THE ROLE OF BATHYMETRY IN INTERNATIONAL MARITIME LAW AND IN THE PROVISIONS OF THE UN CONVENTION ON THE LAW OF THE SEA

By NEIL GUY

Executive Summary

For hundreds of years hydrograpers have conducted bathymetric surveys on which to base the compilation of nautical charts and publications. These surveys were composite surveys in that consideration was also given to geographical and geological features, climatic and weather conditions and in fact anything that could impact on the safety of navigation of vessels. This service changed as technology changed and today the most sophisticated surveying, positioning and compiling systems are available to the hydrographer. As a result his role has changed to degree that he has data that can be put to a multitude of uses.

While bathymetry is still the primary basis of nautical charting in all its forms, the coming into force of the United Nations Convention on the Law of the Sea (1982) has highlighted the importance of bathymetry to the many conditions and provisions contained in the Articles of this Convention. This paper attempts to highlight this importance and to draw attention to the arbitrary use of bathymetric data without reference to its meta-data.

Introduction

The role of bathymetry in both the legal aspects of safe navigation and in the UN Law of the Sea Convention (1982) (UNCLOS) has not been truly appreciated. Although these two areas may be considered as disparate this is in fact not the case. The legal obligations of the acquisition, processing, utilisation and maintenance of bathymetric information in the realm of the mariner is obvious. Poor surveying, cartography and poor maintenance of the chart or nautical publications should easily be recognised as negligence. Where a greater lack of appreciation and understanding exists is the role of bathymetry in UNCLOS. The essential role, availability and reliability of existing bathymetric information are considered in this paper.

The traditional rights of innocent passage and freedom of navigation have been codified in UNCLOS. In addition the rights and privileges of the coastal State through whose waters these rights are being exercised have been defined by UNCLOS. There has been a marked increase in the rights of a coastal State in that it is now able to exert its jurisdiction beyond the 12 nm territorial sea for the protection of its environment and its resources. It should be borne in mind that not only does the coastal State have rights but it also has obligations. These include the provision of maritime safety information and the requirement that coastal State activities, such as the laying of pipelines or the erection of structures on the seabed in all zones, except internal waters, should not interfere with the right of innocent passage and freedom of navigation or the safety of vessels.

In addition, the depiction of any boundary has to be such that it is practical for the user. A boundary may subsequently be required for consideration should an international incident occur on, or in close proximity to, a boundary. The accuracy and the clarity of the public presentation of the boundary could be important for those involved in enforcement, for those operating commercially and for those in innocent passage or exercising freedom of navigation. With a clear demarcation of the maritime zones it is possible for the coastal State to legislate for the rights, privileges and obligations of both the coastal State and for other States and their nationals using these zones.

Archipelagic States are obligated to provide acceptable sea-lanes through their archipelagic waters. The selection of these sealanes requires careful hydrographic analysis and co-operation with international shipping and relevant international organisations.

Coastal States have the rights to the natural resources in the exclusive economic zone and on and in the seabed of a UNCLOS Continental Shelf. The sea and the seabed contain far more than the obvious, and mud, clays, oozes, manganese nodules, polymetallic sulphides, and energy sources are factors that should be considered. For a coastal State to be aware of these assets significant surveys must be undertaken.

National Zones and Activities in Them

The more important technical aspects that are related to the legal regimes of the various zones are commented on as follows:

a) Internal waters are under the total sovereignty of the coastal State. UNCLOS does not detract from this sovereignty. As internal waters are inside baselines and closing lines the importance of straight baselines and bay closing lines is apparent as very little water can be found inside the normal baseline which is the low-water line.

b) Territorial Waters are also under the sovereignty of the coastal State but the right of innocent passage has to be accepted by the coastal State in these waters. The passage must, however, be innocent and continuous. There is an obligation in international law, however, for a coastal State to ensure that this passage is as safe as possible.

c) Coastal States may benefit from an exclusive economic zone, which can have a maximum outer limit of 200 nm from the baselines of the State. In these zones additional rights and obligations exist in regard to the exploration and exploitation of resources and obligations in regard to the safe passage of international shipping.

d) Lastly a coastal State may claim rights over the seabed and its subsoil in what is known as a Continental Shelf claim. A claim to a UNCLOS Continental Shelf could be substantial and care will have to be exercised by a coastal State in the application of the technical criteria contained in Articles 76 and 121. A coastal State will have to undertake substantial research to justify such a claim and unless the technical data can be produced to substantiate any claim made to the UN CLCS its acceptance is debatable.

e)

Physical Features

Marine-geoscience terms for geographical aspects and features are constantly used either as references for various criteria or as for important general consideration. Geographical features such as banks, bays coastlines, deltas, harbour works, islands, natural entry points of bays, river mouths, straits, continental margins, sedimentation, beach dynamics, seamounts and guyots, and subsurface plateaux must be clearly understood and their positions accurately determined if they are to be of use during a delimitation process or in unilateral claims in the maritime zones.

It is normal for a coastal State to first undertake a "desktop" survey using existing available data to determine the technical requirements and the data needed for these determinations. Sophisticated equipment is now available for accurate surveys to be undertaken in the specific areas identified but could be expensive. The accurate positioning of baselines is fundamental to the delimitation of maritime boundaries and to the delineation of maritime zones.

Marine Scientific Research

The term ‘marine scientific research’ is used frequently in UNCLOS not clearly defined. It can be accepted to mean any type of research, survey or investigation undertaken in marine areas.

Although all States irrespective of their geographical location have the right to conduct marine scientific research providing it is in accordance with the rights and duties of other States provided by UNCLOS. The conduct of marine scientific research may be divided into two categories:

a) Research under the jurisdiction of the coastal State.
b) Research under the jurisdiction of the Seabed Authority.

Marine Scientific Research under the Jurisdiction of the Coastal State

As a coastal State has sovereignty over its territorial waters this implies that it may conduct any form of marine scientific research provided it does not interfere with the right of innocent passage of vessels in those waters. [1] Vessels in transit or exercising right of innocent passage may not, however engage in any form of marine scientific research or hydrographic activity without the permission of the coastal State. [2] Coastal States are expected to consent to marine scientific research by other States and international organisations, outside of their territorial waters, providing certain conditions are met. These include;

a) the research is not related to the exploration or exploitation of the living or non-living resources in the region;
b) the research does not involve drilling on the continental shelf, the use of explosives, the use of harmful substances, the construction, operation or use of artificial islands, installations or structures;
c) in accordance with UNCLOS information related to projects to be undertaken in an area have to be provided to the coastal State. This includes nature and objective of the project, the methods and means, including the names, tonnage, type and class of vessels and equipment to be used, the precise geographical area, the dates of first arrival or deployment of vessels or equipment and the final departure date, the sponsoring institute its director and person in charge's names and the extent to which the coastal State may participate in the project. If any of this information is inaccurate or not forthcoming or if there are any other outstanding it could be grounds to deny consent;
d) the coastal State may designate specific areas where exploration will shortly commence and therefore decline consent
e) the coastal State may also undertake projects with international organisations. [3]

One of the criteria used to establish a Continental Shelf claim is a requirement for the outer limit to be less than 100 nm from the 2500 m isobath.
A second requirement is that the outer limit must be less than 350 nm from the baselines from which the territorial sea is measured. [4] A coastal State may use whichever is the greater of these two criteria. Within these maximum limits, two additional criteria must be met for a claim to comply with UNCLOS. The outer limit must not be further seawards than either 60 nm from the foot of the slope or a position at which the sediment thickness is equivalent to 1% of the distance of that position from the foot of the slope, whichever is the greater. [5] As can be seen the necessity for bathymetry to substantiate claims based on these criteria is essential.

[1] UNCLOS Articles 2 &17
[2] UNCLOS Articles 19(2)(c)(j), 40
[3] UNCLOS Articles 245-248
[4] UNCLOS Article 76 (5)
[5] UNCLOS Article 76 (4)(a)(i)&(ii), GP Francalanchi "Geological Interpretation of Art 76 of the United Nations Convention on the Law of the Sea" Proceedings of the TALOS Working Group Symposium (May1990) p13-19

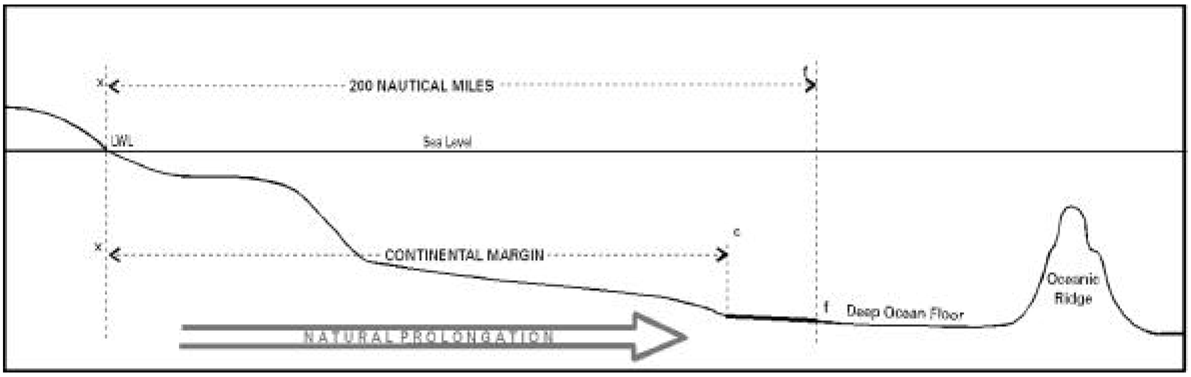

Figure 1 THE MINIMUM CONTINENTAL SHELF THAT A COASTAL STATE IS ENTITLED TO CLAIM

(If there are no overlapping claims, this is 200 nm from the baselines; this could therefore include portions of the deep ocean floor)
xc represents the geological continental margin
xf represents 200 nm from the baselines
cf represents that portion of the deep ocean floor that would be included in the claim

Providing that delimitation with an opposite State is not necessary the following options are open to a coastal State:

a) if it can be reliably estimated that the outer limit, would fall within 200 nm of the baselines little purpose would be served by additional expensive surveys being undertaken as a coastal State may, in terms of its exclusive economic zone, claim the seabed to a maximum of 200 nm from its baselines without additional information being obtained;
b) if it is considered that the location of the foot of the slope indicates that the required distances measured from it will extend beyond 200 nm then the foot of the slope should be accurately surveyed;
c) if 60 nm from the foot of the slope reaches the greater of the distances of 100 nm from the 2500 metre isobath and 350 nm from the baselines then it is unnecessary to consider sediment thickness and seismic surveys need not be undertaken;
d) Where 60 nm from the foot of the slope does not extend to the maximum allowed only then should seismic surveys be considered.

Due to the fact that UNCLOS [6] provides for claims by a coastal State to continental shelf, which may include areas that are geologically considered to be deep ocean floor, bathymetric and seismic surveys may have to be conducted to depths below 3000 metres. It should be possible to establish, from hydrographic data available, the areas where the position of the 'foot of the slope', the 2500 metre isobath and sediment thickness will have to determined. It should not be necessary, in most cases, for expensive seismic surveys to be undertaken of the entire potential UNCLOS continental shelf.

[6] UNCLOS Article 76(4)(a)

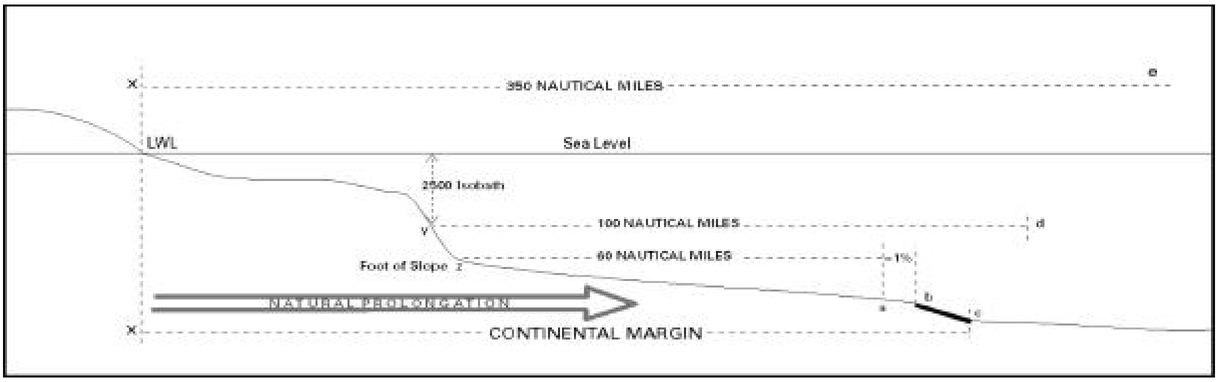

Figure 2 THE OUTER LIMITS OF A CLAIM MAY NOT EXCEED 350nm FROM THE BASELINES OR 100nm FROM THE 2500m ISOBATH, WHICHEVER IS THE GREATER.
(Within these criteria claims may be made to positions that are either 60 nm from the 'foot of the slope' or where the sediment thickness is equal to or greater than 1% of the distance at that position to the 'foot of the slope')

Surveys

The types of survey, that are necessary, vary. Information must be obtained by terrestrial or land surveying, hydrographic or bathymetric surveying, seismic surveying, and bottom sampling. The availability of surveys of both the coastline and the seabed, adequate for boundary and zonal delimitation, is usually rare. Most of the research resulting in data held by Hydrographic offices, research institutions, and other coastal authorities and engineering organisations was undertaken for other purposes such as the production of charts for navigation, coastal zone management and research, and the exploitation of seabed resources. While the data is able to provide a reasonable reconnaissance record of the area, it is usually necessary to undertake specific surveys to obtain further necessary data. This would apply to baselines, boundaries between littoral or opposite States and the outer limits of the zones.

Where baselines, on which the outer limits of the maritime zones are based, have to be determined the coastal mapping available should be assessed as to whether it could be considered as adequate for the task and whether it is necessary for new surveys to be undertaken. It is also necessary to study the gradients in the intertidal zones. To establish the position of either the low-water-line, as a ‘normal’ baseline, or as the terminal points of straight baselines, the height of the low-water-line has to be determined from the tidal observations available. Accurate horizontal positioning of the low-water-line must then be undertaken, preferably related to a global ellipsoid such as WGS 84.

Coastal States involved in delimitation must agree on a number of issues.

a) the ellipsoid and the datum on which the geodetic computations are to be made,

b) the type of boundary line, such an the equidistant line method,
c) the geographical features that will affect the delimitation,
d) the methods to be used in the surveys should also be agreed on.

Other factors that must be taken into consideration when the surveys are being undertaken are as follows:

a) the positions of other geographical features such as islands, low tide elevations, the entry points of bays, the entry points of rivers, the 2500 metre isobath, and the foot of the continental shelf,
b) the thickness of sediment on the continental rise, and

c) the identification of the structure of the geological crusts. This may be necessary to substantiate aspects of a continental shelf claim.

Subsurface features are more difficult to survey and the position of subsoil features may require seismic surveys that are usually more expensive when compared with hydrographic or terrestrial surveying. Whatever is adopted, the boundary will have to be surveyed and depicted in a manner that is understandable by those involved in the delimitation and by the national and international communities thereafter.

The outer limits of the continental shelf claimed by a coastal State have to be accepted by the CLCS the Guidelines produced by the CLCS are meant to serve as advice to a State preparing a submission to the CLCS as to what the CLCS would consider favourably.

The positions of above-surface features are also required by surveys and should be determined at times that are most advantageous to maximise the results. Subsurface features are more difficult to survey but unless they are low-tide-elevations, the vertical component may not be as vital. The position of subsoil features will require seismic surveys that are usually more expensive when compared with hydrographic or terrestrial surveying. Finally, however, whatever is adopted, the boundary will have to be surveyed and depicted in a manner that is understandable by those involved in the delimitation and by the national and international communities thereafter. The outer limits of the continental shelf claimed by a coastal State have to be accepted by the CLCS the Guidelines produced by the CLCS are meant to serve as advice to a State preparing a submission to the CLCS as to what the CLCS would consider favourably.

Data Sources.

Most Hydrographic Offices of coastal States have conducted extensive surveys on the continental shelf. These surveys have been specifically conducted to produce charts for the use of mariners. As such the data cannot always be used to satisfy other requirements. The coverage of this data is usually to a depth of 200 metres. Deeper surveys, in terms of the GEBCO Programme, could be used for reconnaissance purposes. It is clear that surveys would have to be conducted in specific areas to be able to determine the configuration of the continental margin in the areas necessary to substantiate claims made in accordance with the Articles of UNCLOS.

Ellipsoids, Datum and Projections

When delimitation is based, wholly or partly, on existing surveys the relationship of the ellipsoids, and the datum used during these surveys is vital. It may be possible to easily transform the data from one ellipsoid and one set of datum to another but it may also be necessary to re-compute some of the information. Failure to relate ellipsoids and datum could have a major influence on the positioning of features and boundary points in the delimitation calculations.

Existing Data
Leadline

Much of the existing data was undertaken by lead-line type surveys. These surveys determined the depth of water under the survey vessel and were not much different from those in use for the previous 2000 years. [7] An indication of the coverage of these soundings at these depths is that at a natural plot scale of 1/6 250 the sounding interval would be in the region of 15 metres, and at a scale of 1/50 000 it was approximately 45 metres. As these surveys were obviously concentrated in shallower water, and as the deeper soundings were

[7] N Bowditch American Practical Navigator (1958) p27

relatively far apart, it is very unlikely that there would be sufficient data to define either the foot of the continental slope or the 2500 metre isobath. In large portions of the oceans and seas, however particularly around Africa, these are the only surveys available.

Echo-Sounder

Technical developments in these systems increased the depths to which soundings could be taken and depths below 500 fathoms (1650 metres) were obtainable. [8] This did not eliminate the problem that all the soundings were confined to lines and that there were gaps between the lines where no depths were recorded. Modern single-echo sounder systems have improved to the point where the accuracy is more than adequate for both survey and navigation purposes, but they still have the problem that the coverage is only that portion of the seabed immediately below the transducer.

Side Scan Sonar

As it became essential to widen the width of the echo survey path, dedicated systems evolved. Many systems were developed which allowed for a towed metal 'fish' to obtain data from the seabed by recording sonar transmissions from strip transducers fitted along the length of each side of the fish. The transducers on this strip were placed at half-wave frequency to give an enhanced transmission envelope so that, if the height of the fish above the seabed were correctly regulated, the surveyed path would cover the optimum area either side of and up to the central course line. [9]
Reference must be made to GLORIA

Geological Long Range Inclined ASDIC (GLORIA)

In 1969 the United Kingdom's Institute for Oceanographic Sciences, now the Southampton Oceanographic Centre, developed a deep-ocean side-scan-sonar system to assist with the identification of the following;

a) locations of strategic and other minerals- polymetallic nodules and crusts;
b) locations of hydrocarbons- oil and gas;
c) sites for 'farming' of shellfish and other marine life;
d) sites for harnessing ocean thermal energy;
e) optimum routes for cable- and pipe-laying;
f) sites for disposal of toxic and other waste;
g) location of earthquake and volcanic zones;
h) exclusive economic zone and continental shelf territories in terms of international law. [10]

In 1984, the United States Geological Survey decided to map their entire exclusive economic zone using the GLORIA system. This was essentially for reconnaissance purposes and was an effort to gain information about the configuration of the margin and deep-sea-bed out to 200 nm.

[8] ibid
[9] A E Ingham Hydrography for the Surveyor and Engineer 2nd Ed (1984) p84-85
[10] Marine Underwater Systems GLORIA Deep Ocean Surveys (1987) p3

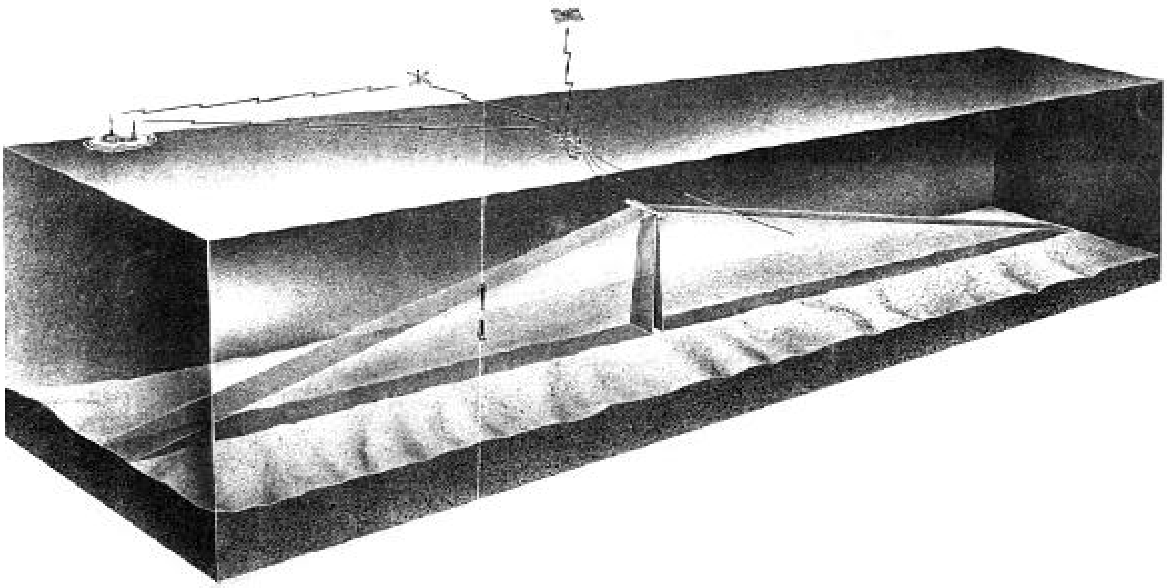

Figure 3 THE WIDE COVERAGE OF THE GLORIA MULTI-BEAM SYSTEM (Coverage could be as much as 60 nm)

Over a period of 4 years, 1,5 million square miles were mapped. Many previously unknown volcanoes were located and the evidence of the fracture zones facilitated the development of sea-bed-mapping of the zone. Some of these volcanoes had well-formed craters and it is anticipated that they will contain cobalt-enriched manganese oxide. [11]
The system was capable of mapping swathes, 60 km wide, of the deep seabed at vessel speeds of 8 knots. It is possible therefore to map 20 000 square kilometres per working day. The great benefit of a system such as this is that it enables vast areas of the seabed to be mapped, regardless of depth, and identifies the areas that should be surveyed later in greater detail. [12] It is unlikely that these data could be used for final boundary or maritime zone delimitation.

Precision Depth Recorders

In the 1950s, further improvements to transducers, especially in the accuracy of the timing of transmissions, led to the development of precision depth sounders and recorders (PDR). PDRs were able to establish the configuration of the seabed but, as the beam width was from 30-60 degrees, only gross relief could be delineated. For economic reasons, the lines were spaced up to kilometres apart and the record of the seabed could only be considered as sampling. Contouring is difficult and less accurate where the data is concentrated in the lines of soundings with no data between the lines. An attempt to obviate this narrow path was to mount a series of these transducers on long booms extended from the side of the vessel, to arrange a series of towed vessels fitted with the multi-beam transducers that travelled astern, but on either side of the main vessel, or for a series of small launches to be fitted with transducers and navigated from, and on either side of, the survey vessel. [13]

Multi Beam Swathe Bathymetry

The multi-beam echo-sounders usually consist of hull-mounted transducer arrays, with appropriate transmission timers, generators and beam-configuring networks. There is also an echo processor digitising the echoes from the various beams corrected for the roll, pitch and

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[11] AS Laughton "The First Decade of GLORIA" IHR Monaco LX (1)(January 1983) p42, BA McGregor & GW Hill "Seafloor Image Maps of the US Exclusive Economic Zone" The Hydrographic Journal No 53 (July 1989) p9-10

[12] ibid p4

[13] R Burke et al "2 088 000 Depth Measurements per hour : A Formidable Data Processing Challenge for any Hydrographer" Canadian Hydrographic Conference Proceedings (1987) p2, R Burke, S Forbes & K White "Processing 'Large' Data Sets from 100% Bottom Coverage 'Shallow" Water Sweep Surveys" IHR Monaco LXV (2)(July 1988)

heave of the vessel and refraction. Most of these processors are capable of producing underway plots of the seabed with contours to metre accuracy. [14]

Large-Scale Charts

Two terms that are used extensively throughout UNCLOS are 'large-scale charts officially recognised by the coastal State.' and 'low water line along the coast'. In the majority of cases, the only large-scale charts available are those of ports or harbours and their approaches, which have been prepared for navigational purposes. These scales are usually between 1/5000and 1/50 000, of which only the lower range can be considered large scale. Most of the rest of coastline will have been charted at scales of 1/150 000 or less. [15]

The second factor, that the baseline is the low-water line, creates further problems in the use of these charts. Unless the beach gradient is sufficiently low to create substantial lateral movement with the fall of the tide, the coastline was usually accepted as being the position of high water springs.

General Bathymetric Chart of the Oceans

Much has already been said at this Conference about the origins and achievements of the GEBCO Programme so it is only the intention therefore to relate the significant role that GRBCO has played in charting and now in UNCLOS delimitations.

Contours or depths in the region of 2500 metres are usually beyond the interest of hydrographic surveyors. GEBCO data are available from the GEBCO programme,
The collection of sounding data of the deep ocean floor is used for;

a) specific GEBCO programmes;
b) data gathered during the course of other research programs as additional information;
c) data gathered by vessels in transit.[16]

The standard of the collection of GEBCO data can vary from dedicated surveys to passage-of-convenience recordings. Many of the vessels submitting data to the GEBCO data bank follow regular routes and many of the soundings occur in the same areas of the deep ocean or along the same track. The vessels may be engaged in other research and as it is now relatively simple to record these data, these vessels record as much bathymetric data as possible. The GEBCO data should be carefully assessed to establish whether it would be suitable but by using acceptable and available data, the areas where it will be necessary to conduct specific bathymetric surveys and to compile profiles to position the 2500 metre isobath or the foot of the continental slope can be identified.

Global Positioning System (GPS)

The introduction of satellite positioning systems such as the GPS system is generally regarded as being the most significant development in navigational services for decades. The GPS system is based on a constellation of 24 US military satellites now fully deployed. [17] The user is now able to position himself accurately with GPS and even more so by the use of Differential GPS. Unfortunately these positions relate to the orbit of the satellite and much of the early survey data relates to different ellipsoids. Care has to be exercised in the transformation of this survey data.

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[14] ibid p28
[15] Bowditch n7 p104
[16] IHO/IOC Guidelines for the General Bathymetric Chart of the Oceans (2nd Ed) (1991) p1.2
[17] Sercel - Inc (France) The High Accuracy of Positioning : Technical Specifications (undated)

Submarine Features.

Submarine features could effect consideration of a Continental Shelf claim and their positioning could be very necessary for any claim submission. The continental slope, and in some instances the shelf itself, are interrupted with submarine valleys, ravines and canyons. They do not necessarily lie at right angles to the shelf break and could be at any angle. Similarly to seamounts, the knowledge of the existence of submarine canyons has expanded considerably in recent decades.

Submarine Canyons

There are three major types of submarine canyon;

a) small gorges, usually near the edge of the continental shelf, that run down the slope to the rise;
b) similar canyons, starting usually at the mouths of major rivers that run across the entire continental shelf, down the slope to the deep sea-bed;
a) a complex series of branches, similar to land-based dendritic systems. These are incised into the shelf break and the slope. [18]

These canyons are used for the transportation of sediment across the shelf to the deep seabed. Substantial deposits may be found on the seabed seaward of the foot of a canyon in a submarine fan. The presence of a canyon may give an indication of the presence of substantial sediments in the region. Examples are the Cape Canyon [19], the Natal Canyons [20], and the Hudson Canyon. [21]

<u>Submarine and Oceanic Ridges</u>

Submarine ridges could be a part of the continental margin of a coastal State. These ridges may be considered when an UNCLOS continental shelf is determined. [22] *The bathymetric survey of these features could therefore be a requirement.*

<u>Foot of the Continental Slope</u>

It should be is possible, but could be difficult, to identify the foot of the slope automatically over a large area or to confirm the foot of the slope adopted by other methods. To establish the position of the foot of the slope for the determination of a UNCLOS continental shelf claim, the configuration of the seabed must be investigated over a relatively large area. The seabed could have a simple profile enabling an easy identification of the foot of the slope. It could equally be complex with multiple slopes and it is imperative that adequate surveys be undertaken before any assumptions are made. These surveys could be both bathymetric and seismic.

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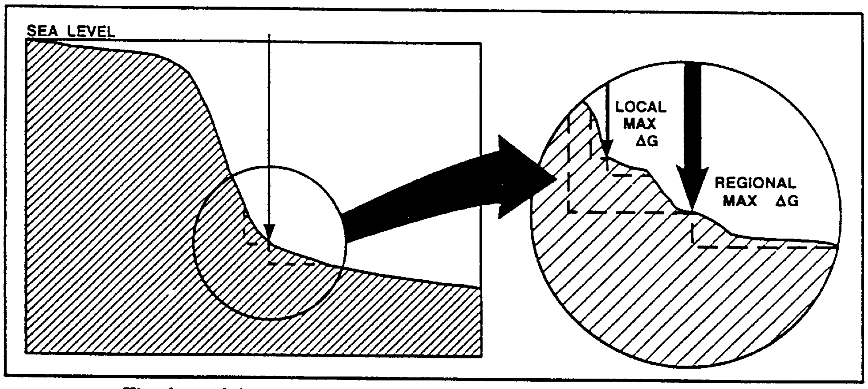
[18] CAM King <u>Beaches and Coasts</u> (1961) p65
[19] ESW Simpson & E Forder "The Cape Submarine Canyon Part 1 Bathymetry" <u>Fisheries' Bulletin of South Africa</u> 5 (1968) p35-37
[20] ND Bang "Submarine Canyons off the Natal Coast" <u>South African Geophysical Journal</u> 50 (1968) p45-54
[21] FP Shepard <u>Submarine Geology</u> (2nd Ed) (1963) p328-329
[22] UNCLOS Article 76(6)



The foot of the continental slope is defined as the location of the maximum change on bottom gradient. As shown in the enlarged section, this location may vary according to the range over which the gradient is calculated, i.e. the feature may be determined on a local basis (thin arrow) or a regional basis (thick arrow).

Figure 4 THE COMPLEXITIES OF IDENTIFYING THE POSITION OF THE 'FOOT OF THE SLOPE '

Seismic survey has accuracy that is not comparable with those of the methods used in the surveys of other disciplines. The position of the foot could be complicated by virtue of the fact that more than one position can be identified. The criterion that must be met is that the foot of the slope is the position where the maximum change in gradient at the bottom of the slope occurs. Geodesists have calculated the possible horizontal error that could occur with various levels of data density and the positions of the foot of the continental slope between observations are interpolated. [23]

<u>Foot of the Continental Slope in a Passive Margin</u>

Passive margins are distinguishable by relatively small geological, bathymetric and geophysical changes from the continent to the deep ocean floor. Some passive margins, such as the one north of San Francisco Bay California, have simple almost monotonous configurations where it is relatively easy to identify a foot of the slope. [24]

<u>Foot of the Continental Slope in an Active Margin</u>

Active margins, such as on the Pacific Rim, have relative velocities that could be of the order of 10 cm per year. With the crusts converging, and one of the crusts being subducted in a trench, the boundary between the crusts is easily identified. As a result of the frictional heat generated by these activities large masses of igneous material are formed. This erupts as lava and forms an extensive chain of islands on the inner side of the trench. This creates an arc of islands, surface or submarine, around the continent or island and complicates the identification of the foot of the slope. It also makes it extremely difficult to establish the extent of sediment thickness on any rise that may be present. It is also difficult to distinguish between the ocean floor with its oceanic ridges and the continental slope with a trench and surrounding volcanic islands. [25] This is not relevant to the South African situation.

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[23] Z Ou & P Vanicek Automatic Tracing of the Continental Slope <u>Proceedings of the 2nd GALOS Conference</u> (1996) p1

[24] AL Shalowitz <u>Shore and Sea Boundaries</u> (Vol 1) p185

[25] T Sato & S Oshima "Continental Shelf Survey Project of Japan" <u>IHR</u> LXV(1)(January 1988) p41-55

Resources

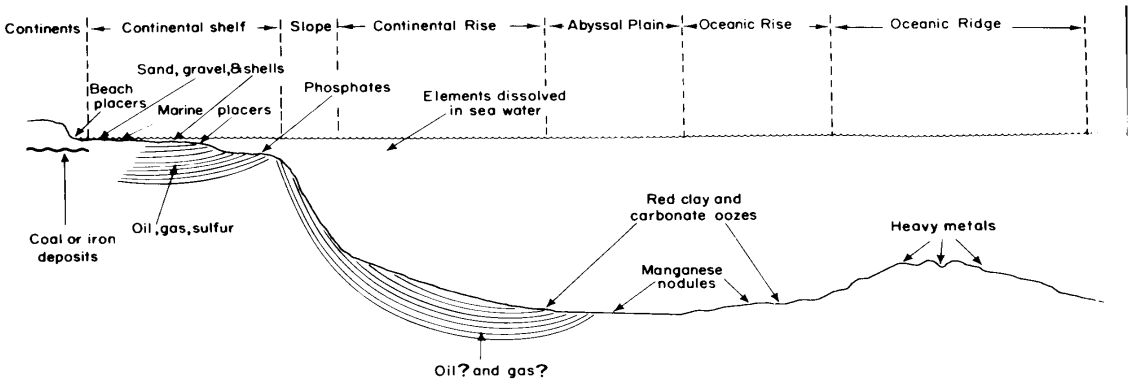

Figure 5 GENERAL AREAS WHERE MINERALS ARE FOUND IN SEDIMENTS ON, AND IN, THE SHELF, THE SLOPE, THE RISE, AND THE DEEP SEABED

Coastal States have the rights to natural resources in the exclusive economic zone and on and in the seabed of a UNCLOS Continental Shelf. For a coastal State to be aware of these assets significant research has to be undertaken. This would include bathymetric surveys.

CONCLUSION

Accurate bathymetry is essential to the production of nautical charts and publications and the legal responsibilities related to this service and accurate bathymetry is essential to the substantiation of the UNCLOS claims of a coastal State to maritime territory and marine resources.