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Ecology of Marine Ports of the Black and Azov Sea Basin

Introduction

> Modern ecology is a science about ecosystems uncovering the laws of their composition, structure, functioning and evolution.
>
> V.D. Fedorov, T.G. Gilmanov

The present book proposes to the reader revised, expanded and improved material partly based on the previously published monograph "Ecosystems of marine ports aquatories of the Black–Azov Sea basin (introduction to marine ports ecology)" (Odessa, Astroprint, 2012). In the new sections of this edition, particular attention has been given to ecological peculiarities of organization and general ecological mechanisms of marine port (MP) aquatories ecosystems functioning.

Coastal and estuarine MPs are typically located within the sea shelf in "land–sea" and "land–river–sea" transitional zones. MPs constitute peculiar marginal ecosystems in which natural and anthropogenic components are variously combined. All MPs have unique individual features, but, at the same time, they are all created with the main objective of reducing the wave and wind influence on ships to an acceptable level. MPs of the classical type include three main components in their structure: (1) protected aquatories, (2) artificial hydrotechnical structures (HTS) located in the aquatories and protecting them; (3) access channels (AC) with depths matching those in aquatories.

In the Black–Azov Sea basin, the targeted exploitation of the shores and the construction of port cities started during the seventh–eighth centuries BC, during the period of the "great colonization" by the Greeks. After three to four centuries, several dozens of MPs were already operating on the shores of the Black and Azov Seas. The absolute majority of modern MPs are operating at the same locations as the ports existing in ancient times. Until the fourteenth–fifteenth centuries AD, the use of rowboats and sailing rowboats with draft up to 2–2.5 m has not resulted in an urgent need for the construction of harbours with deeper aquatories. During the sixteenth–seventeenth centuries, shifting to multi-decker sailing vessels with draft up to 5–6 m placed new requirements on MPs. During the period nineteenth–twentieth centuries, the appearance of steamships with iron and, later on, steel hulls provided an impetus for construction of berths with depths of 8–10 m in the Black and Azov Seas. Berths with depths of 15–20 m appeared in Novorossiysk, Odessa, Yuzhny and Constanza during the period from the end of the twentieth to the beginning of the twenty-first centuries. Invention of steam and diesel engines allowed to mechanize the necessary dredging activities. Over 2500 years, each of the ship dimensions (length, width and draft) has increased ten times, while draft and carrying capacity (deadweight) have increased threefold. At present, ships with lengths up to 300–320 m, drafts up to 20 m and displacements up to 220–230 thousand tonnes are considered the most economically viable for navigation in the Black Sea.

At the end of the eighteenth—beginning of the nineteenth century, merchant shipping started to develop on the Russian coasts of the Black Sea and merchant harbours were constructed along with military ones. The Treaty of Küçük Kaynarca (1774) established a "free and unrestricted navigation of Russian flagged merchant ships" sailing into the Black Sea via the Dardanelles and Bosphorus straits, thus making Russia a fully legitimate Black Sea state. The opening of the commercial ports in Kherson, Feodosiya and Sevastopol was announced in 1784 by Tsar's manifesto and the Russian Black Sea trade started in the 1790s. Odessa was proclaimed a free trade zone (porto-franco) in 1794. The Treaty of Adrianople (also called the Treaty of Edirne) with the Ottoman Empire (1829) granted Russia the freedom of commercial navigation in the Black Sea straits and the freedom of trade for Russian merchants within the Ottoman Empire. At the end of the twentieth century, after the collapse of the USSR, MPs located on the northern coast of the Black and Azov Seas and in Crimea, previously belonging to Russian Empire and the USSR, were acquired by Ukraine.

MPs were located in gulfs, bays, limans and estuaries already having some natural protection. Several ports were initially built for military purposes and later became merchant ports. During the period of their existence, all ports have undergone, and continue to undergo, periods of rise and fall with human activity ceasing for decades or centuries in some of them.

Dimensions, depths, peculiarities and general economical significance of each MP are primarily determined by its hinterland, or zone of economic attraction, and the influence of associated logistic. Ships, ports and cities in which they are located belong to systems centred on the flow of merchandise, cargo and freight. Shipbuilding has progressed along with navigation and port builders have been adapting ports aquatories and infrastructures to the newly originating requirements [9].

The analysis shows that there is a close direct and inverse connection between the sizes of a city and its port. Already in ancient time, MPs acted as "city-forming enterprises". They were providing not only connections, but also economic well-being of the maritime cities. Changing of conjuncture, resource deterioration, appearance of new itineraries of transportation could all lead to reduction of the role of a port. Increase of cargo traffic creates the need for reconstruction of old berths and construction of new ones as well as dredging in MP aquatories and their AC.

There are direct and indirect ecological links and interrelationships among ships (length, draft, number, etc.), ports (sizes, depths, access channels, number of artificial HS) and marine cities (population, communications and infrastructures). Changes in one of the above-mentioned components inevitably cause direct and indirect consequences in the others. Thus, the port city of Istria throve in ancient times and then totally declined due to sand accumulation in its navigating channel. In port cities, the growth of population and number of circulating vessels were increasing the volume of domestic effluents and faecal wastes directly discharged into the protected MP aquatories, which favoured processes of local eutrophication. The more numerous the populations of ancient port cities grew, the bigger their influence on terrestrial and aquatic ecosystems. The overgrowing of hydrobionts on ships' hulls during more than two thousand years favoured species exchange between the aquatories of various MPs.

Various manufactures (smelting and working of metal, production of pottery and glass, leather working, etc.) developed in wealthy port cities over the centuries. These first workshops did not have a pronounced negative influence on the environment until the eighteenth–nineteenth centuries. During the nineteenth–twentieth centuries, the big Black and Azov Seas' ports, which nowadays are located on the continental territory of Ukraine and Crimea, were connected by railway lines with industrial and agricultural regions. MPs such as Odessa, Ilyichevsk, Yuzhny, Nikolaev, Kherson, Kerch and Mariupol became big transport and industrial complexes, with evident negative impact on terrestrial and aquatic ecosystems including MPs aquatories and adjacent sea zones.

Ecosystems of the modern MPs of the Black–Azov Sea basin in general, and of Ukrainian MPs in particular, comprise three more or less autonomous subsystems: (1) the pelagial zone, (2) the periphytal zone, (3) the benthal zone [2]. In a given port, the pelagial connects all the subsystems into an integrated ecosystem. In spite of individual differences, MPs are constructed and functioning on the basis of some general principles. MPs ecosystems experience conditions of weakened hydrodynamics and water exchange. The artificial increase in MP depths opens the possibility for the vertical stratification of water masses and the formation of a stable pycnocline. The presence of high quantities of HS (hard substrata) in MP ecosystems stimulates biological production. Accumulation of organic matter (OM) takes place as a consequence of protection and lowered hydrodynamics of MP aquatories. In MPs, the coastal shallow waters and associated biocenoses are partially or totally destroyed and the conditions of the shallow shore are substituted by deep shore ones. On the bottom and the near-bottom layer of MPs, saprobiotic situations causing mass mortality occur quite often. At the same time, there is no fishing in MPs aquatories and their biota comprises hundreds of hydrobionts species [1, 2, 10], so that MPs ecosystems are a source of larval material for adjacent ecosystems. Given all these peculiarities, the authors consider that MPs aquatories should be regarded as complete, specific aquatic ecosystems.

Construction and operation of port moles and AC not only changes the bottom relief, but also directly and indirectly influences longshore drifts flow, processes of seashore abrasion and origin of new accumulative formations. Bottom drifts enter MPs aquatories mainly via passages in HTS, notably in the correspondence of ACs.

The problem of sediment accumulation in MPs aquatories is directly connected with that in AC.

The Romanian port of Constanza has the biggest aquatory area (26 km^2) among marine ports of the Black and Azov Seas located on seashore and artificially protected. The aquatory of the Bulgarian marine port Varna-West is formed by the interconnected lakes Varna and Beloslav and has a total area of more than 20 km^2. MP Sevastopol has an aquatory of the estuarine type (i.e. Sevastopol Bay) with an area of about 7 km^2. The aquatories of Ilyichevsk and Yuzhny MPs, located in Sukhoy and Grigorievsky Limans respectively, both have an area of about 6 km^2.

Because HTS in MPs are stationary, accumulation of drifts in aquatories and changes in water level have a significant impact on their normal functioning. Fluctuations of water level have a naturally determined character and are difficult to forecast. In MPs, offshore–onshore phenomena and seiches can be observed all year round. The speed of water level rise in the Black Sea is 1.83 ± 0.07 mm $year^{-1}$ or 18 cm for 100 years [6]. Ports in the Black and Azov Seas experience nearly invisible tides; contrary to many ports, located in different regions of the World Ocean, whose aquatories are regularly washed out by tides. Tidal amplitude is 7 cm in Constanza, 8–9 cm in Poti and in 5–6 cm Odessa. The tidal currents are scarcely observed [4].

In many regions of the Black Sea, anthropogenic changes affect not only MPs aquatories, but also the shores adjacent to them. From the 1960s to the 1990s, about 600 drifts-trapping groins (for a total length slightly exceeding 30 km) were constructed on the shore zone of the South Crimean Coast. In the zone of Odessa Gulf, shore protection works were carried out along more than 12 km from Cape Bolshoy Fontan to Cape Lanzheron [3, 7].

In the Azov Sea, construction of Glukhoy canal and Temryuk port caused accumulation of drifts carried by the Kuban River on the windward side of these structures. Consequently, the vast, so called Chaika sandbar has formed between Glukhoy canal and the Petrushin arm of Kuban River; with depths decreasing from 6 to 1.5 m at a distance of 1 km from the shore [11].

For many ports, the "Pilot chart of the Black Sea" [5] indicates the water depth at distances of 1 and 5 m from berths. Taking Odessa MP for example, depth changes with distance from the berths can range from 0.5 to 3.0 m; causing heterogeneous conditions at the bottom. A similar situation is observed in most ports of the Black and Azov Seas and can be connected with the constant deposition at the HTS basis of the matter formed in the fouling biocenoses of underwater surfaces. It could also be explained by the danger of damage to berths' underwater parts during dredging and by peculiarities of the water flows in the near-bottom layer. The round form of ships' submerged hulls is compatible with such differences because, when moored, the deepest draft is at the keel part of ships' bottom.

According to international classification, ports of I, II and III class are accepting ships with draft up to 20, 12 and 9 m, respectively [8]. The deepest water ports of Ukraine are Yuzhny, Odessa and Ilyichevsk MP can accept vessels with draft of more than 12 m and, at some berths of Yuzhny and Odessa MPs, up to 15–17 m.

In sea ports, the patterns of hydrobionts distribution, the flows of live and dead (suspended and dissolved) OM and the formation of aggregates of living material are mainly determined by physical, physical-chemical and chemical processes.

Up to now, the ecological role of marine ports located on the shores of tideless seas such as the Black and Azov Seas is poorly described in the scientific literature. However, according to tentative estimations, the total area of anthropogenically modified MPs aquatories in this basin comprises more than 50 km^2. Furthermore, the cumulative length of access channels (AC) to MPs is more than 350 km and the total extension of HTS in MPs exceeds 300 km; the area of their submerged parts being over 2 millions m^2. In MPs, moles, breakwaters, berths and floating docks represent hard substrata artificially introduced into marine coastal ecosystems and are classified as artificial reefs (AR) [2]. For fouling hydrobionts, wetted surfaces of ship's hulls also represent HS. The ruins of ancient ports and towns submerged by the sea a long time ago (Dioskoyrias, Kállatis, Sinop and other) also serve as HS for fouling organisms. Taking all this into account, the authors consider the elaboration of general recommendations to ameliorate the ecological situation in MPs aquatories as an imperative task.

Contents

Chapter 1
Main Characteristics of Marine Ports of the Northern Coast of the Black and Azov Seas and of Their Access Channels

In the Black–Azov Sea basin, natural sheltered areas (gulfs, bays, limans and estuaries) served as ports already B.C. In the seventeenth–eighteenth centuries, under the Russian Empire, the MPs were called “marine shelters”. Construction of commercial harbours on the Russian coast of the Black Sea started in the nineteenth century when the creation, in 1857, of the Russian Steam Navigation and Trading Company (ROPiT) gave a huge input to commercial navigation in the Black Sea.

A port (from the Latin “portus”—harbour, quay) is a seashore area with an adjacent aquatory, usually well protected from wind and wave action, and a territory equipped for ships’ anchorage, cargo storage and loading–discharging operations. In MPs, the natural protection of the aquatory is usually completed by an artificial one. During berths construction in MPs, the coastal line undergoes smoothing and simplification. Ports are provided with infrastructure for ships maintenance and repair. Terminals for handling of container and package cargoes, wheeled equipment and other specialized subdivisions for gaseous, liquid and bulk cargos (including toxics and explosives) are also part of MP zones. Berths, located at quays and moles, are the main HTS in MPs. Ports of the classical type are built in order to satisfy the principle of “bringing the ship alongside the berth”.

In MPs, shore zones protected by harbour walls and equipped by bitts, cargo-handling gear, railways, warehouses, etc., are called quays.

Moles (from the Latin “moles”—embankment) are HTS, whose external surfaces safeguard port aquatories from roughness. One end of the moles is connected to the shore. Berths are quite often located on the internal sides of protective moles. The intra-port moles are usually called piers and are equipped with berth on two or three sides. Protecting moles not connected to the shore are called breakwaters and have no berths. They are used to protect aquatories having a large width, as for example, in Odessa and Berdyansk MPs.

HTS are constructed by various methods, using different materials and construction units. For long time berths, moles and breakwaters were build mainly from stones and concrete blocks weighing from a couple of tonnes up to dozens and hundreds of tonnes. In hydro construction, artificial concrete blocks with a regular

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form (cubes, parallelepipeds, and pyramids) are called continuous pours. In some cases, the concrete blocks are placed in regular rows (regular laying), as in Reydovy (Raid) mole and the Stary (Old) breakwater in Odessa MP. In other cases, blocks are dumped or irregularly piled, as for example in the Novy (New) breakwater in Odessa MP. For wave-protection of the moles' external surfaces, monolith concrete walls are installed at zones adjacent to the shore such as in the case of the Container terminal at Karantinny mole in Odessa MP. Berths and moles are built using metal and concrete sheet-pile walls and different pile foundations from metal and concrete. Modern moles and breakwaters are continuous (gravitational) or pile constructions. To facilitate construction and to save raw materials, there where sediments availability permits, concrete masses are cast in the form of boxes, transported by floating to the zone of installation and sunk by filling with quarry stone or sand.

Where a random distribution is possible or necessary, concrete bodies with masses of 0.5–1.5 t are used. Tetrapods (quadrupted) and dolosse (two cylinders connected by crosspiece) are the most known, but hexalegs (cross-shaped solids composed from six elements) and others are also used.

Protective constructions, built by regularly piling stones and blocks or by using sea concrete walls and sheet-pile walls, reduce the wave energy hitting against the external surfaces. In HTS built by dumping, the wave energy is dumped inside the construction by repeated reflection of the differently directed water jets. Irregularly dumped HTS create more diversified life conditions for hydrobionts.

Drifts accumulate at the external sea side of moles' basement and in pockets along the shore, while bank erosion occurs downstream of the port. This happens because the material of the longshore flow is temporarily retained by moles, breakwaters and AC until filling of the shore prominences formed by these structures. Periodical or constant dredging of ACs worsens the situation. Downstream from ports, erosion sometimes affects vast shore zones (kilometres, dozens of kilometres) as it happened after moles' construction in Sochi and Ochamchire MPs [20]. In 1915–1917, a continuous mole, about 150 m long and almost perpendicular to the shore, was constructed in Gagra. Towards 1923, as a consequence of sand accumulation on its western side, the shore line had shifted up to the mole's end while a beach line about 6 m wide was washed away over 0.8 km on its eastern side [17].

In 1978, the construction of a deepwater berth with a length of 200 m was completed in Yevpatoriya port. Within a couple of years, an artificial sandbank had formed on one side of the berth and beach erosion had started on the opposite side. The regular dredging activity in the AC to the MP became one of the causes of beaches erosion [10, 11].

The construction of jetties and AC to Ilyichevsk and Yuzhny MPs affected longshore drifts flow, intensifying the processes of beaches destruction at some shore zones and sand accumulation at others.

The aquatories of most MPs are usually accessible via one or more access channels (e.g. three for Odessa MP), which significantly limits water exchange with the adjacent zones and reduces currents' velocity in the water column of MPs. The highest hydrodynamical activity is usually preserved in the AC to the MP and adjacent zones. In the Ukrainian MPs located in gulfs shores, bays, limans and estuaries of small and "dying" rivers, vertical stratification according to density could quite often be observed with a series of negative consequences, especially in the near-bottom water layer. According to some data, the Coriolis effect is more marked in MPs than in aquatories with homogeneous water masses [24].

In MPs aquatories, the presence of protective structures, several HS, division of aquatories into separate harbours, artificial increase of depth and a series of other factors create a wide spectrum of conditions, different from those of the adjacent sea zones.

1.1 Main Characteristics of Aquatories of the Marine Ports of the Northern Coast of the Black and Azov Seas and Their Access Channels

Ecological peculiarities and ecological roles of the Ukrainian MPs aquatories are mainly determined by their position in the "sea–rivers" systems and by the salinity conditions for hydrobionts. Dissolved and suspended organic matter (OM) and biogenic matter (BM) produced in the aquatories of MPs located at rivers' mouths and in backwaters enter the lower reaches of the rivers and contribute to eutrophication in the ecosystems of riverine and coastal MPs.

Depending on their location, some MPs on the northern coast of the Black and Azov Seas belong to inner (riverine and estuarine) ports, with indirect influence on the ecosystems of coastal MPs. Examples of inner ports are Reni and Izmail MPs, as well as Vilkovo and Kiliya port-stations, on the Danube. Kherson MP, located on the Dnieper, Nikolaev MP, Oktyabrsk, Dnieper-Bug MPs on Yuzhny Bug can be classified as mouth MPs (Fig. 1.1).

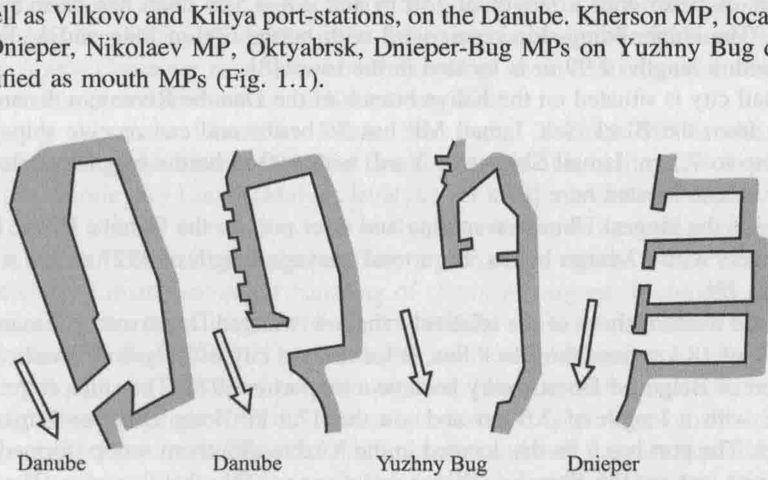

Fig. 1.1 Main scheme of the inner (riverbed) marine ports aquatories: *1* Reni MP, cargo zone № 3; *2* Izmail MP, cargo zone № 3; *3* Nikolaev MP aquatory; *4* Kherson MP, boat-yards №№ 1–3

Coastal MPs are located in gulfs and bays on the sea coast (Odessa, Skadovsk, Khorly, Yevpatoriya, Yalta, Feodosiya, Arshintzevo, Kerch, Krym, Genichesk, Berdyansk and Mariupol MPs) and on the coasts of big limans (Belgorod-Dnestrovsky MP in the Dnestrovsky Liman, Ochakov MP in the Dnieper-Bug Liman).

A number of narrow estuary type basins, formed by ancient or "dying" rivers, are used as MPs aquatories: Sukhoy Liman (Ilyichevsk MP, Fishing port), Grigorievsky Liman (Yuzhny MP, berths of "Transinvestservice" company), Uzkaya Bay (Chernomorsk MP), Sevastopol Bay (Sevastopol MP), Kamishovaya Bay (Fishing port), Balaklava Bay (Balaklava port station). MPs located in estuarine basins have the best natural protection. In such MPs, protective HTS are located at the mouth of the estuary and consists in two moles protruding towards each other from both shores and with a single passage between them. In the presence of bay-bars that separate MPs aquatories from the sea, access channels are constructed (e.g. in Yuzhny and Ilyichevsk MPs). Protective jetties, extending up to a certain distance into the sea to weaken sediment accumulation in the passage, are built parallel to access channels.

The Ukrainian MPs are mainly located on flat coasts with loose sediments. However, Crimean MPs Sevastopol, the fishing port in Kamishovaya Bay, Chernomorsk MP, Balaklava port-station, Yalta MP and Sudak port-station are located on rocky shores.

Ust–Dunaysk MP is located in the southern part of Zhebrianskaya Bay (Black Sea). It was built at the end of the 1970s mainly for handling of lighter aboard ships. It has a small aquatory and no berths. Vilkovo port-station, located in 20 km from the sea, is subordinated to Ust–Dunaysk port and has a berth with a length of 117 m and depths of 1.5–1.6 m depths. Kiliya port-station is also subordinated to Ust–Dunaysk MP and is located at 47 km from the Black Sea on Kiliya arm of the Danube. A berth with a length of 150 m and 2.8–4.5 m deep has been built in Kiliya. The shipbuilding-ship repair yard with berths 600 m long and a slipway dock with a length of 99 m is located in the town [8].

Izmail city is situated on the Kiliya branch of the Danube River at a distance of 80 km from the Black Sea. Izmail MP has 26 berths and can receive ships with drafts up to 7.2 m. Izmail Shiprepair Yard, with 600 m berths length and floating docks, is also located here [8].

Reni is the biggest Ukrainian marine and river port on the Danube River. It has backwaters with 37 cargo berths, for a total quayage length of 3927 m and a ferry complex [8].

On the western shore of the relatively shallow-watered Dnestrovsky Liman, at a distance of 18 km from the Black Sea, is located the city of Belgorod-Dnestrovsky. The port of Belgorod-Dnestrovsky became a seaport in 1971. The ships enter it via an AC with a length of 2.6 km and via the 17.1 km long Dniester–Limanskiy channel. The port has 9 berths, located in the Yuzhny Southern scoop (formed by a sand spit) and on the Shiroky (Wide) and Severny (Northern) moles. The total extension of berths is 1159 m with depths of 3.5–5.2 m near the berth walls. One passage leads into the MP aquatory [8, 18]. Bugaz port station, located at the entrance into Dnestrovsky Liman, is subordinated to Belgorod-Dnestrovsky MP and its berth has an extension of 127 m and depths up to 5.0–5.5 m.

The construction of Ilyichevsk MP started in 1957 on the western shore of Sukhoy Liman. An AC of 1.5 km channel was dug in the liman's bay-bar to connect this port with the sea. The depths near the berths were increased up to 10–14 m. The total number of berths is 28 and their cumulative length exceeds 6.0 km. The berths and floating docks of Ilyichevsk Shiprepair Yard are also located in Sukhoy Liman. Total berths' length is 2895 m, berths of the shipbuilding yard zone having a length of 210 m. The berths of ferry line and Ilyichevsk fishing port are located on the eastern shore of Sukhoy Liman. A series of small berths belongs to other enterprises. The total extension of berths and other HTS in Sukhoy Liman is about 10 km. One access leads into the port and the shipping channel with a maximum depth of 13 m passes along the liman axis [2, 8, 18].

Odessa MP is located along the western and south-western shores of Odessa Gulf and belongs to the MPs constructed on open marine shores. At present, in Odessa MP, there are 38 berths specialized in trans-shipment of various cargoes. Oil harbour and Container terminal berths occupy a special place. The berths of Odessa MP are located along the shore and on moles having various orientations with respect to the shore. Moles with piers divide the MP aquatory into 7 harbours, each one being connected with the waters of Odessa Gulf. The south-western part of the MP is protected from winds blowing from the sea and from the north by Karantinny (Quarantine) mole, Reydovy (Raid) mole and Stary (Old) breakwater. The western part of the MP is protected by Zavodskoy breakwater, Novy (New) breakwater and Neftyannoy (Oil) mole. Three passages and three ACs lead into the port aquatory. The depths of the different harbours vary from 3 up to 18 m. In 2013, the main berths and the protective constructions of Odessa MP extended over more than 9 and 5 km, respectively. Shiprepair yard "Ukraina", adjoining to Odessa MP, has HTS with depths up to 7.1 m and is equipped with three floating docks. A new Container zone with a berth length of about 850 m and a breakwater has been completed in the zone of Karantinny mole.

Among the main Ukrainian Black Sea ports, Yuzhny MP is the most deep-watered, rarely frozen, recent and fast developing. It is built on the shores and basin of Grigorievsky Liman (Maly Adzhalyk), 30 km north-east of Odessa city. As in the case of Sukhoy Liman, it is a naturally protected aquatory connected with the sea via an artificial AC. Freight-handling region № 1, on the western shore of Grigorievsky Liman, serves for handling of chemical cargoes. It consists of three specialized berths (total length 713 m) that mainly serve Private Stock Company (PSC) "Odessa Port Plant". One berth for sand trans-shipment, a terminal for handling liquid oils and Zernovoy (Grain) berth function on the same shore.

Freight-handling zone № 2, on the eastern coast of Grigorievsky Liman, includes two specialized terminals. The terminal for general and bulk cargoes trans-shipment has an extension of 915 m. The terminal for trans-shipment of chemical fertilizers, with a length of 566 m, is practically not used according to its original destination, but for grain and other bulk cargoes transfer.

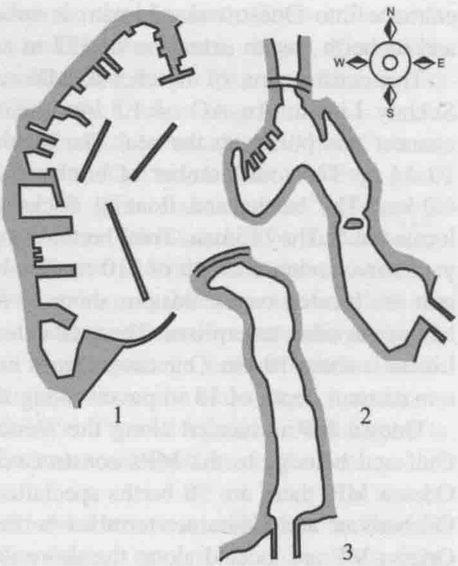

Fig. 1.2 Scheme of marine ports aquatories: *1* Odessa MP, *2* Sukhoy Liman–Ilyichevsk MP, *3* Grigorievsky Liman–Yuzhny MP

HTS of the oil terminal are located in the lower part of Yuzhny MP. In the upper part of the basin, "Transinvestservice" (TIS) company constructed a number of berths and one container terminal on the eastern shore. The depths near the berths and in the passage to them have been increased up to 15–17 m and further dredging up to 18–20 m and more is planned. About 18–19 million tonnes of various cargoes are trans-shipped each year via "TIS" berths and the total amount of cargoes transferred in Yuzhny MP exceeded 40 million tonnes in 2013.

In Yuzhny as well as in Ilyichevsk MP, the berths are located alongshore and, at present, their total length is about 7 km. According to an integrated development project, 47–48 berths with a total extension of 12 km should be constructed in Grigorievsky Liman and depths should be increased up to 20–21 m (Fig. 1.2).

Skadovsk MP is located on the northern shore of Dzharylhach Bay. The port presents a long basin with depths up to 6 m and its entrance is protected by two dykes. The port is equipped with 6 berths having a total length of 825 m [8, 18].

Port Khorly, subordinated to Skadovsk MP, is located on the southern part of the Gorky Kut peninsula and is protected by a mole from the west. Its three berths have a total length of 305 m with the depths near them ranging from 2.1 to 4.3 m [8, 18].

Big marine ports such as Nikolaev, Oktyabrsk, Dnieper-Bug, Kherson and Ochakov are located in the aquatory of Dnieper-Bug Liman and in the lower reaches of the rivers flowing into it. All of them have long access channels.

Ochakov port-station was founded in 1934 and received the statute of marine port in 1999. The port is located near the entrance into Dneprovsky Liman and on its northern shore. Ochakov harbour is formed by a double-knee mole protecting the aquatory from the south and by a breakwater. In Ochakov port, there are 5 berths with a total length of 726 m and with depths near them from 3.5 up to 5.5 m.