Methods of Maritime Outer Limits Delimitation

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Abstract. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is the document that serves as the public and customary law, codifies the various maritime zones and their regime. Jurisdiction over maritime zones is important in terms of security, exploration and exploitation of natural resources, international relations and effective ocean management. Scientists and professionals from a variety of disciplines are concerned with maritime zones, the legal and the technical aspects of the competing interests among coastal states. However, of great importance is the technical expert himself who is responsible for taking full account of the provisions and requirements of UNCLOS, advice and inform the governments on its technical aspects and employ methods for delineating maritime outer limits in accordance to its provisions. The present paper is concerned with the delimitation methodologies proposed by cartographers and applied by States and juridical bodies, with respect both unilateral and bilateral limits and aims at contributing to an update to the relevant literature by providing detailed guidelines on how to construct the outer limits graphically.

Keywords: Maritime Zones, Graphical Methods, Equidistance, Territorial Sea, Continental Shelf, Contiguous Zone, Exclusive Economic Zone, UNCLOS, Law of the Sea

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INTRODUCTION

The United Nations Convention on the Law of the Sea (UNCLOS) provides the framework for the delimitation of maritime outer limits and the jurisdiction over maritime space, but yet it remains silent with respect to the technical aspects of the delimitation in some of its provisions. This gap has been fulfilled by cartographers who developed technical guidelines and by states and juridical bodies with their practices on precedent delimitation cases. Formerly, the delimitation of maritime space was carried out solely with traditional graphical methods employed directly on charts of suitable scales. With the advent of computers, specialized software applications provided the technical expert with the ability to tackle problems that had been difficult to handle previously. Tasks, such as the performance of geodetic computations to allow for variations arising from the curvature of the earth's surface, have now been resolved quickly and efficiently. Nevertheless, the methods themselves have not changed; on the contrary GIS (Geographic Information Systems) applications incorporated these methods.

This paper reviews the predominant graphical methods for the delimitation of outer limits, unilaterally and bilaterally. Additionally, it delves into juridical bays, the tests for verifying their legal status and the methods for establishing the natural entrance points from which the closing lines should be drawn. Every subject discussed is supported by colored figures developed specifically for this work. The legal background is provided when necessary for the progress of

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the work to be done. Issues related to datum, baselines and charts are not considered but are taken for granted, although, from a technical perspective, they all constitute factors of great importance in the process of delimiting a state's maritime zones.

HISTORICAL BACKGROUND

The Third United Nations Convention on the Law of the Sea (hereinafter: UNCLOS III) was opened for signature in Montego Bay, Jamaica, on December 10th 1982 and came into force on November 16th 1994, twelve months after receiving its sixtieth ratification. The 1982 Convention revised the previous 1958 Convention, codified customary law and State practices of the time and also introduced new provisions regarding maritime space.

UNCLOS III represents the perpetual effort of coastal states to codify rights and duties over waters both adjacent to and distant from their territory and is the result of a long time process beginning in antiquity. From the division of the southern hemisphere oceans between the two thalassocratic states of Spain and Portugal in their favor (*Treaty of Tordesillas*, 1494), we shifted to the doctrine of *Mare Liberum* (the free seas) propounded by Grotius at the beginning of the 17th century. According to Mare Liberum doctrine, the sea is common to all humanity and no state is entitled to claim dominion over it. The doctrine was opposed, especially by the big powers of the era, but remained the cornerstone of the law of the sea for quite some time (until the 1945 Truman Proclamation for jurisdiction over the sea bed and subsoil). In 1639, John Selden, who opposed the Mare Liberum Doctrine, supported, among others, the right of a state to control a narrow zone of sea along its coast (*Mare Clausum* doctrine) mainly for protection purposes against piracy and other hostile actions. The exercise of effective control over that sea zone (the predecessor of the *territorial sea zone*) was limited by the range of cannons on the coasts (*cannon shot* rule). Around the end of the 18th century, it was recognized that the maximum range of a cannon shot was 3 miles and hence the breadth of the zone that could be claimed by coastal states. Later, in the early 20th century, many nations demanded jurisdiction over extended areas for protecting fish stocks; an area known as *fishery zone*.

The first attempt in 20th century of the international community to codify maritime zones and delimitation methods failed (Hague Conference, 1930). On the contrary, the next attempt came off and resulted in four separate treaties (UNCLOS I, Geneva, 1958); the conventions on the Territorial Sea and Contiguous Zone, on the Continental Shelf, on the High Seas and the Convention on Fishing and conservation of living resources of the High Seas. At the second Conference (UNCLOS II), held in Geneva (1960), States tried to resolve the issues of the territorial sea and the fishery zone, with respect the maximum breadth of the zones, but that effort was unsuccessful and they did not come to an agreement, On the contrary, after ten sessions (1973 – 1982), the third Conference resulted in the public international law of the sea as it exists nowadays and which is accepted as the codification of customary international law of the sea.

BASELINES

One of the fundamental concepts in UNCLOS is that of the baseline which divides the land and the inland waters from the sea. A baseline serves as the line from which the maritime zones are measured and normally coincides with the low-water line (*normal baseline*) as marked on large-scale charts officially recognized by the coastal State (*rule of tidemark*). The low-water mark prevailed over the high-water mark as it gives the coastal State the right to measure the maritime zones from the outermost land above water at low tide(1).

Alternatively, in localities where the coastline is deeply indented or cut into, or if there is a fringe of islands along the coast in its immediate vicinity, *straight baselines* may also be used.

The concept of straight baselines was introduced to the international law with the Anglo-Norwegian case in which Norway drew straight lines along the Norwegian coast. Much of the Norwegian coast is dominated by the so called *skjaergaard* (meaning rock rampart), fjords formations fringed by numerous islands, rocks and reefs. Norway has been using straight lines since the mid 19th century, a practice contended by the United Kingdom. The dispute was eventually taken to the International Court of Justice (ICJ) in 1949 and ultimately ICJ, in its 1951 judgment, upheld Norway's practice and found the system of straight baselines in conformity to the international law [(2)].

The newly proposed concept was incorporated within the provisions of the 1958 Convention and bequeathed to the 1982 Convention. From a technical perspective straight baselines prevent the construction of highly irregular outer limits impractical for the coastal State and every other party involved, but they are permissible only where the local geography justifies such departure from the normal baseline. As they are codified in the convention, straight baselines may not be drawn from low tide elevations unless a lighthouse or similar installation, permanently above sea level, is built. They also cannot be drawn "*in such a manner that they cut off the territorial sea of another State from the high seas or an exclusive economic zone*" [(3)]. For the identification of the suitable points on coast from which drawing a straight baseline is permissible, P.B. Beazley suggested a simple criterion according to which a straight line can be drawn from two features if they are enclosed within the same continuous or overlapping belt of territorial sea (see Figure 1) [(4)].

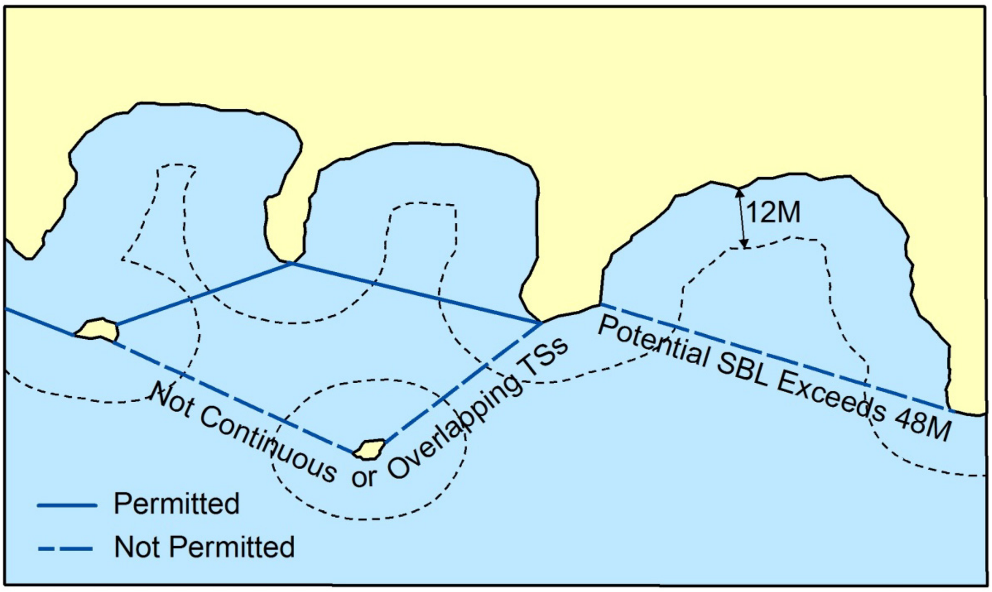

FIGURE 1. Beazley's criterion for drawing straight baselines

There is no restriction for the maximum length of the straight baselines (Beazley suggested they should not exceed 48 nautical miles), with the exception of the special providence for the system of straight archipelagic baselines. Archipelagic States may draw straight lines, joining the outermost points of the outermost islands and drying reefs of the archipelago, not exceeding 100 nautical miles (NM) with the exception of an up to 3 per cent of the total number of the lines that may reach up to 125NM. Often a combination of normal and straight baselines is used (*mixed baseline*).

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MARITIME ZONES – LIMITS AND RIGHTS

The convention parcels the sea into a variety of maritime zones a coastal state may claim (see Figure 2). Each zone grants certain rights to the coastal State and carries certain obligations to the foreign States and vessels. Subject to Article 87, every state and vessel enjoy six freedoms in high seas, namely the freedom of navigation, the freedom of overflight, that of laying submarine cables and pipelines, the freedom of marine scientific research, of constructing artificial islands and installations, and that of fishing. The general principle is the closer to the coast the greater the degree of rights for the coastal State which consequently curtails some or all of the six freedoms for the foreign States and vessels. In detail:

• *Internal Waters* (IW), which cover all water on the landward side of the baseline. The internal waters are considered part of the State's territory and the coastal State exercises full sovereignty over them [(5)]. Sovereignty, which is applied over seabed, water column and air space, postulates that foreign vessels and states are deprived of all of the high seas freedoms.

• *Territorial Sea* (TS), measured from the baseline seaward, the breadth of which may not exceed 12NM. The coastal State's sovereignty is extended beyond its land territory and internal waters in the territorial sea [(6)], but within this zone the freedom of innocent passage for the foreign vessels is retained [(7)].

• *Contiguous Zone* (CZ) which is adjacent to the territorial sea and may not extend beyond 24 NM from the baseline. Typically, that is 12 NM wide, but may be more if a state claims territorial sea less than 12NM. In the contiguous zone the coastal State has the jurisdiction to regulate and put laws into in order to prevent and punish infringements of its customs, fiscal, immigration or sanitary laws committed within its territory or territorial sea[(8)]. Within contiguous zone the coastal state has no further rights and the high seas freedoms remain unaffected.

• *Exclusive Economic Zone* (EEZ), which is adjacent to the territorial sea and may not extend beyond 200 NM from the baseline. In the Exclusive Economic Zone the coastal state has sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, both living or non-living and the jurisdiction to establish artificial islands or installations and to conduct scientific research. Coastal state is responsible for the protection of marine environment. Foreign vessels enjoy three of the six high seas freedoms, namely the freedoms of navigation, the freedom of overflight and that of laying submarine cables and pipelines [(9)].

• *Continental Shelf* (CS) which is again adjacent to the TS but, in contrast to the other maritime zones, not only distance dependent. The outer edge of the continental shelf is delineated by combining three lines. Firstly, the distance-constrained line which cannot exceed the 350NM from the baseline; secondly, the depth-constrained line which may not extend beyond 100NM from the 2,500 meter isobath and thirdly, the formula line extending 60NM from the foot of the continental slope (see Figure 3). The regime of continental shelf is similar to that of the EEZ but the rights it grants are limited to the seabed and subsoil, excluding the superjacent water column and airspace. Unlike EEZ, which has to be proclaimed by the coastal State, the sovereign rights of the coastal State over the continental shelf exist *ipso facto* and *ab initio*. In other words coastal State's rights over CS "*do not depend on occupation, effective or notional, or on any express proclamation and, therefore, can be exercised at any time*" [(10)].

• *High Seas* are all parts of the sea that are not included in any of the above maritime zones. Over High Seas, all freedoms are retained for every state. Mention should be made of "*The Area*" which comprises the sea-bed, ocean floor and subsoil below the high seas with the exception of that which is claimed as a state's *extended continental shelf* (the part of the CS extending beyond 200NM). The Area with its resources is common heritage of mankind and must be used for the benefit of all states.

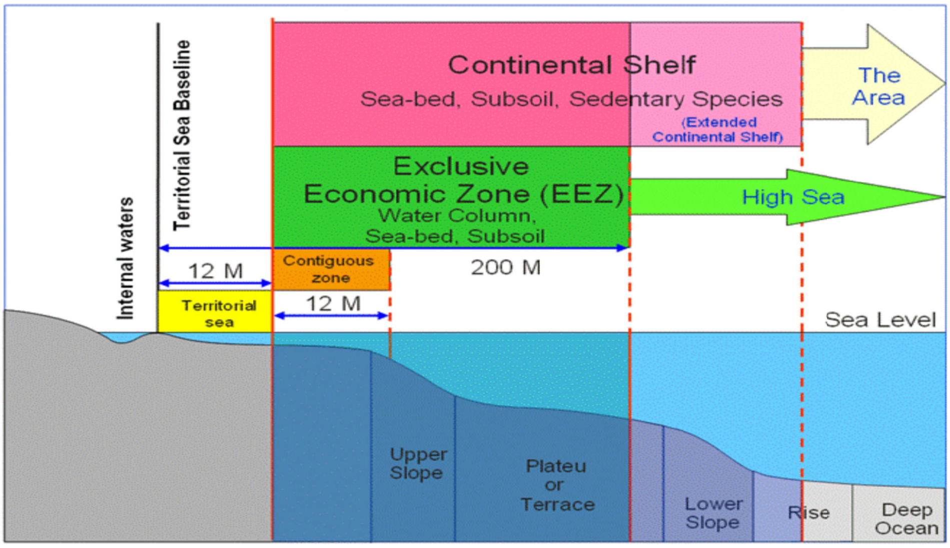

FIGURE 2. Maritime jurisdictions of a coastal State [11]

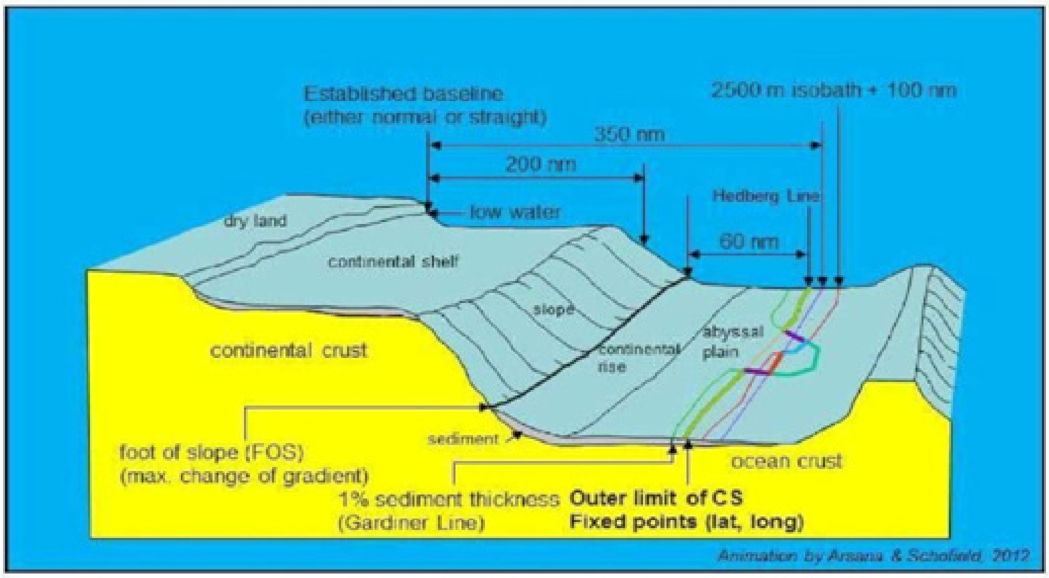

FIGURE 3. How the Continental Shelf is delineated.[12]

JURIDICAL BAYS

According to the 1982 convention, a bay is "a well-marked indentation whose penetration is in such proportion to the width of its mouth that it contains landlocked waters and constitutes more than a mere curvature of the coast" [13]. With the exception of historic bays, for which there are no such requirements, an indentation qualifies as a juridical bay when two objective criteria are met. Firstly, the length of the bay closing line does not exceed 24NM (see Figure 4) and secondly, the enclosed area is at least as large as, or larger than, that of the semi-circle whose diameter equals to the length of the closing line (see Figure 5). The waters on the landward side of the closing line constitute inland waters and the closing line itself becomes a part of the baseline from which the maritime zones are measured. On the contrary, if either of the criteria is not satisfied the bay is not considered legal. A bay should belong to a single State otherwise drawing a closing line is prohibited.

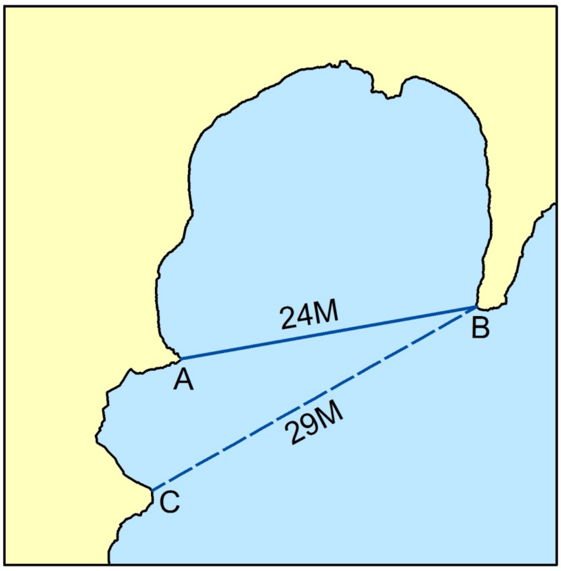

FIGURE 4. The distance test

To graphically examine the semi-circle criterion, the expert draws the semi-circle on the landward side. If it is fully enclosed in the bay, the criterion is met (see bay AB in Figure 5), otherwise the bay is not juridical (see bay CD in Figure 5). Wherever the distance between the low-water marks of the natural entrance points of a bay exceeds 24NM, the coastal state can draw a closing line up to 24 NM within the bay, given that the area condition is also satisfied.

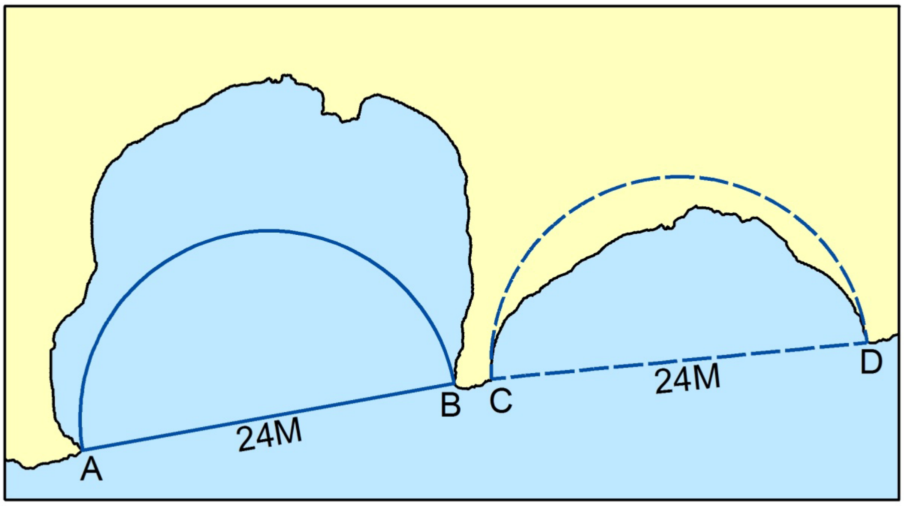

FIGURE 5. The semi-circle test.

Often, geographic features create more than one entrance/ mouth. In the existence of multiple mouths, due to the presence of islands, the diameter of the semicircle equals to the combined length of the lines across the different mouths (14). With regards to their location, the islands may lie across the mouth of the bay and, therefore, intersected by the direct line between the mainland headlands (see bay AB in Figure 6), or may lie on the seaward side of it and the additional water area is also landlocked (see bay CD in Figure 6). Again both criteria must be satisfied.

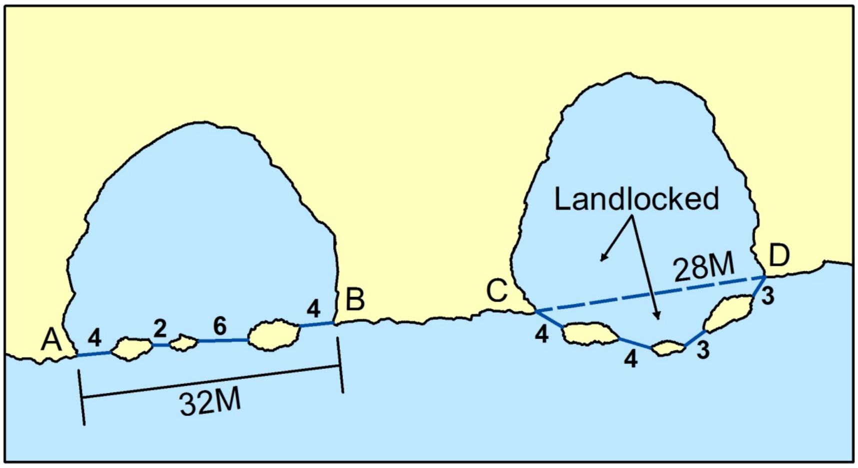

FIGURE 6. Bays with islands in mouths.

In localities where the semi-circle test cannot be explicitly verified, by conducting the semi-circle test as described above, the technique of reduced areas originally proposed by Boggs can be used [15]. With a radius equal to one-fourth the length of the mouth, an envelope of arcs is drawn (similar to constructing unilateral outer limits as described later in this study) from every point within the bay. The remaining reduced area (dotted area in Figure 7) is compared to the reduced semicircle whose radius equals to one-fourth the closing line's length. If the area test is now satisfied the bay is considered legal.

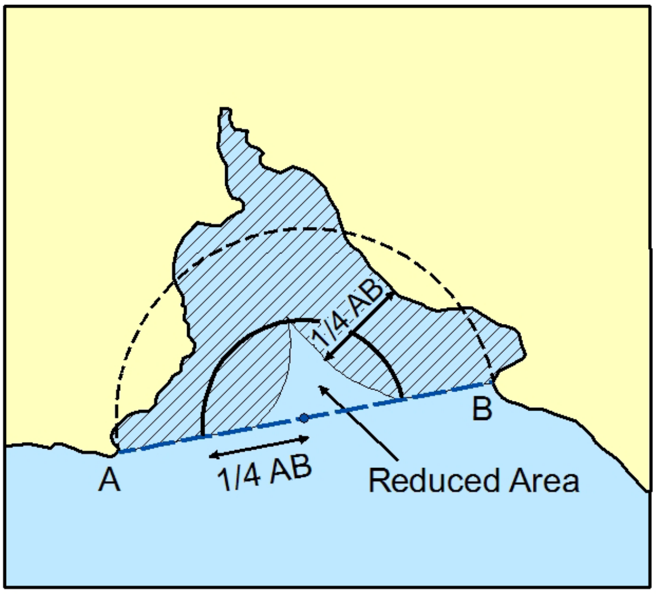

FIGURE 7. Reduced area test

Often, the terms "*headland*" and "*natural entrance point*" (hereinafter: NEP) of a bay are used interchangeably; however, a distinction between the two has been made by experts. Hereinto, the former refers to an extension of the land out into the water, while the latter to the precise point on a headland from which the bay closing line is drawn. The graphical determination of the

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NEP is a challenging task and the convention is of no assistance on this matter. There is an indefinite number of potential entrance points, depending on the local geography, that could be selected for drawing the bay closing line (16). To standardize the procedure, three objective techniques, applicable to the various geographic situations, have been proposed, namely the 45-degree test, the bisector of the two-tangent test and the shortest-distance test (17).

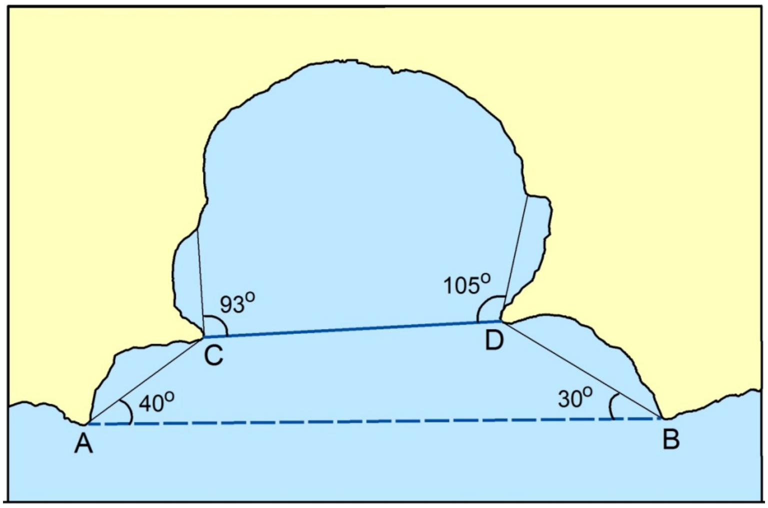

FIGURE 8. The 45-degree test

The *45-Degree Test* (Hodgson and Alexander) is the first of the alternatives for the determination of the NEPs and is mainly applicable in the existence of a pronounced headland of the coast. The expert begins by drawing the closing line between the selected headlands. From each headland a line to the next headland inside the bay is drawn. If the general direction of the lines on both sides of the bay is more than 45 degrees, with respect to the bay closing line, the headlands from which the tests were conducted are the NEPs (see closing line CD in Figure 8). If not (see closing line AB in Figure 8), the test can be repeated for the next headland until both angles are greater than 45 degrees.

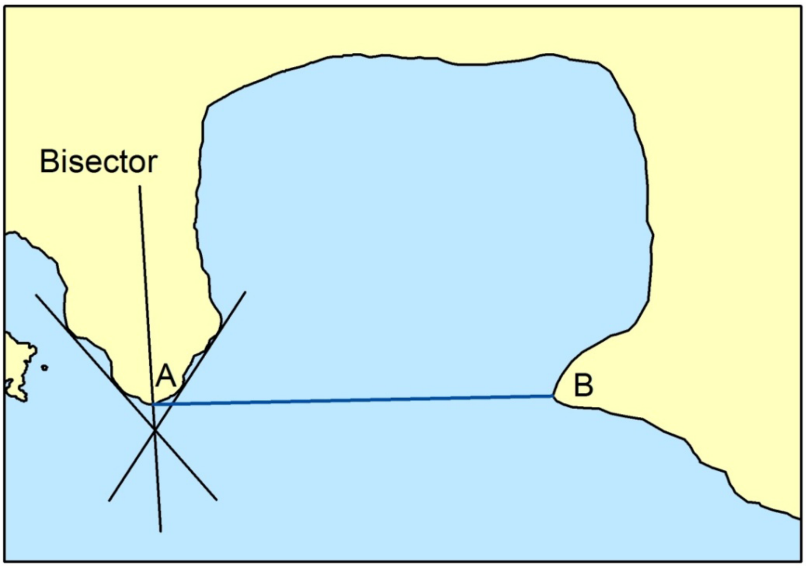

FIGURE 9. The bisector of the two tangents test

The *Bisector of the Two Tangents Test* is an alternative to the 45-degree test for the determination of the NEP to the bay. Reed stressed that "*the bisector of the angle test is employed when the shores facing on the open sea and interior water body are joined by a smooth curve, or arc, rather than a pronounced headland*" (18). The NEP is found by the intersection between the baseline and the bisector of the angle formed by two line tangents to the general direction of the coast (see point A in Figure 9).

The *Shortest Distance Test* is best to be applied when the coastline is featureless on the one side of the bay while the other entrance comprises of a distinct geographic feature such as a headland or arc (for which the NEP can be easily determined with one of the other two tests). If that is the case neither of the aforementioned two tests can assist locating the NEP on the featureless side and the technical expert should draw the shortest distance line between the headland and the opposite coast (see closing line AB in Figure 10). One of the variations of this test suggests that, instead of drawing the shortest distance between the opposite coasts, a connecting line whose general direction is not smaller than 45 degrees is also accepted (see closing line AC in Figure 10). By drawing the connecting line not at a right angle a larger area of the sea is enclosed within the bay, though in this case the question raised is whether the waters are enclosed or not.

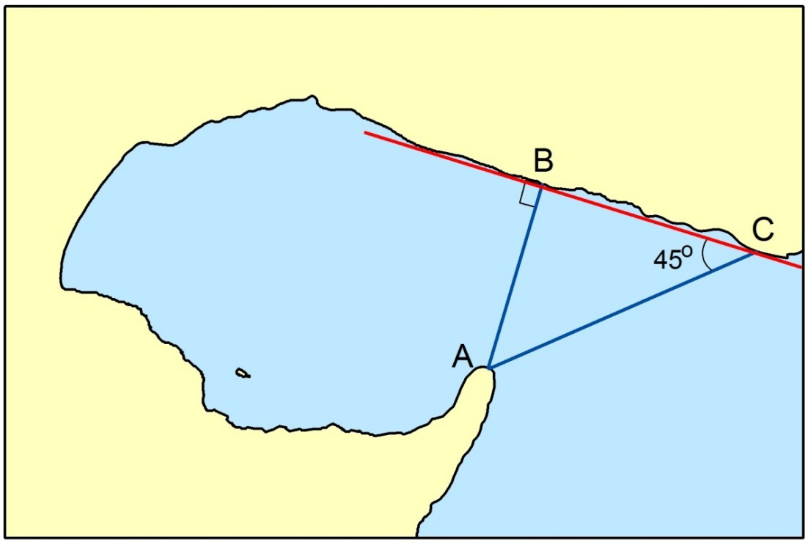

FIGURE 10. The shortest distance test

UNILATERAL AND BILATERAL LIMITS

The delimitation of maritime outer limits begins with the selection of the proper nautical charts officially recognized by coastal State(s) which depict the coastline(s) at the largest possible scale. Charts will be used either for the graphical construction of maritime zones directly on them or for taking the basepoints' (a "*basepoint*" is any point on the territorial sea baseline) coordinates off them for use with GIS software. One can discriminate between two broad categories; "*unilateral*" and "*bilateral*" limits. The former is the case when, in the absence of overlapping claims between the maritime zones of neighboring states, the coastal State has the right to claim its outer limits to the maximum extent. On the contrary, bilateral are the limits when the maritime zones of two neighboring coastal states (either adjacent or opposite), at their maximum extent, overlap ("multilateral" for more than two states, but the method does not differ from the method for the bilateral delimitation). Unilateral or bilateral, outer limits can be constructed graphically or automatically utilizing one of the existing GIS software.

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Automated Delimitation

With the invention of computers, specialized software applications provided the technical expert with the ability to tackle problems that had been difficult to handle previously. The software developed in the early '80s was capable of performing geodetic computations to allow for variations arising from the curvature of the earth's surface quickly and efficiently as well as for storing large datasets in digital form.

DELMAR (DELimitation of MARitime boundaries), developed by Carrera in 1989 for the Canadian government, was an innovative solution but had its drawbacks (i.e. geodetic calculations had to be done in separate programs, it was designed to operate under the MS-DOS environment) and soon became obsolete (Collier et.al 2002). Following DELMAR, in 2000 the Department of Geomatics at the University of Melbourne, Australia completed the development of the MarZone ("Maritime Zone") software on behalf of AUSLIG (now Geoscience Australia).

Nowadays, the leading software in maritime boundaries delimitation is the LOTS ("Law Of The Sea") by CARIS which has been in the geomatics applications industry for more than thirty five years. LOTS is currently being used by more than 50 coastal states (CARIS, 2014) and is designed to aid in the delineation and delimitation of marine boundaries as required by the United Nations Convention on Law of the Sea (Sutherland and Nichols, 2002). LOTS is also capable of delimiting the outer limits of the CS, in accordance with the provisions of article 76 of UNCLOS.

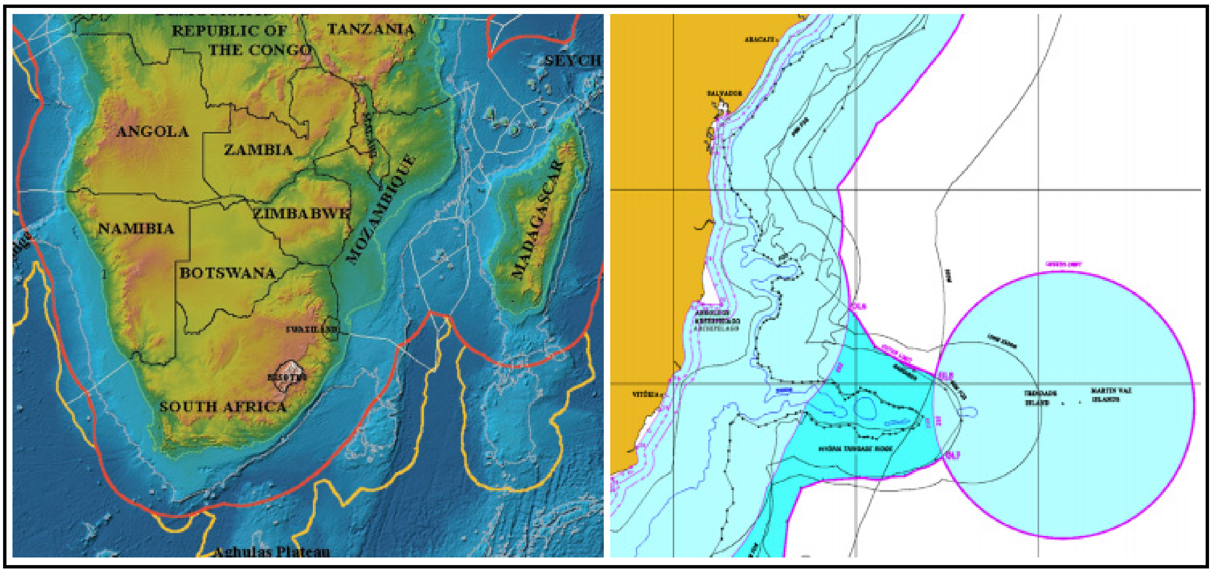

FIGURE11 – Maritime Boundaries with CARIS LOTS(19)

One of the latest efforts in the maritime boundaries delimitation market is the Maritime Zones Plug-in by Geocap, released in December 2013. The plugin works directly with the ESRI's ArcGIS software. It provides a wizard that lets the user setup calculation parameters for the various maritime zones which are then automatically delineated. Lastly, it would be an omission not to mention ESRI's ArcGIS, because despite not being software of dedicated use like the above, it can also be utilized by the technical experts for the construction of maritime limits.

Unilateral Limits

In this chapter the methods for the construction of a state's Territorial Sea at its maximum width are examined. These methods apply to the delimitation of CZ and EEZ which are, as well as the TS, solely depended on the distance from baselines. The delimitation of the Extended Continental Shelf (the part of the CS extending beyond 200NM) depends on the bathymetry and sediment thickness of the area in question and before applying the methods described in this chapter, the technical expert needs to establish the foot of the slope, the 1% sediment thickness and the 2500m isobath. Article 76 of the convention and the UN's publication "Scientific and Technical Guidelines of the Commission on the Limits of the CS" (20) delve into the methods for determining the above requisite parameters.

The predominant graphical method for delimiting the outer limit is the "*envelope of arcs*". Envelope of arcs produces a line complying with the dictates of Article 4 for a line "*every point of which is at a distance from the nearest point of the baseline equal to the breadth of the territorial sea*" (21). The technical expert, using a compass set to 12NM, draws successive arcs centered on points along the baseline and the outer limit which is generated by the continuous series of the seawardmost intersecting arcs (see Figure 12) is known as the envelope line. The inverse use of the envelope of arcs is the method the navigators apply when they examine whether they sail inside or outside a State's TS. Particularly, the navigator draws an arc with a 12 NM radius from his known position and if the arc intersects the coastline the ship sails within the State's TS, otherwise it sails outside of it.

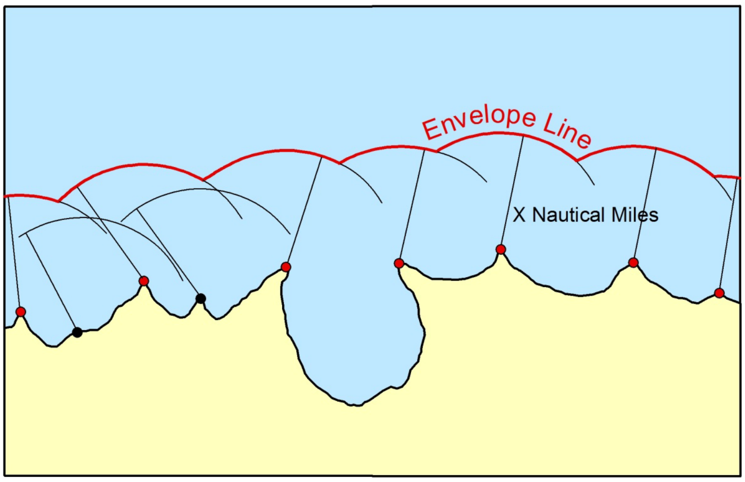

FIGURE 12. The envelope of arcs method

The TS's outer limit can also be constructed as the continuous line traced by the center of a circle of radius equal to the breadth of the TS which rolls tangential along the baseline (see Figure 13)[1].

Another approach to the delineation of the outer limits, prescribed by ICJ in its Anglo-Norwegian Fisheries Case, is the *replica line* (or *trace parallel*). The replica line is constructed as an exact copy of the baseline shifted seaward to a distance equal to the width of the TS (see

[1] The idea of running a circle along the seashore was introduced by Julian Perkal in his work "On the length of Empirical Curves, (1958)" in which he brought attention to the need of simplifying the geometrical shape of an arc. The constructed outer limit, as described in the text, represents the Perkal's "ε-generalized edge of the land in the sea" displaced X NM seaward. Perkal extended the use of the ε–convex circle for measuring the length of linear features on maps.

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Figure 13). With terms of a normal baseline IHO C-51 publication disputes whether replica line can meet article 4 requirements [(22),] (see how an arc drawn from a point on coastline intersects the replica line in Figure 13), though it is the preferred method for the construction of outer limits from straight baselines.

Figure 14 depicts the replica line of the same coastline as the one used in Figures 12 and 13 but this time a closing line at the mouth of the bay has been drawn.

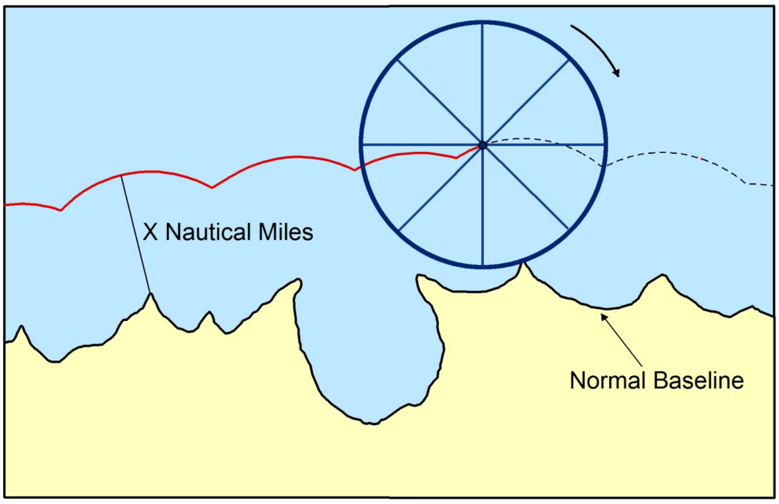

FIGURE 13. The method of the tangent circle.

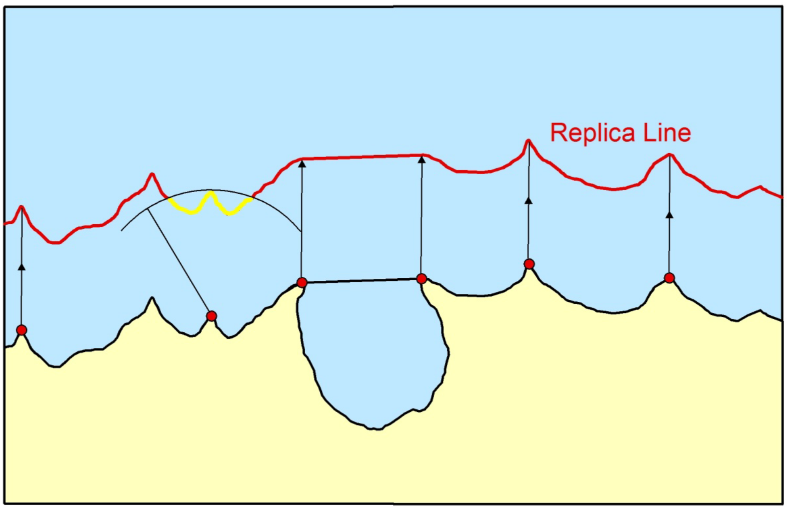

FIGURE 14. The replica line method

Lastly, the so called "*conventional line*" [(23)] is the combination of the aforementioned methods (see Figure 15). In detail, from a normal baseline, the technical expert draws an envelope of arcs with the compass set at 12NM, while from straight baselines or bay closing lines he draws replica lines at a distance of 12NM. The conventional line is generated by the continuous series of the intersected arcs and straight line segments.

The quality of the constructed outer limit is not only a matter of the spacing among the points but of selecting the appropriate salient points on the baseline as well. If these points are correctly selected, the method is so definite that it can only come up with one line. The number of the *critical points* on the baseline that affect the delimitation is inversely proportional to the breadth of the maritime zone. Furthermore, the farther the outer limit from the baseline, the lesser the sinuosity and detail of the baseline reflected (in Figure 16 the black and red circles indicate the location of critical points for the outer limits "1x" and "4x" respectively).

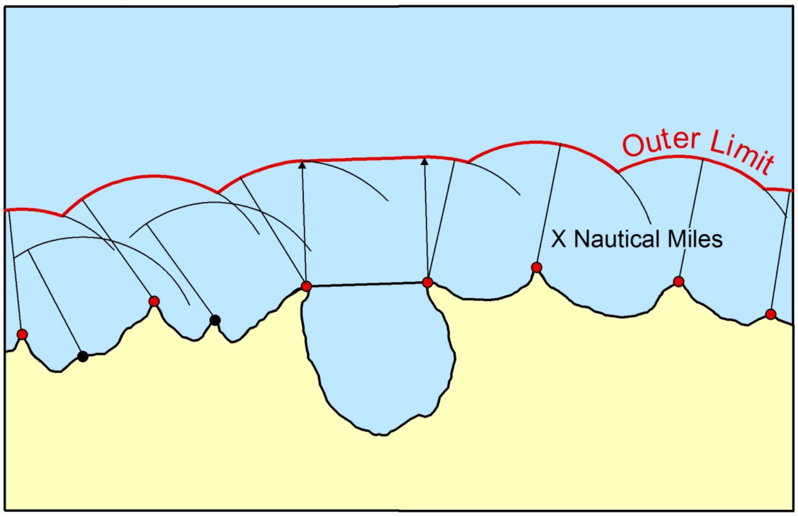

FIGURE 15. The conventional line constructed as a combination of the envelope of arcs and the replica line.

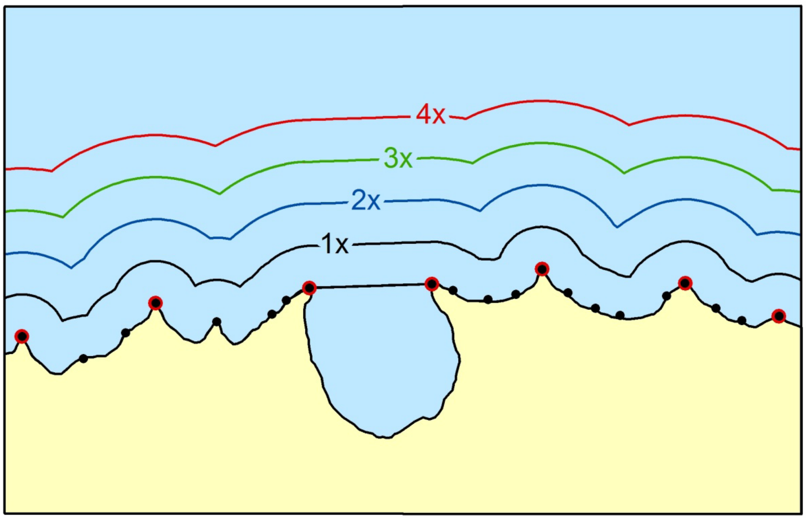

FIGURE 16. The farther the outer limit from the baseline, the lesser sinuosity of the baseline is reflected and lesser the number of the critical points.

Bilateral Limits

With respect the delimitation of bilateral limits, "neither of the two States is entitled, failing agreement between them to the contrary, to extend its territorial sea beyond the median line, every point of which is equidistant from the nearest points on the baselines, from which the breadth of the territorial seas of each of the two States is measured" [24]. The above provision does not apply where necessary by reason of historical title or other special circumstances. The

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median line is the method that must be applied between overlapping territorial seas. The construction of a limit under the median line principle is geometrically objective and results in a unique, unambiguous line. In 1958 Convention, it was clearly stated that the equidistance method had to be followed in the absence of an agreement between the coastal States with regards to their TS, CZ and CS [(25)]. At the 1982 conference the equidistance principle was opposed so strongly that made the French author Prosper Weil describe it as a “holy war against equidistance” [(26)]. Eventually, the opponents of equidistance managed to diminish its role in favor of the equity principle with regards to the delimitation of the EEZ and CS; “the delimitation of the EEZ and CS […] shall be effected by agreement […] in order to achieve an equitable solution” [(27)]. Nevertheless, practice on precedent EEZ and CS delimitation cases has shown that often both courts and governments resort to the equidistance line as their starting point, adjusted in the existence of special circumstances that justify departure from the equidistance in order to achieve an equitable result. That was expressly stated by ICJ in its judgment for the Qatar – Bahrain case: “for the delimitation of maritime zones beyond the 12 mile zone, they would first provisionally draw an equidistance line and then consider whether there were circumstances which must lead to an adjustment of that line.” [(28)].

In the above paragraphs both “median line” and “equidistance line” terms are used and the reason is that academia and literature never abandoned the rational distinction between the two. That distinction was present in the 1958 Convention but absent in the 1982 Convention. Median line (present in the 1982 convention) is defined as the line every point of which is at an equal distance from the nearest points on two opposite baselines, while equidistant line (absent in the convention of 1982) is defined as that at equal distance from two adjacent baselines. Technically speaking, the distinction between the two definitions seems geometrically correct since a median line presupposes that it lies in the middle of the other two geometric features while the equidistance line is apparently not in the middle and is therefore not a median [(29)].

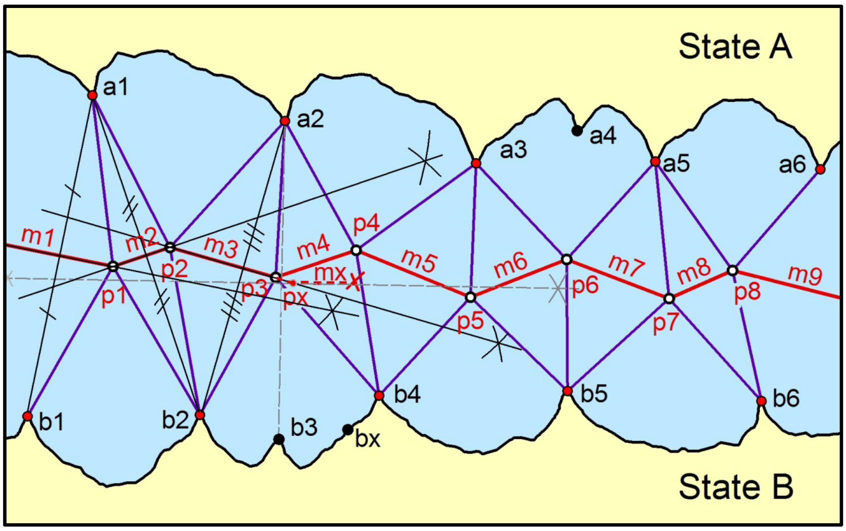

FIGURE 17. The construction of median line

For the graphical construction of the median line, the points where the median line changes direction (hereinafter: turning points) must be established. We can discriminate between two geographic situations, viz the distance between the two states’ baselines does or does not exceed twice the breadth of the TS at some area. When it does, the starting turning point is established as the point of intersection between the TSs of States A and B. Otherwise, the following direct procedure for the graphical solution of the three point problem is suggested (see

Figure 17): Locate a prominent headland on the baseline of State A (a1 in Figure 17) and next locate the potential nearest point on State B's baseline (b1). Center the dividers on b1, draw a circle with radius equal to the a1b1 distance and verify that the original point on State A is the nearest to it. If that is the case then repeat the procedure from point a1 in order to verify that b1 is the nearest to a1. If not, the procedure must be repeated until two other points are found.

Once the critical points a1 and b1 have been established, draw the perpendicular passing through the midpoint of a1b1 line (that is m1 in Figure 17). Line m1 defines the direction of the median line and remains constant until a point (p1) equidistant to a1, b1 and to a third point on either baseline is reached. Let this point be b2 on State B's baseline which is found by the trial and error method. A perpendicular (m2) is then drawn at the mid-point of line a1b2, which must pass through p1. Likewise, the next point p2 on median line, equidistant to a1, b2 and the nearest point on either coast, let this point be a2 on baseline A, should be established. Draw again the perpendicular bisector m3 and continue this process until the median line is fully delimited and reach the ending point of the median line, which should be the point of intersection of two unilateral maritime zones. The median line is generated as the contiguous series of line segments m1, m2, m3 and so on. Similar to the construction of the median line is that of the equidistant line between two adjacent States. In such geographic situation, the terminal point is the land boundary of the two States.

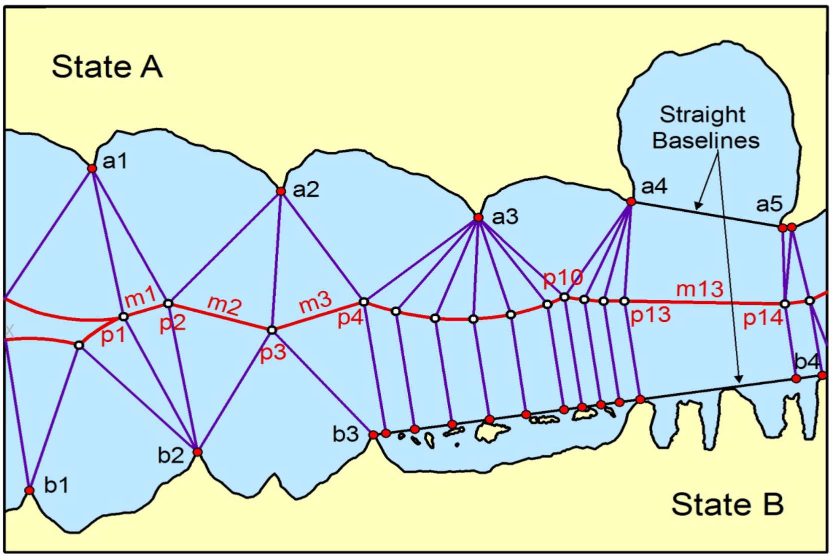

FIGURE 18. Three situations can be observed when constructing a median line: Between two points, between point and line and between two lines

In localities where the critical points on baseline can easily be discerned, the median line can be constructed using an alternative, to the method previously discussed, approach. Particularly, draw the perpendicular bisectors to the lines connecting the salient headlands a1, b1 and b2 which constitute potential critical points on baseline; those are m1 for a1b1 and m2 for a1b2 lines. Before proceeding to the next line segment construction, verify whether the point of intersection between m1 and m2 (that is p1) is an actual turning point of the median line, meaning whether it is equidistant to points a1, b1 and b2 on coast and that the circle having radius equal to the distance to any of these three points, does not intersect the coast elsewhere. If both tests are satisfied, p1 is indeed a turning point and we may proceed to the construction of the next line segment. Next prominent headland is a2 on coast A. Draw the midpoint perpendicular to line a2b2 (m3) and, likewise, can be easily verified that p2 is a turning point. The next prominent headland and potential critical point is basepoint b3 on coast B. Draw mx which intersects m3 at px (Figure 17). Though, after examining the two tests, px is not equidistant to a2, b2 and b3 and the circle drawn intersects coast B at bx, hence both px and mx are disregarded. Next is the headland b4 which can be easily proven to be a contributing basepoint (critical point), m4 a line segment of the median line and p3 an actual turning point. The procedure is repeated until median line is fully constructed.

When constructing a segment of the median line three situations may be observed as they are depicted in Figure 18. First, between two points on the two opposite (or adjacent) baselines which yield a straight line, i.e. segment m1 constructed by critical points a1 and b2 and segment m2 constructed by critical points a2 and b2. Second, between two lines, which yield a straight line (that is m13 in Figure 18). Third, between a basepoint and a line which yield a parabola[2]. In example, segments m4 to m9 among turning points p4 and p10, constructed by critical point a3 and the opposite straight baseline. When dealing with the third situation, it is important to densify the vertices from which distances are measured by dividing the straight line into shorter line segments. Otherwise, if only the start and end points are considered, instead of a parabola, a straight line will be yield.

The previous constitute the methodology for constructing a “*strict equidistance line”* where every point on coast is taken into account. Such a line is unambiguous and unique but is usually also complex and impractical since it comprises of numerous turning points and short-line segments. Instead, once the strict equidistant line has been constructed, the number of critical points and straight median line segments can be reduced for the construction of a *simplified equidistance line*. Simplified equidistance line has the advantage of being simpler while it keeps roughly the same distribution of net sea area between the two States [(30)] (see Figure19).

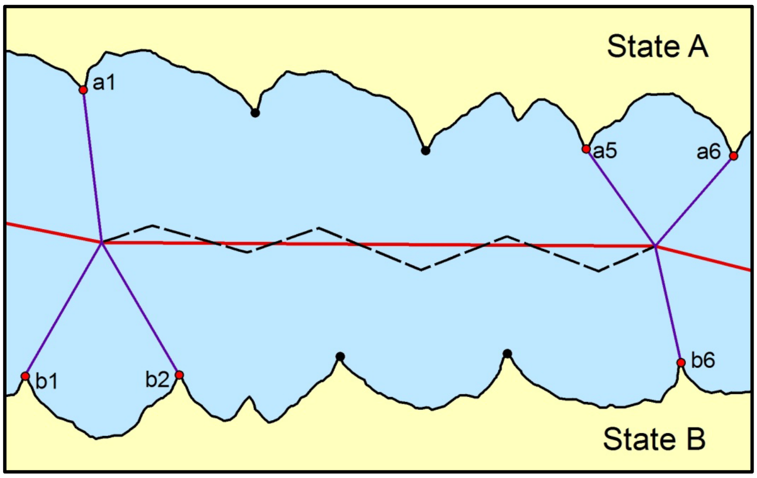

FIGURE 19. Strict and simplified equidistant lines

Another application of the equidistant method is the *modified or adjusted equidistant line* usually used for the achievement of an equitable solution under the provisions of UNCLOS for EEZ and CS. How an equitable solution is achieved varies depending upon the type of the features but they often result in increased maritime space for one State at the expense of the

[2] The described methodology has its theoretical roots in the Voronoi Diagrams, or Tessellation, named after the Russian mathematician Georgy Feodosevich Voronoy. Each of the constructed median line segments is a “Voronoi Edge”, the bisector part on the boundary between two adjacent Voronoi polygons, while critical points and straight baselines represent the n-generators for which the plane is partitioned according to the nearest neighbor rule (Gold C.M., Remmele P.R. and Ross Th. 1997. “Voronoi Methods in GIS”. In Algorithmic Foundations of Geographic Information Systems (Van Kreveld M., Nievergelt J., Roos Th. and Widmayer P. eds.), Berlin: Springer, pp. 21-35).

other. It usually refers to islands distant from any other geographic feature of the coastal state and which are considered to create a disproportionate effect on the delimitation process. Previous delimitation cases clarify State and judicial practices on this matter, which have shown a tendency to shift from an older practice to a newer one [31].

In detail, an older practice, mostly encountered in delimitation cases before 1979, was that of giving only a limited effect to the islands or even fully enclaving them in the other state's CS. *Enclaving* occurs when no effect is given to the island with respect to the CS. In such cases, the maritime jurisdiction of the island is not denied and a belt of maritime zone, usually equal to the breadth of the territorial sea, is drawn around it. As shown in Figure 20 three geographic situations are observed. First, the island of State B with its potential belt of maritime jurisdiction lays fully within the same State's CS, second the island with its maritime belt is partially connected to State B's CS (partial enclave) and third, the island is completely isolated from State B and lays fully within State B's CS (fully enclaved).

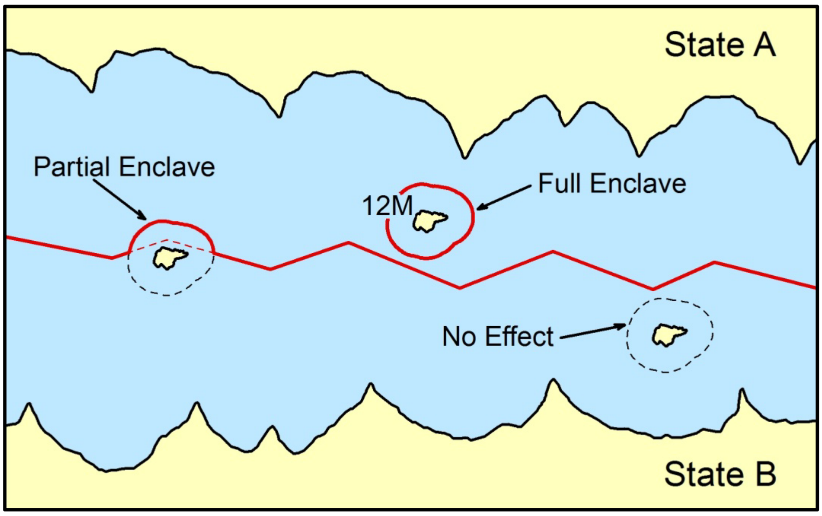

FIGURE 20. Fully and partially enclaved features of State B.

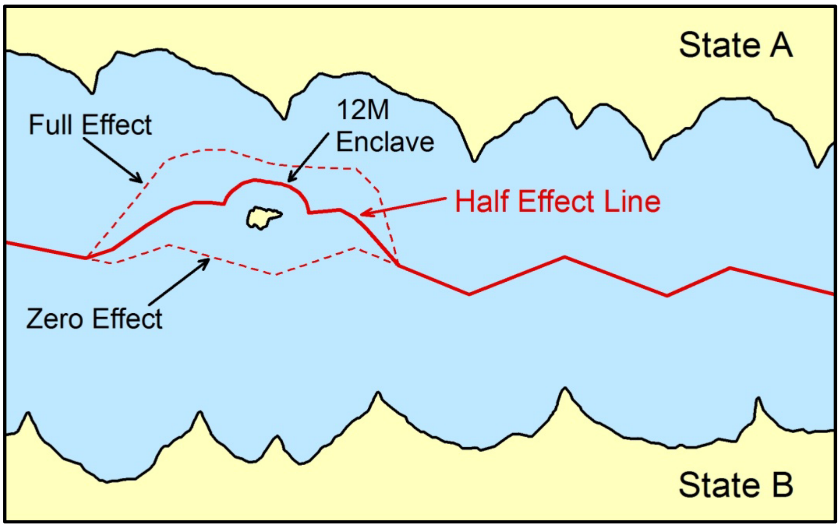

FIGURE 21. Half effect and modified median line.

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In cases after 1992, judicial and States' practice is that of assigning islands with extended rights regardless of their distance from the state's mainland and even if they lay in close proximity to the other state's large mainland. The most common method for the creation of a modified equidistant line is that of assigning a partial effect to the islands or other particular features. Although any ratio is possible, the practice is that of giving half-effect to the feature in question. For the graphical construction of the half effect line, draw the full effect line with the feature in question having full effect to the delimitation and the line of no effect with the feature being totally disregarded. The half-effect line lays half way between the two (see Figure 21).

Among the methods that have been used are those of the *perpendicular to the coast lines*, the *meridians and parallels*, the *coastal length comparison*, and the *General Direction*. Though, these methods are either applicable at certain local geography or they are used as a test of equitability once the delimitation has been completed [(32)].

CONCLUSIONS

The current work reviewed the established methods for the construction of the outer maritime limits to their full extent and the predominant methods for bilateral limits. With respect to the latter, literally countless methods can be employed as long as the coastal states come to an agreement. Therefore, it was impossible for the current study to consider and present every possible delimitation methodology but instead it cast light on the method proven to be the most significant; that is the equidistance line and its variations.

Delimitation methods remain the same regardless if they are employed directly on charts for the graphical construction of outer limits or indirectly with the development of GIS applications that make the calculations automatically. Hence, a good knowledge and understanding of these methods by technical experts is apparently necessary and they should not regret they are accountable for providing political authorities with the most accurate information before they enter into negotiations and discussions with neighboring states. Additionally, two of the most important factors, that cartographers should not underestimate and which govern the accuracy of the exported results, are the precision and generalization to which the baseline has been constructed, although they were not covered by the current study and, instead, taken for granted.

Finally, from this point onwards, an extensive study, with the purpose of verifying whether they have been applied and at what extent in the precedent delimitation cases, must be conducted with respect to the proposed methods for the establishment of the natural entrance points and the construction of straight baselines as recorded in this paper.

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