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THE NATURAL AND ANTHROPOGENIC FEATURES OF THE COASTAL ZONE OF THE EASTERN GULF OF FINLAND

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Abstract. The development of the coastal zone of the eastern Gulf of Finland has a long geological history and depends on the several main factors. The primary configuration of the shoreline is connected with tectonic movements, which even at present are displayed in slow uplifting of the northern coast and slow sinking of the southern one. However, the main features of the recent coastal zone were formed during degradation of the last glacial cover and essentially transformed during post-glacial period of different water bodies' existence. The processes of the modern morpho- and litho-dynamic are very changeable and expressed in the different accumulative and erosion forms of relief. The anthropogenic activity during last centuries results in local reconstruction of the conditions of existence and development of the coastal zone.

Key words: coastal zone, recent processes, geological history, Gulf of Finland.

INTRODUCTION

The eastern Gulf of Finland is the area of the Northern–Eastern Baltic Sea corresponding to the Russian Sector of the Gulf of Finland. From the different point of view, this area is very important for the Russian Federation, since the main shipping routes from the Russia to Europe are started from St. Petersburg — the biggest city of the Baltic Sea coast. More than 70% of population of the region is concentrated within the coastal areas. The main features of the state and development of geological environment in the coastal zone of the eastern Gulf of Finland were formed during long geological history of this area. It is also possible to mention about the geological hazards within the coastal zone connecting with the natural processes and phenomena, as well as with the processes derived by anthropogenic activity.

TERMINOLOGY

From our point of view, the coastal zone includes area of the near-shore bottom of the gulf up to the sea depths of intensive wave influence and also the seaside land, where the landscape forming processes are in many respects connected with the influence of the modern sea basin (Spiridonov *et al*., 2001a, b). The overland part of the coastal zone partially overlaps a surface of Littorina terrace, being confined by the forms of coastal marine and eolian accumulation. The underwater part of the coastal zone at the eastern Gulf of Finland extends to the sea for several kilometers up to the sea depth of 15–20 m (Fig. 1).

GEOLOGICAL HISTORY OF THE COASTAL ZONE DEVELOPMENT

On the one hand, the modern coastal zone of the eastern Gulf of Finland can be considered as geological ephemera fixing only a moment of postglacial development of the region. However, some considerable features of the coastal zone were formed by processes of long-time geological history of the region (Yakovlev, 1928; Markov, 1931; Malahovsky, Markov, 1969; Kvasov, Raukas, 1970; Znamenskaya, Cheremysinova, 1974; Kvasov, 1975; Rychagov, Serebryanny, 1982 etc.) situated within the boundary area between Baltic Crystalline Shield and Russian Platform. The modern appearance of the

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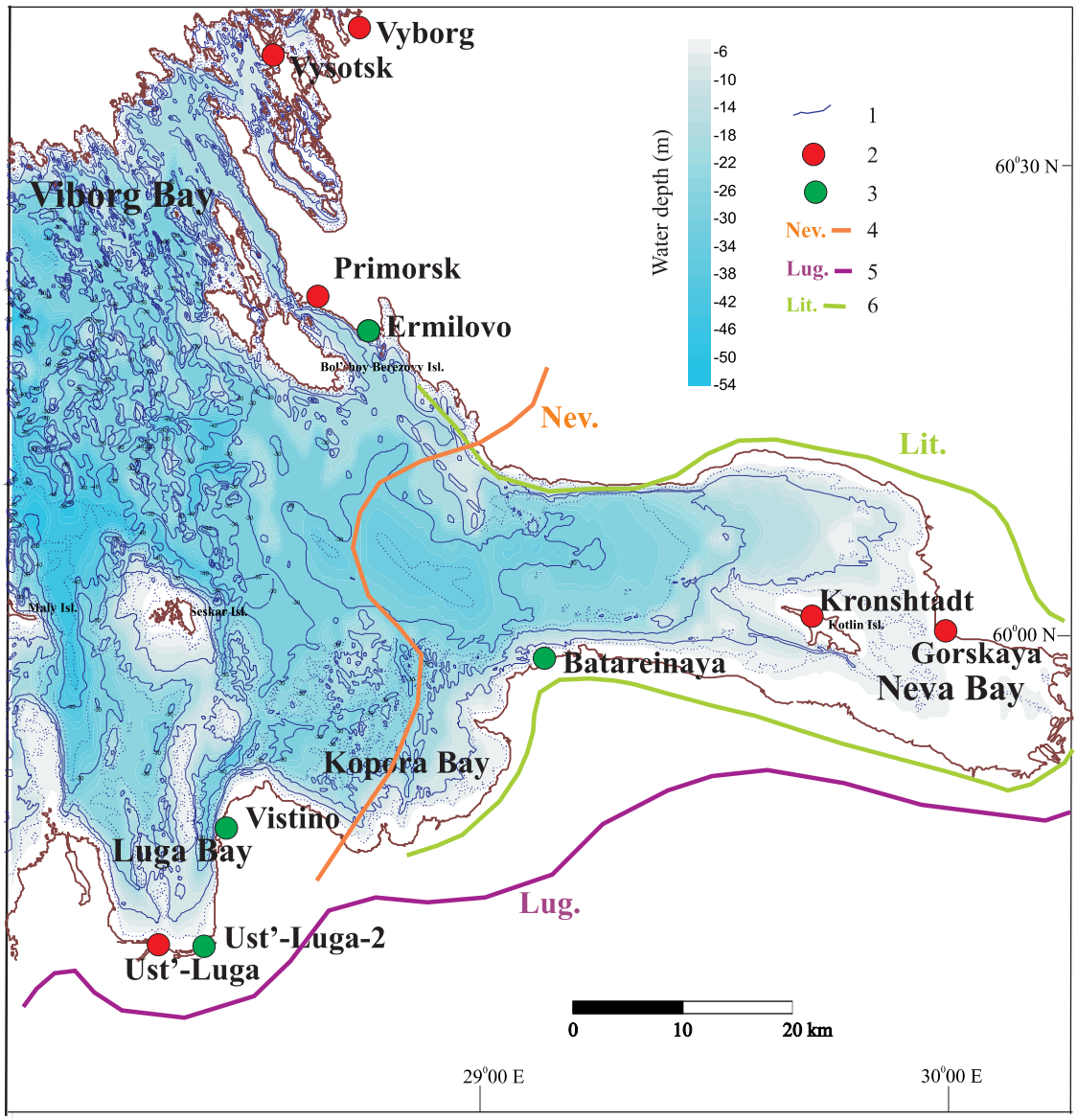

Fig. 1. Bathymetric scheme of the eastern Gulf of Finland

1 — isobaths, *2* — existing and growing sea ports, *3* — new constructed ports, *4* — supposed position of the Neva Stage end moraine forms of relief, *5* — supposed position of the Luga Stage end moraine forms of relief, *6* — supposed position of the Litorina Sea transgression coast line

Gulf of Finland coastal zone was formed first of all by tectonic movements and especially tectonic faults. In this case, practically all tectonic faults are connected with geodynamic, of the Crystalline Shield and in general are corresponded to planetary fracturing system (Amantov *et al.*, 2002) (Fig. 2). Sub-latitudinal direction of tectonic lines controls the general orientation of the gulf itself and its coastal zone. At the same time, existing turns of the coastal zone within the areas of Primorsk and Sestroretsk are most likely predefined by the system of sub-meridian faults.

The numerous deep (up to altitude of 100–150 metres) erosion cuts off and buried narrow valleys worked out in the terrigenous pre-Quaternary sediment rocks can be regarded as additional evidence of the ancient location of the coastal zone in this region (Pitulko, Spiridonov ed., 2003). In some cases, the ancient valleys filled in by Quaternary deposits are situated within the areas of modern coastal zones. Formation of these buried valleys corresponded with regional transformation of river system in Pliocene and following development of the marginal and radial system of melting glacial waters (Fig. 3).

Forming of specific loose sediment cover should be considered as the most significant event of the Pleistocene stage of Region development. This sediment cover was formed mainly by glacial and water-glacial deposits. In particular, the glacial or moraine substratum caused forming of so-called moraine coasts of the eastern Gulf of Finland. This type of the coast (or the coastal zone) is characterised by alternation of the plain shoreline with small capes and bays. Within the capes as well as

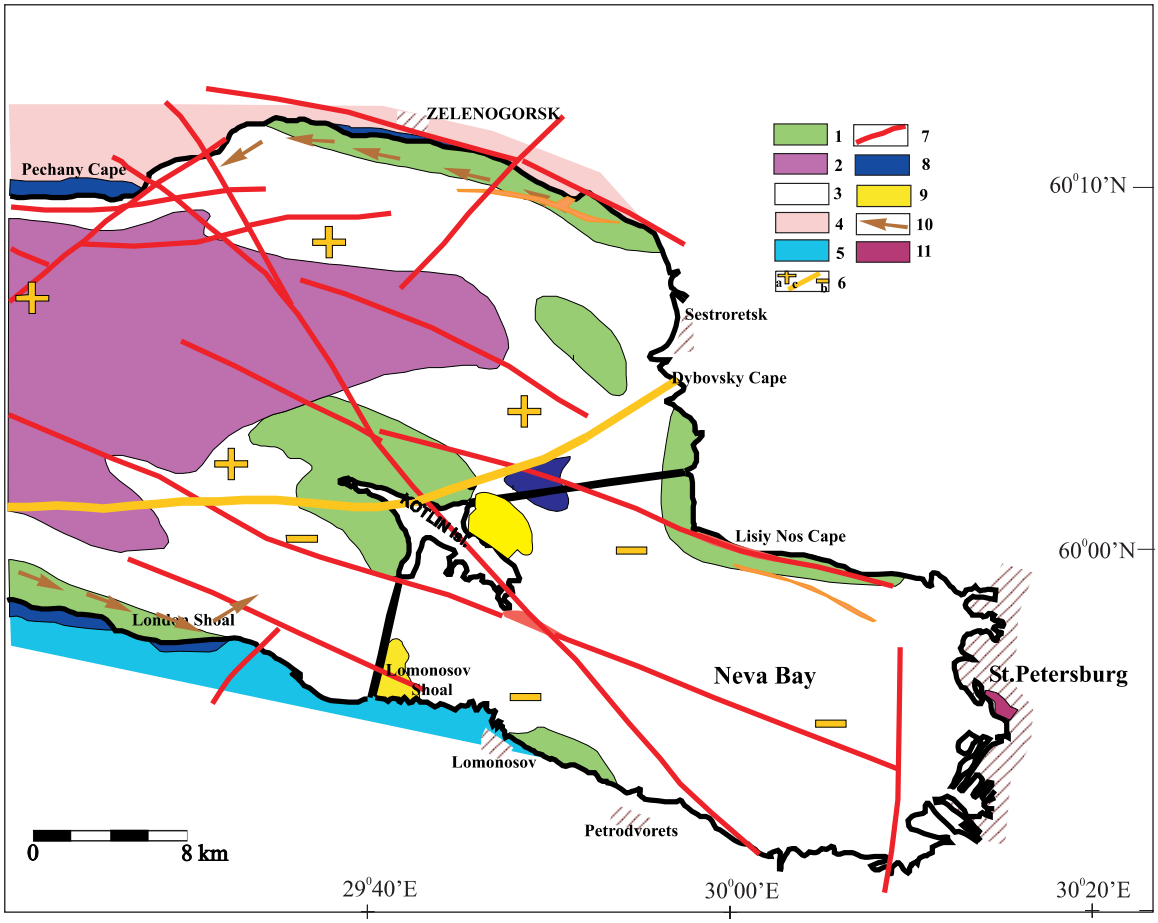

Fig. 2. Scheme of the geodynamic processes in the eastern Gulf of Finland (after Pitulko, Spiridonov ed., 2003)

Exogenic processes at the bottom surface: *1* — prevalent bottom erosion, *2* — prevalent sediment accumulation, *3* — non-sedimentation (development of mainly relict sediments); elements of endogenic dynamics: *4* — coastal zones in the area of stable regional uplifting, *5* — coastal zones in the area of stable regional sinking, *6* — areas of modern uplifting (!) and sinking (%), separated by 0-izobase (E), *7* — suspected faults; geodynamic hazards in the coastal zone: *8* — intensive coastal erosion, *9* — intensive coastal zone silting, *10* — local alongshore streams of detrital deposits, *11* — landslides

at the shallow water areas the glacial deposits outcrop that is seen by specific accumulation of boulders sometimes forming natural boulder pavement.

Besides, the coastal zone shows the clear traces of glacial influence that first of all displays in configuration of the secondary bays of the Gulf of Finland, such as Luga, Kopora and Vyborg bays (Fig. 1). In essence, these objects of the coastal zone represent original "casts" of glacial tongues during the Luga and Neva stage of Valdai glaciation in Late Pleistocene.

In the Postglacial time the area of the modern coastal zone was repeatedly influenced by active coast processes concerned with different limno-glacial and marine water basins of the various dimensions and configuration.

The transformation of the shoreline, as one of the basic boundaries of the coast zone had, as a rule, tectonic primary nature. The Late-Pleistocene and Holocene tectonic movements controlling development of the modern coastal zone had, first of all, glacio-isostatic nature. The easternmost part of the Gulf of Finland coincides with the zero isobases of the modern tectonic movements. At the same time majority areas of the coastal zone of the eastern Gulf of Finland during Late Pleistocene and Holocene underwent differentiated elevation. The level and velocity of this elevation was moderated within the area from northwest to southeast and in time from the Late Pleistocene to the Present. It seems that general elevation was non-uniform, that is seen in configuration of the shoreline of the Baltic Glacial Lake, and the hinge of this elevation is extended from coastal zone of the Vyborg Bay to the northern coast of the Ladoga Lake.

The modern tectonic movements show some inversion tendencies conditioning slow rising of the northern coast of the eastern Gulf of Finland and slow sinking of its southern coast (Fig. 2). The analysis of the modern and neotectonic movements in the limits of the area of recent coastal zone show existing inheritance of geodynamic processes and conforming morphostructural similarity during Late Pleistocene and Holocene.

Within the modern area of the coastal zone, it is possible to find out relict coastal terraces, bars and spits, areas of accumulation of boulders and pebbles, as well as water-glacial deltas and covering surfaces of water-glacial nature. These forms of relief allow to determine configuration and level of glacial wa-

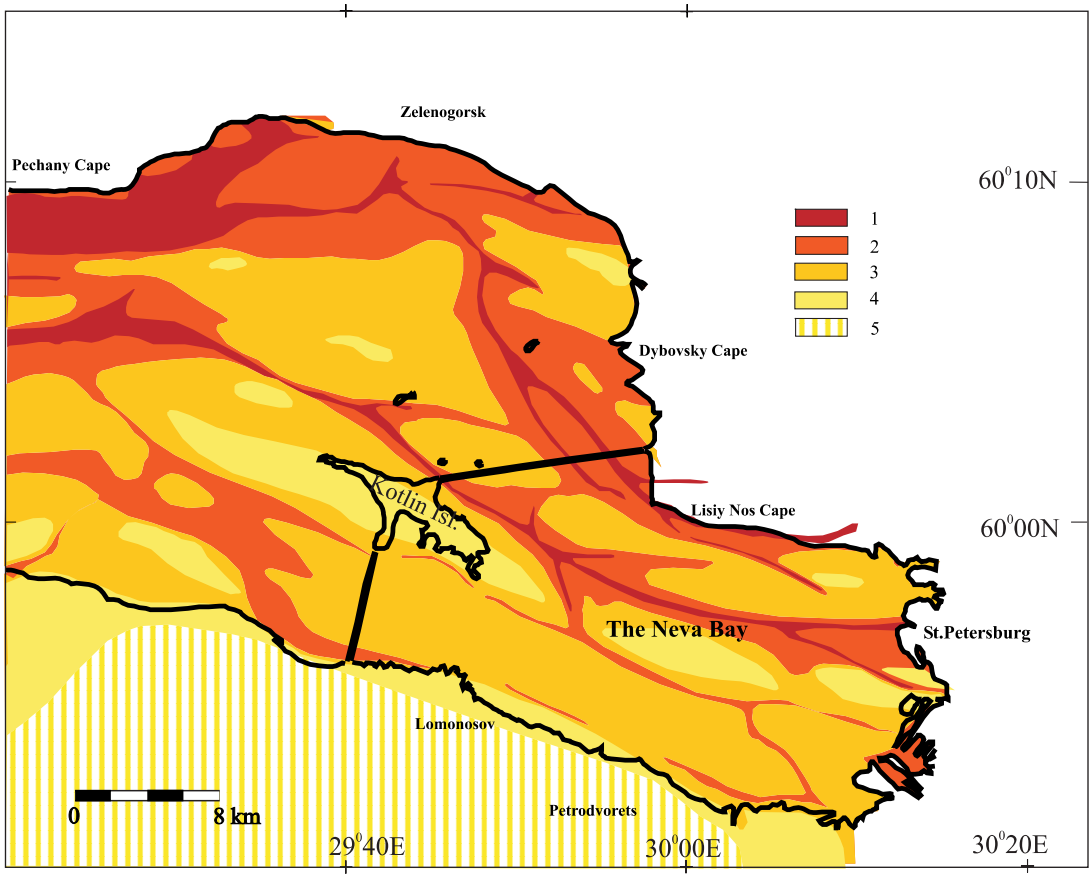

Fig. 3. Scheme of the pre-Quaternary relief in the Neva Bay (after Pitulko, Spiridonov ed., 2003)

Altitude: *1* — deeper than –80 m, *2* — –50 ÷ –80 m, *3* — –25 ÷ –50 m, *4* — 0 ÷ –25 m, *5* — 0 ÷ +50 m

ter-basins, part of which is fixed within the coasts and at the modern sea bottom.

It is quite evident that the principal features of the recent coastal zone were formed mainly during two large stages of region development: stage of fresh water basins including Baltic Ice Lake, Yoldia Sea and Ancilus Lake, and stage of brackish water basins including Mastogloja, Littorina and Limnea seas. Some relicts of the coastal line of the Baltic Ice Lake (12,000 yrs) are fixed within the recent coastal zone at the altitude mark — 36–38 metres. The coasts of the Littorina Sea (8000–6000 yrs) are determined more definitely at the altitude mark — 50 metres within the northern coast of the gulf near Zelenogorsk (Fig. 1). Thus, the modern coastal zone of the Gulf of Finland shows essential features of inheritance of the coastal zones of previous water basins existing at this area during Late Pleistocene–Holocene.

However, it is possible to consider the coastal zone of the eastern Gulf of Finland as young and developing geological object, since the modern exogenic geological processes continue its transformation. Wave activity, eolian and slope denudation-accumulative processes are the common relief-forming factors reshaping coastal zone features.

The under-water part of the coastal zone is influenced by alongshore and transversal detrital deposits flows modifying

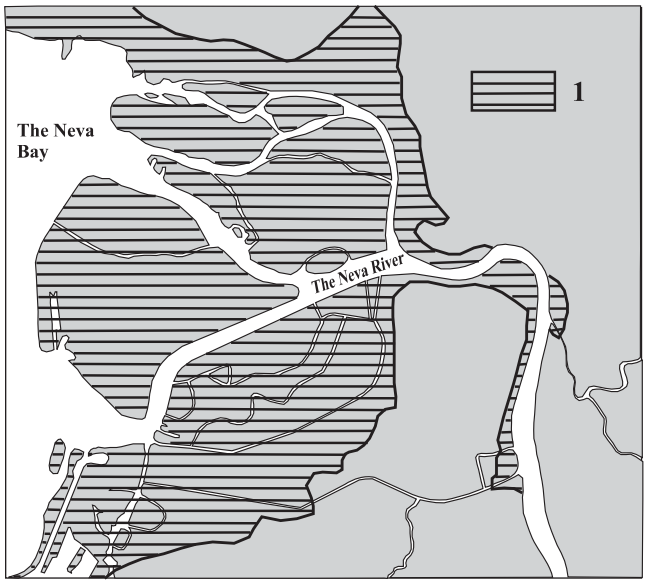

Fig. 4. The area of the Neva River "delta" within the boundaries of St. Petersburg

1 — the area of historical (November 7, 1824) catastrophic flood influence (water rise – 4.10 m)

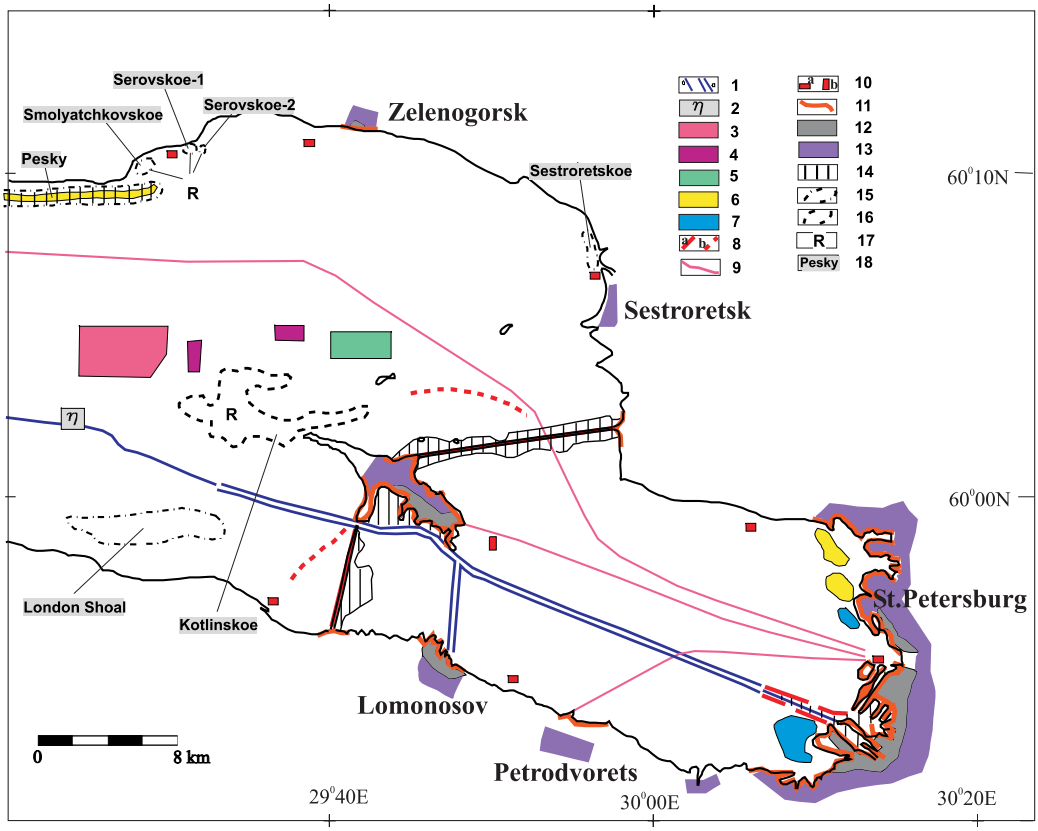

Fig. 5. The scheme of anthropogenic objects located within the Neva Bay

1 — navigable water-way (a) and marine channels (b), *2* — important anchorage, *3* — areas of training mine fields, *4* — areas of explosive dumping, *5* — ground dumping, *6* — under-water sand-pit and sandy-gravel quarry, *7* — quarry using for hydraulic-filling of urban territories, *8* — dams, embankments: a — above water, b — under water, *9* — cable, *10* — important discharge outlets of industrial objects and water-purifying constructions (a), water scoop (b), *11* — anthropogenically changed coasts, *12* — port areas, *13* — urban areas, *14* — technogenic facies conditions, *15* — areas of under-water economic sand deposits, *16* — areas of under-water economic boulder-pebble deposits, *17* — reserved economic deposits, *18* — name of economic deposit

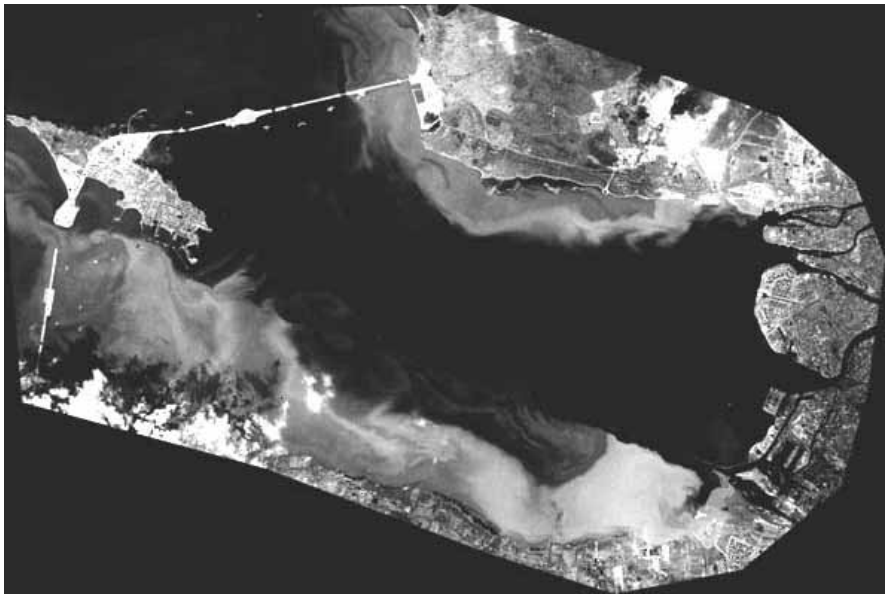

Fig. 6. The satellite photo of suspension flows in the Neva Bay derived from anthropogenic activity

sediment distribution and bottom relief, and forming alongshore bars and beaches. All this is combined with development of the flat profile of equilibrium underwater coastal slope. Additionally, the periodic fluctuations of the sea level including catastrophic flood rise of sea level, which can be combined with the often wind-effected phenomena, have the principle relief forming significance (Fig. 4). Ice abrasion connected with fluctuations of sea level in the winter season is also additional factor of active morphogenesis.

At present, some specific features of the recent coastal zone of the eastern Gulf of Finland are formed by active and almost common anthropogenic activity (Spiridonov, Winterhalter, 1995; Pitulko, Spiridonov, 2002). Locally, the coastal zone underwent almost total transformation by the influence of hydraulic-fill territories, underwater opencasts, hydraulic engineering constructions and various communications (Fig. 5). Such type of transformation is especially visible in the area of building of the Flood Protective Complex of St. Petersburg known under a title of the St. Petersburg Dam and new ports in Ust'Luga, Visotsk, Primorsk and other towns of Leningrad Region (Fig. 1). The anthropogenic influence locally causes disturbance of natural equilibrium of the coastal zone that result in intensive silting (Fig. 6), erosion, rush overgrowing of beaches, waterlogging, landslides etc.

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