

(*Paper No. 2909.*)

“The Survey of the Delta of the Danube in 1894.”

(Abstracted from the Report of Sir CHARLES HARTLEY, K.C.M.G.,
M. Inst. C.E.)

By LEVESON FRANCIS VERNON-HARCOURT, M.A., M. Inst. C.E.

FOUR surveys of the sea-coast of the delta of the Danube have been made previously to the one taken in July to October 1894, namely, in 1830, 1856, 1871, and 1883, from a comparison of which with each other, and with the recent survey, the changes that have occurred during these periods in the coast-line and foreshore at the mouths of the Danube have been ascertained. In the first Paper on the delta of the Danube, by Sir Charles Hartley, K.C.M.G., M. Inst. C.E., in 1862, besides a general description of the delta, reference is made to the changes which had taken place between 1830 and 1856;¹ and in his second Paper, in 1873, a full account is given of the changes in the sea-coast of the delta,² gathered from a comparison of the surveys of 1856 and 1871. In a third Paper, by Mr. C. H. L. Kühl, M. Inst. C.E., in 1888, describing the variations in depth in front of the Sulina mouth, a plan is added showing the changes which had occurred along the sea-coast of the delta between 1871 and 1883.³ In a Report, with diagram and tables, addressed by Sir Charles Hartley in June 1887, to the European Commission of the Danube, reference is further made to changes that took place in the bed of the sea adjacent to the Sulina mouth during the previous twenty-nine years.⁴

The following particulars are taken, by special permission, from a Report in French, made by Sir Charles Hartley, in May 1895, to the European Commission of the Danube, on the changes since 1883, indicated by the survey of 1894; and the three *Figs.* in the text are reductions of the chart of the sea-coast of the delta accompanying the Report, showing the coast-lines and 1- and 5-fathom lines of 1883 and 1894, and also the fathom lines of 1856.

¹ Minutes of Proceedings Inst. C.E., vol. xxi. p. 283.

² *Ibid.*, vol. xxxvi. pp. 214 to 219, and plate 24.

³ *Ibid.*, vol. xci. pp. 329 to 333, plate 4.

⁴ *Ibid.*, vol. xci. pp. 334 to 339.

The survey of 1894 has been carried out in compliance with the wish expressed by Sir Charles Hartley at the close of his Report of November 1883, and urged again on the Commission in 1893, that a survey might be made every ten years of the sea-coast of the delta, to ascertain the changes in operation.

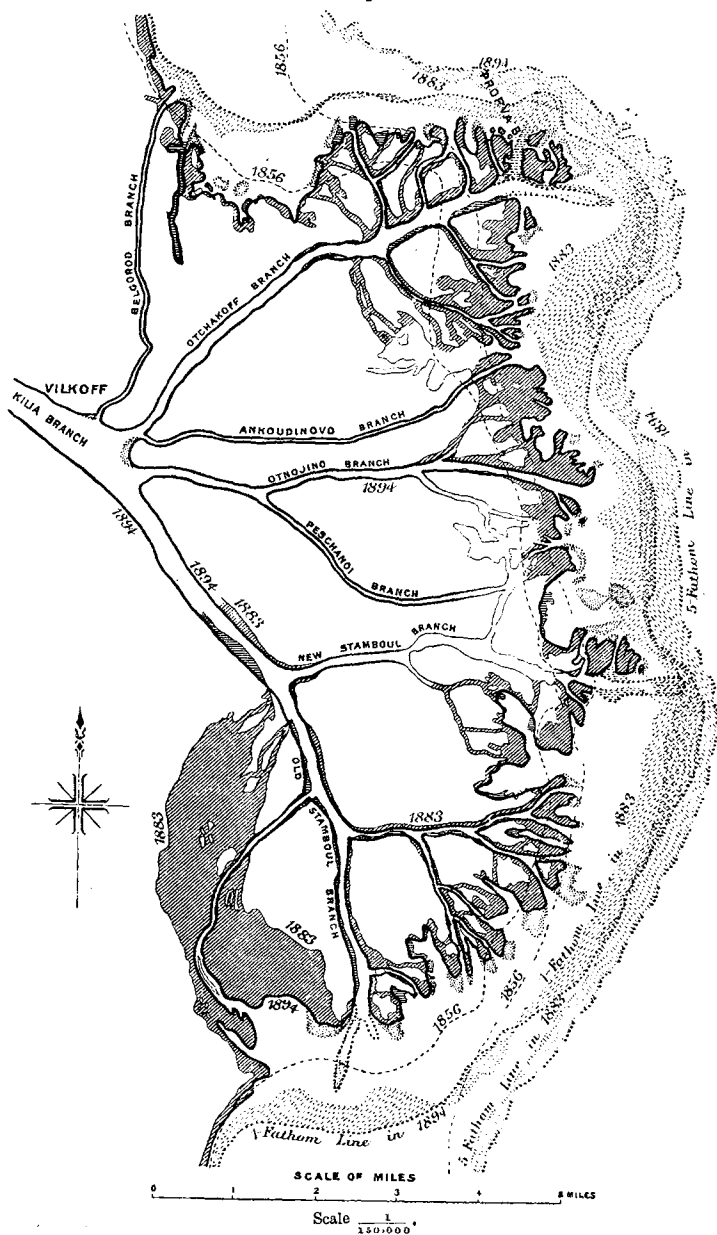
Kilia Mouths.—The Otchakoff branch was directed north in 1830, north-east in 1856, east-north-east in 1871, east in 1883, and east-quarter-south in 1894. The average yearly advance of the 1- and 5-fathom lines of soundings, in front of this mouth, to the north-east, between 1830 and 1856, was only 192 and 115 feet respectively; whereas the yearly advance towards the east, between 1856 and 1883, was 489 and 437 feet, and between 1883 and 1894 was 236 and 291 feet respectively. The total advance of the 1- and 5-fathom lines eastwards amounted to 5,600 and 4,800 feet respectively from 1856 to 1871; 7,600 and 7,000 feet from 1871 to 1883; and only 2,600 and 3,200 feet respectively from 1883 to 1894, *Fig. 1.*

The yearly average advance of the 1- and 5-fathom lines in front of the coast, between the Otnojino and New Stamboul mouths, was 177 and 185 feet respectively between 1830 and 1856; 213 and 133 feet between 1856 and 1871; 317 and 375 feet between 1871 and 1883; and 318 and 273 feet respectively between 1883 and 1894. The total advance of these fathom lines amounted to 11,600 and 11,300 feet from 1830 to 1883; 7,000 and 6,500 feet from 1856 to 1883; and 3,500 and 3,000 feet from 1883 to 1894.

At the mouth of the Old Stamboul branch, the average yearly advance of the 1- and 5-fathom lines towards south-south-east was 230 and 134 feet between 1830 and 1856; 200 and 7 feet between 1856 and 1871; and 125 and 167 feet respectively between 1871 and 1883; whilst there was an average yearly retrogression of the 1-fathom line of 45 feet, and a yearly advance of the 5-fathom line of 109 feet between 1883 and 1894. The advance of these lines of soundings towards south-south-east was 10,500 and 5,600 feet from 1830 to 1883; 4,500 and 2,100 feet from 1856 to 1883; and 4,000 and 3,300 feet respectively from 1856 to 1894, or 105 and 87 feet per annum. The advance of the 1-fathom line towards the south was 6,600 feet from 1830 to 1856; 2,000 feet from 1856 to 1871; 1,000 feet from 1871 to 1883; and 2,000 feet from 1883 to 1894, or an average of 132 feet annually between 1856 and 1894.

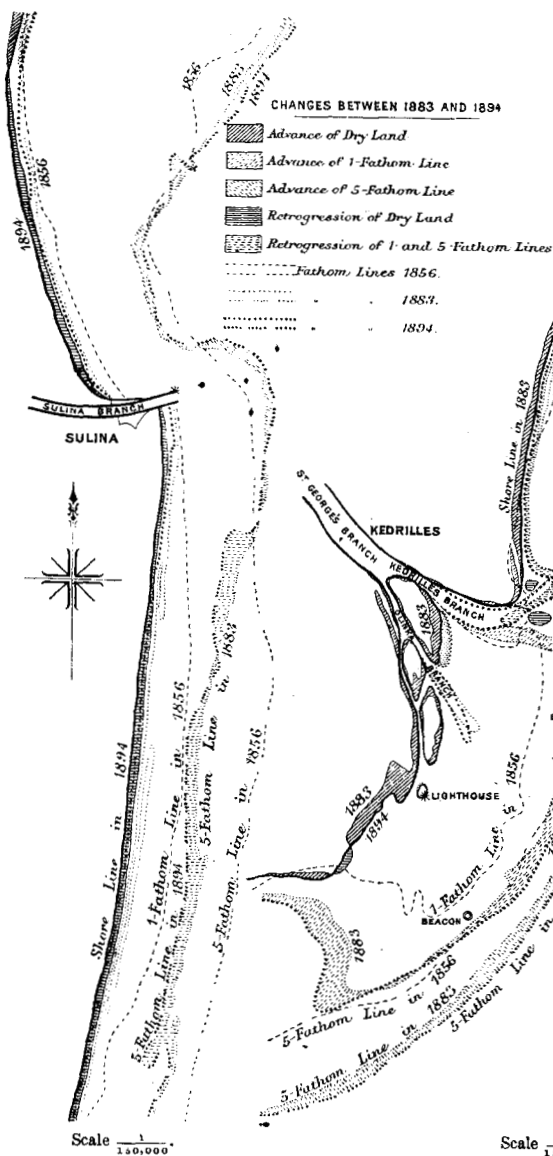
These figures show that, at the Otchakoff mouth, the average yearly advance of the 1- and 5-fathom lines towards the east, between 1856 and 1883, was three times as great as the advance towards the north-east between 1830 and 1856; whereas, on the

Fig. 1.



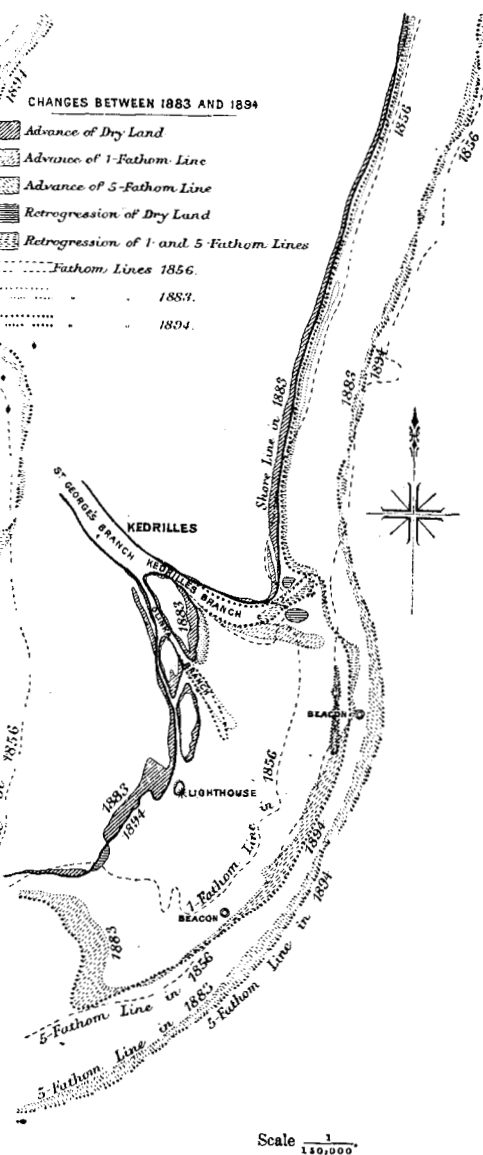
KILIA MOUTHS.

Fig. 2.



SULINA MOUTH.

Fig. 3.



ST. GEORGE'S MOUTH.

contrary, the yearly advance between 1883 and 1894 was only about half the average advance between 1856 and 1883. This reduction during the last eleven years is accounted for by the smaller number of great floods, as well as by the formation of the new Prorva branch which carries a portion of the discharge, and of the sediment of the Otchakoff branch, straight to the north. The unusually rapid advance of the Otchakoff mouth, about 2 sea-miles eastwards, between 1856 and 1883, was attributed by Sir Charles Hartley, in his Report of November 1883, to the ever-increasing discharge of the Otchakoff branch, and the remarkable succession of great floods during twelve years, which causes also produced the increased rate of advance of the coast between the Otchakoff and New Stamboul mouths between 1871 and 1883.

The diminution in the rate of progress of the accretions of the Kilia delta towards the south-south-east, notwithstanding the exceptional floods between 1871 and 1883, indicates that not only has the diversion of a considerable volume of the discharge of the Old Stamboul branch to the northern branches promoted the accumulation of deposit in front of the other Kilia outlets, and diminished the rate of advance of the 1-fathom line at the Old Stamboul mouth, but also that this fortunate reduction in the rate of advance of the shore towards south-south-east is partly due to the erosion by the waves, the action of which is more marked in proportion as the south-east angle of the projecting Kilia delta advances seawards. On the other hand, the southward advance of the Old Stamboul mouth has averaged 182 feet a year between 1883 and 1894, as compared with 111 feet annually between 1856 and 1883, and 181 feet between 1830 and 1883.

Sulina Mouth.—About 4 miles to the north of the Sulina jetties, the 5-fathom line advanced about 1,200 feet from 1883 to 1894, as compared with 1,800 feet from 1871 to 1883; then, somewhat nearer the jetties, this line approximates to the 5-fathom lines of 1856, 1871, and 1883; whilst at 2 miles north of the jetties, the 5-fathom line advanced 1,500 feet from 1883 to 1894, instead of remaining stationary as it did between 1871 and 1883, *Fig. 2*. A powerful scour by the sea has occurred along the coast, and in depths of 1 fathom, for 2 miles to the north of the jetties, where the retrogression has been 500 feet from 1883 to 1894, and 1,100 feet from 1856 to 1894. The average yearly advance of the 5-fathom line between 1883 and 1894, has been 32 feet at about 1 mile to the north of the jetties, 45 feet in front of the mouth, and 32 feet $\frac{1}{2}$ mile to the south; whereas the advances, in the same places, between 1871 and 1883, were 42 feet, 113 feet, and

42 feet a year. About 1 mile south of the jetties, the 5-fathom line receded 1,500 feet from 1883 to 1894, in place of an advance of 600 feet from 1871 to 1883.

The Coast between the Sulina and St. George's Mouths.—From 2 to 8 miles to the south of the Sulina jetties, the retrogression of the 5-fathom line averaged 750 feet from 1883 to 1894, in place of 600 feet from 1871 to 1883, *Fig. 2*. From the eighth to the ninth mile, the 5-fathom line has been stationary since 1883; whilst it receded 200 feet from 1871 to 1883; and from the ninth to the fourteenth mile, the advance of this line has been 200 feet from 1883 to 1894, as compared with an advance of 90 feet from 1871 to 1883.

As regards the relative positions of the 1-fathom line in 1856, 1871, 1883, and 1894, between the Sulina and St. George's mouths, with the exception of a slight advance near the root of the southern Sulina jetty, there has been a continuous retrogression of about 43 feet annually along the fourteen miles between these mouths. The erosion of the coast has been nearly in the same proportion.

St. George's Mouths.—Along the six miles in front of the Kedrilles and Olinka mouths, the advance of the 5-fathom line averaged 450 feet from 1883 to 1894, *Fig. 3*, 1,300 feet from 1871 to 1883, and 967 feet from 1856 to 1871.

Summary of Changes since 1883.—(1) The erosion of the coast north and south of the Sulina jetties has unceasingly continued, *Fig. 2*. (2) The annual rate of advance of the deposits of the Kilia mouths seawards has not for the most part been so great as in previous years, and much less at the Sulina and St. George's mouths, as indicated for the 5-fathom line in the following Table:—

Position of 5-fathom Line.	Direction.	1856-71. Annual Advance.	1871-83. Annual Advance.	1883-94. Annual Advance.	1856-94. Annual Advance.	1830-94. Annual Advance.
Opposite Otchakoff mouth	E.	Feet. 320	Feet. 583	Feet. 291	Feet. 395	Feet. 266
Between the New Stamboul and Otnojino mouths	E.	133	375	273	250	223
Opposite Old Stamboul mouth	S.S.E.	7	167	109	87	106
In front of Sulina mouth	E.	40	113	45	59	
In front of St. George's mouths	E.	64	108	41	68	

The slow advance of the deposits in front of the St. George's and Sulina mouths, in comparison to their rapid increase in front of the northern Kilia mouths, *Figs. 1, 2, and 3*, may be attributed, irrespectively of the relative volumes of water discharged by these branches, to three principal causes, namely, (1) the stronger action of the littoral current; (2) the more erosive effect of the waves on the sea-bottom during the prevalence of strong winds from the north to north-east; and (3) the much flatter slope of the bed of the sea in front of the Kilia mouths, especially the Otchakoff mouth, than in front of the Sulina and St. George's mouths, as the sea becomes shallower towards the north.

The very marked reduction in the annual rate of advance of the 5-fathom line between 1883 and 1894, all along the coast of the delta, as compared with the advance between 1871 and 1883, may be principally attributed to the notable diminution in the yearly volume of water discharged between 1883 and 1894, in comparison to the volume annually discharged in the twelve preceding years. This accords with the theory propounded by Sir Charles Hartley, in his first Report to the Commission, in October 1857, that the distance of the bar from the coast in front of a mouth is, to a great extent, proportionate to the volume of water discharged by that mouth. It must, however, also be borne in mind, as he remarks in his last Report, that, in comparing the changes during different periods, the favourable or unfavourable action of the winds, and of the littoral currents, may greatly modify the effects produced by the discharge of the river-water, highly charged with alluvium in flood time.

With reference to the interesting question of the eventual absorption of the Sulina mouth by the deposits of the Kilia mouths, though the advance of these northern mouths since 1830 has been very remarkable, sheltering the roadstead of Sulina more and more from northerly winds, nevertheless the advance of the 5-fathom line of the Kilia delta towards the south-south-east has notably diminished in the last eleven years. On the hypothesis, however, that the advance of the 1-fathom line of 181 feet per annum between 1830 and 1894 will be maintained, the incorporation of the Sulina mouth in the zone of deposits of the Kilia delta will only occur 175 years hence.