A New Technique about Selecting Base Points of the Territorial Sea Based on the Principle of Convex Hull Creating

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1. Introduction

The baseline is a line from which the outer limits of a State's territorial sea and certain other outer limits of coastal State jurisdiction are measured. According to the United Nations Convention on the Law of the Sea (UNCLOS), the baseline can be normal baseline, straight baseline or combination baseline based on actual instance of coastal states.

The normal baseline is the basic element from which the territorial sea and other maritime zones are determined. It is defined as the low water line along the coast, as marked on large-scale charts of the coastal state (UNCLOS' Article 5). Straight baselines are defined by straight lines that join points on the coastline which have been selected according to the criteria listed in UNCLOS' Article 7. They delineate internal waters from territorial seas and other maritime zones.

Straight baselines are a system of straight lines joining specified or discrete points on the low-water line, usually known as straight baseline turning points, which may be used only in localities where the coastline is deeply indented and cut into, or if there is a fringe of islands along the coast in its immediate vicinity (UNCLOS' Article 7).

In maritime boundary delimitation practice, in order to manage and maintain the baseline conveniently, and to protect national maritime rights and interests, straight baseline was adopted in most countries including China. When straight baseline scheme adopted, selection of baseline points of the territorial sea, i.e., the number of selected points and their spatial distribution, has an important influence on the result of maritime boundary delimitation. The reason is, once the position of baseline point is determined, the baseline (connecting neighbouring two points), as then the internal water, territorial sea, contiguous zone, exclusive economic zone(EEZ) which are based on the baseline, will be determined, too. Here internal water means the water on the landward side of the baseline of the territorial sea, the sovereignty of this water area belongs absolutely and exclusively to the coastal state. As a result, the first aim of maritime boundary delimitation is to ensure the maximum area of internal water.

UNCLOS has set restrictions on base point selection. For example, the drawing of straight baselines must not depart to any appreciable extent from the general direction of

the coast; any baseline of archipelago can not exceed 125 nautical miles, etc. However, in the conventional manual selection of base points, as restricted by technical condition, it is very difficult to set up the mathematic model of base points selection which accord with these prescription, so the selected base points can not ensure optimization (maximum internal water area) in accordance with these prescription. Therefore, this paper brings forward the idea and method to realize the optimized selection of base points using convex hull creating technique. A case study of an archipelago's base point selection is given at the end of this paper.

As China only partly publicized the base points of the territorial sea (baseline) in continental area and Xisha Islands area, and the base points of the territorial sea (or baseline) in many other areas are not determined yet, the research on the best technology of base points selection and confirmation can be of great value to China.

2. Selection of Candidate Base Points

Candidate base points are the points which project towards the sea at the brim of continent, islands or drying reefs, and can help to make the internal water area maximum. In another word, candidate points are the points that may be selected finally as the points of the territorial sea. Candidate points are selected from official charts at largest available scale. Obviously, suitable selection of candidate points is the necessary precondition of the formal points of territorial sea. However, as the spatial distribution of candidate points is usually loose, it is quite difficult and unreasonable to directly select candidate points from the largest scale charts. Therefore, a pre-selection process is usually needed to appropriately determine the places of candidate points on smaller scale charts that cover the entire sea area.

Although this happened mainly in analogy mode, similar process is used even under GIS circumstances. GIS can only help to achieve efficiency, precision and reduction in work intensity. The process with GIS support is:

1) Select the possible candidate points and get the sketchy position by using GIS at a smaller scale;
2) Switch to the largest scale display containing the same point from the database by using direct scale-switch display function;
3) Mark and catch the candidate points precisely, and obtain the coordinates of each point.

For the archipelago shown in Figure1, according to UNCLOS, 22 convex points projecting towards the sea on the outer side of the brim islands of this archipelago are selected as candidate points (marked with +). Segments, each of them connects two neighbouring candidate points, and their lengths (nautical miles) are shown in table 1.

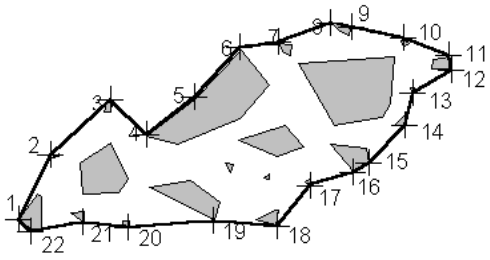

Figure 1. Candidate points of an archipelago

Section	1,2	2,3	3,4	4,5	5,6	6,7	7,8	8,9	9,10	10,11	11,12
Length	63	72	45	56	60	35	49	20	48	4	14
Section	12,13	13,14,	14,15	15,16	16,17	17,18	18,19	19,20	20,21	21,22	22,1
Length	40	30	46	16	41	47	57	78	41	48	16

Table 1. Segments and their lengths of candidate points (unit in nautical mile)

3. Polygon Convex Hull Creating Technique and Ideal Points Selection

3.1 Concept of polygon convex hull

The key problem is how to select, as formally announced point set which will set the maximum internal water, the best point set from the candidate points. By research, we believe the best way is by using polygon convex hull creating technique. Thus the concept of convex hull (also called minimum convex or minimum convex polygon) will be introduced as following.

The convex hull of a finite polygon P is the smallest polygon PC that contains P. That is, there is no other polygon P0 with $P \subseteq P0 \subset PC$. Also, this convex hull has the smallest area and the smallest perimeter of all polygons containing the set P. Thus, for any polygon, if it is not convex, the area of it will always be less than the area of its convex hull. To obtain maximum area, the candidate point set is not the best choice, for the polygon it forms may not be convex, and the area it surrounds may be less then that of its convex hull. So it is quite obvious now that the point set which forms the convex hull is the ideal set of points, because we can get the maximum internal water area from it. GUO[1997] has introduced in detail the method of creating polygon convex hull.

3.2 Ideal point selecting by convex hull creating technique

In the same case in Figure1, we can use foregoing method to get the only minimum convex polygon (convex hull) from the polygon formed by the 22 candidate points. As shown in Figure2, the points that form the convex hull are candidate point No.1, 2, 3, 6, 8, 9, 10, 11, 12, 14, 15, 18 and 22.

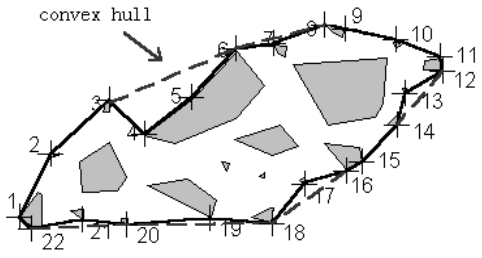

Figure 2. The polygon and convex hull from candidate point set

3.3 Determination of the formal point set

Although the point set chosen by convex hull is ideal, the selection of point must accord with the prescription of the UNCLOS. The set can not be directly applied as the formal point set of territorial sea yet. As shown in Figure 2, some baseline is too long and some departs obviously from general direction of the coast. An improvement is needed as follows.

1) Calculate the geodesic distance between the two nodes of the convex hull, as shown in Figure 2;
2) Divide the long baseline that exceeds 125 nautical miles into two or more segments, by inserting node(s) selected from candidate points which are relatively extruding and good in location. This ensures the point set according with the prescription of the UNCLOS.

It can be seen in table 2 that the baseline between points No.3 and No.6 exceeds 125 nautical miles, one point should be inserted. Two candidate points, No.4 and No.5, may be the inserting point. Polygon area respectively with No.4 and No.5 is calculated to choose the better one (see Tab.3 sequence 1.1 and 1.2). For convenience, the area of the convex hull is set as one unit.

The baseline between points No.18 and No.22 is 221 nm long and exceeds 125 nm, too. At lease one or more point(s) should be inserted. The candidate points are No.19, 20 and 21. No.20 is the most extruding and nearest to the central location, but the distance from it to No.19 is 134nm. So No.19 is necessary. Since No.19 is more than 125nm from No.22, a mid-point is still needed. No 20 is better for this place according to the larger surrounding area. The possible polygons and their areas are shown in Tab.3 sequence 2.1 and 2.2. Therefore, point No.1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 14, 15, 18, 19, 20, 22 are determined as the formal point set (marked by symbol ⊕ in Figure3). It should also be noticed that candidate point No.20 will locate outside the baseline, which is obviously wrong.

Edge	1,2	2,3	3,6	6,8	8,9	9,10	10,11	11,12	12,14	14,15	15,18	18,22	22,1
Length	63	72	126	83	20	48	43	14	64	46	100	221	16

Table 2. Each edge's length of the convex hull（unit in nautical mile）

Polygon sequence number	The sequence of polygon vertex(candidate point)	Area (compared to the area of convex hull)
1.1	1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 14, 15, 18, 22	0.964
1.2	1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 14, 15, 18, 22	0.942
2.1	1, 2, 3, 6, 8, 9, 10, 11, 12, 14, 15, 18, 19, 20, 22	0.935
2.2	1, 2, 3, 6, 8, 9, 10, 11, 12, 14, 15, 18, 19, 21, 22	0.924

Table 3. Possible polygons and their areas for different point set

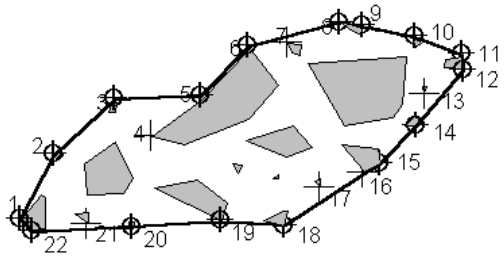

Figure 3. Points and their relevant straight baselines

3.4 Analysis and evaluation of the points selection

The point set for an archipelago was analyzed by using the foregoing scheme and method. Two points were found not ideal, which located inside of the polygon convex hull and the direct distance between its two neighbouring points is less than 100 nautical miles, which results in an area loss of 28 square kilometres. So, these 2 points can be deleted from the point set. The analysis focuses the value and necessity to evaluate the current official point set.

4. Conclusions

Convex hull of the candidate point set determines in fact the maximum possible area of internal water, so it can be considered as the ideal mathematic model of point set selection, and may lead to the ideal solution more scientific than the conventional analogy method on experience. It provides the possibility select point set totally by computer. However, because of the restriction by UNCLOS, adjustment on point set by convex hull is still necessary, on which we have discussed the method and scheme in the former part. For example, when the baseline goes off the main trend of coastline and its length exceeds the limit, when the ratio of water area to land area exceeds the limit, proper candidate point(s) should inserted in order to make it reasonable for the last selection scheme. The quantitative evaluation of whether straight baseline goes off the main trend is very complicated a technique problem. Only part of the question, of whether the distance is too long to cause the departure in direction, was discussed in this paper. The question whether there is other effective quantitative estimation model is also worthy of further research.

The case discussed in this paper is of the archipelago area, but its principle and method are applicable to the base point selection of continental edge territorial sea delimitation on straight baseline scheme. For example, the continent outline can be similar to that of "archipelago" geometrically when a suitable seal line is appended the inner side of the continent; thereby the optimized method above can be applied to the delimitation of territorial sea.

5. References

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Biography

PENG Rencan, professor, Ph.D, Ph.D supervisor, majors in the theories and methods of charting, the development and application of military oceanic geographical information system, and the high precision models and methods of oceanic delimitation based on the earth ellipsoid.