Advanced Materials Research *Online: 2013-12-13*
ISSN: 1662-8985, Vols. 850-851, pp 1347-1350
doi:10.4028/www.scientific.net/AMR.850-851.1347

Hydrological and Sediment Characteristics of Sand Ridge Field in Jiangsu coastal area of China

Cheng Chen[a], Yigang Wang[b], Huiming Huang[c], Dake Chen[d], Chunguang Yuan[e]

Key Laboratory of Coastal Disaster and Defence, Ministry of Education, Hohai University, Nanjing, 210098, China

[a] chencheng_1117@163.com, [b] ygwang@hhu.edu.cn, [c] hhm@hhu.edu.cn, [d] chdake@126.com, [e] 494482125@qq.com

Keywords: Sand ridge field, Coastal area, Hydrology, Sediment

Abstract. The sand ridges field in Jiangsu coastal area has been the key region of tidal flat reclamation, waterway regulation and port construction. Adopting the hydrological and sediment data in winter, the tidal patterns were revealed. In addition, the depth-averaged velocity, sediment grain size and sediment concentration in each station were analyzed and compared in detail. The result shows that the tidal in study area is regular semidiurnal and diurnal inequality. The velocity has a decreasing tendency with the Tiaozini water area being centered towards the surrounding areas. The grain size gradually decreases and then increases from north to south, while the sediment concentration gradually increases and then decreases from north to south.

Introduction

The sand ridge field located in the eastern coast of Jiangsu has special landform characters, with rich resource of tidal flat (Fig 1). Sand ridge fields consist of large, elongate sand bodies and channels formed by tidal dynamics in shallow seas with abundant sediment [1-3].

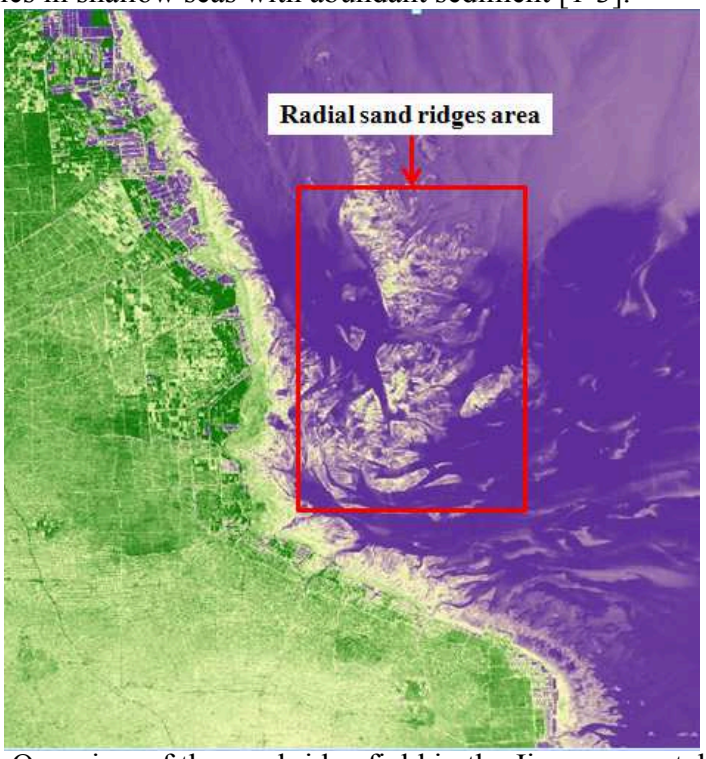

Fig.1 Overview of the sand ridge field in the Jiangsu coastal area

The sand ridge field spans more than 20,000 km² in the south west Yellow Sea [4]. It is about 200km in length and 90km in width, consisted of more than 70 sand ridges which have deep tidal channel between them [5]. It is unique in the world. Tidal channels rang up to about 25m in depth [6].

The entire sand ridge field approximately distributes with 160 degree radiation to the north, the northeast, the east and the southeast, as Jianggang Port for its vertex. The distribution is asymmetric and biased toward the north. The sand ridge field has more than a dozen large sandbars and four deep tidal channels.

This paper analyzed tidal characteristics, tidal current, and sediment grain size distribution, sediment concentration distribution based on the hourly observations of hydrology and sediment of the sand ridge field in winter. The source of sediment will also be briefly analyzed based on the spatial distribution of sediment concentration. Approximate positions of each station are shown in Table 1.

Table 1 Positions of each station in Jiangsu coastal area

Station	Position
S1	Xiyang sea area
S2	Xiaoyangkou harbor
S3	Xiaobeicao
S4	Waimaozhusha
S5	Huangsha sea area
S6	Lvsi harbor

Tidal Pattern

The forward tidal waves from East Sea and the anticlockwise rotational tidal waves that are generated by the incident waves reflecting from Shandong Peninsula join together and generate a radial tidal current field which has a great tidal range and strong tidal current in the sand ridge field. The whole region is subject to the M_2 tidal wave，mainly regular semi-diurnal tide. In a lunar day two-times high tide and two-times low tide turn up regularly, which presents obvious semidiurnal tidal characteristics. The average tidal range decreases gradually from the center which is Jianggang Port-Yangkou Port to the south and to the north. The average tidal range of Yangkou Port is 4.29m, and that of Jianggang Port is 4.14m. While in the north Sheyang estuary has an average tidal range for 2.12m and in the south Lvsi estuary has an average tidal range for 3.65m. The maximum measured tidal range in Huangsha Channel out of Yangkou Port and in Lansha Channel out of Changsha Port is 9.28m and 7.64 m, respectively. And the measured tidal range out of Jianggang Port is 5.72m.

Tidal Current

Table 2 Mean flow velocity in each station

Station	Mean flow velocity(m/s)	
	spring tide	neap tide
S1	0.92	0.74
S2	0.83	0.58
S3	0.57	0.39
S4	0.56	0.47
S5	0.75	0.40
S6	0.62	0.43

Tidal sand ridges are a characteristic feature of tide-dominated continental shelves. According to the tidal current measured data (Table 2), it is known that the velocity from large to small is as follows: Xiyang waters, Waimaozhusha, Xiaoyangkou Port, Huangsha waters, Lvsi Port, Xiaobeicao. So it is easy enough to see that tidal current decreases radiating toward the surround seas from the sand ridge field. The tidal current dynamic of Xiyang Channel in the northern sand ridge field is slightly stronger than that of Old Yellow River delta. In the south side of the sand ridge field near Xiaoyangkou the near-shore tidal current is relatively strong, while offshore tidal is relatively week. Spring tide flow velocity is larger than neap tidal flow rate, especially near the western waters and Xiaoyangkou.

Sediment Grain Size

In the sea areas of Jiangsu province, the suspended sediment particle sizes are almost close, especially in Xiyang waters and Lvsi Port waters, and the median particle size range is between 0.007 ~ 0.01mm. Meanwhile, the suspended sediment particle size distribution shows offshore relatively coarse sediment and near-shore relatively fine sediment，overall, the suspended sand median diameter of this sea area is significantly smaller than that of Jiangsu northern and southern nearshore waters. While in the south sea area of Xiaoyangkou, the suspended sediment particle size which changes slightly mainly between 0.009～0.013mm is only slightly larger than that in the central waters, and significantly smaller than that in the northern waters of Jiangsu. Generally, the Jiangsu coastal suspended sediment particle size decreases and then increases gradually from north to south, presenting a "U-shaped" distribution. Jiangsu coastal suspended sediments are evenly fine, belonging to cohesive fine sands, and the gain size amplitude is basically under 0.003mm from Old Yellow River estuary to the eastern waters of Yangkou Port. This preliminary indicates that the suspended sediments of Jiangsu coastal central sea areas have nearly the same sources.

Table 3 Suspended sediment median particle size in each station

Station	The median particle size (mm)	
	spring tide	neap tide
S1	/	0.0074
S2	0.0083	0.0071
S3	0.0079	0.0064
S4	0.0101	0.0073
S5	0.0101	0.0074
S6	0.0087	0.0071

Note: "/" for the missing data

Sediment Concentration

In order to discuss the sediment concentration, the depth-averaged sediment concentrations are shown in Table 4. By analyzing the depth-averaged sediment concentrations in table 4，we can find that in the southern Yellow Sea the sediment concentration distributions from big to small is as follows: Xiyang waters, Waimaozhusha, Huangshayang waters, Xiaobeicao, Xiaoyangkou Port, Lvsi Port.

Sediment movement of sand bank field in Jiangsu coastal area is complex as it is mainly affected by the complex tidal current. The sediment concentration is at a high value in nearshore waters, and gradually reduced toward open seas. The results show that the Old Yellow River delta and the central seas of the sand ridge field with Jianggang Port as its center form two high sediment concentration areas where its depth-averaged sediment concentration can be up to 1.0-1.3kg / m³. In Dongda Port located at the end of Xiyang channel the measured maximun setiment concentration is up to 2.39kg / m³ during flooding tide and 3.12kg / m³ during falling tide, while the measured maximun setiment concentration is up to 3.35kg / m³ during flooding tide and 4.25kg / m³ during falling tide out of the Old Yellow River delta.

The average sediment concentration of Jiangsu coastal waters in winter present a "V-shaped" trend which is increases gradually and then decreases gradually from north to south, and the high concentration waters mainly appear in Wang Port to Jianggang Port frontier waters. The average sediment concentration of Haizhou Bay waters on the northern coastline in Jiangsu is ralatively low and is mainly between 0.1 ~ 0.3kg / m³, while the average sediment concentration of the Old Yellow River estuary to Xiaoyangkou Port waters is generally 0.6kg / m³ above, significantly higher than that of the northern and southern Jiangsu coastal waters.

Table 4 The depth-averaged sediment concentrations in each station

Station	Mean flow velocity(m/s)	
	spring tide	neap tide
S1	1.33	0.85
S2	0.47	0.38
S3	0.49	0.40
S4	0.61	0.38
S5	0.47	0.38
S6	0.21	0.12

Conclusions

The characteristics of hydrology and sediment in redial sand ridges area in South Yellow Sea are complicated; the tidal in study area is regular semidiurnal and diurnal inequality. The velocity has a decreasing tendency with the Tiaozini water area being centered towards the surrounding areas. The grain size gradually decreases and then increases from north to south, while the sediment concentration gradually increases and then decreases from north to south.

Acknowledgement

This work was funded by grants from the Cultivation and Innovation Project for Postgraduate in Jiangsu (No.CXZZ13_0258), the National Key Technologies R&D Program of P.R.China (No.2012BAB03B01), and the Jiangsu Natural Science Foundation for the Youth (No.BK2012411).

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