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POSSIBILITIES OF REGENERATION OF PALANGA COASTAL ZONE

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Abstract. An intensive abrasion of the coast of the most popular Lithuanian Palanga health-resort necessitates consideration of the most effective ways of its stabilization. Based on the data of field investigations and literary sources, the possibilities of Palanga coastal zone regeneration using the sand dredged from the entrance channel of Klaipėda port are considered. Based on the current geodynamic trends of Palanga coastal zone and results obtained by comparative analysis of granulometric composition of sediments dredged from the entrance channel of Klaipėda Port, the optimal possibilities of using the dredged sand for coast regeneration were determined. It was established that formation of underwater sandbar (analogue of natural bar) in the surf zone of coastal sector between the Palanga Pier and Birutė Mount at a depth of 3 m would be the best solution for coast regeneration under the current conditions.

Keywords: replenishment of sediments in the coastal zone, artificial sandbar, granulometric composition of sediments.

1. Introduction

Lithuania has a short (only 90.6 km long) stretch of Baltic Sea coast. Marked deterioration of the state of marine coast is a matter of great concern not only for researchers but also for the Government, press and public. The space of recreation zones shrinks as a result of coastal erosion endangering the hydrotechnical constructions and other industrial objects and their infrastructure.

Coastal erosion noticeably intensified at the end of the 20th–the beginning of the 21st century. In the last 30 years (1978–2008), the rates of erosion of the Lithuanian coast have increased more than 10-fold in comparison with the previous 30 years (1948–1978). Unfortunately, the highest rates of erosion are observed near the Palanga pier which is the most attractive recreational zone of the popular Palanga resort (Žilinskas 2008).

Along with other measures of coastal protection designed for stabilization of the coast, the Lithuanian Baltic Sea coastal management programs (Lietuvos Baltijos … 2003; 2007; Pajūrio juostos … 2005) provide for replenishment of the nearshore with transported sand from other sources.

The first attempts of beach restoration (using the sediment dredged from the Klaipėda entrance channel) carried out in Lithuania in 2001 and 2005 in the sector Melnragė II–Giruliai produced a positive effect on the coast: mitigated the destructive impact of long-lasting winter (2001–2002) storms and sustained the raging hurricane "Ervin" and strong winter storms of 2006–2007. Moreover, the undertaken actions stopped the dominant erosion processes in the mentioned sector and in 2003 even sand accumulation processes (somewhere up to 1.5 m^3 per year) set in (Žilinskas *et al.* 2003).

During storms, marine sediments overflow the Klaipėda port entrance channel and its "pockets". About 120 000–160 000 m^3 of marine sand have accumulated in these areas and has to be removed to maintain a safe exploitation depth. It is suggested to use this sand for restoration of the recreational nearshore sector between the Palanga pier and Birutė Mount. For this purpose it is first of all necessary to choose the optimal place and depth for sand dumping, to determine the technical parameters of the artificial sandbar (analogue of the natural sandbar) and to assess the compatibility of sand to be used for coast restoration taking into consideration the requirements for coast and environment protection. Solution of these tasks is the aim of the present article.

2. Methods

The investigation was carried out in a 6 km long shore sector of Palanga recreation zone where 13 key profiles were selected. A repeated levelling of the profiles was performed using an electronic tachometer. It must be pointed out that in 9 profiles (1–4, 6, 7, and 11–13), the annual observations of the shore status have been carried out since 1993 and in the remaining three (5, 8 and 9) since 1999 (Fig. 1).

The status of the nearshore has been evaluated based on the data stored in the archive of the Branch of Coastal Research and Management, Department of Marine Research of the Lithuanian Institute of Geology and Geography, and on the data contained in the Coastal Atlas of the Baltic Sea (Baltijos jūros … 2004) and reports of mathematic modelling of the impacts of Palanga groyne Atstatomos … 2004), studies of the possibilities of sand use (Smėlio panaudojimo … 2006a, b) and Environmental Impact Evaluation program.

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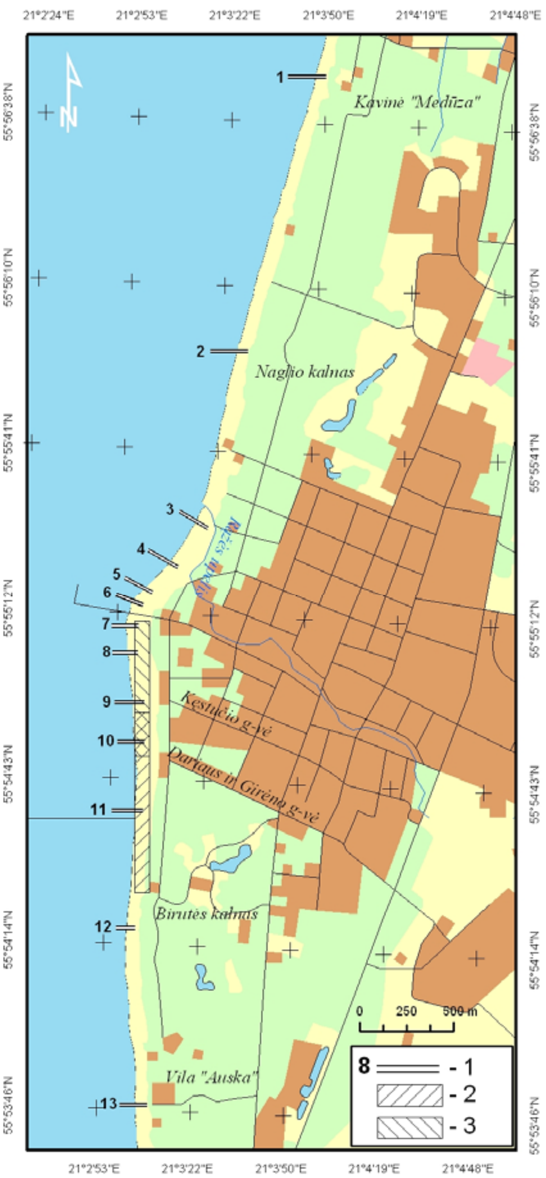

Fig. 1. Scheme of the study area: 1 – measuring profiles, 2 – site of sand replenishment in 2006, 3 – site of sand replenishment in 2008

The authors also used the data of depth at the Palanga pier measured by the Hydrographic Survey of Safe Navigation Administration of Lithuania.

For compositional analysis of coastal sediments, sediment samples were taken from three shore profiles (7, 10 and 12) and from one nearshore profile (10) at depths of 1, 2, 3 and 5 m (Fig. 1). The evaluation of the composition of the nearshore sediments also was based on the data contained in the Baltic Sea Coastal Atlas (Baltijos jūros … 2004). Sand samples were mechanically screened using a shaker. A set of 11 sieves was used for distinguishing the following fractions: >1.6; 1.6–1.0; 1.0–0.63; 0.63–0.4; 0.4–315; 0.315–0.2; 0.2–0.16; 0.16–0.1; 0.1–0.063; 0.063–0.05; <0.05 mm. Yet the world practice of similar investigations has shown that it is insufficient to base merely on comparison of sand fractions, granulometric composition and coefficients (average, median diameter and sorting) (what has been a common practice in Lithuania) because there is no ideal compatibility of the sand from other sources with the sand in the replenishment area. For this reason, other indices were used as well: *James'* criteria (R_A and R_J) which allow a more precise compatibility evaluation of the sand designed for shore restoration (James 1975). In the present work, the *James'* criteria R_A and R_J have been calculated following the R. G. Dean's modification given in the "Shore protection instructions" (Shore protection … 1984).

The universal practice of similar theoretical and practical works has been taken into consideration (Komar 1983; Vellinga 1983; Birkemeier 1985; Sallenger *et al.* 1985; Shore protection ... 1984; Manual on artificial ... 1987; Graaff *et al.* 1991; Swart 1991; Tjalle Haan 1992; Mierzynski 1989; Committee on beach ... 1995; Pruszak 2003, Есин и др. 1987; Белошапков, Фельдман 1987; Зенкович 1987; Лащенков 1987; Кнапс 1987; Хомицкий и др. 1987 and others).

Yet the attention of the present work has been focused on the: shore status and its specific local features in the studied sector, empirical dependences between the morphological indices of the Lithuanian marine coast and losses of shore sediments during hurricanes (Jarmalavičius, Žilinskas 1997, 2001), empirical dependences between the morphometric parameters of the underwater shore slope (Žilinskas, Jarmalavičius 2007), sand differentiation patterns in the Lithuanian coastal zone (Jarmalavičius, Žilinskas 2006), and the experience and knowledge accumulated by the Branch of Coastal Research and Management (Vietos … 2000, 2001; Žilinskas *et al.* 2003; Senkaimio įlankos … 1991–1993).

The authors have taken into consideration the environmental requirements given in the Environmental Impact Evaluation report (Smėlio panaudojimo … 2006b), letter No V3-10.7.-1556 issued by the State Service for Protected Areas (Lithuanian Ministry of Environment) and letter No (9.14.2)V4-4678 issued by the Klaipėda Department of Environment Protection (Lithuanian Ministry of Environment).

3. Results

Shore status assessment. Different aspects of the present status of Palanga recreational zone have been described in a number of publications: (Žilinskas, Jarmalavičius 1996, 1997, 2003; Jarmalavičius, Žilinskas 1996, 1997, 2001, 2002; Žilinskas *et al.* 1994; 2000, 2001, 2005, 2008; Žilinskas 2005, 2008; Dubra 2006). The present article contains the evaluation of the status only of the regenerated shore sector (Palanga pier–Birutė Mount).

The studied shore sector (about 1680 m long) is most problematic in terms of coastal protection in the Lithuanian coastal area. The western slope of the beach foredune ridge (altitude 4–6 m) is intensively eroded by waves and run-up. The crest is dissected by blowouts and multiple deflation forms. The eastern slope of the ridge has the greatest number of deflation forms: hollows, depressions, large open sand areas. They are separated by sand hillocks overgrown with willows. The slopes of hillocks also are eroded. Especially large blowout areas are situated south of the Darius and Girėnas Street.

The intensity of shore abrasion on the southern side of the pier (profile 7) before the restoration works had reached 8 m^3/m year, at the Kęstutis Street (profile 9) 12.3 m^3/m, in the middle of the bay (profile 10) even 13.5 m^3/m (Fig. 2), and at the cape of Birutė Mount (profile 12) 0.5 m^3/m. The beach was narrow (during the season of storms it reached only 12–20 m and in summer time 15–35 m) and low (somewhere less than 1 m in height). Even medium waves would flood it and surge and run-up would intensively erode the artificial beach foredune ridge.

In the spring of 2006, the beach in the northern part of the studied sector (Fig. 1) was restored through replenishment with 40 000 m^3 of sand transported from the Kunigiškiai quarry. In two years, the replaced sand reduced to 8000 m^3 or 20% of the initial amount (Fig. 3) (Žilinskas *et al.* 2008). In the spring of 2008, the beaches of the central and southern parts of the studied area (Fig. 1) were again replenished with 111 000 m^3 of sand dredged in the nearshore of Preila–Juodkrantė polygon. The levelling performed in November, 2008, showed that in half a year about 30% (about 40 000 m^3) of replaced sand had been lost (Fig. 4). The beach nourishment with sediments performed in 2006 and 2008 though for short protected the beach, the foredune ridge in particular, from erosion yet did not change the long-term pattern of coast erosion in the studied sector.

Assessment of the status of the nearshore. The nearshore of the sector under consideration is predominated by glacial sediments of the next-to-last glaciation and is in many places covered by gravel, pebble and boulder layers. The bottom relief of the nearshore is complex, strongly dissected by 2–3 m high ridges and 1–2 m deep depressions (Fig. 5). The morainic sediments approach the shore till the 3–4 m isobath at the Palanga pier, 1 m isobath at the Birutė Mount and 6–6.5 m isobaths in the middle of the bay between the Palanga pier and Birutė Mount.

Fine-grained sands are dominant among the morainic sediments. The thickness of their layer usually does not reach 2 m. The sand-covered sector of the nearshore south of the pier has been narrowing every year: in the autumn of 1999, it was about 300 m wide whereas in 2002–2005 its width was only 220–240 m. The layer of loose sediments in the nearshore slope approximately 100 m from the shore-line is 0.8–1.3 m thick Its thickness at a distance of 200–300 m from the shore is only 20–40 cm (Smėlio panaudojimo … 2006b).

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Thus the nearshore of the sector under consideration is distinguished for especially small sand resources (reducing every year). They are insufficient even for generation of the nearshore sandbar. For this reason, the above described sand replacement in the beach produced only a short-lasting protective effect. In order to stabilize the shore it is first of all necessary to replenish the nearshore sand resources.

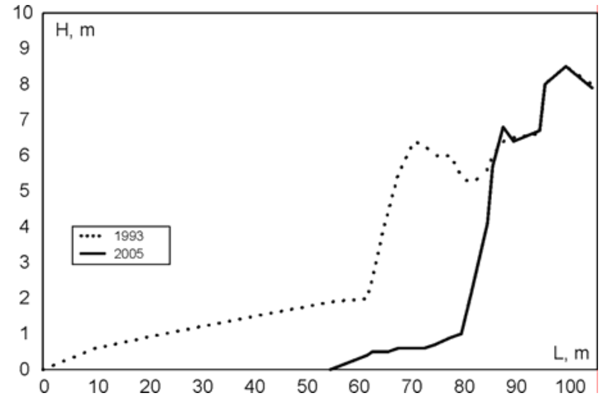

Fig. 2. Coastal transformations (profile 10) at the Darius and Girėnas Street in 1993–2005. The location of the profile is shown in Fig. 1

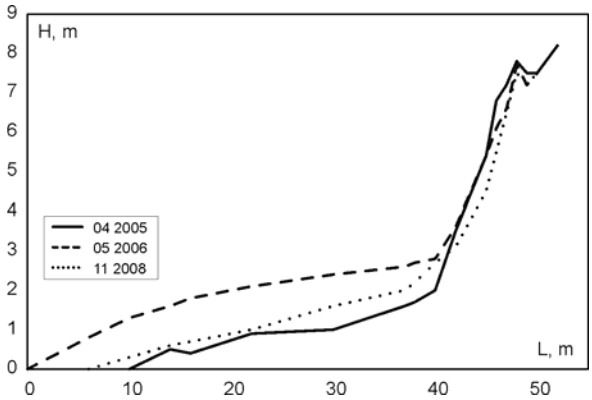

Fig. 3. Coastal transformations (profile 10) at the Darius and Girėnas Street in 2005–2008: 2005 – coastal profile before the beach regeneration, 2006 – coastal profile after the regeneration, 2008 – coastal profile two years after the regeneration. The location of the profile is shown in Fig. 1

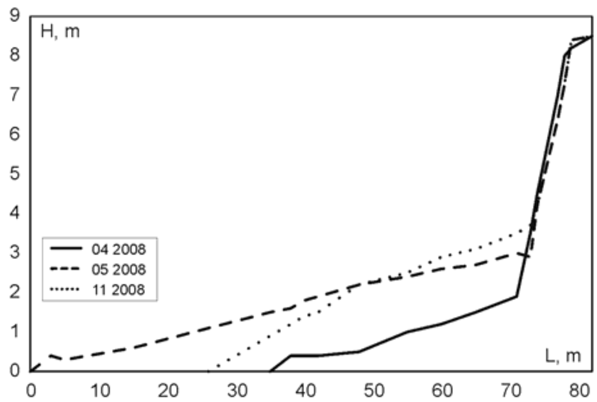

Fig. 4. Coastal transformations (profile 11) south of the Darius and Girėnas Street in 04 2008–11 2008: 04 2008 – coastal profile before the beach regeneration, 05 2008 – coastal profile after the regeneration, 11 2008 – coastal profile 6 months after the regeneration. The location of the profile is shown in Fig. 1

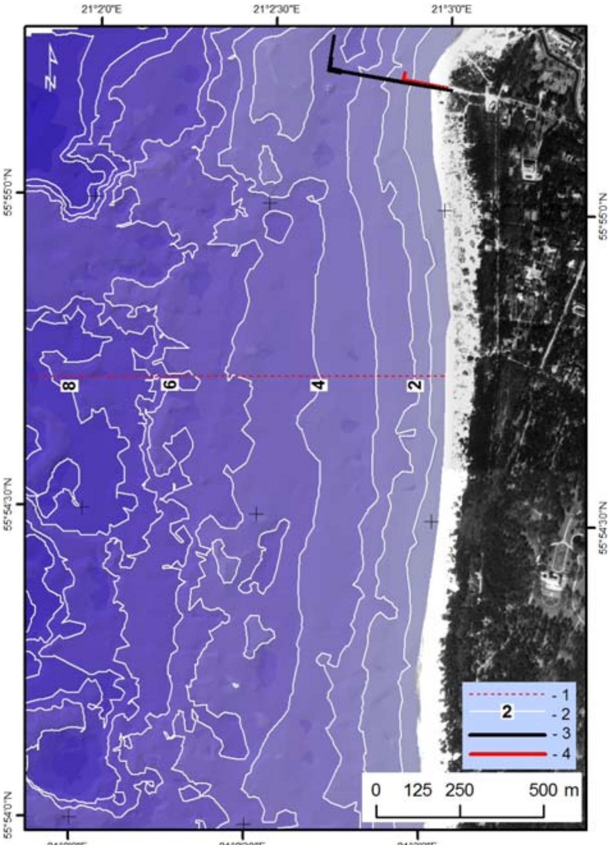

Fig. 5. Nearshore bathymetry of the investigation area: 1 – nearshore profile (is shown in Fig. 6), 2 – isobath, 3 – Palanga pier, 4 – groyne. The bathymetry was made according Lighthouse and Hydrography Service 2007 data

A comparative analysis of the sediments in the Palanga coastal zone and Klaipėda entrance channel. Sand compatibility assessment must be based on compatibility of granulometric composition of sand from other sources with the local sand in the restored sector. Already the preliminary data (Table 1 and 2) show that that the granulometric composition of the sand designed for replacement is rather comparable with the granulometric composition of the "native" sand (except samples 7–9 predominated by finer sand fractions): fine-grained well sorted sands are dominant.

It should be noted that bottom sediment samples collected from the entrance channel of Klaipėda port represent different dredging polygons, i.e. they show the polygons with compatible and incompatible sand. Based on the recommendations proved reasonable by world practice (since the beginning of the seventies) (Shore … 1984 and others), sand compatibility has been assessed using *James'* criteria R_A and R_J. The sand is compatible for regeneration when R_A of the sand from other source and the local sand is between 1.00 and 1.05 and R_J about 0.2. The calculated values of the mentioned factors are given in Table 3. The results given in tables 1–3 lead to a conclusion that the granulometric composition of the sand dredged from the entrance channel of the port is suitable for restoration of the Palanga nearshore. The sand from polygons 7–9 makes an exception. It does not meet the compatibility requirements for granulometric composition. It seems likely that after dumping in the nearshore it would be washed away to deeper sea areas. Moreover, this sand is heavily contaminated with oil products and heavy metals what makes it unsuitable for shore restoration (Sunkiųjų metalų … 2007).

Table 1. Granulometric composition (%) of bottom sediments in the entrance channel to the Klaipėda Port

No.	Fraction						d, mm	M_Φ	σ_Φ
	>1	1–0.5	0.5–0.25	0.25–0.1	0.1–0.063	<0.063			
1	0.61	2.90	10.61	77.14	7.92	0.82	0.21	2.87	0.91
2	1.37	1.96	6.57	82.62	6.66	0.82	0.20	2.88	0.87
3	0.47	0.76	5.82	87.84	4.42	0.69	0.19	2.91	0.85
4	0.30	4.77	35.12	57.64	1.58	0.59	0.27	2.71	1.05
5	0.20	0.36	14.98	81.12	2.42	0.92	0.21	2.86	0.89
6	0.28	0.57	10.53	81.70	4.73	2.19	0.19	2.89	0.87
7	–	0.30	9.30	18.85	29.40	42.15	0.12	3.24	0.79
8	0.10	2.40	15.84	31.71	20.30	29.65	0.17	2.98	0.97
9	–	0.20	8.40	11.67	31.50	48.23	0.11	3.34	0.73

No – number of sample taken from the entrance channel; d – mean diameter of sand grains; M_Φ – median diameter of sand grains at phi scale; σ_Φ – sorting coefficient at phi scale

Table 2. Granulometric composition (%) of sediments of coastal zone in the sector under consideration

Sample No.	Depth, m	Fractions						d, mm	M_Φ	σ_Φ
		>1	1–0.5	0.5–0.25	0.25–0.1	0.1–0.063	<0.063			
1	1.0	–	4.24	3.58	77.57	14.49	0.12	0.19	2.92	0.86
2	2.0	–	3.69	3.87	58.50	33.01	0.93	0.17	2.99	0.84
3	3.0	–	3.14	4.35	48.85	41.75	1.91	0.16	3.04	0.82
4	5.0	–	1.16	2.92	88.58	7.26	0.08	0.18	2.93	0.84
5	Pv.	–	0.11	13.78	85.09	1.02	0.00	0.20	2.87	0.87

Pv – the middle of the beach

Table 3. Evaluation of suitability factors (R_A and R_J) of granulometric composition of the sand in the entrance channel to the Klaipėda Port for different coastal sectors of Palanga

Sample No	Depth 5.0 m		Depth 3.0 m		Depth 2.0 m		Depth 0.8 m		Pv.	
	R_A	R_J	R_A	R_J	R_A	R_J	R_A	R_J	R_A	R_J
1	1.02	0.4	1.00	0.2	1.02	0.3	1.02	0.3	1.05	0.3
2	1.02	0.2	1.01	0.2	1.01	0.2	1.01	0.2	1.05	0.3
3	1.02	0.3	1.01	0.3	1.02	0.3	1.05	0.3	1.15	0.4
4	1.05	0.2	1.02	0.2	1.05	0.2	1.04	0.3	1.05	0.3
5	1.02	0.3	1.00	0.2	1.01	0.3	1.02	0.3	1.03	0.3
6	1.02	0.3	1.00	0.2	1.00	0.2	1.02	0.3	1.10	0.3
7	1.75	0.5	1.40	0.5	1.75	0.5	2.00	0.6	2.25	0.6
8	1.13	0.3	1.10	0.2	1.10	0.3	1.15	0.3	1.20	0.3
9	2.5	0.5	2.25	0.6	2.50	0.8	3.00	0.8	3.50	0.8

Pv. – the middle of the beach

A detailed analysis of sand samples 1–6 has shown that the nearshore depth zone of 2–3 m is a place with ideal conditions for its dumping. The compatibility factors of the sand from the entrance channel and the local sand are the best ones (R_A in most cases ranges from 1.00 and 1.01 what is an ideal case). In the adjacent areas (closer to and farther from the shore), the conditions for sand dumping also are good. A comparison of the sand from the entrance channel with the shore sand has shown that it is compatible for the restoration of the nearshore rather than of the beach.

Determining technical parameters of the artificial sandbar. Selection of the dumping site depends on the intended form of relief to be generated. According to the collected material and results of calculations made taking into consideration the specific local conditions of the Palanga nearshore, the base of the underwater artificial sand sandbar should be about 120–140 m and its crest 40–60 m in width and the depth between the crest and the average long-term water level should be 1.5 m. Depending on the dumping depth, the altitude of the sandbar could be 1.5 m (at a depth of 3 m), 2.5 m (at a depth of 4 m) and 3.5 m (at a depth of 5 m) (Fig. 6). Thus the morphological body of this size would not only bear the features of the natural analogue of the sandbar typical of the Lithuanian nearshore (Žilinskas, Jarmalavičius 2007) but also would play the function of a breakwater. According to *McCowen* criterion showing the wave breaking depth (h/H where h is wave height and H depth), the breaking height of waves above the crest of the artificial sandbar would be 1.17–1.20 and more. Namely the setup (η = 0.30 h_S) and surge of the waves of significant height (h_S) inundate the shore and erode the dune ridge. It should be pointed out that the parameters of the intended sandbar-breakwater could be more optimal but this requires larger amounts of sand from other sources (the currently planned amount of sand is only 120 000–160 000 m^3).

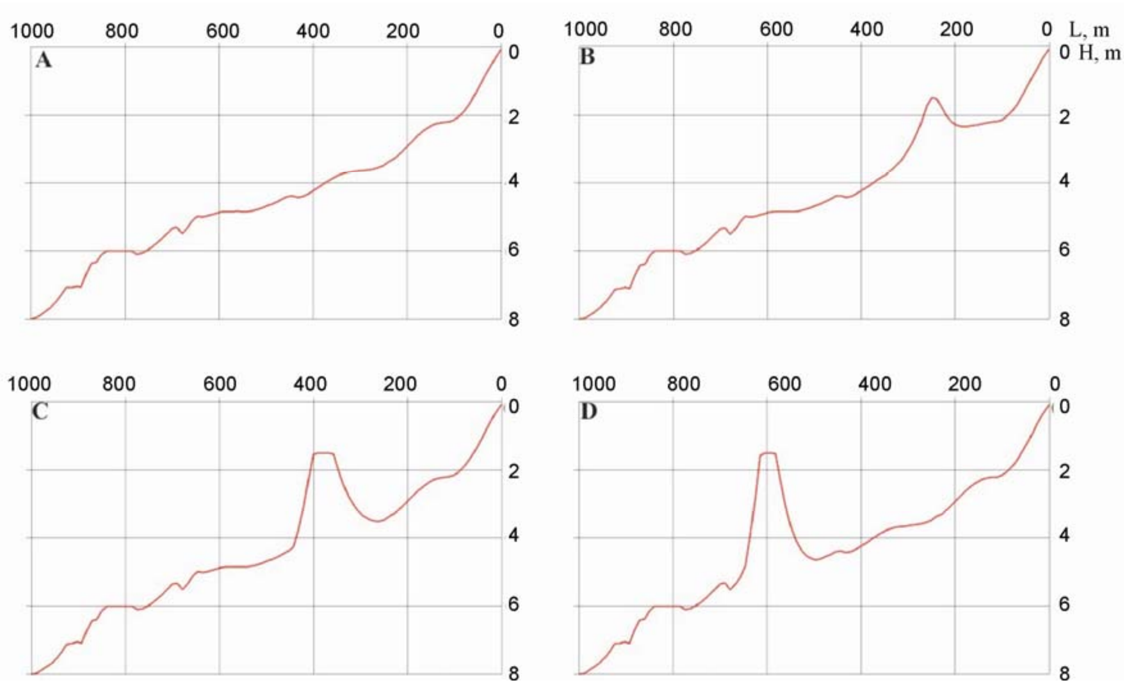

Fig. 6. Dependence of the altitude of the artificial sandbar on the chosen depth of dumping: A – the present coastal profile, B – depth 3 m, C – depth 4 m, D – depth 5 m. The location of the profile is shown in Fig. 5

Conditions limiting the localization of the dumping site. In order to stabilize the chosen shore sector it is first of all necessary to straighten the shore-line in the large-radius bay between the head of the groyne at the Palanga pier and cape of Birutė Mount. The requirements for territorial preservation and use had to be taken into consideration selecting the dumping site because the studied sector is included in the talasological reserve of the Baltic Sea and the nearshore territory (NATURA 2000) important for preservation of birds' habitats (1170 reefs) and spawning grounds of fish. The mentioned territories in the studied sector actually coincide with the spread areas of till outcrops which are covered by boulders, gravel and pebble (Oleninas *et al.* 1996; Smėlio … 2006b). In the light of the above mentioned limiting factors, the fact that till outcrops in the restored shore sector are situated farther from the shore (at 5–6.5 m isobaths) can be taken as a very favourable circumstance. Moreover, morainic ridges (the altitude ranges from 1 to 2.5 m) extend along the whole restored nearshore sector in front of the outcrops serving as a possible natural obstacle to the dumped sand in case it started to move to deeper areas dislodged by waves and currents. Their presence in the suggested nourishment sector eliminates the possible adverse effect of restoration of the talasological reserve: its biological diversity, habitats and spawning grounds.

On the other hand, sand dumping behind the 5 m isobath, i.e. in the zone of morainic outcrops, would not produce any protective effect on the shore because the sand would remain "buried" among the morainic ridges. In the case under consideration, the interests of *coast protection and environment preservation* coincide!

Analysis of the differences of alternative technical parameters (amount of dumped sand 120 000 m^3 or 160 000 m^3 and dumping depth 3 m, 4 m or 5 m) shows that they are important in deciding about the length of the designed sandbar-breakwater (Table 4).

Table 4. Dependence of the length of projected sandbar on the alternatives of the amount of dumped sediment and dumping depth

Alternatives		Sandbar length, m	
A12	(A16)	800	(1060)
B12	(B16)	500	(660)
C12	(C16)	315	(420)

The data given in the table clearly show that the artificial sandbar-breakwater formed at a greater depth would be considerably shorter than at smaller depths.

Based on the calculation data, alternatives of sediment dumping sites have been modelled for the actual conditions of Palanga nearshore. The modelling results are demonstrated in Fig. 7.

Analysis of sediment replenishment alternatives in the nearshore. The alternatives of sediment replenishment have been analysed taking into account the specific character of the nearshore, project amounts of dredged sediment and coast protection and environment preservation requirements:

<u>Alternative 0</u>:
- the nearshore sediments are not replenished.

<u>Alternative 1</u>:
- the nearshore sediments are replenished with 120 000 m^3 of sand at a depth of 3 m **(A12),**
- the nearshore sediments are replenished with 160 000 m^3 of sand at a depth of 3 m **(A16).**

<u>Alternative 2:</u>
- the nearshore sediments are replenished with 120 000 m^3 of sand at a depth of 4 m **(B12),**
- the nearshore sediments are replenished with 160 000 m^3 of sand at a depth of 4 m **(B16).**

<u>Alternative 3:</u>
- the nearshore sediments are replenished with 120 000 m^3 of sand at a depth of 5 m **(C12),**
- the nearshore sediments are replenished with 120 000 m^3 of sand at a depth of 5 m **(C16).**

<u>*Alternative 0:*</u>
Advantages:
- no additional impact on the natural environment (habitats, fish, birds, etc.)
- no need of additional money for sand transportation to the chosen shore sector.

Disadvantages:
- the supplies of loose sediments will reduce not only in the sector under consideration but also in the adjacent shore sectors,
- the shore-line will retreat into the continent and dune ridge will be intensively eroded,
- the remnant sand dumped in 2006 and 2008 will be intensively washed out from the shore,
- the beach will narrow and the recreational space will shrink,
- the probability of damaging the proximal part of the Palanga pier will increase,
- the annual expenditures for restoration of recreational infrastructure (stairs, paths, etc.) ravaged by stronger autumn–winter storms will increase,
- in the course of time, the objects of Palanga infrastructure (e.g. pier, Meilė Alley, etc.) and urban objects (e.g. café "Voveraitė vardu Salvadoras") will be endangered.

<u>*Alternative 1*</u>*:*
Advantages:
- protects the longest shore sector (A12 – 800 m, A16 – 1060 m),
- granulometric composition of sediments designed for replacement ideally coincides the composition of the local nearshore sediments (R_A= 1.00 – 1.02),
- high temporal stability of the artificial sandbar-breakwater is expected (R_J = 0.2 – 0.3),
- the impact on the animate nature is minimized

Disadvantages:
- the small depth encumbers the navigation of loaded barges more than in alternatives B and C.

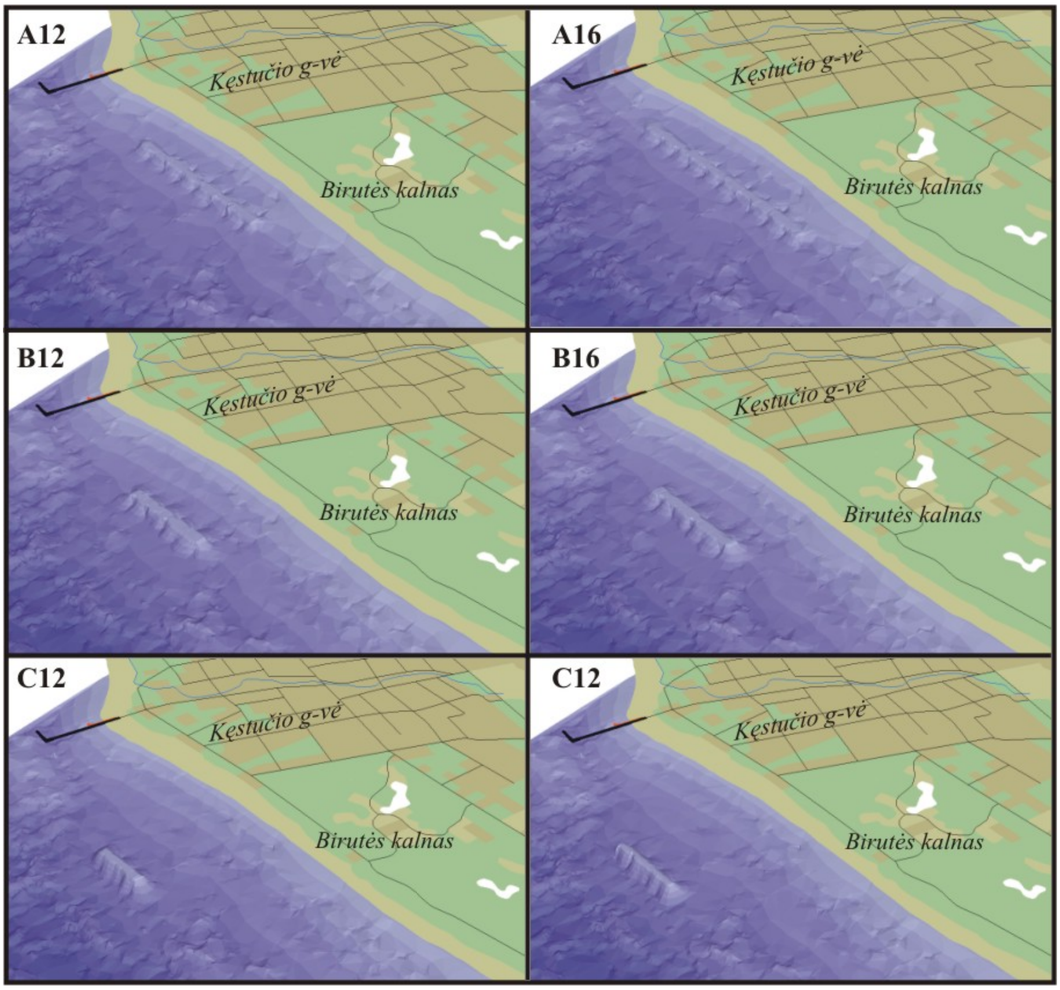

Fig. 7. Alternatives (A12, A16, B12, B16, C12, and C16) of modelled artificial sandbar in the surf zone of the sector under consideration

<u>Alternative 2</u>:
Advantages:

- protects a rather long shore sector (B12 – 500 m, B16 – 660 m),
- granulometric composition of sediments designed for replacement is in good correlation with the composition of the local nearshore sediments (R_A= 1.02),
- sufficiently good temporal stability of the artificial sandbar-breakwater is expected (R_J = 0.4),
- minimal impact on the animate nature,
- the navigation of loaded barges is easier than in alternatives A.

Disadvantages:

- the protected shore sector is shorter than in alternatives A,
- the navigation of loaded barges is more difficult than in alternatives C.

<u>Alternative 3</u>:
Advantages:

- though the protected shore sector is short (C12 – 315 m, C16 – 420 m), replacement of lost sediments in it is better than no replenishment at all (alternative 0),
- granulometric composition of sediments designed for replacement is in a rather good correlation with the composition of the local nearshore sediments (R_A= 1.02–1.05) though worse than in alternatives A and B,
- satisfactory temporal stability of the artificial sandbar-breakwater is expected (R_J = 0.4),
- navigation of the loaded barges is easier than in alternatives A and B.

Disadvantages:

- the protected shore sector is considerably shorter than in alternatives A and B,
- the impact on the animate nature probably will be stronger than in alternatives A and B,
- the expected temporal stability of the artificial sandbar-breakwater is only satisfactory (R_J = 0.4), i.e. worse than in alternative A and B.

The performed analysis has shown that from the point of view of coast and environment protection alternatives A and B are most acceptable. Alternative C could be applied only in supreme cases whereas alternative 0 is unacceptable.

4. Conclusion

The nearshore of the shore sector between the Palanga pier and Birutė Mount is distinguished for an especially high deficiency of sediments. This is why shore restoration by replacement of lost sediments carried out in 2006 and 2008 produced only a short-lasting coast protection effect. In order to stabilize the shore in the mentioned sector it is first of all necessary to replenish its sediment supplies.

Analysis of granulometric composition of the sand in the port entrance channel and its compatibility assessment for restoration of the Palanga recreation zone based on *James'* criteria showed that the sand dredged from polygons 1–6 is most compatible for restoration of the nearshore rather than the shore. The sands from the channel are in best correlation with the nearshore sands at a depth of 2–3 m.

Evaluation of possible shore restoration alternatives taking into account the properties of sands in the Palanga nearshore and port channel, specific features of the shore sector under consideration and requirements for coast and environment protection and seeking to achieve the maximal protective effect it is recommended to use the clean sand dredged from the port entrance channel for restoration of the nearshore sector of Palanga recreation zone between the Palanga pier and Birutė Mount dumping it at a depth of 3 m. An artificial sandbar-breakwater parallel to the shore should be formed. Its size parameters should be: width of the base 120 m, width of the crest 60 m and height 1.5 m. Its crest would be below the average long-term sea level at a depth of 1.5 m.

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PALANGOS KRANTO ZONOS REKULTIVAVIMO GALIMYBIŲ TYRIMAI

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S a n t r a u k a

Intensyvi populiariausio Lietuvoje Palangos kurorto jūros kranto arda verčia ieškoti efektyvių kranto stabilizavimo metodų. Pastaruoju metu (2003–2008 m.) atlikti apsauginio paplūdimio kopagūbrio tvirtinimo bei paplūdimio sąnašų atsargų papildymo Palangos rekreacinėje zonoje darbai lėmė tik trumpalaikį kranto apsaugos efektą. Straipsnyje, remiantis natūrinių tyrimų bei literatūros duomenimis, įvertintos smėlio, iškasamo iš Klaipėdos įplaukos kanalo, naudojimo Palangos kranto zonai regeneruoti galimybės. Atsižvelgus į dabartines Palangos kranto zonos geodinamines tendencijas bei atlikus šio ruožo ir iškasamo iš Klaipėdos uosto įplaukos kanalo birių sąnašų sudėties lyginamąją analizę, nustatytos optimalios iškasamo smėlio panaudojimo kranto zonai regeneruoti galimybės. Esant dabartinei situacijai efektyviausias kranto zonos regeneravimo būdas – povandeninio volo (gamtinio sėkliaus analogo) 3 m gylyje kranto ruožo tarp Palangos tilto ir Birutės kalno gožos zonoje formavimas.

Reikšminiai žodžiai: kranto zonos sąnašų papildymas, dirbtinis sėklius, sąnašų granuliometrinė sudėtis.

ИССЛЕДОВАНИЕ ВОЗМОЖНОСТЕЙ РЕКУЛЬТИВАЦИИ БЕРЕГОВОЙ ЗОНЫ ПАЛАНГИ

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Р е з ю м е

Интенсивный размыв морского берега в рекреационной зоне самого популярного курорта Литвы – Паланге вынуждает искать эффективные способы его стабилизации. Выполненные за последнее время (2003–2008 гг.) работы по укреплению дюнного вала и попытка пополнить пляж наносами в береговой зоне г. Паланги дали лишь кратковременный берегозащитный эффект. На основе натурных данных в статье оценены возможности использования для регенерации береговой зоны Паланги песка, выкапываемого из подвходного канала порта Клайпеды. Учитывая полученные результаты исследований современных геодинамических тенденций береговой зоны г. Паланги, состав наносов подвходного канала порта г. Клайпеды и изучаемого участка, установлены оптимальные возможности использования добываемого песка для стабилизации береговой зоны г. Паланги.

Установлено, что при нынешней ситуации самым эффективным способом регенерации береговой зоны является формирование подводного вала (аналог природного) в прибойной зоне на глубине 3 метров на участке между Палангским мостом и мысом горы Бируте.

Ключевые слова: подпитка береговой зоны, искусственный подводный вал, гранулометрический состав наносов.

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