THE DETERMINATION AND ACCURACY OF THE MARITIME BOUNDARIES AND ZONES OF SOUTH AFRICA.

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Introduction

The definition of South Africa's maritime boundaries and zones is a comparatively straight forward task apart from those with France with respect to the Prince Edward and Crozet Island groups in the South Indian Ocean. On main land Africa and in terms of maritime boundaries, South Africa has only two adjacent neighbouring coastal states with which it shares boundaries namely Mozambique and Namibia. In the case of South Africa and Namibia, a clearly defined maritime boundary which is acceptable to both parties is important not only for fishing rights and so on but also for access to both diamond and possible gas or oil deposits in the vicinity of the boundary. At present the South Africa / Mozambique and South Africa (Prince Edward Islands) / France (Crozet Islands) maritime boundaries do not straddle any known mineral deposits and their definition is not as critical from that aspect as that of the Namibian boundary.

The South Africa / Namibia Photogrammetrically Determined Maritime Boundary

In 1920, after World War 1, the League of Nations granted South Africa jurisdiction over the previous German Protectorate of South West Africa (now Namibia). South Africa administered Namibia until 1977 when that country became self-governing. In terms of a United Nations peace plan for the region, Namibia became independent in 1990. In preparation for Namibian self-governing status and eventual independence, it was deemed necessary, among other things, to determine the position and extent of the maritime boundary between the two countries. In accordance with the internationally accepted 1958 Geneva Convention on the Territorial Sea and the Contiguous Zone, the principle of equidistant points or median lines was used to determine the position of the maritime boundary between the two countries.

In preparation for the determination, the coast line north and south of the Orange River mouth was digitized from 1:250000 topographical maps to identify features which would affect the calculation of the boundary. From this preliminary investigation it was found that approximately 264km of coast line would affect the position of the median line. In the light of the economic importance of the natural resources close to the boundary, the shifting nature of the coast, particularly in the vicinity of the mouth of the Orange River where the boundary starts, and the cost of a full terrestrial survey of the coast line, it was decided to turn to photogrammetry as the primary measurement tool. This project was undertaken in 1976.

One of the first aspects to consider was the determination of the low water line. In terms of both the 1958 Geneva Convention and the later United Nations Convention on the Law of the Sea (UNCLOS) the low water line is used to determine both the various territorial zones of maritime States and the maritime boundaries between adjacent States where the principle of median lines is used. The 1958 Geneva Convention, which was in force at the time (1976) did not elucidate on the definition of the "low water line" other than that it is to be "the line as marked on large scale charts officially recognized by the States". The South African Territorial Waters Act (Act 87 of 1963) defines low water as "… the lowest line to which the water of the sea recedes during

periods of ordinary spring tides". Such a situation does not occur very frequently and, additionally, the occurrence of spring low tide during any one given lunar cycle is not necessarily the most optimal time for aerial photography. For practical reasons, therefore, low water was defined as " the mean height of the low waters during a full tidal cycle of 19 years" and became known as the mean low water mark (MLWM). In terms of this definition, the tide reaches this level on 4 or 5 days during each lunar cycle and on each of these days it reaches this level twice, once on the falling and once on the rising tide. The mean tidal range on this stretch of coast between low water spring and low water neap tides is in the vicinity of 0.6m. By using this definition the window of opportunity for the aerial photography was greatly increased.

The closest tide gauge to the Orange River mouth is situated at Port Nolloth which lies approximately 80km south of the mouth. Data from this tide gauge and the South African Tide Tables for 1976 prepared by the Hydrographer of the South African Navy were used to predict the most appropriate time to carry out the photography. The stretch of coastline that affected the development of the first 138km of the median line lies approximately 50km and 30km north and south of the Orange River Mouth respectively. In considering the time required to fly such a strip, a 0.1m tolerance on either side of the predicted mean low water level was accepted which allowed 40 minutes for the completion of a single strip of photography at a scale of 1:30000. Two periods were identified between August and September 1976 which gave the most suitable tide conditions and the opportunity was taken to carry out the photography on both of these occasions.

At the time of the project, the geodetic networks of South Africa and Namibia were based on different reference datums and spheroids. In 1976, the Cape Datum based on the Clarke 1880 spheroid was used in South Africa while the Schwarzeck datum based on the Bessel spheroid was used in Namibia. In order to achieve uniformity, the WGS72 system, which was generally used for satellite based surveying and navigation at the time, was used as the reference system for the boundary determination. A high precision geodetic traverse was surveyed along the coast to improve the control survey network in the area and was used as the basis for the survey of the pre-marked photo ground control points.

A set of 19 orthophoto maps at a scale of 1:10000 was thus prepared and, after a considerable amount of experimentation, was used to determine the mean low water mark. 138km (approximately 75nm) of median line could be computed from this determination of the low water mark while beyond this, the line was determined from either a combination of the 1:10000 orthophoto and available 1:50000 topographical maps or entirely from the 1:50000 mapping. From estimates of the accuracy of the determination of the low water mark from the 1:10000 orthophoto mapping, points on the median line for the first 138km could be in error by approximately 50-100m. Beyond this distance and using digitized 1:50000 mapping it has been estimated that the positional error of points close to the 648km (350nm) limit is probably in the region of 200-300m assuming a 50m error in digitizing the coastline at each of the extremities of the baseline. In the former case the baseline used to calculate the median line at 138km is approximately 52km while in the latter case the baseline is just over 215km.

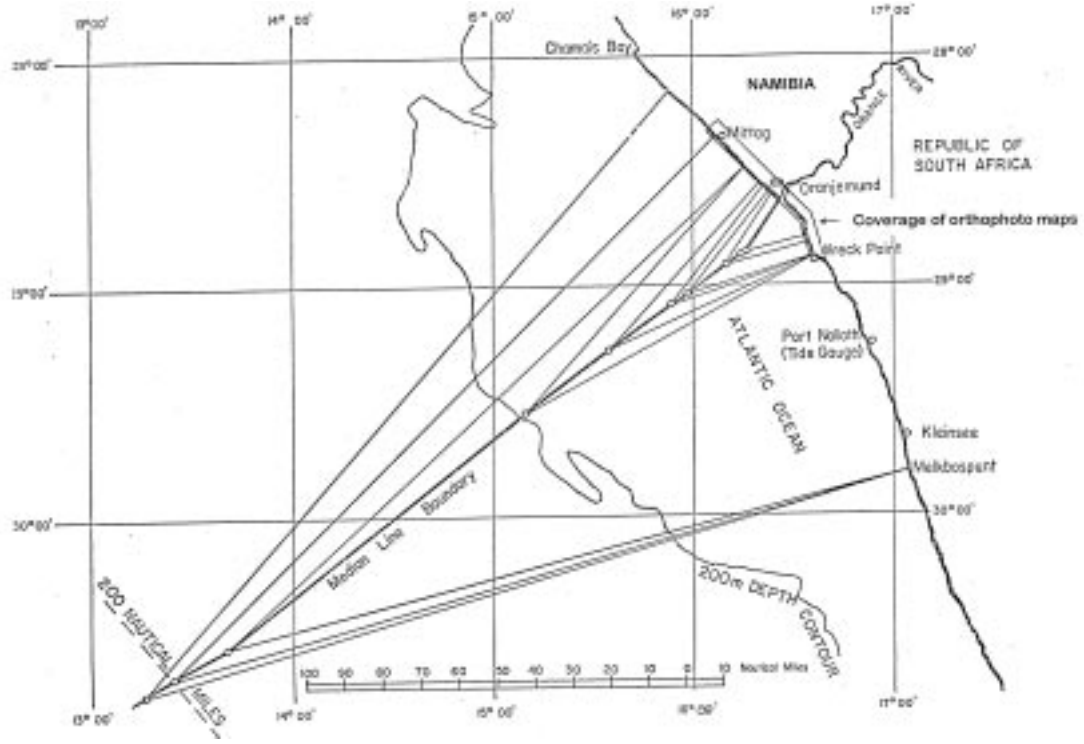

Figure 1 The first 200 nm of the South Africa / Namibia median line boundary. Only the first 200nm is shown.

The South Africa / Mozambique Surveyed Maritime Boundary

The landward boundary between South Africa and Mozambique in the Maputoland area was agreed to between Great Britain and Portugal in 1897 and is described as "with the exception of some slight deviations, follows the parallel of the confluence of the Rivers Pongolo and Maputo (Usutu) to the Indian Ocean and is situated in latitude 26° 31' 12".96". The last beacon which was described in the agreement was "at the summit of Oro Peak….." which is approximately 120m high and 400m from the edge of the ocean. No clear agreement regarding the delimitation of the boundary from the intersection of this line with the ocean seawards appears to have been made, and it was not until 1991 that a special effort was made to clearly define the maritime boundary between the two countries. By this time the principle of defining maritime boundaries using median lines was well established in international law through UNCLOS.

In preparation for the determination, a provisional calculation was done using data digitised from a 1:2.5 million wall map. From this it was found that less than 1.5km of the coast on the Mozambican side of the boundary from Ponta Do Ouro affected the determination of the median line. The next part of the Mozambican coast to affect the median line lies more than 330 km north west of Ponta Do Ouro close to the village of Quissico and which, once again, is only a comparatively short 34km section of coastline. On the South African side of boundary the situation is not much better with a 28km section of the coastline immediately south of the

boundary affecting the median and then one point a further 116km south at Cape Vidal affecting the remainder of the line. Because of these comparatively short and very widely spaced sections of coast line, as in the case of the northern most Mozambique section of coast, ground survey was considered to be the most appropriate method to determine the position of the low water line at these points rather than by photogrammetry as in the case of the South Africa/ Namibia median line. As a second approximation to the identification of the points which affected the determination of the median line, 1:250000 or 1:50000 topographical maps were used to better identify the areas to be surveyed.

One of the difficulties that had to be resolved was the timing of the survey to coincide with mean low water mark (MLWM) which was once again as defined for the South Africa/Namibia boundary determination. The closest reliable tide gauge in the area was situated at Richards Bay, which lies approximately 230km south of Ponta Do Ouro. By agreement between the national survey organisations of Mozambique and South Africa, the predicted tides for this port were used to determine the time at which the mean low water mark was to be surveyed. For practical reasons, the survey of the MLWM was to be carried out at a time when the tide was within 0.10m of this predicted height. The timing of the survey was therefore somewhat critical.

The survey was carried out in March 1993 from the South African Navy's hydrographic survey vessel, SAS Protea, which was able to provide helicopter and motor cycle support and accommodation for a total survey crew of 12 surveyors – 6 each from Mozambique and South Africa. By the time that this survey was carried out, GPS had become a well established and economical method of survey and was used for this survey. Earlier, between 1991 and 1992, the Chief Directorate of Surveys and Mapping had completed a survey of about 200 permanent points in the South African national geodetic network using GPS. These points were spaced approximately 100km apart covering the entire country and were surveyed in preparation for the conversion of the network to an International Terrestrial Reference Frame (ITRF) based co-ordinate system. This network was connected to the Hartebeesthoek Radio Astronomy Observatory which is a key point in the ITRS (International Terrestrial Reference System) which defines the ITRF. For the purpose of the median line survey, 10 control points were established between Quissico and Cape Vidal and were surveyed relative to 4 of the 200 points in the South African network of GPS surveyed points. The longest baseline in this survey is about 300km and yielded the worst residual of about 0.25m which was considered more than adequate for the purpose of the survey. In this way the entire survey and the determination of the maritime boundary between South Africa and Mozambique has been referenced to an internationally accepted co-ordinate system viz., the ITRF. All the main control survey points are marked with 1.2m concrete pillars.

The GPS survey of the mean low water mark in the predefined areas north and south of Ponta Do Ouro was carried out by small teams of both South African and Mozambican surveyors who jointly selected points to be surveyed at the predicted low water times. In most areas sufficient time was available to be able to survey these sections twice with all points being used in the final median line calculation. In total 150 surveyed low water mark points were available for the median line calculation and of these only 10 on the South African side and 14 on the Mozambican side of Ponta Do Ouro affect the calculation.

A total of 24 turn points were calculated on the median line between the low water mark at Ponta Do Ouro and the 350nm outer limit. Of these 9 were located within 48km (25.9nm) of the coast and were calculated off a maximum baseline length of 13.5km. Thereafter the baseline length increased dramatically to between 313.6 km and 479.7km for the remainder of the median line. The only major turn point on the median line lies within 387.1km (209nm) of the coast and has

been calculated off a 348.0km baseline. Between the coast and this turn point and again between the turn point and the outer limit at 350nm the median line is generally straight and conducive to a “give and take” boundary. The accuracy of the GPS survey of the MLWM points is estimated to be well within 0.5m and is probably closer to 0.2m.

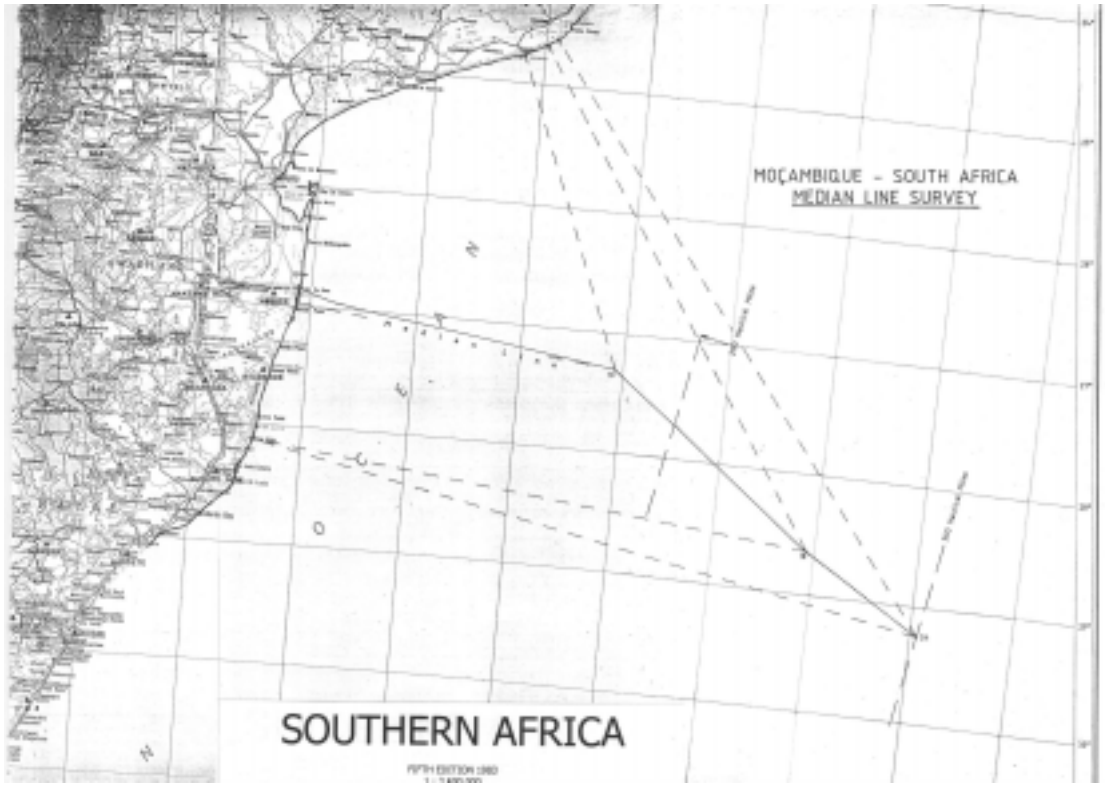

Figure 2 South Africa - Mozambique median line boundary.

The Continental Maritime Zones of Mainland South Africa

Between the lateral maritime boundaries with Namibia and Mozambique described above, the extent of South Africa’s continental maritime zones was determined by digitizing either existing 1:50000 topographical or 1:10000 orthophoto maps at approximately 50m or 10m intervals respectively. The 1:10000 orthophoto map coverage is restricted to areas around major ports. The determination of these zones was a reasonably simple matter. The continental shelf off the coast of Durban as determined from the 2500m isobath extends the position of the outer zone beyond the 350nm limit. Apart from this, there are very few complex coastal features or islands along the coast that unduly affect the limits and position of the zones.

The South Africa / France Cartographically Determined Maritime Boundary

The Prince Edward Island group, consisting of Prince Edward Island itself and nearby Marion Island, was annexed by South Africa in 1948 while the Crozet Islands became French territory in 1772. The two island groups lie approximately 520nm apart in the Southern Indian Ocean. Besides either of the two island groups, the closest land to the Crozets is the southern tip of

Madagascar which is approximately 1269nm away while the Prince Edward group is approximately 1150nm from South Africa.

In spite of lying somewhat far apart, the position of the maritime boundary between the two island groups is complicated, firstly, because the Crozet's lie on the Del Cano Rise and approximately 500nm south of the South West Indian Ridge and, secondly, the Prince Edward group lie almost at the junction of the Rise and the Ridge. The determination of the boundaries between the two island groups is dominated by these two submarine features which add enormously to the total territorial waters of both France and South Africa. If one considers the distance between the islands, then the 200nm Exclusive Economic Zones of each group do not interfere with one another. The position of the continental shelf and the subsequent boundary between the two island groups is, however, strongly influenced by the position of both the South West Indian Ridge and the Del Cano Rise. The extent of the Exclusive Economic Zone around the Prince Edward Island group has been determined by digitizing 1968 editions of 1:50000 topographical maps of the two islands in the group. Subsequent to this determination, a 1:25000 map of Marion Island only has been prepared for publication. Positioning for the latest edition of this map (surveyed in 1988) has been determined by satellite positioning techniques while the position for the 1968 map (surveyed in 1965) was determined by astronomical methods. The difference in position between the two determinations would indicate that the new position of Marion Island is approximately 200m west of the old position. Topographical detail for both editions was derived largely from aerial photography. 1998 satellite imagery was also used for the later edition. The extent of the continental shelf surrounding the Prince Edward Island group has been determined by digitizing the 2500m isobath from 1:1000000 GEBCO charts of the Southern Indian Ocean. Most of the information used for the preparation of the GEBCO charts was based on soundings from the 1960's when astronomical and dead reckoning positioning techniques were used and could be a few hundred metres in error. The combined consequence of the difference in the coastline between the old and new maps for Marion Island, the old and new position of the Island's survey network, the accuracy of the position of the 2500m isobath and the accuracy of the digitized 2500m isobath has not been yet been considered. Current South African legislation which describes the countries maritime zones, viz. the Maritime Zones Act (Act 15 of 1994), includes a schedule of co-ordinates which describes the various zones around the South African coast including the Prince Edward Island group. Since none of the zones described in the Schedule of co-ordinates in this Act have been ratified in terms of UNCLOS resolutions, closer investigation of the impact of these factors may require that amendments have to be made to the Schedule of co-ordinates before ratification.

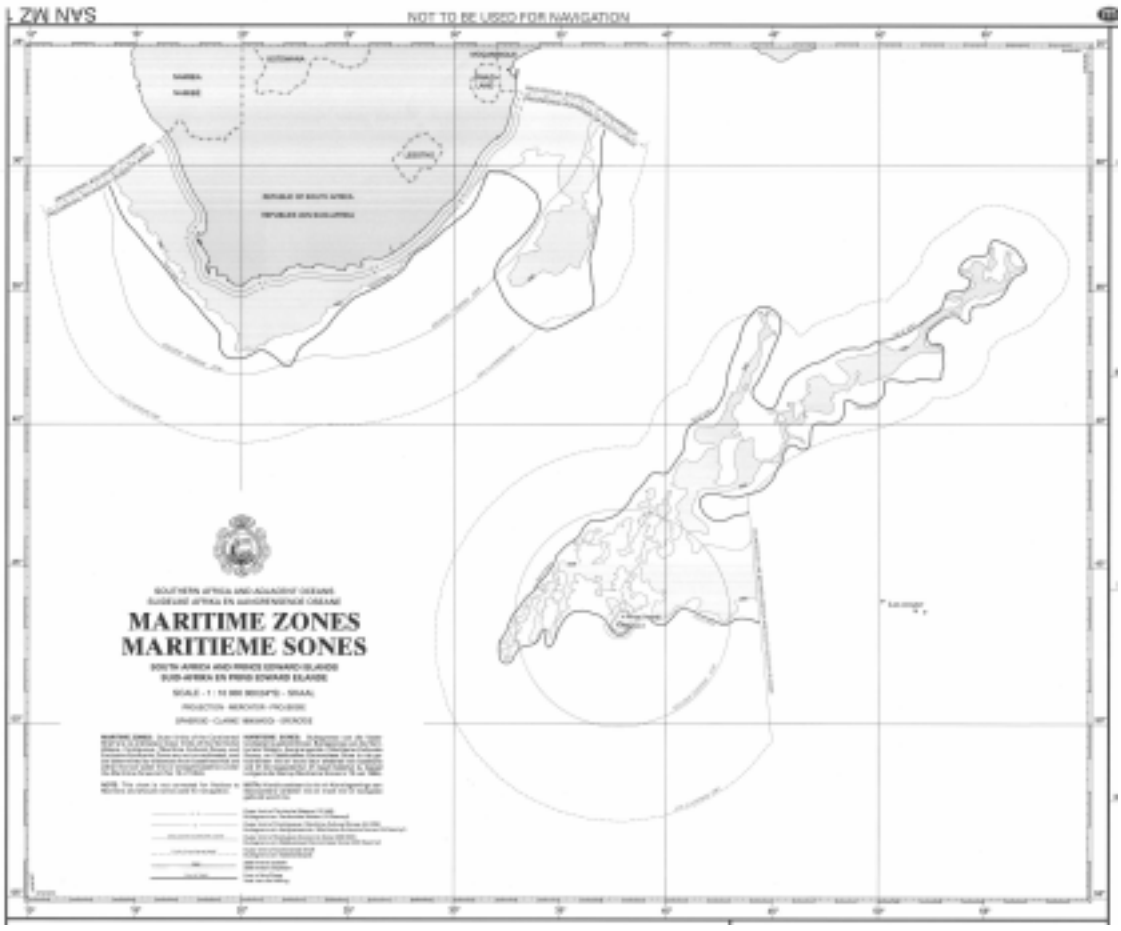

Figure 3 South Africa's maritime zones and boundaries

Conclusion

South Africa's maritime boundaries and zones as described above have been determined by a variety of methods all varying in their level of accuracy. Since the mean low water mark points used for the determination of the boundary with Mozambique at Ponta Do Ouro were agreed upon and surveyed jointly by South African and Mozambican surveyors, the accuracy of their determination is of little consequence. In spite of this, this boundary enjoys perhaps the highest level of accuracy of those described since the final determination is free of photogrammetric or cartographic interpretation. It is also directly connected to an internationally accepted ITRF co-ordinate system.

The determination of the boundary with Namibia at the Orange River mouth was determined without Namibian involvement since, at the time of the determination, the country did not have its own independence. The boundary was, nevertheless, determined well within the norms and standards set by UNCLOS which requires among other things that the boundary be determined from the largest available scale of charts or maps. At the time of planning for the determination, 1:50000 topographical maps were the largest scale maps available. A set of special 1:10000

orthophoto maps was prepared from aerial photography flown at the time that the mean low water mark was reached. Although the interpretation of the low water line from this mapping was not easy, it was considered better than using 1:50000 mapping for the initial section of the boundary.

The maritime boundary with France between the Prince Edward Isands and the Crozets is the least accurately determined of the three having been based on 1:1000000 GEBCO charts. At present this is the only method of determination available. The combined effects of the error sources that affect the position of the 2500m isobath and the subsequent continental shelf will have to be examined carefully and if necessary the Schedules of co-ordinates amended.

It must be pointed out that none of the boundaries or zones described in this paper has been formally ratified by South Africa, France, Mozambique or Namibia and that these boundaries are purely technical at this stage.

Acknowledgement

I would like to acknowledge the efforts and hard work of the many surveyors, photogrammetrists, cartographers and sailors who were involved in the determination of South Africa's maritime boundaries and zones. In particular I would like to acknowledge the late Mr FO Wande, Chief Programmer at the Chief Directorate of Surveys and Mapping, who prepared the software and data to compute all these zones and boundaries. The Hydrographer of the South African Navy is also acknowledged for granting me permission to use a portion of the 1:1000000 SAN MZ1 (Maritime Zones – South Africa and Prince Edward Islands, Published 1995)

The views expressed in this paper are solely those of the author and do not reflect the official view of the Chief Directorate or the Department of Land Affairs.

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