Annex 28

Physiographic and Climatic Characteristics of the Ukrainian section of the Danube delta and area of deep water Navigable Pass

1 Basic information about the Danube delta and dynamics of Kiliya delta formation

The estuary area of the Danube belongs to the river-delta type and consists of sub-delta plot, the length of which is about 85 km, delta (one of the largest in Europe), the territory of which is 5640 km and estuary beach about 1360 km [3]. The length of delta on its main branch is 116 km, its top is the place of division of the river in two largest branches – the Kiliya (left) and the Tulchinskiy (right) (appendix 6). The extent of marine margin of delta is about 180 km, the average breadth of the beach is 6-10 km. The total area of estuary area is about 7000 km [4].

The Kiliya branch serves as a sequel of the Danube river and is the main branch of delta. On its extent the branch forms two internal and one external (marine or Kiliya) deltas. Internal deltas were formed as a result of inwashes of miscellaneous parts of once huge The Danube bay. To the present day the majority of branches of two internal deltas died off. The largest of extant branches are Sredniy, Tataru, Kislitskiy (the first internal delta), Solomonov, Pryamoy, Babina (the second internal delta). In Kiliya delta the basic branches are the Ochakov (left) and the Starostambulskiy branches (right). Ankudinov, Poludenny, Prorva, Potapovskiy, Gneushev branches are detached from the Ochakov branch, and the Bystry, Vostochny, Tsyganskiy, Limba and other are separated from the Starostambulskiy branch. All these branches run directly into the sea.

The length of the Tulchinskiy branch is 17 km, which is divided in the Sulinskiy (69 km) and the Georgiyevskiy (109 km) branches. There is a small individual delta in the estuary of the Georgiyevskiy branch.

Northern border of delta adjoins to the radical coast of Budzhakskiy plateau and pervades on the tops of lakes Yalpug, Katlabuch and Kitay and on the systems of the Kiliya branch water-currents. The south-west border of estuary area coincides to the western shore of lacustrine - lagoon complex Razelm - Sinoye. Numerous basins (lakes, lagoons, firths), the total area of which is about 1400 km, enter into a compound of delta.

22 percent of the delta area, namely 1240 km, belongs to Ukraine; the remaining part belongs to Romania. The state border between Ukraine and Romania passes on a fairway of the Danube, the Kiliya branch and its forkings – the Sredniy, the Pryamoy, the Starostambulskiy and the Limba branches.

The present-day delta of the Danube began forming approximately 5000 years ago in the extensive marine bay, which has arisen as a result of postglacial advance of sea when the level of the Black Sea was some meters higher than the modern one. Thousand years ago the bay was partly blocked from the sea side by the long marine foreland and was transformed into a huge lagoon. Nowadays the series of sand waves, dragged inside the modern delta from the north-east to the southwest (Zhebryanskiy, Letya, Karaorman patches, reminds about this foreland. Inside the Danube bay - lagoon, under the foreland protection, a fast forming of delta replacement took place. At first the most southern branch of delta (nowadays Georgiyevskiy) come over the line of foreland [4]. Later the foreland had been broken through in the middle part by the central branch of delta (by the Sulinskiy). In the estuary of this branch the extensive delta of promotion had been formed, nowadays it is partly degraded by marine heaving.

It is believed [3], that fast promotion of the Sulinskiy branch in the sea had happened in 5 - 1 centuries BC that was promoted, probably, by lowering of the sea-level on 2-4 m about the modern one. Then the Georgiyevskiy branch became more active again, which had formed the small delta in the sea. And only approximately in the 16th centuries the northern branch of delta (nowadays Kiliya) became more active. It had by degrees increased the water-bearer and formed in a shallow-water bay two consecutive internal deltas swiftly. In the middle of the 18th century, after inwashes filling of the almost all the northern part of the bays - lagoon, the Kiliya branch had left the line of forelands and began to form the delta of promotion called nowadays marine or Kiliya.

According to I.V.Samoylov's data [5] there was no islands jet in the sea on the Bauer's map (1770) in a place of outlet of the Kiliya branch. One island is shown on the map of Pustoshkin (1775), and on the map of Kushelev (1800) seven small islands had been marked already. The further history of Kiliya delta development can be recovered by the analysis of more authentic maps from 1830 to 1980 (fig. 1) [4].

In its development the Kiliya delta had passed four consecutive phases: one-branched (1740-1800), mild-branched, when the amount of branches did not exceed 20 (1800-1856), multi-branched, when the quantity of estuary branches amounted to 40-60 (1856-1956) and again the mild-branched one (since 1957), when the quantity of estuary branches had been decreased (from 19 in 1957 up to 16 in 1980, 15 in 1989 and 14 in 1993) (tab. 1).

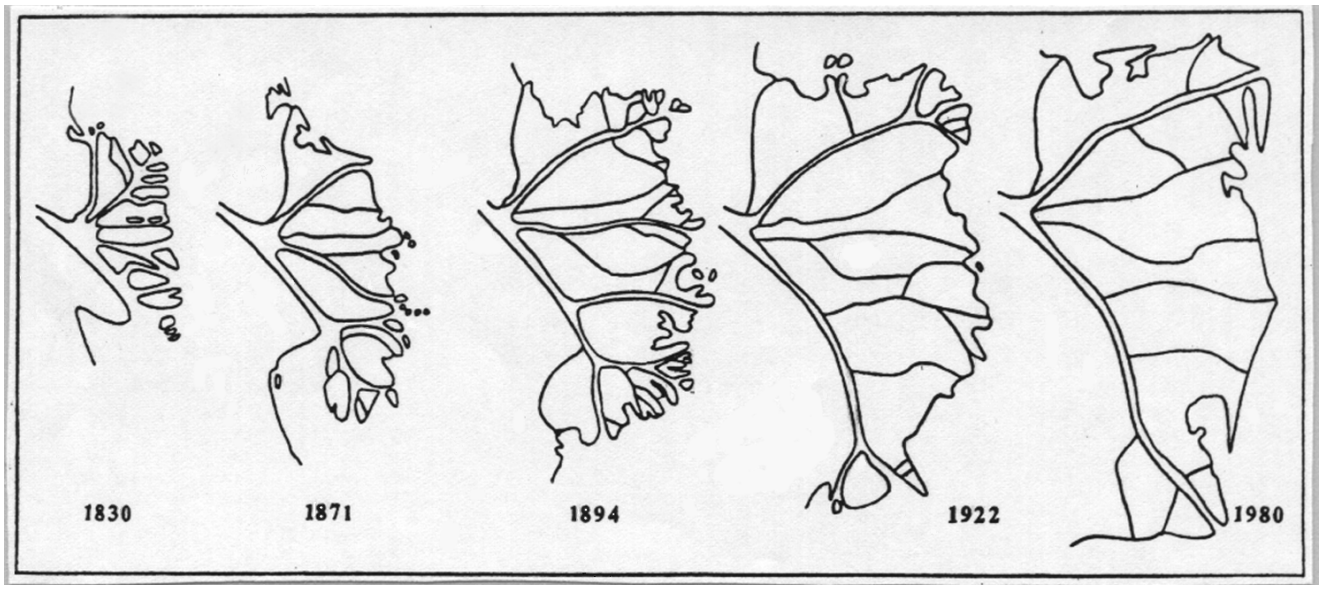


Fig. 1 The further history of Kiliya delta development

Table 1 - Morphometrical characteristics of Kiliya delta [6]

Year	Length, km		Area, km^2	Volume of an alluvial fan, km^3	Length of marine margin, km	Quantity of estuary branches
	the Starostambulskiy branch	Average				
1830	9,3	8,4	80	2,26	36,2	17
1856	13,6	11,5	111	2,89	47,0	20
1871	13.5	11,9	122	3,45	49,5	23
1883	15,5	13,6	174	4,05	55,6	56
1894	15,6	14,2	214	4,64	47,6	36
1922	19,0	16,3	285	5,66	55,2	47
1930	19,3	16,7	291	6,02	53,6	39
1943	21,3	17,4	308	6,55	56,0	25
1948	22.3	17,7	309	7,01	63.0	23
1957	22,3	18,4	328	7,54	70,0	19
1980	23,3	19,3	348	8,26	59,0	16

Kiliya delta was advanced in to the sea, always preserving its asymmetry. In the process of deceleration of delta advancement to the sea and the reduction of the quantity of estuary branches the indented marine margin of delta (MKD) was levelled by degrees. After 1930 the line of delta sand beaches became to form along a bank. Their total length increased: from 4 km in 1930 up to 12 km in 1943, 17 km in 1957 and 20 km in 1980 by degrees. Simultaneously the general length of the marine margin of delta reduced a bit, because the forelands had superimposed small bays - kuty [4].

The most active growth of Kiliya delta is marked in abounding in water 1871 - 1922; the area of delta for this time had increased for 163 km^2 at the average annual gain of

3,1 km^2. In the last decades the growth of the area of delta slowed down (in 1943-1980 it was only 1,1 km/year) in connection with an outlet of delta on deep - waters, raise of the level of the Black Sea and reduction of an effluent of inwashes of the Danube. For the period of 1955-1979 (fig. 2) the shore advanced in the areas of a confluence in the sea of the Ochakov and the Starostambulskiy branches swiftly, in a smaller measure - at the branch of the Bystry (Novostambulskiy) [7]. By 1980 the area of delta made up 348 km, volume of an alluvial fan - 8,26 km³.

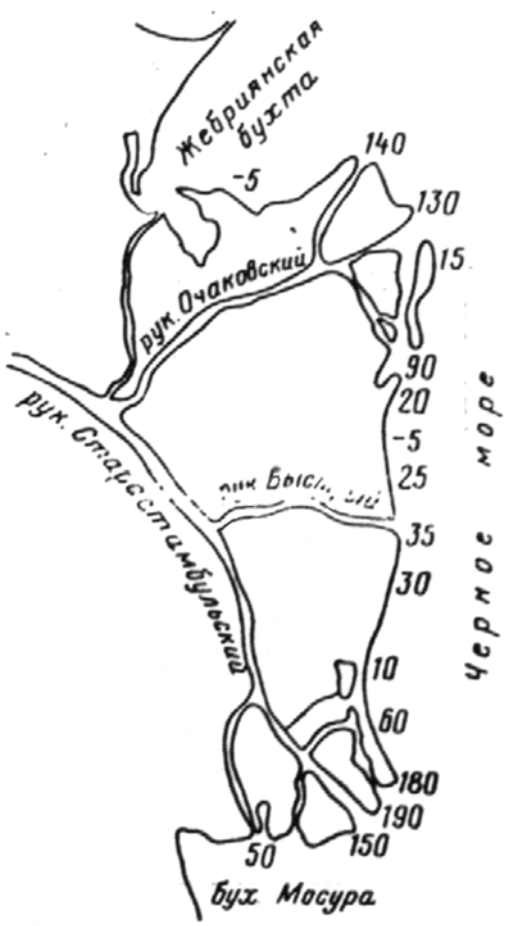


Fig.2 Schematic Map of the Chilia Delta of the Danube
(the numerals indicate average annual rates (m/year) of land advance or retreat)

In some parts of marine margin of delta of the Danube in the last 30 years washout became more active and deviation of a shore takes place. Such plots of washout of a shore are located between the estuaries of the Bystry and Vostochny branches (delta Kiliya) where washout in some years achieves 10-15 m/yr and on the big extent of a shore to the south from the estuary of the Sulinskiy branch. For 1962-1992 here the general loss of lands had made 2200 hectare (77 hect./yr); washout of a shore in the most cases was about 200 m (in some places up to 340 m) [8].

The amount of the effluent of the Kiliya branch the most abounding in water increased up to the end of 19th - the beginnings of 20th centuries, and then began to reduce, having been decreased to the present day up to 53% (tab. 2). Apparently, this redistribution of an effluent for the benefit of the Tulchinskiy and the Sulinskiy branches was stimulated by deepening and rectification of the Sulinskiy branch in 1880-1902, and also due to grinding and advancement of the Kiliya branch to the sea. For the last 140 years the amount of effluent of the Sulinskiy branch has constantly increased (especially since the beginning of the century) from 7-8 up to 17% of an effluent of The Danube.

The amount of the effluent of the died Georgiyevskiy branch was decreased approximately from 30 up to 20%. In 1984 a line of bends on Georgiyevskiy branch has been straightened. At present the effluent of Georgiyevskiy branch makes up 27% from the effluent of the Danube [4, 9].

Table 2 - Water flow distribution on the basic branches of the Danube delta

In percent from the average effluent of the Danube

Year	Distributaries			
	The Kiliya	The Tulchinskiy	The Sulinskiy	The Georgiyevskiy
1872	63	37	8	29
1895	70	30	7	23
1921	68	32	12	20
1928	66	34	14	20
1943	64	36	16	20
1960	63	37	17	20
1970	61	39	18	21
1980	59	41	20	21
1990	56	44	20	24
2000	53	47	20	27

Channel network of the Kiliya branch is very dynamic. There were large lateral branches, *viz*. Potorocha, Kartenko, Rydvan, Dibab, Kislitskiy, Stepovoy (to the north of the basic channel), Popadya, Tataru, Dzhetkovo-Saha, Repedeya (to the south from the basic channel) in the first internal delta of this branch in the 18-19 centuries. Nowadays the majority of them died off. The Kislitskiy branch still exists, but decreases the amount of the effluent (from 10% from the effluent of the Danube in 40’s years up to 5% in 70) rapidly. Stepovoy branch practically died off in 50th years and had been covered. Tataru bears no more than 1% of the effluent of The Danube. The basic effluent is centred in Sredniy branch gath-

ering about 90% of the effluent of the Kiliya branch (more than 50% of the effluent of The Danube).

In the second internal delta of the Kiliya branch the effluent is distributed on branches Solomonov (27% of the effluent of The Danube), Pryamoy (19%) and Babin (about 10%) nowadays. A set of lateral branches died off: Laptysh, Murza, Chat, Zolotoy, Dyra, Stepovoy (Dunayets), Abraimok (to the north from the basic branches), Chernovka, Sulimanka, Khamdzhyyev, Bretushka, Potakova (to the south of the basic branches).

In Kiliya delta a process of concentration of a run-off of the water in the limited amount of the largest branches evidently takes place (tab. 3). Thus such large branches as Polunochnyy, Shabash, Sredniy, Zavodninskiy has already died off; rather large branches such as Potapovskiy, the Starostambulskiy, and as well as small lateral branches such as Belgorodskiy and Limba reduced in the share of the effluent. At the same time the branches became more active in the direction of the Starostambulskiy (headstream) – the Bystry. It is evident that a pronounced redistribution of the effluent from the Ochakov system to the Starostambulskiy takes place. These branches would die off in the middle of XX century. [4, 9] but for the constant deepening of an inlet in the Belgorodskiy branch and deepening of a bar of Prorva branch.

Table 3 – Water flow distribution on branches of Kiliya delta in% from the average effluent of The Danube

Branch	**1894-1895**	**1942-1943**	**1958-1960**
Ochakov			25,3
Belgorodskiy	1,4		0,1
Polunochnyy	1,0	0,4	0
Prorva	10,0	4,6	6,1
Potapovskiy	5,7	20,0	15,0
the Starostambulskiy headstream			37,2
Sredniy	10,5	1,7	0,7
the Bystry		6,6	10,2
Vostochnyy		1,0	1,5

Continuation of table 3

Branch	1966-1970	1976-1980	1986-1990	2000
the Ochakov	20,7	18,0	16,9	14,5
the Belgorodskiy	0,1	0,1	0,1	0,1
the Polunochnyy				
the Prorva	7,7	7,6	7,6	7,1
the Potapovskiy	8,2	4,3	3,1	2,7
the Starostambulskiy headstream	40,5	40,7		38,5
the Sredniy	0,2	0,1	0	
the Bystry	12,4	14,3	16,5	17,6
the Vostochnyy	1,7	2,3		2,3

The Bystry is a most perspective branches of Kiliya delta; it existed in Kiliya delta even in the beginning of 19th century. In connection with degradation of the other minor branches in the southeast part of Kiliya delta the share of the effluent of the Bystry steadily increased. In the end of 19th - the beginning of 20th century it made up ≤5% of the effluent of The Danube. Since the 40ths, this share has increased from 6,6 up to 17,6% gradually.

The most dynamic plots of the channel network of delta are the delta bars. Their natural depth does not exceed 2-2,5 m even in the most abounding in water branches (the Potapovskiy, the Bystry, the Starostambulskiy, the Georgiyevskiy) [10].

The basic morphological elements of the delta bar (fig. 3) are the left and the right estuary forelands (1,2) and their underwater parts (3,4), the central sea bar or the bar part (5), the bar hollows (6). The line, perpendicular to the axis of the stream passing through the extremity of the shortest surface estuary foreland, is considered to be the estuary range (7). The delta bar has a crest (7) – this is a line connecting estuary forelands and passing through the most shallow-water parts of sea bar [11].

Morphological and morphometrical characteristics of delta bars depend on the run-off of water and inwashes of the river or the river-delta branch and the features of the estuary beach (depth and fall of the bottom, heaving, rising tides, whipped and fetched phenomena), as well as ice processes and artificial measures conducted on the estuary plot of the river and beach.

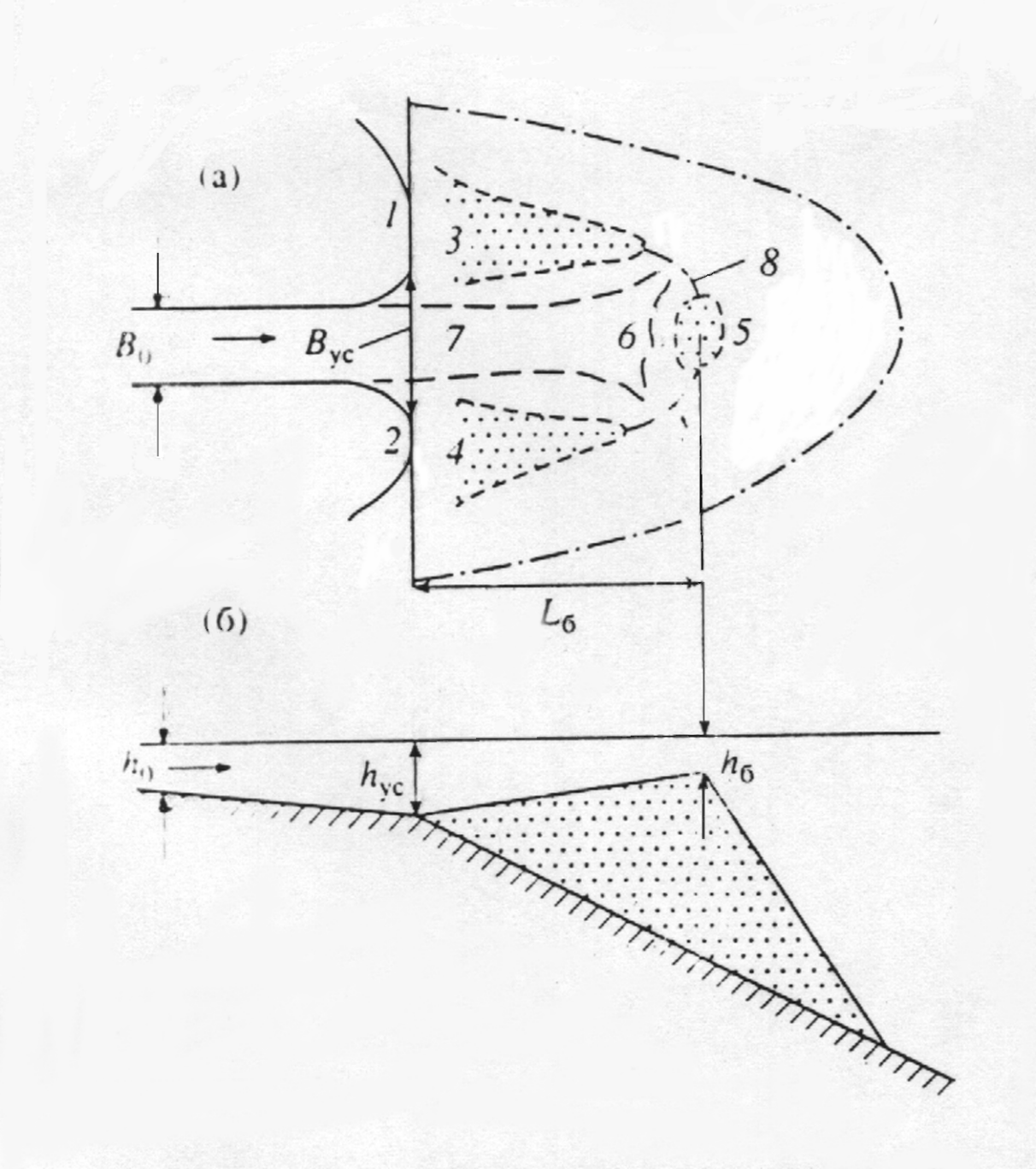


Fig. 3 The Plan Showing the Delta Bar Layout (a) and Cross-Section (b)

1,2 – the left and right estuary forelands; 3, 4 – their underwater parts; 5 – the central sea bar or the bar part; 6 – the bar hollows; 7 – the estuary range, the delta bar crest; $L_б$ – the bar length; $B_б$ – the bar width (the width of isobathic curve in the estuary), $h_б$ – maximum depth of bar hollow; B_{yc} – the estuary range width; h_{yc} – the average depth in the estuary range, B_y – the average width of river channel in the mouth section; H_y – the average river depth in the mouth section.

In the non-tidal rivers estuaries the effluent of inwashes of a water-current and energy of marine heaving have a basic influence on forming of bars and their dynamics. The role of the effluent of inwashes in a bar morphodynamics increases in a snow melt flood, and a role of marine heaving - in a mean water. Depending on combination of these two factors in non-tidal estuaries of the rivers river bars(I) and river - marine (II) types are formed [12, 13]. The second type of bars, typical for the branches of the Danube delta, consists of four subtypes.

Promotion of a bar and snowmelt flood and partial wave breaking down in a mean-water is typical for subtype IIa. The delta bars of the large branches having well expressed estuary forelands, bar part and 1-2 bar hollows relate to the bars of this subtype.

Promotion in a snowmelt flood and practically complete wave breaking down in a meanwater is peculiar to the bars of subtype IIб. Such bars are formed in the medium-sized branches. They are poorly advanced to the sea, their estuary forelands are very short, bar part are not expressed and frequently have only one bar hollow.

The basic features of the bars of the subtype IIв are negligible promotion in a snow-melt flood and exceeding wave breaking down in mean-water. Such bars can be formed in the estuary of the small river-delta water-currents. The bars of this subtype are split along the seacoast, their estuary forelands are very short, usually the bar hollows are curved aside a prevailing alongshore flow of inwashes.

The blocked bars of subtype IIг are formed in the estuaries of the dying off branches. In a mean-water the wave effect can superimpose the channel flow by wave-cut slanting completely.

Characteristics of the bars are changed during the natural or anthropogenous redistribution of the effluent between the branches. The bars are extended when the effluent of branches are consequently increased and their depth is normally increased [12, 14]. In particular the bar length in the estuary of the Bystry branch has been increased from 500 up to 1400 from 1940 to 1973, and then - up to 2500 m by 1994 (fig. 4). The bar was appreciably advanced into the sea, and its subtype II-б was replaced by subtype IIa for the last 30-40 years [11].

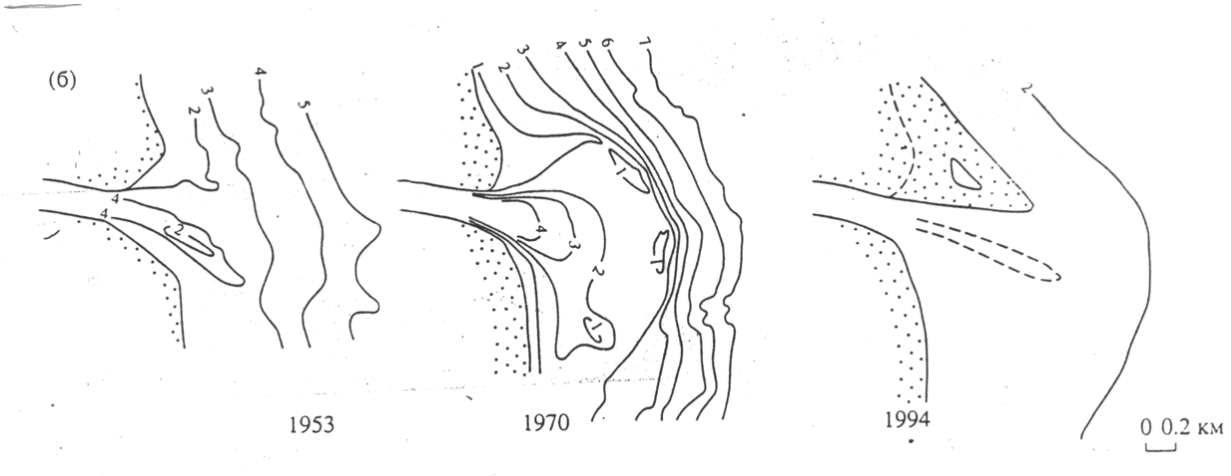


Fig. 4. The Plan Showing the Bar Development Process in the Mouth Section of the Bystre Branch (Chilia Branch of the Danube Delta)

The area of the Danube delta relates to the deflection areas with the speeds of land lowering ~1 mm / year. According to [11] the intensity of land subsidence makes up 1,8 (Seaside, 8 cm for 40 years) - 0,2 mm / year (Reni town, 0.8 cm for 40 years). This phenomenon can be explained by a deflection of the earth crust under the heaviness of river-delta sedimentation and their gradual condensation [15].

2. Geomorphology and relief

In the geomorphological plan the territory of Kiliya delta of the Danube is within Dunaysko-Dnestrovskiy subregion of geomorphological area of Prichernomorskaya lowland and flat Crimea. The surface of delta is almost horizontal, with small rise in northern part where its crossing to loessial steppe it is raising above the sea level not more than 5-7 m of the absolute mark.

Its highest parts are sub channel patches and seaside foreland of the islands, the average relative height of which is 0,5-1,0 m. The central parts of islands have the flat lowered relief with lakes and channels.

Sub channel patches are formed along the branches and erikos. The asymmetric structure caused by washing away activity of water-currents is peculiar to them. The highest parts of patches are located near water-currents. They are lowered in the direction of the center of islands, which defines the general relief as a saucerform. Forming of the patches directly depends on the magnitude of inwashes, especially during snow melt flood, owing to their increase at the expense of sedimentation of slurry and sand. Thus the height of the patches in

the crown of islands (1,0-1,5 m) is considerably large in comparison with the bottom (0,5 m) where the snowmelt flood is much weaker. The patches are interrupted by lowerings of the miscellaneous area, which have been formed in the places of former interisland water-currents. Subchannel patches are the places of the basic forestry forming and, partially, meadows.

On the territory of Kiliya delta of the Danube there are artificial raises - dikes, shafts alluvial (formed owing to deepening of the channel plot) except natural ones.

The seaside forelands are the positive ground features besides the sub channel patches. They are formed on the defined distance from the islands being a result of the inter-actions of the water-currents and the sea. At the first stage (Vostochnaya foreland, for example) they have no appreciable rises of the relief, negligible as for the length (up to 1,5 km). Seaside forelands play an important role in the desalted bays forming. Increasing in the sizes, they fence off a part of the beach shoals from the seawater influence. Further on the upper plots of forelands incorporate with the sub channel patches of islands, forming the bay, which is transformed to a half-closed basin gradually. Depending on the character of alluvial process the seaside forelands incorporate to the land geocomplexes of delta further and function altogether as a structure of geocomplexes either of the island.

Stentsovsko-Zhebriyanskiy fluxes (SZhF), which are the internal basin of initial delta of the Danube, may serve as an example. These fluxes were formed after the ancient marine firth siltage, which had been separated from the sea by Zhebriyanskiy foreland. In the central and eastern parts of fluxes on depth of 4-7 m the plastic slurries of firth origin with initializations of numerous marine shell macaroni products has been found out, that proves the existence of the marine superficial firth here in the past. Fluxes are located in the northern part of delta between the inhabited locality Kiliya and Vilkovo. The fluxes are separated from Solomonov branch of Kiliya delta of the Danube by the sub channel levees and a radical shore, and in the southeasten part from the Black Sea –by sandy intersperse – Vilkovo composed of siltage sands predominatingly of marine origin.

3 Climate

The climate of Kiliya delta is moderately continental with rather short and warm winter and long, hot summer. Among the flat areas the Black Sea Coast is characterized by the warmest winter (the average temperature of January is 2, 0 ^{0}C). The frost-free period continues up to 200 days, vegetative - 235-245 days, the sum of active temperatures is 3500-3600 ^{0}C. The mid - perennial amount of precipitations achieves 400 mm, and evaporation power - 800 mm / year. According to the general climatic zoning of Ukraine the territory relates to the continental area of the climatic zone of moderate latitudes, and according to the agroclimatic zoning of the territory of Ukraine - to the very arid moderately hot zone with mild winter.

Duration of solar radiation in the Danube regions exceeds 2300. The highest month significances are in July - till 350 hours, the lowest - in December - within 60 hours. The total solar radiation makes up to 4800 MJ/m^2, minimum is in December (about 110 MJ/m^2) and a maximum - in June (up to 800 MJ/m^2). The radiation balance during one year is positive and for a year is about 2100 MJ/m^2. The large part of heat of radiation balance is spent for turbulent heat interchange of the earth's surface with the atmosphere, the rest - for moisture evaporation from the earth's surface.

The atmospheric circulation has a well-defined seasonal character. During a year about 48 revolving storms and 36 anti-cyclones pass on in the south of Ukraine at an average. Anti-cyclones are less mobile, therefore anticyclonic weather lasts about 230 days, and cyclonic - up to 135 in the course of a year. Cyclonic activity is more intense in the cold periods of a year, the amount and duration of anti-cyclones increases in summer and in autumn.

Short and rather warm winter proceeds from the middle of December till the second decade of February. The beginning of spring falls on the last decade of February and the first decade of March. The long and hot summer begins in the first decade of May and lasts till the third decade of September. Autumn begins at the end of September - the beginning of October.

The average temperature of July is 22,4-23,7°C in miscellaneous areas of delta. The greatest raise of monthly average temperature is overseen within the period from April to May (on 10^0), and the decrease gradually on 5-6°C takes place every month since August till December. The annual amplitude of temperature between the coldest and the warmest

months is 24,4°C. The amplitude of daily average temperatures makes up 41,5 °C. The absolute annual amplitude of temperatures is 70°C. The frost-free period proceeds within 200 days.

The least relative humidity is fixed in May when the air temperature (up to 70%) is increased rapidly, the greatest - in January (up to 90%).

The mid-annual temperature of water in delta of the Danube is 12,7°C. Waters of the estuary part are getting warm mostly in July - August (at an average up to *24,1°C*). The maximum in this period reaches 27,6°C. The duration of the period with the temperature of water up to 5°C makes up 265 days (16.03-06.12) at an average, up to 10°C - 213 (10.04-09.11), up to 15°C - 16 (04.05-13.10), up to 20°C - 108 (31.05-16.09).

Abundance of heat, water and high fertility of soils promote the development of dense vegetation, moisture-loving including, which occupies fluxes, shores of water-currents and basins. The most spread is cane, which occupies more than 2300 km^2 (about 1850 km^2 – in the territory of Romania). Cane-brake in delta of the Danube are the most compact in the world. There are afloat and fixed thick carpets of died and alive greenery - "plaura", formed from the residuals of cane, reed-mace, bulrush in some lakes of delta.

The fauna of delta is very rich and diverse. 150 species of birds, inherings to 18 groups inhabit and hibernate here [3]. White, grey, red and yellow herons, big cormorant, pink and curly pelicans, grey goose, the mute swan, grey duck, bald-coot and other are the most spread. Among the mammal such as wild boar, mink, otter, muskrat, hare, wild wildcat etc. live in the delta.

Delta – is the place of spawning and graziery of valuable breeds of fishes; ways of migration of checkpoints and half – checkpoints fishes pass through it. Ecological effect of delta is felt far outside of it. In delta natural reserves, including the Danube biosphere reserve, are located.

4 Hydrophysical conditions of delta formation

The average annual aquatic runoff of the Danube for the period from 1921 till 1993 made up 203 km^3 per year (6460 m^3/sec) (tab. 4). Mid-annual flow rate of the Kiliya branch of the Danube is 3990 m^3/sec, mid-annual effluent volume of the Kiliya branch is 126 km^3.

Table 4 - Perennial characteristics of water runoff and The Danube inwashes.

Period	Average water consumption, m^3/s	Maximum drain of water, m^3 per sec.		Average drain of inwashes, kg/s	Average feculence of water, gr/m^3
		average	maximal		
1921-1960	6320	10100	15300 (1941)	2150	340
1961-1993	6630	11700	16000 (1970)	1340	202
1921-1993	6460	10800	16000 (1970)	1790	277

A share of the Kiliya branch makes up 61-62% from the total amount of an effluent for the perennial period. In turn, at bifurcation of the Kiliya branch in a marine part of delta in the Starostambulskiy branch passes about 67% of an effluent, in the Ochakov branch it makes up 30%, in Ankudinov is 2-3%, in Belgorod and Sredniy up to 1%. For the period since 1884 till now the length of the Starostambulskiy branch has been increased for about 9 km, Ochakov for 6 km, Belgorod for 2 km, that accordingly has changed a share of an effluent which passes through them (see tab. 2, 3).

The most big-water months in a year are April, May and June the share of which makes up 10-12% of the annual water runoff (tab. 5). The least effluent is observed on September - October (about 5,5-6% of an annual effluent). Maximum drain of water in a high-water reaches 15-16 thousand of m^3/sec. Drain of water are dropped up to 1300-1500 m^3/sec in a mean water[4].

Table 5 - Averaged intraannual the Danube flow distribution for the period of 1921-1997, m^3/sec.

Month											
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
3700	3960	4660	5400	5690	5190	4370	3330	2800	2630	3030	3570

The note: flow rates since 1950 were measured at top of the upper internal delta - at Izmail fold (50 km above the city of Kiliya on Kiliya narrow strait), for the period till 1950 flow rates has been recovered.

In the last decade the sharp swing over of an effluent of the Danube from 132 up to 236 km per year (tab. 6) has been marked.

Table 6 - Dynamics of annual volume of an effluent of the Danube, км^3*

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Effl.	213	207	177	132	198	172	154	181	230	236	224

***** *According to the data of Izmail Hydrometobservatory.*

Non-reversible drawoff in the Ukrainian part of delta consists of 0,9 km/year at an average. Economic activity has not caused the reduction of a run-off of water of the river, moreover, the period of 1961-1993 (when the water storage basins on the Danube and its runs were built and irrigation diversion had been increased) appeared to be more abounding in water, than the period of 1921-1960.

At the same time for the last decades the average intensity of flow for October (approximately on 500 m^3/sec) have appreciably increased, and the average intensity of flow for May, on the contrary, were lowered (approximately on 800 m^3/sec) as a result of a control of an effluent of the river [15].

In the Kiliya branch the mid-annual intensity of flow were lowered almost for 570 m^3/sec (at an average from 4250 up to 3680 m^3/sec), average intensity of flow for October have increased approximately on 70 m^3/sec (with 2740 up to 2810 m^3/sec), and for May were decreased approximately for 470 m^3/sec.

The greatest flow rates are fixed, as a rule, in May, within the period of passing of a spring snow melt flood, and the minimal ones - during an aestivo-autumnal low-water. Extreme intensity of flow in delta of the Danube are shown in tab. 7.

Table 7 - Maximum intensity of flow in Kiliya delta for the period of 1921-1997, m^3/sec

River-Fold	Daily average flow rates	
	Maximum	Minimal
Kiliya narrow strait – Kiliya	8380	1410
Kiliya narrow strait – Vilkovo	9290	1360

Changes of the Kiliya branch effluent are caused by two reasons: "external" (change of an effluent of the Danube) and "internal" (redistribution of an effluent between branches). For the period of 1958-1997 the share of the Kiliya branch effluent in an effluent of the Danube was decreased from 62 up to 58% under the average conditions and from 65 up to 59% in a low-water [15]. Therefore in a sleeve reduction of mid-annual the intensity of flow has been increased, and ascending of the mean water rates was slowed down to some extend.

The angles of a water table in Kiliya delta are changed within the limits of 1-7 cm/km (disregarding the whipped-fetched events).

The Danube delta level regime is characterised by sharp and continuous fluctuatings during the year. In its annual course the high spring-and-summer snow melt flood, autumn

and winter high waters - snow melt floods, the low summer and winter low water is outlined. Spring snowmelt flood is characterised by the highest levels, and takes place almost every year (from March till July) and passes with the several waves, superimposed on each other. The aestivo-autumnal low-water (that takes place in the period from July till November) is characterised by the lowest annual horizons. Low-level aestivo-autumnal high waters, which spikes exceeded spikes of a spring snowmelt flood in shallow years (1972, 1974), were sometimes observed. In the period from December till March winter high waters, the spikes of which in some years (1942,1985, etc.) was observed also could exceed the spikes of spring snow melt flood. Largely it is linked to formation of ice gorges, the reason of which were the exclusively high levels on the marine delta part (1925, 1946, 1967, 1998).

Perennial amplitude of levels fluctuatings in city-Reni range (the distance is 136 km from the delta margin) makes up 6,26 m (the maximum level is 5,83 m, the minimal is 0,43 m), in the Kiliya range (distance from delta margin is 47 km) - 3,04 m, in Vilkovo range (distance from the delta margin is18 km), connecting the lower internal and marine deltas, - 2,39 m and 2,09 m in harbour area of the Black Sea adjacent to delta.

Characteristic settlement water levels in various ranges are introduced in the tab. 8.

Tab. 8 - Daily water levels (mBS) of various provision in the period of 1990-2002

Provision, %	Name of water posts and points							
	the Prut mouth	Reni	Izmail Chatal	Izmail	Kiliya	Vilkovo	Bystroye, km 10	MKD
1	5,41	5,18	3,85	3,22	1,71	0,83	0,61	-
10	4,60	4,33	3,11	2,53	1,31	0,63	0,46	-
50	2,81	2,66	1,87	1,50	0,71	0,29	0,19	-
99	**0,49**	**0,41**	**0,17**	**0,05**	**-0,18**	**-0,24**	**-0,26**	**-0,48**

For settlement for shipping industry according to snip 2.06.01-86 the lowest shipping water-level by provision of 99%, defined on the daily data for the paleocrystic period is accepted.

Delta basins and fluxes are the natural effluent regulators, collecting a part of water on the snow melt flood rise and returning it in the branch on the snow melt flood recession and in the mean water. The areas of delta deluging on unreinforced spaces depend on the flow intensity of the river. Earlier all delta territory except for the high patches, deluged at the flow intensity about16000 m^3/s. Owing to branches reinforcement and islands at the flow intensity 16000 m^3/s in the Ukrainian part of delta no more than 1/4 of the territory is

deluged, that has resulted in raise of maximum water levels in the snow melt flood on 0,2-0,3 m. Complete double-ended delta branches reinforcement can increase maximum levels of water for 0,5-1 m [4].

Whipped-fetched phenomena have the defined effect on the level regime of internal Kiliya delta of the Danube. Whipped phenomena are formed by the action of western winds, fetched - eastern directions. From the winds of wavedangerous directions, the activity of which is the factor of shores processing intensity, the winds of N, NE, E, SE and S rhumbs, creating heavy sea and longshore transference of inwashes to the north from Bystryi branch, are the most important. The closer to delta margin, the whipped-fetched phenomena effect is stronger. Fetches, caused by strong north-easten, eastern and southeastern winds, sometimes on the Danube beach makes up to 1 m. The greatest fetch has been fixed on December 5-9 1945, when the magnitude of water-level rise was 78 cm in Vilkovo region, 59 cm – in Kiliya region and 4 cm – in Reni region. Thus a number of islands had been flooded in the marine delta part. At the wind change the fetch can vary on whip as it was observed on 20.11.1960, when the fetched rise of the level up to 45 cm was interchanged on fall up to 75 cm. Thus, the whipped-fetched phenomena considerably influence on forming of the delta level regime.

The propagation fetch length in delta is the bigger, the more is their magnitude in the beach and less the river effluent. The fetch in the sea of 1 m can be spread by the magnitude of 350 km at the Danube flow intensity about 3000 m^3/s. So, the fetch magnitude on January, 30 - on February, 2, 1962 has made: up the beach of 88 cm, in Prorva (3,6 km from the sea) - 56 cm, in Vilkovo (18 km) - 50 cm, Izmail (93,6 km) - 30 cm, Reni (163 km) - 10 cm, Brail (206 km) - 8 cm. The ordinary fetches, the height of which is 0,4-5 m) do not spread further than 200 km from the sea.

Even the strongest whips on the estuary beach makes up no more than 0,6 m. Such whips are spread in the delta branches to the distance up to 100 km. So, whip in September, 28-30, 1959 has made: on the beach of 56 cm, in Prorva - 36 cm, in Vilkovo - 40 cm, in Kiliya - 24 cm, in Kislitsy (68 km from the sea) - 6 cm. Whip was not spread up to Izmail (94 km) [4].

In tab. 9 the meanings of the Danube monthly average levels in Kiliya delta for the periods of observations are indicated: 1921-1998 - on the Kiliya ranges (1) and Vilkovo (2),

1945-1998 - according to Primorskiy post in Zhebriyansk bay of the Black Sea (3), actually on the threshold of marine delta margin.

Table 9 - Monthly average water-levels of the Danube Kiliya delta for the period of observations, m

N	Month												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
1	0,56	0,65	0,84	1,07	1,13	1,02	0,77	0,44	0,26	0,20	0,34	0,53	0,65
2	-0,04	0,09	0,15	0,25	0,28	0,23	0,13	-0,03	-0,13	-0,16	-0,09	0,01	0,06
3	-0,14	-0,13	-0,10	-0,06	-0,06	-0,06	-0,10	-0,13	-0,18	-0,20	-0,20	-0,17	-0,13

The statistical analysis of the data concerning the actual mid-annual ones which are the average for the most shallow month (October) and the most water abounding month (May) water-levels on hydrological posts (h/p) in the Kiliya branch of the Danube delta (Izmail, Kiliya, Vilkovo) and on the estuary beach (Primorskiy) for 1958-1997 has shown, and it is evident that the mid-annual water-levels on h/p Izmail and Kiliya were sank, and on h/p Vilkovo and Primorskiy were increased; monthly average levels during October on all posts were increased; on h/p Izmail and Kiliya the mean levels during May were sank, and on h/p Primorskiy were increased a bit; on h/p Vilkovo the trend of May levels is not detected [15]. The main reasons of water-levels changes are : in the crown of branch (Izmail, Kiliya) – the changes of the branch effluent, in the bottom (Vilkovo) - raise of the Black Sea level. The carried out contribution account of the effluent changes in the water-levels changes has shown, that the mid-annual levels because of these changes in the Kiliya branch were decreased, and the mean water levels were increased.

Raise of the Black Sea level in the 20th century – is the well known fact, which is explained by the majority of explorers as the positive water balance. In [16] it is marked, that, since 40th of 20th century, the intensity of eustatic rise of the Black Sea level on the average is 3-4 mm/year. According to the accounts carried out [15], retaining component of water-levels changes for 40 years in Primorskiy (beach) has made of 17 cm at the average conditions of the effluent and 24 cm in the low water, and the zone of by degrees fading affluent has captured, accordingly, 70 and 160 km upstream the Danube.

The effluent of the Danube inwashes according to V.N.Mikhaylov's calculations [4] in 1921-1960 was at an average 67,7 million t/year. After recommission of some reservoirs, in particular, Dzherda reservoir (Zheleznyye vorota) in Romania and Yugoslavia (1969-1971) with the payload volume of 3,0 km³ and the affluent magnitude at the lock of 34 m,

the inwashes effluent was decreased at an average up to 42,2 million t/year. The water muddiness in the river was accordingly decreased from 340 g/m in 1921-1960 up to 202 g/m³ in 1961-1993 (see tab. 4).

Flow distribution of inwashes on sleeves of delta of the Danube is approximately proportionally to the flow distribution of water. An exception is made only for the most intensely developing and dying off sleeves. It is pointed out that the first has relative ascending effluent of inwashes, and the second - a reduction in comparison with the shares of an aqueous runoff.

The change of the inwashes effluent along the large and long branches (Kiliya, S linskiy, Georgiyev) is not significant, and an alluviation inside the delta in the modern phase of its development is also insignificant. By some estimations [17] the flow rates reduction of inwashes lengthways of the Kiliya branch in the snow melt flood is no more than 5-10%, that. is within the limits of measurements accuracy of inwashes flow rates. Nevertheless, an alluviation on the indefensible plots takes place and the slow increase of the delta surface and siltage of lakes proves it. Siltage of lakes is promoted by the development and degradation of aquatic greenery. The area of some lakes is slowly moderated in the internal part of delta.

The water temperature in delta branches is the greatest in July - August (at an average of 23-24°C, maximum 28°C), and the least - in December - February (at an average of 1-1,5°C, minimal – about 0°C).

The ice phenomena in the Danube delta does not happen every year, and the resistant ice standing is fixed less, than for 50% of winters. Quite often the branches are plated with ice 2-3 times for winter but in some winters there is no even ice motion on the river. The average ice standing duration is 18 days, maximum - 70 (1954-1955). The average dates of pre ice standing and spring ice motion are accordingly on January, 6-15 and on February, 18-25. The greatest ice depth is 60 cm (on separate plots - up to 80 cm) is fixed at the end of January. Ice motions (especially spring) are rather frequently escorted by the ice blocks. In the last decades for the navigation extension and prevention of ice gorges the ice sheet is broken artificially. The strong ice gorge in the Kiliya branch low ground has taken place, for example, at the end of January, in 1967. The water-level was lifted up to 2-2,5 m. [4]. The threat of catastrophic deluging has hung above Kiliya and Vilkovo cities. 2400 houses were

flooded In Vilkovo. Within 5 days scrambling with element was led; thus icebreakers and aim bombing from aeroplanes were applied.

In 40-50's years of the last century the effluent of the Danube river salts was equal at an average of 52 million t/yr [18] that corresponded to the average mineralisation about 260 mg / dm³. The precise tendency of increase of the average mineralisation of the Danube water in delta about 290-300 mg / dm³ in 1948-1965 up to 370 mg / dm³ in 1985-1989 [19] has been revealed in the next years. Thus, the effluent of the Danube salts has increased from 60 up to 76 million t/yr.

The seawaters as "wedge" of salted waters can penetrate into some delta branches during the low effluent and fetches. This is the shallow branch such as Belgorod one or rather large branches, the bars of which are deepened for the purposes of shipping industry (Prorva and Sulinskiy). Seawaters regularly penetrate at the bottom of these branches during the low water. The maximum range of seawaters penetration has been fixed in Prorva on 20.11.90 - 16,8 km [20]. The critical flow intensity in Prorva and Sulinskiy branches, at the excess of which the seawaters do not penetrate in to the branches makes up 570 and 1350 m³/ s.

5 Hydrophysical conditions of estuary beach of Danube

There are two types of beach currents - wind and effluent. Within the Danube estuary beach the wind currents are usually directed alongshore - from the north on the south - at the winds of northern rhumbs and from the south north-up - at the winds of southern rhumbs. Almost all the year above the beach the winds of northern rhumbs predominate. Their repeatability within the year exceeds 40-50% and only in May and June is decreased up to 38-39%. Repeatability of the southern rhumbs winds during the most part of the year makes up 30-38%, being increased only in May and June up to 40-44%. Therefore and the longshore currents are directed more often to the south. Consequently the most part of inwashes is transferred to the same part and the coast forelands and all Kiliya delta accrue more intensely in the same direction. Velocities of wind currents at steady wind more than 14-15 km/s can makes up to 1 km/s [4].

Discharge currents are watched on the beach before the mouths of large branches. Simultaneously behind the delta bars crests of the Potapov, the Bystry, the Starostambulskiy, the Sulinskiy and the Georgiyev branches the discharge currents in the snow melt flood

makes up to 1-1.5 km/s. Discharge currents swiftly die off aside the seas, being traced not further 3-4 km from the mouth.

Heaving on the Danube beach is moderate. The average height of waves is about 0,5 m for the period from 2,5 up to 5,5 cm. According to the prevailing winds the wind heaving of the northern rhumbs (65%) predominates, which is also the strongest. So, the winds with the velocity more than 10 km/s are characterised by repeatability in January of 16-18%, in February of 12-14%, and on March up to 15%. All of them basically relate to the northern half of the horizon. Virtually no strong winds and heaving are observed in summer [4].

The accumulation of fluvial sediments on the beach happens basically during the calm weathers or moderate seas up to 2-3 balls. The velocities of discharge currents from the Kiliya delta estuary even at 1,5-2.0 km from the estuary ranges fall to such extend, that the mass accumulation of the basic part of the material [12] appears to be possible. Distribution of the weighting inwashes in the thickness of waters also proves it: lime concentration in the estuary ranges makes up to 200-300 mg / dm³, and in 4-5 km from the range aside the open sea - only 30-50 mg / dm³, that. is 4-10 times less. This difference of concentration is one of the parameters of fluvial sediments intensity accumulation on the beach. At the same time, after heavy seas the local washouts of being already formed of accumulative cone surface [7] had been fixed.

According to M.V.Mikhaylova [6] the total formation of Kiliya delta for 240 years the components of inwashes balance are the following: the gain of volume of the alluvial fan - 8,26 km³; the inwashes effluent of the branch - 8,363 km³; carrying out of inwashes on the big marine depths - 0,03 km³; contribution of marine inwashes from the north with the long-shore flow - 0,029 km³ and contribution out of inwashes to the south - 0,102 km³. Thus, on the forming of estuary alluvial fan (within the marine depths 15 m) and delta almost 99% of fluvial sediments were taken. A share of the inwashes, which have been carried away from delta and estuary alluvial fan, makes up little more than 1%. Thus it was specified, that a share of the fluvial sediments remaining in the estuary alluvial fan, in the process of Kiliya delta development was steadily being increased (from 60-80 up to 99%). As a whole it is possible to consider, that to the present time the Kiliya delta is in the condition of dynamic equilibrium within the quantity indicators of river and marine inwashes [21]. mentioned above

By U.D.Shuiskiy's [7] estimation, made on the comparison of cross profiles of the underwater slope of the Danube Kiliya delta, the average specific accumulation for the period of 1955-1979 makes up 220 m³/m annually. At the length of line, which is outlined the marine delta margin and is to, equal 53 km the total volume of alluviations has averaged 11,5 million m³ annually inwashes or 71% of the flow rate of inwashes in Vilkovo. The similar estimation for the underwater slope of the Bystry bar has shown, that only 21% of the Bystry branch effluent (147,1 m³ / m year) is accumulated on the beach. It can explain why the promotion is slowed down in the sea of the bank line on this delta plot. According to the estimation (7) about 4,7 million m³ of weighting and inwashes come from the Danube Kiliya branch in the open sea, which had the Deep-Water sediments of the adjoining part of the Black Sea. The carried out sedimentary material is transferred to suspensions by currents basically to the southeast and to the south, alongshore within the harbour area, adjoining Romania and Bulgaria shores [3].

Researches of river-delta processes of the Danube river, received as a result of the comparative analysis of the retrospective data of space shooting (1975-1988, 1988-2001) [22], have shown, that the Starostambulskiy branch system is in the condition of activation as a whole. The sediment runoff in the Starostambulskiy, the Bystry and the Tsyganka branches has increased. In some places of the Bystry branch the processes of shores processing takes place. At the expense of the effluent accumulation islands (forelands) on the south from the Bystry and the Starostambulskiy branches (see Annex 11) were formed. Dry territory has increased in the Tsyganskiy Kut bay and the area of Kuriles islands. Accumulation process of the bank line along all marine coast from the Potapov branch to the Starostambulskiy branch is obscured. The analysis of snapshots has shown, that the tendency to the changes, described above, has a constant character within the period of not less than 30 years (fig. 5, 6).

The temperature of water in the surface layer of the beach has definitely seasonal course, being increased in July - August on the average up to 21-22°C (maximum is up to 26-27°C) and being dropped in December - February at an average up to 2-4°C (sometimes up to-0, 3 -0,4 ^{0}C). In summer the temperature of water in the surface layer is higher, than the temperature on the depth for 4-6°C (sometimes for 12°C). During the greatest heating in the layer of temperature curve its vertical gradients reach 3-5°C on 1 m of depth. Homo-

thermia (the identical temperature on miscellaneous depths) is observed on the beach only in March - April and September - October [4].

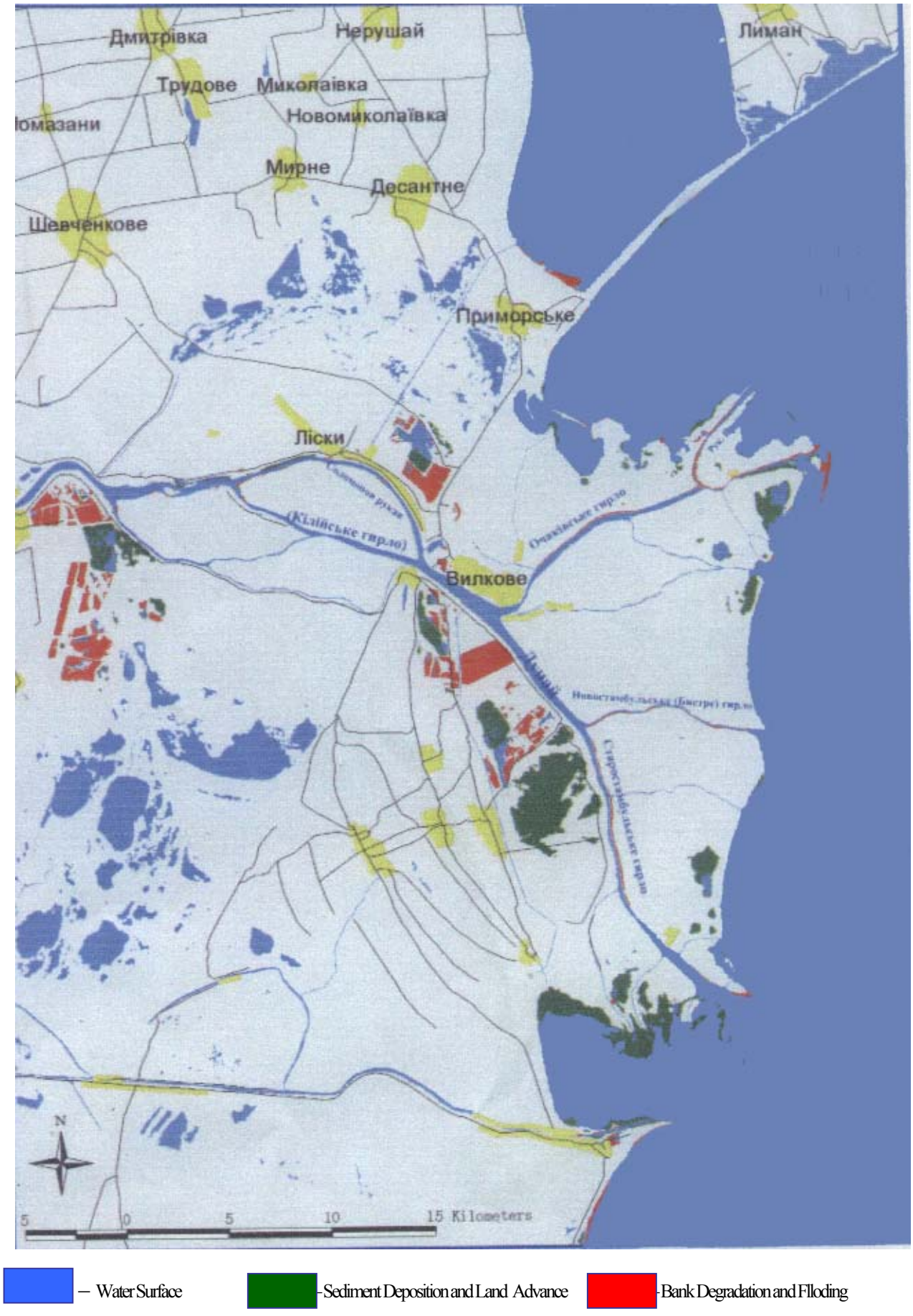
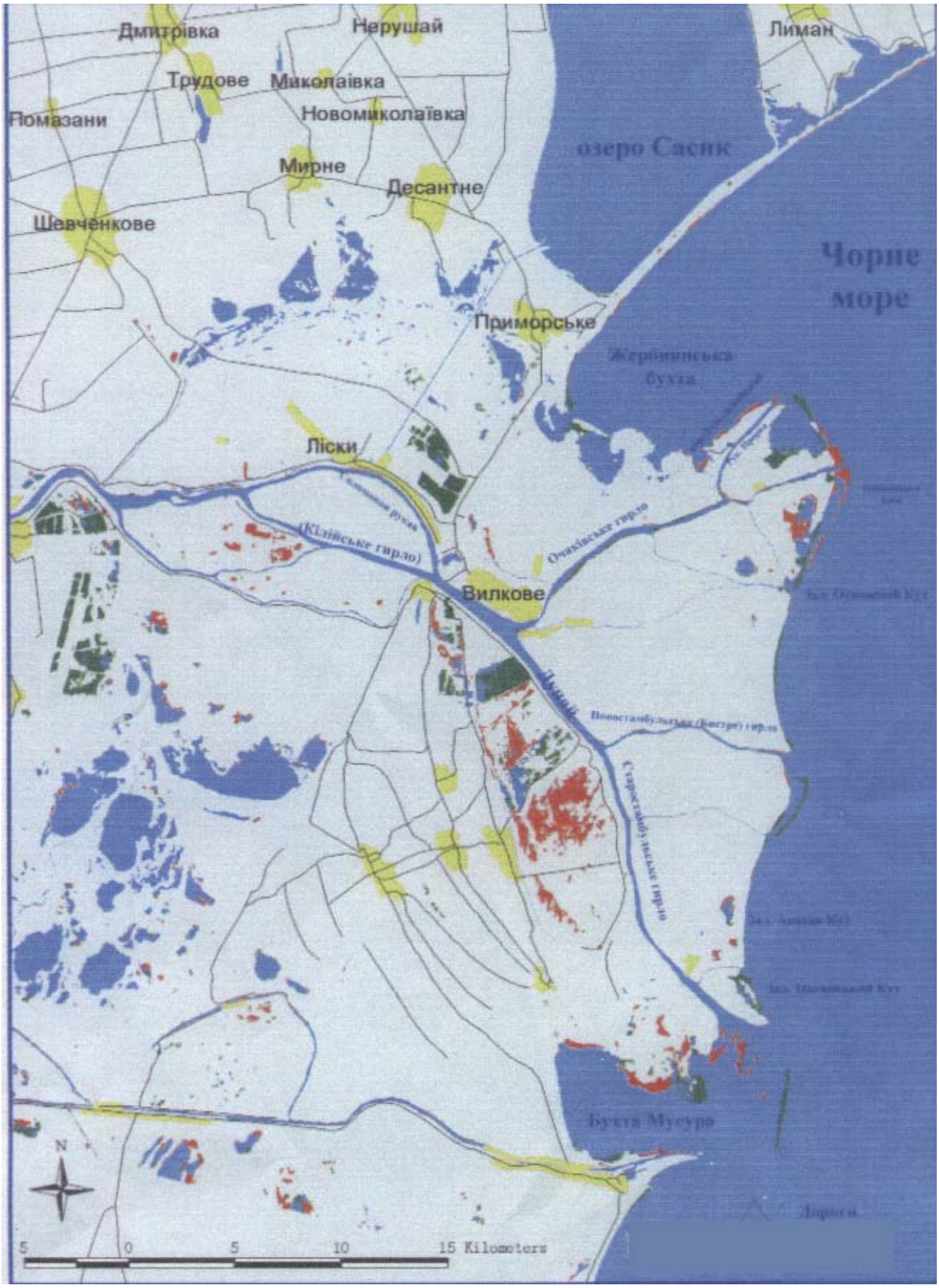


Fig. 5. The Schematic Map Illustrating the Danube Delta Dynamics (Coast-Line Modification and Changes in Water Surface Areas), Based on the Analysis of the Landsat Imagery of 1975 and 1988



– Water Surface -Sediment Deposition and Land Advance -Bank Degradation and Flloding

Fig. 6. The Schematic Map Illustrating the Danube Delta Dynamics (Coast-Line Modification and Changes in Water Surface Areas), Based on the Analysis of the Landsat Imagery of 1988 and 2001

The ice phenomena on the beach are not observed annually. The process of ice formation normally begins in December - January (for 2-4 days later, than in delta branches). The solder breadth in Zhebriyansk bay (to the north from delta) can reach 20-25 km, in other places of the beach - 10-15 km. In the second half of February the ice sheet starts to demolish. In March the beach is completely cleared of ice.

Main and ecologically the most important feature of the estuary beach regime is the dependence of water saltiness and the areas with the various degree of water desalination on the Danube effluent and wind regime [3, 23]. The surface layer of waters on the beach, where the saltiness of water can be changed from 4 up to 15-16 ‰, is the most subject to the effect of the effluent and wind to the grate extent. On the depths more than 8-10 m the saltiness of water in all seasons of year is usually more than 16%.

By the recent researches [23] it is revealed, that the internal border of mixture zone of the river and seawaters in the surface layer on the estuary beach (isohaline of 2 ‰) is at an average of the distance of 0-4 km from the estuary branch depending on the phase of the river regime. The external border of mixture zone (≈16 ‰) is located at the distance of 3-20 km from the marine delta margin in miscellaneous seasons. The increase of the Danube effluent widens a zone of water desalination, the reduction of the effluent narrows it; and it happens being late in time.

Winds of eastern rhumbs as a whole narrow a zone of water desalination in the surface layer, winds of western rhumbs widen it.

"Tongues" of desalted waters against the estuary of large branches are normally spread in the snowmelt flood to the distance up to 20 km. During significant snow melt flood or strong whipped wind the desalted waters in the surface layer can reach Zmeinyi island, located more than in 30 km from the marine delta margin, resulting in decrease of water saltiness up to 4-7 ‰ (at ordinary meanings of 14-16 ‰). At the same time at the interbranch plots seawaters with saltiness up to 10-12 ‰ approach marine delta margin.

6 Economic activities impact on the Danube delta formation and hydrophysical conditions

Anthropogenous effect on the river bed evolutions of delta forming is traced from the end of the 19th century. [4]. For example, it is known, that at the end of the last century the tendency of Tulchin branch degradation, for the renewal of which hydrotechnical works on

its rectification and deepening were conducted in 1880-1902, had been revealed. Before the First World War Russia performed similar works in Severny branch with the purpose of its usage for shipping industry. Thus a period of large-scale intervention to the natural regime of the Danube delta had begun. First of all, it was practically complete bilateral reinforcement of the riverbanks (from Reni to Vilkovo from the Ukrainian side practically completely and partially from Romanian, the islands including, with the subsequent involving inundated continental and island lands to the agriculture processes; to the branch of the Danube basins from the river system of locks and channels; replacement of natural anabranch for channels (the Skunda, the Rapida and other), clearing and deepening of the beds (the Sulinskiy branch), the intake and interception of water along the river, etc.

The reinforcement of shores, which, handicapping the water outlet on the wide bottomland, changes slopes, velocities, regime of inwashes movement, especially during the active forming of the channel (high waters, snow melt floods) and has great influence on the delta forming. For example, in the range of 40-th km (the Laptysh branch, the Mezhkolkhozny channel now) the breadth of water flood reached up to at a passing of significant high waters in natural conditions 10 km. In the conditions of reinforcement the flow was concentrated in the basic channel up to 900 m of breadth, that had excluded a number of stabilising capacities of great volume, which transformed freshet waves and essentially changed the water regime of the Danube delta from water exchange.

By 1971 the area of diked lands in the Romanian part of the delta has already reached 430 thousand hectares, in Ukrainian - more than 30 thousand hectares. The length of dams only in the Ukrainian territory along the Danube and delta branches has made up to 118 km, and from the Danube lakes side - 71 km, on the islands - 102 km.

The largest Danube lakes adhered to Kiliya delta and located in the territory of Ukraine days play the role of reservoirs, with which the irrigating areas about 73 thousand hectares are linked that correspond to the normative volume of drawoff of 250 million m^3. The actual area of irrigation and the volume of drawoff varies from year to year, but these meanings give the idea concerning the degree of delta water resources involving in the agriculture processes. In the delta the rich net of irrigating and drainage channels, where water goes by gravity, through locks or with the help of the pumps, is built. Lagoon Sasyk (to the north from delta) is railed off the sea and also converted into the reservoir for the Danube

water; complete and useful volumes of this reservoir makes up accordingly to 0,53 and 0,235 km³ [4].

In the beginning of 20th century the harbour area of Stentsovsko-Zhebriyansk fluxes stretches from Shevchenko village up to Primorsk village [24]. In the middle of the 30th the motorway Vilkovo-Primorskiy had been built, and in the 50-60 the active assimilation of inundated lands with the reinforcement of separate plots began, which were then built up, occupied and actively involved in the crop rotation. For the prevention of periodic delugings of localities the protective lock lengthways Kiliya estuary and Solomon branch had been built. At the same time the Laptysh channel, which was the water-supply of the fluxes, had been graveled and the lock and the Mezhkolkhozny channel (1950), lock and the Tupikovy channel (1974) are built instead of it, which have bridged Danube and SZhF in modern borders. In 1971 the Mezhkolkhozny channel has been continued by the Danube channel, which had crossed the bottomland up to the radical shore and had submitted the Danube water up to the file of irrigating (Tatarbunar irrigating system), that had actually converted the basic rivers of the drainage basin of Nerushay and Drakulyu fluxes into the antirivers. Simultaneously northern border of fluxes also had been separated by the locks within the stripe message of the radical shore with the bowl of fluxes down up to Primorsk village. In the body of the lock of Vilkovo-Primorsk motorway, built in 30th, bridges in 70th have been replaced by locks - spillways and, thus, fluxes have been ultimately separated from the Danube and the Black Sea and inhibited in modern borders. Their regime became to be completely under control. These structures have decreased the SZhF area almost for 20%. In the 70th the southern part of fluxes was separated by the Prapor and Gosleskhoz locks and occupied for I, II and III Liskovsk rice systems that has decreased the SZhF area by 30%. Thus, prior to the beginning of 80th the general SZhF area was moderated in the comparison with the natural almost by 50%. In 1980 the channel Danube – Sasyk was built, which crossed SZhF area and shared this area in Stentsovsk and Zhebriyanskiy parts, informed only through duker under the channel with the general area of cross section of 8 m^2, which is places at-sight the mouth of Murza river. Thus, the forming of not only modern bowl, but also the circuit of water flow in SZhF area had been finished.

In the natural regime fluxes ate the Danube water and the natural runoff of own drainage area. At the modern level of the development on water-producing SZhF area a number of irrigating systems, five reservoirs is placed, the water-producing net is converted into the

collector-drain ways and submits to fluxes the mixture of natural runoff and collector-drainage waters. Contribution of the Danube water thus happens practically by the residual principle. Hydrodynamic regime of SZhF area has a number of differences from the regime Danube branches: the slowed down current of water, the big roughness of the channel because of the greenery development, availability of dead spaces in ranges, etc.

As the subject of anthropogenous effect fluxes are unique proceeding from the ratio magnitude of the anthropogenic load and the natural resources.

Conclusions

1. Kiliya delta of the Danube River, which contains the Deep-Water Navigable Pass, represents a constantly changed system of branches and territories between them (islands), the majority of their surface being covered with water and occupied with the fluxes. High velocity of delta evolution is connected with the big mass of the river sediment runoff.
2. The feature of consideration of medium factors in the EIA of the Deep-Water Navigable Pass in the Kiliya delta is that the continuous delta evolution and therefore the consequent variability of hydrological and hydrophysical conditions render determining effect on all natural and technogenic entities located within the delta.
3. The general direction of delta evolution is determined by the interaction of the river and the sea and revealed in the following phenomena and processes which permanently take place:

   - Advancement of changeable marine delta margin aside the sea;

   - Origin of new and degradation of old delta branches, the change of their quantity and redistribution of the river flow between them;

   - Formation of the shallow-water plots of the beach - bars – in front of the branches mouths as a result of sedimentation and inwashes in a zone of river and flow interaction with the marine currents and heaving;

   - Change of the water regime of the islands territories in the direction of water exchange deceleration in fluxes, and lowerings of the water level during the process of degradation and reduction of the branches number.
4. The analysis of the Kiliya delta history shows, that its alluvial fan, basically, was formed at the beginning of the 20th century. Within the 20th century computed range-

component increment of volume of the alluvial fan has made about 10% of its volume, that allows to characterise the modern condition of Kiliya delta as a phase of relative dynamic equilibrium. As a whole the accumulative processes in delta and the processes of abrasion (capes and bars) compensate each other. Thus the alluvial fan almost completely consists of fluvial sediments.

5. Since the end of the 19th century on the delta development escalating effect is rendered by anthropogenous factors, first of all – branches reinforcement reduced to the scale change of the water regime of branches and islands and laid the foundation of agricultural assimilation of inundated continental and island territories. Anthropogenous intervention has amplified with the regulating and drain of some delta water-currents. So, on the water-producing area of Stentsovsko-Zhebriyanskiy fluxes a number of irrigating systems, five reservoirs is placed, the water-producing net is converted into the collector-drain ways and the mixture of own natural runoff and collector - drainage waters submits to fluxes. However even such large-scale technogenic effect has not resulted in significant changes of the basic laws of the delta development, though has seriously broken the water regime of some territories.
6. At the same time the effluent regulating on the overlying plots of the Danube river has resulted in the consecutive reduction of hard inwashes effluent during the last several decades without reduction of a mid-annual aqueous runoff of the river. This phenomenon measurably inhibits the process of branch siltage and can be considered as the positive factor for the creation of Deep-Water Navigable Pass.
7. If the present tendency of sediment runoff reduction in the Danube river will be preserved hereinafter, then on the background of the predicted rising of the sea level and growth of the relative role of marine heaving the Kiliya delta can change the tendency of the development further on and proceed in the delta type, which is formed in the conditions of marine factors prevailing.
8. Together with evolutionary changes in the delta there is also a number of periodically repeating processes takes place, the most important major of which are the whipped-fetched phenomena in the estuary zone, inside and interannual changes of flow intensity and hard inwashes in the Danube river. These processes cause the fluctuatings of water levels in the branches and fluxes, and also deformations of the bottom and of water-currents shores.

9. The technogenic effects of construction and Deep-Water Navigable Pass operation will happen on the background of the determining effects of the above-stated natural processes, strengthening or weakening some of them.

10. According to the analysis of delta hydrodynamic conditions in the area of the approved variant of the Deep-Water Navigable Pass line it follows, that for its creation the positive factors of environment are:

- the slowest promotion of marine delta margin in comparison with the other plots in the estuary area of the Bystry branch;
- constantly increasing share of the river flow of Kiliya delta, passing through the Bystry branch;
- carrying out of the great bulk of inwashes effluent from the Bystry branch outward the beach (though this factor is not stable: for the last years the process of bar prolongation in front of the branch and its advancement in the sea with the simultaneous development of the right-bank foreland, which has received the name of Ptichya) became more active;
- rather fast ascending depths of water behind the bar area.

1. Оценка воздействия на окружающую среду (ОВОС) ТЭО инвестиций строительства глубоководного судового хода в украинской части р. Дунай. Институт биологии южных морей НАН Украины, одесский филиал. Одесса, 2001.

2. Оценка воздействия на окружающую среду (ОВОС) вариантов трассы судового хода Дунай - Черное море: по шлюзованному каналу Соломонов рукав – Жебриянская бухта и по рукаву Быстрый. Сводный том. УкрНИИЭП. Харьков, 2002. - 145 с.

3. Гидрология устьевой области Дуная. – М.: Гидрометеоиздат, 1971. – 383 с.

4. Михайлов В.Н. Устья рек России и сопредельных стран: прошлое, настоящее и будущее, ГЕОС, 1997. – 413 с. 5. Самойлов И В. Устья рек. – М.: Географгиз, 1952. – 526 с.

5. Самойлов И В. Устья рек. – М.: Географгиз, 1952. – 526 с.

6. Михайлова М.В. Формирование дельты выдвижения Килийского рукава и баланс наносов в устье Дуная // Водные ресурсы. 1995. – Том 22, №4. – С.489-495.

7. Шуйский Ю.Д. Динамика морского края Килийской дельты Дуная // Гидрология устьев рек. Труды ГОИН, вып. 172. Московское отделение Гидромета, 1984, с. 50-58.

8. Postolache I., Buga L., Diaconeasa D., Malciu V. Erosion control in Romania // Poceedings of the Second International Conference on the Mediterranean Coast Environment, MEDCOAST 95, October 24–27, 1995. Tarragona, Spain. – Vol. 2, 1995. – P. 1025–1032.

9. Звіт «Екологічна оцінка проектних варіантів (на стадії ТЕО інвестицій) створення глибоководного суднового ходу Дунай – Чорне море на українській ділянці дельти». Інститут гідробіології. Національна академія наук України. Київ, 2002.

10. Петреску И.Г. Дельта Дуная. Происхождение и развитие. – М: Изд-во иллюстр. литры, 1963. – 280 с.

11. М. В. Михайлова. Динамика устьевых баров и методы расчета их морфометрических характеристик // Водные ресурсы, 1999, том 26, № 4, с. 427-437.

12. Михайлов В.Н., Рогов М.М., Макарова Т.А., Полонский В.Ф. Динамика гидрографической сети неприливных устьев рек. – М.: Гидрометеоиздат, 1977. – 296 с.

13. Михайлов В.Н., Рогов М.М., Чистяков А.А. Речные дельты. Гидрологоморфологические процессы. Л.: Гидрометеоиздат, 1986. 280 с.

14. Полонский В.Ф. Расчет изменений и возможность регулирования, устьевых баров на примере дельты Дуная // Труды ГОИН. – 1982. – Вып. 161. – С. 54-68.

15. Михайлов В.Н., Повалишникова Е.С., Морозов В.Н. Многолетние изменения уровней воды в килийском рукаве дельты Дуная // Водные ресурсы, т. 28, № 2, 2001.

16. Горячкин Ю.Н., Иванов В.А. // Вод. ресурсы. 1996. Т. 23. № 2. С. 246.

17. Mikhailova M.V. Formation of the Danube and Rioni deltas and their coasts // Poceedings of the Second International Conference on the Mediterranean Coast Environment, MEDCOAST 95, October 24–27, 1995. Tarragona, Spain. – Vol. 2, 1995. – P. 911–920.

18. Алмазов А.М. Гидрохимия устьевых областей рек (Северное Причерноморье). – Киев: Изд-во АН УССР, 1962. - 255 с.

19. Гидроэкология украинского участка Дуная и сопредельных водоемов. – Киев: Наукова думка, 1993. – 328 с.

20. Mikhailov V.N., Morozov V.N. Influence of marine factors on hydrological regime of the Danube delta// Proceedings of the XVII Conference on the Danube Countries on Hydrological Forecasting and Hydrological Bases of Water Management, Budapest, 5-9 September, 1994.- Vol. 2 – Budapest, 1994. -P.403-408.

21. Отчет по теме "Разработать рекомендации по минимизации заносимости экспериментально-эксплуатационной прорези глубоководного судового хода на баре Новостамбульского гирла Килийской дельты р. Дунай. Институт гидромеханики НАН Украины. Киев, 2003. 141 с.

22. Звіт "Дослідження дельтових процесів р. Дунай за результатами аналізу співставлення ретроспективних матеріалів космічної зйомки" Український центр менеджменту землі та ресурсів. Київ, 2002. 26 с.

23. Михайлов В.Н., Морозов В.Н., Михайлова М.В., Гранич П.С. Гидрологические процессы в устьевой области Дуная и их возможные изменения // Водные ресурсы. – 1988, №1, С.24–32.