CHINESE GEOGRAPHICAL SCIENCE
Volume 4, Number 3, pp.242–251, 1994
Science Press, Beijing, China

THE CHANGE OF THE GENERAL FORM AND THE TRANSPORT OF THE WATER, LOAD AND SALT ABOUT THE NORTH-BRANCH OF THE CHANGJIANG RIVER MOUTH

Chen Baochong (陈宝冲)
(Nanjing University, Nanjing 210008, PRC)

ABSTRACT: The general form of the north-branch of the Changjiang River mouth has changed much as a result of the change of the main stream lines of the Nantong reach of the Changjiang River and the influence of human activities since 1915. By the 1930s, the main stream lines of the Nantong reach of the Changjiang River has shifted to the Tongzhou Bar west channel. The north-branch at the Changjiang River mouth has become atrophic because of Tongzhou Bar east channel's deposition. After 1958, Tonghai Bar and Jiangxin Bar were exploited. And in 1970, the north channel of Jiangxin Bar was blocked up. All these things make the water of the north-branch more difficult to pass through. It leads to the decline of the total discharge percentage of the north-branch. And it causes the rising tide to go back to the south-branch. However, since 1978, with the development of Tongzhou Bar east channel and its left bank being scoured, the water amount of the north-branch has been increasing. And the water, load and salt of going back to the south-branch has been becoming less.

KEY WORDS: north-branch of the Changjiang River mouth, change of river form, transport of water, load and salt

The Changjiang River mouth is divided into two branches: the south-branch and north-branch by Chongming Island. The north-branch begins from the top of Chongming Island in the west and reaches to Lianxing Port in the east, being about 78.8km long. The general form of the north-branch looks like a loudspeaker (Fig.1). The width and the deep trough are changing much. The river at the top of Chongming Island is about 4.5km wide, its deep trough is close to the south bank, and its river bottom is −9.5m high. From the top of Chongming Island to the east of it, the river channel gradually becomes narrower and narrower and the deep trough gradually moves to the north bank. The river channel is only

2.2km wide at Qinglong Port. The elevation of the close-to-north deep trough can be −10m or even lower. From Qinglong Port to the east of it, the river channel is widened to about 4.0km wide. But at Daxin Port, the river channel is narrowed to 2.5km and is deepened at its north side. The river channel is gradually becoming wider and wider and at the same time the south deep trough and the north deep trough appear below Daxin Port. The tides are mainly rising ones in the north deep trough and falling ones in the south deep trough. The river channel between the two troughs is densely covered with bars. Among them Yonglong Bar has been exploited and is connected with Chongming Island. Xinglong Bar has been exploited too. So the north-branch is actually a braid river channel. From Santiao Port to the east of it the river channel of the north-branch has been widened to more than 10km. Its northern side is deeper than the southern side. The width is 16km at Lianxing Port cross section and it is about 7.3 times as wide as Qinglong Port cross section.

I. THE CHANGE OF THE GENERAL FORM OF THE NORTH-BRANCH OF THE CHANGJEANG RIVER MOUTH

Great changes have taken place in the north-branch of the Changjiang River mouth in recent 70 years. In 1915, the total discharge percentage of the north-branch of the Changjiang River mouth is about 25%. At that time the proportion of the cross sectional areas of the south-branch channel to the north-branch channel, in the entering reaches, is 2.4:1, under the lowest tide level. The wetted perimeter condition was usually fit for the discharging of water and load. The −10m depth curve went straight to the north-branch.

After 1931, the channel to the east of Tongzhou Bar had gradually been depositing with the shifting of the main stream at the upstream from the east channel of Tongzhou Bar to the west of it. Thus the channel entering the north-branch was becoming atrophic and deflective. But till 1958, the water depth near Qinglong Port still remained −10m.

After 1958, Tongzhou Bar and Jiangxin Bar were exploited one afte another and Laobaimao Bar shifted northward to Chongming Island. From 1958 to 1970, the volume of the channel of the north-branch, under zero-metre, had been declined from 2060 million m^3 to 1460 million m^3. The average deposition rate was about 50 million m^3/a. The stream line entering the north-branch became more impeded. So the deposition rate became larger and the volume of the channel of the north-branch obviously became smaller. The channel to the north of Jiangxin Bar was blocked in 1970. The river at Xuliujing was narrowed to 5.8km. The stream line entering the north-branch met the main stream line of the Changjiang River to form a right angle. The water amount of the falling tide entering the north-branch was becoming smaller and smaller, which made the north-branch become the rising channel. The load brought by the rising tide of the north-branch could

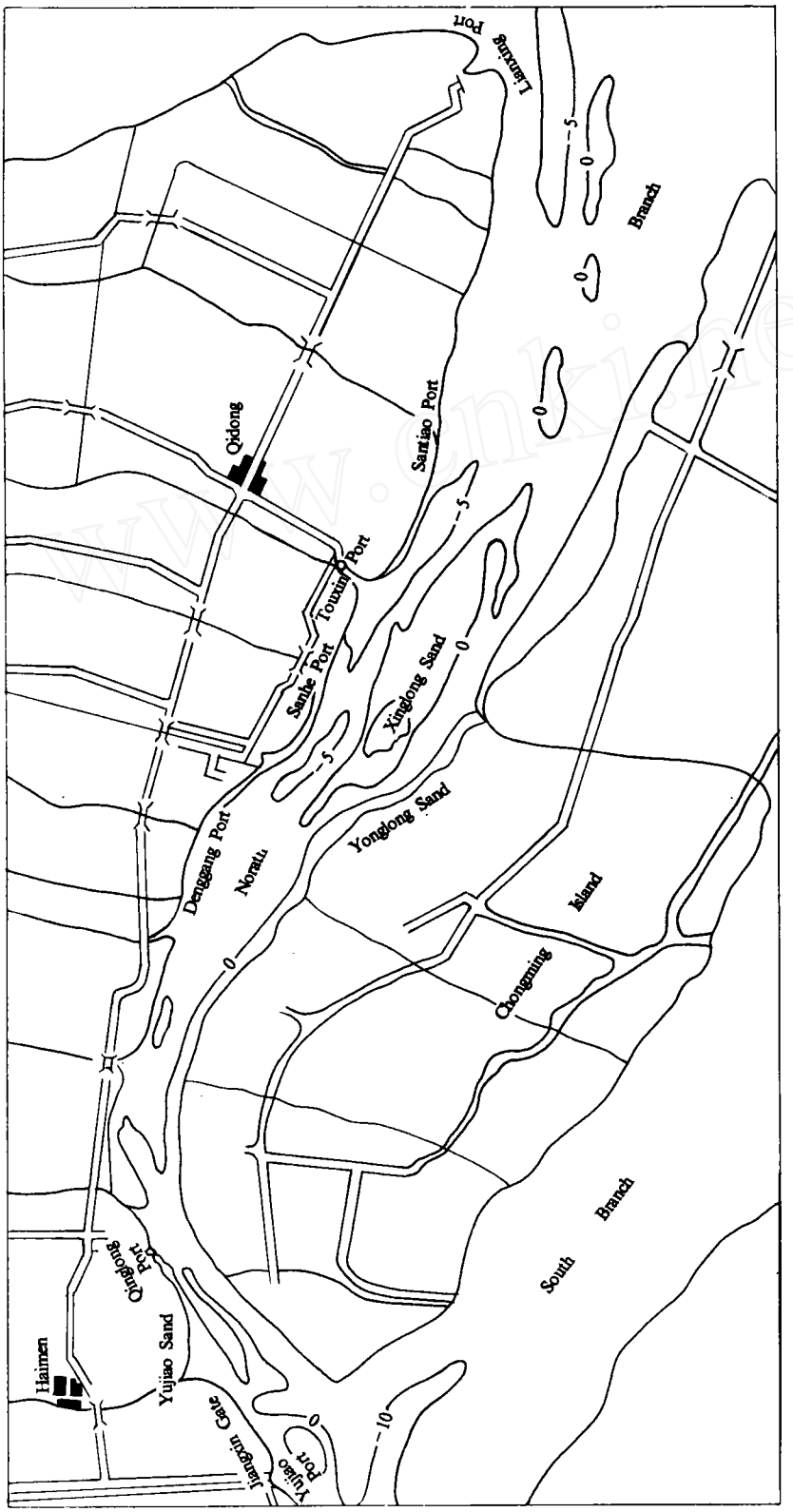

Fig.1 The recent general form of the north-branch of the Changjiang River mouth

not be completely carried away by the falling tide, which led the load to deposition. From 1970 to 1978, the average deposition rate reached about 9 million m^3 / a.

After 1978, the water amount entering the north-branch had been increasing with the development of the east channel of Tongzhou Bar and with the scouring of its left bank. But the velocity of the rising tide flowing upstream along the north-branch became smaller because of the deposition in the river channel, and the reclamation of the bars which led the intersection points of the rising tides of the south-branch and the north-branch to move to the section between Xujiao Port and Qinglong Port from the entrance of the north-branch. The effect of water and load of the north-branch going back to the south-branch was weakened. And so during this period, the deposition effect of the north-branch was larger than that from 1970 to 1978. The volume of the channel of the north-branch under zero-metre decreased from 1390 million m^3 in 1978 to 1210 million m^3 in 1986. The deposition rate was 22 million m^3 / a. The rate of the scouring and depositing was different among each reach of the north-branch (Table 1). The rate of the deposition was large in the entering reach of the north-branch. From 1958 to 1986, the volume of the channel under zero-metre decreased about 82% in the reach between the top of Chongming Island and Xujiao Port and 57% in the reach between Xujiao Port Qinglong Port. That is because the intersection point of the rising tides of the south-branch and north-branch lay near the entering reach of the north-branch. The two rising tides clashed here to form the retarding flow area, which made a lot of load deposit near the entering point of the north-branch, on the contrary from 1958 to 1986, the volume of the channel of the north-branch under zero-metre decreased only about 40% in the braid channels, and 33%-35% in the exit reach because the lack of the intersection. It showed that the deposition amount here was smaller than that in the entering reach of the north-branch. In some years of this period, some reaches were't deposited but were scoured. From 1978 to 1981, the volume of the channel under zero-metre was increasding in the reach from the top of Chongming Island to Daxin Port. From 1983 to 1986, it was also increasing in the reach from Daxin Port to Touxin Port (Table 1) because of the development of the east channel of Tongzhou Bar, which made its left bank scour after 1978. This kind of scouring was extending from the top of Chongming Island to Daxin Port and to Touxin Port. In the past tens of years, the deposition amount has been larger than the scouring amount, and the volume of the channel has been decreasing in the north-branch. From 1958 to 1986, the volume of the whole channel of the north-branch decreased by 849.28 million m^3 all together. The deposition rate was 30 million m^3 / a.

In the past twenty years or more, the general form of the Changjiang River near Tongzhou Bar at the upstream of the north-branch has changed much, and the main stream line of the east channel has come to move to the left bank, by which Dongfanghong Farm and other places have been heavily scoured. The bank along Dongfanghong Farm

was destroyed 250m during the flooding period in 1982. And till 1983, the destroyed bank was more than 1,500m long. The main stream line of the Changjiang River was shifted 2350m to the left at No. 4 dam, which not only made east channel of Tongzhou Bar wider but also made the total discharge percentage of the north–branch larger[1].

Table 1 The volume of the channel of the north–branch of the Changjiang River mouth under zero–metre ($1000m^3$)

River reach	1958	1970	1978	1981	1983	1986
Top of Changming Island–Xujiao Port	84270	42950	20230	26700	24020	15270
Xujiao Port–Qinglong Port	59000	29050	21770	28000	30620	25360
Qinglong Port–Dahong Port	50780	28060	20060	20500	23680	23950
Dahong Port–Daxin Port	65380	46230	41280	48500	42340	38880
Daxin Port–Lingdian Port	64730	49160	44210	41500	39570	41730
Lingdian Port–Denggan Port	77830	56540	46190	44500	40940	44280
Denggan Port–Sanhe Port	82620	62090	51940	51000	44210	45770
Sanhe Port–Xinhe Port	100010	74270	60340	63500	57380	60850
Xinhe Port–Touxing Port	86690	62270	64190	57500	51560	52930
Touxing Port–Huiyang Port	146130	99210	97460	83000	85660	81490
Santiao Port	243540	138110	134340	122000	117410	110940
Santiao Port–Wucang Port	298530	154200	168940	150000	153400	140090
Wucang Port–Zhongcai Port	502410	233200	240380	198000	199630	194250
Zhongcai Port–Lianxing Port	2060800	383840	377050	344000	325200	335730
Total		1459180	1388380	1278700	1235620	1211520

All these weakened the effect of water and load in the rising tide of the north–branch going back to the south–branch. So the increasing of the total discharge percentage of the north–branch didn't weaken its deposition. On the contrary, the volume of the channel keeps on decreasing as the deposition amount increases (Table 1). And so the north–branch tends to atrophic.

II. THE TRANSPORT OF THE WATER, LOAD AND SALT ABOUT THE NORTH–BRANCH OF THE CHANGJIANG RIVER MOUTH

1. The Movement of the Water

With the change of the river general form at the upstream reach and the north–branch itself, the movement of the water changes much at the north–branch of the Changjiang River mouth. the changes are shown in following aspects:

1.1 From the exit of the north–branch to the upstream reaches the duratin of the average duration difference between the falling tides and rising tides shortens while that of the falling tides lasts longer. The duration difference between the falling tides and the rising tides enlarges towards the upstream.

The measuring data obtained in August 13–24, 1959 showed that the average duration of the falling tides was 6 hours and 27 minutes, the average duration of the rising tides was 6 hours and 6 minutes; and the rising tides was 21 minutes at the exit of the north–branch of the Changjiang River mouth. During the same period (August 13–24, 1959), the average duration of the falling tide was 7 hours and 13 minutes, and the average duration of the rising tides is 5 hours and 16 minutes; and the average duration difference was 1 hour and 57 minutes at Santiao Port. And also during the same period, the average duration of the falling tides was 7 hours and 40 minutes, and the average duration of the rising tides was 4 hours and 50 minutes; and the average duration difference was 2 hours and 50 minutes at Qinglong Port.

1.2 The high tide level becomes higher, the low tide level becomes lower, and the tidal range becomes large.

As the tidal wave changes in the north–branch, the annual average high tide level in the north–branch is higher than that in the south–branch, and the annual average low tide level in the north–branch is lower than that in the south–branch. And thus the average tidal range in the north–branch is larger than that in the south–branch.

According to the data from the Shanghai Channel Bureau, the annual average high tidal level is 3.49m, the annual average low tidal level is 0.8m at Qinglong Port of the north–branch; the annual average high tidal level is 3.36m, the annual average low tidal lwvel is 1.29m at Xuliujing of the south–branch. And so the tidal range is 2.69m at Qinglong Port of the north–branch, and only 2.07m at Xuliujing of the south–branch.

1.3 The current velocity of the rising tide is mostly larger than that of the falling tide.

According to the measuring data from 1958 to 1987, during the period of the high and middle tide level, at the cross section of Qinglong Port, the current velocities of the rising tides are larger than that of the falling tides. And during the periof of the low tide level, the current velocities of the rising tides are smaller than that of the falling tides; while at the cross section of Santiao Port during the period of the high, middle and low tide level, the current velocities of the rising tides are larger than that of the falling tides.

1.4 The tide water of the north–branch goes back to the south–branch

According to the measuring data from the Shanghai Channel Bureau and other units, the tide water of the north–branch began to go back to the south–branch of the

north–branch began to go back to the south–branch in 1959, till the 1970s the tide water amount which was brought back to the south–branch form the north–branch reached the top. Till the 1980s this kind of tide water amount became less because of the increasing of the total runoff volume into the north–branch. Only during the low water seasons, the tide water of the north–branch went back to the south–branch when the water amount from the upstream reach was small.

2. The Load Transport

In 1985, at Xujiao Bar and Qinglong Port of the north–branch, the measuring data from three cross sections showed that in the north–branch, the suspended load was mainly made up of silt and clay, whose transport and deposition had something to do with the current veolcity. The bed load in the north–branch was mainly made up of silt at the point bars, and fine sand at the deep troughs. The strength of against–scouring of the two kinds of load was smaller and easy to carry upwards, drag about and move saltantly. The tides in the nroth–branch were mainly rising tides. The current velocity and silt content of the rising tides were mostly larger than that of the falling tides. The load was carried by the rising and falling tides back and forth. But generally, it tended to transport towards the upstream. The rising tides moved northward, the current velocity was larger and the duration was short, while the falling tides moved southward, the current velocity was smaller and the duration was long, therefore the north bank tended to be scoured and the south bank tened to be deposited. Besides, the load transport and deposition in the north–branch had something to do with the intersection of the rising tides of the south and north branches. In the 1970s, the intersection point of the south and north branches was at the entrance of the north–branch, where the retarding flow area and the deposition area came into being. After the 1970s, the intersection point moved to the inside of the entrance of the north–branch. And so the retarding flow area and the deposition area moved downstream along the north–branch.

The depositing load in the north–branch is brought by the runoff of the Changjiang River as well as by the coastal current outside the Changjiang River mouth. According to the measuring data, all the year round the suspended load out of the Changjiang River mouth is carried to form the depoition southeastward, and the rest is transpored southward along the coast of the Zhejiang. In summer, the water out of the Changjiang River mouth tends to flow northward, but the time and the range are limited, the fluidal tendency is weak, and thus it hasn't much effect; while the coastal current flows southward along the coast of North Jiangsu all the year round. It is strong in winter and weak in summer, From the North Jiangsu riffle to the Changjiang River mouth, there is a turbid water belt which is more than 30km long. It passes the North Jiangsu mouth into the north–branch together with mud and fine silt, and becomes the main deposition origin of the north–branch.

3. The Transport of the Salt

In the north–branch of the Changjiang River mouth, the largest range of the chlorinity is 7 mg / kg – 15,500mg / kg, the average range is 780 mg / kg – 8,400mg / kg. Along the Changjiang River, the chlorinity is higher in the east than that in the west. Along the same longitude, the salinity is much higher in the north–branch than that in the south–branch. For example, on February 16,1987, the average daily chlorinity was 14,420 mg / kg at Santiao Port of the north–branch, while during the same period, at Baozheng of the south–branch, it was only 1,750 mg / kg, and 833 mg / kg at Gaoqiao.

The amounts of the runoff, tide and tidal range have the effects on the transporting of the salt water and the salinity. According to the measuring data, when the total runoff volume is more than 25,000 m^3 / s at Datong cross section, the river water at Qinglong Port cross section is mainly made up of fresh water, and the water at Santiao Port cross esction tends to freshen. When the total runoff volume is less than 10,000 m^3 / s at Datong cross section, the chlorinity at Qinglong Port' cross section changes a little as the tidal range changes, and Santiao Port cross section is in stable condition of high chlorinity for a long time. And when the total runoff volume is 10,000—25,000 m^3 / s at Datong cross section, the chlorinity at Santiao port cross section obviously changes as the tidal range changes.

According to the measuring data, the salt water goes back to the south–branch from the north–branch mainly during the high tide level. During the high tide level, each time, the water amount which goes back to the south–branch from the north–branch is about 100 million m^3, and the salt amount is 1.5 million t. The water amount is about 15,200 milliom m^3, the salt amount is about 228million t during the whole low water season[2].

The research work, from the River Port Observation of the Nanjing Water Conservancy Research Institute, comes to a conclusion that when the salt water goes back to the south–branch form the north–branch, the water chlorinity in Baogang reach of the south–branch has something to do with the water amount from the upstream, the tidal range of the north–branch and the extended length of–10m depth curve (L) at the entrance of the north–branch. The formula is:

$$\overline{CL}_B = 10100exp(-0.0041L^{0.4}\frac{Q}{\Delta H^3})$$

Where $\overline{CL}_B$:the average chlorinity of the three days during which the chlorinity is the highest of all (mg / I) When the water goes back to Baogang reach from the

north–branch.

Q: the average runoff volume at Datong cross section of the Changjiang River, during a week before the high tide level (m^3 / s).

ΔH: the average tidal range of the rising tides of the three days during which the range is the highest of all, during the high tide level at Qinglong Port cross section (m).

III. ENDING REMARKS

The change of the general form and the inverted transport of the water, load and salt of the north–branch of the Changjiang River mouth has a series of effects on the south–branch. First of all, the load brought back from the north–branch forms a tongue–like deposition body in the entrances of the north and south branches It retards the rising tides flowing upstream along the north channel of Baimao Bar, while the water amount of the rising tides of the south channel increases. At the same time, the falling tides in the north channel of Baimao Bar move to the south by the effect of the deposition body, and the water amount of the falling tides in the south channel increases. And thus it comes to the condition under which north channel is gradually depositing and the south channel is gradually scouring. In 1970, the rate of the volume between the south channel and the north channel of Baimao Bar is 1:1; In 1973, 58:42 and in 1977, 67:33. The change of the general forms of the south channel and the north channel of Baimao Bar, and the rise of the hydridynamic effect of the south channel make the falling tides which enter Qiyakou reach from the south and north channels of Baimao Bar move to the north. Xinqiao channel was formed by scouring the middle part of Biandan Bar, which makes the water amount of Beigang Port increases, at the same time, the deposition has taken place and Xinliuhe Bar is formed at Liuhe of the Nangang Port. Next, the inverted transport of the salt from the north–branch to the south–branch of the Changjiang River mouth brings the changes of the salinity in the south–branch. According to Shanghai Surveying and Designing Institute, at Datong cross section, when the total runoff volume of the Changjiang River is 7,500 m^3 / s, and when the river water goes back to the south–branch from the north–branch the chlorinity is 6,200 mg / kg at the top of Chongming Island, 330 mg / kg at Qianjingkou,600 mg / kg at Yanglin 410 mg / kg at Baogang, and 280 mg / kg at Wushong.

In recent years, because the main stream of the east channel of Tongzhou Bar straightly scours the bank of Dongfanghong Farm. The upstream runoff into the north–branch changes its angle in a certain degree. That is to say, the stream line into the north–branch is more smooth than before. In July, 1983, when the Changjiang River was in flood, the flood runoff volume was 66,200 m^3 / s at Datong cross section, the tongue–like deposition body at the entrance of the north–branch was almost scoured away, which smoothed away the difficulty of the water from the south–branch to the north–branch. So

at present the water of the upstream reach and the south–branch is much easier to enter the north–branch than before. The intersection point of the south and north branches is close to Qinglong Prot cross section of the north–branch. What is more, the cross section area of the north–branch itself becomes smaller commonly because of the load deposition and thus the inverted transport effects of the water, load and salt from the north–branch to the south–branch become weaker than before.

REFERENCES

[1] 邹德森，长江口南通河段的演变及整治设想。人民长江，1986,(10): 42.

[2] 韩乃斌，南水北调对长江口盐水入侵影响的预测，地理研究，1983, 2(2): 100.