Journal of Coastal Research	11	4	1037–1041	Fort Lauderdale, Florida	Fall 1995

A Channel Erosion and Accretion Analysis of One Port in Beibu Bay, China

Ling Yongning and Xia Hualiang

Communication Planning Surveying Design
Institute of Guangxi
Nanning, China

ABSTRACT

YONGNING, L. and HUALIANG, X., 1994. A channel erosion and accretion analysis of one port in Beibu Bay, China. *Journal of Coastal Research*, 11(4), 1037–1041. Fort Lauderdale (Florida), ISSN 0749–0208.

The deep water channel for the port in Beibu Bay is located along the original deep channel of the ancient river port and flows in the direction of the rising and falling tide. The tide at the port is continuous with the outgoing tide generally flowing swifter than the incoming tide; waves are seasonal and usually run parallel to the channel. As a result, the channel erodes in winter and accretes in summer. There is minimal erosion and accretion during the year which is very beneficial to the development of the channel (at the sand block in the mouth of the Gulf).

ADDITIONAL INDEX WORDS: *Tidal channel, tidal wave, sand bar, coastal flooding.*

INTRODUCTION

The Port is located along the southwestern coast of China, near Beibu Bay. The bay is surrounded on three sides by hills and the mouth of the Gulf is toward the south. To the east of the bay, there is a peninsula called Q.S. Peninsula; the B.L Peninsula lies to its west. Thus, the bay is blocked from the wind and the waves inside its perimeters are gentle.

The total area of the bay is about 160 km^2, and there are many isolated hills and little islands distributed about the bay. The largest of the islands is "Y" Island. It is about 2 km wide and about 8 km long; it stretches from east to west and divides Beibu Bay into two areas, the outside gulf (eastern gulf) and the inside gulf (western gulf). The area of the former is about 120 km^2 and the latter about 40 km^2; the mouth of the inside gulf is about 13 km from the mouth of the Bay and runs the length of the port channel.

The continental sea shore is about 80 km long with 10 streams or little rivers flowing from shore to Gulf. Many of them are seasonal streams that only flow during the flood season. Among them, "F" River is the longest river and it flows the entire year. It originates at the Great Mountain with an approximate length and watershed area of 100 km and 810 km^2 respectively. There are heavily vegetated hills on both sides of the river and its discharge rate varies strongly from the flood to the drought season. The river's discharge rate during the heavy flood season reaches more than 5,400 m^3 s^{-1} and during the drought season is less than 10m^3 s^{-1}. The average annual runoff is 17 $\times$ 10^8 m^3, 20% of the amount concentrated in that duration is less than 3% of the whole year. The sediment load of the river is minimal with an average annual sediment content of about 0.12 kg/m^3, the average sediment discharge rate is about 20 $\times$ 10^4 tons.

"F" River is divided into an eastern and western branch and flows from the north shore to the inside gulf. The eastern branch flows into the outside gulf from the northern end of "Y" Island, then joins the Ringjing River and the Fengliujing River. Finally, it flows to the south along "A" River; then its western branch flows in a southerly direction from the wharf front in the port to the mouth of the gulf combining with the eastern branch on its final march to the sea.

DISCUSSION

Soil samples were taken and an analysis and study of the geological and geomorphological features of the sea bottom completed. The deep water channel of the inside and outside gulf was formed by the ancient "F" riverbed and "A" riverbed by geologic and geomorphologic changes and tide and sea breaches over many centuries. It is possible that the sand block in the mouth of the

94063 received and accepted in revision 5 May 1994.

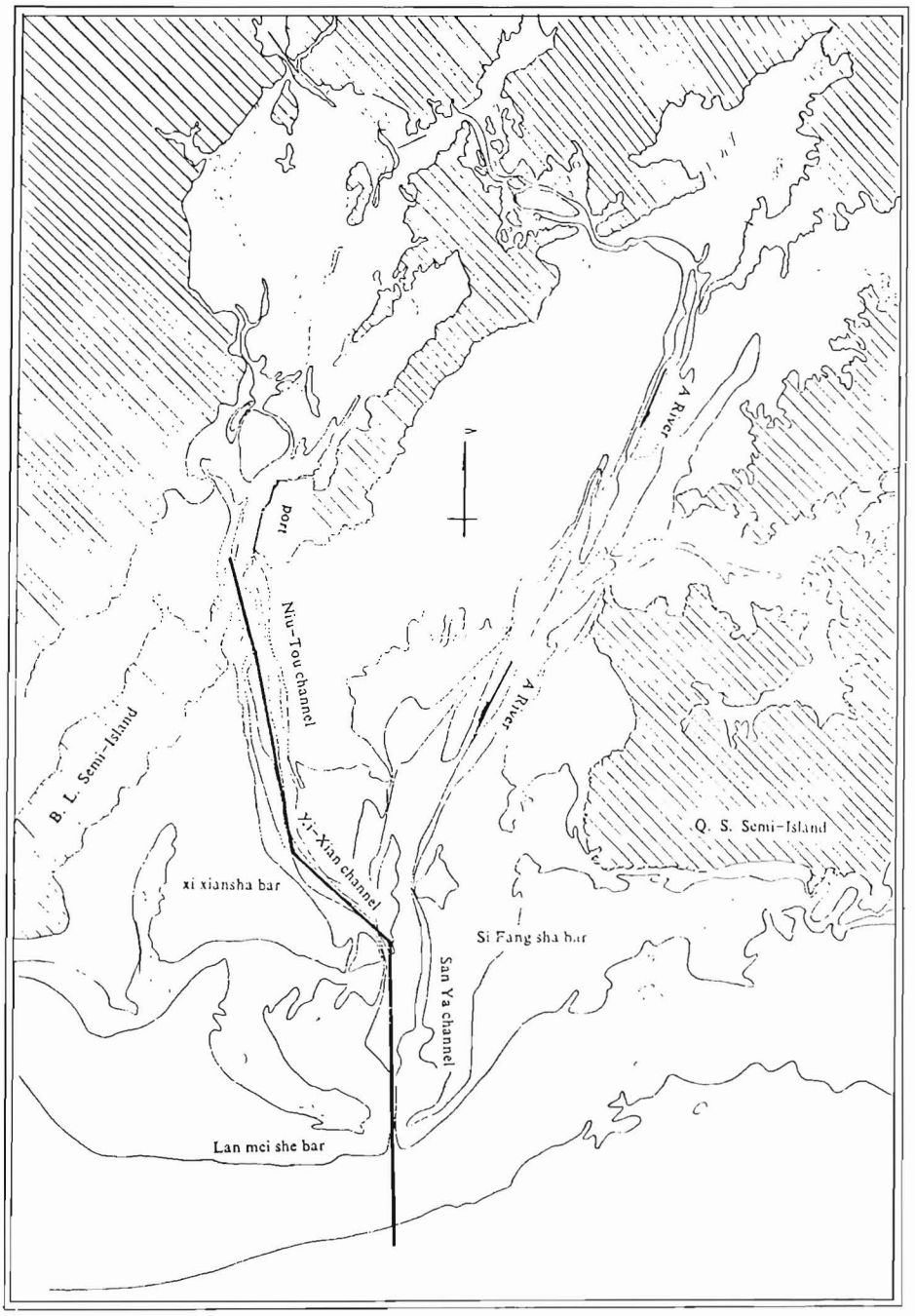

Figure 1. A port of Guangxi.

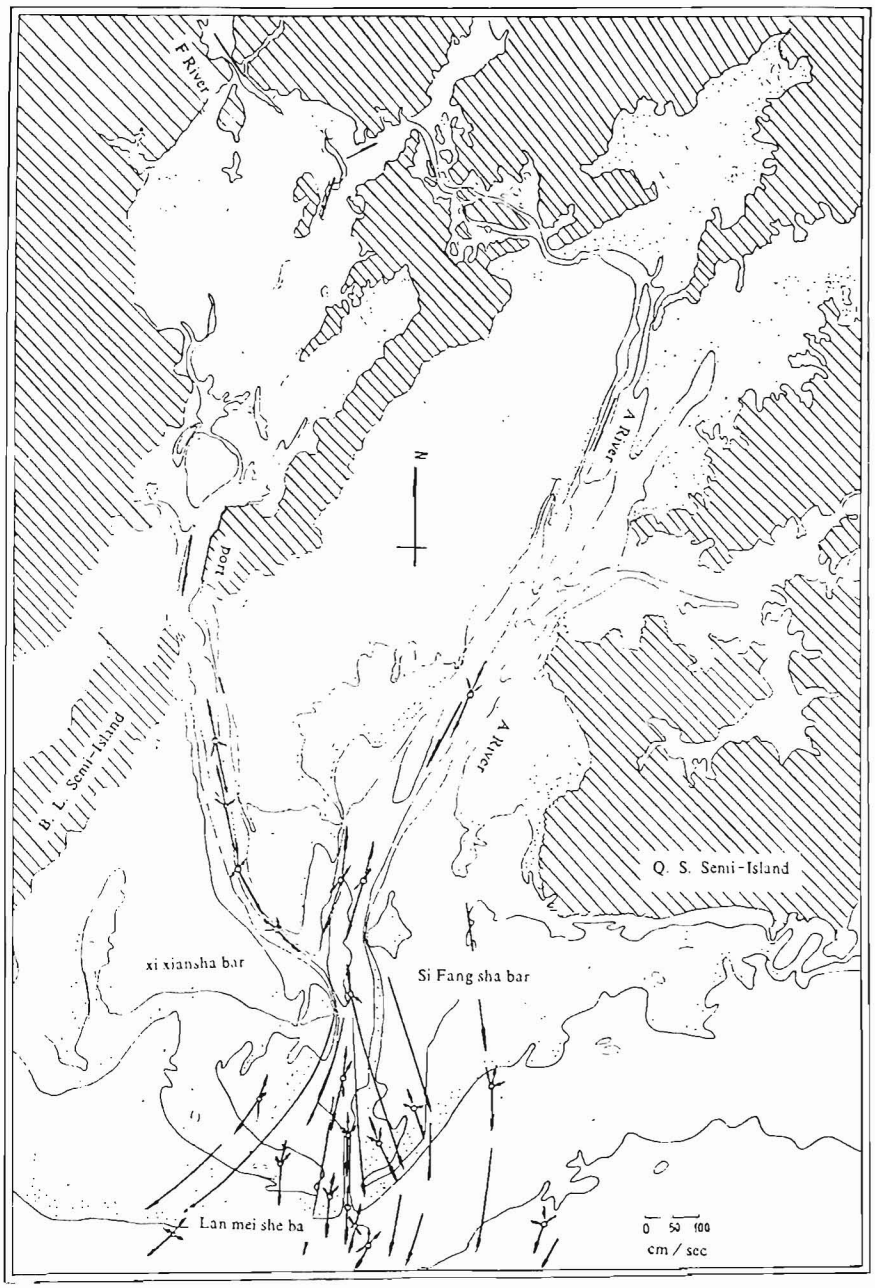

Figure 2. Maximim flow vector and current line of average rising and ebb tide.

Bay was part of an ancient delta (5,000 to 6,000 years ago).

Because of long term topographical, geomorphological, wave and tidal action and the sand block, sand shoals such as Gusifengsha on the eastern side, Xixiansha on the western side and Niujiaosha, where the two meet, were developed in the two sides of the bay and near its mouth.

Table 1. *Tidal current distribution before/after trial-channel.*

Station:	A		B		C	
Item	Rising Tide	Ebb Tide	Rising Tide	Ebb Tide	Rising Tide	Ebb Tide
Direction (degree)						
Before cut	8	195	0	175	4	183
After cut	9	191	358	178	358	175
Velocity (cm·sec)						
Before cut	40	51	42	75	34	63
After cut	44	58	48	78	48	79

Table 2. *The statistics of the full time wave feature.*

Wind Direction	Each Grade		>3 Grade		>5 Grade	
	P	H	P	H	P	H
N	0.571	0.43	0.028	1.00		
NNE	20.411	0.47	0.946	1.03	0.014	2.45
NE	12.182	0.42	0.515	1.05	0.014	2.20
ENE	2.229	0.41	0.180	1.12		
E	3.615	0.40	0.421	1.09		
ESE	5.131	0.50	0.811	1.15	0.028	2.3
SSE	6.862	0.58	1.373	1.23	0.084	3.08
S	14.655	0.72	5.714	1.16	0.139	2.31
SSW	8.233	0.86	4.275	1.25	0.166	2.22
SW	1.9944	0.57	0.4991	1.12	0.007	2.5
WSW	0.1899	0.53	0.049	1.11		
W	0.272	0.60	0.097	1.18		
WNW	0.091	0.61	0.035	1.23		
NW	0.056	0.31	0.007	1.00		
NNW	—	—	—	—		

These sand shoals occur above the sea surface when the tide level is low. In some parts, caves form wide shallow water areas under the sea surface.

Due to the topographical condition of the Bay and its relative stability and the fact that the channel was formed by long term dynamic factors, the deep water channel of the port has always been on the "F" River. The general flow of the channel is from north to south and depending on direction and position, the channel can be divided into three sections as follow: (1) Niutou Channel (NNW-SSE) (2) Xixian Channel (NW-SE), and (3) the sand shoal channel in the mouth of the bay (N-S). The direction of each channel is in line with the rising and falling tide (Figure 1).

Since the port authority dredged the channel, siltation is less than expected and little maintenance is needed to keep the channel open. Before the channel was dredged, the natural water depth at zero-meter tidal level was only 3–4 m, now the water depth at zero-meter tidal level is 8 m. The port administration plans to deepen the channel so as to increase its tonnage capacity. The success of the waterway mainly depends on the large tidal volume of the port (3–5.5 $\times$ 10^8 m^3), the flow velocity of the ebb tide, and favorable seasonal wind-wave action. In addition, the peninsula is formed by the double jetty-like extension at the entrance to the bar which blocks silt from entering the channel. This natural bar contributes greatly to the fact that this deep water port requires minimal maintenance.

The inner bay is influenced by the progressive tidal wave of the Northern Bay and is characterized by a standard full-day tide. The tidal range is maximal (> 4.5 m), and its lift delay average of 14.73 hr is much longer than its ebb delay average of 9.83 hr. When a half-tidal constituent is obvious, the tidal range is minimal (> 0.5 m) and the delay of the rising tide and ebb tide is almost the same. Observations prove that outside the sand bar in the open sea, tidal currents rotate; inside the sand bar, the tidal current is swift, and its direction is basically parallel to the axial line of the waterway (see Figure 2). On the whole, the flow velocity of the ebb tide is greater than that of the rising tide, usually 1.3–1.6 times (see Table 1). The flow velocity of the rising tide is 0.35–0.5 m/sec and that of the ebb tide is 0.5–0.8 m/sec.

Apart from the land block on three sides by hills, there are sand bars including Xian and others at the entrance which are effective in wearing down the energy of waves as they pass the entrance. Hence, it is calm and tranquil in the bay. During typhoons, wave heights inside the port are not large, generally below one meter. Along the two sides of the waterway as you enter, especially on the sand bar waterway and Xixian Waterway, there are wide shallow sand bars, and another sand bar cuts across these shallow sand bars. Hence, the silt of the shallow sand bar is roiled by the waves and carried by tidal current into the main channel and is the main source of silt build-up in the port.

The monsoon at this port is predictable. In the summer, the wind comes from the south (SE-SSW), and its frequency is up to 32.4%; and in the winter, the wind is from the north (NE-N-NW) and its frequency is up to 45.94%. Thus, the direction of the waves is mostly S, SE, SSW, SSE in summer and N, NE, NNE in winter; wave fre-

quencies are 47.52% and 33.17% respectively, and their average height is 0.65 m and 0.45 m respectively. The direction of the strongest wave is S-SSW, frequency is 22.99% and average wave height is 0.77 m. The average annual frequency of waves of the magnitude 3–5 is 17.7% of which 9.97% come from a S-SW direction and the average wave height is 1–1.25 m. The wave frequency (> 5) is only 0.53% of which 0.305% come from a S-SSW direction, and the average wave height is 2.2–2.5 m (see Table 2).

Information obtained by tracking the sand indicates that both the silt from the east side, outside the entrance which drifts along the coast of the Qi Shar Peninsula, and the silt from the west side, outside the Bei Longwei Peninsula, do not enter the port. This study supported the thesis that the waterway silt does not come from this source but from silt carried along both sides of the waterway around the sandbar, due to continuous wave and tide-current action. In summer, there is little re-siltation in the waterway because of continued SE-S-SSW waves and rising tide-current action; in the winter, the waterway silt is scoured away by the continued N-NE wave and ebb tide-current co-action. The total amount of silt in the waterway is about 3×10^4–5×10^4 m^3 and average silt thickness is under 5-8 cm per year. This is corroborated by available waterway topographic surveying data. By means of a known mathematical formula, experts estimated the scour and deposition, and their figures supported the results as stated above (see Table 3).

The sediment concentration of "F" River is minimal, but the annual average sediment load is 20×10^4 tons, 80 percent of which is carried by flood runoff. The flood sediment concentration is large and last 10 percent of the year. Due to flow diffusion, most of the silt carried by "F" River is deposited near the estuary and a small amount is deposited in the harbor basin channel or carried to the entrance of the port by tidal current. During winter, the silt deposited gradually moves out and is carried to the port entrance by the co-action of the north wind, the waves, and the large ebb tide current. Some of the deposited silt becomes waterway re-siltation in the process but this is the exception as opposed to the rule. During the summer, if the strong S-SE typhoons coincide with a swiftly rising tide and its subsequent flood, the re-siltation of the waterway is greater than usual, likely up to 20×10^4 m^3 or more.

Table 3. *Scour and deposition of 1984 in sand bar waterway section.*

Method	Computation Method: Wave Energy Method	Energy Flow Method	Stress Shear Method	Actual Measurement Method
Scour and deposition	+0.37	+0.90	+0.02	+0.43

+ = deposition, − = scour

CONCLUSION

In this region, typhoons only occur 1–3 times per year and their directions are tumultuous and unpredictable and often coincide with swift rising tides and flood conditions. Therefore, the chance of a sustained S-SE typhoon is minimal. If the natural characteristics and favorable seasonal conditions of the bay are properly utilized, especially the sand bar waterway entrance, it will be possible to continue to use and expand this port and exploit its value from a social and economic standpoint.