SPATIAL MORPHOLOGICAL CONCEPTUAL MODEL OF BAY

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ABSTRACT:

Located in the conjunct part of sea area and land area, the morphology of bays is complicated and is changing seriously by the mutual action of natural and artificial factors. Therefore, the scientific and systematic description of bay is rather difficult. The research of the spatial morphological conceptual model of bays is meaningful for the representation of the bay and the construction of digital bays. Furthermore, it is also important for the change monitoring, exploitative intensity evaluation, as well as the further use of the bays. Nevertheless, the correlated research is rather less. A multi-scale expression model of bay is put forward in the paper. Firstly, the general morphological model of the bay which is in a bay-range scale is abstracted by Geometric Abstract according to the characteristics of bays, and then in the coast scale, five categories of coasts—— rocky coast, silty coast, sandy coast, artificial coast, and other type of coast were classified, a coast-range scale model of the bay based on these categories were proposed. Finally, through the construction of the spatial morphological conceptual model of the several typical bays—Daya Bay, Zhelin Bay and Jiaozhou Bay , the validity of the conceptual model is verified.

1. INTRODUCTION

The bay is a body of water partially enclosed by land, and with a baymouth opening to the sea (United Nations, 1983). It extends from the landward limit of tidal facies at its head to the seaward limit of coastal facies at its mouth, and covers the range of intertidal zone flat and offshore water area (Buatois,L.A,et al.,2003).With ascendant natural resources, dominant geographic location and environment condition, the bay area has become a natural region where is not only the most active of the earth surface, but also a part of coastal zone with highest intensity of human activities(Edition Committee of the Bay Chorography in China, 1999; Hugo,V.Z.et al.,2008). Meanwhile, by the mutual action of natural and artificial factors, the morphology of bays is changing all the time. Nevertheless, as a complex system with rich resource, multi-fields, multi-elements, and multi-level (Edition Committee of the Bay Chorography in China, 1999), the description of bays is rather difficult, therefore the systematic expressing and analyzing method of bays is rather less. The exiting research of the bay's spatial morphology can be categorized into two types: qualitative description and quantitative expression. For the qualitative way, the bays were described as bell-mouthed bay, door-shape bay, ζ -shape bay(Halligan,1906), half-heart-shape bay(Silvester,R.,1960), arc-shape bay(Rea, C. C., Komar, P. D,1975) and so on. For the quantitative way, indicators like open degree, shape coefficient were abstracted, and the bays were categorized into open bay, half-open bay etc. according to the values of open degree, shape coefficient and other indicators. Nevertheless, Neither of these shape description method of the bay can express the complex dynamic environment, as well as the land-sea interactions well. Therefore, an effective way of describing the morphology of bays is urgently needed.

This paper aimed at the morphological and structural characteristics of bays, a multi-scale conceptual model based on the differences of bays' type and characteristics of coasts were put forward. The following of this paper is organized as follows: part two is the abstraction method of bays' morphology and structure, and the construction method of conceptual model in the bay's scale as well as in the coast's scale; part five is case study of the conceptual model of three typical bays in china; part five is conclusions.

2. METHODOLOGY

2.1 Physical Characteristics of Bays in China

There are more than 200 bays with the area bigger than 5km^2 distributed along China's coastal zone. And most of these bays are distributed in Liaoning, Shandong, Zhejiang, Fujian, Guangdong, Guangxi, and Hainan province. Even located near each other, the morphological, dynamic characteristics are always different. The difference of the causing type, geographical environment, landform and hydrological characteristics lead to the morphology of bays are very different. They are not only appears in regular rectangle-shaped, half-circle-shaped, circle-shaped, door-shaped, but also in narrow-mouth-wide-bingy shaped, horn shaped, multi-vessel shaped and so on(Shown in Figure 1).From the quantitative point of view, the bays can be categorized into several types according to water area rate(WR), open degree(OD), and morphology coefficient(MC) (Wu S.,Y. ,2000; Zhang,D.D., 2008). Through these indicators, and the result of the coastal survey of the nation in 1980s, there werev31 Entire-water bays, 9 Much-water bays, 17 Middle- water bays,9Little-water bays,2Dry-water bays;15 Open bays,17 Half-open bays,21Half–close

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bays,3Close bays; 17Long-narrow bays,13Wide-long bays,7 Square-round bays,5Long-wide bays,11Short-wide bays.

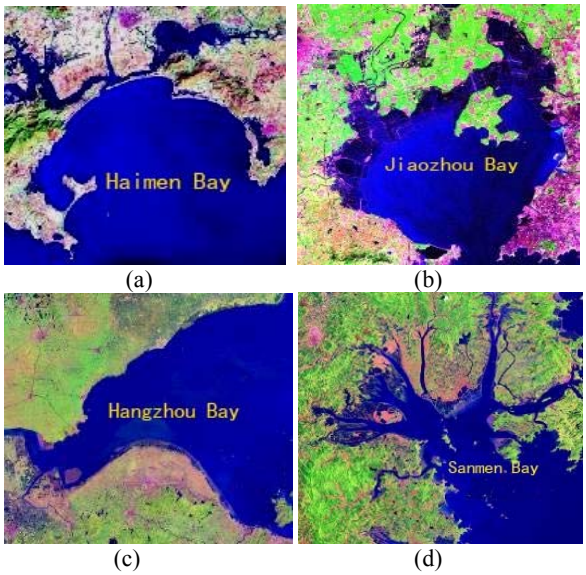

Figure 1 Different morphology of bays.(a) half-arc shaped;(b) heart-shaped;(c) horn-shaped;(d) multi-vessel shaped

2.2 General Model— bay-range scale model

According to the definition of China Bay Records, an integrated bay includes three parts: alongshore land area, tidal zone, and alongshore sea area. The baymouth is the borderline of bay and sea, the mean low-tide line is the borderline of sea area and tidal zone, while the mean high-tide line is the borderline of tidal zone and coastline. Therefore, a bay can be seen as a systematic structure formed by four axes: baymouth, mean low-tide line, coastline, land boundary, and three areas surrounded by these axes, namely alongshore land area, tidal zone, and alongshore sea area. Among these four axes, the up-boundary of land area can be establishment according to the research objective, coastal type, and the influencing range to land of different type of bank. However, due to the sea-land interaction, as well as the exploitative activities of bays by human beings, a large volume of silty soil fill up, coastline was eroded and is falling back gradually, tidal level was raising, the location and shape of the four axes were changing. As a result, the shape, structure, location and range were changing all the time, and the dynamic axis-area structure was forming. Among the axes, the coastline is most important for the shaping of the bay's structure, and fluxed obviously, because it endures intense land-sea interaction. Therefore, it was seen as the main axis of the structure. Figure 2 is the sketch map of the conceptual model of the spatial morphological of bay.

In this way, the complex of bay can be dissolved into separate geographical features, namely axis and area. And the bay can be expressed formally through formula (1), Formula (2) ~formula (4) is the expression of each areal geographical feature:

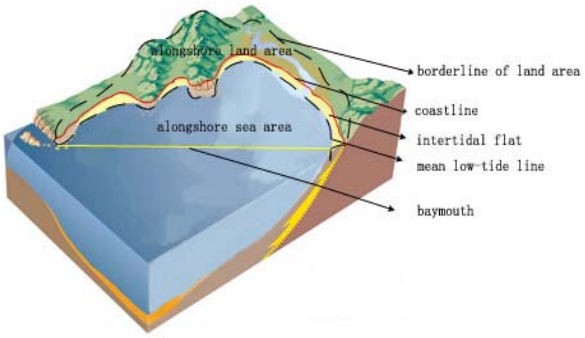

Figure 2 Sketch map of the conceptual model of spatial morphological of bay

$$M_{Bay} = f(L_C, L_{ML}, L_{UB}, L_{BM}, R_{AS}, R_{AL}, R_{TF}) \quad (1)$$

$$R_{AS} = f(L_{ML}, L_{BM}) \quad (2)$$

$$R_{AL} = f(L_C, L_{UB}) \quad (3)$$

$$R_{TF} = f(L_C, L_{ML}) \quad (4)$$

Where M_{Bay} = the morphology of the bay,

L_C = the location of coastline;

L_{ML} = the mean low- tide line

L_{UB} = the location of the upper borderline of the land area

L_{BM} = the location of the baymouth

R_{AS} = the range of alongshore sea area

R_{AL} = the range of alongshore land area

R_{TF} = the range of intertidal flats.

2.3 Conceptual Model in Coast Scale

According to the difference of the offshore coasts, conceptual models based on the characteristics of them are established. Considering of the differences of influencing intensity of offshore coasts to each axis and area, the establishing method of the location of axis and borderline of the area is different (Dandan Zhang, 2008).The location of coastline, baymouth, mean low-tide line is easy to established. Comparatively, the range of land area of different bays is complicated. A method of dynamic buffer zone which use dynamic degree of the most sensitive land use type at the alongshore coasts to establish the range of land area （SL）is brought out. The dynamic degree is established through Dynamic Degree Model of single land use change which can express the changing rate of some land use type, and it can be expressed in formula (5).

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{\mathrm{T}} \times 100\% \quad (5)$$

Where K = the dynamic degree of certain kind of land use

U_a = the area of land use in the beginning of the research period of time

U_b = the area of land use in the ending of the research period of time

T = represents the research time

Formula (6) ~ formula (9) is the formal expression of the range of alongshore land area with different coast types. Four types of

coasts were categorized: rocky coast, silty coast, sandy coast, artificial coast, and other type of coast. The main sediment materials of rocky coast are rocks, and the intertidal flat is always sandy beach, or rocky shore platform, while the alongshore land area always developed dune, ridge plain, cliff , sloping bedrock terrain; Sandy coast develops sandy beach well in the intertidal flat, while the alongshore land area always develops bedrock terrain and dune; The intertidal flat of silty coasts are mainly loose sediments ,while the alongshore land area can develop cliff, bedrock terrain. Figure 3 is the profile sketch map of the sandy coast, rocky coast, and silty coast. In the point view of land use, different types of landform on coastal zones is suitable for different kind of land use type ,and the land use types suggests obviously regional characteristics, Figure 4 is the sketch map of the land use regional profile.

$$SL_{rock} = f(\mathrm{DD}_{\mathrm{woodland}}) \quad (6)$$

$$\mathrm{SL}_{\mathrm{silt}} = \mathrm{f}(\mathrm{DD}_{\mathrm{auquculture}}) \quad (7)$$

$$SL_{sand} = \mathrm{f}(\mathrm{DD}_{\mathrm{grassland}}) \quad (8)$$

$$SL_{artifical} = \mathrm{f}(DD_{\mathrm{farmland}}, DD_{\mathrm{Resident}}) \quad (9)$$

Where

SL_{rock} = the range of the bays with most rocky coasts

$\mathrm{SL}_{\mathrm{silt}}$ = the range of the bays with most silty coasts

SL_{sand} = the range of the bays with most sandy coasts

$SL_{artifical}$ = the range of the bays with most artificial coasts

$\mathrm{DD}_{\mathrm{woodland}}$ = the Dynamic Degree of woodland

$\mathrm{DD}_{\mathrm{aquaculture}}$ = the Dynamic Degree of aquaculture

$\mathrm{DD}_{\mathrm{grassland}}$ = the Dynamic Degree of grassland

DD_{farmland} = the Dynamic Degree of farmland

DD_{Resident} = the Dynamic Degree of residential land area.

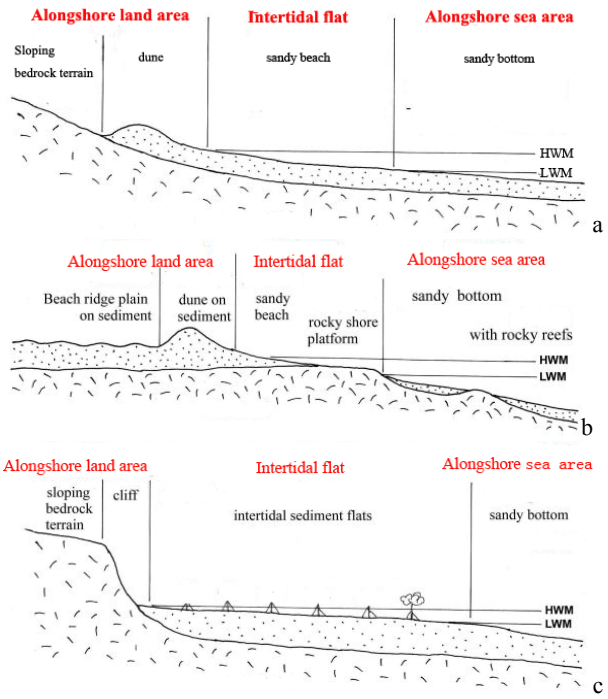

Figure3 Profile sketch map of three coastal type of bays.(a) sandy coast; (b) rocky coast; (c) silty coast.HWM stands for meanHigh-water Mark, LWM stands for mean Low-water Mark

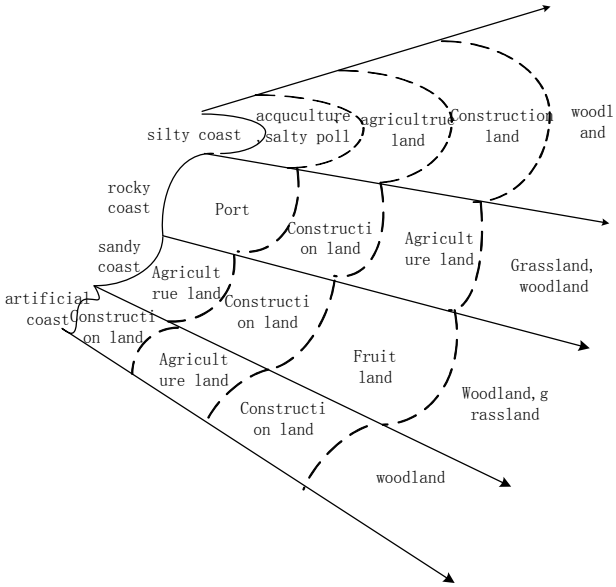

Figure 4 The sketch map of the land use regional profile

3. CASE STUDY

3.1 Study Area

For the further explanation of the construction process, Daya Bay, Zhelin Bay and Jiaozhou Bay with different coastal types and morphologies were taken as examples.

For these three bays, Daya Bay and Zhelin Bay is located in Guangdong province, while Jiaozhou Bay is in Shandong province; For the sea-area belonged, the formal two belongs to the South China Sea, while the later belongs to the Yellow Sea. The Main characteristics of the bays are shown as Table1.

Category	Values		
	Daya Bay	***Zhelin Bay***	***Jiaozhou Bay***
Open Degree	Half-open	Half-open	Half-close
Water Rate	Entire-Water	Entire-Water	Much-Water
Morphology Coefficient(MC)	Long-Wide	Wide-long	Square-round
Location	Huiyang,Guangdong	Raoping, Guangdong	Jiaozhou,Shandong
Main use type	Nuclear Power Station, port, aquaculture	Aquaculture,	aquaculture, port
Coast types	sand,rock, artifical	Sand,artifical	sand,rock,artifical

Table 1 Characteristic Comparisons of the three typical bays (Wu,S.Y.,2000;Zhang,D.D.,2008)

3.2 Data Source

Data used were for two objectives: one is for the establishment of the bay's coastal type in a quantitative manner; the other is for the Dynamic Degree analysis of different land use type in the establishment of the upper-border of the land area. Meanwhile, some basic data like the basic geographical features are also needed. Therefore, these data can be categorized into following types:

(1) Seamap. It is used for the definition of coastline as well as the location of the contour with 0m. The production date of these maps are 1984,1984 and 2005 for the Daya Bay, Zhelin Bay and Jiaozhou Bay respectively, while the scale is 1:60 000 ,1:25 000,1:35 000 respectively.
(2) Thematic data from the National Coastal Survey of china in 1980s.These data include the thematic of land use and landform, the scale is 1:20 000, while the projection is WGS_1984.
(3) Satellite imageries. TM, ETM, as well as SPOT imageries are all required. The usage of these images is for two purposes, one is for the background browse, and the other is for the acquirement of the thematic data. TM data in 2000 for Daya Bay, SPOT5 data in 2003 for Zhelin Bay, while ETM data in 2006 for Jiaozhou Bay is used.

3.3 Analysis Results

Through analysis of the coastal characteristics of Daya Bay,Zhelin Bay and Jiaozhou Bay by remote sensing images ,sea maps, and landform thematic maps of the coast in the 1980s, it is indicated that most part of the coast of Daya Bay is rocky coast, most part of the coast of Zhelin Bay is silty coast, while the Jiaozhou Bay is a sandy coast bay. The ratio of each type of coast of the three bays is shown in Table1.

Ratio of coastal types	Values (%)		
	Daya Bay	Zhelin Bay	Jiaozhou Bay
Sandy coast	34.1	14.8	38.8
Rocky coast	37.2	16.4	10.1
Silty coast	16.5	37.4	29.3
Artifical coast	11.1	30.6	16.2
Other type	1.1	0.8	4.6

Table 1 Ratio of the main coastal types of the typical bays

According to the coast-range model proposed, the ranges of the three typical bays were established. The land area of the Daya Bay,Zhelin Bay,Jiaozhou Bay is 3km buffer, 2km buffer and 1km buffer from the coastline respectively.Figure 5~Figure 7 is the range of them.

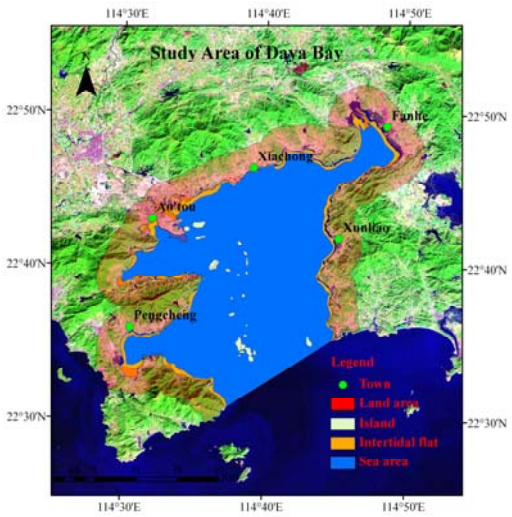

Figure 5 The range of Daya Bay with 3 km buffer zone from the coastline of land area

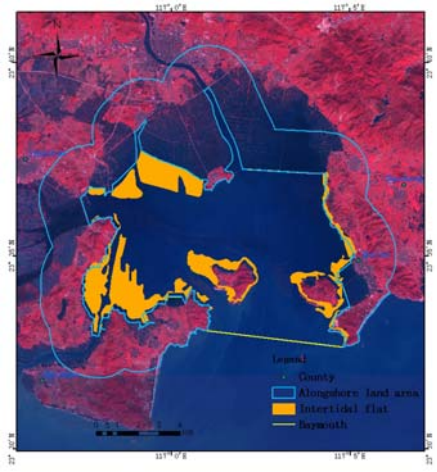

Figure 6 The range of Zhelin Bay with 2 km buffer zone from the coastline of land area

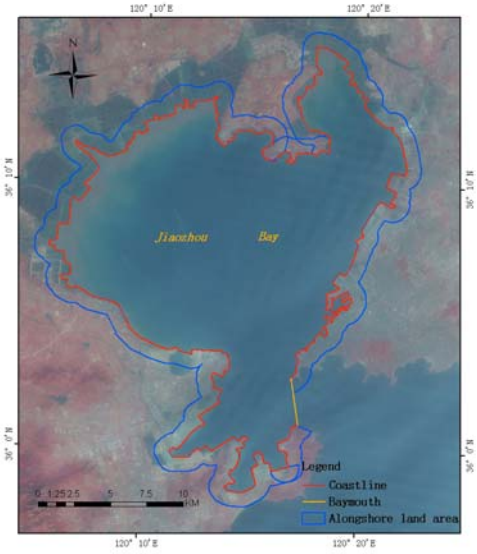

Figure 7 The range of Jiaozhou Bay with 1 km buffer zone from the coastline of land area

4. CONCLUSIONS

Aiming at the characteristics of multi-level and multi-field of bays, this paper proposed a multi-scale method for the expression of bays, and conceptual models in the bay-range scale, as well as the coast-range scale were constructed. Through the case study of three typical bays of Daya Bay, Zhelin Bay and Jiaozhou Bay, it is conclude that the conceptual model proposed in this paper is valid for the description of the morphology of bays, and therefore is meaningful for the construction of bay database and information management system.

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