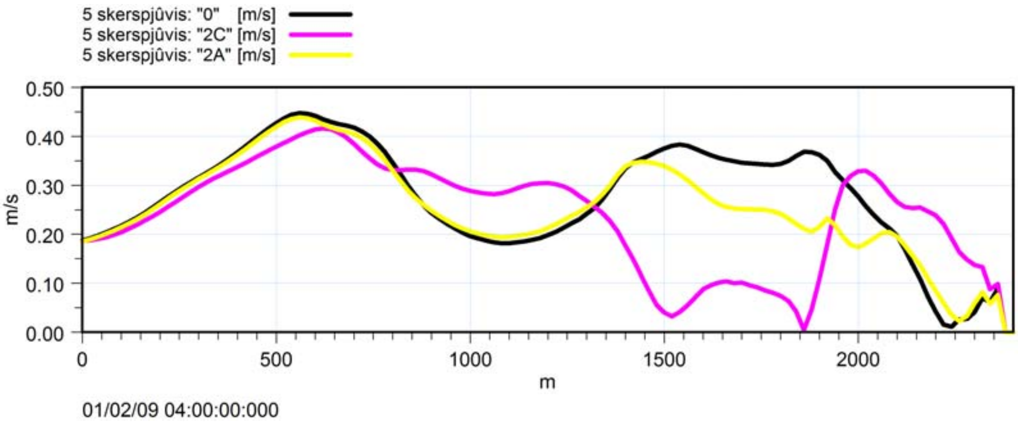


Fig. 26. Flow speeds for zero alternative, “2C” and “2A” options in the three cross-sections (Fig. 10). The blowing wind direction W: 1 (a), 2 (b) and 3 (c) cross-sections

a)



b)



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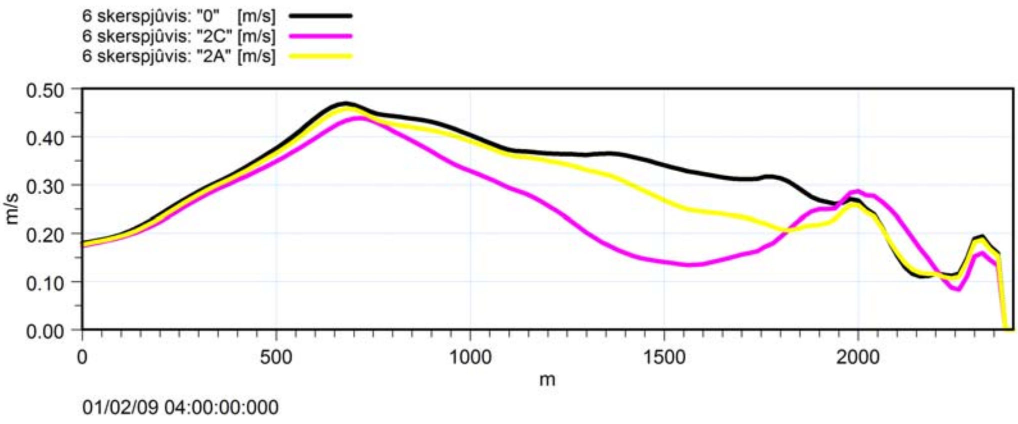


Fig. 27. Flow speeds for zero alternative, “2C” and “2A” options in the three cross-sections (Fig. 10). The blowing wind direction W: 4 (a), 5 (b) and 6 (c) cross-sections

Analysis of the simulated flow structure shows (Fig. 28) that changes of the flow speed in the sea cross-sections near the Lithuanian-Latvian border are very small for the port option “2B” and “3D” after restoration of the Šventoji Seaport.

Model of the sediment transport was created by the two-dimensional flow model MIKE 21 [7] (Fig. 29). Distribution of the sediment transport of unitary discharge (m^3/year/m) for W wind of 20 m/s speed is given. Influence of all port restoration options has also been studied for SE and NW winds.

The biggest changes of the sediment flow observed between 2-4 and 5-7 cross-sections. Port hydrotechnical constructions (breakwaters) influence erosion of the bottom and shores, and accumulation processes are most evident at the 2-2.5 km distance, because port breakwaters are between 4 and 5 cross-sections (Fig. 30a).

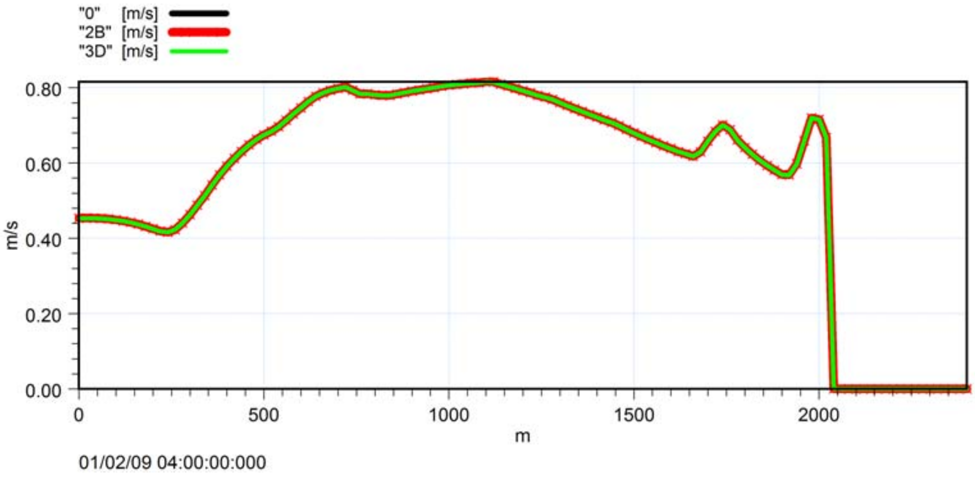
Sediment flow in the nearest cross-sections (1 and 2), that belong to the Latvian territory, slightly increased for SW wind (Fig. 30b). This tendency is typical for zero alternative, "2B" and "3D" options. After evaluation of the highest frequency of the strong winds of this direction, the digital simulation confirms shore and bottom erosion phenomena are identified during monitoring. Meanwhile, the stormy (W and SW) winds stimulate erosion processes between 2 and 4 cross-sections (Fig. 30a and 30b) and accumulation on the south side of the port (between 5 and 6 cross-sections).

The most significant changes in sediment flow (up to 15-20%) are caused by “3D” option of the port. Meanwhile, the Šventoji Seaport reconstruction under “2B” option makes little change on present situation (zero alternative).

Simulation results confirm that changes of the Šventoji Seaport by the “2B” option do not have significant impact on the beaches conditions of the neighbouring territory of Latvian country. Port restoration by the “3E” option, with longer breakwaters (800 m), will have bigger impact on shore condition for both territories of Lithuania and Latvia.

It is proposed to use compensatory measures – to complement the coastal sediment flow with the sand, which was excavated during the port entrance channel dredging in order to stop sediment washing-out from the north shore section.

a)



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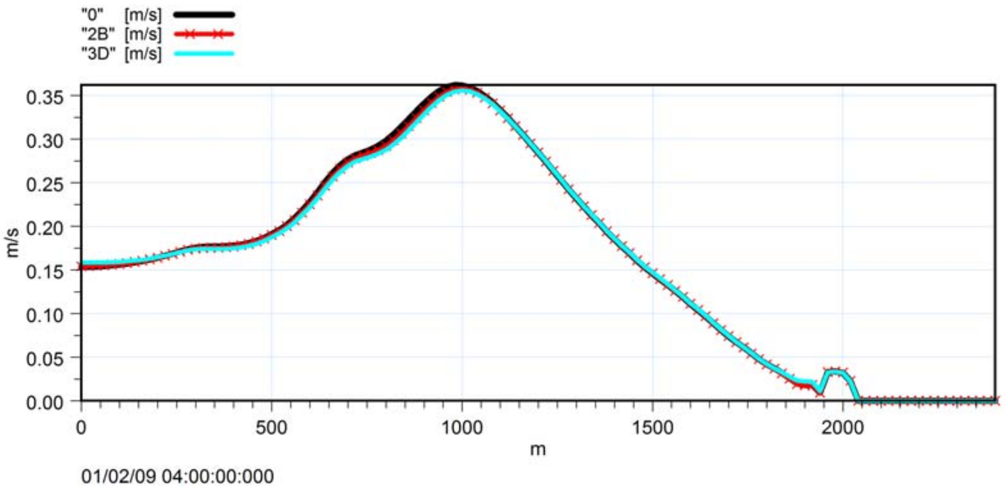

c)

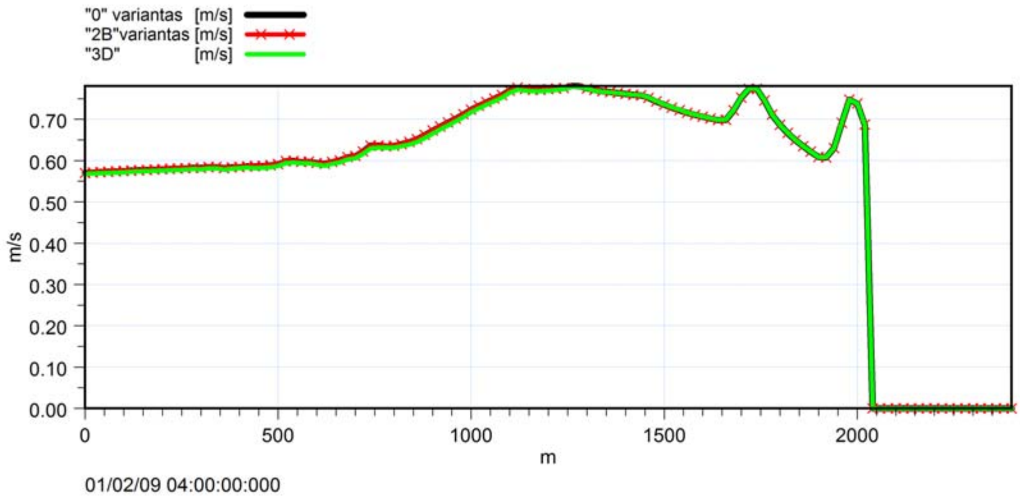

Fig. 28. Flow speeds for zero alternative, "2B" and "3D" options in the cross-section, which is situated 5 km from the Šventoji breakwater to the north (Latvian territory), for the wind directions NW (a), W (b) and SW (c). Cross-section starts (0) at the sea and ends at the mark 2050 m

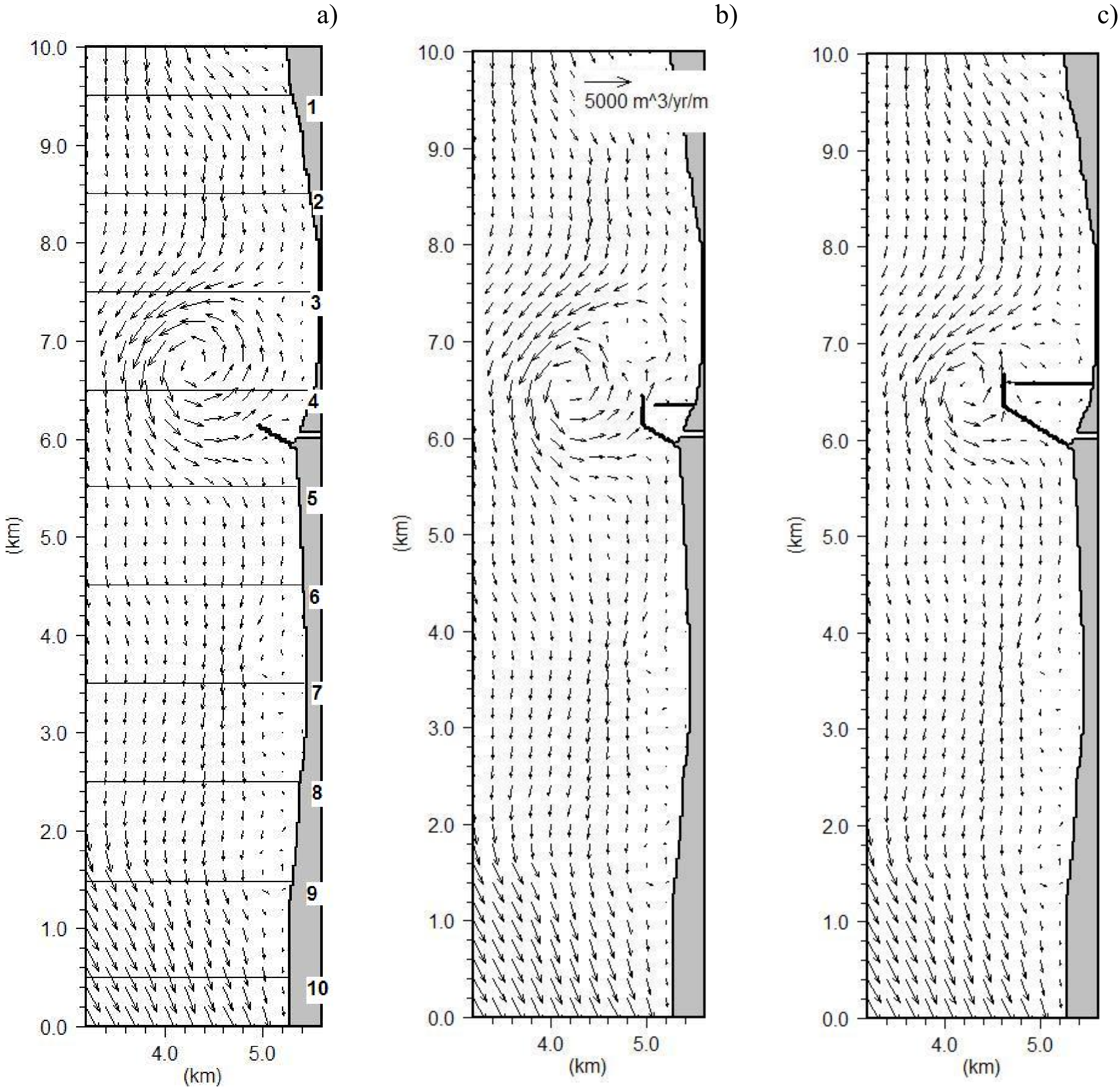

Fig. 29. Distribution of the sediment unitary discharge (m³/year/m) for W wind with speed 20 m/s for zero alternative, "2B" and "3D" options (calculations of the sediment discharge is done from 10 till 1 cross-section)

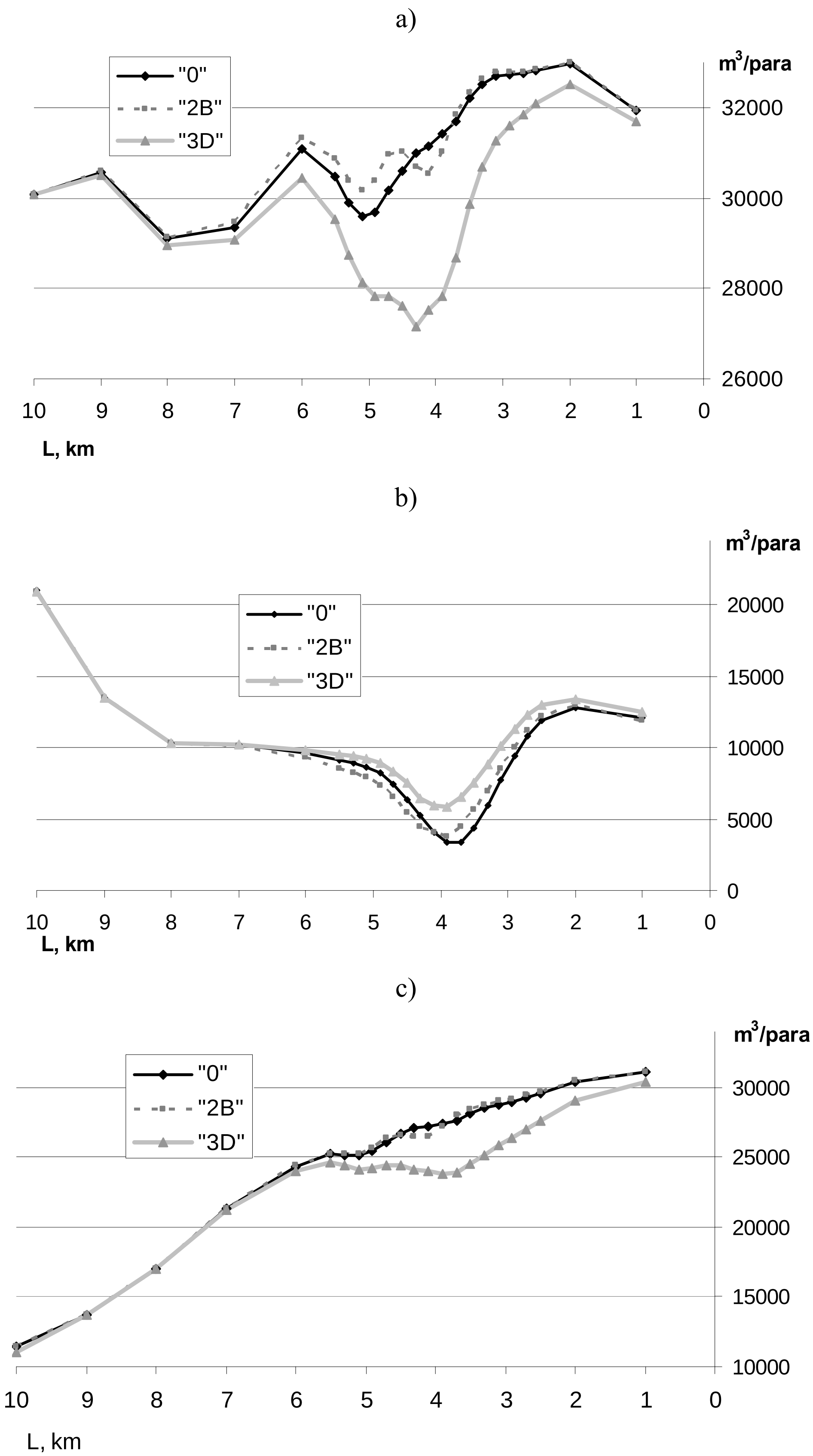

Fig. 30. Distribution of the sediment discharge (m³/day) from cross-section 10 (the Ošupis stream) to 1 (1 km to the LT-LV border) for zero alternative, "2B" and "3D" options, for the wind speed 20 m/s and directions NW (a), W (b) and SW (c). Ports breakwaters are between 4 and 5 cross-section

4.2. Assessment of engineering geological conditions of dredging activities

The results of performed engineering geological investigation show that if Šventoji port is dredged to 4-5 m depth, cutter suction dredger has to be used and the excavated soil will be sand. Deeper, than 4-5 meters, the soils, that can be excavated only using bucket dredger, are located.

In 2010 32 bottom soil samples were taken from Šventoji Seaport water territory that is planned to be dredged. The water territory is covered by sandy sand. The concentrations of harmful substances in all tested soil samples did not exceed requirements for the soil of the 2nd pollution class.

Besides, there are 3 stations of the state environmental monitoring in the seashore of Šventoji State Seaport, where samples of the bottom soils are taken for analysis once a month. The results of these observations indicate that the soils in monitoring stations are weakly polluted and can be attributed to the 1st and 2nd pollution class according to LAND 46A-2002 Table 2. Such soils can be dumped in the sea water territory away from the nearshore (deeper than 30 m), in the selected sites.

Fine sand that prevails in the bottom sediments of the port sea area is attributed to the 1st pollution class and therefore can be used for the shore nourishment.

4.3. Impact on biological diversity

The negative impact of Šventoji port reconstruction and exploitation on the territories of NATURA 2000 and its natural valuables is not foreseen. The distance from water territory of Šventoji port to the areas of bird assemblages is quite large, therefore the short local activity (dredging of bottom sediments) and 1-3 m changes of the Baltic Sea nearshore depth cannot make influence to the bird wintering or migration conditions in the protected areas.

A water territory of Šventoji Seaport is located on the migration route of river lamprey. In this case the dredging of port water territory can have a positive impact, while the cross-section of the flow increases. The plan of mitigation measures of the port dredging activities was prepared to mitigate an impact on fish migration, spawning places and fish nourishment sources.

4.4. Impact on public health

After evaluation of the possible risk factors (noise, air pollution, water quality) during the planned port water territory dredging and exploitation, it can be stated, that the planned activity can have a negative impact on the public health. In order to avoid the negative impact on the public health, compensation measures are proposed to implement.

Evaluation of the territory of the planned activity in regard to Šventoji beaches and of the requirements of the public health protection legislation – Lithuanian hygiene standards HN 92:2007 enabled to state that a negative impact of the seaport activity on Šventoji beaches as well as on public health is possible.

According to the feasibility study prepared by Spanish engineering, consulting and architecture company “Alatec”, the water territory is dredged using dipper bucket dredger and cutter section dredger, whereas to dredge the 10 meter wide strip near the quays dredger dipper dredger is going to be used. Temporal effects during the dredging are short-term. There will be no effects left after the end of the dredging works. Reconstruction of Šventoji State Seaport is going to have a short-term impact on environment and residents because of the increased noise during construction works. Since the distance to the Šventoji settled districts is small, during summer season noisy activities will be carried out only by industrial necessity and not at night.

5. Conclusions

In the report of environmental impact assessment the impact of different options of Šventoji Seaport reconstruction is analysed. It was estimated that impact on public health, biota, water and air pollution, activity risk, social-economical environment and cultural heritage is insignificant if the mitigating and compensating measures are applied. However the impact of the port hydrotechnical constructions can have significant impact on the state of the sea coastline.

Summing up the results of the cartographic material analysis, it can be stated that the long southern breakwater constructed in 1939, have caused an intense sediment accumulation in the port gate and southward. The port construction also caused the formation of the accumulative cape. Meanwhile, the coastline erosion processes have become especially intense northwards from the formed cape to the Latvian border.

Thus, over the years, the southern breakwater has become more and more pervious to sediments. The monitoring data collected during the last 17 years show sediment volume stabilization on the northern side of the breakwater, and accumulation in the southern part of the port tendencies. Therefore, the coastline shrinkage intensity on the northern side of Šventoji port has been decreasing recently.

Results of sediment transport modelling confirm that the reconstruction of Šventoji port according to “2B” option (length of breakwaters – 400 m) answers the minimal requirements of port and makes the least impact for the hydrodynamic and lithodynamic processes in the Baltic Sea nearshore. The reconstruction of port according to “3E” option (length of breakwaters – 800 m) will cause more significant erosion processes northwards from the port breakwaters.

Due to the fact that the reconstructed Šventoji port is going to be located almost in the same place, and its planned parameters (breakwater length, aquatory depth, etc.) resemble the ones of the old port, the tendencies of the coastline dynamics in adjacent regions should be similar to the ones discussed in the paper (i.e., should resemble the ones that were prevalent previously). The intensity of the coastline dynamics may differ for different options of port reconstruction. To stop the coastline shrinkage intensity on the northern side of Šventoji port, a compensating measure - supplementing the coastline sediment flow with sand during the annual dredging of the port entrance channel, is proposed.

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