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A MANUAL ON TECHNICAL ASPECTS OF THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA – 1982 (TALOS)

IHO

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PREFACE

The United Nations Convention on the Law of the Sea (UNCLOS) was signed at Montego Bay, Jamaica, on 10 December 1982. The signing of the Convention marked the conclusion of the Third United Nations Conference on Law of the Sea, which had lasted from 1973-1982. The Convention entered into force on 16 November 1994, twelve months after the sixtieth instrument of ratification or accession had been deposited with the United Nations.

It is not necessary to dwell on the accomplishments of the Conference or the future impact of the Convention on humankind. It is sufficient to note that the Convention combines in one treaty the four conventions that were signed at Geneva in 1958, dealing with the Law of the Sea, namely: The Territorial Sea and the Contiguous Zone; the High Seas; Fishing and Conservation of the Living Resources of the High Seas; and the Continental Shelf. In addition, within its 320 articles and 9 annexes, the 1982 Convention covers many new areas of concern, including in particular the protection and preservation of the environment and the resources of the deep ocean floor.

Aspects of the Convention that are of particular concern to hydrographers include those articles dealing with delimitation of maritime boundaries, the conduct and promotion of marine scientific research and the development and transfer of marine technology. It was clear that the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) would have a part to play in some of the technical aspects of implementing the Convention. Accordingly, in July 1983 a meeting was arranged between Ambassador Bernardo ZULETA, Mr. Jean-Pierre LEVY (UN), Rear Admiral Frank FRASER (President IHB)[1], Vice Admiral O.A.A. AFFONSO (Director, IHB), Dr. Mario RUIVO (Secretary IOC) and Mr. Desmond SCOTT (Secretary GEBCO). As outlined in IHB Circular Letter 28/1983, the IHO was invited to provide technical advice and information on baselines and geodetic datums.

First Edition

In order to fulfil its obligations the President of the IHB initiated the concept of a Working Group to develop an IHO Special Publication on the Technical Aspects of the Law of the Sea Convention. Participation in this group was invited in IHB Circular Letter 37/1984 and Circular Letter 16/1985 announced the twelve members of the group. The TALOS (Technical Aspects of the Law of the Sea) Working Group was duly constituted. (See Appendix 4 for the Group's membership).

At the Working Group's first meeting in Monaco, 2-4 October 1985, the late Rear Admiral FRASER agreed to assume the Chairmanship. There was consensus that the manual should have the following structure:

(a) Introduction - explaining the scope of the manual.
(b) List of hydrographic terms and concepts related to the Law of the Sea including illustrations of a general nature.

[1] IHB - International Hydrographic Bureau - the Secretariat of the International Hydrographic Organization (IHO).

(c) Possible practical applications - field work, charting work and computations. Appendix of computer programmes.
(d) Annotated bibliography - this section would not have an IHO endorsement and would simply list available published literature, work done in different countries, etc.

During 1986 work proceeded on (b) which became Part I - the GLOSSARY and the Appendix to (c) which became Appendix 2 - Computer Programmes. The latter was completed under the supervision of Japan. Work commenced on (c) which became Part II - Practical_Applications. France and Italy undertook initial work on this section and the IHB Consultants provided editorial and general assistance for both Parts I and II.

Three further meetings were held in Monaco. At the second meeting, 1-3 April 1987, the first draft of the Glossary was reviewed. At the third meeting, 27-29 April 1988, the Glossary was completed, a major revision of Part II undertaken and a decision taken that Part III - Computer Programs should be slightly expanded and become an appendix. At the fourth meeting, 22-24 May 1989, Part II - Practical Applications was reviewed.

Second Edition

During 1989, the International Association of Geodesy (IAG) formed a Special Study Group on the Geodetic Aspects of the Law of the Sea. In view of the special expertise within this group it was invited to join the TALOS Working Group at its fifth meeting, held in Monaco from 16-18 May 1990. It was decided, whenever applicable, to make reference throughout the text, to a report on geodetic applications which would be produced by the IAG Special Study Group. This report would provide the reader of this Manual with greater detail on the application of geodetic methods. Consequently it was decided to omit the Appendix on the Calculation of Angles and Distances on the Ellipsoid from this text. Additionally in view of the need for consistency with the newly published Fourth Edition of the Hydrographic Dictionary (S-32) it was decided to amend Part I - the GLOSSARY, which had been published separately in 1988.

Third Edition

For the third edition it was decided to omit Appendix 2 - Computer Programmes due to the rapid obsolescence of such information.

Fourth Edition

In late 2002, the joint IHO / IAG / IOC Advisory Board on Hydrographic, Geodetic and Marine Geo-Scientific Aspects of the Law of the Sea (ABLOS), the Terms of Reference of which now included the review and updating of the TALOS Manual, decided to set up an editorial group to prepare a 4th Edition. The Editorial Group first met at the IHB on 23rd and 24th October 2003 prior to the 3rd ABLOS Conference where it elected Ron Macnab of Canada as its chairman. A second meeting was held at the IHB on 29th and 30th March 2004.

It was agreed that the 4th Edition would primarily be a digital publication and would be aimed at a non-specialist audience. However, with the use of extensive cross-referencing and hyper linking made possible by digital publishing, it would be a useful first point of reference for the specialist user. It was decided to incorporate the additional material on “The Nautical

Chart” in Appendix 1 to the 3rd Edition, into the main chapter. It was further decided to incorporate material from the “Geodetic Commentary to the TALOS Manual”, largely prepared by P. Vaníček, and published by the IHO as a separate Appendix in 1996, into the Manual. The Chapter dealing with the “Outer Limits” would now include a review of the nomenclature used in “Article 76”. Finally, it was agreed that there should be a new Chapter dealing with “Digital Methodologies” reflecting the great increase in computing and digital data since the 3rd Edition was published in 1993.

Fifth Edition

After the Fourth Edition of the TALOS Manual had been in circulation for four years, members of ABLOS considered that certain portions of the publication needed updating. Accordingly, a new Editorial Group was formed in 2010 to define the scope of the updates and to develop a project plan for creating the Fifth Edition. Members of that Group are identified in Appendix 4.

Upon review of the old text, the Editorial Group determined that Chapter 2 (Geodesy) was most in need of substantial revision in order to better reflect current theory and practice in surveying and satellite-based positioning. To all intents and purposes, that Chapter has been re-written.

Minor changes were recommended and implemented for Chapters 4 and 6 (Baselines and Bilateral Boundaries, respectively); recommended alterations to Chapters 3 and 5 (Nautical Charts and Outer Limits, respectively) were identified but in light of scheduling issues, their implementations were deferred to a later edition.

In a significant departure from previous editions, selected illustrations throughout the Manual have been rendered as animations by Clive Schofield (Wollongong University) and Andi Arsana (Gadjah Mada University), with a view to better explaining certain concepts and procedures. Where appropriate, figure captions contain links to the website of the International Hydrographic Organization where the animations may be accessed.

Sixth Edition

After completion and publication of the Fifth Edition of the TALOS Manual, it was recognised that work was required on chapter 3 covering nautical charts and projections to reflect the introduction of the revised carriage requirements for electronic navigational charts (ENCs) as laid down in the International Convention for the Safety of Life at Sea (SOLAS) 1974, as amended, Chapter V. This sixth edition contains a comprehensive revision of chapter 3, which addresses the use of both ENCs and traditional paper charts. The opportunity was taken, where possible, to harmonize the Glossary contained in Appendix 1 with the IHO publication S-32 – *IHO Hydrographic Dictionary* – and the IHO GI Registry to ensure consistency of terminology.

Disclaimer

During the preparation of this Manual, every effort has been made to present information and advice in keeping with the provisions of the UN Convention on the Law of the Sea. Some of these provisions are complex and subject to varying interpretations, so the editors cannot accept responsibility in situations where applications of the proffered information and advice lead to unintended outcomes. In all cases, readers are strongly advised to consult the text of the Convention and to seek authoritative advice in the implementation of its provisions.

THROUGHOUT THE TEXT THE ARTICLES REFERRED TO ARE THOSE OF THE LOS CONVENTION.

Spelling and symbols

Astute readers will notice that English spelling conventions have not been uniformly applied throughout the text, and that certain symbols may not conform to expectations. These are a reflection of the multinational character of this Manual, which has engaged editors from countries that adhere to different spelling conventions, and which use language-specific fonts that vary in their renderings of symbols

CHAPTER 1 – INTRODUCTION

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1.1 INTRODUCTION

UNCLOS is a complex and broad-ranging formulation of international law that seeks to regulate the use of the world's oceans for the benefit of humankind. Numerous scientific and technical considerations impinge upon the application of UNCLOS, just as UNCLOS has implications for the practice of marine science and technology. This Manual addresses the interplay between the Law of the Sea and the disciplines of Geodesy, Hydrography, and Marine Geoscience. It provides an overview of a series of technical issues whose satisfactory realisation is key to the orderly practice of international law in the ocean environment.

The present Chapter contains a general introduction to the Law of the Sea, and to the technical and scientific activities that will be discussed at length in the remainder of the Manual.

1.2 A SHORT HISTORY OF THE LAW OF THE SEA AND UNCLOS

1.2.1 Prior to 1982

The first known line drawn in the seas of the world was declared in 1493 by the Bull *Inter Caetera* by Pope Alexander VI. He declared that the islands and mainlands to the west of a meridian of longitude 100 leagues west of the Azores and Cape Verde, through Brazil were to be considered Spanish and those to the east of this meridian to be Portuguese, provided no Christian king was in actual possession of the territory.

This meridian was adjusted in 1494 by the Treaty of Tordesillas between Spain and Portugal westwards to a line 370 leagues to the west of the Cape Verde Islands. The "Eastern Sea" was divided between Spain and Portugal by the Treaty of Zaragoza of 1529. Again, a meridian of longitude was used running through the centre of Australia with the lands to the east being Spanish and to the west Portuguese.

In the United Kingdom, James I of England declared the "King's Chambers" in 1604. This Proclamation enclosed seas around England and Wales joining some 27 headlands with straight lines and declared that the water thus enclosed were under the sovereignty of the King. Diagrams of these claims can be found in "Lines in the Sea" edited by Francalanci and Scovazzi.

In contrast to early claims to control the seas, in the early seventeenth century the right of the freedom of the seas was contained within a treatise by Grotius entitled *Mare Liberum*. This work purported to prove that there was a right to trade freely and was published as a direct challenge to the Portuguese claim to the "Eastern Seas".

So already by the seventeenth century there were two camps – coastal State control and freedom of the seas - that remain to this day. However, it was accepted by both camps that coastal States did have a right to control waters close to their land territory, by force if necessary. The "cannon shot" rule, as it became known therefore grew to mean control of inshore waters by the use of cannon on headlands and other promontories. This in turn developed into a general recognition that one marine league around the coast was under the control of the State that owned the coast.

Following the First World War, the international community recognised that a codification of international maritime law, as it applied to the generation of coastal State maritime space, was needed. Accordingly, the League of Nations sponsored a conference in The Hague in 1930 to discuss the codification of the law relating to coastal State controls within the Territorial Sea, and to freedoms of the High Seas. No Treaty was produced from this conference, largely because of the politically sensitive issue of fisheries, but it was agreed that the conference should be reconvened at a later date.

Following the Second World War and the establishment of the United Nations, an early task was to look again at the question of the codification of international maritime law. The International Law Commission was charged with the formulation of draft articles for a treaty or treaties on the Law of the Sea. The Commission began its work in 1950, submitting its results to the General Assembly in 1956.

In the meantime, the first maritime boundary to be delimited beyond the territorial sea was created between Venezuela and the United Kingdom on behalf of Trinidad and Tobago in 1942. This established a right to the continental shelf, provided it was occupied. In 1945, the Truman Proclamation on the continental shelf asserted that a State had a right to its continental shelf as an extension to its landmass out to 100 fathoms. In Latin America, along the lines of Mexico and other countries, a significant step was adopted on June 23, 1947, when Chile declared its sovereignty and jurisdiction over the sea and continental shelf adjacent to its coasts up to a distance of 200 nautical miles. On August 1, 1947 Peru published a Supreme Decree N° 781 with similar characteristics. This is recorded in the negotiated legal instruments, which also include Ecuador, entitled Declaration on the Maritime Zone or Santiago Declaration dated 18 August 1952 and Agreement relation to a Special Maritime Frontier Zone signed in Lima on 4 December 1954.

Other developments in Law of the Sea matters included an important International Court of Justice (ICJ) case in 1951, between the United Kingdom and Norway concerning the use of straight baselines from which to calculate the territorial sea. The Court found in favour of Norway, thus declaring that this type of baseline was legal in that particular geographical circumstance.

Thus followed the First Geneva Conference of the Law of the Sea in 1958. What emerged were four Conventions rather than one, which was not originally intended. However, it was the first time that the Law of the Sea had been codified. It can also be said that several parts of these Conventions were considered progressive and were intended to be enhanced by custom with advances in ocean development. The four Conventions were: The Convention on the Territorial Sea and the Contiguous Zone; The Convention on the High Seas; The Convention on Fishing and Conservation of the Living Resources of the High Seas; and the Convention on the Continental Shelf. Each Convention had to be ratified separately and the take-up was not universal.

The Convention on the Territorial Sea and the Contiguous Zone was ratified by 45 States, but it failed to agree on the width of these zones. This led to the requirement to hold a second Law of the Sea Conference to try and resolve this issue. This was convened in Geneva in 1960, but again the width question was not resolved. An agreement for a 6 nautical mile (M) Territorial Sea and a further 6M for the Contiguous Zone failed in plenary by one vote.

The Convention on the High Seas was largely a success and was ratified by 56 States. Much of its content remains in force today and is reflected in the present Law of the Sea Convention. The Convention on Fishing and Conservation of the Living Resources of the High Seas was not a success. Only 35 States have ratified this Convention.

The Continental Shelf Convention on the other hand has been very successful with 53 States ratifying. It enabled States to explore and exploit the non-living resources of their seabeds from the early 1960s with confidence. Moreover, it proved significant that the wording of the Convention stated that the continental shelf was the seabed and subsoil adjacent to the coast out to 200 metres or as far as it could be exploited. It was thus effectively open-ended.

During the 1960s and 1970s several Law of the Sea issues developed. The unilateral extension of Territorial Sea claims, some out to 200M, caused concern to those States trying to maintain freedom of the High Seas, while others claimed that these extensions maintained their rights over resources. Fishery zones had progressively extended from 12M in the 1950s to 200M by the middle of the 1970s. This was in part due to the three “Cod Wars” between the United Kingdom and Iceland between 1958 and 1976. There were also several court cases regarding delimitation during this period, including the ICJ North Sea Continental Shelf case of 1969 between Germany, The Netherlands, and Denmark and the Western Channel arbitration between the United Kingdom and France in 1977.

Perhaps the most significant development during this period was the discovery of manganese nodule fields in the deep ocean basins of the World. It was feared that this supposedly vast mineral wealth would be exploited by the major industrialised nations for their own benefit. In an attempt to curtail this, Ambassador Pardo of Malta submitted a resolution at the General Assembly of the United Nations in 1967, introducing the concept that the resources of the deep ocean should be exploited for the benefit of all mankind. This sowed the seed for the beginning of the process leading up to the Third United Nations Conference on the Law of the Sea.

A Seabed Committee was constituted by the General Assembly to look into this matter, and it soon became apparent that it would be necessary to consider the existing Geneva Conventions in their entirety. The Third United Nations Conference on the Law of the Sea began this task in Caracas in 1974. This activity culminated in the drafting of the United Nations Convention on the Law of the Sea (UNCLOS), which was opened for signature on 10 December 1982.

The work of the Conference was divided among three main committees. The first committee was required to draft the articles concerning the deep seabed provisions, including the mechanisms for their implementation. The second committee covered the more traditional maritime zones and navigation provisions, with the introduction of two new concepts: the Exclusive Economic Zone, and the Archipelagic State provisions. The third committee covered the complex areas of marine scientific research and the protection and preservation of the marine environment, as well as the other miscellaneous provisions. The results were placed into various negotiating texts by a fourth committee.

The successful outcome of this conference, lasting some eleven sessions over a period of about eight years, is considered by many to be one of the most significant achievements of the United Nations to date.

1.2.2 After 1982

The 1982 Convention (UNCLOS) required 60 States to deposit articles of ratification or accession with the Secretary General of the United Nations to bring it into force one year after the date of the sixtieth ratification. It became clear that by the early 1990s the sixtieth ratification was close, but that most States that had ratified up to that time were Developing Nations.
The reason for this situation was a perceived problem with the provisions for the deep seabed within the Convention. When these articles were drafted and approved, the major industries in the world economy were largely State owned and run. This changed during the late 1970s and 1980s to privately run international companies with very different requirements. The deep seabed provisions in Part XI of the Convention simply would not work as they were drafted. The dilemma facing the international community, and the Secretary General in particular, was how to change those provisions without altering the Convention. A convention can be neither accepted nor applied in selective fashion, so if Part XI were to be re-drafted in the traditional sense, then the whole of the Convention would have been liable to revision. This would have endangered the carefully negotiated package between State jurisdiction and freedom of navigation issues, which was not acceptable to the international community.

To resolve this problem, the Secretary General launched a series of meetings between the industrialised nations and those nations that had already ratified the Convention. Time was short: the sixtieth ratification was deposited on 16th November 1993 and it was considered that an agreement was vital before the Convention came into force for those States that had ratified. An ingenious and innovative solution was achieved in the early summer of 1993, and a special sitting of the General Assembly was organised to debate and agree on the solution. This result was achieved and the Implementing Agreement Relating to Part XI of the UN Convention on the Law of the Sea was opened for signature on 28 July 1994.

This agreement enabled the vast majority of the industrialised nations to sign and ratify the Convention. To date (June 2010) some 160 States have ratified or acceded – a remarkable achievement.

1.3 COMPOSITION OF THE CONVENTION AND RELATED AGREEMENTS

The Convention comprises 320 Articles divided into 17 Parts, with nine Annexes. The Agreement relating to Implementation of Part XI of the Convention consists of 10 Articles and nine annexed Sections.

The Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks came into force on 11 December 2001. It contains 50 Articles in thirteen parts, with two Annexes.

Details concerning the contents and the status of the Convention and the related Agreements are available on the website of the UN Division of Ocean Affairs and the Law of the Sea (DOALOS): http://www.un.org/Depts/los/index.htm

1.4 TECHNICAL ASPECTS OF UNCLOS

This Section defines the broad objectives of the disciplines of Geodesy, Hydrography, and the Geosciences, and outlines their relevance to UNCLOS.

1.4.1 Geodesy

The Ancient Greeks developed theoretical and applied geometry, later called geodesy (from Greek: $\gamma\eta$ = earth, $\delta\alpha\iota\omega$ = I divide), as a branch of astronomy to determine the size and shape of the Earth. Today geodesy is the science related to positioning, gravity field mapping and geodynamics in the broadest sense.

Geodesy can be studied at the global, regional and local scales, each of which calls for its specific theory and methodology. At the local scale, geodesy is frequently referred to as surveying. Geodesy can also be divided into geodetic (natural) science, which is part of the geosciences, and geodetic engineering. Geodetic science includes topics such as gravimetry, physical geodesy, ellipsoidal geodesy, global and regional geodetic networks; while geodetic engineering includes land surveying, topographic mapping, hydrographic surveying, mining surveying, geomatics, etc.

Historically, the global aspects have dominated geodetic science, while geodetic engineering has been related to regional and local applications and methods. However, the advent of tools of satellite geodesy such as GPS (Global Positioning System), or more generally GNSS (Global Navigation Satellite Systems), has more or less erased the boundaries between global and local methods of geodesy. This implies a trend towards the use of global reference systems in the vertical and horizontal, as well as rigorous observation and computational methods in local applications. For instance, the International Association of Geodesy encourages the use of the International Terrestrial Reference System and the International Terrestrial Reference Frame; the latter including a global network of precisely determined fixed points, for the establishment of local and national geospatial networks for mapping and other applications.

1.4.2 Hydrography

Hydrography is defined by the IHO as: *That branch of applied sciences which deals with the measurement and description of the features of the seas and coastal areas for the primary purpose of navigation and all other marine purposes and activities, including inter alia: offshore activities, research, protection of the environment and prediction services.*

Hydrography therefore deals with all those operations necessary to determine the configuration of the ocean / sea floor. In addition to measuring the depth of the seafloor, it includes a wide variety of other measurements for instance: tides, currents, gravity, magnetic field strength, and the physical, chemical and structural properties of the water column and the seabed.

The process of hydrographic surveying may be summarised as:

a. The conduct of systematic surveys at sea and along the coast of geo-referenced data relating to:

- Coastal morphology, including man made infrastructure, for maritime navigation (aids to navigation and port configuration).
- The depth of water including all hazards to navigation and items pertinent to other marine activities.
- The composition of the seabed.
- Tides, tidal streams and currents.
- The physical and chemical properties of the water column.

b. The processing of this information in order to create organised databases to facilitate the production of thematic maps, nautical charts and other documentation for varied uses including inter alia:

- Safety of navigation (includes traffic control and separation schemes).
- Naval operations.
- Coastal management and defence.
- Protection of the marine environment.
- Exploitation of marine resources and laying of submarine cables/pipelines.
- Maritime boundaries definition (Law of the Sea implementation).
- Scientific studies pertaining to the sea and near-shore zone.

1.4.3 Marine Geoscience

Marine geoscience is the study of the material that comprises the coastal zone, the seabed, and sub-sea structures, and of the processes that affect that material. It is concerned with the composition and distribution of sedimentary and non-sedimentary material, as well as the mechanisms of their emplacement. In addition to direct sampling and measurement, its investigative techniques include remote sensing observations (transmission of acoustic signals, measurement of terrestrial gravity and magnetic fields) for determining the physical and chemical characteristics of structures that cannot be directly accessed.

The scope of marine geoscience ranges from the atomic to the planetary. Its findings help explain the shape and variability of the shoreline and of the seabed, placing them within regional contexts that evolve over time frames which span the seasonal to the geological. Coastal and seabed features that represent local hazards to navigation can be understood for the most part as the consequences of geological and tectonic processes. The characteristics of those features may impact not only the determination of maritime boundaries, but also the consequences of certain boundary configurations insofar as they could affect ease of navigation and access to resources.

An appreciation of an ocean basin's tectonic history and framework can be crucial to the delimitation of outer continental shelf limits according to the provisions of Article 76 (see Chapter 5). It is also fundamental to an understanding of the nature, distribution, and value of non-living resources of the seabed, which are addressed in Parts VI and XI of the Convention (Continental Shelf and The Area, respectively).

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CHAPTER 2 – GEODESY AND POSITIONING

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2.1 INTRODUCTION

In the late nineteenth century, geodesy was defined as "the science of the measurement and mapping of the Earth's surface" (Helmert, 1880). As the Earth's surface is to a great extent formed by the gravity field and as most geodetic measurements depend, directly or indirectly on this field, the definition of geodesy includes the determination of the gravity field, on and above the Earth's surface. Moreover, because of advances in geodetic technology, principally due to the refinement of a variety of space geodetic techniques, the classical definition has been extended to include the temporal variations of the shape of the Earth's surface and its gravity field. That is, geodesy is no longer only relevant to three-dimensional positioning and mapping, but also to the determination of the time-varying components of the Earth's geometry and its gravity field. In this extended definition, geodesy is both part of the geosciences and is an engineering science (including surveying, mapping and navigation), and it can be further divided for pragmatic purposes into "global geodesy" and "geodetic high-accuracy positioning". Over the past two decades, there has been a clear trend towards unique global models, and the adoption of local or national datums and reference surfaces that are derived from or linked to global reference frame definitions and gravity field solutions.

2.2 MODERN SPACE GEODESY

The importance of Earth observations, provided with increasing spatial and temporal resolutions and with better accuracy, should be seen in the context of not only supporting scientific understanding of the Earth and as a foundation for mapping of features on, or near, the Earth's surface and the sea floor, but also in supporting fundamental societal activities such as managing natural resources, environmental protection, disaster mitigation and emergency response (Grejner-Brzezinska and Rizos, 2009). Although the latter applications of geodesy are not explored further in this section, it is necessary to draw attention to the characteristics of "modern geodesy", as the enhanced capabilities of space geodesy underpin what is now considered the primary mission of geodesy: the definition and maintenance of precise geometric and gravimetric reference frames and models, and the provision of high accuracy techniques for users in order to connect to these frames.

The International Association of Geodesy (IAG) has established services for all the major satellite geodesy techniques (IAG, 2012): International Global Navigation Satellite System (GNSS) Service (IGS); International Laser Ranging Service (ILRS); International Very Long Baseline Interferometry Service (IVS); International Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) Service (IDS); International Earth Rotation and Reference Systems Service (IERS); and International Gravity Field Service (http://www.igfs.net/). These services generate a wide range of products, including precise satellite orbits, ground station coordinates, Earth rotation and orientation values, gravity field quantities and atmospheric parameters. Of particular reference to Law of the Sea (LOS) matters is geodesy's contribution to the definition of national and international datums and the geoid, and to GNSS-based precise positioning.

2.2.1 International Terrestrial Reference System

Although modern geodesy is now equipped with an array of space technologies for mapping and monitoring the geometry of the surface of the solid Earth and the oceans, as well as its gravity field, the fundamental role of geodesy continues to include the definition of the terrestrial and celestial reference systems. These reference systems are the foundation for all operational geodetic applications for mapping and charting, navigation, spatial data acquisition and management, as well as for the scientific activities associated with geodynamical studies and the geosciences, and in particular in support of global change studies (Grejner-Brzezinska and Rizos, 2009).

The locations of points in three-dimensional space are most conveniently described by Cartesian coordinates: X, Y and Z. Since the start of the Space Age, such coordinate systems are typically "geocentric", with the Z-axis aligned with either the Earth's conventionally defined or instantaneous rotation axis. Because the Earth's geocentre, or centre of mass, is located at one focus of a satellite's orbital ellipse, this point is the natural origin of a coordinate system defined by satellite-based geodetic methods. However, until about the 1980s, with the first use of the Global Positioning System (GPS) for the establishment and/or renovation of national geodetic surveys, national datums were not geocentric.

The International Celestial Reference System (ICRS) forms the basis for describing celestial coordinates, and the International Terrestrial Reference System (ITRS) is the foundation for the definition of terrestrial coordinates to the highest possible accuracy. The definitions of these systems include the orientation and origin of their axes, scale, physical constants and models used in their realisation, e.g., the size, shape and orientation of the "reference ellipsoid" that approximates the geoid (Section 2.2.2) and the Earth's gravity field model. The coordinate transformation between the ICRS and ITRS is described by a sequence of rotations that account for precession, nutation, Greenwich apparent sidereal time, and polar motion, which collectively account for variations in the orientation of the Earth's rotation axis and its rotational speed.

While a reference system is a mathematical abstraction, its practical realisation through geodetic observations is known as a "reference frame". The conventional realisation of the ITRS is the International Terrestrial Reference Frame (ITRF), which is a set of coordinates and linear velocities (the latter due mainly to crustal deformation and tectonic plate motion) of well-defined fundamental ground stations. In the case of the ITRF these are the observatory stations of the IGS, ILRS, IVS, IDS ground networks, derived from space-geodetic observations collected at these points, and computed and disseminated by the IERS (2012). The solid surface of the Earth (including the sea floor) consists of a number of large tectonic plates (and many smaller ones whose boundaries are less well defined) that slide across the Lithosphere, in the process colliding with other plates (see Figure 2.1). The speed of the plates may be as high as a decimetre or more per year, though typically tectonic plate motion is of the order of a few centimetres per year relative to a fixed coordinate framework. That framework is realised by the fixed axes of the ITRF – defined in an inverse sense by tracking the orientation of the axes relative to the Earth's (moving) crust, and tracking of the location of the origin of the Cartesian system with respect to the (moving) geocentre, using geodetic techniques.

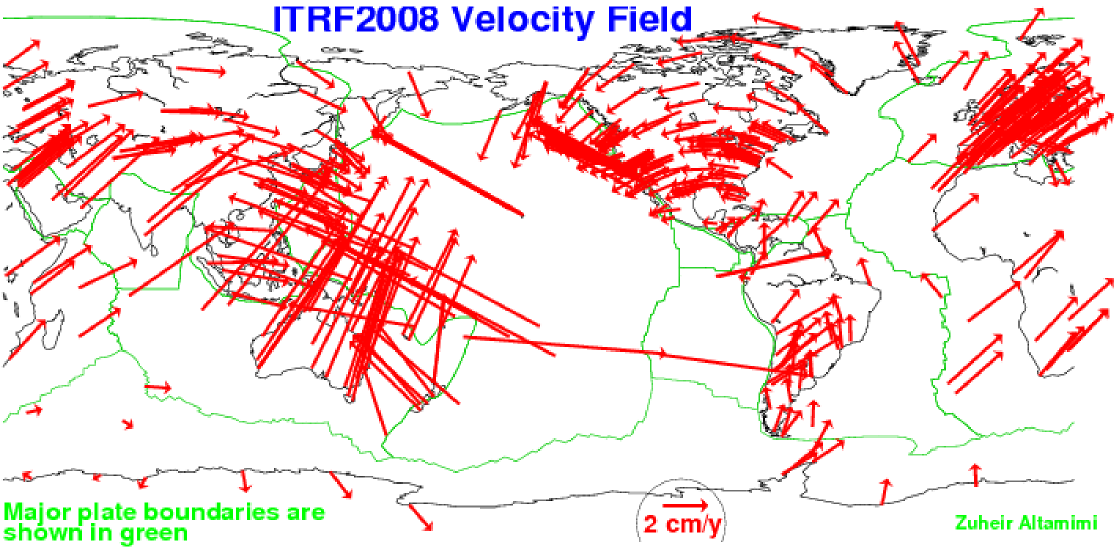


Figure 2.1 – Global model of the Earth's tectonic plates with estimated velocities (ITRF2008, 2012).

There have been several different realisations of the ITRF since 1989, each designated as ITRFyyyy where yyyy refers to the year of release. Since 1997, it generally also refers to the reference epoch year for station coordinates and velocities. Initially computed on an annual basis, since 1997 the new ITRF realisations have been released by the IERS at 3-5 year intervals, with the latest being ITRF2008 (2012). Although each successive ITRFyyyy is more internally accurate and contains the coordinates and velocities of more fundamental ground stations than the previous one, the primary difference in the coordinates of the ground stations between different ITRFs reflects the motion of stations due to crustal deformation and plate tectonics between the reference epochs of the two frames. The linear velocity of a ground station can be used to propagate the coordinates of that station backwards or forwards in time (see Section 2.3.2).

A modern datum (or reference surface from which to measure position relative to) is defined by the 3D, or 2D if only the latitude and longitude are used to define horizontal position on an ellipsoid (see Section 2.2.3), coordinates of a global, local or national network of fundamental stations at an instant in time. It may be the same epoch year as the ITRFyyyy reference frame, or any arbitrary epoch. Note that today it is comparatively easy to compute the coordinates of any ground station in a geocentric reference frame such as ITRF, at that instantaneous epoch of measurement, using Global Navigation Satellite System (GNSS) technology such as GPS and GLONASS. However, coordinates must still be transformed into the datum system, even if the datum is actually based on the current ITRF realisation, because the epoch year will be different. Datums are discussed further in Section 2.3.

2.2.2 The Geoid

The word geoid is used to designate that special equipotential or geopotential surface which coincides with, but is not exactly equivalent to, the mean sea level (MSL) surface of the oceans in an average sense. It is that surface to which the oceans would conform over the entire Earth, if free to adjust to the combined effect of the Earth's mass attraction and the centrifugal force of the Earth's rotation, the forces of which are collectively referred to as the Earth's gravity field.

Although the above definition refers to sea level, conceptually the geoid extends under the continents and differs from a best fitting ellipsoid by vertical distances that are up to one hundred metres or so (see Figure 2.2). Ignoring for the moment that soundings on charts are referred to a low water chart datum, the geoid is the reference surface for heights used in mapping. As such, the geoid is often called a vertical datum and the heights referred to it are commonly known as heights above mean sea level. The practical realisation of the vertical datum is typically achieved by accepting a mean sea level at the locations of tide gauges along the coast for the area of coverage of the vertical datum. This realisation carries with it some inherent errors due to the existence of sea surface topography (SST) that may reach well over one metre, and which varies with location and time. SST is a result of the stationary mean sea level not being in equilibrium in a gravity sense, due to standing steric effects, and any wind or tidal effects. Furthermore, the local MSL is determined indirectly, by analysing the tide gauge record at one or several sites for a certain time period, and is thus tacitly valid for that time period. However, for all intents and purposes MSL on average is well approximated by the geoid surface.

Note that the term vertical datum is, in some surveying circles, used to mean one control point or benchmark, or a network of benchmarks, with an arbitrarily selected zero point. This usage is somewhat confusing and should be avoided in discussions concerning charts, maritime datums or tidal height systems. The geoid is, of course, not the only vertical datum used in practice for maritime applications. Chart datums, treated in Section 2.4.1, are examples of vertical datums used for nautical charting. Other definitions of a world height datum, and the means of realising it in practice are now being investigated by the IAG (see Section 2.4.2).

Before discussing the geoid itself, the two basic height definitions, as they are used in geodesy, are reviewed. Orthometric heights are the standard heights used in surveying practice and in land mapping. The orthometric height of a point is defined as the length of the section of the plumb line between the geoid and the point. Thus, clearly, the orthometric height of any point located on the geoid equals zero. Dynamic heights are used whenever it is necessary to deal with phenomena where the laws of physics play a dominant role. This situation is encountered, for instance, in hydrological investigations. Dynamic height is defined in such a way that all points are on the same level surface. Thus, all points on an equipotential surface of the Earth's gravity field have the same dynamic height. If one point has a larger dynamic height than another point, a fluid will flow from the higher point to the lower point. This is not the case with orthometric heights. The dynamic height of any point located on the geoid is also equal to zero. Readers interested in learning how levelled height differences obtained from field measurements are transformed into orthometric or dynamic heights should consult such standard geodesy texts as Vaníček and Krakiwsky (1986). Section 2.3 introduces yet another height, the geodetic or ellipsoidal height, which refers to the reference ellipsoid of a horizontal datum and is commonly used when GNSS-derived 3D Cartesian coordinates are converted to the latitude, longitude and geodetic height system (see Figure 2.6).

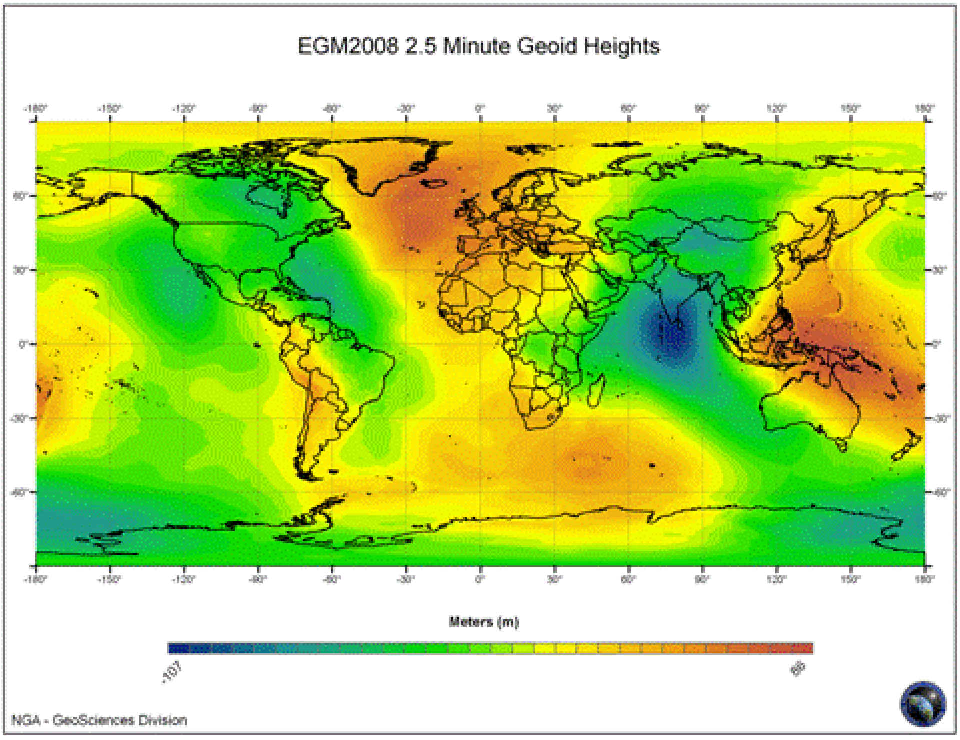


Figure 2.2 – Earth Gravity Model EGM2008 geoid heights, derived from a combination of surface gravity data principally on land, satellite altimetry over ocean areas and an analysis of the observed orbit perturbations of many near-Earth satellites (EGM2008, 2012).

The geoid is probably the most important surface in geodesy. Two broad families of techniques are used for geoid computations and, correspondingly, two categories of results are available: global solutions and regional solutions. Global solutions are available in terms of equations involving a number of functions and their spherical harmonic coefficients, whereas regional solutions are typically given by numerical values on a geographical grid. In both cases, the geoid is described at each point by its departure, called the geoid(al) height or geoid(al) undulation, from the reference ellipsoid of a horizontal datum. When one wishes to use the geoidal height, it is thus absolutely essential to know to which reference ellipsoid it is referred.

The short, up to several hundred kilometres, wavelength features of the geoid derived from terrestrial or airborne observations of gravity acceleration are now quite well known, with errors at the sub-decimetre level across many of the land areas of the world. At sea, the geoid can be measured directly by satellite altimetry. Several satellite altimetry missions have been flown, with the most recent missions, the Jason altimetry satellite and follow-on missions, yielding the most accurate map of the sea surface yet. Because satellite altimetry measures the height of (instantaneous or mean) sea level above a reference ellipsoid, the geoid obtained from this system is only approximate, accurate to perhaps a metre due to the SST, i.e., the separation of mean or instantaneous sea level from a geopotential surface such as the geoid. Data from satellite gravity mapping missions such as CHAMP, GRACE and GOCE are rapidly improving our knowledge of the geoid shape, with geoid models now available even reflecting the temporary changes in the long wavelength gravity field features (thousands of kilometres) due to ground and surface water transport. The most recent general purpose global gravity field model is EGM2008 (2012).

2.2.3 The Reference Ellipsoid

The geoid is a very irregularly shaped surface (Figure 2.2) and therefore for geodetic and mapping purposes it has been necessary to use a simplified geometric shape – the ellipsoid, which closely approximates the shape of the geoid (Figure 2.3) for all calculations. In the past, there were a number of different "reference ellipsoids" in use, most of which were satisfactory approximations of the geoid, or MSL, in certain regions of the world but not in others (Figure 2.4). The IAG recommends the use of the "GRS80" reference ellipsoid. However, the slightly different WGS84 ellipsoid is also commonly used. The size and shape of these ellipsoids of revolution are defined by two parameters: the semi-major axis ('a') and the semi-minor axis ('b'), or sometimes by the flattening parameter ('f'), of an ellipse (Figure 2.3). Rotating the ellipse about its semi-minor axis will then producing the 3D ellipsoid figure. A reference ellipsoid with its centre at the geocentre best fits, in a geometric sense, the geoid globally – resulting in the maximum separation of these two surfaces being of the order of 100 metres (Figure 2.2). The geoid height is mathematically defined as so many metres above (+N) or below (-N) a given ellipsoid (Figure 2.5):

$$h = H + N$$

where:
h = geodetic height (height above the ellipsoid)
H = height above MSL
N = geoidal height

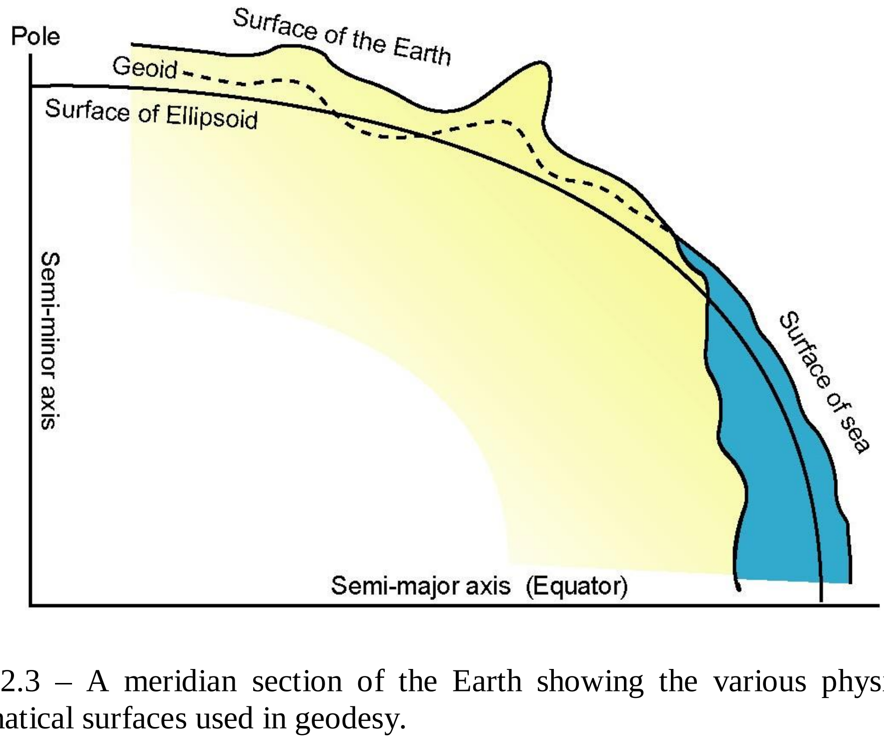


Figure 2.3 – A meridian section of the Earth showing the various physical and mathematical surfaces used in geodesy.

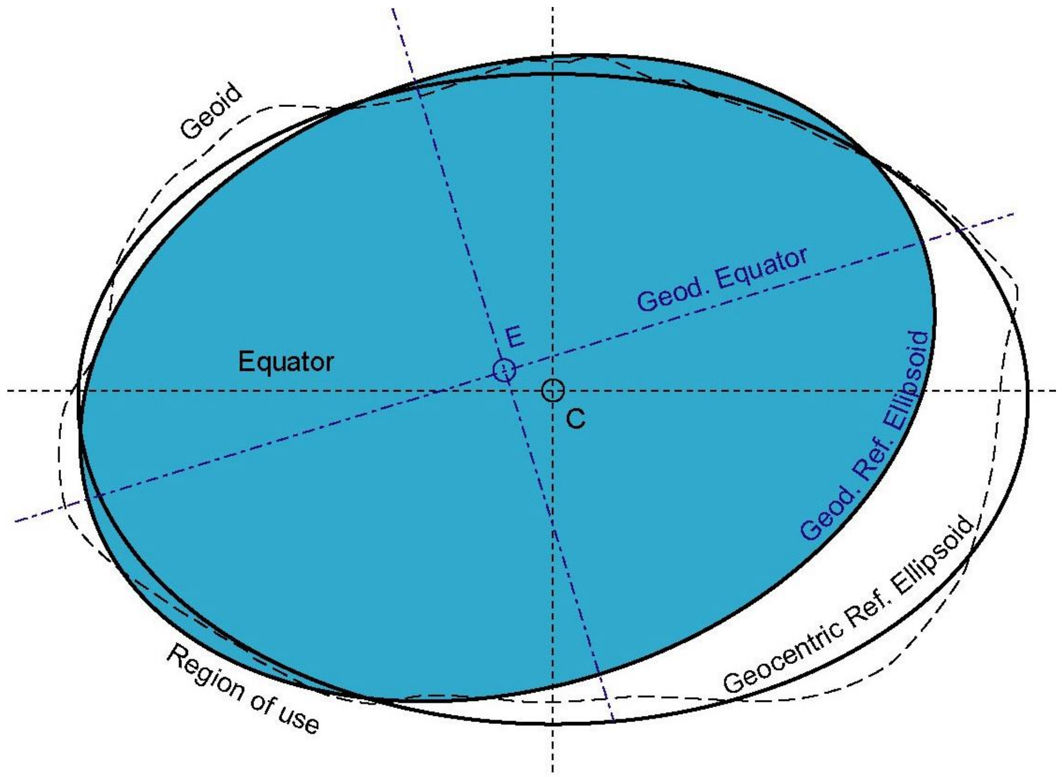


Figure 2.4 – Geocentric and non-geocentric regional ellipsoids. Meridian cross-section showing 'best fit' region of use.

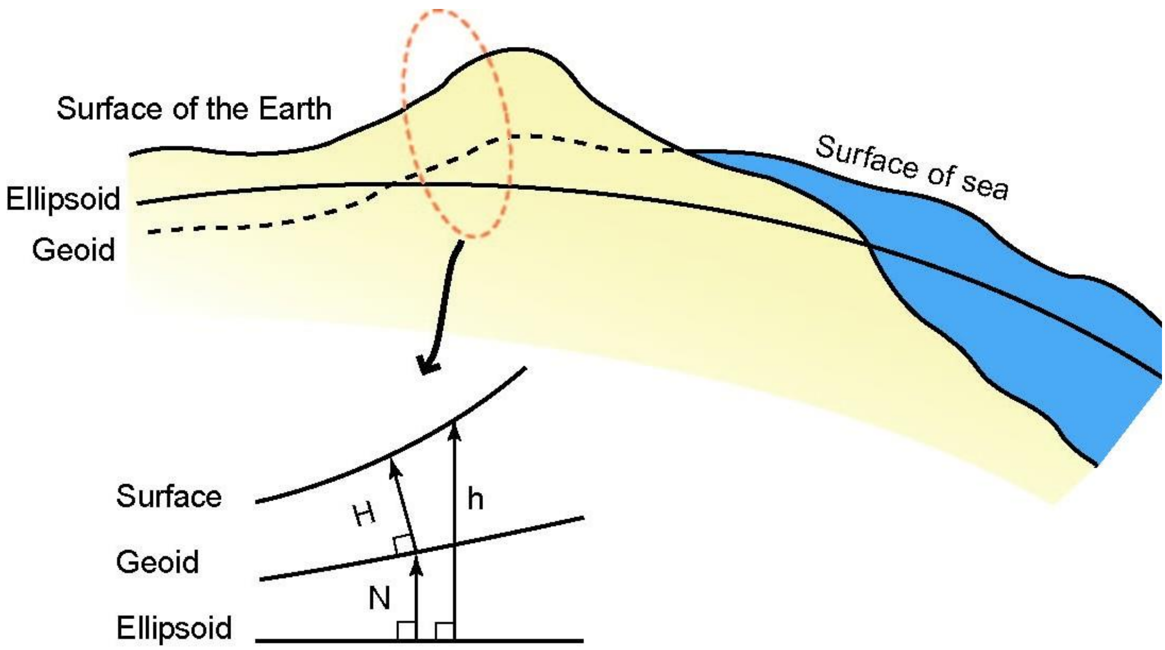


Figure 2.5 – Geodetic height (h), orthometric height (H), geoid height (N) and their interrelations.

2.3 GEODETIC DATUMS

We may distinguish between non-geocentric datums and geocentric datums. In the case of the former, the origin of the Cartesian coordinates is arbitrarily located to satisfy some local condition of best fit of the geoid to the reference ellipsoid upon which coordinate calculations are performed (Figure 2.4), while the latter implies the origin is at the Earth's centre of mass. Furthermore, the definition of a reference ellipsoid for geodetic computations also provides a convenient means of expressing horizontal positions, in terms of geodetic latitude (ϕ) and longitude (λ) (Figure 2.6). In this context, the reference ellipsoid is also sometimes referred to as the horizontal datum. Vertical datums are dealt with in Section 2.4.

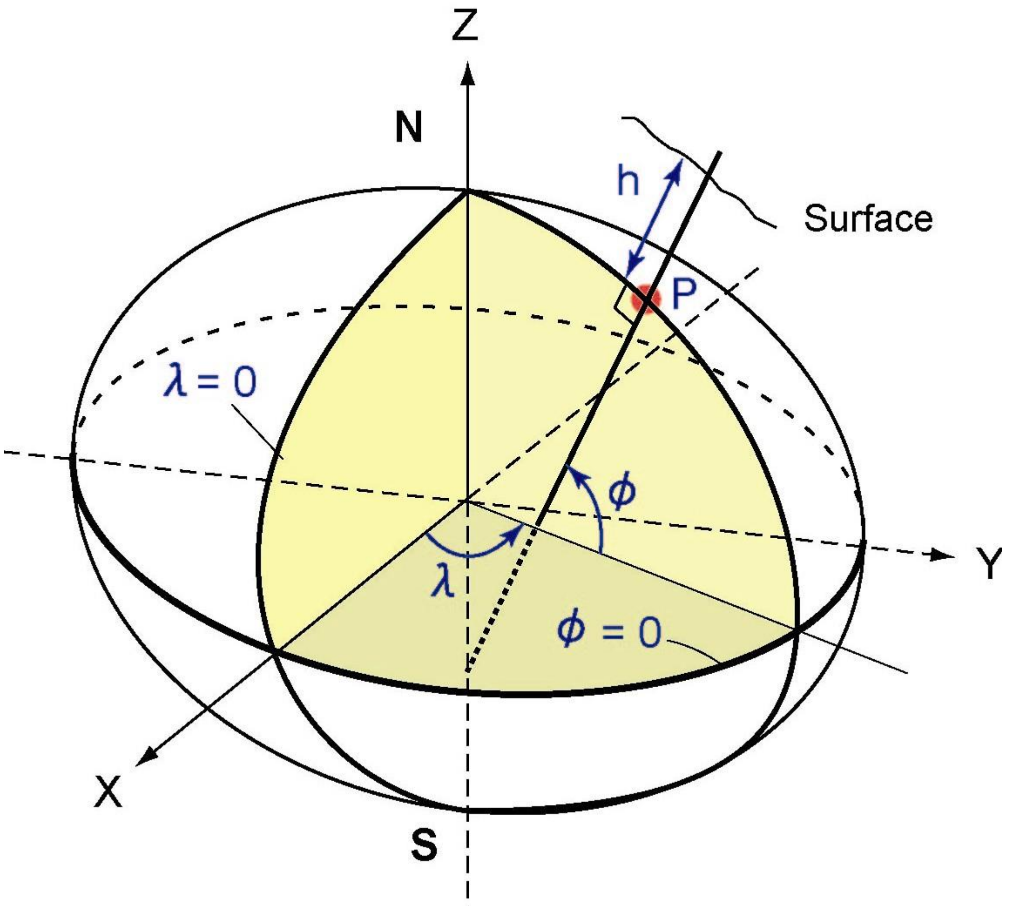


Figure 2.6 – The reference ellipsoid, illustrating the relation between Cartesian coordinates (X, Y, Z) and the geodetic coordinates ϕ, λ and h in a geometrical relation only – the origin of the axes and reference ellipsoid may be geocentric or non-geocentric. (Animation: Figure2_6.ppt)

Map datums are invariably defined at the national or local level, and they are for the most part 2D or horizontal datums. A national datum is a mathematical means of expressing the positions of all ground stations, terrain and natural or manmade features of interest to a national mapping or charting authority, as well as the coordinates of a user navigating with the aid of that State's charts, in relation to an unambiguously defined reference ellipsoid. The map datum of one country will invariably be different from that of another country. In the past, the differences between such map datums were much greater than at present, with the coordinates of the same point being shifted by perhaps hundreds of metres, or more, because the origin of the reference ellipsoid and the orientation of its semi-major/minor axes were different (Figure 2.4). The adoption of the geocentre as the origin of national datums means that the differences between national datums is now at the metre-level at most, largely reflecting the different epoch year at which the coordinates of fundamental ground stations were fixed. A list of national datums is given in Appendix B.1 of WGS84 (2012). Note that many are more than two decades old, and hence are non-geocentric. Maps of land surfaces, and modern medium and large-scale nautical charts indicate the geodetic datum used.

As already mentioned, for the reference ellipsoid of a selected size and shape to be of use as a coordinate reference surface, its position and orientation with respect to the Earth have to be also uniquely defined. A geocentric Cartesian system is used today because GNSS positioning techniques express coordinates in such datums (Section 2.5). In fact, the reference ellipsoid and its location and orientation are currently very strongly constrained due to the almost universal use of ITRF as the basis for national datums. In such a case, the reference ellipsoid is actually a surface of convenience for the ITRF, and not fundamental to its definition as was the case in the past (Section 2.3.1). That is, it is the origin and orientation of the Cartesian axes relative to the physical Earth that is critical, and their changes with time. Apart from the reference ellipsoid's centre being defined as being at the geocentre, its semi-major axis is coincident with either the rotation axis of the Earth at the epoch year or its conventional definition, as indicated in Figure 2.7.

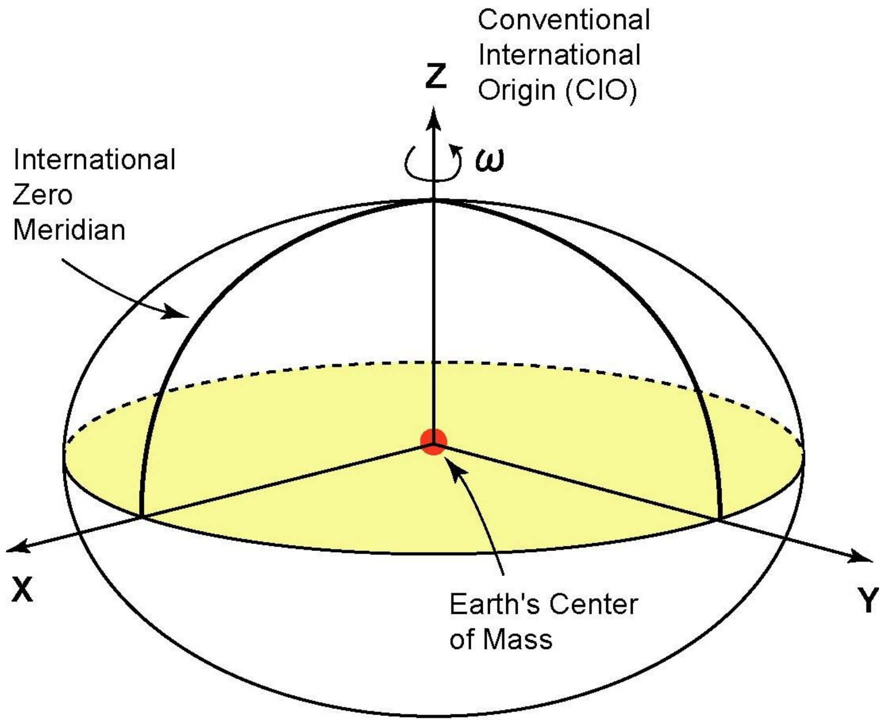


Figure 2.7 – Geocentric reference ellipsoid, the basis of ITRF and geocentric datums derived from it.

The horizontal geodetic coordinates ϕ and λ, and the geodetic height h, can be readily converted to Cartesian coordinates X, Y, Z. The inverse conversion (i.e., from Cartesian coordinates to geodetic coordinates) is less straightforward; see for example Vaníček and Krakiwsky (1986). All conversions assume the relationships between Cartesian axes and reference ellipsoid axes as illustrated in Figure 2.6, and that the size and shape of the reference ellipsoid is known.

Currently, the most commonly used reference ellipsoid is either that of the GRS80 or WGS84 model (See Appendix A of WGS84 [2012] for a list of reference ellipsoids used in the past for geodesy and mapping). It must be emphasised that the reference ellipsoid is used as the basis for computations involving geodetic latitude and longitude, such as computing the distance between two points on the ellipsoid defined by their horizontal coordinates or defining the straight or shortest line between two points as is sometimes required in LOS matters. Furthermore, all points to be displayed on a map or chart must have horizontal coordinates expressed in relation to the datum's reference ellipsoid in order for these coordinates to be correctly transformed into map projection coordinates (see Section 3.5). Note that a map projection is always necessary whether a paper chart or an electronic chart is used. GNSS-derived Cartesian 3D coordinates must first be transformed into geodetic latitude and longitude before they can be transformed into the required chart map projection for the purposes of navigation or mapping.

2.3.1 Non-Geocentric Datums

Although such datums were, and in many cases still are, of local or regional extent, of most interest to LOS matters are the datums that underpin a State's charting. They have limited areal coverage and the geometric relationship of the reference ellipsoid relative to the Earth's centre of mass and rotation axis is illustrated in Figure 2.3.

How were such non-geocentric datums established in practice? These non-geocentric geodetic datums used ellipsoids of various shapes and sizes, positioned and oriented with respect to the Earth in some well-defined manner. Classically, this definition had been done with the following specifications:

- The ellipsoid normal to be oriented. This is done by specifying the latitude and longitude of some so-called datum point.
- The orientation of the datum point's ellipsoid normal with respect to the local gravity vertical. This is done by specifying the deflection of the vertical components at the datum point.
- The geoid-ellipsoid separation at the datum point. Often selected to equal zero.
- The orientation of the datum with respect to the Earth. This is done by selecting a value for the geodetic azimuth of a line of the network originated at the datum point.

After the coordinates of the datum point were determined or assigned, and the orientation and location of the non-geocentric reference ellipsoid was defined using a procedure such as that outlined above, geodetic control survey principles could be employed to determine the coordinates of a network of geodetic control points. This was accomplished via the complex analysis of distance and angle measurements made between the control points. With the advent of satellite positioning techniques, first the Transit Doppler System during the 1960s and 1970s, and later GPS, the ground station coordinates could be determined directly. However, until the national datum itself was redefined using modern geodetic principles, these satellite-derived coordinates were merely transformed into quasi-observations and incorporated into the geodetic control network adjustment process. The result was a set of coordinates of the geodetic network stations that realised the non-geocentric datum that was the basis of that State's maps and charts.

What are the implications of the use of non-geocentric datums for LOS matters? Figure 2.8 shows how land surveys of the coordinates of a State's normal baselines were traditionally undertaken by making direct connections to the established geodetic control network, via distance and angle observations from the control points to the baseline points.

Furthermore, as a consequence of the use of coordinate systems based on different non-geocentric datums, the same point shown on charts compiled by different countries may be assigned different values of latitude and longitude. These differences could have a significant effect on the positions. To avoid any possibility of cartographic incompatibility when positioning maritime boundary delimitations, it is recommended that a common geodetic datum be adopted. The transformation models that can be used to convert coordinates in a non-geocentric datum to that of the global WGS84 geocentric datum are available for all major national datums (see Section 2.3.3).

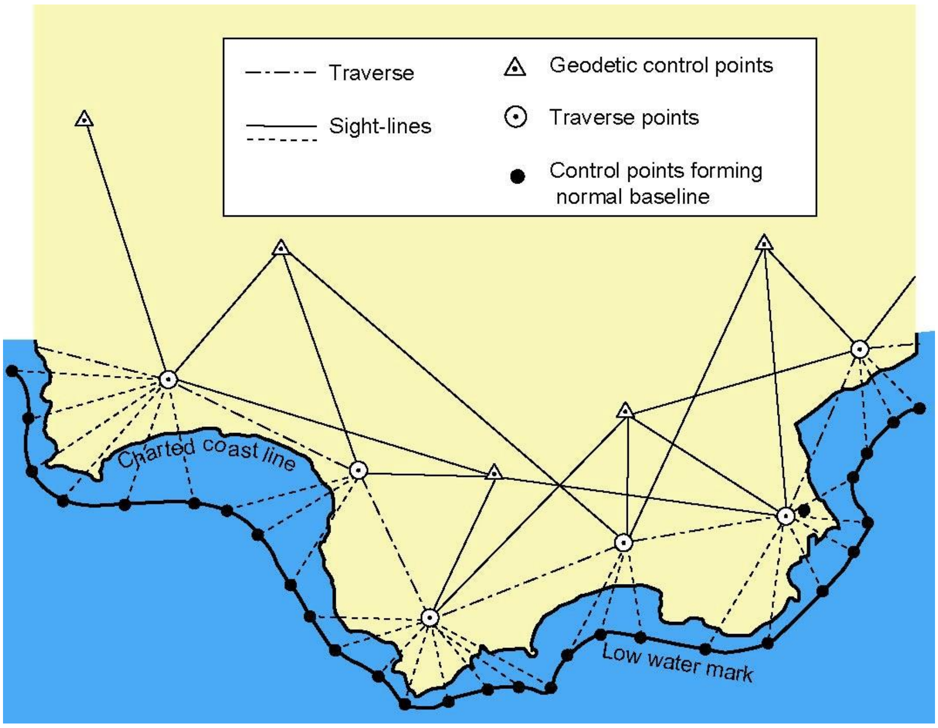


Figure 2.8 – Determination of normal baseline control points by survey from the geodetic control network (from Thamsborg, 1983).

At the present time, it is preferable that both: (a) the geocentric datum(s) is (are) used for maritime boundary delimitation, and (b) GNSS techniques are employed to determine the coordinates of the delimitation points.

2.3.2 Geocentric Datums

Geocentric datums may be globally applicable, such as WGS84 and ITRF, or they may be only relevant with respect to a national datum. However, unlike non-geocentric datums, each of which was defined at a local or regional level completely independently of other datums, all national geocentric datums are ultimately derived from, or aligned with, a particular ITRF frame.

The ground stations that realise an ITRF reference frame are not necessarily located in sufficient number or density to satisfy the needs of a particular State. A national geocentric datum is therefore typically realised by the coordinates of a much larger set of geodetic control points, though perhaps not at the same density as the traditional control networks referred to in Section 2.3.1, and implied by Figure 2.8. A national datum is said to be defined by, or aligned to, an ITRF frame through the adoption of the fixed coordinates of the subset of ITRF stations that may be located within the borders of that State and surrounding it. The dense national geodetic control network coordinates are computed by connecting to the selected ITRF regional network stations referred to above, using GNSS geodetic survey techniques (see Section 2.5). These fixed ITRF stations are sometimes also referred to as fiducial stations.

Note that the reference epoch year for the particular ITRF frame may not be the same as that of a national geocentric datum that is derived from that ITRF frame. For example, older fiducial coordinates can be propagated forward in time using published velocity values. These can then be held fixed in subsequent datum adjustment computations, involving the combination of traditional terrestrial geodetic observations (of distance and angle) and GPS-derived relative coordinates, that output a homogeneous set of coordinates for all geodetic control stations on the same geocentric datum.

The ITRF coordinates can be changed to account for site motion using the relations:

$$X_{t1} = X_{t0} + (t_1 - t_0)_{yrs} \times V_x$$
$$Y_{t1} = Y_{t0} + (t_1 - t_0)_{yrs} \times V_y$$
$$Z_{t1} = Z_{t0} + (t_1 - t_0)_{yrs} \times V_z$$

where:
X_{t1}, Y_{t1}, Z_{t1} = station's ITRF coordinates at year t_1
X_{t0}, Y_{t0}, Z_{t0} = station's ITRF coordinates at epoch reference year t_0
V_x, V_y, V_z = station's ITRF velocity components at epoch reference year t_0

The first global geodetic datum was defined in 1960 by the United States, and was known as the World Geodetic System (WGS60). For the first time it was possible to have a truly geocentric worldwide coordinate system for global mapping, charting and navigation. Refinement of the model has been continuous, and the most recent version of the system is WGS84 (2012). The broadcast ephemeris of GPS is expressed in the WGS84 datum, hence all coordinates determined using absolute GPS techniques are automatically provided in the WGS84 datum. (Other GNSSs such as Russia's GLONASS, the E.U.'s Galileo and China's Compass/BeiDou have slightly different implementations of geocentric datums, differing from ITRF by no more than a few centimetres.)

In 1983, an agreement was reached within the International Hydrographic Organization (IHO) to adopt WGS84 as the global datum for nautical charts, though more correctly it is the datum for the horizontal representation of points on a chart. The height datum on charts is defined differently as discussed in Section 2.4.1.

It must be emphasised that the coordinates of the same point in, say, the U.S., expressed in the different geocentric datums – national datum (NAD83), ITRF datums (ITRF97, ITRF2000, etc.) and WGS84 (or other GNSS geodetic datums) differ by at most a metre or so, and even less if expressed in the same epoch year. Hence, although a transformation model is still required for geodetic applications, for mapping purposes, for maritime boundary delimitation and for other LOS matters, there is no such need as all geocentric datums can be considered equivalent.

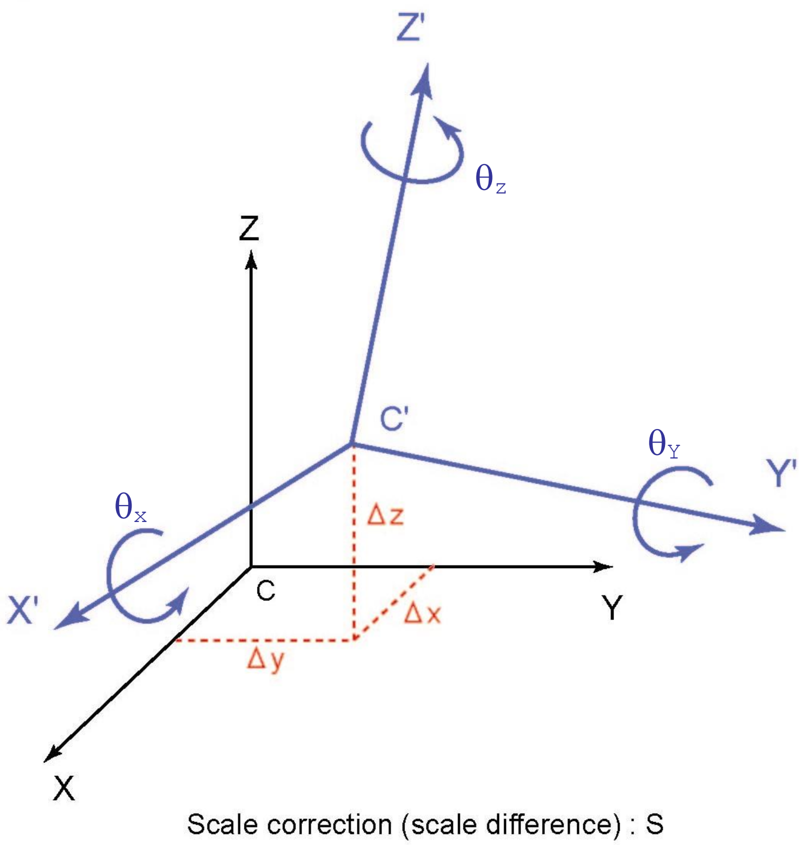
2.3.3 Transformation between Geodetic Datums

To convert coordinates from one datum to another, it is necessary to know the datum transformation parameters. Usually the transformation can be represented by a Helmert or similarity transformation, in which case the parameters consist of three translation components (Δx, Δy, Δz), three rotations (θ_x, θ_y, θ_z) and a scale correction (see Figure 2.9). The rotations are usually small enough to allow the use of small angle approximations of sine and cosine functions, and sometimes may be neglected completely.

The parameters of the transformation between two geodetic datums are determined empirically from the coordinates of a set of identical points on both datums. These positions are always distorted due to the inevitable presence of both systematic and random errors, and hence the determination of transformation parameters must be done carefully. It is recommended that the transformation parameters relevant to a State's datum be obtained from the appropriate national mapping or charting agency. There are also published 14-parameter transformation models that incorporate time-rate-of-change of the standard 7 similarity transformation parameters. With such a model, it is possible to both accommodate epoch year differences between datums, as well as origin, orientation and scale effects.

Apart from transformations involving national datums, there are also parameters available that permit coordinates to be transformed between the different ITRF realisations, as well as between WGS84 and ITRF (IERS, 2012).

A set of transformation parameters for many of the world's datums, past and current, in the form of X, Y, Z geocentre offsets are listed in Appendices B and C of WGS84 (2012). If one wishes to transform between Datum A and Datum B, and there are no official transformation parameters or model available, it is possible to transform from Datum A to WGS84 (i.e., geocentric datum), and then to transform from WGS84 to Datum B using the published origin offsets. The values of the origin offsets in the WGS84 (2012) publication are expressed to the nearest metre, and although not accurate enough for geodetic purposes, they are adequate for LOS and mapping applications.



$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} x \\ y \\ z \end{pmatrix} + \begin{pmatrix} s & -\theta z & \theta y \\ \theta z & s & -\theta x \\ -\theta y & \theta x & s \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} + \begin{pmatrix} \Delta x \\ \Delta y \\ \Delta z \end{pmatrix}$$

Figure 2.9 – Similarity transformation model relating two geodetic datums.
(Animation: Figure2_9.ppt)

2.4 VERTICAL DATUMS

While advances in geodesy in the last few decades have resulted in a significant simplification in the procedures for determining position, the issue of vertical datums remains complex. Sections 2.2.2 and 2.2.3 introduced the concepts of the geoid and the reference ellipsoid, both of which can be used as datum surfaces for zero height (Figure 2.5). Heights above the geoid may be expressed as orthometric or dynamic heights. Heights above the reference ellipsoid are geodetic or ellipsoidal heights. However, the operational definitions of both the geoid and the reference ellipsoid are surfaces of best fit to MSL over the whole Earth. The geoid is a physical surface, i.e., an equipotential surface of the Earth’s gravity field. The ellipsoid is a mathematical surface that has no reality, but is used as a computational convenience.

For land height systems, the geoid and MSL are assumed to coincide at the fundamental benchmark(s) or tide gauge(s) that define(s) a State’s geodetic height datum to which heights on land maps are referred (see Figure 2.10). A high water level, determined by some procedure that samples the high tide, may define the so-called hydrographic shoreline, where land mapping transitions to marine charting. In some countries a high water level marks the limit of land property that can be registered in a cadastre (register of rights of property owners). Chart datum is discussed in Section 2.4.1.

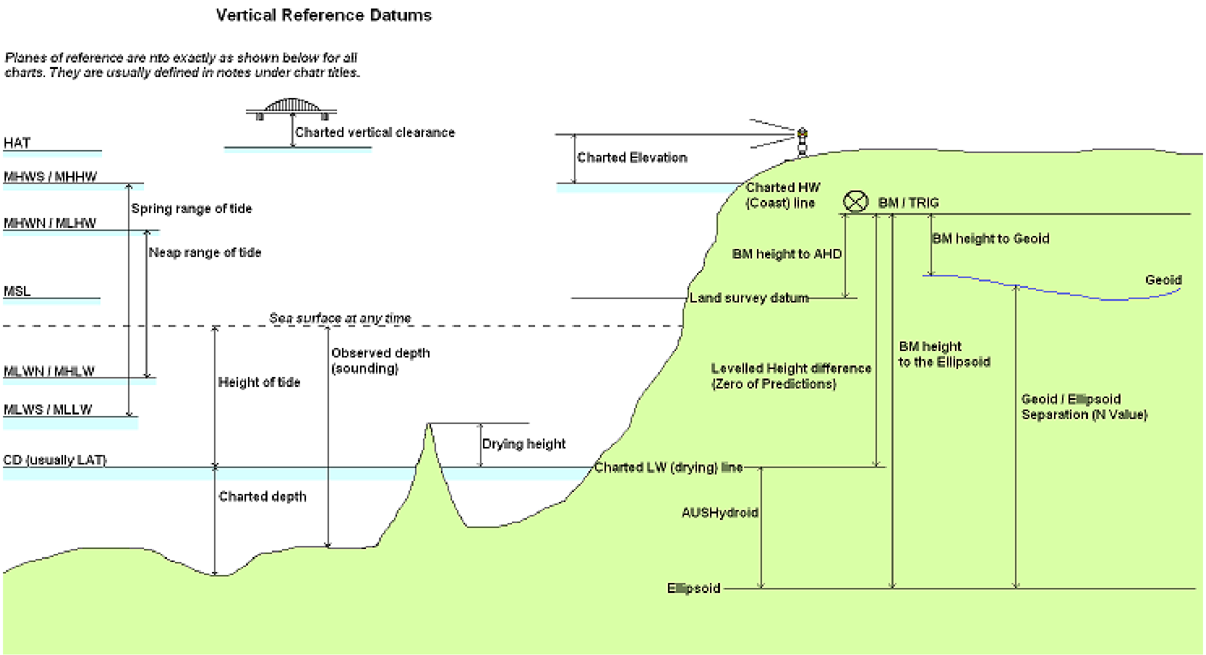


Figure 2.10 – Vertical datums for mapping and charting (courtesy Australian Hydrographic Office).
(Animation: Figure2_10.ppt)

Sea level and land heights undergo secular changes at varying rates, as well as periodic changes (see Lambeck, 1988). While sea level rises globally by a few millimetres per year, the land rise or subsidence may reach several centimetres per year or more, particularly in active tectonic regions or where water or hydrocarbons are being pumped out of the ground. This may seem trivial along most coasts, but when the coast has a low gradient, the effect of such changes may be significant. For example, through the post glacial rise of the Earth's crust in the Hudson Bay area, Canada is steadily gaining many hundreds of square kilometres of territory each year (Walcott, 1972).

As with all datum issues, transformations between different kinds of vertical datums must be handled with care. Furthermore, as in the case of 3D reference frames and datums, a distinction must be made between definitions of datums that are theoretically rigorous, but which in reality cannot be realised with precision, as in the case of the geoid. However, even though the practical realisation of a tidal datum is challenging, for LOS applications, such as maritime boundary delimitation, consistency and traceability of datum definitions is more important than accuracy in an absolute sense.

In the last few decades, much effort has been focused on the development of the definition and implementation of the International Height Reference System (IHRS), in order to observe more clearly the changes that the ocean level experiences at regional and global scales. For this purpose, the IAG at the IUGG meeting in Prague in 2015 adopted one convention for the definition of the IHRS (https://office.iag-aig.org/doc/5d7b8fd9d31dc.pdf). Also, during the IUGG 2019 in Montreal, IAG adopted resolution Nº3 for the purpose for the establishment of the International Height Reference Frame (IHRF), with several recommendations for individual countries to guide them for the realisation of the IHRF (https://office.iag-aig.org/doc/5d7b8fd9c6aa0.pdf)

2.4.1 Chart Datum

To provide the mariner with a margin of safety in terms of depth measurements, all charted depths are referred to chart datum, which is equated to the datum of tidal predictions and defined by the IHO as a plane so low that the tide will not frequently fall below it (see Figure 2.10). Thus, unlike heights on land maps, which are normally referred to MSL as a proxy surface for the geoid, depths on charts are referred to a low water level. For the determination of chart datum, it is necessary to observe heights of points above the low water. Thus, the height of low water below MSL must be determined. This is done by analysing the records of tide gauges from the vicinity of the area of interest, which may require a specific expertise that is generally available within a State's hydrographic survey authority or harbour port authorities.

At many coastal sites, such as major ports, tide gauges are operated continuously. These sites, which are variously called primary control tide gauge stations or reference ports, have been in continuous operation at many sites around the world. The extensive data that have been gathered at these sites provide a sound basis upon which to establish an accurate chart datum elevation. However, it is often impractical to operate permanent tide gauges at all locations where chart datum is required. Therefore, secondary stations are established at various points between the primary stations. Chart datum at these sites is derived using much shorter periods of data, often as little as one month. These data are analysed through comparison with simultaneous observations at a nearby primary tide gauge. Obviously, an adequately dense network of primary stations is vital, because these comparisons can only render accurate results if the tidal characteristics at the primary and secondary stations are very similar and there are no significant local effects due to river discharges, shoal areas, etc. Along extensive and diverse coastlines, the remoteness of a secondary port from a suitable primary station is often a problem, which can sometimes adversely affect the accuracy of chart datum determination.

Note that the local sea level variations are caused not only by ocean tides, also called astronomical tides in hydrography, but also by other phenomena such as storm surges, currents, wind action, barometric pressure variations, thermohaline changes, etc. Even though these non-tidal variations may be occasionally as large as the tidal variations, they are not generally considered in analyses. For more detailed discussion, the reader is referred to oceanographic textbooks such as Warren and Wunsch (1981).

Establishing a suitable chart datum can be complicated because low water is not a fixed level. The range of the tide varies from day-to-day, month-to-month, and year-to-year. The factors primarily responsible for these variations are mainly associated with lunar and Earth movements including:

- Phase of the Moon, i.e., alignment of the Moon and the Sun produces larger tides and vice-versa.

- Elliptical orbits of the Moon and Earth, i.e., larger tides when the Moon is closer to the Earth and vice-versa.
- The Moon's changing declination, i.e., the closer the Moon is to being over the equator in its orbit, the more similar the morning and afternoon tides will be and vice-versa.

Tidal ranges can also vary within relatively short distances along a coastline, due largely to coastal configuration. Theoretical lunar tides are modified by coastal physiography, sometimes dramatically.

Owing to the many varied tidal characteristics existing throughout the world, a precise, scientific definition for chart datum, which could be used universally, has not been agreed upon. Over the past 200 years, different countries have adopted different methods for computing chart datum, depending usually on the type of prevailing tide. In accordance with an IHO Resolution of 1926, chart datum should:

- Be so low that the water will but seldom fall below it.
- Not be so low as to cause the charted depths to be unrealistically deep.
- Vary only gradually from area to area and from chart to adjoining chart, to avoid significant discontinuities.

In very basic terms, a chart datum can be defined as the mean of specific low waters over an extended period of time. The time period should ideally be 19 years or more, in order to include all the significant astronomical variations described above. Opinions vary, however, in terms of which low waters should be used to arrive at this mean value, and as a result different definitions are in use. For example, some countries define chart datum as the mean of all the lower low waters (MLLW) over a specified 19 year period. Others use a chart datum called lower low water large tides (LLWLT), which is defined as the average of the lowest low waters, one from each of 19 years of prediction. Yet others use the lowest low water spring tide (LLWST), which is the average of the lowest low water observations of spring tides, over a specified period. The most conservative use the lowest astronomical tide (LAT), which is the lowest level that can be predicted to occur under average meteorological conditions and under a combination of astronomical conditions (see Figure 2.10).

2.4.2 Global Gravity Field Models and the World Height Datum

The proliferation of vertical datums around the world and the difficulty in transferring heights between these datums has led to renewed efforts by the IAG towards the unification of these datums and the creation of a World Height System (WHS). These efforts were originally led by IAG's Inter-Commission Project 1.2 (ICP1.2): "Vertical Reference Frames" (Ihde, 2007) and are currently continued by Theme 1: "Unified Global Height System" of the IAG's Global Geodetic Observing System (GGOS). There are still many difficult problems to be resolved by these efforts, such as the realisation of a unified global reference surface for physical heights, the relation of tide gauge records to this reference surface, the separation of sea level changes and vertical crustal movements at tide gauges, and the connection with the terrestrial horizontal reference system.

The selection of the zero-height surface or datum, and its potential value W_o, is the most important one that needs to be resolved first. Since as already mentioned in Section 2.2.2 this surface is typically selected to be the geoid as best approximating the mean sea surface at rest, one important question is how to best compute an accurate global static geoid, its W_o, and its temporal variations. Furthermore, since physical heights (orthometric or dynamic) depend on the differences between the potential of the geoid W_o and the potential W_P of points on the Earth's surface (this difference is called the "geopotential number" C_P), a second important question is how to best compute precise potential differences or precise W_P values.

For a World Height System, as well as for datum unification, it is recommended that W_P values, and the global datum surface itself, be obtained by use of a global gravity field model that is independent of inconsistencies in local and regional data. This implies the use of one of the satellite-only global geopotential models (GGMs) such as those produced from a combination of GRACE and GOCE satellite data only (Section 2.2.2). To reach cm-level accuracy for the geoid surface of the vertical datum, the GGM has to be augmented with local or regional gravity data.

It is clear from the above discussion that the definition of a WHS involves a geometrical and a physical component, related to h and N, H, respectively (from Figure 2.5). The geometrical component is provided by the ITRS and the fundamental parameters of a reference ellipsoid (Section 2.3). The coordinates are the ellipsoidal heights h and their time variability dh/dt. The physical component is provided by the conventional W_o value, with coordinates provided by the potential differences or geopotential numbers C and their time variability dC/dt. Although orthometric or normal heights can be used as the vertical coordinates, C is preferred in order to avoid the various approximations involved in estimating heights from geopotential numbers. The adoption of the zero-tide system is strongly recommended in height system definition and realisations.

The realisation of the WHS by a network of physical points (stations) with precisely determined geopotential numbers and geocentric coordinates referred to ITRF will provide the International Vertical Reference Frame (IVRF). The equipotential surface of the Earth's gravity potential with a conventional value W_o that will serve as the zero-height surface for physical heights will define the World Height Datum. Then vertical datum unification could be accomplished simply by estimating the potential differences between the various local/regional height datums and the global one. Currently, countries such as New Zealand have already adopted geoid-based vertical datums. Canada and the USA have decided to do the same in 2013 and 2022, respectively. Scientific associations and space agencies are promoting the establishment of geoid-based vertical height systems internationally by taking advantage of the new GOCE-based GGMs that provide 1-2 cm geoid accuracy with 100 km spatial resolution. Therefore, the establishment of a WHS for heights, similar to the ITRF for 3D geometric coordinates that will comprise a geoid-based global height datum may soon be a reality.

2.4.3 Implications for Maritime Boundary Delimitation

The fact that there are different levels of chart datum means that adjacent or opposite States may use different levels at which to establish their baselines. Consequently, differences in the development of equidistance lines can result. It is necessary to take into account the possibility of different datums existing between opposite or adjacent States, such as the case when one State may utilise Mean Lower Low Water Springs (MLLWS) as the height datum that defines the maritime boundary normal baseline, while another State may utilise Lower Low Water Large Tides (LLWLT). In such a situation, a low tide elevation could be identified on the chart of one State, but not on the other.

Considerable differences may also occur in areas where rocks, islands or reefs, exposed at low tide, are used as baseline points. The choice of the level of chart datum may decide whether they are charted as features permanently below water and thereby eliminated from boundary delimitation calculations, or whether they are charted as low tide elevations for possible inclusion in such calculations.
Just as the precise definition of chart datum is crucial in boundary delimitation, so too is the accuracy of the data used in the actual calculations. The accuracy of the vertical datum depends on:

- The length of the tidal records.
- The remoteness of the area to be delimited from the secondary station, i.e., the closest place where the tide has actually been observed.
- The remoteness of that secondary station from the primary station.

In arriving at a reliable, accurate chart datum it is essential to have a good knowledge of the nature of the water level fluctuations for that area. This knowledge is obtained through water level observations of at least one year, but ideally much longer. It also implies an appropriately dense network of tide gauge stations, as mentioned in Section 2.4.1.

The suitability for boundary delimitation purposes of a chart datum that has been derived from, e.g., only 30 days of data, or of a chart datum derived for a location which is remotely situated from a primary tide gauge location, may sometimes be questionable in terms of accuracy. When datums have been properly established it is the practice to provide one or more reference monuments or benchmarks, permanently set in the ground, ideally in bedrock, in order that the elevation may be recovered at some later date. However, in certain parts of the world, care must be taken, if there is a very lengthy period between measurements, that the level of the land and the level of the sea have not moved relative to each other due to isostatic uplifting of the land, or subsidence of the land due to fluid extraction, or other geodynamic phenomenon.

2.5 SATELLITE POSITIONING

Global Navigation Satellite Systems (GNSSs) are comprised of satellites, ground stations and user equipment, and are now used to support many activities within today's society. The U.S. Global Positioning System (GPS) is the best-known GNSS. All discussion of positioning and datum principles, operational techniques, and user applications will proceed in this text using GPS as the exemplar. Note that although we will use the phrase GPS positioning in this chapter, it must be understood that the phrase will be interchangeable with the phrase GNSS positioning when the other GNSSs, specifically Russia's GLONASS, the European Union's Galileo and China's Compass/BeiDou, become fully operational and gain the trust of users.

2.5.1 Introduction to GPS

The only continuously fully operational satellite-based Positioning, Navigation and Timing (PNT) system is GPS. The first GPS satellite was launched in 1978, and GPS as a PNT system was declared operational with 24 orbiting satellites in 1995. For more details about GPS, the reader is referred such textbooks as Hofmann-Wellenhof et al. (2008) and Leick (2004), while the current status of GPS can be monitored via the web site NavCen (2012). GPS has revolutionised first the disciplines of geodesy and surveying (from the early 1980s), and subsequently has made a considerable impact on all navigation communities, as the availability of satellite signals and appropriate user receiver equipment improved (since about the mid-1990s).

The GPS satellite constellation, at time of writing, consists of 32 active satellites of various models (NavCen, 2012), significantly more than the 24 satellites required for the system's Final Operational Capability. The orbital configuration comprises four near circular orbital planes, each inclined at about 55° to the equatorial plane, with nominally six satellites per plane. The satellites orbit at approximately 20,200 km above the Earth's surface, with resultant orbital periods of approximately 12 hours.

GPS is a one-way ranging system, using satellites at known positions continually transmitting time synchronised signals. It is a 24 hour, global, all weather service, accessible to an unlimited number of military, civilian and commercial users with access to the open-sky. Fundamentally, GPS is a timing system. Orbiting precise atomic clocks, at known positions, transmit known signals to user receivers to synchronise low quality receiver clocks. This time synchronisation allows for the measuring of signal travel time from satellite to receiver, which is converted to range or distance. These satellite-to-receiver ranges are used in a variety of processing modes, providing few metre-level to mm-level absolute or relative positioning. All GPS receivers are capable of making pseudorange (also called code) measurements, and, in addition, receivers used for high accuracy (sub-metre) applications also make carrier-phase (also called phase) measurements. Both types of measurements are made on the tracked microwave L-band frequencies transmitted by the satellites. PNT accuracy is dependent on such factors as measurement type, quality of receiver hardware, algorithm design, and mode of operation (see Section 2.5.2).

The GPS constellation has operated for several decades without any gaps in operational status, and while it is beyond the scope of this section to provide detailed review material on GPS, the following points concerning the GPS signals and measurements are useful for subsequent discussions:

- The majority of the GPS satellites broadcast two signals in the L1 (1575.42 MHz) and L2 (1227.60 MHz) frequency bands.
- As GPS signals are of the type known as Code Division Multiple Access (CDMA), each satellite is distinguished from the other by a special ranging code that is modulated on the L-band carrier waves.
- The phase measurements are approximately one thousand times more precise than the code measurements.
- Simultaneous measurements of code or phase made on two frequencies permit the ionospheric measurement bias to be determined and subsequently removed, hence improving positioning accuracy (see Section 2.5.2).
- Civilian navigation receivers currently only can make code or phase measurements directly on the L1 signal using the C/A-codes. This means that such receivers are unable to correct for delays to the signal as it passes through the ionosphere, which is now one of the two dominant causes of error for such users, the other being multipath.

- High-quality geodetic receivers make code and phase measurements on both the L1 and L2 frequencies, and are comparatively expensive due to: (a) their dual-frequency, phase-tracking capability, (b) high quality antennas, and (c) sophisticated measurement processing software.
- Military receivers can access the ranging codes on both the L1 and L2 frequencies, which enable them to correct for ionospheric errors and achieve higher accuracy and reliability of PNT results.
- Those GPS satellites launched since 1999 have commenced broadcasting on a third L5 frequency (1176.45 MHz).

2.5.2 GPS Positioning Modes

At its most basic level, a GPS, and in fact any GNSS, positioning mode or technique is classified according to whether it provides absolute or relative positioning results. These are each briefly discussed below.

Single Point Positioning (SPP) is the operational mode for which GPS was originally designed. Standard civilian receivers currently deliver real-time, horizontal, absolute accuracy performance of the order of 5-10 m in the GPS reference frame (i.e., WGS84, Section 2.3.2). Vertical accuracy is typically 2-3 times worse than horizontal accuracy. The civilian users achieve such an accuracy using the GPS Standard Positioning Service (SPS) (NavCen, 2012), whether the user is stationary or moving. Code measurements made on only the L1 frequency are the basis of the SPS, and, as the name of the service implies, the vast majority of GPS user equipment falls in this category, including receivers installed on ships to support marine navigation.

Differential GPS (DGPS) can overcome some of the limitations of SPP by applying corrections to the basic code measurements at the user receiver to mitigate or eliminate some of the more serious satellite system and atmospheric biases, based on a second receiver, a base or reference station, making similar measurements at a known point. The relative positioning accuracy achievable can range from the metre-level down to a few decimetres, depending on the quality of the receivers, distance between the user receiver and the reference receiver generating the correction data, and the particular DGPS technique and perhaps the DGPS correction service that is used.

Guidelines and specifications relating to the use and transmission of real-time DGPS corrections are defined by the International Association of Lighthouse Authorities (IALA), the International Maritime Organization (IMO) and the Radio Technical Commission for Maritime Services (RTCM). DGPS supports navigation in challenging areas, such as approaches to ports and harbours and inside them, in reef or shoal areas, where vessel separation schemes may be in force, and for positioning of a vessel undertaking hydrographic or scientific research.

Relative GPS refers to the most accurate of the positioning techniques, using the DGPS principles with one or more reference stations relative to which receiver coordinates are computed from phase measurements besides the noisier code measurements. Geodetic applications have been using GPS extensively since the early 1980s to address regional and global reference frame applications that do not require real-time results, nor need to account for the user receiver being in motion. Relative GPS has therefore mainly supported national renovated geocentric datums and global datum definition, such as the ITRF realisations (see Section 2.3.2) and maintenance, as well as Earth science users, but at ever increasing levels of accuracy. Currently, relative positioning accuracies are typically at the few parts per billion of the inter-receiver distance (or a few millimetres of error over a one thousand kilometre baseline, i.e., the 3D vector connecting the reference station to the user receiver). Hence GPS geodesy underpins the definition of modern geocentric datums, permits control surveys to be conducted to extend or densify a State's geodetic control network, and is used to monitor the stability of tide gauge sites or datums (Section 2.4.3). More details on relative GPS as used in geodesy can be found in, e.g., Rizos and Brzezinska (2009).

Real-Time Kinematic (RTK) is a relative positioning technique that can achieve centimetre-level accuracy in real-time, using pairs of receivers, even if the user receiver is moving, i.e. kinematic. Operational efficiencies and high accuracy are assured when both code and phase measurements are made on both L1 and L2. Hence RTK techniques require expensive, compared to single-frequency SPP/DGPS receivers, dual-frequency instrumentation and specialised phase baseline processing algorithms. A detailed description of the different modes and algorithms of phase-based positioning are given in, e.g., Rizos (2010a).

A critical enabler for the RTK technique is the widespread establishment of permanent, continuously operating reference stations (CORS) at the necessary density. Depending upon whether single-base RTK or so-called network RTK techniques are used the separation of CORS ranges from about 30 to 100 km. Most CORS providing RTK services are commercial operations, and a user must be a subscriber to the service. The RTK technique is commonly used for precision hydrographic, harbour and offshore engineering applications, including precision navigation of large vessels when there is little keel clearance, for dredging operations, and various engineering and construction tasks. For such near-shore, or even internal waters applications it is not difficult to ensure CORS deployment satisfies the baseline length constraints for efficient and reliable RTK. However, RTK techniques cannot be used when operating more than a few tens of kilometres offshore. As with DGPS techniques, the datum of the resulting coordinates is that on which the CORS coordinates are defined.

Precise Point Positioning (PPP) is a newer processing technique, which applies very accurate GPS satellite orbit and clock information computed separately from global CORS networks to a single high-quality receiver via specific processing algorithms, in order to produce decimetre to centimetre-level coordinates without any baseline constraints. The technique is now an industry standard for hydrographic surveys and marine construction, given its accuracy and performance near and far from shore. Coordinates are computed in the datum of the satellite orbit and clock products, typically ITRF. Efforts to further improve this technique are ongoing (Bisnath and Gao, 2009).

2.5.3 The Future of GNSS

By the year 2020 it is expected that the number of GNSS satellites broadcasting navigation signals will double from the current number of about 70 satellites, to over 140 satellites (see, e.g., Rizos, 2010b). Extra satellites improve continuity. GPS, GLONASS, Galileo and Compass/BeiDou being independent systems mean major system problems, unlikely as they are, have a very remote possibility of occurring simultaneously.

Extra satellites and signals can improve accuracy, thus:

- More satellites being observed means a given level of accuracy can be achieved faster.
- More signals means more measurements can be processed by the receiver's positioning algorithm.
- Position accuracy is less susceptible to the influence of satellite geometry.
- Vertical accuracy will approach the performance of horizontal positioning.
- The effects of multipath and interference/jamming could be mitigated through implementation of receiver autonomous integrity monitoring (RAIM) type satellite signal selection algorithms, ensuring that only measurements of high quality are processed.

Extra satellites and signals can improve efficiency. For phase-based positioning to centimetre accuracy, extra satellites and signals will significantly reduce the time required to resolve carrier-phase ambiguities.

Extra satellites and signals can enhance signal availability at a particular location, crucial for users wanting PNT solutions in areas that do not satisfy the open-sky conditions, though this is not as serious an issue for maritime users.

Extra satellites and signals can improve reliability:

- Extra measurements increase the data redundancy which helps identify measurement outliers.
- The current L2 GPS measurements are noisier and less continuous than those which will be made on either of the new signals L2C or L5, hence dual-frequency operation will be enhanced in future.
- More signals mean that service is not as easily denied due to interference or jamming of one frequency or set of signals, which may prevent the making of critical pseudorange and/or carrier-phase measurements on one or more GNSS.

Finally, any discussion of mixing different satellite navigation signals so that users can improve the performance of their receivers invariably raises the issue of interoperability and compatibility. Interoperability is defined as the ability of GNSS services to be used together to provide the user better capabilities than would be achieved by relying solely on one service or signal. At the very least, this term would imply the same or very similar transmitted frequencies, but ideally the broadcast of the family of spreading codes by all GNSS. Compatibility is defined as the ability of GNSS to be used separately or together without interfering with each individual service or signal. The degree of interoperability and compatibility that will be achieved in a multi-GNSS world is still unclear.

2.6 SURVEYS AND COMPUTATIONS

In order to determine maritime boundaries, it may be necessary to perform surveys both on land and at sea, as follows:

- Geodetic and topographic surveys.
- Tidal and oceanographic surveys.
- Bathymetric/hydrographic surveys.
- Geoscientific surveys.

This section will focus on land operations that make use of geodetic methodologies. The use of geodetic and topographic surveys and calculations may be required in the following cases:

- Determination of the low water line, which defines a coastal State's normal baseline and/or the base points of a straight baseline.
- Positioning and/or verification of the geodetic coordinates of points and benchmarks.
- Conversion from one geodetic datum to another, or definition of a common datum.
- Determination of the datum that was used for original positions, and which may not have been properly or adequately documented.
- Readjustment of ancient and/or distorted surveys.
- The determination of areas.

2.6.1 Determination of Baselines

Generally, the baseline from which territorial waters are measured corresponds to the low water coastline that is indicated on the official nautical charts of the coastal State (see Chapter 4). Situations arise where the coastline is not defined clearly, or where it is improperly described on official charts on account of marked variations due to recession or other phenomena, such as erosion or accretion. In that case, a new geodetic survey may be desirable to determine the positions of the points that define the low water line. Before starting, the State should decide which system of baselines it wishes to adopt, i.e., normal or straight. If both will be used, the State needs to determine the sections of coast to which each will apply. All necessary documents that relate to the coastal zone of interest should be assembled, i.e., charts, list of geodetic points, aerial photographs, etc. It is also important to verify that tidal stations exist and that they are operating in that zone. It is necessary to define the vertical datum (see Section 2.4), as well as the horizontal datum (see Section 2.3) in use.

Field reconnaissance is used to identify and select those points along the coast that will be used to define the baseline. Such points may consist of turning or terminal points of a straight baseline system, or they may describe the low water line that defines a normal baseline. Off-lying rocks, islands and low tide elevations are particularly important in this respect. It is also necessary to locate all geodetic control points in the area, which may be used to reference the baseline points.

Where the coastline is deeply indented or fringed with islands with numerous embayments, headlands and off-lying rocks and islands, and when it is planned to use a system of straight baselines, care must be taken to carry out a detailed reconnaissance in order to select the proper points. An accurate, large-scale chart is most desirable for this purpose, but if one is not available, other maps, aerial photographs or satellite imagery may be used.

The field reconnaissance may involve many hundreds of points. A field survey is not normally carried out, but it is advantageous if some of the points can be connected to the geodetic network and become themselves geodetic reference points.

Article 7 of the LOS Convention indicates the required geographical conditions that must be satisfied prior to employing straight baselines. However, considerable interpretation has taken place on paragraph 3 concerning the stipulation that "the drawing of straight baselines must not depart to any appreciable extent from the general direction of the coast". Figure 2.11 demonstrates just some of the possible choices that may exist on a fictitious length of coastline.

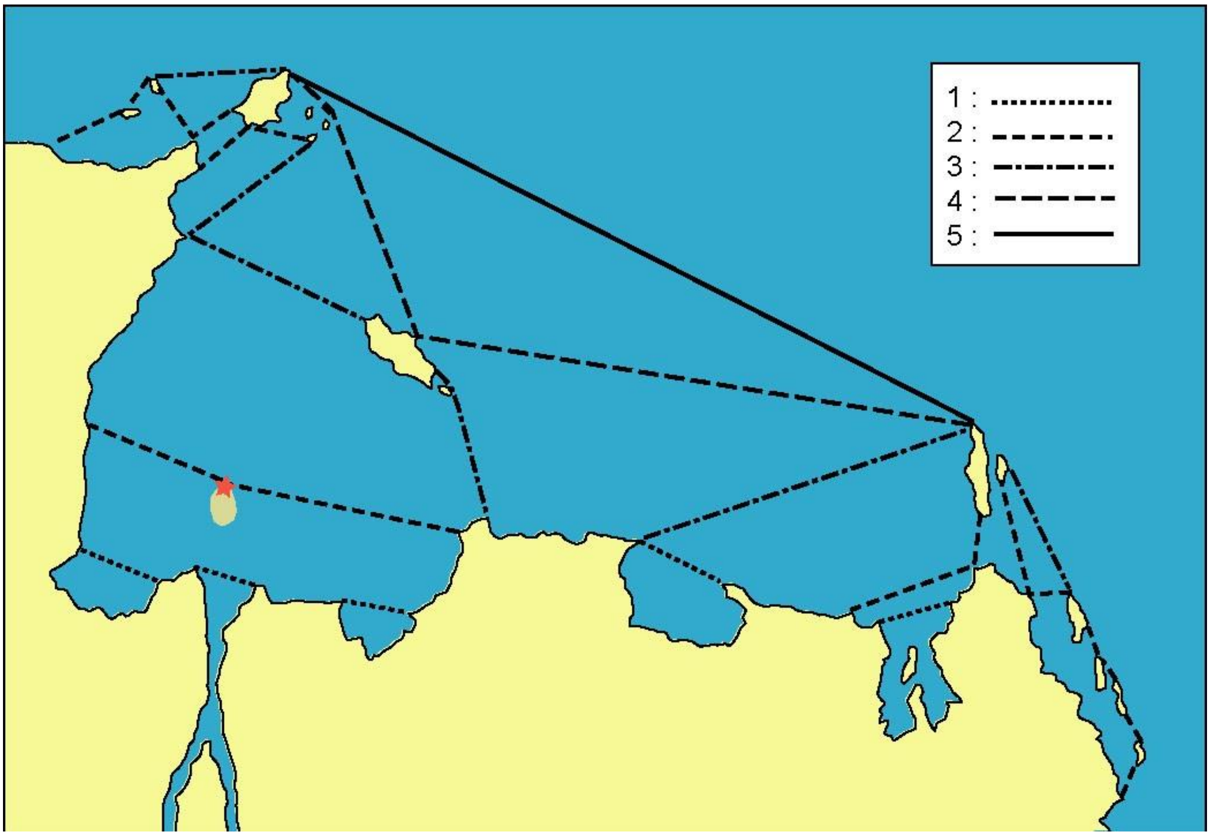


Figure 2.11 Different interpretations of general direction of the coast and selection of straight baselines. (Animation: Figure2_11.ppt)

It may be necessary to establish horizontal control by means of geodetic measurements when determining the position of the low water line, or of the points that define the straight baselines. A study of existing charts and maps, complemented by field observations, is essential for examining the configuration of the land and coastline, and to note the existence of established geodetic control points and benchmarks.

In most countries, a system of primary first order control (defining the foundation points in the national datum) will already have been established. Monuments made of concrete, bronze or other permanent substance will mark the physical positions of this control. Increasingly States are establishing networks of CORS as a means of both physically marking geodetic control points as well as providing an easy means of connecting to the datum using differential or relative GNSS techniques (Section 2.5.2). From these points, lower order control points must be established in order to define precisely the geographical location of the coastline and other features of importance to the delimitation.

Horizontal control may be extended from the primary control by any of several methods. Historically, this has been achieved through triangulation, traversing, and trilateration, but GNSS methods are used exclusively today (Section 2.5.2). The use of phase-based techniques, i.e., relative GNSS or PPP ensures horizontal accuracies at the decimetre-level or better. This is sufficient for determining the coordinates of baseline points in a State's national datum.

A few words about vertical measurements and the necessary vertical control are also in order. Geodetic vertical control consists of a network of levelling benchmarks the orthometric heights of which, as already indicated in Section 2.4, are referred to the geoid via the local mean sea levels.

The location of the low water line will require careful tide measurements in areas where the coast is gently sloping, because any error in vertical measurement may result in a considerable horizontal displacement. It is important to obtain the exact height above low water datum of all off-lying rocks, sandbars and other features. At the same time the tidal range must be precisely determined in order that it will be known if these features are above or below high water. Whether or not a feature is a low tide elevation (see Article 13) or a feature permanently above high water may assume considerable importance. It is thus necessary to pay maximum attention not only to the trend of the tide, but also to the possible influence of meteorological factors on sea level. Such influence is greater in shallow waters and in coastal areas that feature low gradients.

Determining the coastline becomes more difficult in zones having large differences in tide and where ice and storm surges may exist. By the end of the survey, the coastline will be represented as a continuous polygon line with straight legs of varying length depending on the configuration of the coast. Photogrammetric processing of airborne or satellite imagery (remote sensing) may be used in addition to the geodetic methods to define precisely the entire extent of the low water line, thereby providing details between the surveyed points.

Remote sensing "… embraces all methods of acquiring information about the Earth's surface by means of measurement and interpretation of electromagnetic radiation either reflected from or emitted by it" (Kraus, 2007). Contemporary remote sensing sensors can be categorised as:

1. Optical (visible and infrared region of the electromagnetic spectrum)
2. Microwave (active: Synthetic Aperture Radar, altimeter; passive: scatterometer)
3. LIDAR (LIght Detection And Ranging)

Some of the products that can be obtained from remote sensing are Digital Terrain Models (DTMs) and Digital Surface Models (DSMs). The former strictly refers only to the bare terrain (topography), after eliminating heights of buildings, trees, etc., while the latter strictly refers to the uppermost surface of topography and culture (buildings, vegetation, etc.) as seen on an aerial photograph or detected from the first return pulse of a laser scanner (Newby, 2012).

Based on remote sensing observations, coastline points for areas with limited or even no access can be determined by the following specific image processing steps:

1. Orthorectification (the process of removing the effects of image tilt and terrain effects resulting in a planimetrically correct image) using a DTM or DSM
2. Coastline extraction using a specific edge detection algorithm or a combination of various ones
3. If necessary, manual coastline refinement by digitalisation in order to overcome uncertainties to obtain the mean low water spring or, mean lower low water or, lower low water large tides, lowest low water spring tide
4. Determination of the most significant coastline points suitable for the corresponding situation.

2.6.2 Determination of Areas

In the application of the LOS, the areas of closed polygons limited by meridian lines, parallels, great circles or geodesics are of primary interest. For very small areas, straight lines in the projection plane can usually serve as an acceptable approximation, and the area they enclose can be determined by the coordinate formula, e.g., Richardus (1984). On the sphere, the area of any closed polygon can be precisely determined by considering the spherical excess, provided that the angles between the polygon sides are known.

Although the reference surface for applying the LOS is an ellipsoid, the spherical approximation of the area will be sufficient for small closed polygons. Then the radius of the sphere corresponding to the so-called Gaussian curvature should be chosen. For explicit formulas the reader is referred to, e.g., Kimerling (1984). However, as angles are not measured in modern space methods, these quantities must first be determined from the coordinates of the polygon points.

Another approximate method is to perform the area calculation by the coordinate method in an area preserving (equality) projection. The disadvantage is that geodesics are not straight lines in such a projection plane, which inevitably leads to approximation uncertainties that increase with the size of the area. As an example, Gillissen (1994) used this method with Abel's equality projection. Alternatively, if the polygon lines are loxodromes, the polygon is composed of straight lines in Mercator's projection; however, as this projection is not area preserving, the calculated area will again be in error.

Sjöberg (2006b) extended Kimerling's method to a series solution to the desired accuracy for a geodetic polygon of any size. Alternatively, the series derived by Danielsen (1989) for the area under the geodesic could be useful. Baeschlin (1948) presented a closed but approximate equation for the area of an ellipsoidal triangle. Also, for any closed polygon on the ellipsoid, limited by meridian lines and parallels, the area can be exactly determined by adding closed expressions for the areas of blocks; see, e.g., Baeschlin (1948). Finally, Sjöberg (2006a) presents practical formulas for the numerical computations of areas, arc lengths, etc., related to geodesics.

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CHAPTER 3 – CHARTS

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References:

S-4, Regulations for International (INT) Charts and Chart Specifications of the IHO
S-32, Hydrographic Dictionary
S-66, Facts about Electronic Charts and Carriage Requirements IHO
Mariner's Handbook, NP100 UK Hydrographic Office

3.1 INTRODUCTION

UNCLOS prescribes that the normal baseline for measuring the breadth of the territorial sea is the low-water line along the coast as marked on large-scale charts officially recognized by the coastal State. The straight baselines, baselines closing the mouths of rivers and bay closing lines (or the limits derived therefrom), as well as lines of delimitation between two states etc. are to be shown on charts of a scale or scales adequate for ascertaining their position. Alternatively, a list of geographical co-ordinates of points, specifying the geodetic datum, may be substituted. The coastal State shall give due publicity to such charts or lists of geographical co-ordinates and shall deposit a copy of each such chart or list with the Secretary-General of the United Nations. This applies also to the archipelagic baselines, and the outer limits and boundary delimitation of exclusive economic zones and continental shelves. (Articles 16, 47, 75, 84).

3.2 NAUTICAL CHARTS

Nautical charts are special purpose maps specifically designed to meet the requirements of marine navigation, showing amongst other things depths, nature of the seabed, elevations, configuration and characteristics of the coast, dangers, and aids to navigation. Nautical charts provide a graphical representation of relevant information to mariners for executing safe navigation.

Nautical charts are based on hydrographic surveys. The characteristics of hydrographic surveys are time consuming and done area by area, even on the same chart. Normally, hydrographic surveys are not carried out to cover the whole area of a nautical chart simultaneously but conducted area by area over a number of years. Hydrographic data for some areas may be dated and may not meet modern standards. In consequence, it should be noted that information shown on a chart can be different from the reality.

Nautical charts are available in analogue form as paper charts, or digitally as electronic charts. The requirements for the carriage of nautical charts are laid down in the International Convention for the Safety of Life at Sea (SOLAS) 1974 Chapter V. The relevant regulations are:

- Regulation 2, which defines the nautical chart as follows:

  Nautical chart or nautical publication is a special-purpose map or book, or a specially compiled database from which such a map or book is derived, that is issued officially by or on the authority of a Government, authorized Hydrographic Office or other relevant government institution and is designed to meet the requirements of marine navigation.

- Regulation 19, which specifies the equipment (including charts) to be carried on different types of ships as follows:

  2.1 All ships irrespective of size shall have:

  2.1.4 nautical charts and nautical publications to plan and display the ship's route for the intended voyage and to plot and monitor positions throughout the voyage. An electronic chart display and information system (ECDIS) is also accepted as meeting the chart carriage requirements of this subparagraph.

- Regulation 27, which specifies the requirement to keep charts and publications up to date as follows:

  Nautical charts and nautical publications, such as sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage, shall be adequate and up to date.

The three regulations referred to above show that the carriage requirement for charts can be fulfilled by:

- Carriage of official and up to date paper charts, or
- Carriage of a type-approved ECDIS (Electronic Chart Display and Information System, in accordance with the requirements of the IMO ECDIS Performance Standards) supplemented by an appropriate back up arrangement, and up to date Electronic Navigational Charts (ENC).

Nautical charts which do not meet the definition prescribed in SOLAS do not meet its carriage requirement. Such charts are by definition not hydrographic charts and are often referred to as private charts, but may meet the requirements for official recognition for due publicity under UNCLOS. As for electronic charts, ECDIS with non-ENC database or ENCs displayed on non-ECDIS platform do not satisfy the carriage requirement.

The IHO adopts international standards for nautical charts published by IHO's member states to bring about the greatest possible uniformity in them, and within which the SOLAS Convention provisions are to be taken into account wherever possible.

The chart is a useful tool to use in order to study or display the inner and outer limits of national jurisdiction, or the boundary between national jurisdictions of one or more States. The chart should be recognized by the coastal States and it should represent, in sufficient detail, the configuration of the coast and the morphology of the coastal zone including the sea floor. Alternatively, the coastal States concerned can provide lists of coordinates.

In almost all countries at present, the nautical chart is the only type of chart (or map) that comes close to meeting the needs of legal bodies and cartographers responsible for carrying out the task of boundary delimitation. It must be borne in mind that the nautical chart was specifically designed for the safe passage of vessels and it is incidental that it may contain some of the basic elements which are necessary to satisfy the above-mentioned purposes, e.g.:

a. The coastline, with a reasonable part of the hinterland;
b. The seaward area over which the delimitation is to be made.

It should be borne in mind that in order to represent the curved Earth surface on a plane it is necessary to use a projection. The use of a projection will introduce distortions, which must be accounted for in its use for any delimitation and/or delineation.

The following properties fundamental when using a chart:

a. Chart projection;
b. Chart scale;
c. Horizontal datum;
d. Vertical datum.

These factors have such an important influence in the depiction of maritime boundaries that awareness of their properties is of fundamental importance, especially when plotting boundaries on charts with dissimilar characteristics and datums. The charts to be used should reflect the present situation as accurately as possible and they should be based on the most recent surveys. There are two different types of nautical charts: paper and electronic. Electronic charts are further divided into Raster Nautical Charts (RNC) and Electronic Navigational Charts (ENC).

3.2.1 Paper Charts

Paper charts have a long history. The paper chart is compiled in accordance with the IHO publication S-4: Regulations for International (INT) Charts and Chart Specifications.

3.2.2 Electronic Charts

Electronic Charts comprise chart database and its display system.

3.2.2.1 Electronic Chart Database

Electronic chart database is of two general types:
- Electronic Navigational Charts (ENC), and
- Raster Navigational Charts (RNC).

The inner construction of ENCs and RNCs is fundamentally different:
- ENCs are vector charts, and
- RNCs are raster charts.

A raster chart is a digital database of a scanned and passive image of a paper chart, whereas a vector chart is a digital database of numerical expression of all the objects (points, lines, areas, etc.) represented on a chart.

3.2.2.1.1 Raster Navigational Charts

RNCs are digitized optical copies of paper charts conforming to IHO publication S-61 – Product Specifications for Raster Navigational Chart (RNC). RNCs are issued by, or on the authority of a national Hydrographic Office. When displayed on an ECDIS screen RNCs appear as a facsimile of the paper chart however, they contain significant metadata to ensure that they have a certain minimum functionality; such as a geo-referencing mechanism that allows geographic positions to be applied to and extracted from the chart, automatic updating of the RNC from digital files (and the ability to show the state of correction) and the display of the RNC in day or night colours. An RNC is a digital copy of the current paper chart, or in some cases rasterized vector information which creates ENCs these days. As such the chart content cannot be analysed by a computer program to trigger alarms and warnings automatically as is the case with a vector chart; however, some alarm and warning functions can be achieved by manual user input to the ECDIS.

3.2.2.1.2 Electronic Nautical Charts

ENCs are vector charts comprising a database of individual geo-referenced objects extracted from a Hydrographic Office's records including existing paper charts with the IHO ENC Product Specification that is part of the chart data transfer standard known as S-57. When used in an ECDIS, the ENCs content can be displayed as a seamless chart-like image on the ECDIS screen at user selected scales. Due to the limited size and resolution of electronic displays the chart image generated from ENCs may not fully replicate the traditional appearance of a paper chart. This apparent shortcoming is more than compensated by the special operational functions of ECDIS which continuously monitors the ENC data content (rather than the display) to provide warnings of impending dangers in relation to a vessel's position and its movement.

3.2.3 Electronic Chart Display System

Electronic Chart database is not visible for human eyes. It should be displayed on a screen to be recognized as navigational information. There are two types of such display system which visualizes the chart database; ECS and ECDIS.

3.2.3.1 Electronic Chart Systems

All electronic charting systems, which are not tested and certified as meeting the IMO ECDIS Performance Standards, are generically designated as "Electronic Chart Systems" (ECS). An ECS may be able to use ENCs, RNCs or other chart database produced privately and could have functionality similar to ECDIS.
Some ECDIS and ECS equipment manufacturers produce private vector and raster database to be used in their products. These private charts are usually derived from Hydrographic Office paper charts or Hydrographic Office digital data but these derived charts have no official status.

3.2.3.2 Electronic Chart Display and Information System

ECDIS equipment is specified in the IMO ECDIS Performance Standards (IMO Resolution MSC.232 (82) as follows:

> Electronic Chart Display and Information System (ECDIS) means a navigation information system which, with adequate back up arrangements, can be accepted as complying with the up-to-date chart required by regulation V/19 & V/27 of the 1974 SOLAS Convention, as amended, by displaying selected information from a system electronic navigational chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and if required display additional navigation-related information.

ECDIS is a ship borne navigational device and as such the rules governing its use come under the jurisdiction of the IMO through SOLAS Convention. The IMO has adopted performance standards for ECDIS (IMO Resolution MSC.232 (82) and subsequent amendments). ECDIS equipment must be certified as meeting these performance standards if it is to be used to meet the chart carriage requirements of SOLAS V/19. Certification of ECDIS equipment is achieved through type-testing and certification.

Within an ECDIS, the ENC database contains chart information in the form of geographic objects represented by point, line and area shapes, carrying individual attributes. Appropriate mechanisms are built into the ECDIS to query the data, and then to use the information to perform various navigational and monitoring functions (such as, anti-grounding surveillance) and to generate a chart-like display.

The presentation of ENC data on a screen display is specified in IHO standard S-52 "Specification for Chart Content and Display Aspects of ECDIS". The style of presentation defined in S-52 is mandatory.

Only a type-approved ECDIS operating with up to date ENCs and with appropriate back up arrangements may be used to replace paper chart navigation. Where ENCs are not available, the SOLAS regulations allow Flag States to authorize the use of RNCs (together with an appropriate folio of paper charts). In all other cases the vessel must carry all the paper charts necessary for its intended voyage.

3.3 CHART MAINTENANCE

The maritime world, as portrayed in the nautical chart, is not static. For example: increasingly sophisticated surveying methods provide more accurate details of the bathymetry, which in some areas is constantly changing; shipping patterns and ships' draughts change; ports are developed; aids to navigation are changed and moved; safety and environmental concerns result in new routeing measures and navigational restrictions; exploitation of natural resources is increasing; new navigational obstructions are discovered.

All this nautical information must be assessed and brought to the attention of the mariner as required, in order to support SOLAS and environmental protection. To achieve this goal, nautical information must be systematically and continually collected from many different sources, e.g. surveyors, maritime institutes, harbour masters, lighthouse authorities, so that charts can be maintained.

Some information is safety related and must be passed to the mariner urgently; other information, while navigationally significant, is less urgent; some is only useful for making up the overall picture of the maritime environment and is not urgent. The importance of keeping charts up-to-date cannot be over-emphasized. If charts are not kept up-to-date, their value is seriously diminished and they may become misleading, potentially contributing to maritime casualties.

3.3.1 New Chart

A New Chart (NC) is the first publication of a nation's chart that may be additional to existing cover and will not usually supersede existing charts on a one for one/scale for scale basis.

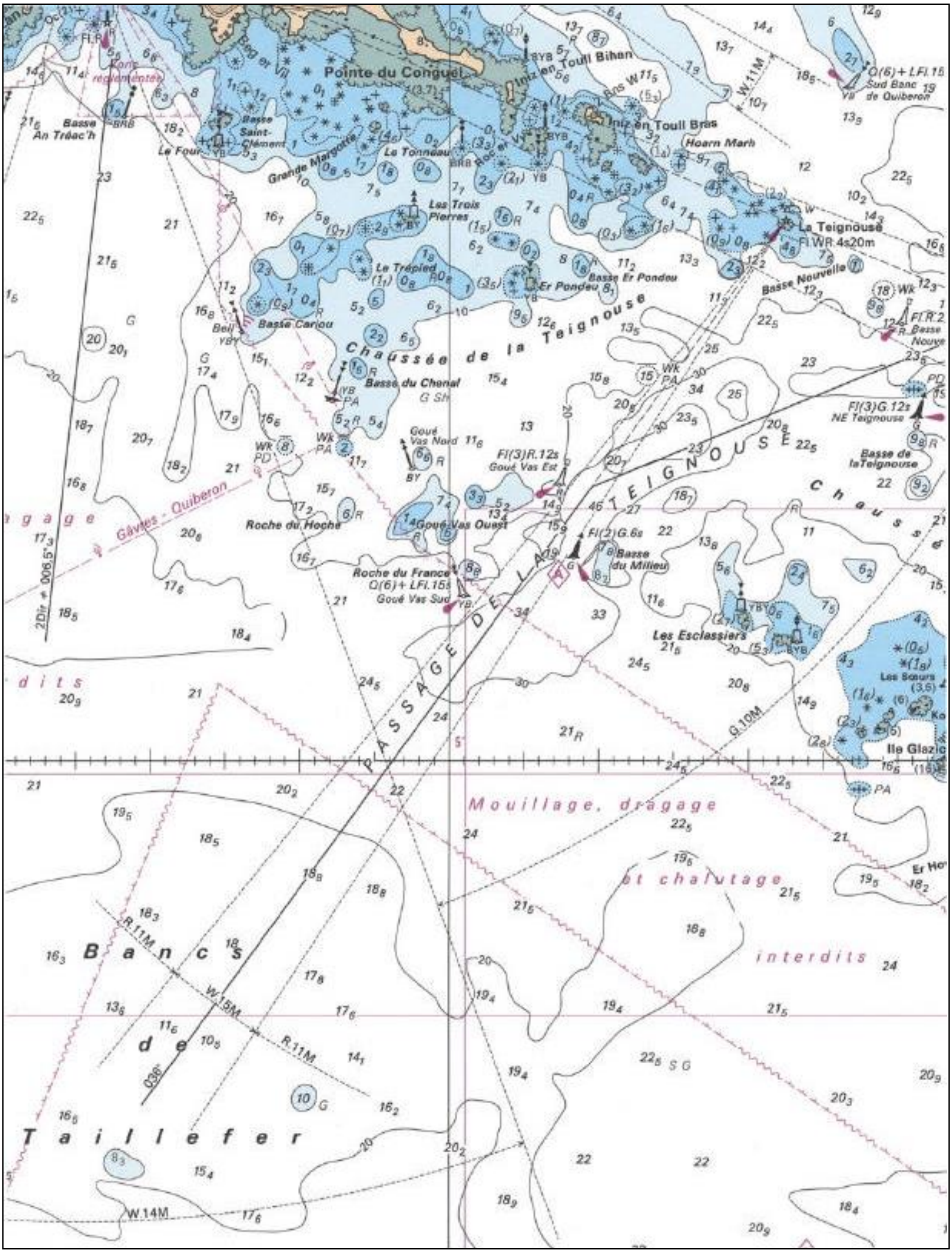


Figure 3. 1- Example of paper chart
(courtesy of Service hydrographique et océanographique de la marine (Shom))

3.3.2 New Edition

A New Edition (NE) is a new publication of an existing chart, containing changes significant to navigation that will normally have been derived from more recent information. It will usually include changes additional to those previously promulgated in Notices to Mariners (NM). However, it should be noted that parts of the chart might remain unchanged. The previous edition must normally be cancelled and will no longer be maintained by NM; this should be made clear to all users in the announcement of the NE. Once cancelled, a previous edition must not be used, in accordance with SOLAS carriage-compliance.

3.3.3 Limited New Edition

A Limited New Edition (LNE) may be prepared if there is information which needs to be included on a chart quickly, but which cannot be promulgated by Notice to Mariners (NM) or NM Block, because of the geographical extent or complexity of the information, or where there are other reasons to produce a NE to short time scales.

3.3.4 Reprint

A reprint (also called Revised Reprint or Corrected Reprint) is a new print of the current edition of a chart incorporating no amendments of navigational significance other than those previously promulgated in Notices to Mariners (if any). It may, however, contain amendments from other sources provided they are not significant to navigation. Previous printings of the current edition of the chart always remain in force.

Because previous printed copies always remain in force, great care is required when incorporating any new information to ensure that the new information would never need updating by Notice to Mariners. In such cases, a NM would then only apply to some copies of the chart, which could cause confusion to the user.

3.3.5 Notice to Mariners

Notice to Mariners (NM) are used for the prompt dissemination of information which is safety-related or which otherwise needs to be advised to the mariner urgently. They are regularly published (usually weekly, fortnightly or monthly) by most hydrographic offices, in paper booklets and/or on websites. Electronic chart updates may be promulgated on digital media, or by utilizing remote updating systems.

a. Chart-updating (permanent) textual NM.
b. NM block (also called a Chartlet or Patch).
c. Temporary (T) NM.
d. Preliminary (P) NM.

Temporary NM and Preliminary NM are not permanent.

3.4 RELIABILITY

Historical survey and cartographic data may be needed to help prove or disprove the existence of features that could justify different or particular applications of the articles of UNCLOS. Most charts are compiled from the results of hydrographic surveys that are very time consuming operations, even with modern equipment. Ocean surveys have only been undertaken by a limited number of maritime States. Consequently, large areas of the world's ocean floor have never been properly surveyed, and surprisingly significant areas of coastal waters have not been surveyed in the detail required for today's shipping or to support the determination of maritime limits and boundaries. The significance of this variable quality of charts is that:

a. Geographical positions may be based upon inaccurate, imperfect or inadequate observations;

b. In areas where the low-water line is composed of soft materials like mud or sand, the details are most likely to have changed since the surveys were undertaken, particularly in areas of strong currents or tidal streams, or along coasts that are subject to major storms.

c. If the chart has been based on the original printing plates it may not be clear from the symbols used at that time which contour line or lines represent the low-water line.

The publication date of a chart is not an indication of the age of the source material from which it is compiled. A chart with an early publication date may have had modern work added to it, whilst a recently published chart, in a modern format, may have been compiled from old surveys. An indication of the true situation may be found on the chart, for instance in the title block of an older chart. Recently produced charts may include "source data" diagrams, which provide details of the origin of the surveys, the spacing of the sounding lines, and the methods used in the surveys. These allow the user to evaluate the quality of the chart.

As for ENCs, Category of Zone of Confidence (CATZOC) information is provided as an attribute to the depth data to indicate the accuracy of data presented on charts to assist mariners to assess the safety of navigation. CATZOC values are assigned to geographical areas to indicate whether data meets a minimum set of criteria for position, depth accuracy and seafloor coverage. By understanding the accuracy limitations of the underlying data in greater detail, the mariner can manage the level of risk when navigating in a particular area. ECDIS displays these CATZOC values in ENCs using a triangular or lozenge shaped symbol pattern.

3.4.1 Source Diagrams

In order to show the degree of confidence in the adequacy and accuracy of charted depths and their positions, a ‘Source Diagram’, which includes both the graphic showing the limits of the source data used, and the accompanying text is inserted in most nautical charts.

There are two main types of diagrams for summarising hydrographic sources:

- Conventional Source diagrams provide the areas and dates of source surveys from which the user can deduce the degree of confidence to place in charted depth data, see Figure 3.4

- Zone of Confidence (ZOC) diagrams are a type of source diagram providing a more qualitative assessment of the source information, see Figure 3.5. They replace the former Reliability diagrams, which are obsolescent.

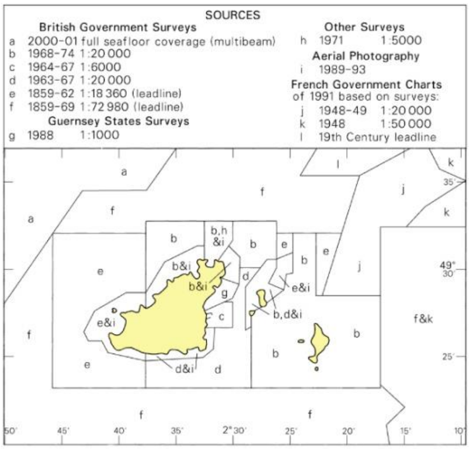
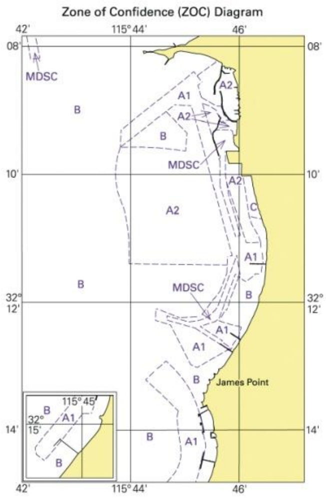


Figure 3. 2– Conventional Source Diagram
(From Chart Specifications of the IHO, S-4)



ZOC CATEGORIES
(For details see Australian Notice to Mariners No 25)

ZOC	POSITION ACCURACY	DEPTH ACCURACY	SEAFLOOR COVERAGE
A1	±5m	=0·50m + 1%d	All significant seafloor features detected.
A2	±20m	=1·00m + 2%d	All significant seafloor features detected.
B	±50m	=1·00m + 2%d	Uncharted features hazardous to surface navigation are not expected but may exist.
C	±500m	=2·00m + 5%d	Depth anomalies may be expected.
D	Worse than ZOC C	Worse than ZOC C	Large depth anomalies may be expected.
U	Unassessed - The quality of the bathymetric data has yet to be assessed.		
MDSC	Maintained Depth See Chart		

Figure 3. 3– Zone of Confidence Diagram
(From Chart Specifications of the IHO, S-4)

3.5 PROJECTIONS

The surface of the Earth, being a non-planar two-dimensional surface, cannot be depicted on a two-dimensional mapping plane without distortions. These distortions may occur in the depiction of distance, angles or shapes. Map or chart projections have been developed to minimize or to eliminate as many of these distortions as possible over certain areas, and the projection used depends on the specific requirement for a chart or map. No projection can retain all the terrestrial relationships exactly and to retain one, another must be sacrificed. For most nautical charts the Mercator projection is used because it has the useful navigational feature that loxodromes or rhumb lines (see Section 3.9.3) are portrayed as straight lines, i.e. they intersect all meridians at the same angle. Unfortunately, distances and areas become greatly distorted in higher latitudes when using a Mercator projection. Some projections are "conformal" in that angles are preserved and the shape of areas is retained, even if the scale must vary from one point to another.

The charts used for maritime boundary determination should preferably be on conformal projections, which provide the best available angle measurements, distances and directions (see Figure 3.6). In practice and taking into account the availability of existing charts as well as the characteristics of the area involved (location and extent), a suitable projection will be chosen.

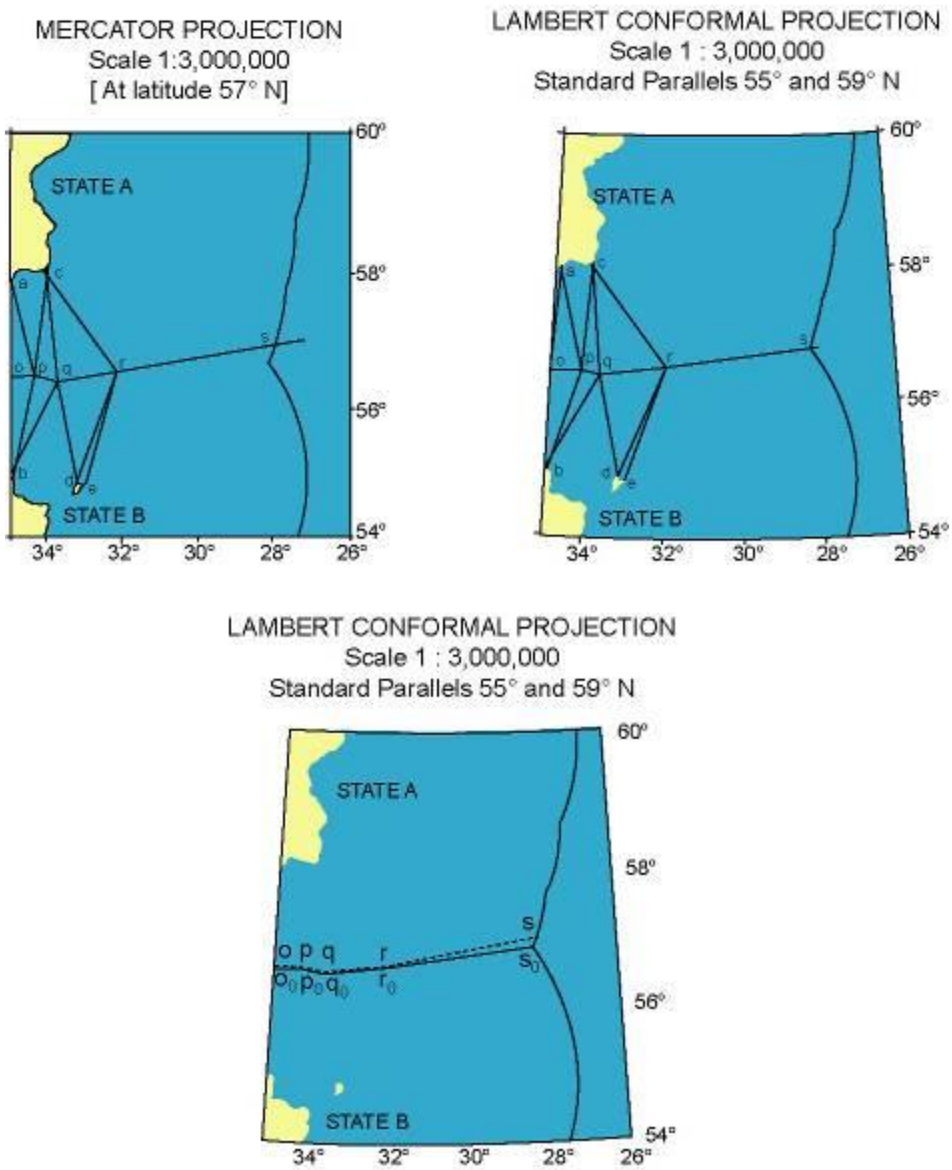


Figure 3. 4 – The effects of the Mercator and Lambert Projections on the development of a hypothetical equidistant line delimitation.

3.6 UNITS

3.6.1 Distance

The standard unit of distance and length measurement stipulated in UNCLOS is the International nautical mile (M). This nautical mile, approved by IHO at the International Hydrographic Conference of 1929, has a value of 1852 metres and is equivalent to the length of a minute of arc of geographical latitude at about 44 degrees of latitude.

3.6.2 Area

The unit of area measurement is normally the square kilometre (km2), in preference to the square nautical mile (M2).

3.7 SCALE

The scale of a chart, termed its natural scale, is expressed either as a fraction of unity or as a ratio. The comparison is theoretically between the length of a line measured on the chart and the distance that line represents on the surface of the earth (or more accurately on the surface of the imaginary ellipsoid chosen to represent the surface of the earth). A scale of 1/500,000 or 1:500,000 indicates that a length of 1 cm on the chart represents a distance of 500,000 cms (or 5,000 metres) on the surface of the earth. Similarly, a scale of 1/500 or 1:500 indicates that a length of l cm on the chart represents a distance of 500 cms (or 5 metres) on the earth's surface at the point(s) of projection. This relationship does not hold true for charts based on certain projections e.g. the Mercator projection.

Having chosen the most suitable projection, it is necessary to prepare or select a chart at the largest useful scale in relation to the area to be portrayed. The provisions in UNCLOS call for limits and boundary lines to be depicted on charts of a suitable scale. This requires that the scale chosen should be large enough to cover the area concerned and to ensure the greatest accuracy possible. In accordance with Article 16, straight baselines and closing lines (or the limits derived therefrom) and lines of delimitation shall be shown on charts of adequate scales for ascertaining their position, or alternatively a list of geographical coordinates of points shall be given with the geodetic datum specified. The accuracy of depiction of various lines and features on a chart is a function of the scale. A criterion in the choice of the scale is that it must provide the resolution necessary for the user to determine baselines and lines of delimitation to the same level of accuracy as originally achieved by the coastal State.

The choice of scale has a direct bearing on the accuracy with which a position can be determined on a chart by the user. The range of suitable scales will normally be from 1:100,000 to 1:1,000,000 for limits or lines of delimitation of the exclusive economic zone (EEZ) and continental shelf, while the scale for depicting baselines, limits, and boundaries within the territorial sea should be of the order of 1:50,000 to 1:100,000. The plotting errors (approximately 0.2 mm on paper, which is equivalent to the width of a drawn ink line) in the determination related to the various scales used are approximately as follows:

Scale	1:50,000	» 10 m
	1:200,000	» 40 m

When delimitation problems require numeric or geodetic solutions, it is necessary to extract numeric information from existing nautical charts. This is achieved by digitising the low water line and any other relevant features. In essence, the digitization process consists of a transformation from local coordinates that have been produced by a digitising apparatus (x, y in cm or inches) to geodetic latitude and longitude.

This process offers several advantages: -

a. If more recent and accurate positions have been geodetically derived, they can be used to correct the older information provided by the chart. This is achieved by using the new positions to determine the parameters of the coordinate transformation.

b. The digitization process has to be performed only once, whereas graphic solutions impose repetitive tasks.

c. The use of digital information allows for the utilization of very fast and accurate geodetic delimitation methods implemented in digital computers.

ENCs made from digital data (not from corresponding paper charts) permit a great increase in accuracy, with no plotting. Dedicated software is available that permits the use of ENCs for determining marine limits, thereby reducing the potential for error.

3.8 GRADUATION AND GRATICULE

3.8.1 Graduation

The graduation is the division and subdivision of latitude and longitude shown in the borders of a chart. All charts and most plans are graduated. A plan may be graduated on 2 sides only or it may be left ungraduated if it is of very small size or if the numbering of the graduation becomes impracticable, e.g. if successive half-minute-ticks do not occur within the limits. The pattern of graduation will vary with the scale of the chart.

3.8.2 Graticule

The graticule is the network of lines representing meridians and parallels on the chart.

3.9 STRAIGHT LINES AND DISTANCES

An important factor in the determination of some baselines, limits, and boundaries is to clearly define the nature of the "straight lines" that are to be used to join adjacent points. The following “curves” have been used for "straight lines".

3.9.1 Geodesic

The Geodesic also called a geodetic line is a curve giving the shortest distance between two points on a given surface. In the context of this manual it is assumed that the geodesic is calculated on a specific reference ellipsoid. (Generally, a geodesic is neither the line of sight, nor the chord, nor a plane curve). It will normally appear as a curve on a map projection.

3.9.2 Great Circle

A Great Circle is a circle drawn on the surface of a sphere, where the centre of the circle is coincident with the centre of the sphere. The shortest distance between two points on the surface of a sphere is defined by the segment of the Great Circle that passes through those two points.

3.9.3 Loxodrome / Rhumb Line

A loxodrome or rhumb line is a true straight line on a Mercator chart. Projected back onto the reference ellipsoid, it will generally differ from the geodesic curve and will generally not be a plane curve (see Figures 3.5, 3.6, and 3.7). A loxodrome has a constant azimuth. The difference between a loxodrome and geodesic can be significant, depending upon the length and direction of the line and its latitude (see Figure 3.8).

3.9.4 Normal Section

On a reference ellipsoid, the normal section is the curve obtained by intersecting the ellipsoid with a normal plane, i.e. a plane that contains the normal to the ellipsoid at one of the end points. If the ellipsoid had no flattening, i.e. it were a sphere, then all normal sections would be great circles because all normal planes would pass through the centre of the sphere.

3.9.5 Chord (on a mapping plane)

The chord is a straight line connecting two points on the map surface. On the Mercator projection the chord coincides with the loxodrome. Chords are generally not plane curves on the ellipsoid.

3.9.6 Line of Constant Bearing

Sometimes abbreviated as the "bearing", this line can have different shapes according to the meaning of the term “bearing”. If geodetic bearing (azimuth) is specified then the line coincides with the loxodrome. Generally, it is a curved line on the map, and not a plane curve on the reference ellipsoid.

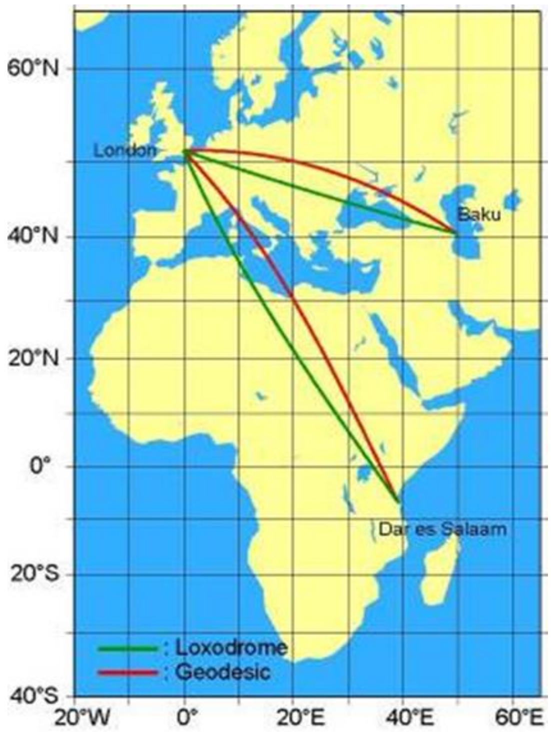


Figure 3. 5 - Loxodrome and geodesic on a Mercator chart

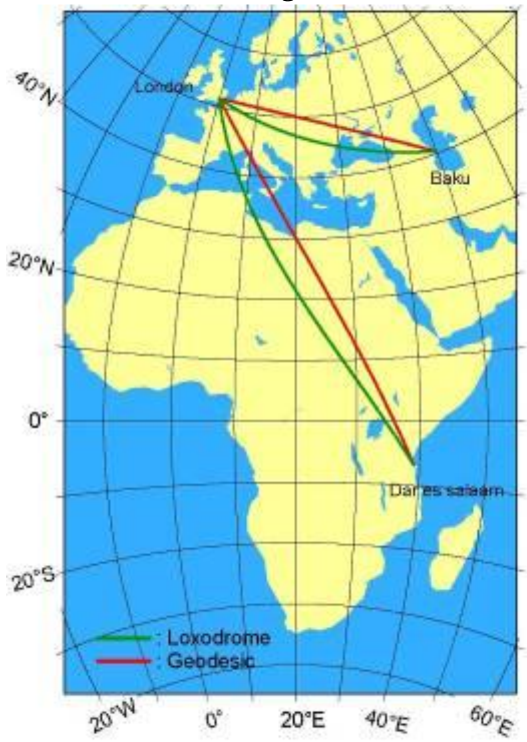


Figure 3. 6 - Loxodrome and geodesic on a Transverse Mercator chart

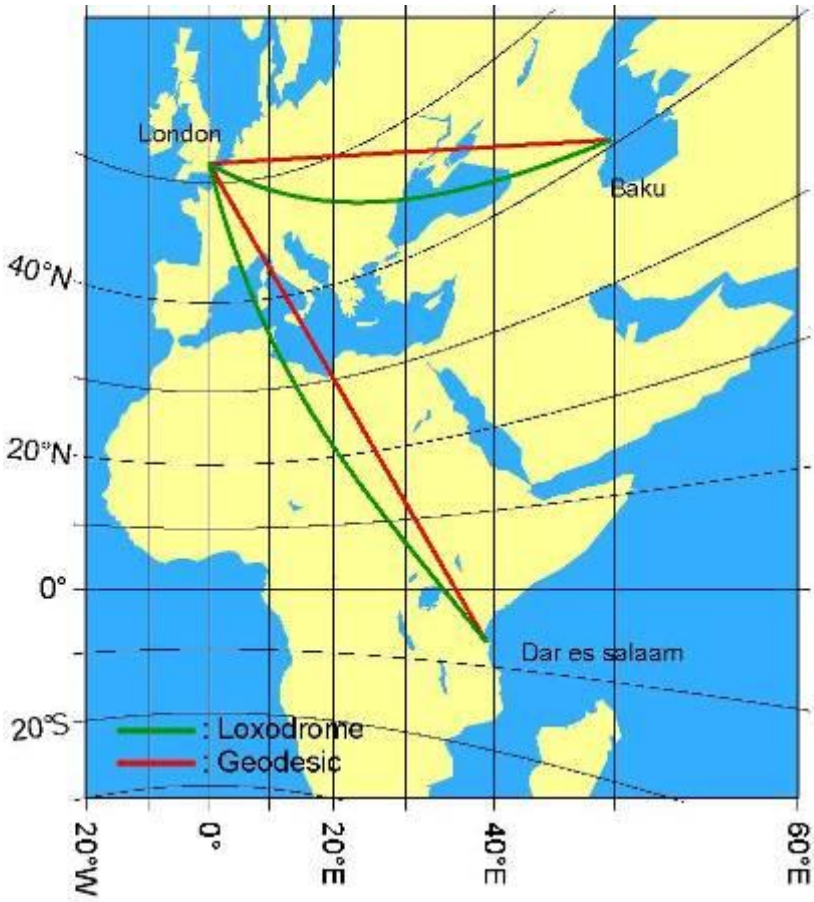


Figure 3. 7 - Loxodrome and geodesic on a gnomonic chart

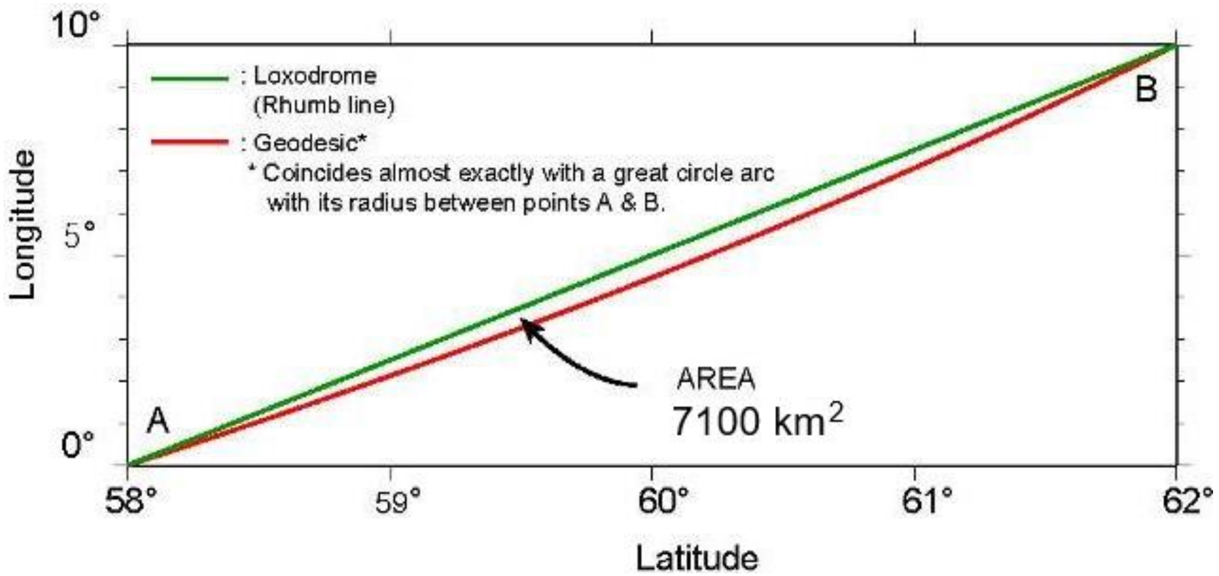


Figure 3. 8 - Comparison between a loxodrome and a geodesic connecting two points

3.9.7 Straight Lines on Charts

In baseline descriptions and in boundary definitions, the term "straight line" is frequently used, so it is necessary to appreciate that a "straight" line on one projection may not appear as a "straight" line on another.

On a Mercator projection the equator and all meridians appear as straight lines, and as they are also great circles, they must represent a straight line “shortest distance” on the earth's surface. But parallels of latitude are also shown as straight lines, and they are not great circles; in fact, the equator and the meridians are the ONLY great circles shown as straight lines on a Mercator chart. All other great circles will plot as curved lines with their centres of curvature on the side away from the nearest pole (Figure 3.9).

Figure 3. 9 - Part of the North Atlantic Ocean on the Mercator Projection, showing great circle (curved) and rhumb-line (straight) paths between Halifax and Lerwick

At first sight this seems to be a contradiction, since it suggests that a curved line between two points is shorter than a straight line. But earlier it was explained how the scale of the projection increases towards the poles, so that a given measurement on the chart will represent greater terrestrial distances near the equator than near the poles.

In Figure 3.9 it can be seen that the great circle appears longer than the rhumb line. However, if this had been plotted on a Gnomonic projection, the same curved line would appear as a straight line and the rhumb line would appear as the longer curved line.

3.10 BEARINGS

The bearing is the horizontal direction of one terrestrial point from another, expressed as the angular distance from a reference direction. It is usually measured from 0° as the reference direction clockwise through 360°. The terms Bearing and Azimuth are sometimes used interchangeably, but in navigation the former customarily applies to terrestrial objects, and the latter to the direction of a point on the celestial sphere from a point on the Earth. A bearing is designated as True, Magnetic, or Compass North (Hydrographic Dictionary, IHO Publication S-32)

3.11 WORKING ON THE CHART

3.11.1 Introduction

When working on maritime limits and boundaries it will be necessary to read off geographical positions from appropriate charts or maps, or to plot geographical positions on them. It may also be necessary to construct lines on charts for illustrative purposes, or to assist in identifying the base points to be used in computing a straight baseline, limit, or boundary. The construction of boundaries and selection of base points is considered in Chapters 4, 5 and 6.

A chart must be treated with care if it is not to give misleading results. Since charts are usually made of paper they are liable to shrink or stretch with changes of temperature and humidity. But provided they are treated with reasonable care, such changes should not significantly affect accuracy. Charted parallels and meridians are generally spaced sufficiently close together to limit the effects of distortion so long as measurements (of bearing, distance, latitude or longitude) are read off as close to the positions being measured as possible. Charts should be maintained in good condition. If possible, the folding of charts should be avoided. They should be stored and transported flat or rolled up. Damp conditions should also be avoided.

3.11.2 The Nautical Mile

As has been explained in Chapter 2, the regular mathematical figure that most closely approximates the true shape of the earth is the spheroid or ellipsoid and this is the figure used by geodesists, surveyors and cartographers. In this representation the equator is a true circle, but the meridians are slightly flattened at the poles (see Figure 3.10).

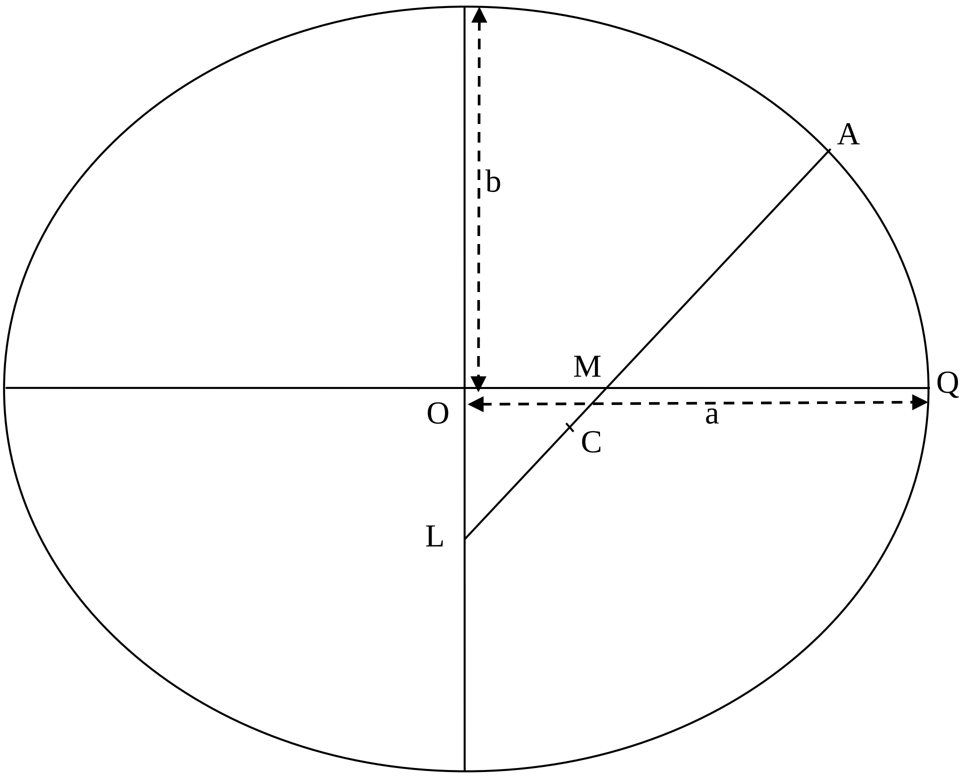


Figure 3. 10– Cross-section through an Ellipsoid, to illustrate polar flattening

The effect is greatly exaggerated in the diagram. In fact the flattening is not great, and the polar ‘diameter’ is about 0.997 of the equatorial ‘diameter’. It can be seen from the diagram, though, that the radius of curvature of a meridian (PAQ) is not constant, and that it is least at the equator Q and greatest at the pole P. Having moved away from the concept of the earth as a sphere, it is necessary to reconsider the basis of the angular measure of latitude: a minute of latitude is correctly defined as the length along a meridian that subtends an angle of one minute at the centre of the radius of curvature. Because of the flattening of the ellipsoid the radius of curvature varies with latitude, and so also must the length of a minute of latitude. It is least at the equator and greatest at the poles. The actual length varies from about 1843 metres to about 1862 metres.

For general navigational purposes these differences are not significant, but where accurate measurements are needed it is convenient to have recourse to a standard length. For this purpose a value of 1852 metres has been adopted as the length of the International Nautical Mile, and is equivalent to the length of a minute of latitude at about 44° latitude. It is the length normally meant when referring to the "nautical mile".

It should be noted that the variation in the length of a minute of latitude on the Earth's surface (or rather on the ellipsoid that represents it) has nothing to do with the continuous change of scale along the latitude graduation of the Mercator projection. The former has to do with the shape of the earth and affects all projections. The latter has entirely to do with a particular method used to represent the earth's curved surface on a flat piece of paper and affects only charts constructed on the Mercator projection. (Other distortions will affect other projections!)

It must be remembered that it is the international nautical mile that is used for describing the breadth of zones such as the territorial sea and EEZ. As described above it is not the same as a minute of latitude except at one particular latitude. For accurate plotting of distances this difference can be significant and must be taken into account.

3.11.3. Latitudes and Longitudes

There are many ways in which a position on the surface of the earth may be defined. The global system that is best known and universally used in marine navigation is that of geographical coordinates, latitude and longitude. In this system, the surface of the Earth is gridded with "parallels of latitude" that are oriented east and west and measured and numbered as angles north and south of the equatorial plane. Perpendicular to these are the "meridians" or lines of equal "longitude" that are oriented north and south and converge at the poles. Conventionally the meridian known as the Prime Meridian, running through Greenwich, UK, is assigned as the zero reference, and the longitude is measured as an angle to the west or east of the Greenwich meridian. On most projections, due to their convergence, the meridians do not cut the parallels of latitude at right angles but the Mercator projection is designed so that the lines of latitude and longitude are perpendicular to each other.

To ease the problems of computing positions on a spherical surface, both latitude and longitude are expressed in angular measure. Latitude is measured from 0 to 90 degrees north or south of the Equator. The Equator is 0°, the North Pole is at Latitude 90° North, and the South Pole is at Latitude 90° South. Longitude is measured from 0° to 180° East, and from 0° to 180° West, of the Prime Meridian. The meridian of Longitude 180° East is the same as the meridian of Longitude 180° West. It lies diametrically opposite the Prime Meridian (of 0°). The international meridian of zero longitude was originally defined by the rotation axis of the Earth and a specific point located at the former Royal Observatory at Greenwich, near London in the UK. It has in recent times been modified by international agreement to have a physical location close to, but not identical with, the original line as defined by the International Earth Rotation Service (IERS).

The angular measure of a "degree" (denoted by the symbol °) is usually sub-divided into minutes (') and seconds ("). There are 60 minutes to a degree, and 60 seconds to a minute. It should be noted that mathematical calculations require a high level of precision and that consideration should always be given to providing coordinates to decimals of a second if required. To avoid confusion with units of time or temperature these units of angular measure may be referred to as degrees, minutes and seconds "of arc".

The majority of charts, excepting some older large-scale sheets, are graduated in latitude and longitude. The graduations are shown along the borders of the chart. The inner neat lines of the border are almost always oriented due north-south and due east-west, so that they are meridians (along which the latitude graduation is shown), and parallels (along which the longitude graduation is shown). In addition, a selection of meridians and parallels are shown on the face of the chart, spaced so as to facilitate the plotting or reading of positions. The resulting network of intersecting meridians and parallels is called a graticule

3.11.3.1 Reading Latitudes and Longitudes on Mercator Charts

Two methods are available for reading geographical coordinates from a Mercator chart: one using a parallel ruler and the other using dividers. In the first method one edge of the parallel ruler is aligned with the charted parallel or meridian (depending on whether the latitude or the longitude is required) nearest to the point whose coordinates are to be read off. The ruler should be positioned to overlap both the graduation on one border and the required point. The ruler is then carefully rolled to bring an edge over that point. With a well sharpened pencil held against the edge of the ruler a fine line should be drawn through the point (to check alignment). Then, holding the pencil at the same angle to the edge of the ruler, draw a fine line across the graduation scale on the border. The parallel ruler may then be moved to allow the latitude or longitude of the line on the scale to be read and recorded. Exactly the same procedure is followed for reading the other coordinate. Care must be taken in rolling the ruler to ensure that uneven pressures do not cause it to slew out of parallel. Graduated set squares may be used in lieu of a parallel ruler.

In the second method, dividers are held so that one point of the dividers is placed on the exact position whose coordinates are to be read. The dividers are carefully adjusted so that the other point just touches the nearest charted parallel or meridian, as appropriate, due north or south, or due east or west, of the position to be read. The dividers are then placed against the appropriate border graduation nearest to the position to be read, with one point at the intersection of the charted parallel or meridian and the graduation. The latitude or longitude indicated on the scale by the other point of the dividers is that which is required.

It takes practice to learn how to hold the dividers at an angle to the paper so that the points are on the required positions but not sticking into the paper. If the points are continually pushed in, the exact position on the chart will become obscured by the resultant damage to the paper.

Charts used to be engraved on copper printing plates. Subsequent corrections were made by hammering out the engraved work in the relevant area before inserting the corrected detail. The hammering inevitably slightly distorted the plate in the area of the correction, and frequently one or more of the charted parallels or meridians would be bent. Although there are probably no charts in current use that have been printed directly from copper, many older charts have been transferred to more modern plates, and the distortions will have been transferred also.

If at all possible, charts based on old plates should be avoided, and alternative sources or charts should be sought. That may not always be possible, however, in which case considerable care must be taken, and it must be recognized that the results will probably be less accurate than is desirable. In these cases the parallel ruler method is often to be preferred because the rulers may be aligned along a sufficient length of parallel or meridian for the effect of local distortions to be eliminated. It may, however, be impossible to find an alignment that is entirely satisfactory, and in particular, if the position is near the middle of the chart, comparison of intersections with opposite borders may show a discrepancy. It may be necessary to take a mean of two readings.

3.11.3.2 Plotting Positions by Latitude and Longitude on Mercator Charts

On a Mercator chart, plotting a position is the reverse of the parallel ruler method of reading it from the chart. The ruler is aligned on a parallel or meridian as near the required position as possible, and overlapping both the appropriate border graduation and the longitude or latitude of the position. It is then carefully rolled to a point where a fine pencil line can be inscribed across the graduation at the required latitude or longitude. Another line is inscribed of sufficient length to be sure that it will pass through the desired position to be plotted. This is repeated for the other coordinate, and the intersection of the two lines marks the position.

3.11.4 Use of Bearings and Distances on Mercator Charts

Plotting positions on a chart by a bearing and distance from a known charted position may be required in boundary delimitation. However, it is only accurate (within the limitations of scale) over quite short distances because of the problems of distance measurement on the Mercator projection, or because of the difficulty of projecting a line of constant bearing on non-Mercator projections that depict meridians as converging lines.

The bearing is measured either with reference to a nearby meridian using a protractor or specially designed parallel ruler, or it may be made with reference to the compass roses, which will be found located at convenient points on the chart. In the case of the latter, great care should be taken in using the compass circle referenced to true and not magnetic north. After drawing the line of bearing, the distance may be measured either with reference to the latitude scale (at the same parallel at which the measurement is being made), or to the distance scale on non-Mercator charts. The distances can be set off using dividers.

A position determined by bearing and distance is generally described as being so many degrees and such and such a distance from a specific feature (which may be called the reference point) which is either defined by precise geographical coordinates or is clearly identifiable as an unambiguous point on the chart. Such an identifiable feature might be a lighthouse or a beacon; if it cannot be identified as an unambiguous point the accuracy of the position is immediately in question. That might occur if the feature were a rounded headland.

Compass bearings are usually given in "whole circle" notation from 0° to 360° where true North is both 0° and 360°, and bearings are measured clockwise (i.e. towards east, south and west in that order). Alternately, they may be given in quadrantal notation e.g. N36E, although this notation is rarely used today. They may, of course, be expressed in the form of degrees and decimals of a degree, degrees and minutes (and decimals of a minute), or they may be given in degrees, minutes and seconds (and decimals of a second). But if the position has been taken off a chart, or has been determined by compass bearings it can only have been read off to within about a quarter of a degree (15'). Distances, which will be quite short if this method is being used (see above), are most likely to be given in nautical miles (probably without regard to the difference between a minute of latitude and the International Nautical Mile - see earlier text).

3.11.5 Working on Non-Mercator Charts

The positions of base points must generally be determined by reference to the largest scale chart available. Where existing charts are inadequate, precise geographical coordinates may have to be taken off a large-scale land map of the area. Large-scale charts may be found to be on a non-Mercator projection, and it is almost certain that no land map of the type being considered would be on the Mercator projection.

At the large scales likely to be used in these instances, the convergence of the meridians and curvature of the parallels that occur on other projections will be practically undetectable within the bounds of adjacent mapped or charted meridians and parallels. In that case plotting by latitudes and longitudes may be carried out as already described. Readings should always be taken by reference to the nearest set of graduations.

If the curvature of the parallels is detectable between the area concerned and the nearest latitude graduation, it will be necessary to inscribe a meridian by joining the appropriate longitude graduations at the required position. The latitude difference from the nearest parallel (taken off with dividers) may then be referred from this inscribed meridian to the border graduation or vice versa.
Similarly, if the convergence of the meridians is such that different readings would be obtained from the lower and upper border graduations, it will be necessary to inscribe a local meridian by connecting like values along the two graduations as near as possible to the required position. Use the dividers to measure the longitude difference between this meridian and the desired position and then transfer it to the nearest graduated border for reference. This reduces the chance for significant error.

On many maps the main positional reference system is provided by a square grid. These generally refer to distances (usually in metres or kilometres) north or south, and east or west, of a local Point of Origin. Despite the use of the familiar terms "north" and "east" these 'rectangular spheroidal coordinates' cannot be converted to latitude and longitude by a simple process of adding or subtracting some fixed value. Such grids often have much closer mapped sub-divisions than is provided for the geographical graduation, and may be much more convenient to use. The local (or national) grid coordinates so obtained can be converted to geographical coordinates using an appropriate formula, a time-consuming process without the aid of a computer and appropriate software!

A feature of many large-scale maps is that the borders frequently do not show close latitude and longitude graduations, and often there are no continuous lines denoting meridians or parallels. Furthermore, if the map is gridded the borders are unlikely to be oriented north-south and east-west. In such cases intervals of latitude and longitude are shown around the border, but often widely spaced and with no intermediate values. Their points of intersection may be indicated on the map by small crosses. By joining the appropriate intersection points with pencilled lines a local graticule can be constructed.

The lack of any sub-division of the border graduation should present no difficulty. The appropriate distances to the nearest meridians and parallels may be read off a ruler graduated, preferably, in millimetres. These distances may be compared with the measured distances between adjacent meridians or parallels, and by simple proportion the interval may be converted to a difference of latitude or longitude. There is no problem of a constantly changing latitude scale as is found with Mercator. (Changes of scale do occur with these projections, but they are seldom significant for plotting purposes. They are, however, significant if computational precision is required, and calculations of positions using the mathematics of the projections have to take this into account).

3.11.6 Working on Electronic Navigational Charts within GIS

Although positions plotting or distance measuring with GIS look much easier than with the paper chart, it is important to be fully conversant in the procedures of plotting or measuring in the GIS you are using. Some simple GIS or even full GIS may use a simple method like the measurement of only counting dots on the display between two positions. Depending on objectives, it may be necessary to introduce a prepared special calculation library or to develop an appropriate calculation program from scratch.

3.12 Generalization

When analysis on charts is done, it is necessary to bear in mind that features on any map have the possibility to be generalized. Generalization is defined by S-32 as follows:

The omission of less important detail when compiling a chart. Its purpose is to avoid overloading charts where space is limited.
http://hd.iho.int/en/index.php/generalisation

Map scale is not 1:1 so that any depiction of features is denser than the real world. In addition, printing density is regulated by printing technology and (this is more important) the limit of eye acuity (approximately 0.02mm). It is difficult to reduce the width of printing lines. Normally, it is approximately 0.1mm at the minimum. In order to express the shape or importance of a feature a larger size is used. The minimum size can be regarded as the element unit of the portrayal similar to the resolution.

Thus, there is a minimum size in order to illustrate a feature on a paper map. Environmental conditions also have an impact such as colour, contrast of print or the light environment around maps that may have the effect of reducing the minimum size that can be clearly seen. Nautical charts are used for navigation at the sea in a challenging environment and for this reason features are often depicted larger than the minimum figures discussed above.

The minimum size of features is governed by the scale of map; the smaller the scale the larger the minimum size. For example, 0.2 mm on paper at a scale of 1:1,000 can be recognized in the ideal situation although in practice this may be worse, 0.2 mm on a map of this scale equals 20 cm in the real world, which means it is impossible to portray anything smaller than 20 cm. When using a smaller scale such as 1:1,000,000 the minimum size of 0.2mm on the map represents 200 m on the ground. This can increase to 1000 m in some cases and is the reason why large scale charts or maps should be used for UNCLOS work.

As nautical charts are designed for navigational safety, it must be borne in mind that some features that are not critical for navigational safety but are still considered important enough to be depicted will be moved slightly so as not to mask the navigationally critical feature. An example would be the symbols for the nature of the bottom such as mud, sand or rock that would be moved so as not to mask critical bathymetric depths.

Sinuous lines such as depth contours and coastline are often simplified on smaller scale charts for clarity. Depth contours in particular will be merged in steep bottom topography.

CHAPTER 4 – BASELINES

(The reader of this Section is advised to refer to a more detailed treatment of the subject contained in the U.N. Publication E.88.V.5 Baselines: An Examination of the Relevant Provisions of the United Nations Convention on the Law of the Sea)

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4. BASELINES

This chapter addresses three types of baseline: normal, straight, and straight archipelagic.

The normal baseline is the basic element from which the territorial sea and other maritime zones are determined. It is defined as the low water line along the coast, as marked on large-scale charts of the Coastal State (Article 5).

Straight baselines are defined by straight lines that join points on the coastline, which have been selected according to the criteria listed in Article 7. They delineate internal waters from territorial seas and other maritime zones.

Straight archipelagic baselines define the periphery on an island group by joining the outermost islands with a succession of straight lines constructed in accordance with Article 47.

4.1 THE NORMAL BASELINE

The general definition of the normal baseline comprises the elements addressed in UNCLOS Articles 5, 6, 11, and 13, namely the low-water line along the continental shore and around islands, including the outer limits of permanent harbour works, the low-water line around certain low-tide elevations, and the seaward low-water line of atoll reefs and of fringing reefs around islands.

In well-surveyed and well-charted areas, the low-water line is clearly depicted on large-scale nautical charts. Usually the largest scale chart of any section of low-water line will incorporate the most recent survey results, and will depict them in most detail. However, it should be noted that in many parts of the world the area between the high-water line and the 5 metre isobath is often based on old data. As mentioned in Chapter 3, the low-water line corresponds to the local level of chart datum. In places where there is little or no tidal range, or where the coast is very steep, no area may be visible between the high- and low-water lines depicted on the chart. In that case, the coastline that is shown on the chart may be taken as the normal baseline.

On older charts, particularly in areas where there are numerous sandbanks or near-shore reefs, or where in general the shallow water features may be rather complex, the symbols used may not always make a clear distinction between the low-water line and shallow water contours. Sometimes the representation is intended more to indicate the presence of a feature, than to specify its precise nature. Sailing Directions (which are normally published by the publisher of the chart) may provide some assistance in resolving whether or not an isolated shoal or reef is a low-tide elevation. In some cases, it may be possible to resolve the problem through reference to more modern land maps, or by inspection of aerial photography or satellite imagery that may have been used in the construction of the original charts. If there is serious doubt, the matter should ideally be resolved with a field survey operation.

There may be instances where the only available charts are based on inadequate geodetic control. Not only may there be an overall positional discrepancy, but there may also be errors in the relative positioning of the different topographical features. Such discrepancies can only be properly resolved by a new survey. If bilateral boundary negotiations cannot be delayed for the considerable time needed to carry out such work, the best supplementary information available should be used, which will usually be found on a land map. If systematic aerial photographic coverage of the region is available, the actual coastline (low-water mark) or the potential base-points can be identified. This method of coordinate determination is often superior to coordinates taken from maps. High-resolution satellite imagery can again be considered.

Article 5 requires that the low-water line, which defines the normal baseline should be determined from charts which are officially recognised by the Coastal State. Not all Coastal States publish their own charts, and for many coastal areas, it could be years before charts are produced at scales suitable for baseline definition. In such cases, it is recommended to adopt if possible the charts published by the State that undertook the primary charting.

When referring to charts, maps, aerial photographs, satellite images or other documents, care should be taken to always use the most recent and up-to-date editions. In addition, it is important to verify that corrections issued after a given chart's publication date have been incorporated.

4.2 THE STRAIGHT BASELINE

A baseline may be defined by one or more sections of straight line in circumstances specified by UNCLOS:

a. across the mouth of a river;
b. across the mouth of a juridical bay or a historical bay;
c. as part of a system of straight baselines; or
d. as an archipelagic straight baseline.

When considering the application of any of these relevant UNCLOS Articles, the technical provisions of the relevant Articles must be carefully studied, even though truly objective criteria are not always provided.

4.2.1 Mouth of a River

If a river flows directly into the sea, the baseline shall be a straight line across the mouth of the river between points on the low-water line of its banks (Article 9).

4.2.2 Bay Closing Line

The determination of juridical bay closing lines is a complex operation, with detailed and objective criteria provided by Article 10. UNCLOS provides for closing lines only in juridical bays where the coasts belong to a single State. The treatment of historic bays is less well defined, and is mentioned in Article 298 within the context of dispute resolution.

Two distinct determinations must be made in developing the closing line of a juridical bay: whether a well-marked indentation exists; and the locations of appropriate points to define the ends of the closing line(s).

The identification of "natural entrance points" may present difficulties, although the requirement of the Convention is that the bay should be a "well-marked indentation". Difficulties may exist in this determination when there are islands in the entrance of the bay, or where one side of the bay curves gently inwards from the general direction of the coast. There is no universal agreement for determining natural entrance points, although some States have developed their own methods. A bay has more than one entrance point if one or more islands are situated at the mouth of the bay. The term "low-water mark" is used in Article 10, which has been consistently interpreted as being synonymous with the term "low-water line".

UNCLOS specifies some objective tests to determine whether or not a well-marked indentation is a juridical bay by comparing two areas (see Figure 4.1):

a. the area of a semi-circle the diameter of which is equal to the length of a line joining the bay’s natural entrance points. If there is more than one mouth, then the diameter (twice the radius r) of the semi-circle is to equal the sum of the lengths of the lines joining the entrance points of the different mouths. The area may be approximately calculated using the normal rule for the area of a semi-circle on a plane. For critical cases where a more precise result is needed, geodetic methods should be used.

b. the area of the waters of the indentation enclosed by the lines across the entrance points and the shore (low-water line) of the indentation. The area of any islands within the indentation is to be included as part of the water area.

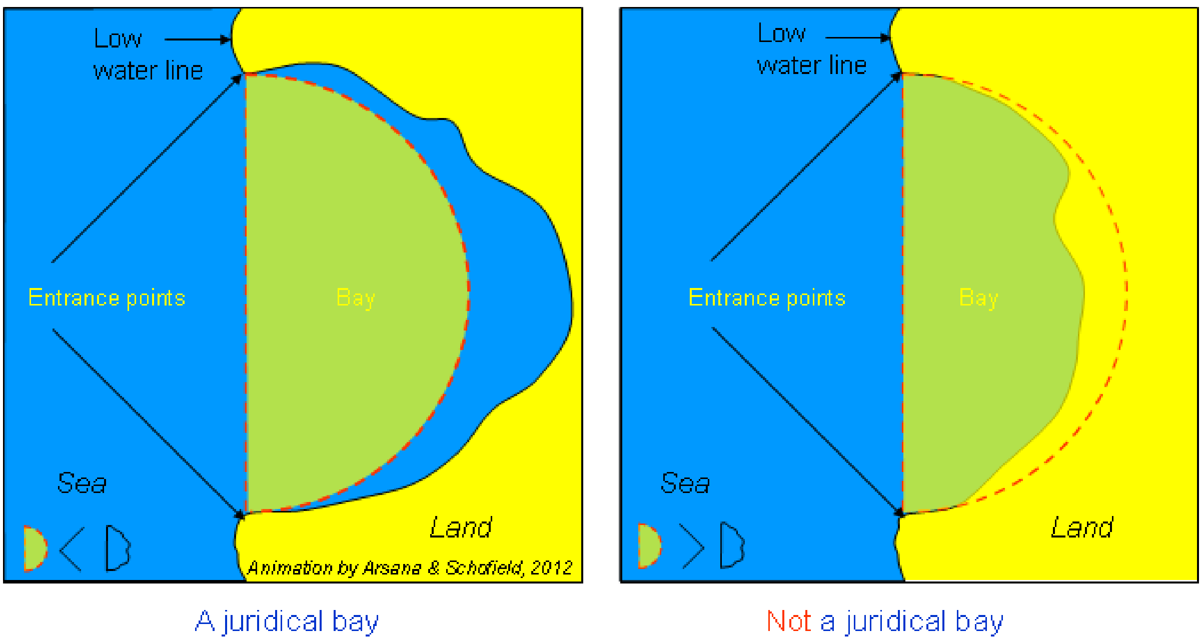

Figure 4.1 – Juridical bay – On the left, the area bounded by the bay closing line and the low water line of the indentation is larger than the area of the semi-circle and therefore does qualify as a juridical bay. On the right, the area bounded by the bay closing line and the low-water line of the indentation is smaller than the area within the semi-circle and hence does not qualify as a juridical bay.
(Animation: [Figure4_1.ppt)](Figure4_1.ppt)

Having determined that an indentation is a juridical bay, it then becomes necessary to consider where the closing line(s) may be placed. The critical parameter in this process is the length of the closing line between entrance points, or the combined lengths if there are two or more closing lines. For the purposes of this discussion, that length will be referred to as the "closing length".

If the closing length does not exceed 24 nautical miles, then the line or lines may be used to close the bay. If the closing length exceeds 24 nautical miles, it will be necessary to develop a new and shorter closing line within the bay. Usually, this location is not difficult to determine, since an inspection of the chart should identify its approximate position.

It frequently happens that a single large indentation may have a number of smaller indentations around its shores, some of which may individually satisfy the criteria of a juridical bay. If the large indentation has a mouth that is greater than 24 nautical miles wide, it may not be acceptable to close it off as a juridical bay, however the smaller indentations can be treated as juridical bays if they satisfy the conditions individually.

If A1 is greater than the area of the bay, the indentation may not be considered a juridical bay, and may not be closed. Sub-indentations may exist within the main bay, and some of these may individually satisfy the conditions for a juridical bay. Islands within an indentation must be considered as part of the water area when testing whether the indentation may be treated as a bay.

4.2.3 Straight Baseline System

Article 7 permits a Coastal State to draw straight baselines in place of or in combination with normal baselines, i.e. the coastal low-water line, provided certain conditions specified in the Article are met, namely:

> "Where the coastline is deeply indented and cut into, or if there is a fringe of islands along the coast in its immediate vicinity."

The rationale for allowing straight baselines in these circumstances is to obviate the determination of highly irregular normal baselines, which in turn would generate similarly irregular outer limit lines of maritime zones. While the LOS Convention itself contains no criteria or guidance as to what constitutes a coastline, which is "deeply indented and cut into" or "fringe of islands", a detailed discussion of this subject is contained in the UN Publication Baselines. This publication also elaborates on what may constitute "fringe of islands" and "immediate vicinity". In the paragraphs that follow, extracts from this publication are presented as quotations, followed in some cases by amplifying comments:

> "Where a coastline is highly unstable due to the presence of a delta or other natural conditions, base points may be selected along the furthest seaward extent of the low-water line."

The instability may be checked by comparing modern surveys, maps, aerial photography, etc., with older ones. The reliability of the conclusions will depend to some extent on the duration of the study period: some coastlines are subject to large short-term changes whilst retaining relative stability over the long term. This provision should not be confused with Article 9, which deals with the closing of river mouths.

> "Straight baselines must not depart to any appreciable extent from the general direction of the coast."

From a technical standpoint, this description refers to the angle of convergence or divergence between the general direction of the coastline; however, it may be determined, and the bearing of a proposed straight baseline. In this context it is also noteworthy that UNCLOS does not specify any maximum permitted length for a straight baseline.

> "Sea areas lying within straight baselines must be sufficiently closely linked to the land domain to qualify as internal waters."

There is no definitive mathematical criterion for determining what is "closely linked" in terms of physical proximity.

> "Straight baselines may be drawn to and from low tide elevations only where lighthouses or similar installations have been built permanently above sea level on such elevations. An exception is provided for instances where general international recognition has been given even if the above condition has not been met."

> "In determining particular straight baselines, economic and historical factors peculiar to the region concerned may be taken into consideration."

> "It is prohibited to draw straight baselines in a manner such that it prevents access by another State from its territorial seas to either the high seas or an exclusive economic zone."

4.3 STRAIGHT ARCHIPELAGIC BASELINES

Article 46 states the defining characteristics of an archipelago and of an archipelagic state. Article 47 contains specific technical criteria for the construction of archipelagic baselines.

Archipelagic baselines must encompass the main islands of the archipelago, although "main islands" are not clearly defined in Article 47. Within the area enclosed by the baselines, the ratio of area of water to area of land must be between 1:1 and 9:1. The area of land may include the area of any atolls, islands, drying reefs and enclosed lagoon waters, also waters lying within the fringing reefs of islands.

Baselines must not depart to any appreciable extent from the general configuration of the archipelago. As with 'general direction of the coast', this is a subjective criterion. In most cases it is probable that the archipelagic baselines will themselves suggest the general configuration of the archipelago.

The length of the individual baselines must not exceed 100 nautical miles, except that up to 3 per cent of the total number of archipelagic baselines may be up to 125 nautical miles in length. There is no limit to the number of baseline segments that may be drawn. If, however, in order to include a number of segments of more than 100 nautical miles, it is decided to increase the number of shorter lines, so that the 3 per cent criterion is satisfied, care must be taken that the other criteria are still satisfied.

Baselines (see Figure 4.2) may be drawn to join the outermost points of the outermost islands and drying reefs of the archipelago. But they cannot be drawn to and from a low-tide elevation unless: (a) a lighthouse or similar installation, which is permanently above water has been built upon it; or (b) the elevation is situated wholly or partly within the breadth of the territorial sea from the nearest island. These provisions differ from those of Article 7(4) for a system of straight baselines.

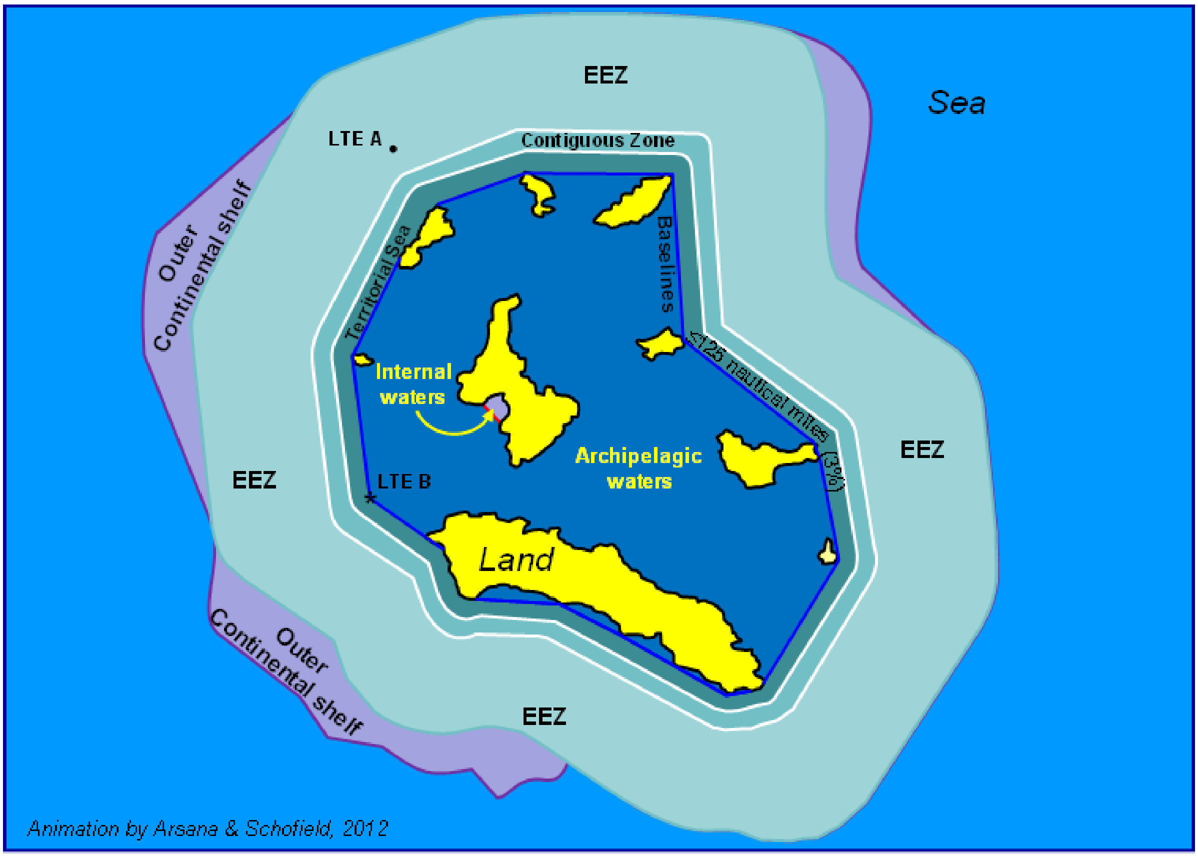

Figure 4.2 - Archipelagic Straight Baselines. EEZ: Exclusive Economic Zone; LTE A: Low-Tide Elevation with no navigational mark; LTE B: Low-Tide Elevation with navigational mark. (after Francalanci and Romano, 1986).
(Animations: Figure4_2.ppt)

Article 47(5) which requires that the system of archipelagic baselines "... shall not be applied ... in such a manner as to cut off from the high seas or the exclusive economic zone the territorial sea of another State."

4.4 ISLANDS

Even on a detailed chart, it is not always possible to determine whether a small feature is a natural island, an artificial island, or a low-tide elevation with a structure built upon it. It may be possible to resolve the matter by reference to the Sailing Directions. Failing that, it may be necessary to undertake a visual inspection or a hydrographic survey, to determine if the feature is a low-tide elevation or an island.

An island is defined in Article 121(1) as any naturally formed area of land that is surrounded by water and which is above water at high tide. The low-water line surrounding such a feature, regardless of its size, may form the baseline or a part of the baseline from which to measure the maritime zones. If the feature is a rock, which cannot sustain human habitation or economic life of its own, then it cannot have an exclusive economic zone or continental shelf. UNCLOS does not explicitly define what a rock is, nor does it distinguish a rock from an island.

According to Article 7(1), a fringe of islands near the coast may be used to establish straight baselines.

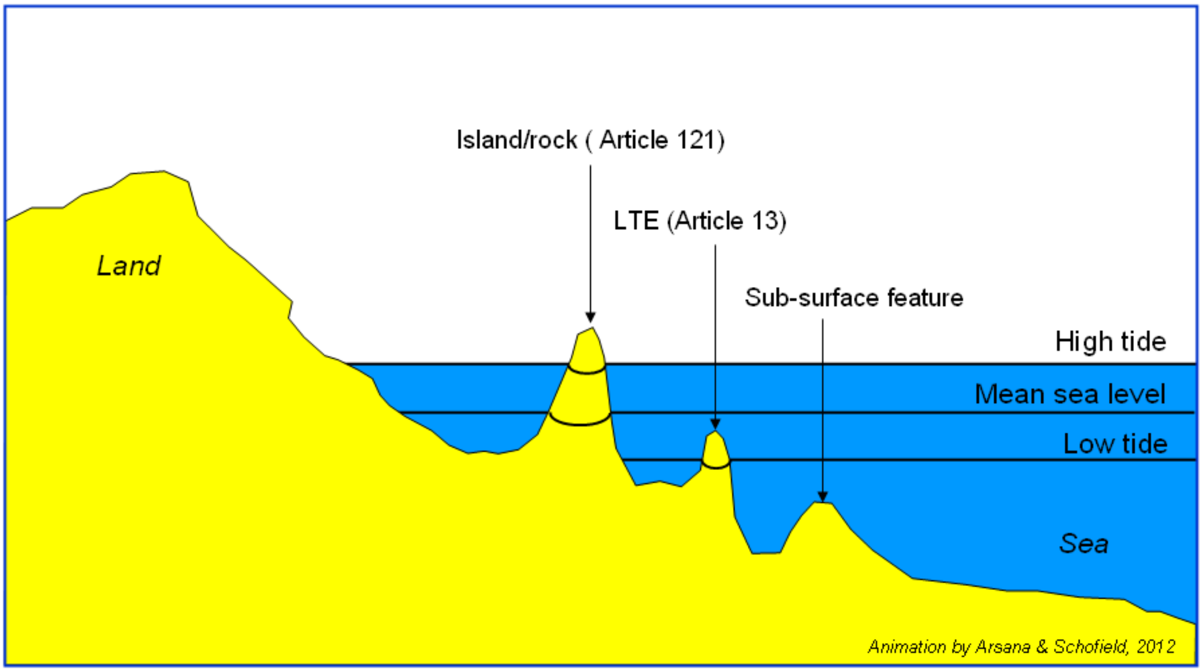

Figure 4.3 – Islands and low-tide elevations. If the low-tide elevation lies wholly outside the breadth of the territorial sea measured from the mainland or an island, it may not be used as part of the baseline. See Figure 4.4.
(Animation: Figure4_3.ppt)

4.5 PARTICULAR CASES

Some particular circumstances pertaining to baselines must be studied. They represent exceptions or limitations to the application of the "normal baseline". They are: coastal installations, offshore installations, low-tide elevations and reefs. Mention will also be made of the termination of a system of straight baselines at a boundary between two States.

4.5.1 Coastal Installations

Article 11 states that "...permanent harbour works which form an integral part of the harbour system are regarded as forming part of the coast". It has been generally recognised that these include all permanent works, such as harbour jetties, breakwater etc., and also such coast protection works as sea walls, which have obscured the natural low-water line. They do not include structures, such as might carry sewage outfalls etc., which are not part of a harbour work and are not associated with coast protection.

4.5.2 Offshore Installations

Such features, which include artificial islands, do not possess the status of islands and do not form a part of the baseline. They have no territorial sea of their own. Note, however, that in some circumstances straight baselines or archipelagic baselines may be drawn to and from low-tide elevations which have lighthouses or similar installations that are built upon them and which are permanently above water (Articles 7 and 47).

4.5.3 Low-tide elevation (Article 13)

A low-tide elevation is defined in Article 13 of UNCLOS as a “naturally-formed area of land which is surrounded by water at low-tide but submerged at high-tide.” (see Figure 4.3).

A naturally-formed low-tide elevation may be part of the "normal" baseline only if all or a part of the elevation lies within the breadth of the territorial sea, measured from the mainland or an island. If the low-tide elevation lies wholly outside the breadth of the territorial sea measured from the mainland or an island, it may not be used as part of the baseline (see Figure 4.4).

Straight baselines may be drawn to low-tide elevations only if they have a lighthouse or similar installation permanently above sea level built on them, except in instances where the drawing of the baselines to and from such elevations have received general international recognition.

Straight archipelagic baselines may be drawn to low-tide elevations if they meet the criterion of distance (as for the normal baseline), or if they have a lighthouse or similar installation built upon them that is permanently above water.

4.5.4 Reefs

In the case of an island situated on an atoll or having fringing reefs, the baseline is the seaward low-water line of the reef, as shown by the appropriate symbol on charts officially recognized by the coastal State (Article 6).

The charting of coral reefs requires some explanation. Coral reefs are constructed by organisms, which can only live in shallow waters, and cannot survive prolonged aerial exposure. By their nature, therefore, reefs of live coral cannot extend much above the low-water line, and their tops tend to be planed off by wave action. Typically, in fact, the shallowest part of the reef may extend over a considerable area as a plateau which is just below low-water level for the most part, but which features numerous small growths of coral that extend just above the low-water level. Such areas are not navigable by anything but very small boats or canoes, and their seaward edge is generally unapproachable on account of breaking waves.

Customarily, areas of reef plateau are charted as a single area of drying coral since it is impossible to chart all the individual lumps and heads, and the area is for practical purposes un-navigable. The symbol for drying coral is used to illustrate the extent of this feature on a chart, and it is the edge of this symbol that is taken as the "... seaward low-water line of the reef, as shown by the appropriate symbol ...". On some charts, actual depths may be shown over a coral area that is charted with the drying coral symbol. Usually, this merely indicates that the hydrographic surveyor was able to obtain some depths between the numerous obstructions.

Isolated reef patches that are charted by the appropriate symbol and which are not part of an atoll formation are to be considered as ordinary low-tide elevations, and treated as such.

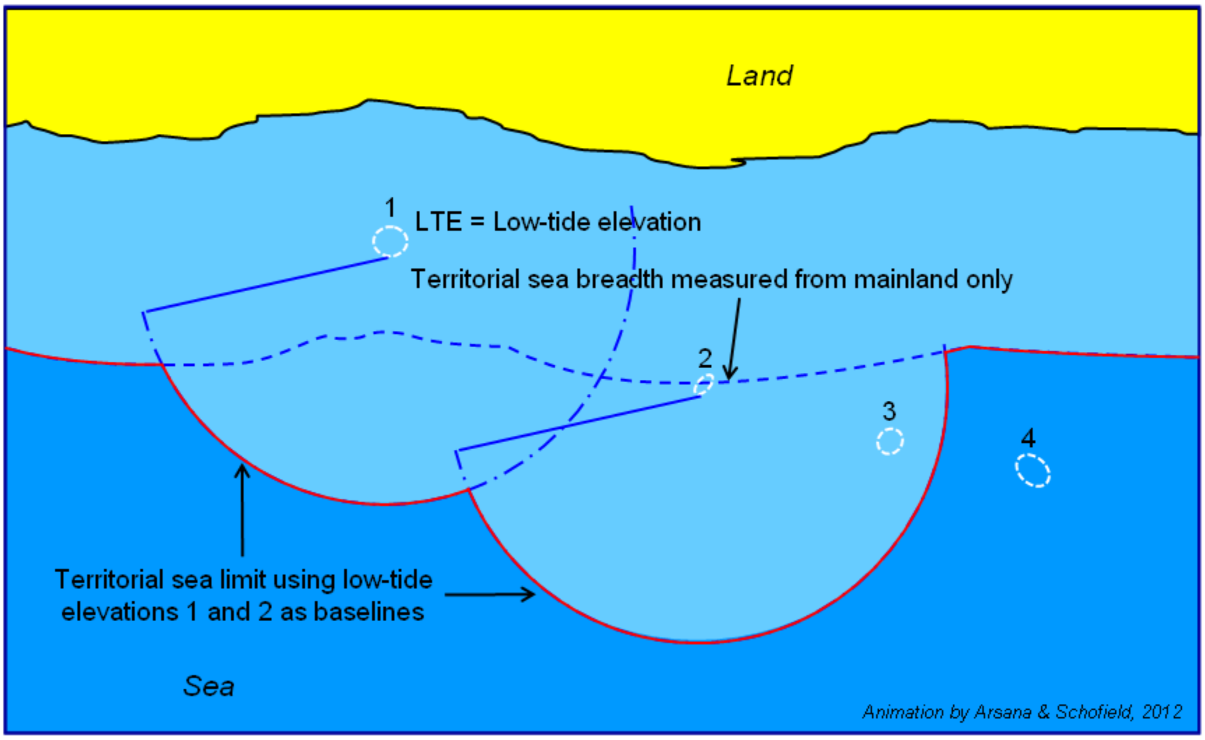

Figure 4.4 – Low-tide elevations and the generation of maritime zones. LTEs 3 and 4 may not be used to define the baseline because they lie beyond the breadth of the Territorial Sea. (Animation: /Figure4_4.ppt)

4.5.5 Straight Baselines at a Boundary

While it is not explicitly stated in the Convention, except in the case of Bays (Article 10), a straight baseline is not expected to be drawn from a base-point in one State to a base-point in another State. Usually, the system should terminate at a point on the low-water line of the State utilizing the straight baselines. Nevertheless, cases do exist in practice where straight baselines have been drawn between States.

4.6 PUBLICISING THE BASELINE

In accordance with Article 16, baselines must be published either on a chart or by a list of geographical coordinates. In general the "normal baseline", consisting of the low-water line, is most conveniently shown by use of the existing officially recognised charts. It would be an excessively tedious task to list sufficient geographical coordinates to define the whole low-water line in the necessary detail. Straight baselines, on the other hand, may be easily and accurately defined by listing the geographical coordinates, referred to a defined geodetic datum, of the terminal points of each segment.

If there are no charts officially recognised by the coastal State, it will be preferable to construct a special baseline chart on which to promulgate the baselines that have been determined, whether "normal" or straight or a combination of them. If this course is adopted, the choice of scale is important. This will be dictated by the accuracy that is required to enforce the laws applicable within the zones, which are measured from the baselines. In order to read off a position on a chart to, say, the nearest 30 metres (about 1 second of arc in latitude), the chart would need to be of a scale of about 1:75,000, but that is an inconveniently large scale on which to show any considerable length of coast. In most cases scales of between 1:100,000 and 1:250,000 will be adequate to display the baselines.

The requirement for high accuracy in defining the baselines and the boundaries that are derived from them is primarily imposed by the need to manage and control significant offshore resources such as hydrocarbons and minerals. Geodetic techniques may well be required to achieve that high level of accuracy.

Geographical coordinates defining base-points are usually given to the nearest second in latitude and longitude; greater precision can sometimes be achieved if the base data is accurate enough.

4.7 GEODETIC COMMENTARY: SURVEYS, LINES, AND AREAS

Chapter 2 includes a comprehensive review of the geodetic and survey issues that are critical to accurate baseline determination. That section should be read in conjunction with the present chapter.

When defining straight baselines it is important to state whether they are Loxodromes (also known as rhumb lines) or Geodesics, particularly if they are long lines. A Loxodrome appears as a straight line on a Mercator projection, where every point along its length maintains a constant azimuth relative to the line’s start or end point. A Geodesic, on the other hand, defines a line on a curved surface (usually the reference ellipsoid) that traces the shortest distance between its two end points. Except in special situations, a Geodesic plots as a curved line in most projections (even when it defines a “straight” baseline), and points along its length define varying azimuths relative to the start and end points.

The difference between a Loxodrome and a Geodesic increases with latitude and with the length of line. For example, at latitude 60° and with end points separated by 45 nautical miles, the maximum separation between a Loxodrome and a Geodesic could be 236 metres. At a chart scale of 1:200,000 this difference amounts to just a little over 1 mm and is negligible to all intents and purposes. But when defining the longest archipelagic baseline permissible (125 nautical miles), the separation between a Loxodrome and a Geodesic at the same latitude could be as much as 1820 metres, or nearly a full nautical mile. In that situation, the difference between the two possible "straight" lines is significant.

Situations arise where it is necessary to calculate the area enclosed by straight baselines, e.g., when working with bays and archipelagos. Generally speaking, the size of the area will vary according to the surface that is used for its description, and for the definition of the circumscribing baselines. When the baselines are straight on a map, the projected area can be evaluated fairly simply by using analytic geometry. Unless the work is carried out in an equal-area map projection; however, the projected area has then to be adjusted to account for the map distortion in order to obtain the correct value, i.e., the area on the horizontal datum. This is not a simple task and is better left to a specialist in mathematical cartography. Several GIS software applications are available which will calculate the area of a polygon on the ellipsoid. The definition of the closing lines of the polygon is again essential for an accurate result.

CHAPTER 5 – OUTER LIMITS

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5.1 GENERAL

This chapter discusses the definition of the seaward or outer limits of a coastal State's maritime zones, where the limit is determined as a maximum that may be claimed under the United Nations Convention on the Law of the Sea (hereinafter referred to as “UNCLOS”), in the absence of overlapping claims by States with opposite or adjacent coasts. It assumes that the baselines have already been determined as discussed in Chapter 4.

Except in the case of the continental shelf, where it extends beyond 200 nautical miles from which the breadth of the territorial sea is measured (hereinafter referred to as “the territorial sea baselines”) in accordance with the provisions of article 76 of UNCLOS, the outer limits may be defined by specified distances measured from the territorial sea baselines (Figure 5.1). The distance shall not exceed 12 nautical miles for the territorial sea (article 3 of UNCLOS), 24 nautical miles for the contiguous zone (article 33 of UNCLOS), and 200 nautical miles for the exclusive economic zone (article 57 of UNCLOS). The precise determination of these outer limits requires an application of the geodesy discussed in Chapter 2. The outer limits drawn by a graphic geometric method are less precise and this method is not recommended.

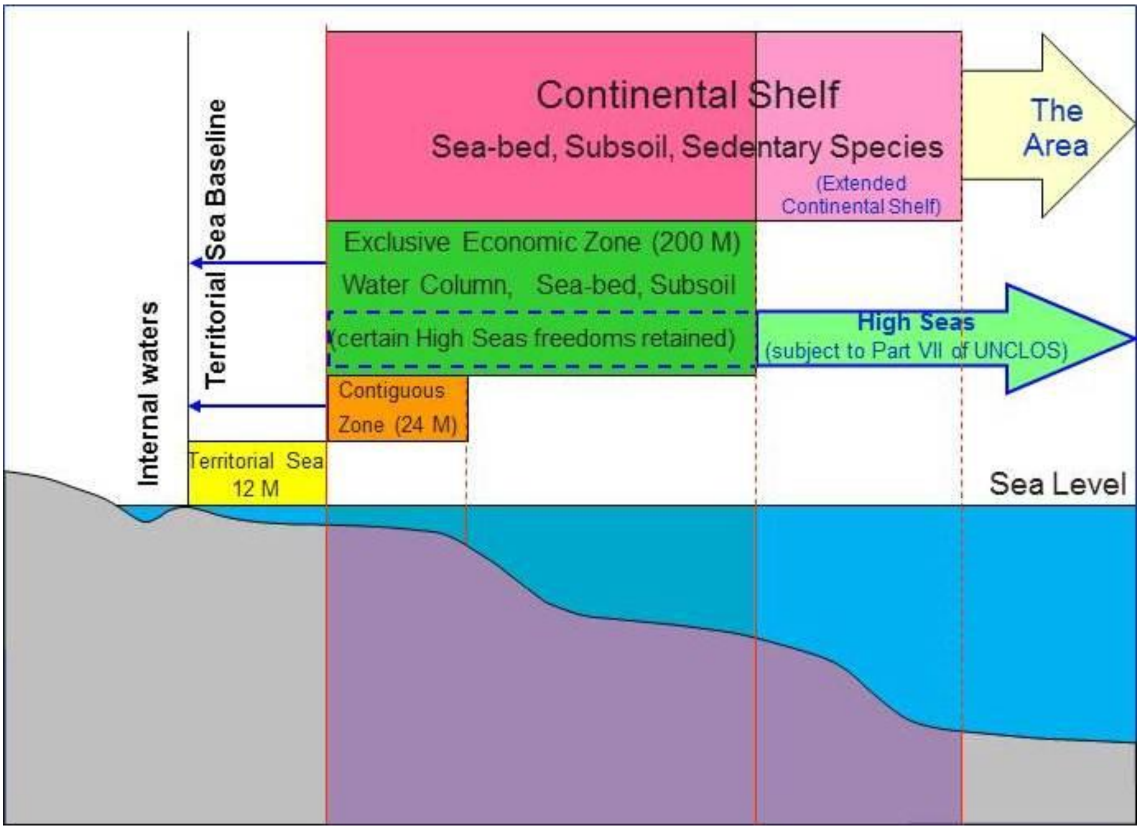

Figure 5.1 – Diagram to illustrate maritime jurisdictional zones of a coastal State.

The continental shelf may extend beyond the territorial sea up to 200 nautical miles from the territorial sea baselines or it may extend up to the outer limits beyond 200 nautical miles from the territorial sea baselines, pursuant to the provisions of article 76 of UNCLOS (Figure 5.1). Its outer limits form the boundaries between national jurisdiction of the coastal State and the Area defined in article 1 of UNCLOS. Although, in accordance with article 121 of UNCLOS, islands are treated identically to other land territories, and rocks, which cannot sustain human habitation or an economic life of their own, shall have no exclusive economic zone or continental shelf.

5.2 LIMITS BASED ON DISTANCE

5.2.1 General Features

Limits based on distance will take their points of origin either from a normal baseline or from a system of straight lines. Geometrically, a straight baseline system will result in the limits with an approximate system of straight lines and arcs of circles, while the normal baseline may result in the limits with an approximate simulation of the low water line itself.

It will be noted that deep coastal indentations tend not to be fully reflected in the limits, because distances measured from opposite sides of an indentation intersect at a point which is situated seaward (Figure 5.2).

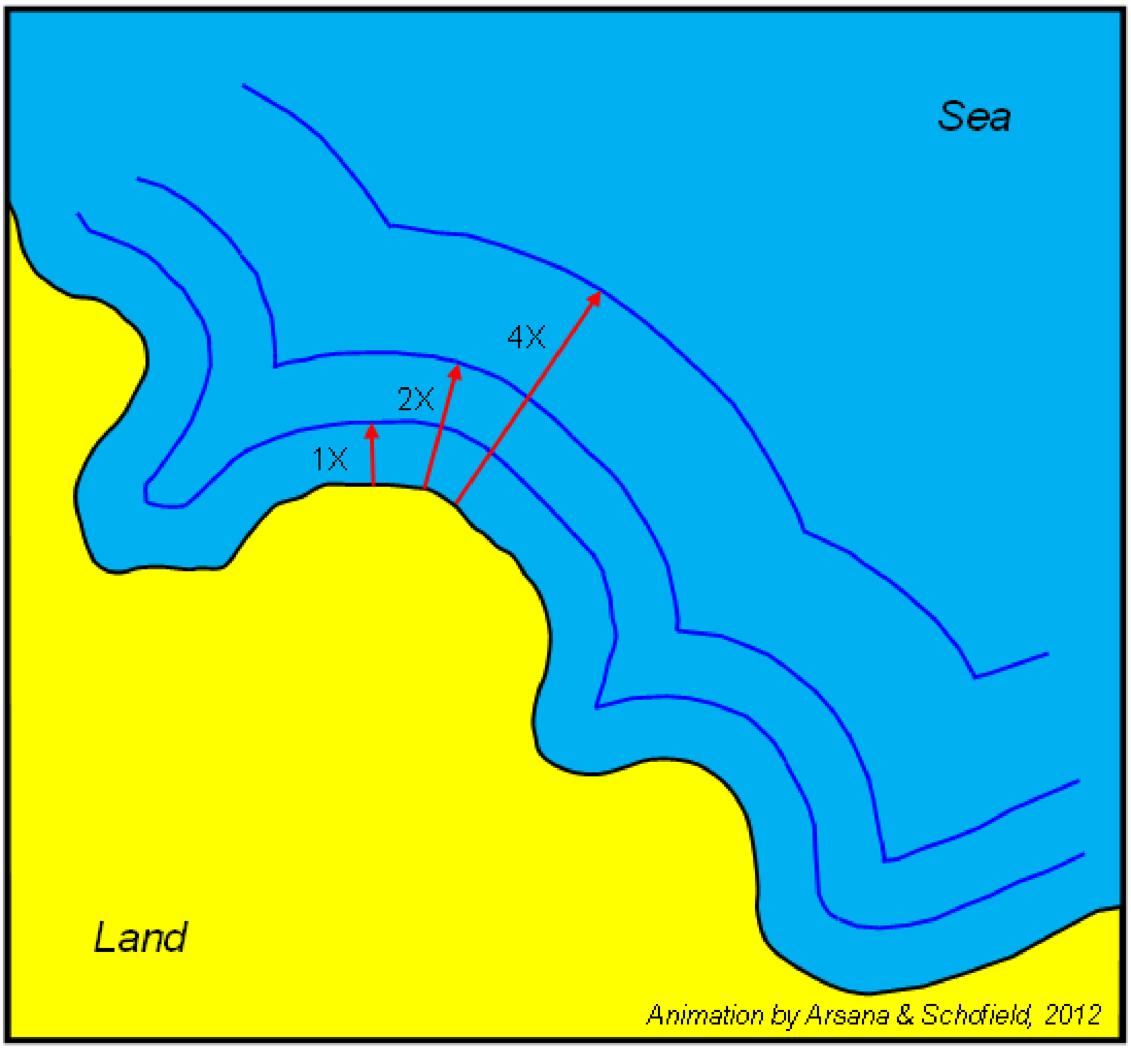

Figure 5.2 – Many limits consist of lines where each point is located at a fixed distance from the territorial sea baseline. Limits that are situated farther offshore have a lesser tendency to reflect the sinuosity of the baseline.

Due to the fact that the Earth is not flat and that all projections result in some distortion (see Chapter 3), the use of traditional graphical methods for constructing limits and boundaries should be restricted to limited areas and limited distances. A long straight baseline, for instance, may be defined as a geodesic or loxodrome, and derivation by purely graphical means could be subject to error.

For descriptive purposes, it is advantageous to disregard the complexities of a curved surface, so for the purpose of this section the terms of plane geometry will be used. However it must be understood that in practice the calculations should be made in geodetic terms, and the "circles" and "straight lines" will not rigorously project into true circles and straight lines on map projection.

In plane geometric terms, the unilateral limits at X nautical miles from a baseline are (see Figure 5.3):

- For a straight baseline, a straight line parallel to it at a distance of X nautical miles.
- For a base point, an arc with a radius of X nautical miles centred on the point.

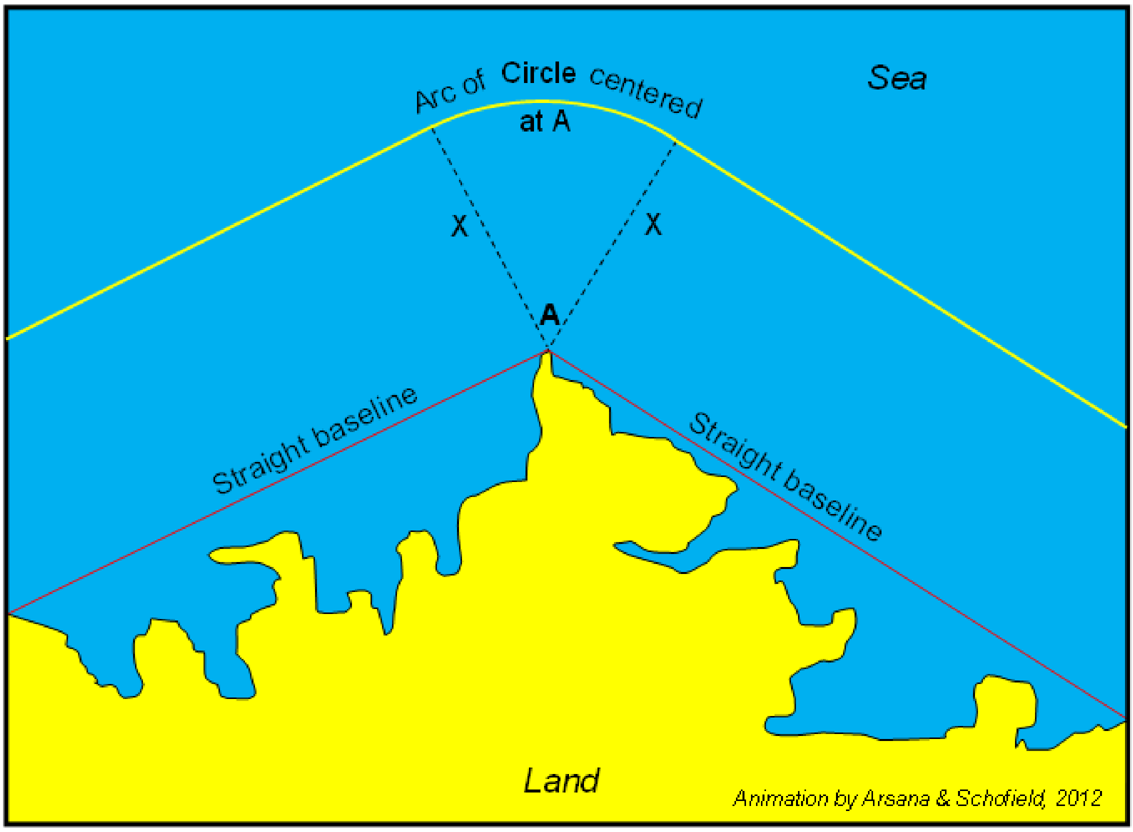

Figure 5.3 – In plane geometric terms, a limit at 12 nautical miles from a straight baseline consists of a straight line parallel to the baseline at a distance of 12 nautical miles. For a single base point, the limit consists of an arc of a circle with a radius of 12 nautical miles, centred on the point (diagram adapted from CARIS Training Manual).

5.2.2 Delineation of Limits Based on Distance

In principle, the normal baseline can be described as an infinite number of points. The limit can be described as the envelope formed by a series of arcs of circles with a radius of X nautical miles centred on the points on the normal baseline (see Figure 5.4). Computer algorithms are available for implementing this approach.

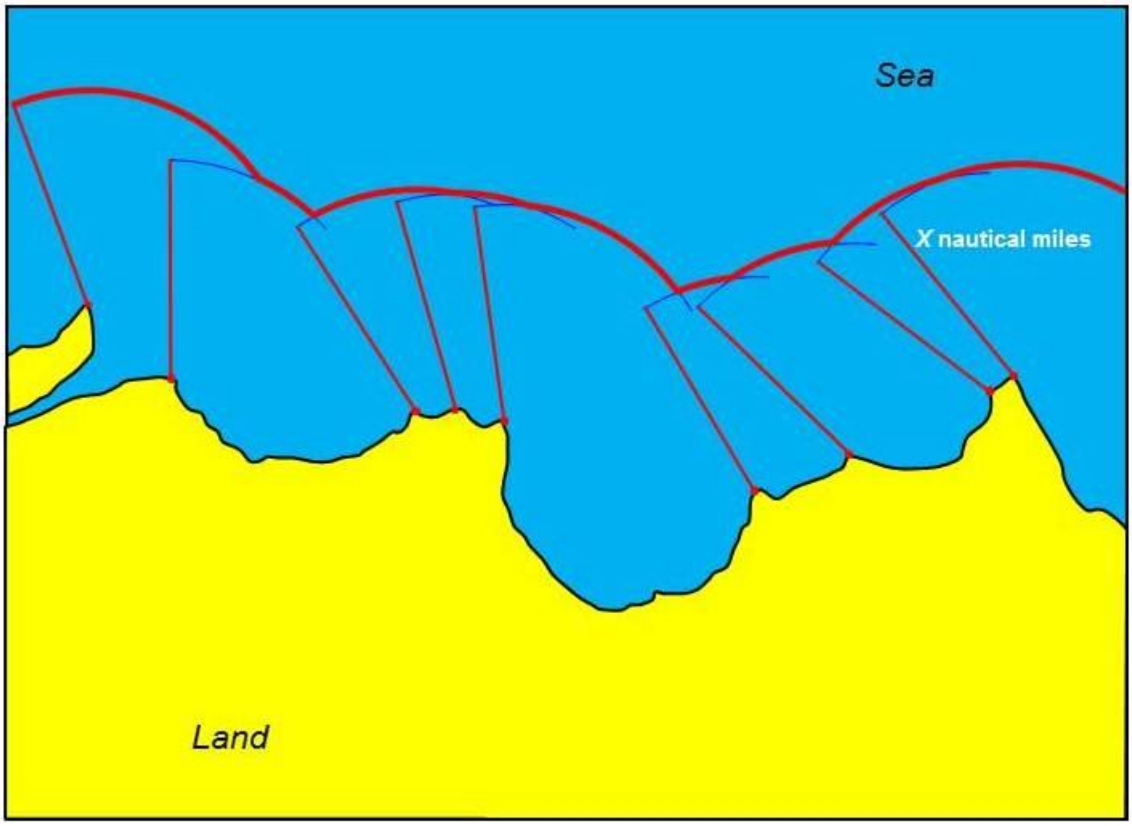

Figure 5.4 – The normal baseline can be described as an infinite number of points, but in practice only a few points may be needed for calculating a given limit. Such a limit can be described as the envelope formed by a series of arcs of circles centred on the selected points on the baseline, also known as the base points (diagram adapted from CARIS Training Manual).

The limit of jurisdiction may also be visualized as the continuous line traced by the centre of a circle that has a radius of R nautical miles and which maintains contact with the baseline as it rolls along (see Figure 5.5).

Note that the above descriptions satisfy the requirement that every point on the seaward limit should be at a distance of X nautical miles from the nearest point on the baseline (Article 4 of UNCLOS). That requirement is not satisfied by the tracé parallèle, or replica line, which results from constructing a line identical in form to the baseline at a distance of X nautical miles from it on a perpendicular to its mean direction; in addition to being impractical in most situations, such a line fails to satisfy the requirements prescribed in UNCLOS.

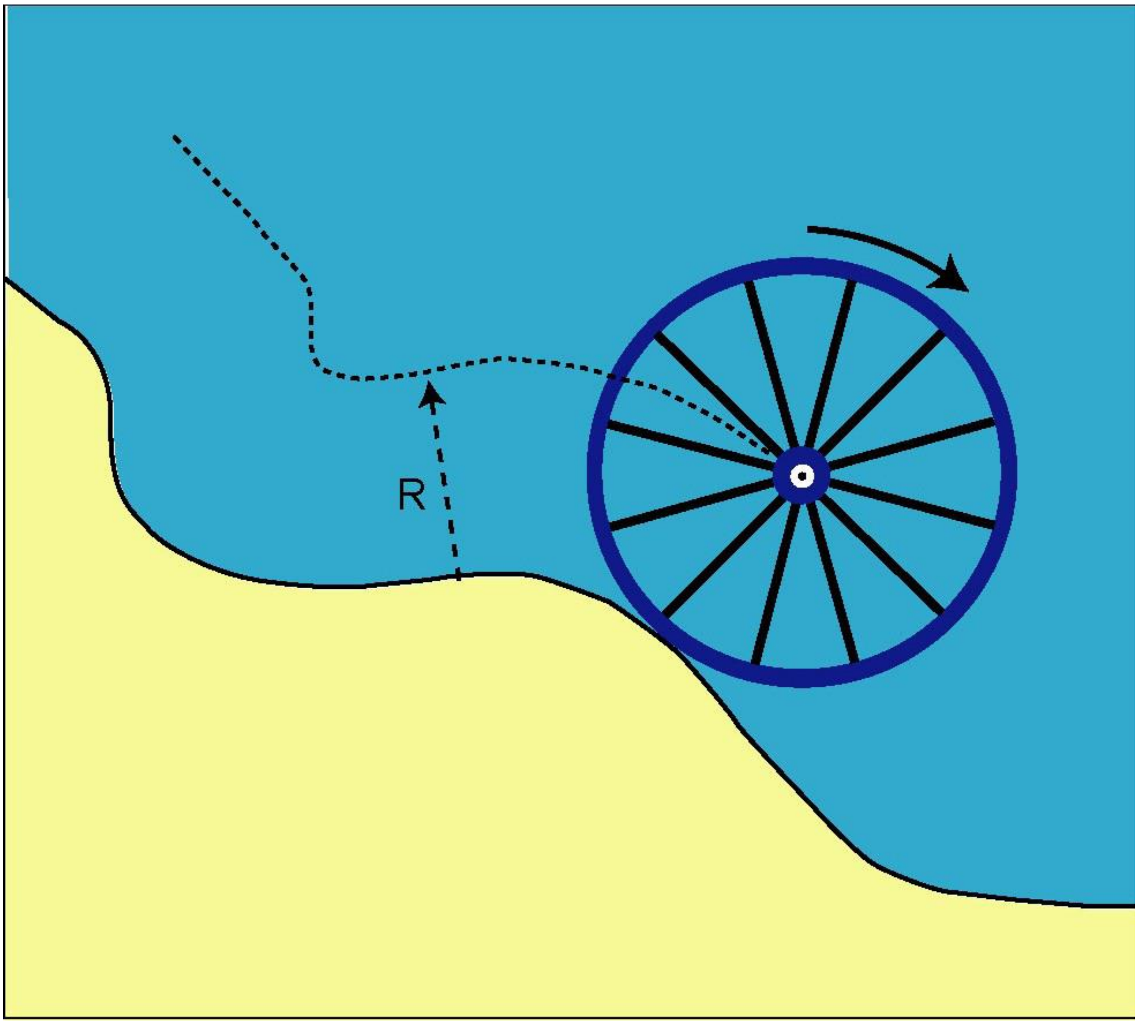

Figure 5.5 – A limit at a distance of R nautical miles may be visualized as the continuous line traced by the centre of a horizontal wagon wheel that has a radius of R nautical miles, and which maintains contact with the baseline as it rolls along.

5.2.3 Graphical Construction

The method of graphical construction, as compared with the geodetic method, may have advantages to approximate outer limits easily and to verify the results by the geodetic method, even though the graphical method is less precise and not recommended to establish any outer limits. Steps for the method of graphical construction are as follows. A compass is set to the required distance to draw outer limits. The point of the compass is then placed successively at suitably spaced locations along the baseline, and a short arc is drawn opposite each location. If the spacing of the locations along the baseline is reasonably close, a smooth outer limit will automatically be formed by the intersecting arcs (see Figure 5.4).

Where the coast is indented, it may be possible to construct the arcs from the headlands forming the entrance to the indentation, and to ignore the coast that lies within. This will depend upon the geometry of the situation, i.e., the indentation will need to recede sufficiently that no point on its coastline can generate an arc that exceeds the arcs constructed from the headlands. (Note that indentations that are juridical bays as discussed in Chapter 4 are not considered here.) In the same way, opposite a headland represented by a single base point, the limit may follow a single arc centred on the headland for a considerable distance before intersecting other arcs generated by neighbouring base points (Figure 5.6).

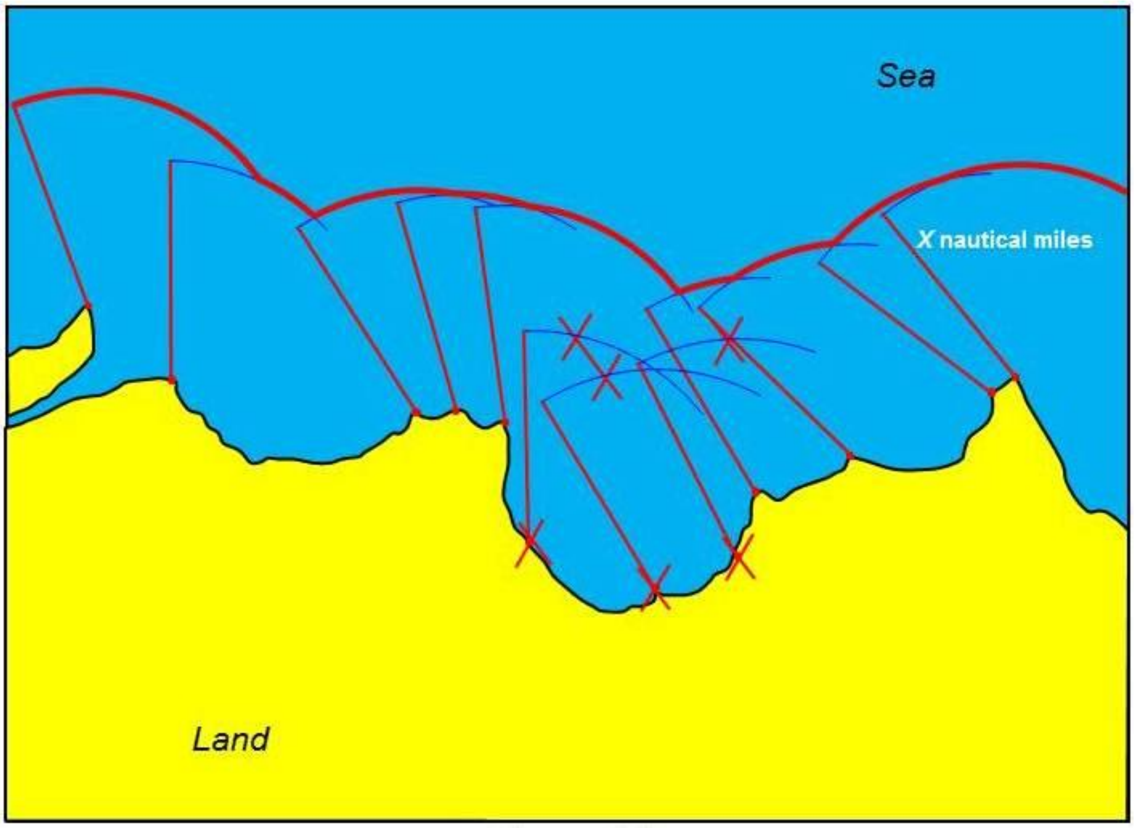

Figure 5.6 – Where the coast is indented, it may be possible to construct the arcs from the headlands forming the entrance to the indentation, and to ignore the coast that lies within.

The spacing of the points along the baseline is significant where the coast is straight or where it forms a smooth convex curve. The choice of spacing will represent a compromise between a 'perfect' outer limit and the level of effort that goes into its construction. With the advent of computer tools, this is no longer the problem that it used to be.

It can readily be verified that irregularities of the baseline will be reflected to some degree in the outer limit line if the latter has been correctly constructed. The greater the breadth of the zone to be measured from the baseline, the smoother will be the course of the outer limit, and the fewer will be the base points that affect its delineation.

5.2.4 Computation

Fully automated or semi-automated methods can be used for computing outer limits. Sufficient accuracy for most requirements can only be obtained by computation.

A basic requirement for computing outer limits is to begin with a sequence of coordinates of the points on the baselines in digital form. In many cases, these coordinates will be tabulated in official documents published by the coastal State government. Where coordinates are not officially promulgated, for the sake of expediency, they may be extracted from suitably detailed charts using a digitizing table, or by visually determining the coordinates of the desired points on the baselines. The spacing and locations of these points on the baselines, and the care with which their coordinates are determined, will affect the accuracy of the outer limit. Chapter 4 discusses the principles of baseline construction.

When calculating outer limit coordinates, it is essential to use software that is capable of performing geodetic computations, to allow for variations arising from the curvature of the earth's surface. Failure to do so can introduce non-negligible errors in the resulting outer limits.

5.3 TERRITORIAL SEA LIMITS

Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles from the territorial sea baselines (Article 3 of UNCLOS). The territorial sea limits can be established by the limits drawn with a distance of 12 nautical miles according to the procedures described in Section 5.2.

Since the breadth of the territorial sea is relatively narrow, sufficient accuracy might be obtained by plotting the limits directly on a chart. If the Mercator projection is being used, care must be taken to correct for the change in scale with latitude. This calculation is particularly relevant to limits based on long straight baselines. The limit may not be a parallel line on the chart if there is a significant change in scale along the length of the line. In practice, it is advisable to use geodetic computation techniques in order to achieve an acceptable degree of accuracy.

5.4 CONTIGUOUS ZONE LIMITS

The contiguous zone may not extend beyond 24 nautical miles from the territorial sea baselines (Article 33, paragraph 2 of UNCLOS). The outer limits of the contiguous zones can be drawn with a distance of 24 nautical miles according to the procedures described in Section 5.2.

5.5 EXCLUSIVE ECONOMIC ZONE LIMITS

The exclusive economic zone shall not extend beyond 200 nautical miles from the territorial sea baselines (Article 57 of UNCLOS). The outer limits of the exclusive economic zone can be drawn with a distance of 200 nautical miles according to the procedures described in Section 5.2.

5.6 OUTER LIMITS OF THE CONTINENTAL SHELF

The procedures for determining outer limits of the continental shelf are prescribed in Article 76 of UNCLOS. They are also elaborated upon in a number of publications, e.g., the Scientific and Technical Guidelines (hereinafter referred to as "S&TG") of the Commission on the Limits of the Continental Shelf (hereinafter referred to as "CLCS") (CLCS, 1999), Continental Shelf Limits: the Scientific and Technical Interface (Edited by Cook and Carleton, 2000), and Training Manual for delineation of the outer limits of the continental shelf beyond

200 nautical miles and for preparation of submissions to the Commission on the Limits of the Continental Shelf (UN/DOALOS, 2006).

Determining the outer limits of the continental shelf beyond 200 nautical miles from the territorial sea baselines (hereinafter referred to as “extended continental shelf”) is more complicated and more difficult than constructing outer limits that are based solely upon distance from the territorial sea baselines. Delineation of the outer limits of the extended continental shelf is performed in two major steps: (1) establishing the outer edge of the continental margin through the application of formulae that are based on seafloor morphology and the thickness of sedimentary rocks as prescribed in Article 76, paragraph 4, of UNCLOS; (2) deriving constraint lines that are based on bathymetry and distance from the territorial sea baselines to restrict the extent of the continental margin established in the previous step.

The following paragraphs offer a commentary and general advice concerning the interpretation of the provisions of Article 76 of UNCLOS, and the measurements that need to be made in order to establish the outer limits of the extended continental shelf.

In many cases there will be very little detailed information available on either the bathymetry or the geology of the area of the continental margin, even though such detailed information is essential to establish the outer limits of the extended continental shelf. The work required to obtain such information is beyond the scope of this study: it requires the expertise of hydrographers, geophysicists and geologists for interpreting the data and for determining the outer limits of the extended continental shelf, as well as vessels and equipment to obtain bathymetric, geophysical and geological information regarding the extended continental shelf.

Since it may involve significant cost and effort to collect bathymetric, geophysical and geological information enough to establish the extended continental shelf, many coastal States will begin by using information that is currently available to approximate the outer limits of the extended continental shelf. This will be followed by studies such as assessment of data requirements, formulation of a plan for acquiring new information, etc. This ensemble of studies is generally pursued within the framework of a desktop study.

The first procedure is to undertake a general examination of the topography of the seabed adjacent to the coastal State, with a view to identifying features that can be considered as ‘the submerged prolongation of the land mass of the coastal State’ (Article 76, paragraph 3, of UNCLOS). Primarily, care must be taken to identify such topographic features, and in so doing to meet the requirements of the Test of Appurtenance as outlined in Section 2.2 of S&TG. It is entirely possible that inadequate data sets will introduce uncertainties in this identification process, in which case it will be necessary to re-visit the identified feature once new information has been obtained, and to justify their classification as the submerged prolongation of the landmass of the coastal State.

Early in the implementation process, a decision will be required concerning methods for managing and archiving geo-referenced data sets in digital form. It will be necessary to choose or to design a suitable cartographic base for displaying different parameters involved in the implementation of Article 76. This may consist of a conventional paper plotting chart, but it is strongly recommended to use a custom digital map that has been created by a

Geographic Information System (GIS), and which covers the entire study area.

A digital GIS map has several advantages over a paper chart:

(a) it can be readily constructed from the contents of digital data;
(b) it can be displayed at any scale;
(c) it is easy to revise as new information becomes available;
(d) its contents can be readily correlated or co-displayed with complementary data sets; and
(e) it can be printed on paper with considerable flexibility as to size and format.

The following geographical information may be managed on the GIS to establish the outer limits of the extended continental shelf:

a) Lines at 200 nautical miles from the territorial sea baselines (referred to as "200 nautical mile lines ");
b) Bilateral boundaries with coastal States with opposite or adjacent coasts;
c) Foot of the continental slope points in accordance with Article 76, paragraph 4 (b), of UNCLOS;
d) 2500 metre isobaths;
e) Formulae lines:
    i. Lines where the thickness of sedimentary rocks is at least 1% of the shortest distance to the foot of the continental slope in accordance with Article 76, paragraph 4 (a) (i) of UNCLOS (referred to as "sediment thickness formula lines", or "Gardiner lines");
    ii. Lines located not more than 60 nautical miles from the foot of the continental slope in accordance with Article 76, paragraph 4 (a) (ii) of UNCLOS (referred to as "60 nautical mile formula lines", or "Hedberg lines");
f) Constraint lines:
    i. Lines located not more than 100 nautical miles from the 2500 metre isobaths in accordance with Article 76, paragraphs 5 and 6, of UNCLOS (referred to as "depth constraint lines");
    ii. Lines located not more than 350 nautical miles from the territorial sea baseline in accordance with Article 76, paragraphs 5 and 6, of UNCLOS (referred to as "distance constraint lines");
g) Outer limits of the extended continental shelf delineated by the inner envelope of the two lines: the outer envelope of the formulae lines (referred to as "the outer edge of the continental margin") and the outer envelope of the constraint lines;
h) Distribution of available data sets (bathymetry, seismic reflection, etc.).

5.6.1 Data Sources

Many data sets already exist that are suitable for use in desktop studies, and they may be obtained in digital form from a variety of sources. Nautical charts do not usually show sufficient isobaths (depth contours) to be useful for determining the position of the foot of the continental slope, nor do they show sediment thickness. For both these purposes, and to trace the 2500 metre isobath, more informative data are needed that portray bathymetry and sediment distribution at a suitable scale.

An overview of data centres, and of the public-domain data sets dispensed by them, is contained in Chapter 15 of Cook and Carleton (2000). S&TG (CLCS, 1999) provide additional advice concerning the admissibility of data sets, as well as the requirements that govern their presentation to the Commission. The UNEP/GRID-Arendal offers One Stop Data Shop (OSDS) for use by coastal States preparing a submission delineating the outer limits of their continental shelf (http://www.continentalshelf.org/). The OSDS consists of a global geospatial and metadata inventory of marine geophysical and geological data.

The General Bathymetric Chart of the Oceans (GEBCO) provides two global gridded bathymetry data sets: the GEBCO One Minute Grid and the GEBCO_08 Grid. The GEBCO One Minute Grid describes the depth of the world ocean in two ways: as vectors that represent depth contours (generally at depths of 200 m, 500 m, and at 500 m intervals thereafter), and as a grid of depth values spaced at intervals of one-minute of square. It was released in 2003 and updated in 2008. The GEBCO_08 Grid, released in 2010, is a 30 arc-second gridded bathymetry derived from ship sounding data interpolated with satellite-derived estimated bathymetry. The both data sets are available from British Oceanographic Data Centre (BODC, URL https://www.bodc.ac.uk/data/online_delivery /gebco/). The US National Geophysical Data Center (NGDC) offers a generalized five-minute square grid of total sediment thickness for the world's oceans and marginal seas. Users are cautioned that global data sets such as these may be based on very general information in some places, with considerable extrapolation from sparse data. Therefore it is desirable to find more detailed data if possible. If local sources cannot provide the material, large oceanographic institutes will usually be aware of what published work is available, and often what projects are in hand. Application to them may produce better data, or advice on where it may be obtained.

Whatever the source of bathymetric and sedimentary data, it will be helpful to import the information to a GIS as a layer that can be displayed on demand for easy correlation with other parameters and data sets.

5.6.2 Foot of the Continental Slope

Article 76, paragraph 4 (b), of UNCLOS defines the foot of the continental slope, in the absence of evidence to the contrary, as the point of maximum change in the gradient at the base of the continental slope. S&TG devote two chapters to this topic: Chapter 5 discusses the determination of the foot of the continental slope as the point of maximum change in the gradient; Chapter 6 addresses the determination of the foot of the continental slope by means of evidence to the contrary. Each chapter considers the applicable methodologies and criteria, and outlines requirements to ensure the acceptability of data and evidence. It is worth noting that use of maximum change in the gradient is considered as a general rule, and that evidence to the contrary is viewed as an exception to the general rule.

The general locality of the line of maximum change in the gradient may be found from visual perception of bathymetric maps. However, this visual approach is unacceptable to the CLCS (S&TG 5.4.7), and a more precise approach is required by means of the mathematical analyses of two-dimensional profiles, three-dimensional bathymetric models and preferably both.

In the mathematical analyses with two-dimensional profiles, a series of transverse bathymetric profiles will be obtained either directly from surveys, or extracted from a compilation product such as a bathymetric map or a digital bathymetric model. The orientation of these selected profiles is recommended by the CLCS (S&TG 5.4.8) to be such that it runs in a perpendicular direction to the isobaths located at the point of maximum change in the gradient at the base of the continental slope.

Points of maximum change in the gradient at the base of the continental slope can be derived by mathematically taking the second derivative of bathymetry. In most cases, this procedure creates a curve with several identifiable maxima that represent the locations of local changes in the gradient. According to S&TG 5.4.12, the selection of the point of maximum change in the gradient is recognized as a general rule to identify the foot of the continental slope point. In other words, the selection of any other local change will be regarded as an exception that should be supported by evidence to the contrary to the general rule.

5.6.3 Sediment Thickness Formula Line

Article 76, paragraph 4 (a) (i), of UNCLOS defines the sediment thickness formula line (or "Gardiner line"). Its position is determined by a succession of points where the thickness of sedimentary rocks is at least 1% of the shortest distance from each point to the foot of the continental slope. The principle is illustrated in Figure 5.7, which portrays an ideal situation that is unlikely to be reflected in the real world.

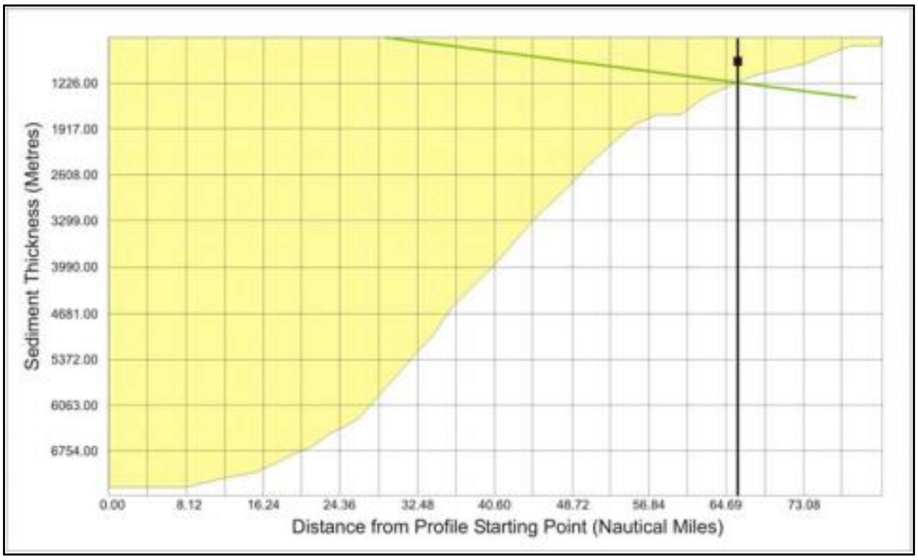

Figure 5.7 – This illustrates the determination of the point where the thickness of sedimentary

rocks is equal to 1% of the distance back to the foot of the continental slope. The coloured portion of the plot represents a profile of sediment thickness (the top 500 metres or so are not shown). The profile starting point (0.00 nautical miles) is located at the foot of the continental slope. The green line intersects the base of sediment at the location where the sediment thickness (1226.0 metres) equals 1% of the distance to the foot of the continental slope (66.2 nautical miles).

Chapter 8 of S&TG consists of explanations concerning the application of the sediment thickness formula. It describes the techniques involved, and it discusses the problems that arise in attempts to reconcile real-world observations with the ideal sediment model that underlies the formula's assumptions. The location of the 1% point is derived on the diagram to show the sediment thickness taken on a line constructed to seaward from the foot of the continental slope. These lines should be drawn at intervals such that the 1% points are not more than 60 nautical miles apart, and that they adequately cover the areas with thicker sediments.

Figure 5.8 illustrates the basic procedures to determine a point on the sediment thickness formula line, in which a profile of sediment thickness along the line is plotted, together with a 1 % line plotted from the zero of the graph, which represents the intersection of the foot of the continental slope and the surface of the sedimentary rocks. The point of intersection between the profile of sediment thickness and the 1 % line is the required point. The sediment thickness formula lines can be constructed by straight lines not exceeding 60 nautical miles in length connecting such points derived on a set of profiles like Figure 5.8.

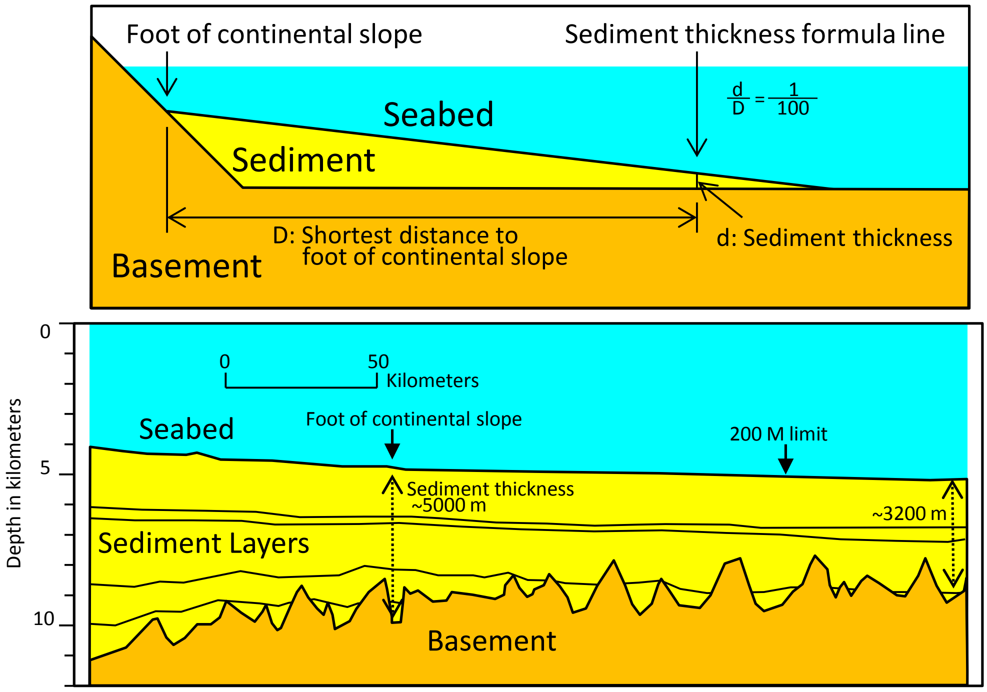

Figure 5.8 – The sediment thickness formula of article 76 of UNCLOS, in principle and in practice: the upper diagram represents a conceptual model of a cross section to figure the formula; the lower diagram represents a typical sediment profile off the Canadian Atlantic margin (courtesy C.E. Keen, Geological Survey of Canada), where the ruggedness of the basement contrasts with the smooth basement of the conceptual model.

5.6.4 60 Nautical Mile Formula Line

Article 76, paragraph 4 (a) (ii), of UNCLOS defines the 60 nautical mile formula line (or "Hedberg line") located not more than 60 nautical miles from the foot of the continental slope. The 60 nautical mile formula lines can be established by the lines drawn with a distance of 60 nautical miles from the foot of the continental slope as the baselines according to the procedures described in Section 5.2.

5.6.5 Distance Constraint Line

Article 76, paragraph 5, of UNCLOS defines the distance constraint line located not more than 350 nautical miles from the territorial sea baselines. The distance constraint lines can be established by the lines drawn with a distance of 350 nautical miles according to the procedures described in Section 5.2.

5.6.6 Depth Constraint Line

Article 76, paragraph 5, of UNCLOS defines the depth constraint line located not more than 100 nautical miles from the 2500 metre isobath. Chapter 4 of S&TG reviews the issues involved in determining the location of the 2500 metre isobath. The depth constraint lines can be established by the lines drawn with a distance of 100 nautical miles from 2500 metre isobaths as the baselines according to the procedures described in Section 5.2.

5.6.7 Limit of the Continental Shelf

In accordance with Article 76, paragraph 4 (a), of UNCLOS, the outer edge of the continental margin can be delineated by the outer envelope of the formulae lines (the sediment thickness formula lines and the 60 nautical mile formula lines) (see Figure 5.9).

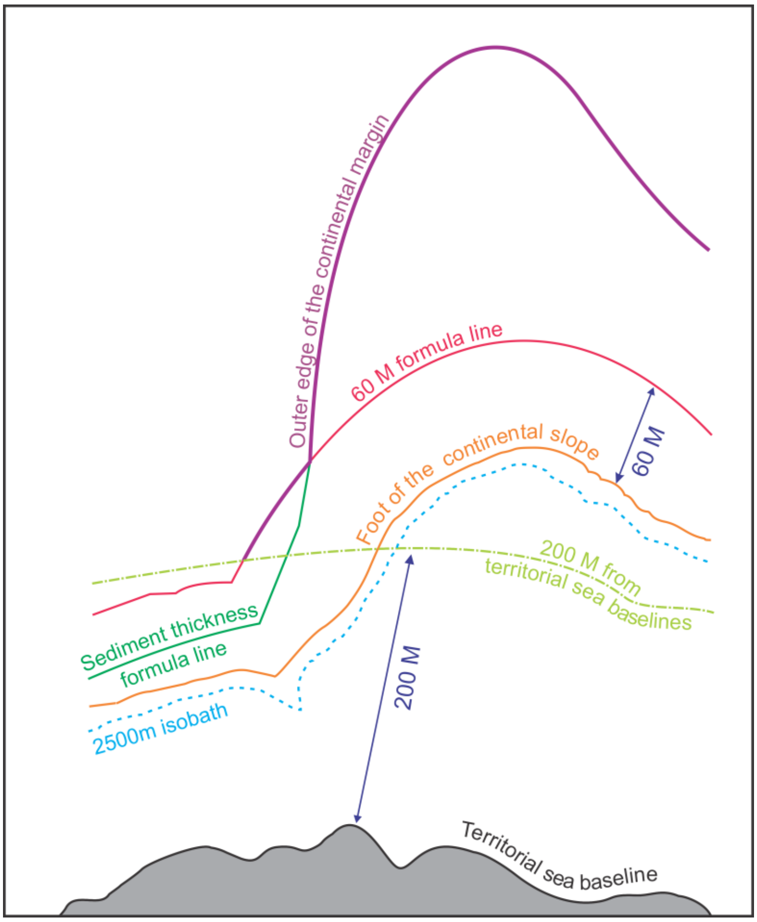

Figure 5.9 – The outer edge of the continental margin can be established by the outer envelope of the two formula lines: the 60 nautical mile formula line, and the sediment thickness formula line. Diagram is not drawn to scale.

In accordance with Article 76, paragraphs 5 and 6, of UNCLOS, the combined constraint lines can be delineated by the outer envelope of the depth constraint lines and the distance constraint lines (see Figure 5.10). According to Article 76, paragraph 6, of UNCLOS, this procedure can be applied to submarine elevations that are natural components of the continental shelf, but not to submarine ridges, where only the distance constraint can be applied.

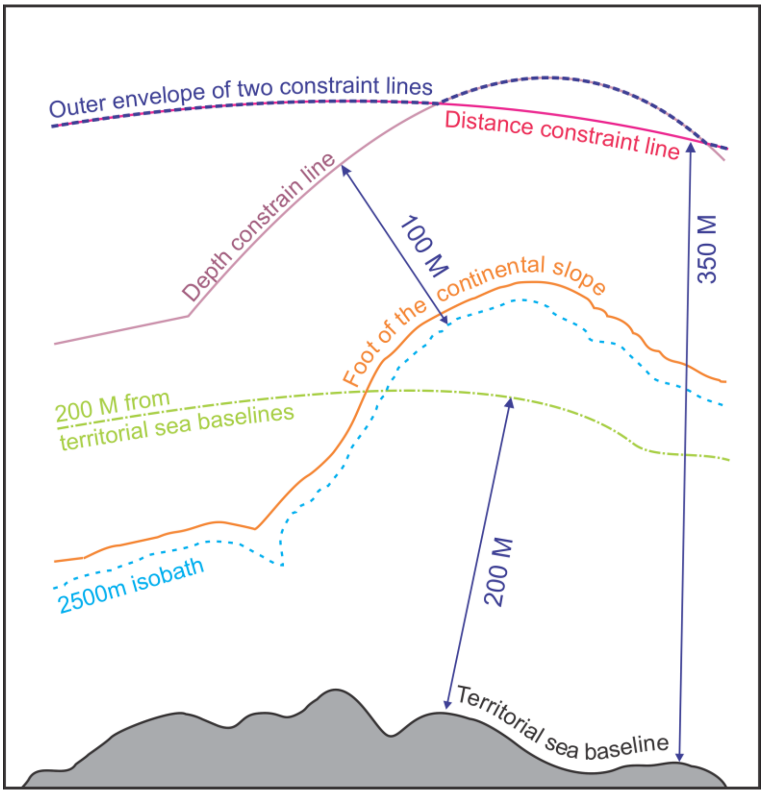

Figure 5.10 – The combined constraint line can be established by the outer envelope of the two constraint lines: the distance constraint line and the depth constraint line. Diagram is not drawn to scale.

Under most circumstances, the outer limit of the continental shelf will be constructed by merging the outer edge of the continental margin with the combined constraint line. If the continental margin lies inside of the combined constraint line, the outer edge of the continental margin will define the outer limit of the continental shelf. If it extends beyond the combined constraint line, the latter will truncate the former and become the outer limit of the continental shelf.

The actual outer limit of the continental shelf will be formally defined by a succession of fixed points joined by straight lines not exceeding 60 nautical miles in length (Article 76, paragraph 7, of UNCLOS). These fixed points may be arbitrarily selected, although they will normally be chosen to maximize the enclosed area. Once selected, their geographical coordinates must be expressed in a specified geodetic datum (see Figures 5.11 and 5.12).

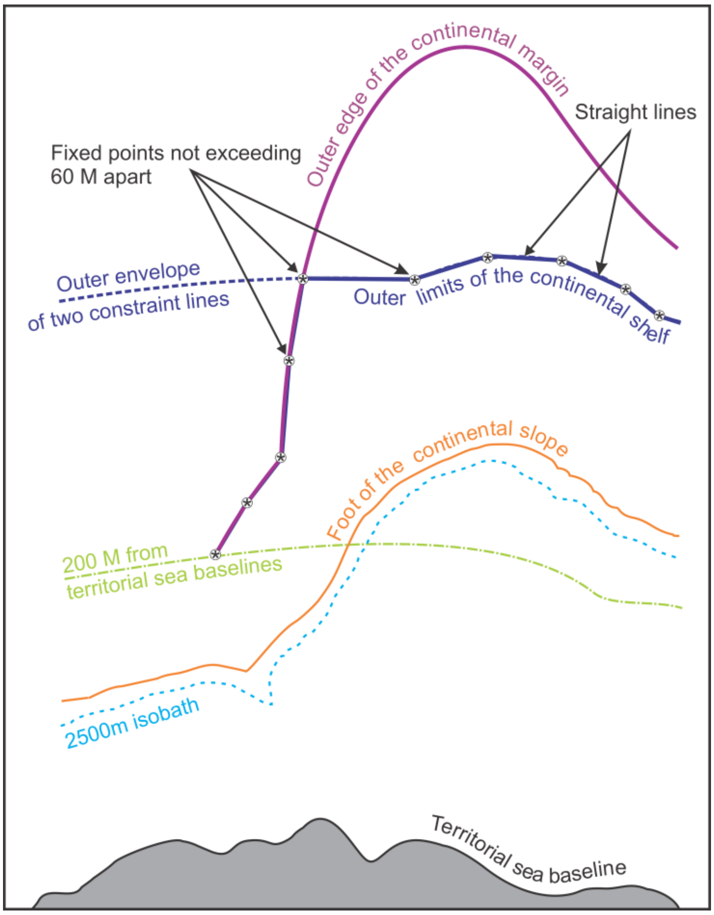

Figure 5.11 – The outer limit of the continental shelf can be established by the inner envelope of the outer edge of the continental margin (Figure 5.9) and the combined constraint line (Figure 5.10). The outer limit of the continental shelf is formally defined by a succession of fixed points joined by straight lines not exceeding 60 M in length. Diagram not to scale.

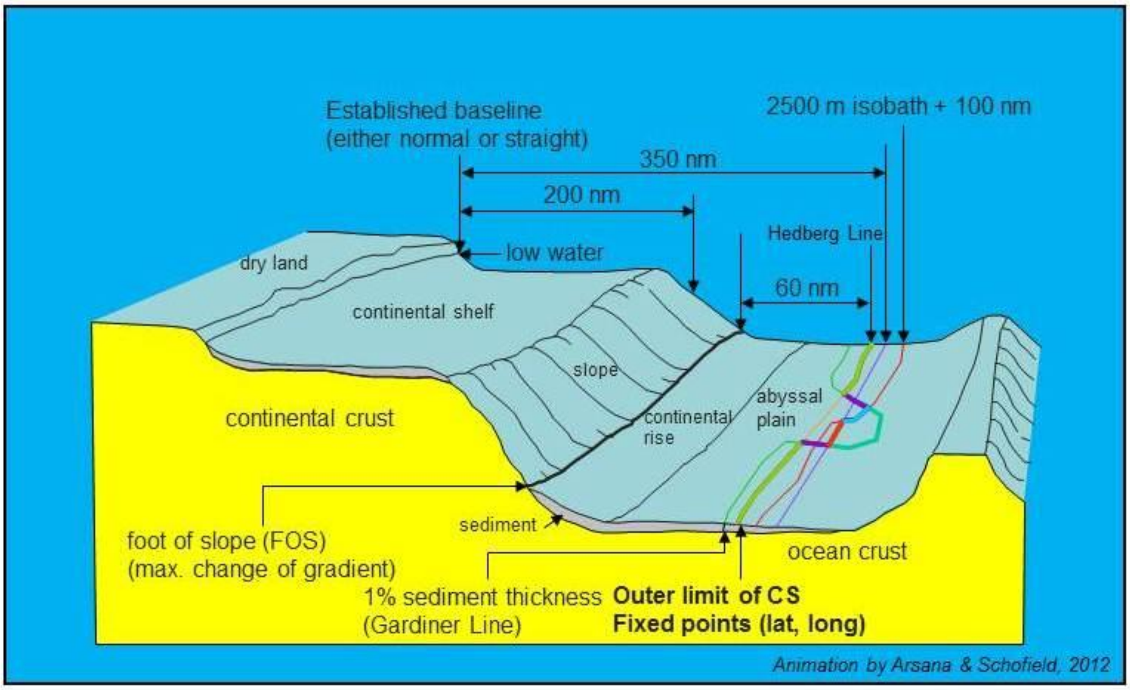

Figure 5.12 – Definition of the outer limits of the continental shelf.

5.6.8 Data Gathering Operations

When the continental shelf extends beyond 200 nautical mile lines, it will probably be necessary to collect new, geographically-referenced data in order to substantiate the coastal State’s claim. For the most part, this will consist of measurements of water depth and sediment thickness, although there may be situations where datasets such as geological samplings, gravity and geomagnetic fields, cross sections of sub bottom profilers, and sea bottom backscatter images can be the supporting data or ‘evidence to the contrary’.

Under some circumstances, bottom sampling may be necessary to establish the nature of material on or beneath the seabed. Regardless of its class or the means of its collection, new information must adhere to high standards of accuracy, with due care given not only to the acquisition process, but to the determination of positions within a known geographic frame of reference.

Existing bathymetric maps are often inadequate for determining the location of the foot of the continental slope or of the 2500 metre isobath, thus necessitating the design and execution of special survey operations to supplement the available information. Survey techniques and patterns will vary according to circumstances, and will usually reflect a compromise between the cost of the operation and the extent of data coverage.

Beneath the deeper waters applicable to Article 76 of UNCLOS, the nature and distribution of the sedimentary material tend to be poorly known, and in many cases it will be necessary to acquire new data for the implementation of the sediment thickness formula. Techniques for measuring and analysing sediment thickness range widely in cost, complexity, and effectiveness. Consequently, the design, implementation and interpretation of a seismic acquisition program are best left to qualified experts who can provide specialized advice and assistance. Additional geophysical observations such as measurements of the Earth’s magnetic and gravity fields may contribute to an improved interpretation of the seismic data.

Current navigation technology is adequate for determining accurately the locations of data and sampling points. However, it is essential to ensure compatibility between the reference datums used by the positioning system and by those used to describe the parameters that are integral to the construction of the outer limits of the continental shelf: the territorial sea baseline, bathymetry, sediment thickness, the foot of the continental slope, and the 2500 metre isobath.

CHAPTER 6 – BILATERAL BOUNDARIES

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6.1 GENERAL

Neighbouring States may be opposite or adjacent. In this chapter it is assumed that in the case of adjacent States, the coastal terminal point of the land boundary is agreed or that, if the boundary terminates at the seaward limit of internal waters, the terminal point is agreed.

It is also assumed that there is no dispute concerning baseline claims.

Article 15 specifies that neither of these States is entitled, failing agreement to the contrary, to extend their territorial seas beyond the equidistance line between them. However, this provision is inapplicable if historic title or other special circumstances make it necessary to use another method.

The legal provisions of Articles 74 and 83, which are identical, pertain to the delimitation of the boundaries of exclusive economic zones and continental shelves, respectively.

Unfortunately for the technical expert engaged on maritime delimitation, an equitable solution has no objective meaning, and there are many possible ways in which an equitable solution may be achieved. In any particular case, though, the approach to the problem is likely to follow a well-known method, such as equidistance, which is then adjusted in the last stages in order to achieve the required result. It is not intended here to consider all the possible ways in which solutions may be reached, but to mention only a few basic techniques on which the expert charged with the technical work may build. Key elements that commonly feature in the delimitation of maritime boundaries are illustrated in Figure 6.1.

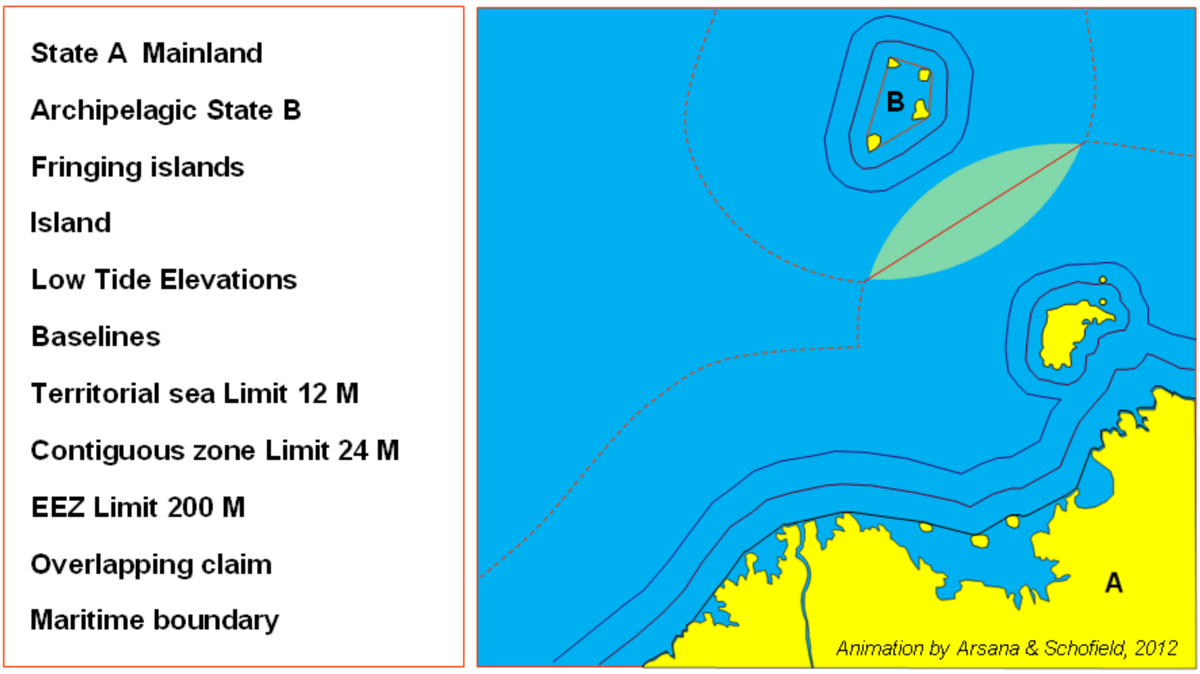


Figure 6.1 – Key Elements in the Construction of a Representative Bilateral Maritime Boundary. (Animation: Figure6_1.ppt)

Before examining the different concepts, there are three technical considerations to be borne in mind.

An appreciation of the appropriate accuracy and precision obtainable or to be achieved is as important in bilateral delimitation as in the determination of baselines or unilateral limits.

Where a dense selection of base-points has been used to arrive at the course of an acceptable boundary, the resulting line may be too complex for description in a treaty or for administration. Some form of simplification may then be necessary.

It is possible, but may be inconvenient from maritime security and management perspectives, to have bilateral boundaries which do not form a continuous division of maritime jurisdiction between States. In order to prevent "gaps" from existing between opposite or adjacent States, it is desirable to have a continuous delimitation line. Similarly, it is possible to have distinct delimitation lines for different maritime zones (e.g. continental shelf and EEZ) but there is a clear preference in practice for maritime boundaries that separate all types of maritime jurisdiction.

6.2 THE EQUIDISTANCE METHOD

In maritime boundary delimitation an equidistance line is defined as a line every point of which is equidistant from the nearest points on the territorial sea baselines of two States. Article 15 refers to this line as a median line, but in the technical literature a distinction has often been made between a median line, defined as an equidistance line between two opposite States, and a lateral (equidistance) line, which is defined as an equidistance line between two adjacent States (see Appendix 1). In practice, however, the concept of adjacent and opposite are often difficult to define and apply, but the method used to determine an equidistance line is the same whatever the relationship of the coasts of the States.

The equidistance method of constructing bilateral limits has become widely acknowledged as the foundation to the technical process of delimitation because:

a) it is the method that must be employed in the territorial sea in the absence of agreement or special circumstances; and

b) it is an objective geometric method which is relatively easy to apply, particularly using computer methods (if the baselines are clearly defined) and gives a unique line.

This has been expressed by the International Court of Justice on several occasions including the latest judgement concerning the Romania-Ukraine case at paragraph 115 of the Court's Report[1], and also in cases taken to Arbitral Tribunal such as the Barbados-Trinidad & Tobago case in paragraph 242 of the Tribunal's Decision[2]. Subsequent cases involving maritime boundary delimitation have similarly applied this three-stage approach to maritime delimitation. These have included cases before the International Court of Justice (ICJ), the International Tribunal on the Law of the Sea (ITLOS) and before international arbitral tribunals[3] [4].

1 http://www.icj-cij.org/docket/files/132/14987.pdf

2 http://www.pca-cpa.org/upload/files/Final%20Award.pdf

3 https://www.icj-cij.org/files/case-related/124/124-20071213-JUD-01-00-EN.pdf

4 https://www.itlos.org/fileadmin/itlos/documents/cases/case_no.23_merits/C23_Judgment_23.09.2017_corr.pdf

When discussing this method all explanations will be given as if calculations and measurements are made on the plane. In practice they are made on the ellipsoid and the plane geometrical terms used are not necessarily absolutely correct for the ellipsoid. For instance, the locus of the points comprising a line equidistant from a single basepoint of one State, and a straight baseline (Geodesic) of another, is here referred to as a parabola. In fact it is a more complex curve and is not even the intersection between a paraboloid and the ellipsoid as this would be true of chord distances rather than those on the surface of the ellipsoid.

Finally, an equidistance line generated by two single basepoints is a unique line that is very nearly but not exactly coincident with a Geodesic. In practice, however, it is considered to be the same as the Geodesic between the successive turning points.

6.2.1 The Construction of the Equidistance Line

An equidistance line can be constructed to define the boundary between two opposite States (see Figure 6.2) or two adjacent States (see Figure 6.3).

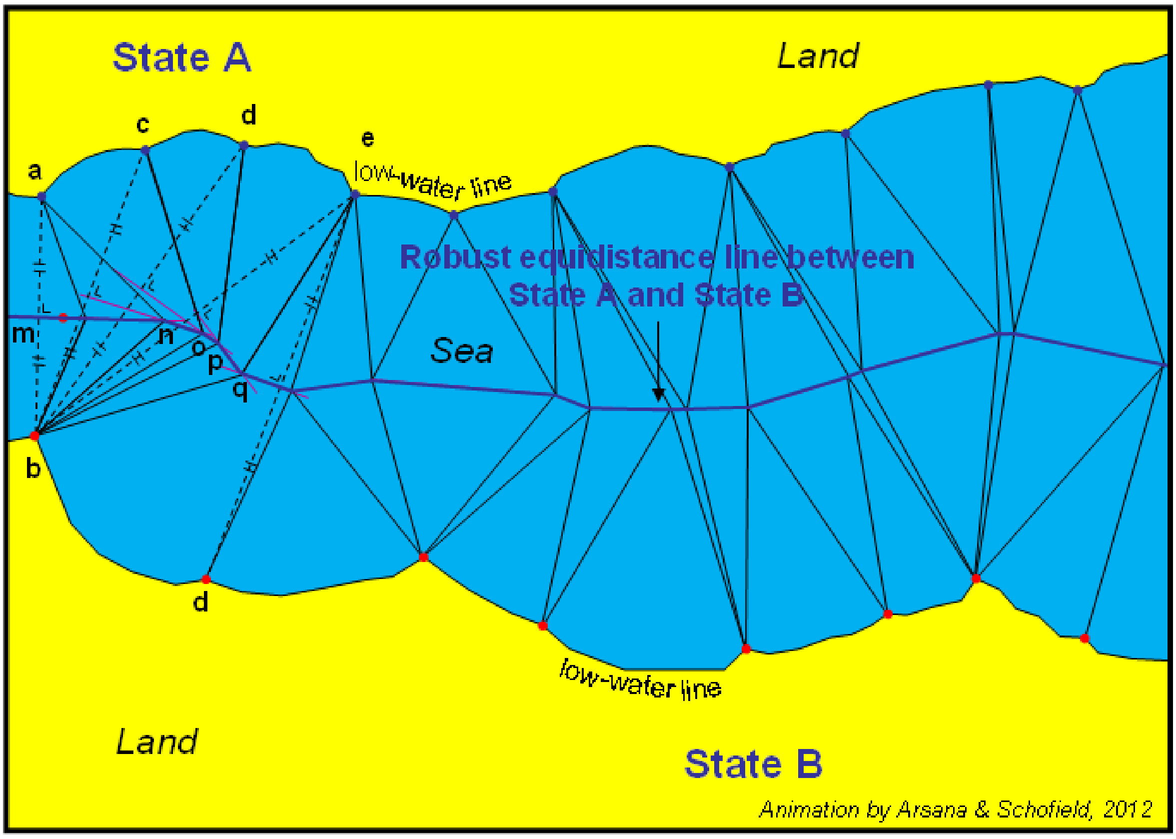


Figure 6.2 – Construction of an Equidistance Line between Opposite States. Both States employ normal baselines (i.e. not a system of straight baselines). The construction of the median line may be seen on the left hand side of the figure. Starting at basepoint **a** in State A and basepoint **b** in State B, the mid-point of the line joining these two points (**m**) defines the position of the equidistance line. The perpendicular to this line (on the direction **m-n**) defines the direction of the equidistance line and this azimuth will remain constant until a third basepoint (**c**), equidistant to points **a** and **b** is reached. In this case a point on the territorial sea

baseline of State A. The perpendicular of the line joining Basepoints **b** and **c** defines the direction of the next leg of the equidistance line. By continuing to proceed to the right in this way the segments of the median line will be constructed until the total median line is derived. The points along the median line equidistant from three points are known as tri-points. (Animation: Figure6_2.ppt)

If two countries decide to use straight baselines instead of normal low-water baselines as some pairs of countries have, then the equidistance line develops into segments of equidistance between:

a) two points, which yields a straight line,
b) two lines, which yields a straight line, and
c) a line and a point, which yields a section of a parabola.

All these examples use plane geometry terminology.

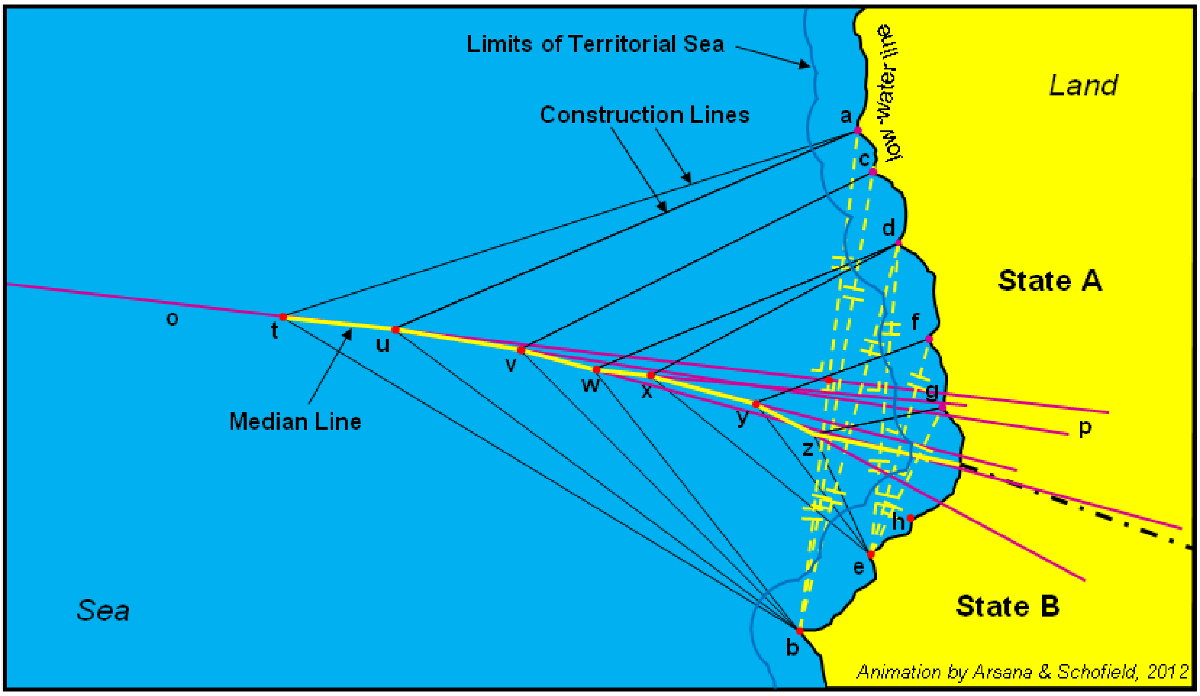


Figure 6.3 – Construction of an Equidistance Line between Adjacent States. Both States employ normal baselines. There is no essential difference between the method of determining the equidistance line in this case and that already described for opposite coasts. Difficulties in determining the link with the land boundary may, however, be avoided by beginning the exercise from seaward rather than from the land boundary terminal. The construction of this equidistance (lateral) line may be achieved as follows: Starting a suitable distance offshore look for two points, in this case **a** and **b**, situated in States **A** and **B** respectively, that are an equal distance from starting point **t**. Produce the angular bisector **o-p**. Proceed shoreward until at point **u** it is found that an additional point **c** is equidistant with **a** and **b**. Now prescribe the angular bisector between **b** and **c** and again continue shoreward until point **v** is reached where a new point **d** is equidistant to **c** and **b**. Continue the process and it will be found that the equidistance line terminates at the land boundary between

States **A** and **B**. (Animation: Figure6_3.ppt)

6.2.2 Selecting Baselines

Only portions of a State's baseline will affect an equidistance line. By definition, the equidistance line will be constructed by using only the salient (seaward-most) base-points. The number actually chosen will depend on the interplay of the relevant segments of baseline of both States, on the configuration of the coastline, and on the distance of the median line from the nearest base-points. The greater the distance, the fewer the base-points that are likely to affect it, and the greater the distance that may be selected between points along a smooth coast.

6.2.3 Graphical Method of Constructing an Equidistance Line

It is both useful and recommended that the technical expert have a basic knowledge of the graphical method of constructing an equidistance line. The construction of an equidistance line using a combination of pure graphical methods and the computation of the turning points requires considerable expertise and can be very time consuming. If this method is used it will only achieve an approximate result, which may not be acceptable as a final solution.

A first step in the delimitation process will be to examine the largest scale nautical chart in detail to decide which points and sections of the coast may be legitimately used in the delimitation. Decisions must be made on such matters as whether features are low-tide elevations or islands, or whether an island has a lighthouse or other navigational aid on it and may therefore be used as a point in a straight baseline system. The coordinates must be derived from and plotted on (as the case may be) the largest scale chart.

It is neither practicable nor necessary to select more than a certain number of these base-points in order to determine the course of the equidistance line. Graphical methods provide the simplest way of selecting (at least initially) the base-points. This requires the use of a suitable chart which shows enough of the baselines of both States (at a scale large enough to see small islands and low-tide elevations), and enough of the water area through which the relevant section of median line will run, to enable a reasonable number of base-points to be selected before moving on to the next chart.

It should be noted that all base-points that affect the calculation should be on the same vertical and horizontal datum (see Chapter 2).

When the possible base-points have been identified, their geographical coordinates must be listed, together with the sequence in which they affect the line. The coordinates should be taken off charts of large enough scale to achieve the desired accuracy. This is likely to be a larger scale than that used for identifying them in the first place. The larger scale is likely to reveal that what seemed to be a single point is now seen to be a feature where more than one point might affect the line. Experience will suggest several ways in which this may be resolved, but if necessary all the coordinates should be read off. Similarly, when selecting base-points on the small-scale general chart it may be unclear which of two or more features really affects the line, or new points on both baselines may appear to become equidistant at the same time. If the problem cannot be resolved by inspection their coordinates should also be listed.

The further resolution of these problems must await the computation process, when accurate distance checks must be made from points on the equidistance line to discover whether other listed base-points are closer than those being used.

6.2.4 Automated Calculation of an Equidistance Line

The generation of an equidistance line using the tools provided in GIS software is the preferred method. It should always be remembered that these systems are only as good as the data that are imported into them. It is also important to ensure that the GIS used carries out all these calculations on the ellipsoid. All the data that are imported into the system for the calculation must be on the same geodetic datum.

In order for the system to select the relevant base-points for the calculation of the equidistance line, the low-water line of both relevant coastlines must be digitised. The baseline may be made up of normal baseline segments, including bay closing lines and river closing lines, straight baselines, and/or archipelagic baselines. Each of these “straight line” segments must be split up into short sections. A decision must be made to define the intermediate points for each of these straight line segments for use in the calculation.

As an example the process of one commonly used GIS is as follows: The low-water line is digitised from the latest edition of the largest scale chart of the area. If other coastline models are used there will be a danger that they will not depict the best low-water line available. The bay closing lines and river closing lines are defined by creating a text file, or logical list of the bay closing line or river closing line terminal point coordinates. Similarly the turning point coordinates of straight baseline systems and/or archipelagic baseline systems are entered as text files or another logical list from the original national legislation, ensuring that the geodetic datum is correctly entered and transformed into the agreed geodetic datum for the equidistance line if different. This data are then joined to form two sets of vector line data. It is from this data that the software will calculate the equidistance line. A report will be generated for each turning point on the line defining the coordinates of the point and the three baseline points from which it has been generated. At this stage it is probable that there will be many more turning points generated that are either practical or needed to accurately define the line. This line will then have to be simplified.

6.2.5 The Simplified Equidistance Line

The equidistance line is composed of a finite, but often large, number of turning points joined by Geodesics (see Chapter 3) or other curves. Very often this produces too complex a line for easy description or practical application, and simplification is needed.

A simplified equidistance line should consist of the smallest practicable number of elements which still maintain the general course of the original line. The turning points should all be linked by 'straight lines', which may be Loxodromes or, preferably, Geodesics, which are considered more suitable for practical application.

Ideally, a line should be simplified so that the resulting course of the line remains the same as the original line, or deviates so little that the resulting area gained or lost by the States is

essentially zero. Under any simplification process this area should be calculated as, with other factors, it may affect the decisions in the boundary negotiations.
It is possible to arrive at other simplified lines, where other more or less objective considerations are taken into account to achieve an equitable result. In particular it is possible to take into account only the most prominent base-points, so that the resulting equidistant line is necessarily less complex than the strict line would be. Whilst these solutions undoubtedly produce a line that is simpler than a strict equidistance line, they are not derived directly from it; neither do they maintain the close relationship with it that is achieved with the "simplified equidistance line" already described. These other lines are sometimes referred to as "modified equidistance lines".

6.3 METHODS DERIVED FROM EQUIDISTANCE

6.3.1 Partial Effect

It may happen that an equidistance line would produce an equitable delimitation except for the effect of some particular baseline feature. Typically such a feature might be situated where it has a disproportionate effect on the course of the line. This distortion may be corrected by assigning such a feature no effect at all, or only partial effect, in the delimitation. In theory the effect to be given may be in any desired ratio, but in practice if partial effect is to be given it is often in the form of half-effect. A classic example is the Arbitral Tribunal award of 30 June 1977 in the United Kingdom – France case where the UK Isles of Scilly were only given half weight. (Report No. 9-3 in Volume II of International Maritime Boundaries – Ed. Jonathan I. Charney and Lewis M. Alexander).

The half-effect line lies half way between the full-effect line and the no-effect line; such as, a parallel line half way between two parallel lines, the angle bisector, or more generally, the locus of points equidistant from the closest point on both the full effect and no-effect lines. Note that this half-effect line may not equally divide the surface area between the full- and no-effect lines, and there has been no suggestion that it should do so.

The most familiar method of application is to construct two equidistance lines: one uses the feature as a base-point, thus giving it full-effect: the other ignores the feature, thus giving it no effect. The half-effect line lies half way between the full-effect line and the no-effect line. See Figures 6.4 and 6.6.

In the case just cited, it might be supposed that the correct method would be to select an imaginary, or notional, basepoint located as though the island were only half as far from the mainland as it really is. The geometry is such, however, that an equidistance line, constructed by substituting the notional base-point for the real feature, would be unlikely to coincide with a half-effect line obtained by the preceding method. Very often the relationship of the distorting feature to the base-points controlling a no-effect line will be such as to make it difficult to decide upon a suitable position for the notional base-point.

There will be occasions when the full- and no-effect lines will be rather complex. That may make construction of a half-effect line in the manner previously described undesirably complicated. In such a case agreement on a notional base-point might provide an easier solution.

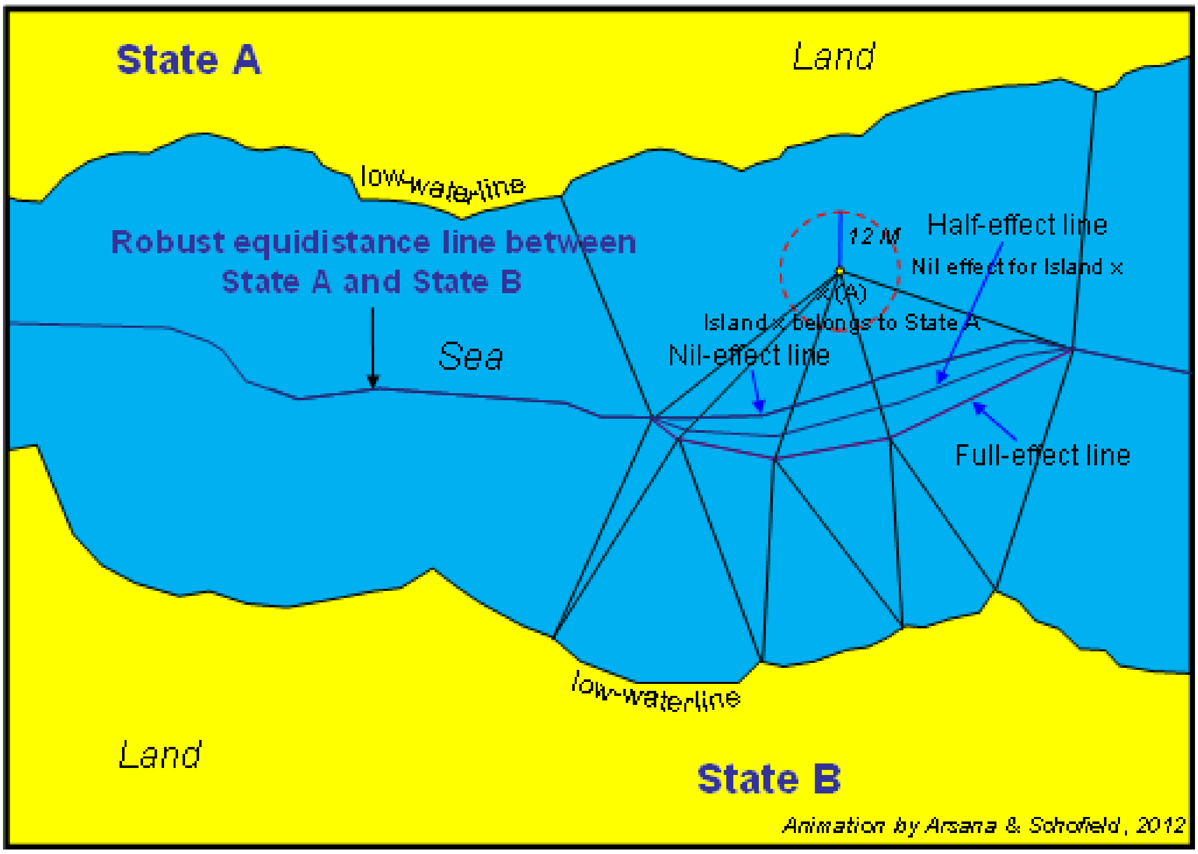


Figure 6.4 – Equidistance Line between Opposite States A and B, showing nil-, full-, and half-effect lines for an island that belongs to State A situated on that State's side of a median line between opposite mainland coasts.
(Animation: Figure6_4.ppt)

6.3.2 Coastal Length Comparison

Comparing the lengths of relevant coasts may have an important role to play in maritime boundary delimitation, and may be relevant to proportionality, or indeed disproportionality, calculations. The first step is to ascertain relevant parts of the coast, then to measure or to calculate the total length of the coast. Several methods may be used, depending on agreement between the Parties:

i) The coastline on a map or chart of chosen scale may be "completed" by drawing closing lines across rivers, and bays, and the total length measured. This length may be measured by digitising and then calculating the length by computer or in the absence of such technology, measured by a curvimeter (opisometer).

ii) The coast is represented by a finite set of discrete points linked by mathematically defined lines (Geodesics, for example). The density of the points will depend upon the required accuracy and the regularity of the coastline. The sum of the length of the linking lines is the total length.

iii) More commonly the coast is represented by a series of straight lines following the lines of general direction taken by the real coastline, and the lengths of the separate sections of generalised coast are summed. This may take two forms: either the lines of general direction reflect only the direction of the coast that 'faces' the area of delimitation, ignoring indentations, etc., or it includes the major indentations but represents their outline by generalised lines. The extreme case of lines of general direction occurs when the whole coast is represented by a single line. This may be done where the whole coastline of the State is a more or less straight line with only relatively minor indentations or by agreement between the Parties. The generalisation of the two coastlines into one or a few segments is now considered to be the preferred option.

If there is a marked difference in coastal lengths between the two States there may be a requirement to move the median line towards the shorter coast in order to achieve an equitable result. See paragraph 237 of the Barbados/Trinidad & Tobago award[5]; see also Libya-Malta[6] and Jan Mayen cases[7].

If the two States can agree on the relevant area to be delimited, it is possible to divide this area in a similar ratio as the coastal fronts. Modern GIS software is capable of calculating areas on the ellipsoid with considerable accuracy (see Chapter 2). This can achieve an equitable result in some cases, but agreement on the relevant area is often difficult to reach. Jurisprudence would suggest that this method should only be used as a test of equitability once the delimitation has been completed.

6.3.3 The Equi-ratio Method

In this method the boundary is defined as the loci of points having a constant ratio of distance between the baselines and base-points of the two States. Any ratio of distances may be chosen to arrive at an equitable solution. The most straightforward application is the ratio 1:1, which results in the equidistant line. Any other ratio chosen will result in a series of conic segments, using the terms of plane geometry, a particularly interesting case being that of a small island State lying off the straight coast of a large State. A set of different ratios will provide a set of ellipses with the island State being located at one focal point of the ellipses. This method has not been used to date (2012). One commercial GIS does have the functionality to calculate this type of boundary.

6.3.4 Methods related to the "General Direction" of the Coastline

This method applies to States that are adjacent to each other. The most common example of this situation is the perpendicular to the "general direction of the coast". The general direction may be determined on a limited length of coastline either side of the land terminus, or it may be determined on the basis of the whole of the coasts of both States, or even on the general direction of a section of the whole land mass embracing several States. A classic example of this method was used in the seaward segment of the boundary between Guinea and Guinea-

5 http://www.pca-cpa.org/upload/files/Final%20Award.pdf
6 https://www.icj-cij.org/files/case-related/68/068-19840321-JUD-01-00-EN.pdf
7 https://www.icj-cij.org/files/case-related/78/078-19930614-JUD-01-00-EN.pdf

Bissau by an Arbitral Tribunal in their judgement of February 1985 (Report No. 4-3 in Volume I of International Maritime Boundaries – Ed. Jonathan I. Charney and Lewis M. Alexander).

A method of establishing the general direction may be to divide a designated sector of coastline, on either side of the boundary, into short segments between evenly spaced basepoints. The azimuths of the lines linking all the consecutive basepoints are averaged to obtain an average 'direction'. This method is unlikely, however, to produce a less arbitrary or more reasonable result than the rather simpler methods already described. This method was used in the Nicaragua-Honduras ICJ judgement of 8 October 2007 para 287[8].

The technical expert should provide, and justify, several alternative general direction lines.

In plane geometry, a perpendicular to a straight line is also a line of equidistance relative to that line. This method of delimitation may therefore be seen as a special case of equidistance, but it will be essential to compute the results in geodetic terms.

The question of what constitutes a "straight line" has already been discussed in Chapter 3. The line of "general direction" has usually been decided from charts on the Mercator projection, and has therefore been a Loxodrome. A Loxodrome is also a line of constant compass bearing, and so at any point throughout its length its direction will be constant. It is possible that in some cases the "general direction" will have been determined on some other projection or by geodetic computation, in which case, the direction will not necessarily be constant throughout its length.

At low latitudes - within 10 degrees of the Equator, the differences between Geodesics and Loxodromes are minimal, particularly if one is dealing with such imprecise concepts as "general direction". At higher latitudes, though, and within the limits for which they are designed, a pictorially more accurate representation of the form of a coastline is given by the Transverse Mercator or Lambert Conformal projections. A straight line representing the general direction on these projections would not be a line of constant bearing: it would be a Geodesic, and the azimuth of a Geodesic changes throughout its length. In high latitudes a "perpendicular" Loxodrome (unless it is also a meridian) is unlikely even to approximate a line of equidistance from the line of "general direction". In any particular case the actual choice of line will depend on a number of factors, and there is no established custom in the matter.

A variant of the perpendicular is the bisector line. In this method the general direction of the coast, or part of the coast, of both the adjacent States, or of opposite States in certain circumstances, is determined. The delimitation line is then taken to be the bisector of the angle formed by these two lines of general direction at the land boundary terminus. This solution is suited to a coast where the general direction changes markedly at or near the boundary. Although superficially attractive, the solution may result in unbalanced areas on the ellipsoid.

8 http://www.pca-cpa.org/upload/files/Final%20Award.pdf

6.4 OTHER METHODS

Many other methods of boundary delimitation may be imagined or have been used. The following are only a few.

6.4.1 The Thalweg Concept

The Thalweg is defined as the line of maximum depth along a river channel or lake but may be considered in any coastal channel. The principle has been employed for centuries where such water bodies form the boundary. Its most obvious use as a boundary lies in areas of shallow water in the territorial sea where it is desirable that the navigational channels giving access to both States should not be under the sole control of one State. In the deeper waters seaward of rivers or estuaries, justification of using the Thalweg method is uncertain.

Where the use of the Thalweg is relevant, its line may be determined from charts. In some cases a special survey may be necessary.

If the Thalweg is following a navigable channel in unstable areas, it will change as the channel changes. It can only remain as a stationary line if it is used in waters too deep for changes in bathymetry to matter. If the inshore section of a maritime boundary is formed by an ambulatory Thalweg it must be linked in some way to the fixed offshore section of the boundary. This may be done by terminating the Thalweg at a defined line (a line of bearing from a fixed point, or a meridian or parallel) which passes through the position determined as the landward end of the fixed section of boundary. The inshore section of the boundary, at any particular time, will be the Thalweg as it is at that time, and will terminate at whatever point it intersects the defined line. The boundary will then continue along the part of the defined line linking the point of intersection and the position of the landward end of the fixed offshore section.

6.4.2 Prolongation of Land Boundaries

If the land boundary pursues a straight course, perhaps more or less perpendicular to the direction of the coast, for some distance before reaching its coastal terminal point, it may be decided to continue it in the same direction to form at least a near-shore section of the maritime boundary. It is unlikely that such a prolongation will be satisfactory as a complete maritime boundary. The same geodetic considerations as before apply in relation to the question of "straight", etc.

6.4.3 Arbitrary Lines

For various reasons, perhaps historical or political, agreed maritime boundaries may be simple Geodesics or Loxodromes such as a parallel of latitude, a meridian, parallel lines forming a corridor, and so on.

Although described as arbitrary, the lines may be supported by a sound rationale. For instance, where the whole length of a continental coastline follows the same general direction, a series of bilateral boundaries all parallel to one another will produce the most equitable solution for all the States involved notwithstanding that, if each delimitation problem were examined in isolation, different solutions might appear equitable. Similarly, where a State has a very short frontage on a regular coastline, the most equitable boundaries with its neighbours might be parallel lines forming a corridor of the same width as its length of coastline.

6.4.4 Enclaving

There are several examples, both judicial and bilateral, where a coastal feature, usually an island or islands distanced geographically from the coastal State, has not been given its full maritime entitlement – it has been wholly or partially enclaved. e.g., in the UK-France Arbitral Tribunal award of 30 June 1977, the Channel Islands were enclaved on the French side of the continental shelf boundary line constructed between their opposite mainland coasts (Report No. 9-3 in Vol. II of International Maritime Boundaries – Ed. Charney and Alexander) (see Figures 6.5 and 6.6).

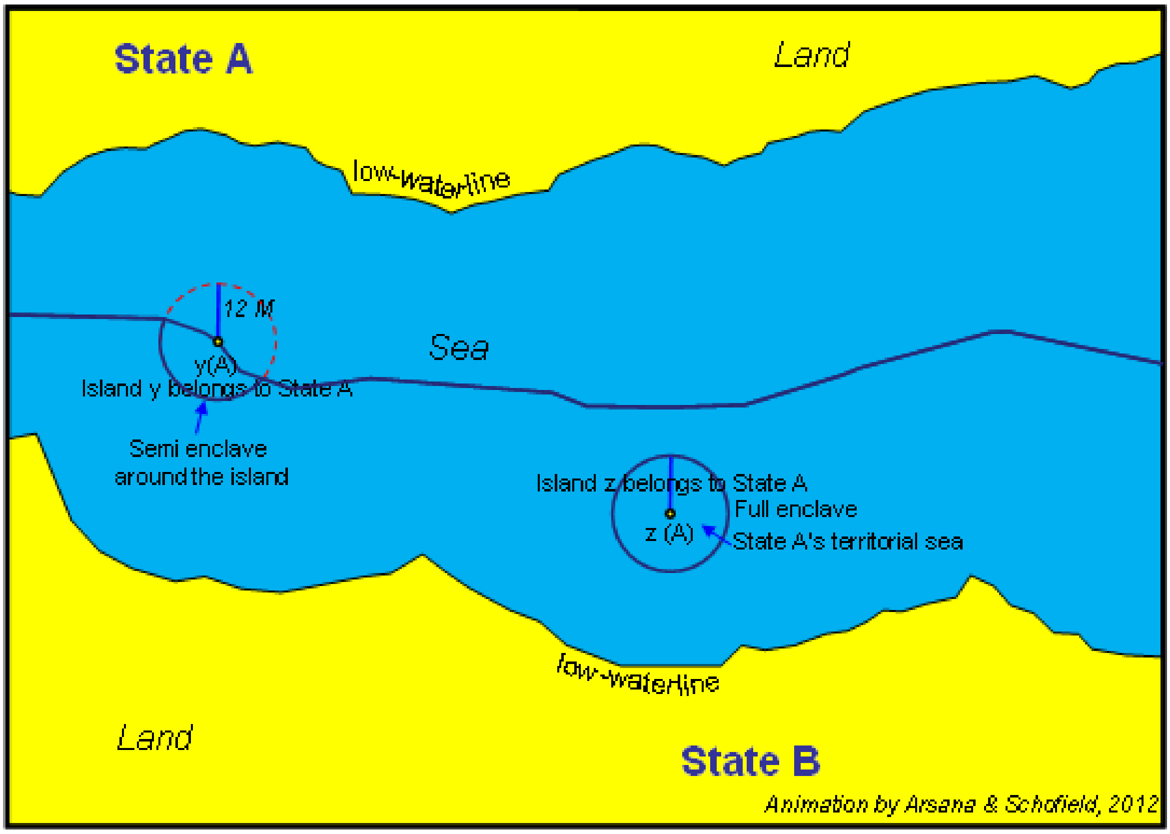


Figure 6.5 – Equidistance Line between opposite States A and B, showing semi and full enclave effects for islands belonging to State A when situated on the Equidistance Line, or on State B's side of a median line constructed between opposite mainland coasts. (Animation: Figure6_5.ppt)

6.5 PROPORTIONALITY

In essence, the concept of proportionality has been taken to date to mean that the relevant maritime areas should be divided in proportion to the relative lengths of the coastline of the two States. This concept may have been applied in bilateral agreements, but has only been used as test of the equitability of the delimited line in court cases to date (2019) with use of the term “disproportionality” used in the context of the third stage in the three-stage approach to maritime delimitation.

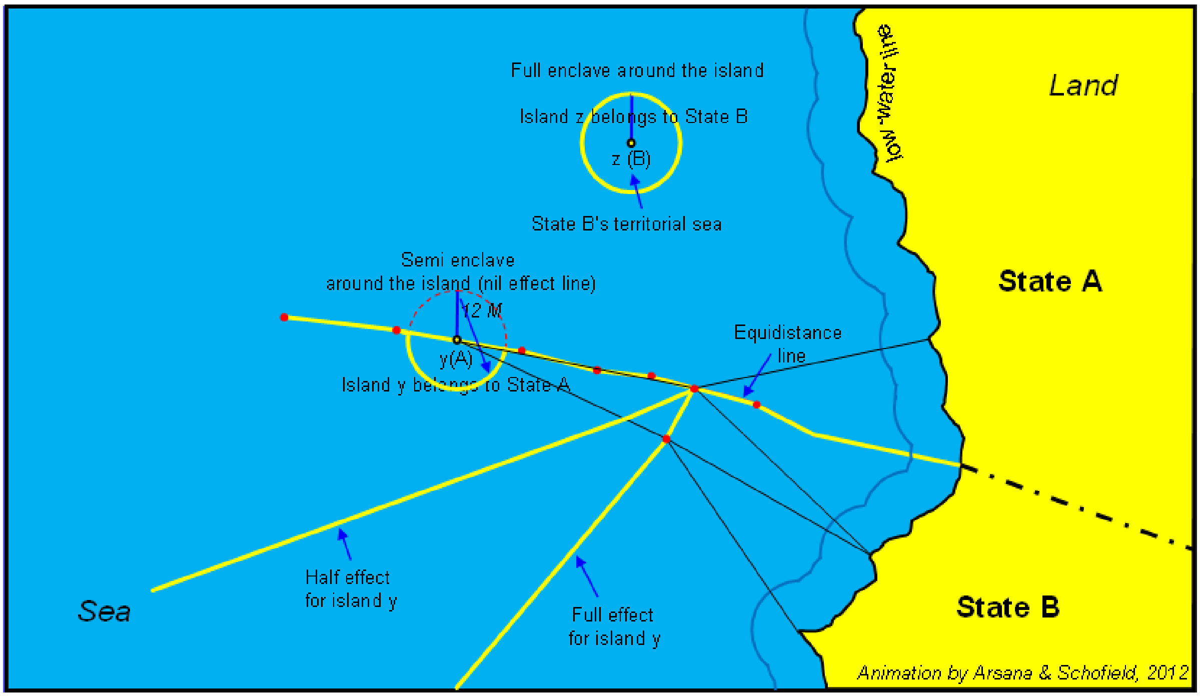


Figure 6.6 – Equidistance Line between adjacent States A and B, showing: the enclave effect for an island belonging to State B but situated on State A’s side of an Equidistance Line constructed between adjacent coasts; the nil-, full-, and half-effect lines, also the semi-enclave effect for an island belonging to State A and situated on the Equidistant Line. (Animation: Figure6_6.ppt)

6.6 GUIDANCE from INTERNATIONAL CASES

There have been several decisions of the International Court of Justice or of ad hoc Tribunals that are of significant interest when considering bilateral delimitation. They are included in the bibliography.

These decisions are essential reading for anyone engaged in delimitation work, but they must be studied with care, so that the particular circumstances that determined the decisions are understood and not misapplied in different circumstances. Finally, it should be emphasised that the technical branch of the government must work closely with the legal and political branch when interpreting the international law of maritime boundary delimitation and applying the principles and methods to a particular situation.

APPENDIX 1

GLOSSARY

INTRODUCTION

The 1982 United Nations Convention on the Law of the Sea includes terms of a technical nature that may not always be readily understood by those seeking general information or those called upon to assist in putting the Convention articles into effect. Such readers could vary from politicians and lawyers to hydrographers, land surveyors, cartographers, geographers and others. The need to understand such terms may become of particular concern to those involved in matters such as baselines, maritime limits, and boundary delimitation. Accordingly, the Technical Aspects of the Law of the Sea (TALOS) Working Group of the IHO has produced this Glossary to assist all readers of the Convention in understanding the hydrographic, cartographic and oceanographic terms used.

Where definitions have been extracted verbatim from the Convention or where the Working Group has defined the terms itself, they will appear in bold type in the documents. Explanatory notes appear beneath these in lighter type. Where appropriate, reference is made to the articles of the Convention.

Care has been taken to provide definitions that are within the context of the subject matter. Where this has not been an overriding consideration, consistency with the Hydrographic Dictionary, Part I, Fourth Edition has been adopted.

The Glossary should be read in conjunction with Appendix 2. This provides more detailed information on the applications of the Convention.

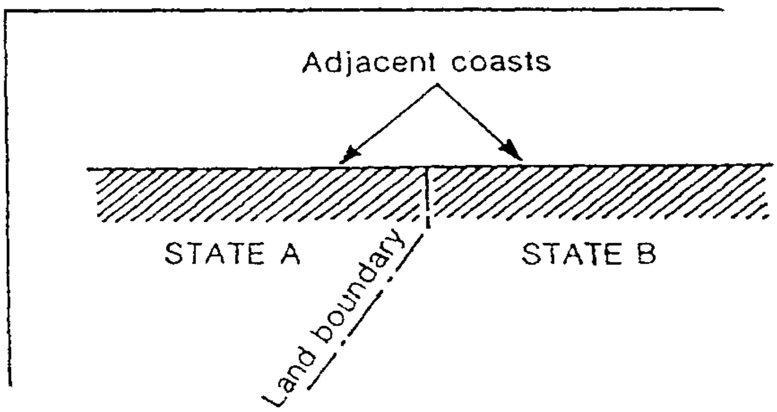
INDEX OF TERMS IN THE GLOSSARY

GLOSSARY

1 **ADJACENT COASTS**

The coasts lying either side of the land boundary between two adjoining States.

Figure 1 - Adjacent Coasts



2 **AID TO NAVIGATION**

A visual, acoustical, or RADIO device, external to a ship, designed to assist in determining a safe COURSE or a vessel's POSITION, or to warn of dangers and/or OBSTRUCTIONS. Aids to navigation usually include BUOYS, BEACONS, FOG SIGNALS, LIGHTS, RADIO BEACONS, LEADING MARKS, RADIO position fixing systems and GNSS which are chart-related and assist safe NAVIGATION.

See the Convention:
navigational and safety aids: 21(1)(b); 43(a)

See: NAVIGATIONAL AID

3 **ARCHIPELAGIC BASELINES** See the Convention (Art 47)

See: BASELINE

4 **ARCHIPELAGIC SEA LANES PASSAGE**

See the Convention:
right of archipelagic sea lane passage: Art 53
regime: Art 49(4)

See: ROUTEING SYSTEM; TRAFFIC SEPARATION SCHEME

5 **ARCHIPELAGIC STATES**

See the convention:
- see generally: Art 46 to 54
- baselines: Art 47;48; 49(1)
- internal waters delimitation: Art 51(2)
- sovereignty: Art 2: 49(1); 49(2); 49(3)
- submarine cable; Art 51(2)
- suspension of innocent passage: Art 52(2)
- traditional rights: Art 51(1)
- use of term: 46(a)

See: ARCHIPELAGIC WATERS; BASELINE; ISLANDS

6 **ARCHIPELAGIC WATERS**

The waters enclosed by archipelagic baselines.

See the Convention:
- delimitation: Art 50
- hot pursuit: Art 111(1)
- legal status of archipelagic waters, of the air space over archipelagic waters and of their bed and subsoil: Art 49; 49(4); 86
- sea lanes passage and air routes: Art 54(1); 53(4)
- sovereignty: Art 2(1); 49(1); l49(2)
- traditional rights: Art 47(6); 51(1)
- use of term: Art 46(b); 49(1)

See: ARCHIPELAGIC STATE; BASELINE; INTERNAL WATERS

7 **AREA**

See the Convention:
- use of term and scope: Art 1(1)

See: BASELINE; CONTINENTAL SHELF; DEEP OCEAN FLOOR; EXCLUSIVE ECONOMIC ZONE; SEABED; SUBSOIL

8 **ARTIFICIAL ISLAND**

See: INSTALLATION (OFF-SHORE)

9 **ATOLL**

A ring or horseshoe shaped reefs enclosing or nearly enclosing a tropical lagoon, with or without an island or islands situated on it, and surrounded by open sea.

See the Convention:
reefs: Art 6
archipelagic baselines: Art 47(1); 47(7)

The reef may be built of coral and/or calcareous algae. An atoll is built on an existing structure such as extinct, submerged volcano.

See: ARCHIPELAGIC WATERS; BASELINE; ISLANDS; LOW-WATER LINE; REEF

10 **BANK**

An elevation of the seafloor over which the depth of water is relatively shallow.

See the Convention:
mouths of rivers: Art 9
occurrence of term: Art 76(6)

See: CONTINENTAL SHELF, LOW TIDE ELEVATION

11 **BASELINE**

The line from which the outer limits of a State's territorial sea and certain other outer limits of coastal State jurisdiction are measured.

See the Convention:
archipelagic: Art 47; 48; 49(1)
bays: Art 10(5): 10(6)
charts or coordinates; Art 16; 47(8)
continental shelf: Art 76(1); 76(4)(a); 76(5); 76(6);76(4)(a);82(1);246(6)
exclusive economic zone: Art 57
method of determining: Art 5; 7; 9; 10(6); 14; 35(a); 47(1); 47(2); 47(3); 47(4); 47(5)
reefs: Art 6
territorial sea: Art 3; 4; 6; 7; 8(1); 13(1); 15; 16(1); 47(4); 48; 57; 246(6)

12 **BASEPOINT**

A basepoint is any point on a baseline.

13 **BAY**

Wide indentation in the coastline generally smaller than a gulf and larger than a cove. For the purposes of the United Nations Convention on the Law of the Sea, a bay is well-marked indentation whose penetration is in such proportion to the width of its mouth as to contain land locked waters and constitute more than a mere curvature of the coast. Compare historic bay.

See the Convention:
mouth of a bay: Art 10(2); 10(3)
disputes involving historic bays: Art 298(1)(a)(i)
historic: Art 10(6)
use of term: Art 10

See: HISTORIC BAYS

14 **CAP**

A seafloor elevation with a rounded cap-like top.

See the convention: Art 76(6)

15 **CHART**

A special-purpose map generally designed for navigation or other particular purposes.

See the Convention:
adequate scale: Art 16(1); 47(8); 75(1); 84(1)
archipelagic baselines: Art 47(8); 47(9)
area: Art 134(3)
continental shelf: Art 76(9); 84
depositary: Art 16(2); 47(9); 75(2); 76(9); 84(2); 134(3)
duties of the flag State: Art 94(4)(a)
exclusive economic zone: Art 75
large-scale: Art 5
officially recognised: Art 5; 6
publicity: Art 16(2); 22(4); 41(6); 47(9);53(10); 75(2); 84(2); 134(3)
sea lanes and traffic separation schemes: Art 22(4); 41(6); 53(10)
territorial sea: 5; 6; 16

BASELINE; COAST; DANGER TO NAVIGATION; GEODETIC DATUM; LOW-WATER LINE; NAVIGATION AID; SEABED

16 CHART DATUM

The tidal level to which depths on a nautical chart are referred to constitutes a vertical datum being called Chart Datum.

See: M-3 IHO Resolution 3/1919

17 **CLOSING LINE**

A line that divides the internal waters and territorial sea of a coastal State, or in the case of an archipelagic State, a line that divides the internal waters and archipelagic waters.

See the Convention:
archipelagic waters: Art 50
bays: Art 10
mouths of rivers: Art 9
ports: Art 11

See: ARCHIPELAGIC STATE; BASELINE; BAY; HARBOUR WORKS; INTERNAL WATERS and LOW-WATER LINE

18 COAST

The edge or margin of the land next to the sea; the seashore. Sometime defined as the meeting of the land and the sea considered as the boundary of the land.

See the Convention opposite or adjacent coasts, *see also* delimitation:
continental shelf delimitation: Art 76(10); 83(1); 134(4); Annex 2/9
exclusive economic zone: Art 74(1)
territorial sea delimitation: Art 15

See: BASELINE and LOW-WATER LINE

19 CONTIGUOUS ZONE

A zone contiguous to a coastal State's territorial sea, which may not extend beyond 24 nautical miles from the baselines from which the breadth of the territorial sea is measured. The coastal State may exercise certain control in this zone subject to the provisions of the United Nations Convention on the Law of the Sea.

See the convention:
archaeological and historic objects: Art 303(2)
archipelagic States: Art 48
breadth: Art 33(2); 48
hot pursuit: Art 111(1); 111(4)
islands: Art 121(2)
use of the term: Art 33(1)

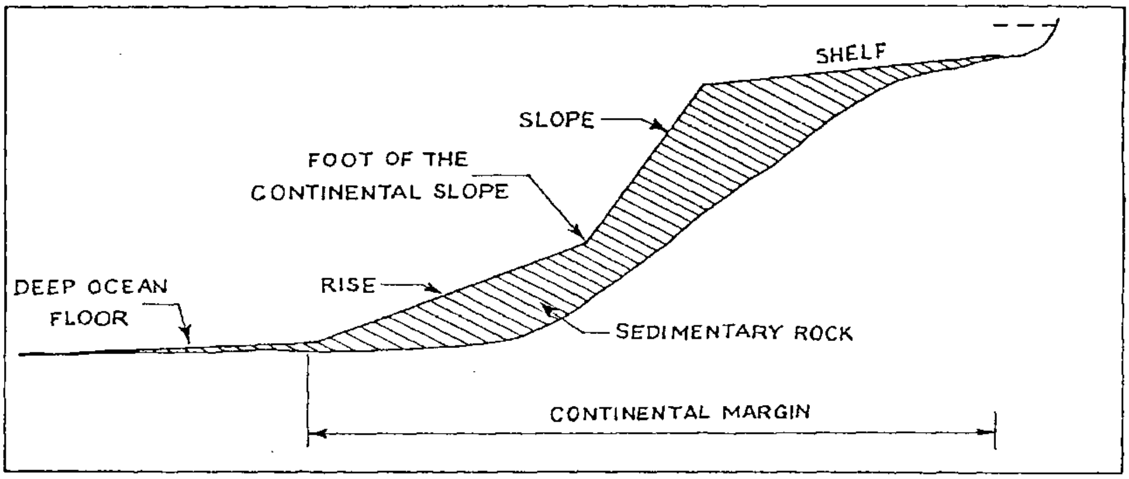
See: BASELINE ; EXCLUSIVE ECONOMIC ZONE ; HIGH SEAS

20 CONTINENTAL MARGIN

The continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the seabed and subsoil of the shelf, the slope and the rise. It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof. Art 76(3)

See the Convention, *see also* outer edge; rocks:
occurrence of the term: 76(1); 76(3);76(4)(a); 76(6)

Figure 2 - Profile of the Continental Margin



See: CONTINENTAL RISE; CONTINENTAL SHELF; CONTINENTAL SLOPE; FOOT OF THE CONTINENTAL SLOPE; DEEP OCEAN FLOOR; SEABED; SHELF, SUBSOIL and Appendix 2.

21 **CONTINENTAL RISE**

A submarine feature which is that part of the continental margin lying between the continental slope and the deep ocean floor; simply called the Rise in the Convention.

See the Convention:
occurrence of the term: 76(3)

See: CONTINENTAL MARGIN; CONTINENTAL SLOPE; DEEP OCEAN FLOOR; FOOT OF THE CONTINENTAL SLOPE

22 **CONTINENTAL SHELF**

The continental shelf of a coastal State comprises the sea bed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance.

See the Convention, *see also* Commission on the Limits of the Continental Shelf; continental margin; continental rise; continental slope:
archipelagic States: Art 48
artificial islands, installations and structures: Art 60(8); 80; 111(2); 147(2)(e)
charts and lists of geographical coordinates: Art 76(9); 84
coastal States rights: Art 77(3); 78; 79(4);81
delimitation: Art 76(10); 83; 134(4); 147(2)(e); 259; Annex 2/9
drilling: Art 81; 246(5)(b)

hot pursuit: Art 111(2); 111(4)
laying of cables and pipelines: Art 79(1); 79(2); 79(3); 79(4); 112(1)
legal status of superjacent waters and air space: Art 78
limits: Art 76(2); 76(5);76(6); 76(7); 76(8); 76(9); 84(1); 84(2); A2/3(1)(a); A2/4; A2/7; Annex 2/9
marine scientific research: Art 246; 247; 248; 249; 253
outer edge: Art 76(1)
payments and contributions derived from exploitation beyond 200 nautical miles: Art 82
pollution: Art 79(2); 210(5); 216(1)(a)
superjacent waters: Art 78
use of the term: Art 76

See: CONTINENTAL MARGIN, OUTER LIMIT

23 **CONTINENTAL SLOPE**

That part of the continental margin that lies between the shelf and the rise. Simply called the slope in Art. 76(3)

See the Convention:
occurrence of the term: Art 76(3); 76(4)(a)(i); 76(4)(a)(ii); 76(4)(b)

See: CONTINENTAL MARGIN; CONTINENTAL SHELF; CONTINENTAL RISE; DEEP OCEAN FLOOR and FOOT OF THE CONTINENTAL SLOPE

24 **DANGER TO NAVIGATION**

Any feature or condition that might hinder, obstruct, endanger or otherwise constitute danger to safe navigation.

See the Convention:
navigation or overflight: Art 24(2); 44; 225

25 **DEEP OCEAN FLOOR**

The surface lying at the bottom of the deep ocean with its oceanic ridges, beyond the continental margin.

See the Convention, *see also* seabed and subsoil:
occurrence of the term: Art 76(3)

See: CONTINENTAL MARGIN; OCEANIC RIDGE; SEABED; SUBMARINE RIDGE and SUBSOIL

26 **DELIMITATION**

The line of the maritime boundary between opposite or adjacent coastal States

See the Convention, *see also* opposite or adjacent coasts:
continental shelf: Art 76(10); 83; 134(4);147(2)(e); 259; Annex 2/9
disputes regarding: Art 298(1)(a)(i);298(1)(a)(iii); 259; Annex 2/9
exclusive economic zone: Art 74; 75(1); 147(2)(e); 259
internal waters of archipelagic States: Art 50
special circumstances or historic title: Art 15
territorial sea: 15; 16(1); 60(8); 147(2)(e); 259

See: MARITIME DELIMITATION

27 **DELTA**

An area of alluvial deposit, usually triangular in outline, near the mouth of a river .

See the Convention:
straight baselines: Art 7(2)

See: BASELINE and LOW-WATER LINE

28 **DUE PUBLICITY**

Notification of a given action for general information through appropriate authorities within a reasonable amount of time in a suitable manner. Used in the context of the United Nations Convention on the Law of the Sea.

See the Convention, *see also* due notice:
charts and lists of geographical coordinates: Art 16(2); 47(9); 75(2); 76(9); 84(2)
coastal States' laws *re* innocent passage: Art 21(3)
coastal States' laws *re* pollution: Art 42(3); 211(3)
laws of States bordering straits *re* transit passage: Art 42(3)
sea lanes and traffic separation schemes: Art 22(4); 41(2); 41(6); 53(7); 53(10)

In addition to notification to concerned States through diplomatic channels, more immediate dissemination to mariners may be achieved by passing the information directly to national Hydrographic Offices for inclusion in their Notices to Mariners.

See: BASELINE; CHART; GEOGRAPHICAL COORDINATES; TRAFFIC SEPARATION SCHEME

29 **ELLIPSOID**

The Ellipsoid is a geometric shape that closely approximates the shape of the Geoid. It is a smooth mathematical surface upon which it is possible to perform exact mathematical calculations that would not be practical on the Geoid with its complex, irregular shape.

There are several reference ellipsoids. Some approximate the Geoid on a global basis, while others approximate it over particular geographic regions. The coordinates of any given point on the surface of the Earth will vary according to the reference ellipsoid that is in use. The process of converting coordinates from one reference ellipsoid to another is known as transformation. Transformation parameters are available for most reference ellipsoids.

See: GEOID

30 **ENCLOSED or SEMI-ENCLOSED SEAS**

A gulf, basin, or sea surrounded by two or more States and connected to another sea or the ocean.

See the Convention, *see also* geographically disadvantaged States:
States bordering: Art 70(2); 123
use of the term: Art 122

31 **EQUIDISTANCE LINE**

See: MEDIAN LINE

32 **ESTUARY**

That portion of a stream influenced by the tide of the body of water into which it flows. A bay, as the mouth of a river, where the tide meets the river current.

See the Convention:
pollution: Art 1(1)(4); 207(1)

See: BAY; RIVER; DELTA

33 **EXCLUSIVE ECONOMIC ZONE (EEZ)**

The exclusive economic zone is an area, not exceeding 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, subject to a specific legal regime established in the United Nations Convention on the Law of the Sea, under which the coastal state has certain rights and jurisdiction.

See the Convention: Part V Art 55 to 75, *see also* artificial islands; breadth; delimitation; dumping; opposite or adjacent coasts; violations.

34 **FACILITIES (NAVIGATIONAL)**

See the Convention:
navigational: Art 21(1)(b)

See: AID TO NAVIGATION

35 **FACILITIES (PORT)**

See the Convention:
port: Art 18(1)(a); 18(1)(b); 25(2)

See: HARBOUR WORKS

36 **FOOT OF THE CONTINENTAL SLOPE**

In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change of gradient at its base.

See the Convention:
foot of continental slope: Art 76(4)(b)

It is the point where the continental slope meets the continental rise or, if there is no rise, the deep ocean floor.

The two methods laid down in Art. 76(4) for determining the outer limit of the continental shelf depend upon the foot of the continental slope.

See: CONTINENTAL RISE; CONTINENTAL SHELF; CONTINENTAL SLOPE

37 **GEOID**

A geoid is a three dimensional surface of equal gravitational acceleration (equipotential). Although there are an infinite number of these equipotential surfaces for the Earth, 'The Geoid' is often used to describe the equipotential surface that best corresponds with mean sea level.

See: ELLIPSOID

38 **GEODESIC**

The shortest line on a mathematically derived surface, between two points on that surface. A geodesic line on a reference spheroid is also called a geodetic line.

The geodesic is one of two types of line (the other being the loxodrome) for defining 'straight line' segments of a maritime jurisdictional limit – the type cartographic projection used for the map or chart will determine whether the lines plots 'straight lines'; for example a loxodrome will plot as a straight line on a Mercator projection hydrographic chart but a geodesic will be a curved line on that chart.

See: BASELINE, LOXODROME, STRAIGHT LINE, and ELLIPSOID

39 **GEODETIC DATA**

Parameters defining geodetic or astronomical reference systems and their mutual relations; horizontal, vertical and/or three dimensional coordinates of points referred to such systems; observations of high precision from which such coordinates may be derived; ancillary data such as gravity, deflections of the vertical or geoid separation at points or areas referred to such systems.

See the Convention: Art 76(9)

See: GEODETIC DATUM; GEODETIC REFERENCE SYSTEMS

40 **GEODETIC DATUM (see Section 2.4)**

An official, fully-defined, spatial reference system or surface to which measurements and/or coordinates upon the Earth may be defined and related.
See the Convention:
geodetic datum: Art 16(1); 47(8); 75(1); 84(1)

See: BASELINE; GEOGRAPHICAL COORDINATES; GEODETIC DATA; GEODETIC REFERENCE SYSTEMS

41 **GEODETIC REFERENCE SYSTEMS (see Section 2.3)**

A geodetic reference system is defined by specifying an ellipsoid of rotation (also termed a spheroid by Anglo-U.S. Geodesists) which requires:

a) Semi-axis major and flattening

or

b) Semi-axis major and second zonal gravity harmonic (J)

The second alternative has been adopted by the IAG (they also specify the earth's gravitational constant, GM, and the angular velocity, W) but the two definitions are equivalent in practice.

Points at zero geodetic height lie on the surface of the ellipsoid, while other points are projected down (by the amount of their geodetic height) to the feet of normals to the ellipsoid.

Coordinates are three-dimensional Cartesians referred to an origin at the centre of the spheroid with the Z-axis along the axis of symmetry, or geodetic geographicals with an associated geodetic height.

See: GEOGRAPHICAL COORDINATES; GEODETIC DATA and GEODETIC DATUM

42 **GEOGRAPHICAL COORDINATES**

A system of spherical coordinates for defining the positions of points on the Earth.

See the Convention, *see also* charts:
archipelagic baselines: Art 47(8); 47(9)
continental shelf: Art 84
deposited with the Secretary-General of the Authority: Art 84(2); 134(3)
deposited with the Secretary-General of the United Nations: Art 16(2); 47(9); 75(2); 84(2)
exclusive economic zone: Art 75
territorial sea: Art 16

43 GREAT CIRCLE

A Great Circle is a circle on a surface of a sphere, where the centre of the circle is coincident with the centre of the sphere.

The shortest distance between two points on the surface of a sphere is defined by the segment of the Great Circle that passes through those two points.

See: GEODESIC, LOXODROME

44 HARBOUR WORKS

Permanent manmade structures built along the coast which form an integral part of the harbour system such as jetties, moles, quays or other port facilities, coastal terminals, wharves, breakwaters, sea walls, etc.

See the Convention:
ports: Art 11

See: BASELINE; PORT

45 HISTORIC BAY

Historic bays are those over which the coastal State has publicly claimed and continuously exercised jurisdiction and this jurisdiction has been accepted by other States. Historic bays need not match the definition of "bay" contained in the United Nations Convention on the Law of the Sea.

See the Convention:
historic bays: Art 10(6); 298(1)(a)(i)
historic title: Art 15; 298(1)(a)(i)

46 HYDROGRAPHIC SURVEY

A survey having for its principal purpose the determination of data relating to bodies of water. A hydrographic survey may consist of the determination of one or several of the following classes of data: depth of the water;

configuration and nature of the bottom; directions and force of current; heights and times of tides and water stages; and location of topographic features and fixed objects for survey and navigation purposes.

See the Convention:
- hydrographic survey: Art 21(1)(g); 40
- survey: Art 19(2)(j); 54

See: BASELINE; GEOGRAPHICAL COORDINATES

47 INSTALLATION (OFF-SHORE)

Manmade structure usually built for exploration or exploitation of marine resources, marine scientific research, tide observation, etc.

See the Convention, *see also* artificial islands; due notice; offshore; structures:
- baseline determinations: Art 7(4); 47(4)
- coastal State: Art 19(2)(k); 21(1)(b)
- continental shelf: Art 79(4); 80; 111(2); 246(5)(c)
- cooperation in the construction and improvement of means of transport: Art 129
- exclusive economic zone: Art 56(1)(b)(i); 60; 79(4); 246(5)(c)
- high seas: Art 87(1)(d)
- inquiries into damage to: Art 94(7)
- legal status: 60(8); 80; 147(2)(e); 259
- marine scientific research: Art 246(5)(c); 249(1)(a); 249(1)(g); 258; 259; 260; 261; 262
- meaning of innocent passage: Art 19(2)(k)
- pollution from: Art 145(a); 194(3)(c); 194(3)(d); 208(1); 209(2); 214
- removal: Art 60(3); 147(2)(a)
- safety zones: Art 60(4); 60(5); 60(6); 60(7); 111(2); 147(2)(c); 260
- unauthorized broadcasting on the high seas: Art 109
- used for activities in the Area: Art 147(2); 147(2)(a); 147(2)(b); 147(2)(c); 147(20(d); 147(2)(e); 153(5); 209(2)

48 INTERNAL WATERS

Waters on the landward side of the baseline of the territorial sea.

See the Convention, *see also* innocent passage:
- archipelagic States: Art 50
- delimitation: Art 10(4); 35(a); 50
- entry into *or* exit from: Art 18(1); 25(2); 27(2); 27(5); 28(3)
- hot pursuit: Art 111(1)
- pollution: Art 211(3); 218(1); 218(2); 218(3); 218(4)
- regime: Art 7(3); 8(2); 10(4)
- sovereignty: Art 2(1)
- use of term: Art 8(1)

See: BASELINE; BAY; COASTLINE; LOW-WATER LINE; HISTORIC BAY; INSTALLATIONS (OFF-SHORE); RIVER

49 **INTERNATIONAL NAUTICAL MILE**

A unit of length equal to 1,852 metres. This value was approved by the International Hydrographic Conference of 1929 and has been adopted by nearly all maritime states..

For general navigational purposes, the International Nautical Mile can be approximated by one minute of latitude, which varies in length from 1843 to 1862 metres depending on latitude.

50 **ISLANDS**

A naturally formed area of land surrounded by water at high tide.

See the Convention, *see also* artificial islands; installations; structures; rocks
baselines: Art 6; 7(1); 13; 47(1); 47(4); 121(2)
installations *or* equipment not possessing the status of islands: Art 60(8); 147(2)(e); 246(5)(c); 259
limestone: Art 47(7)
re archipelagic States: Art 46; 47(1); 53(5)
re bays: Art 10(3)
regime of: Art 121
rocks: Art 121(3)
transit passage: Art 38(1)
with fringing reefs: Art 6; 47(7)
use of the term: 121(1)

See: ATOLL; BASELINE; CONTIGUOUS ZONE; CONTINENTAL MARGIN; EXCLUSIVE ECONOMIC ZONE; ROCK; TIDE

51 **ISOBATH**

A depth curve is a line connecting points of equal water depth.

See the Convention: Art 76(5)

52 **LAND TERRITORY**

Continental or insular land masses that are above water at high tide.

See the Convention:
occurrence of the term; Art 2(1); 76(1); 121(2); 298(1)(a)(i)

See: TIDE

53 **LATITUDE**

Angular distance from a primary great circle or plane. One of the coordinates used to describe a position, the other being longitude.

See: GEOGRAPHICAL COORDINATES

54 LONGITUDE

Angular distance along a primary great circle, from the adopted reference point. One of the coordinates used to describe a position, the other being latitude.

See: GEOGRAPHICAL COORDINATES

55 LOW-TIDE ELEVATIONS

A low-tide elevation is a naturally formed area of land which is surrounded by and above water at low tide but submerged at high tide.

See the Convention:
Art 7(4); 13: 47(4)

Low-tide elevation is a legal term for what are generally described as drying banks or rocks. On nautical charts they should be distinguishable from islands.

See: BANK BASELINE; ISLAND; LOW-WATER LINE; CHART; TERRITORIAL SEA; INSTALLATION (OFF-SHORE)

56 LOW WATER LINE / LOW WATER MARK

The intersection of the plane of low water with the shore. The line along a coast, or beach, to which the sea recedes at low water.

See the Convention: Art 5; 6; 7(2); 9; 10(3); 10(4); 10(5); 13(1)

It is the normal practice for the low water line to be shown as an identifiable feature on nautical charts unless the scale is too small to distinguish it from the high-water line or where there is no tide so that the high and low-water lines are the same.

The actual water level to which soundings on a chart are referred is known as Chart Datum.

See: BASELINE; CHART; TIDE and Appendix 2.

57 LOXODROME

A Loxodrome or Rhumb Line is a true straight line on a Mercator chart, where it has a constant azimuth. It is one of two methods (the other being the Geodesic) used to define straight line segments of a territorial sea baseline.

Projected back onto the reference ellipsoid, a loxodrome will generally differ from a geodesic constructed between the same two points.

See: GEODESIC; TERRITORIAL SEA BASELINE

58 **MARITIME DELIMITATION**

The determination of a maritime boundary between States effected by agreement.

See the Convention (delimitation), see also opposite or adjacent coasts:
continental shelf: Art 76(10); 83; 84(1); 134(4); 147(2)(e); 259; Annex 2/9
disputes regarding: Art 298(1)(a)(i); 298(1)(a)(iii); Annex 2/9
exclusive economic zone: Art 74; 75(1); 147(2)(e); 259
internal waters of archipelagic States: Art 50
special circumstances or historic title: Art 15
territorial sea: Art 15; 16(1); 60(8); 147(2)(e); 259

See: EXCLUSIVE ECONOMIC ZONE; BASELINE; CONTINENTAL SHELF; MEDIAN LINE; TERRITORIAL SEA

59 **MEDIAN LINE**

A line every point of which is equidistant from the nearest points on the baselines of two or more States between which it lies.

See the convention:
Art 15

See: ADJACENT COASTS; BASELINE; EQUIDISTANCE LINE; OPPOSITE COASTS; TERRITORIAL SEA

60 **MILE**

See: NAUTICAL MILE

61 **MOUTH (BAY)**

The place of entrance to a bay from the ocean.

See the Convention:
mouth of a bay: Art 10(2); 10(3); 10(4); 10(5)

Note: Art 10(4) and 10(5) are includes due their reference to the ‘natural entrance points’.

See: BASELINE; BAY; CLOSING LINE; ESTUARY and LOW-WATER LINE

62 **MOUTH (RIVER)**

The place of discharge of a stream (river) into the ocean.

See the Convention:
mouth of a river: Art 9

Note: No limit is placed on the length of the line to be drawn.

See: BASELINE; CLOSING LINE; ESTUARY; LOW WATER LINE and RIVER

63 **NAUTICAL CHART**

A special-purpose map or a specially compiled database from which a map is derived, that is issued officially by or on the authority of a government, authorized hydrographic office or other relevant government institution and is designed to meet the requirements of marine navigation.

See: CHART

64 **NAUTICAL MILE (M)**

A unit of distance used primarily in navigation. Nearly all of the maritime nations have accepted the international nautical mile of 1852 meters approved by the International Hydrographic Conference of 1929. The Convention mentions nautical miles in terms of specific distances of certain lines and limits – see Art 3; 10(4); 10(5); 33 (2); 47(2); 57; 76(1); 76(4); 76(5); 76(6);76(7); 76(8); 82(1)

See: APPENDIX 2

65 **NAVIGATIONAL AID**

An instrument, device, chart, method, etc., intended to assist in the navigation of a craft. An aid to navigation is a navigational aid but the latter expression should not be confused with the former which refers only to devices external to a craft.

See: AID TO NAVIGATION

66 **NAVIGATIONAL CHART**

See: NAUTICAL CHART

67 **OCEANIC PLATEAU**

A comparatively flat topped elevation of the seabed which rises steeply from the ocean floor on all sides, and is of considerable extent across the summit.

See the Convention: Art 47(7)

See: ARCHIPELAGIC STATE; BASELINE

68 **OCEANIC RIDGES**

A long elevation of the deep ocean floor with either irregular or smooth topography and steep sides, often separating ocean basins.

See the Convention: Art 76(3)

Such ridges are not part of the continental margin

See: DEEP OCEAN FLOOR

69 **OPPOSITE COASTS**

The geographical relationship of the coasts of two States facing each other.

Maritime zones of States having opposite coasts may require boundary delimitation to avoid overlap.

70 **OUTER LIMIT**

The extent to which a coastal State claims or may claim a specific jurisdiction in accordance with the provisions of the United Nations Convention on the Law of the Sea.

See the Convention:
anadromous stocks: Art 66
catadromous species: Art 67
contiguous zone: Art 33(1)
continental shelf: Art 76(5); 76(6); 76(7); 76(8); 76(9); 84(1); 84(2); 134(4); Annex 2/3(1)(a); Annex 2/4; Annex 2/7
exclusive economic zone: Art 57; 75(1)
roadsteads: Art 12
territorial sea: Art 4

See: BASELINE; CONTIGUOUS ZONE; CONTINENTAL MARGIN; CONTINENTAL SHELF; EXCLUSIVE ECONOMIC ZONE; ISOBATH; TERRITORIAL SEA

71 **PARALLEL OF LATITUDE**

A circle (or approximation of a circle) on the surface of the EARTH, parallel to the EQUATOR and connecting points of equal LATITUDE. Also called parallel of latitude.

See: GEOGRAPHICAL COORDINATES

72 **PLATFORM**

In oceanographic terminology, any manmade structure (aircraft, ship, buoy, or tower) from or on which oceanographic instruments are suspended or installed. Structures which are erected on or over the seabed and subsoil for the purpose of exploring for, developing, removing and transporting resources therefrom.

See the Convention: Art 1(5)

See: INSTALLATION (OFF-SHORE)

73 **PORT**

A place provided with terminal and transfer facilities for loading and discharging cargo or passengers, usually located in a harbour. The left side of a craft, facing forward. The opposite is starboard.

See the Convention:
- Criminal jurisdiction on board a foreign ship: Art 27(5)
- delimiting the territorial sea: Art 11
- duty to avoid adverse consequences: Art 225
- equal treatment in maritime ports: Art 131
- free zones and other customs facilities: Art 128
- innocent passage in the territorial sea: Art 18(1)(a)
- pollution from vessels: Art 211(3)
- pollution measure enforcement: Art 218; 219; 220
- rights of protection of the coastal state: Art 25(2)

See also Facilities

74 **REEF**

A mass of rock or coral which either reaches close to the sea surface or is exposed at low tide, posing a hazard to navigation.

See the Convention:
- drying: Art 47(1); 47 (7)
- fringing: Art 6: 47(7)

See: ATOLL; BASELINE; ISLAND and LOW-WATER LINE

75 **RHUMB LINE**

See: LOXODROME

76 **RISE**

See: CONTINENTAL RISE

77 **RIVER**

A relatively large natural stream of water.

See the Convention, see also mouth of a river:
occurrence of the term: Art 66(1); 66(2); 66(3)(c); 124(1)(d)(i); 207(1)

78 **ROADSTEAD**

An area near the shore where vessels are intended to anchor in a position of safety; usually in a shallow indentation of the coast.

See the Convention: Art 12

In most cases roadsteads are not clearly delimited by natural geographical limits, and the general location is indicated by the position of its geographical name on charts. If Art. 12 applies, however, the limits must be shown on charts or must be described by a list of geographical coordinates.

See: CHART; GEOGRAPHICAL COORDINATES; MARITIME DELIMITATION; TERRITORIAL SEA

79 **ROCK**

Under the Convention – Regime of Islands – rocks are by definition unable to sustain human habitation or economic life of their own and shall have no exclusive economic zone or continental shelf.
There is no specific definition given in the Convention of the morphology or composition of a rock.

See the Convention, *see also* islands:
thickness of sedimentary rocks *re* continental margin: Art 76(4)(a)(i)
which cannot sustain human habitation or economic life of their own: Art 121(3)

See: ISLAND; LOW-TIDE ELEVATION

80 **ROUTEING SYSTEM**

Any system of one or more routes or routeing measures aimed at reducing the risk of casualties; it includes traffic separation schemes, two-way routes, recommended tracks, areas to be avoided, inshore traffic zones, roundabouts, precautionary areas and deep-water routes.

See the Convention, see also traffic separation schemes:
occurrence of the term: Art 211(1)

81 SAFETY AIDS

See the Convention: Art 43(a)

See: AID TO NAVIGATION

82 SAFETY ZONE

The area around an offshore installation within which vessels are prohibited from entering without permission. Special regulations protect installations within a safety zone and vessels of all nationalities are required to respect that zone.

See the Convention, see also due notice:
artificial islands, installations and structures: Art 60(4); 60(5); 60(6); 60(7)
seabed mining operations: Art 147(2)(c)
scientific research: Art 260
violation in the exclusive economic zone or on the continental shelf: Art 111(2)

See: INSTALLATION (OFF-SHORE)

83 SCALE

The ratio between a distance on a chart or map and a distance between the same two points measured on the surface of the earth (or other body of the Universe).

Note: In the case of charts using the Mercator projection the nominal scale given in the title block is only accurate at the parallel of latitude specified in that title block.

See: CHART

84 SEABED

The top of the surface layer of sand, rock, mud or other material lying at the bottom of the sea and immediately above the subsoil.

See the Convention:
occurrence of the term: Art 2(2); 49; 56(3); 76(1); 76(3); 77(4); 194(3)(c)

Note: some of the references use the term bed rather than seabed.

See: AREA; CONTINENTAL SHELF; DEEP OCEAN FLOOR; EXCLUSIVE ECONOMIC ZONE; SUBSOIL

85 **SEDIMENTARY ROCK**

Rocks formed by accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediments may consist of rock fragments or particles of various sizes (conglomerate, sandstone, shale); of the remains or product of animals or plant (certain limestones and coal); of the product of chemical action or of evaporation (salt, gypsum, etc.); or of a mixture of these materials.

See the Convention: Art 76(4)(a)(i)

86 **SEMI-ENCLOSED SEA**

See: ENCLOSED SEA, Art. 122

87 **SHELF**

Geologically an area adjacent to a continent or around an island extending from the low-water line to the depth at which there is usually a marked increase of slope to greater depth.

See: CONTINENTAL SHELF

88 **SLOPE**

See: CONTINENTAL SLOPE

89 **SPUR**

A subordinate elevation, ridge or rise projecting outward from a larger feature.

See the Convention:
occurrence of the term: Art 76(6)

See: BANK; CAP; CONTINENTAL SHELF; SUBMARINE RIDGE

90 **STRAIGHT BASELINE**

See: BASELINE

91 **STRAIGHT LINE**

Mathematically the line of shortest distance between two points in a specified space or on a specified surface.

See: BASELINE; CONTINENTAL MARGIN and CONTINENTAL SHELF

92 **STRAITS (used for international navigation)**

Geographically, a narrow passage between two landmasses or islands or groups of islands connecting one part of the high seas or an exclusive economic zone and another part of the high seas or an exclusive economic zone.

See the Convention: Part III

Only straits "used for international navigation" are classified as "international straits", and only such straits fall within the specific regime provided in the United Nations Convention on the Law of the Sea.

93 **STRUCTURE**

See: INSTALLATION (OFF-SHORE)

94 **SUBMARINE CABLE**

An assembly of wires or fibres, or a wire rope or chain, which has been laid underwater or buried beneath the sea floor

See the Convention, cables and pipelines (submerged):
archipelagic State: Art 51(2)
continental shelf: Art 79
exclusive economic zone: 58(1)
existing submarine cables in archipelagic state waters: Art 51
high seas: Art 87(1)(c); 112; 113; 114; 115
settlement of disputes: 297(1)(a)

See: SUBMARINE PIPELINES

95 **SUBMARINE PIPELINES**

A string of interconnected pipes used for the transport of matter, nowadays mainly oil and gas.

See the Convention, cables and pipelines (submerged):
continental shelf: Art 79
exclusive economic zone: 58(1)
high seas: Art 87(1)(c); 112; 113; 114; 115
settlement of disputes: 297(1)(a)

See: SUBMARINE CABLES

96 **SUBMARINE RIDGES**

An elongated elevation of the sea floor, with either irregular or relatively smooth topography and steep sides which constitutes part of the continental

margin of a coastal State under the United Nations Convention on the Law of the Sea.

See the Convention:
Submarine: Art 76(6)

See: CONTINENTAL SHELF

97 **SUBSOIL**

All naturally occurring matter lying beneath the seabed.

See the Convention:
occurrences of the term: Preamble (6); Art 1(1)(1); 2(2); 34; 49(2); 56(1)(a); 56(3); 76(1); 76(3); 77(4); 85; 195(3)(c)

See: AREA; CONTINENTAL SHELF; EXCLUSIVE ECONOMIC ZONE; SEABED

98 **SUPERJACENT WATERS**

The waters lying immediately above the seabed up to the surface.

See the Convention:
coastal State jurisdiction over: Art 56(1)(a)
legal status: Art 78; 135
of the Area: Art 135; 155(2)

See: AREA; CONTINENTAL SHELF; EXCLUSIVE ECONOMIC ZONE; SEABED; WATER COLUMN

99 **TERRITORIAL SEA**

A belt of water of a defined breadth but not exceeding 12 nautical miles measured seaward from the territorial sea baseline. In terms of the Convention the territorial sea is the zone of coastal State sovereignty, not only of the water column but also the airspace above that zone and the seabed and subsoil below.

See the Convention, *also see* air space; artificial islands; baselines; charts; conservation management of living resources; delimitation; due publicity; fishing; foreign ships or vessels; geographical co-ordinates; historic title: hot pursuit; innocent passage; jurisdiction; opposite or adjacent coasts; outer limits; sea lanes; submarines; tankers; traffic separation schemes:
legal status: Art 2
limits: Art 3; 4; 12
marine scientific research: Art 245; 259
sovereignty of the coastal State: Art 2(1); 211(4); 245

See: ARCHIPELAGIC SEA LANES; BASELINE; ISLANDS; LOW-TIDE ELEVATIONS; NAUTICAL MILE; ROADSTEADS

100 **THALWEG**

The line joining the lowest points of a valley throughout its length. Sometimes called valley line
Defined also as the line of maximum depth along a river channel. It may also refer to the line of maximum depth along a river valley or in a lake. Also the middle of the chief navigable channel of a waterway which constitutes a boundary line between states

101 **TIDE**

The periodic rise and fall of the surface of the oceans and other large bodies of water due principally to the gravitational attraction of the Moon and Sun on a rotating earth.

102 **TRAFFIC SEPARATION SCHEME**

A routeing measure aimed at the separation of opposing streams of traffic by appropriate means and by the establishment of traffic lanes.

See: ROUTEING SYSTEM

103 **WATER COLUMN**

A vertical continuum of water from sea surface to seabed.

See: SEABED; SUPERJACENT WATERS

APPENDIX 2

THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA

Articles 1 - 123 and ANNEX II Articles 1 - 9

PART I

INTRODUCTION

Article 1
Use of terms and scope

1. For the purposes of this Convention:

(1) "Area" means the sea-bed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction;

(2) "Authority" means the International Sea-Bed Authority;

(3) "activities in the Area" means all activities of exploration for, and exploitation of, the resources of the Area;

(4) "pollution of the marine environment" means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities;

(5) (a) "dumping" means:

(i) any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;

(ii) any deliberate disposal of vessels, aircraft, platforms or other man-made structures at sea;

(b) "dumping" does not include:

(i) the disposal of wastes or other matter incidental to, or derived from the normal operations of vessels, aircraft, platforms or other man-made structures at sea and their equipment, other than wastes or other matter transported by or to vessels, aircraft, platforms or other man-made structures at sea, operating for the purpose of disposal of such matter or derived from the treatment of such wastes or other matter on such vessels, aircraft, platforms or structures;

(ii) placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention.

2. (1) "States Parties" means States which have consented to be bound by this Convention and for which this Convention is in force.

(2) This Convention applies **mutatis mutandis** to the entities referred to in article 305, paragraph 1(b), (c), (d), (e) and (f), which become Parties to this Convention in accordance with the conditions relevant to each, and to that extent "States Parties" refers to those entities.

PART II

TERRITORIAL SEA AND CONTIGUOUS ZONE

SECTION 1 - GENERAL PROVISIONS

Article 2
Legal status of the territorial sea, of the air space over the territorial sea and of its bed and subsoil

1. The sovereignty of a coastal State extends, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea, described as the territorial sea.

2. This sovereignty extends to the air space over the territorial sea as well as to its bed and subsoil.

3. The sovereignty over the territorial sea is exercised subject to this Convention and to other rules of international law.

SECTION 2 - ITS OF THE TERRITORIAL SEA

Article 3
Breadth of the territorial sea

Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles, measured from baselines determined in accordance with this Convention.

Article 4
Outer limit of the territorial sea

The outer limit of the territorial sea is the line every point of which is at a distance from the nearest point of the baseline equal to the breadth of the territorial sea.

Article 5
Normal baseline

Except where otherwise provided in this Convention, the normal baseline for measuring the breadth of the territorial sea is the low-water line along the coast as marked on large-scale charts officially recognized by the coastal State.

Article 6
Reefs

In the case of islands situated on atolls or of islands having fringing reefs, the baseline for measuring the breadth of the territorial sea is the seaward low-water line of the reef, as shown by the appropriate symbol on charts officially recognized by the coastal State.

Article 7
Straight baselines

1. In localities where the coastline is deeply indented and cut into, or if there is a fringe of islands along the coast in its immediate vicinity, the method of straight baselines joining appropriate points may be employed in drawing the baseline from which the breadth of the territorial sea is measured.

2. Where because of the presence of a delta and other natural conditions the coastline is highly unstable, the appropriate points may be selected along the furthest seaward extent of the low-water line and, notwithstanding subsequent regression of the low-water line, the straight baselines shall remain effective until changed by the coastal State in accordance with this Convention.

3. The drawing of straight baselines must not depart to any appreciable extent from the general direction of the coast, and the sea areas lying within the lines must be sufficiently closely linked to the land domain to be subject to the regime of internal waters.

4. Straight baselines shall not be drawn to and from low-tide elevations, unless lighthouses or similar installations which are permanently above sea level have been built on them or except in instances where the drawing of baselines to and from such elevations has received general international recognition.

5. Where the method of straight baselines is applicable under paragraph 1, account may be taken, in determining particular baselines, of economic interests peculiar to the region concerned, the reality and the importance of which are clearly evidenced by long usage.

6. The system of straight baselines may not be applied by a State in such a manner as to cut off the territorial sea of another State from the high seas or an exclusive economic zone.

Article 8
Internal waters

1. Except as provided in Part IV, waters on the landward side of the baseline of the territorial sea form part of the internal waters of the State.

2. Where the establishment of a straight baseline in accordance with the method set forth in article 7 has the effect of enclosing as internal waters areas which had not previously been considered as such, a right of innocent passage as provided in this Convention shall exist in those waters.

Article 9
Mouths of rivers

If a river flows directly into the sea, the baseline shall be a straight line across the mouth of the river between points on the low-water line of its banks.

Article 10
Bays

1. This article relates only to bays the coasts of which belong to a single State.

2. For the purposes of this Convention, a bay is a well-marked indentation whose penetration is in such proportion to the width of its mouth as to contain land-locked waters and constitute more than a mere curvature of the coast. An indentation shall not, however, be regarded as a bay unless its area is as large as, or larger than, that of the semi-circle whose diameter is a line drawn across the mouth of that indentation.

3. For the purpose of measurement, the area of an indentation is that lying between the low-water mark around the shore of the indentation and a line joining the low-water mark of its natural entrance points. Where, because of the presence of islands, an indentation has more than one mouth, the semi-circle shall be drawn on a line as long as the sum total of the lengths of the lines across the different mouths. Islands within an indentation shall be included as if they were part of the water area of the indentation.

4. If the distance between the low-water marks of the natural entrance points of a bay does not exceed 24 nautical miles, a closing line may be drawn between these two low-water marks, and the waters enclosed thereby shall be considered as internal waters.

5. Where the distance between the low-water marks of the natural entrance points of a bay exceeds 24 nautical miles, a straight baseline of 24 nautical miles shall be drawn within the bay in such a manner as to enclose the maximum area of water that is possible with a line of that length.

6. The foregoing provisions do not apply to so-called "historic" bays, or in any case where the system of straight baselines provided for in article 7 is applied.

Article 11
Ports

For the purpose of delimiting the territorial sea, the outermost permanent harbour works which form an integral part of the harbour system are regarded as forming part of the coast. Off-shore installations and artificial islands shall not be considered as permanent harbour works.

Article 12
Roadsteads

Roadsteads which are normally used for the loading, unloading and anchoring of ships, and which would otherwise be situated wholly or partly outside the outer limit of the territorial sea, are included in the territorial sea.

Article 13
Low-tide elevations

1. A low-tide elevation is a naturally formed area of land which is surrounded by and above water at low tide but submerged at high tide. Where a low-tide elevation is situated wholly or partly at a distance not exceeding the breadth of the territorial sea from the mainland or an island, the low-water line on that elevation may be used as the baseline for measuring the breadth of the territorial sea.

2. Where a low-tide elevation is wholly situated at a distance exceeding the breadth of the territorial sea from the mainland or an island, it has no territorial sea of its own.

Article 14
Combination of methods for determining baselines

The coastal State may determine baselines in turn by any of the methods provided for in the foregoing articles to suit different conditions.

Article 15
Delimitation of the territorial sea between States with opposite or adjacent coasts

Where the coasts of two States are opposite or adjacent to each other, 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. The above provision does not apply, however, where it is necessary by reason of historic title or other special circumstances to delimit the territorial seas of the two States in a way which is at variance therewith.

Article 16
Charts and lists of geographical co-ordinates

1. The baselines for measuring the breadth of the territorial sea determined in accordance with articles 7, 9 and 10, or the limits derived there from, and the lines of delimitation drawn in accordance with articles 12 and 15 shall be shown on charts of a scale or scales adequate for ascertaining their position. Alternatively, a list of geographical co-ordinates of points, specifying the geodetic datum, may be substituted.

2. The coastal State shall give due publicity to such charts or lists of geographical co-ordinates and shall deposit a copy of each such chart or list with the Secretary-General of the United Nations.

SECTION 3. INNOCENT PASSAGE IN THE TERRITORIAL SEA

SUBSECTION A - RULES APPLICABLE TO ALL SHIPS

Article 17
Right of innocent passage

Subject to this Convention, ships of all States, whether coastal or land-locked, enjoy the right of innocent passage through the territorial sea.

Article 18
Meaning of passage

1. Passage means navigation through the territorial sea for the purpose of:

   a) traversing that sea without entering internal waters or calling at a roadstead or port facility outside internal waters; or

   b) proceeding to or from internal waters or a call at such roadstead or port facility.

2. Passage shall be continuous and expeditious. However, passage includes stopping and anchoring, but only in so far as the same are incidental to ordinary navigation or are rendered necessary by **force majeure** or distress or for the purpose of rendering assistance to persons, ships or aircraft in danger or distress.

Article 19
Meaning of innocent passage

1. Passage is innocent so long as it is not prejudicial to the peace, good order or security of the coastal State. Such passage shall take place in conformity with this Convention and with other rules of international law.

2. Passage of a foreign ship shall be considered to be prejudicial to the peace, good order or security of the coastal State if in the territorial sea it engages in any of the following activities:

a) any threat or use of force against the sovereignty, territorial integrity or political independence of the coastal State, or in any other manner in violation of the principles of international law embodied in the Charter of the United Nations;

b) any exercise or practice with weapons of any kind;

c) any act aimed at collecting information to the prejudice of the defence or security of the coastal State;

d) any act of propaganda aimed at affecting the defence or security of the coastal State;

e) the launching, landing or taking on board of any aircraft;

f) the launching, landing or taking on board of any military device;

g) the loading or unloading of any commodity, currency or person contrary to the customs, fiscal, immigration or sanitary laws and regulations of the coastal State;

h) any act of wilful and serious pollution contrary to this Convention;

i) any fishing activities;

j) the carrying out of research or survey activities;

k) any act aimed at interfering with any systems of communication or any other facilities or installations of the coastal State;

l) any other activity not having a direct bearing on passage.

Article 20
Submarines and other underwater vehicles

In the territorial sea, submarines and other underwater vehicles are required to navigate on the surface and to show their flag.

Article 21
Laws and regulations of the coastal State relating to innocent passage

1. The coastal State may adopt laws and regulations, in conformity with the provisions of this Convention and other rules of international law, relating to innocent passage through the territorial sea, in respect of all or any of the following:

(a) the safety of navigation and the regulation of maritime traffic;

(b) the protection of navigational aids and facilities and other facilities or installations;

(c) the protection of cables and pipelines;

(d) the conservation of the living resources of the sea;

(e) the prevention of infringement of the fisheries laws and regulations of the coastal State;

(f) the preservation of the environment of the coastal State and the prevention, reduction and control of pollution thereof;

(g) marine scientific research and hydrographic surveys;

(h) the prevention of infringement of the customs, fiscal, immigration or sanitary laws and regulations of the coastal State.

2. Such laws and regulations shall not apply to the design, construction, manning or equipment of foreign ships unless they are giving effect to generally accepted international rules or standards.

3. The coastal State shall give due publicity to all such laws and regulations.

4. Foreign ships exercising the right of innocent passage through the territorial sea shall comply with all such laws and regulations and all generally accepted international regulations relating to the prevention of collisions at sea.

Article 22
Sea lanes and traffic separation schemes in the territorial sea

1. The coastal State may, where necessary having regard to the safety of navigation, require foreign ships exercising the right of innocent passage through its territorial sea to use such sea lanes and traffic separation schemes as it may designate or prescribe for the regulation of the passage of ships.

2. In particular, tankers, nuclear-powered ships and ships carrying nuclear or other inherently dangerous or noxious substances or materials may be required to confine their passage to such sea lanes.

3. In the designation of sea lanes and the prescription of traffic separation schemes under this article, the coastal State shall take into account:

(a) the recommendations of the competent international organization;

(b) any channels customarily used for international navigation;

(c) the special characteristics of particular ships and channels; and

(d) the density of traffic.

4. The coastal State shall clearly indicate such sea lanes and traffic separation schemes on charts to which due publicity shall be given.

Article 23
Foreign nuclear-powered and ships carrying nuclear or other inherently dangerous or noxious substances

Foreign nuclear-powered ships and ships carrying nuclear or other inherently dangerous or noxious substances shall, when exercising the right of innocent passage through the territorial sea, carry documents and observe special precautionary measures established for such ships by international agreements.

Article 24
Duties of the coastal State

1. The coastal State shall not hamper the innocent passage of foreign ships through the territorial sea except in accordance with this Convention. In particular, in the application of this Convention or of any laws or regulations adopted in conformity with this Convention, the coastal State shall not:

(a) impose requirements on foreign ships which have the practical effect of denying or impairing the right of innocent passage; or

(b) discriminate in form or in fact against the ships of any State or against ships carrying cargoes to, from or on behalf of any State.

2. The coastal State shall give appropriate publicity to any danger to navigation, of which it has knowledge, within its territorial sea.

Article 25
Rights of protection of the coastal State

1. The coastal State may take the necessary steps in its territorial sea to prevent passage which is not innocent.

2. In the case of ships proceeding to internal waters or a call at a port facility outside internal waters, the coastal State also has the right to take the necessary steps to prevent any breach of the conditions to which admission of those ships to internal waters or such a call is subject.

3. The coastal State may, without discrimination in form or in fact among foreign ships, suspend temporarily in specified areas of its territorial sea the innocent passage of foreign ships if such suspension is essential for the protection of its security, including weapons exercises. Such suspension shall take effect only after having been duly published.

Article 26
Charges which may be levied upon foreign ships

1. No charge may be levied upon foreign ships by reason only of their passage through the territorial sea.

2. Charges may be levied upon a foreign ship passing through the territorial sea as payment only for specific services rendered to the ship. These charges shall be levied without discrimination.

SUBSECTION - B. RULES APPLICABLE TO MERCHANT SHIPS AND GOVERNMENT SHIPS OPERATED FOR COMMERCIAL PURPOSES

Article 27
Criminal jurisdiction on board a foreign ship

1. the criminal jurisdiction of the coastal State should not be exercised on board a foreign ship passing through the territorial sea to arrest any person or to conduct any investigation in connection with any crime committed on board the ship during its passage, save only in the following cases:

(a) if the consequences of the crime extend to the coastal State;

(b) if the crime is of a kind to disturb the peace of the country or the good order of the territorial sea;

(c) if the assistance of the local authorities has been requested by the master of the ship or by a diplomatic agent or consular officer of the flag State; or

(d) if such measures are necessary for the suppression of illicit traffic in narcotic drugs or psychotropic substances.

2. The above provisions do not affect the right of the coastal State to take any steps authorized by its laws for the purpose of an arrest or investigation on board a foreign ship passing through the territorial sea after leaving internal waters.

3. In the cases provided for in paragraphs 1 and 2, the coastal State shall, if the master so requests, notify a diplomatic agent or consular officer of the flag State before taking any steps, and shall facilitate contact between such agent or officer and the ship's crew. In cases of emergency this notification may be communicated while the measures are being taken.

4. In considering whether or in what manner an arrest should be made, the local authorities shall have due regard to the interests of navigation.

5. Except as provided in Part XII or with respect to violations of laws and regulations adopted in accordance with part V, the coastal State may not take any steps on board a foreign ship passing through the territorial sea to arrest any person or to conduct any

investigation in connection with any crime committed before the ship entered the territorial sea, if the ship, proceeding from a foreign port, is only passing through the territorial sea without entering internal waters.

Article 28
Civil jurisdiction in relation to foreign ships

1. The coastal State should not stop or divert a foreign ship passing through the territorial sea for the purpose of exercising civil jurisdiction in relation to a person on board the ship.

2. The coastal State may not levy execution against or arrest the ship for the purpose of any civil proceedings, save only in respect of obligations or liabilities assumed or incurred by the ship itself in the course or for the purpose of its voyage through the waters of the coastal State.

3. Paragraph 2 is without prejudice to the right of the coastal State, in accordance with its laws, to levy execution against or to arrest, for the purpose of any civil proceedings, a foreign ship lying in the territorial sea, or passing through the territorial sea after leaving internal waters.

SUBSECTION - C. RULES APPLICABLE TO WARSHIPS AND OTHER GOVERNMENT SHIPS OPERATED FOR NON-COMMERCIAL PURPOSES

Article 29
Definition of warships

For the purposes of this Convention, "warship" means a ship belonging to the armed forces of a State bearing the external marks distinguishing such ships of its nationality, under the command of an officer duly commissioned by the government of the State and whose name appears in the appropriate service list or its equivalent, and manned by a crew which is under regular armed forces discipline.

Article 30
Non-compliance by warships with the laws and regulations of the coastal State

If any warship does not comply with the laws and regulations of the coastal State concerning passage through the territorial sea and disregards any request for compliance therewith which is made to it, the coastal State may require it to leave the territorial sea immediately.

Article 31
Responsibility of the flag State for damage caused by a warship or other government ship operated for non-commercial purposes

The flag State shall bear international responsibility for any loss or damage to the coastal State resulting from the non-compliance by a warship or other government ship operated for non-commercial purposes with the laws and regulations of the coastal State concerning passage through the territorial sea or with the provisions of this Convention or other rules of international law.

Article 32
Immunities of warships and other government ships operated for non-commercial purposes

With such exceptions as are contained in subsection A and in articles 30 and 31, nothing in this Convention affects the immunities of warships and other government ships operated for non-commercial purposes.

SECTION 4. CONTIGUOUS ZONE

Article 33
Contiguous zone

1. In a zone contiguous to its territorial sea, described as the contiguous zone, the coastal State may exercise the control necessary to:

   (a) prevent infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea;

   (b) punish infringement of the above laws and regulations committed within its territory or territorial sea.

2. The contiguous zone may not extend beyond 24 nautical miles from the baselines from which the breadth of the territorial sea is measured.

PART III

STRAITS USED FOR INTERNATIONAL NAVIGATION

SECTION 1. GENERAL PROVISIONS

Article 34
Legal status of waters forming straits used for international navigation

1. The regime of passage through straits used for international navigation established in this Part shall not in other respects affect the legal status of the waters forming such straits or the exercise by the States bordering the straits of their sovereignty or jurisdiction over such waters and their air space, bed and subsoil.

2. The sovereignty or jurisdiction of the States bordering the straits is exercised subject to this Part and to other rules of international law.

Article 35
Scope of this Part

Nothing in this Part affects:

(a) any areas of internal waters within a strait, except where the establishment of a straight baseline in accordance with the method set forth in article 7 has the effect of enclosing as internal waters areas which had not previously been considered as such;

(b) the legal status of the waters beyond the territorial seas of States bordering straits as exclusive economic zones or high seas; or

(c) the legal regime in straits in which passage is regulated in whole or in part by long-standing international conventions in force specifically relating to such straits.

Article 36
High seas routes or routes through exclusive economic zones through straits used for international navigation

This Part does not apply to a strait used for international navigation if there exists through the strait a route through the high seas or through an exclusive economic zone of similar convenience with respect to navigational and hydrographical characteristics; in such routes, the other relevant parts of this Convention, including the provisions regarding the freedoms of navigation and over flight, apply.

SECTION 2. TRANSIT PASSAGE

Article 37
Scope of this section

This section applies to straits which are used for international navigation between one part of the high seas of an exclusive economic zone and another part of the high seas or an exclusive economic zone.

Article 38
Right of transit passage

1. In straits referred to in article 37, all ships and aircraft enjoy the right of transit passage, which shall not be impeded; except that, if the strait is formed by an island of a State bordering the strait and its mainland, transit passage shall not apply if there exists seaward of the island a route through the high seas or through an exclusive economic zone of similar convenience with respect to navigational and hydrographical characteristics.

2. Transit passage means the exercise in accordance with this Part of the freedom of navigation and over flight solely for the purpose of continuous and expeditious transit of the strait between one part of the high seas or an exclusive economic zone and another part of the high seas or an exclusive economic zone. However, the requirement of continuous and expeditious transit does not preclude passage through the strait for the purpose of entering, leaving or returning from a State bordering the strait, subject to the conditions of entry to that State.

3. Any activity which is not an exercise of the right of transit passage through a strait remains subject to the other applicable provisions of this Convention.

Article 39
Duties of ships and aircraft during transit passage

1. Ships and aircraft, while exercising the right of transit passage, shall:

(a) proceed without delay through or over the strait;

(b) refrain from any threat or use of force against the sovereignty, territorial integrity or political independence of States bordering the strait, or in any other manner in violation of the principles of international law embodied in the Charter of the United Nations.

(c) refrain from any activities other than those incident to their normal modes of continuous and expeditious transit unless rendered necessary by **force majeure** or by distress;

(d) comply with other relevant provisions of this Part.

2. Ships in transit passage shall:

(a) comply with generally accepted international regulations, procedures and practices for safety at sea, including the International Regulations for preventing Collisions at Sea;

(b) comply with generally accepted international regulations, procedures and practices for the prevention, reduction and control of pollution from ships.

3. Aircraft in transit passage shall:

(a) observe the Rules of the Air established by the International Civil Aviation Organization as they apply to civil aircraft; state aircraft will normally comply with such safety measures and will at all times operate with due regard for the safety of navigation;

(b) at all times monitor the radio frequency assigned by the competent internationally designated air traffic control authority or the appropriate international distress radio frequency.

Article 40
Research and survey activities

During transit passage, foreign ships, including marine scientific research and hydrographic survey ships, may not carry out any research or survey activities without the prior authorization of the States bordering straits.

Article 41
Sea lanes and traffic separation schemes in straits used for international navigation

1. In conformity with this Part, States bordering straits may designate sea lanes and prescribe traffic separation schemes for navigation in straits where necessary to promote the safe passage of ships.

2. Such States may, when circumstances require, and after giving due publicity thereto, substitute other sea lanes or traffic separation schemes for any sea lanes or traffic separation schemes previously designated or prescribed by them.

3. Such sea lanes and traffic separation schemes shall conform to generally accepted international regulations.

4. Before designating or substituting sea lanes or prescribing or substituting traffic separation schemes, States bordering straits shall refer proposals to the competent international organization with a view to their adoption. The organization may adopt only such sea lanes and traffic separation schemes as may be agreed with the states bordering the straits, after which the States may designate, prescribe or substitute them.

5. In respect of a strait where sea lanes or traffic separation schemes through the waters of two or more States bordering the strait are being proposed, the States concerned

shall co-operate in formulating proposals in consultation with the competent international organization.

6. States bordering straits shall clearly indicate all sea lanes and traffic separation schemes designated or prescribed by them on charts to which due publicity shall be given.

7. Ships in transit passage shall respect applicable sea lanes and traffic separation schemes established in accordance with this article.

Article 42
Laws and regulations of States bordering straits relating to transit passage

1. Subject to the provisions of this section, States bordering straits may adopt laws and regulations relating to transit passage through straits, in respect of all or any of the following:

(a) the safety of navigation and the regulation of maritime traffic, as provided in article 41;

(b) the prevention, reduction and control of pollution, by giving effect to applicable international regulations regarding the discharge of oil, oily wastes and other noxious substances in the strait;

(c) with respect to fishing vessels, the prevention of fishing, including the software of fishing gear;

(d) the loading or unloading of any commodity, currency or person in contravention of the customs, fiscal, immigration or sanitary laws and regulations of States bordering straits.

2. Such laws and regulations shall not discriminate in form or in fact among foreign ships or in their application have the practical effect of denying, hampering or impairing the right of transit passage as defined in this section.

3. States bordering straits shall give due publicity to all such laws and regulations.

4. Foreign ships exercising the right of transit passage shall comply with such laws and regulations.

5. The flag State of a ship or the State of registry of an aircraft entitled to sovereign immunity which acts in a manner contrary to such laws and regulations or other provisions of this Part shall bear international responsibility for any loss or damage which results to States bordering straits.

Article 43
Navigational and safety aids and other improvements and the prevention, reduction and control of pollution

User States and States bordering a strait should by agreement co-operate:

(a) in the establishment and maintenance in a strait of necessary navigational and safety aids or other improvements in aid of international navigation; and

(b) for the prevention, reduction and control of pollution from ships.

Article 44
Duties of States bordering straits

States bordering straits shall not hamper transit passage and shall give appropriate publicity to any danger to navigation or over flight within or over the strait of which they have knowledge. There shall be no suspension of transit passage.

SECTION 3. INNOCENT PASSAGE

Article 45
Innocent passage

1. The regime of innocent passage, in accordance with Part II, section 3, shall apply in straits used for international navigation:

(a) excluded from the application of the regime of transit passage under article 38, paragraph 1; or

(b) between a part of the high seas or an exclusive economic zone and the territorial sea of a foreign State.

2. There shall be no suspension of innocent passage through such straits.

PART IV

ARCHIPELAGIC STATES

Article 46
Use of terms

For the purposes of this Convention:

(a) "archipelagic State" means a State constituted wholly by one or more archipelagos and may include other islands;

(b) "archipelago" means a group of islands, including parts of islands, inter-connecting waters and other natural features which are so closely inter-related that such islands, waters and other natural features form an intrinsic geographical, economic and political entity, or which historically have been regarded as such.

Article 47
Archipelagic baselines

1. An archipelagic State may draw straight archipelagic baselines joining the outermost points of the outermost islands and drying reefs of the archipelago provided that within such baselines are included the main islands and an area in which the ratio of the area of the water to the area of the land, including atolls, is between 1 to 1 and 9 to 1.

2. The length of such baselines shall not exceed 100 nautical miles, except that up to 3 per cent of the total number of baselines enclosing any archipelago may exceed that length, up to a maximum length of 125 nautical miles.

3. The drawing of such baselines shall not depart to any appreciable extent from the general configuration of the archipelago.

4. Such baselines shall not be drawn to and from low-tide elevations, unless lighthouses or similar installations which are permanently above sea level have been built on them or where a low-tide elevation is situated wholly or partly at a distance not exceeding the breadth of the territorial sea from the nearest island.

5. The system of such baselines shall not be applied by an archipelagic State in such a manner as to cut off from the high seas or the exclusive economic zone the territorial sea of another State.

6. If the part of the archipelagic waters of an archipelagic State lies between two parts of an immediately adjacent neighbouring State, existing rights and all other legitimate interests which the latter State has traditionally exercised in such waters and all rights stipulated by agreement between those States shall continue and be respected.

7. For the purpose of computing the ratio of water to land under paragraph 1, land areas may include waters lying within the fringing reefs of islands and atolls, including that

part of a steep-sided oceanic plateau which is enclosed or nearly enclosed by a chain of limestone islands and drying reefs lying on the perimeter of the plateau.

8. The baselines drawn in accordance with this article shall be shown on charts of a scale or scales adequate for ascertaining their position. Alternatively, lists of geographical co-ordinates of points, specifying the geodetic datum, may be substituted.

9. The archipelagic State shall give due publicity to such charts or lists of geographical co-ordinates and shall deposit a copy of each such chart or list with the Secretary-General of the United Nations.

Article 48
Measurement of the breadth of the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf

The breadth of the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf, shall be measured from archipelagic baselines drawn in accordance with article 47.

Article 49
Legal status of archipelagic waters, of the air space over archipelagic waters and of their bed and subsoil

1. The sovereignty of an archipelagic State extends to the waters enclosed by the archipelagic baselines drawn in accordance with article 47, described as archipelagic waters, regardless of their depth or distance from the coast.

2. This sovereignty extends to the air space over the archipelagic waters, as well as to their bed and subsoil, and the resources contained therein.

3. This sovereignty is exercised subject to this Part.

4. The regime of archipelagic sea lanes passage established in this Part shall not in other respects affect the status of the archipelagic waters, including the sea lanes, or the exercise by the archipelagic State of its sovereignty over such waters and their air space, bed and subsoil, and the resources contained therein.

Article 50
Delimitation of internal waters

Within its archipelagic waters, the archipelagic State may draw closing lines for the delimitation of internal waters, in accordance with articles 9, 10 and 11.

Article 51
Existing agreements, traditional fishing rights and existing submarine cables

1. Without prejudice to article 49, an archipelagic State shall respect existing agreements with other States and shall recognize traditional fishing rights and other legitimate activities of the immediately adjacent neighbouring States in certain areas falling within archipelagic waters. The terms and conditions for the exercise of such rights and activities, including the nature, the extent and the areas to which they apply, shall, at the request of any of the States concerned, be regulated by bilateral agreements, between them. Such rights shall not be transferred to or shared with third States or their nationals.

2. An archipelagic State shall respect existing submarine cables laid by other States and passing through its waters without making a landfall. An archipelagic State shall permit the maintenance and replacement of such cables upon receiving due notice of their location and the intention to repair or replace them.

Article 52
Right of innocent passage

1. Subject to article 53 and without prejudice to article 50, ships of all States enjoy the right of innocent passage through archipelagic waters, in accordance with Part II, section 3.

2. The archipelagic State may, without discrimination in form or in fact among foreign ships, suspend temporarily in specified areas of its archipelagic waters the innocent passage of foreign ships if such suspension is essential for the protection of its security. Such suspension shall take effect only after having been duly published.

Article 53
Right of archipelagic sea lanes passage

1. An archipelagic State may designate sea lanes and air routes there above, suitable for the continuous and expeditious passage of foreign ships and aircraft through or over its archipelagic waters and the adjacent territorial sea.

2. All ships and aircraft enjoy the right of archipelagic sea lanes passage in such sea lanes and air routes.

3. Archipelagic sea lanes passage means the exercise in accordance with this Convention of the rights of navigation and over flight in the normal mode solely for the purpose of continuous, expeditious and unobstructed transit between one part of the high seas or an exclusive economic zone and another part of the high seas or an exclusive economic zone.

4. Such sea lanes and air routes shall traverse the archipelagic waters and the adjacent territorial sea and shall include all normal passage routes used as routes for international navigation or over flight through or over archipelagic waters and, within such routes, so far as ships are concerned, all normal navigational channels, provided that duplication of routes of similar convenience between the same entry and exit points shall not be necessary.

5. Such sea lanes and air routes shall be defined by a series of continuous axis lines from the entry points of passage routes to the exit points. Ships and aircraft in archipelagic sea lanes passage shall not deviate more than 25 nautical miles to either side of such axis lines during passage, provided that such ships and aircraft shall not navigate closer to the coasts than 10 per cent of the distance between the nearest points on islands bordering the sea lane.

6. An archipelagic State which designates sea lanes under this article may also prescribe traffic separation schemes for the safe passage of ships through narrow channels in such sea lanes.

7. An archipelagic State may, when circumstances require, after giving due publicity thereto, substitute other sea lanes or traffic separation schemes for any sea lanes or traffic separation schemes previously designated or prescribed by it.

8. Such sea lanes and traffic separation schemes shall conform to generally accepted international regulations.

9. In designating or substituting sea lanes or prescribing or substituting traffic separation schemes, an archipelagic State shall refer proposals to the competent international organization with a view to their adoption. The organization may adopt only such sea lanes and traffic separation schemes as may be agreed with the archipelagic State, after which the archipelagic State may designate, prescribe or substitute them.

10. The archipelagic State shall clearly indicate the axis of the sea lanes and the traffic separation schemes designated or prescribed by it on charts to which due publicity shall be given.

11. Ships in archipelagic sea lanes passage shall respect applicable sea lanes and traffic separation schemes established in accordance with this article.

12. If an archipelagic State does not designate sea lanes or air routes, the right of archipelagic sea lanes passage may be exercised through the routes normally used for international navigation.

Article 54
Duties of ships and aircraft during their passage, research and survey activities, duties of the archipelagic State and laws and regulations of the archipelagic State relating to archipelagic sea lanes passage

Articles 39, 40, 42 and 44 apply **mutatis mutandis** to archipelagic sea lanes passage.

PART V

EXCLUSIVE ECONOMIC ZONE

Article 55
Specific legal regime of the exclusive economic zone

The exclusive economic zone is an area beyond and adjacent to the territorial sea, subject to the specific legal regime established in this Part, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of this Convention.

Article 56
Rights, jurisdiction and duties of the coastal State in the exclusive economic zone

1. In the exclusive economic zone, the coastal State has:

   (a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the sea-bed and of the sea-bed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds;

   (b) jurisdiction as provided for in the relevant provisions of this Convention with regard to:

      (i) the establishment and use of artificial islands, installations and structures;

      (ii) marine scientific research;

      (iii) the protection and preservation of the marine environment;

   (c) other rights and duties provided for in this Convention.

2. In exercising its rights and performing its duties under this Convention in the exclusive economic zone, the coastal State shall have due regard to the rights and duties of other States and shall act in a manner compatible with the provisions of this Convention.

3. The rights set out in this article with respect to the sea-bed and subsoil shall be exercised in accordance with Part VI.

Article 57
Breadth of the exclusive economic zone

The exclusive economic zone shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

Article 58
Rights and duties of other States in the exclusive economic zone

1. In the exclusive economic zone, all States, whether coastal or land-locked, enjoy, subject to the relevant provisions of this Convention, the freedoms referred to in article 87 of navigation and over flight and of the laying of submarine cables and pipelines, and other internationally lawful uses of the sea related to these freedoms, such as those associated with the operation of ships, aircraft and submarine cables and pipelines, and compatible with the other provisions of this Convention.

2. Articles 88 to 115 and other pertinent rules of international law apply to the exclusive economic zone in so far as they are not incompatible with this Part.

3. In exercising their rights and performing their duties under this Convention in the exclusive economic zone, States shall have due regard to the rights and duties of the coastal State and shall comply with the laws and regulations adopted by the coastal State in accordance with the provisions of this Convention and other rules of international law in so far as they are not incompatible with this Part.

Article 59
Basis for the resolution of conflicts regarding the attribution of rights and jurisdiction in the exclusive economic zone

In cases where this Convention does not attribute rights or jurisdiction to the coastal State or to other States within the exclusive economic zone, and a conflict arises between the interests of the coastal State and any other State or States, the conflict should be resolved on the basis of equity and in the light of all the relevant circumstances, taking into account the respective importance of the interests involved to the parties as well as to the international community as a whole.

Article 60
Artificial islands, installations and structures in the exclusive economic zone

1. In the exclusive economic zone, the coastal State shall have the exclusive right to construct and to authorize and regulate the construction, operation and use of:

(a) artificial islands;

(b) installations and structures for the purposes provided for in article 56 and other economic purposes;

(c) installations and structures which may interfere with the exercise of the rights of the coastal State in the zone.

2. The coastal State shall have exclusive jurisdiction over such artificial islands, installations and structures, including jurisdiction with regard to customs, fiscal, health, safety and immigration laws and regulations.

3. Due notice must be given of the construction of such artificial islands, installations or structures, and permanent means for giving warning of their presence must be maintained. Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard by the competent international organization. Such removal shall also have due regard to fishing, the protection of the marine environment and the rights and duties of other States. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed.

4. The coastal State may, where necessary, establish reasonable safety zones around such artificial islands, installations and structures in which it may take appropriate measures to ensure the safety both of navigation and of the artificial islands, installations and structures.

5. The breadth of the safety zones shall be determined by the coastal State, taking into account applicable international standards. Such zones shall be designed to ensure that they are reasonably related to the nature and function of the artificial islands, installations or structures, and shall not exceed a distance of 500 metres around them, measured from each point of their outer edge, except as authorized by generally accepted international standards or as recommended by the competent international organizations. Due notice shall be given of the extent of safety zones.

6. All ships must respect these safety zones and shall comply with generally accepted international standards regarding navigation in the vicinity of artificial islands, installations, structures and safety zones.

7. Artificial islands, installations and structures and the safety zones around them may not be established where interference may be caused to the use of recognized sea lanes essential to international navigation.

8. Artificial islands, installations and structures do not possess the status of islands. They have no territorial sea of their own, and their presence does not affect the delimitation of the territorial sea, the exclusive economic zone or the continental shelf.

Article 61
Conservation of the living resources

1. The coastal State shall determine the allowable catch of the living resources in its exclusive economic zone.

2. The coastal State, taking into account the best scientific evidence available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation. As appropriate, the coastal State and competent international organizations, whether sub regional, regional or global, shall co-operate to this end.

3. Such measures shall also be designated to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors, including the economic needs of coastal fishing

communities and the special requirements of developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether sub regional, regional or global.

4. In taking such measures the coastal State shall take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.

5. Available scientific information, catch and fishing effort statistics, and other data relevant to the conservation of fish stocks shall be contributed and exchanged on a regular basis through competent international organizations, whether sub regional, regional or global, where appropriate and with participation by all States concerned, including States whose nationals are allowed to fish in the exclusive economic zone.

Article 62
Utilization of the living resources

1. The coastal State shall promote the objective of optimum utilization of the living resources in the exclusive economic zone without prejudice to article 61.

2. The coastal State shall determine its capacity to harvest the living resources of the exclusive economic zone. Where the coastal State does not have the capacity to harvest the entire allowable catch, it shall, through agreements or other arrangements and pursuant to the terms, conditions laws and regulations referred to in paragraph 4, give other States access to the surplus of the allowable catch, having particular regard to the provisions of articles 69 and 70, especially in relation to the developing States mentioned therein.

3. In giving access to other States to its exclusive economic zone under this article, the coastal State shall take into account all relevant factors, including, **inter alia**, the significance of the living resources of the area to the economy of the coastal State concerned and its other national interests, the provisions of article 69 and 70, the requirements of developing States in the sub region or region in harvesting part of the surplus and the need to minimize economic dislocation in States whose nationals have habitually fished in the zone or which have made substantial efforts in research and identification of stocks.

4. Nationals of other States fishing in the exclusive economic zone shall comply with the conservation measures and with the other terms and conditions established in the laws and regulations of the coastal State. These laws and regulations shall be consistent with this Convention and may relate, **inter alia**, to the following:

(a) licensing of fishermen, fishing vessels and equipment, including payment of fees and other forms or remuneration, which, in the case of developing coastal States, may consist of adequate compensation in the field of financing, equipment and technology relating to the fishing industry;

(b) determining the species which may be caught, and fixing quotas of catch, whether in relation to particular stocks or groups of stocks or catch per vessel over a period of time or to the catch by nationals of any State during a specified period;

(c) regulating seasons and areas of fishing, the types, sizes and amount of gear, and the types, sizes and number of fishing vessels that may be used;

(d) fixing the age and size of fish and other species that may be caught;

(e) specifying information required of fishing vessels, including catch and effort statistics and vessel position reports;

(f) requiring, under the authorization and control of the coastal State, the conduct of such research, including the sampling of catches, disposition of samples and reporting of associated scientific data;

(g) the placing of observers or trainees on board such vessels by the coastal State;

(h) the landing of all or any part of the catch by such vessels in the ports of the coastal State;

(i) terms and conditions relating to joint ventures or other co-operative arrangements;

(j) requirements for the training of personnel and the transfer of fisheries technology, including enhancement of the coastal State's capability of undertaking fisheries research;

(k) enforcement procedures.

5. Coastal States shall give due notice of conservation and management laws and regulations.

Article 63
Stocks occurring within the exclusive economic zone of two or more coastal States or both within the exclusive economic zone and in an area beyond and adjacent to it

1. Where the same stock or stocks of associated species occur within the exclusive economic zone of two or more coastal States, these States shall seek, either directly or through appropriate sub regional or regional organizations, to agree upon the measures necessary to co-ordinate and ensure the conservation and development of such stocks without prejudice to the other provisions of this Part.

2. Where the same stock or stocks of associated species occur both within the exclusive economic zone and in an area beyond and adjacent to the zone, the coastal State and the States fishing for such stocks in the adjacent area shall seek, either directly or through appropriate sub regional or regional organizations, to agree upon the measures necessary for the conservation of these stocks in the adjacent area.

Article 64
Highly migratory species

1. The coastal State and other States whose nationals fish in the region for the highly migratory species listed in Annex I shall co-operate directly or through appropriate international organizations with a view to ensuring conservation and promoting the objective of optimum utilization of such species throughout the region, both within and beyond the exclusive economic zone. In regions for which, no appropriate international organization exists, the coastal State and other States whose nationals harvest these species in the region shall co-operate to establish such an organization and participate in its work.

2. The provisions of paragraph 1 apply in addition to the other provisions of this Part.

Article 65
Marine mammals

Nothing in this Part restricts the right of a coastal State or the competence of an international organization, as appropriate, to prohibit, limit or regulate the exploitation of marine mammals more strictly than provided for in this Part. States shall co-operate with a view to the conservation of marine mammals and in the case of cetaceans shall in particular work through the appropriate international organizations for their conservation, management and study.

Article 66
Anadromous stocks

1. States in whose rivers anadromous stocks originate shall have the primary interest in and responsibility for such stocks.

2. The State of origin of anadromous stocks shall ensure their conservation by the establishment of appropriate regulatory measures for fishing in all waters landward of the outer limits of its exclusive economic zone and for fishing provided for in paragraph 3(b). The State or origin may, after consultations with the other States referred to in paragraphs 3 and 4 fishing these stocks, establish total allowable catches for stocks originating in its rivers.

3. (a) Fisheries for anadromous stocks shall be conducted only in waters landward of the outer limits of exclusive economic zones, except in cases where this provision would result in economic dislocation for a State other than the State of origin. With respect to such fishing beyond the outer limits of the exclusive economic zone, States concerned shall maintain consultations with a view to achieving agreement on terms and conditions of such fishing giving due regard to the conservation requirements and the needs of the State of origin in respect of these stocks.

(b) The State of origin shall co-operate in minimizing economic dislocation in such other States fishing these stocks, taking into account the normal catch and the mode of operations of such States, and all the areas in which such fishing has occurred.

(c) States referred to in subparagraph (b), participating by agreement with the State of origin in measures to renew anadromous stocks, particularly by expenditures for that purpose, shall be given special consideration by the State of origin in the harvesting of stocks originating in its rivers.

(d) Enforcement of regulations regarding anadromous stocks beyond the exclusive economic zone shall be by agreement between the State of origin and the other States concerned.

4. In cases where anadromous stocks migrate into or through the waters landward of the outer limits of the exclusive economic zone of a State other than the State of origin, such State shall co-operate with the State of origin with regard to the conservation and management of such stocks.

5. The State of origin of anadromous stocks and other States fishing these stocks shall make arrangements for the implementation of the provisions of this article, where appropriate, through regional organizations.

Article 67
Catadromous species

1. A coastal State in whose waters catadromous species spend the greater part of their life cycle shall have responsibility for the management of these species and shall ensure the ingress and egress of migrating fish.

2. Harvesting of catadromous species shall be conducted only in waters landward of the outer limits of exclusive economic zones. When conducted in exclusive economic zones, harvesting shall be subject to this article and the other provisions of this Convention concerning fishing in these zones.

3. In cases where catadromous fish migrate through the exclusive economic zone of another State, whether as juvenile or maturing fish, the management, including harvesting, of such fish shall be regulated by agreement between the State mentioned in paragraph 1 and the other States concerned. Such agreement shall ensure the rational management of the species and take into account the responsibilities of the State mentioned in paragraph 1 for the maintenance of these species.

Article 68
Sedentary species

This Part does not apply to sedentary species as defined in article 77, paragraph 4.

Article 69
Right of land-locked States

1. Land-locked States shall have the right to participate, on an equitable basis, in the exploitation of an appropriate part of the surplus of the living resources of the exclusive economic zones of coastal States of the same sub region or region, taking into account the relevant economic and geographical circumstances of all the States concerned and in conformity with the provisions of this article and of articles 61 and 62.

2. The terms and modalities of such participation shall be established by the States concerned through bilateral, sub regional or regional agreements taking into account, **inter alia**:

(a) the need to avoid effects detrimental to fishing communities or fishing industries of the coastal State;

(b) the extent to which the land-locked State, in accordance with the provisions of this article, is participating or is entitled to participate under existing bilateral, sub regional or regional agreements in the exploitation of living resources of the exclusive economic zones of other coastal States;

(c) the extent to which other land-locked States and geographically disadvantaged States are participating in the exploitation of the living resources of the exclusive economic zone of the coastal State and the consequent need to avoid a particular burden for any single coastal State or a part of it;

(d) the nutritional needs of the populations of the respective States.

3. When the harvesting capacity of a coastal State approaches a point which would enable it to harvest the entire allowable catch of the living resources in its exclusive economic zone, the coastal State and other States concerned shall co-operate in the establishment of equitable arrangements on a bilateral, sub regional or regional basis to allow for participation of developing land-locked States of the same sub region or region in the exploitation of the living resources of the exclusive economic zones of coastal States of the sub region or region, as may be appropriate in the circumstances and on terms satisfactory to all parties. In the implementation of this provision the factors mentioned in paragraph 2 shall also be taken into account.

4. Developed land-locked States shall, under the provisions of this article, be entitled to participate in the exploitation of living resources only in the exclusive economic zones of developed coastal States of the same sub region or region having regard to the extent to which the coastal State, in giving access to other States to the living resources of its exclusive economic zone, has taken into account the need to minimize detrimental effects on fishing communities and economic dislocation in States whose nationals have habitually fished in the zone.

5. The above provisions are without prejudice to arrangements agreed upon in sub regions or regions where the coastal States may grant to land-locked States of the same sub region or region equal or preferential rights for the exploitation of the living resources in the exclusive economic zones.

Article 70
Right of geographically disadvantaged States

1. Geographically disadvantaged States shall have the right to participate, on an equitable basis, in the exploitation of an appropriate part of the surplus of the living resources of the exclusive economic zones of coastal States of the same sub region or region, taking

into account the relevant economic and geographical circumstances of all the states concerned and in conformity with the provisions of this article and of articles 61 and 62.

2. For the purposes of this Part, "geographically disadvantaged States" means coastal States, including States bordering enclosed or semi-enclosed seas, whose geographical situation makes them dependent upon the exploitation of the living resources of the exclusive economic zones of other states in the sub region or region for adequate supplies of fish for the nutritional purposes of their populations or parts thereof, and coastal States which can claim no exclusive economic zones of their own.

3. The terms and modalities of such participation shall be established by the States concerned through bilateral, sub regional or regional agreements taking into account, **inter alia**:

(a) the need to avoid effects detrimental to fishing communities or fishing industries of the coastal State;

(b) the extent to which the geographically disadvantaged State, in accordance with the provisions of this article, is participating or is entitled to participate under existing bilateral, sub regional or regional agreements in the exploitation of living resources of the exclusive economic zones of other coastal States;

(c) the extent to which other geographically disadvantaged States and land-locked States are participating in the exploitation of the living resources of the exclusive economic zone of the coastal State and the consequent need to avoid a particular burden for any single coastal State or a part of it;

(d) the nutritional needs of the populations of the respective States.

4. When the harvesting capacity of a coastal State approaches a point which would enable it to harvest the entire allowable catch of the living resources in its exclusive economic zone, the coastal State and other States concerned shall co-operate in the establishment of equitable arrangements on a bilateral, sub regional or regional basis to allow for participation of developing geographically disadvantaged States of the same sub region or region in the exploitation of the living resources of the exclusive economic zones of coastal States of the sub region or region, as may be appropriate in the circumstances and on terms satisfactory to all parties. In the implementation of this provision the factors mentioned in paragraph 3 shall also be taken into account.

5. Developed geographically disadvantaged States shall, under the provisions of this article, be entitled to participate in the exploitation of living resources only in the exclusive economic zones of developed coastal States of the same sub region or region having regard to the extent to which the coastal State, in giving access to other States to the living resources of its exclusive economic zone, has taken into account the need to minimize detrimental effects on fishing communities and economic dislocation in States whose nationals have habitually fished in the zone.

6. The above provisions are without prejudice to arrangements agreed upon in sub regions or regions where the coastal States may grant to geographically disadvantaged States

of the same sub region or region equal or preferential rights for the exploitation of the living resources in the exclusive economic zones.

Article 71
Non-applicability of articles 69 and 70

The provisions of articles 69 and 70 do not apply in the case of a coastal State whose economy is overwhelmingly dependent on the exploitation of the living resources of its exclusive economic zone.

Article 72
Restrictions on transfer of rights

1. Rights provided under articles 69 and 70 to exploit living resources shall not be directly or indirectly transferred to third States or their nationals by lease or licence, by establishing joint ventures or in any other manner which has the effect of such transfer unless otherwise agreed by the States concerned.

2. The foregoing provision does not preclude the States concerned from obtaining technical or financial assistance from third States or international organizations in order to facilitate the exercise of the rights pursuant to articles 69 and 70, provided that it does not have the effect referred to in paragraph 1.

Article 73
Enforcement of laws and regulations of the coastal State

1. The coastal State may, in the exercise of its sovereign rights to explore, exploit, conserve and manage the living resources in the exclusive economic zone, take such measures, including boarding, inspection, arrest and judicial proceedings, as may be necessary to ensure compliance with the laws and regulations adopted by it in conformity with this Convention.
2. Arrested vessels and their crews shall be promptly released upon the posting of reasonable bond or other security.

3. Coastal State penalties for violations of fisheries laws and regulations in the exclusive economic zone may not include imprisonment, in the absence of agreements to the contrary by the States concerned, or any other form of corporal punishment.

4. In cases of arrest or detention of foreign vessels the coastal State shall promptly notify the flag State, through appropriate channels, of the action taken and of any penalties subsequently imposed.

Article 74
Delimitation of the exclusive economic zones between States with opposite or adjacent coasts

1. The delimitation of the exclusive economic zone between States with opposite or adjacent coasts shall be effected by agreement on the basis of international law, as referred in

Article 38 of the Statute of the International Court of Justice, in order to achieve an equitable solution.

2. If no agreement can be reached within a reasonable period of time, the States concerned shall resort to the procedures provided for in Part XV.

3. Pending agreement as provided for in paragraph 1, the States concerned, in a spirit of understanding and co-operation, shall make every effort to enter into provisional arrangements of a practical nature and, during this transitional period, not to jeopardize or hamper the reaching of the final agreement. Such arrangements shall be without prejudice to the final delimitation.

4. Where there is an agreement in force between the States concerned, questions relating to the delimitation of the exclusive economic zone shall be determined in accordance with the provisions of that agreement.

Article 75
Charts and lists of geographical co-ordinates

1. Subject to this Part, the outer limit lines of the exclusive economic zone and the lines of delimitation drawn in accordance with article 74 shall be shown on charts of a scale or scales adequate for ascertaining their position. Where appropriate, lists of geographical co-ordinates of points, specifying the geodetic datum, may be substituted for such outer limit lines or lines of delimitation.

2. The coastal State shall give due publicity to such charts or lists of geographical co-ordinates and shall deposit a copy of each such chart or list with the Secretary-General of the United Nations.

PART VI

CONTINENTAL SHELF

Article 76
Definition of the continental shelf

1. The continental shelf of a coastal State comprises the sea-bed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extent up to that distance.

2. The continental shelf of a coastal State shall not extend beyond the limits provided for in paragraphs 4 to 6.

3. The continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the sea-bed and subsoil of the shelf, the slope and the rise. It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof.

4. (a) For the purposes of this Convention, the coastal State shall establish the outer edge of the continental margin wherever the margin extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by either:

   (i) a line delineated in accordance with paragraph 7 by reference to the outermost fixed points at each of which the thickness of sedimentary rocks is at least 1 per cent of the shortest distance from such point to the foot of the continental slope; or

   (ii) a line delineated in accordance with paragraph 7 by reference to fixed points not more than 60 nautical miles from the foot of the continental slope.

   (b) In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change in the gradient as its base.

5. The fixed points comprising the line of the outer limits of the continental shelf on the sea-bed, drawn in accordance with paragraph 4 (a)(i) and (ii), either shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured or shall not exceed 100 nautical miles from the 2,500 metre isobath, which is a line connecting the depth of 2,500 metres.

6. Notwithstanding the provisions of paragraph 5, on submarine ridges, the outer limit of the continental shelf shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured. This paragraph does not apply to submarine elevations that are natural components of the continental margin, such as its plateaux, rises, caps, banks and spurs.

7. The coastal State shall delineate the outer limits of its continental shelf, where that shelf extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by straight lines not exceeding 60 nautical miles in length, connecting fixed points, defined by co-ordinates of latitude and longitude.

8. Information on the limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured shall be submitted by the coastal State to the Commission on the Limits of the Continental Shelf set up under Annex II on the basis of equitable geographical representation. The Commission shall make recommendations to coastal States on matters related to the establishment of the outer limits of their continental shelf. The limits of the shelf established by a coastal State on the basis of these recommendations shall be final and binding.

9. The coastal State shall deposit with the Secretary-General of the United Nations charts and relevant information, including geodetic data, permanently describing the outer limits of its continental shelf. The Secretary-General shall give due publicity thereto.

10. The provisions of this article are without prejudice to the question of delimitation of the continental shelf between States with opposite or adjacent coasts.

Article 77
Rights of the coastal State over the continental shelf

1. The coastal State exercises over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources.

2. The rights referred to in paragraph 1 are exclusive in the sense that if the coastal State does not explore the continental shelf or exploit its natural resources, no one may undertake these activities without the express consent of the coastal State.

3. The rights of the coastal State over the continental shelf do not depend on occupation, effective or notional, or on any express proclamation.

4. The natural resources referred to in this Part consist of the mineral and other non-living resources of the sea-bed and subsoil together with living organisms belonging to sedentary species, that is to say, organisms which, at the harvestable stage, either are immobile on or under the sea-bed or are unable to move except in constant physical contact with the sea-bed or the subsoil.

Article 78
Legal status of the superjacent waters and air space and the rights and freedoms of other States

1. The rights of the coastal State over the continental shelf do not affect the legal status of the superjacent waters or of the air space above those waters.

2. The exercise of the rights of the coastal State over the continental shelf must not infringe or result in any unjustifiable interference with navigation and other rights and freedoms of other States as provided for in this Convention.

Article 79
Submarine cables and pipelines on the continental shelf

1. All States are entitled to lay submarine cables and pipelines on the continental shelf, in accordance with the provisions of this article.

2. Subject to its right to take reasonable measures for the exploration of the continental shelf, the exploitation of its natural resources and the prevention, reduction and control of pollution from pipelines, the coastal State may not impede the laying or maintenance of such cables or pipelines.

3. The delineation of the course for the laying of such pipelines on the continental shelf is subject to the consent of the coastal State.

4. Nothing in this Part affects the right of the coastal State to establish conditions for cables or pipelines entering its territory or territorial sea, or its jurisdiction over cables and pipelines constructed or used in connection with the exploration of its continental shelf or exploitation of its resources or the operations of artificial islands, installations and structures under its jurisdiction.

5. When laying submarine cables or pipelines, States shall have due regard to cables or pipelines already in position. In particular, possibilities of repairing existing cables or pipelines shall not be prejudiced.

Article 80
Artificial islands, installations and structures on the continental shelf

Article 60 applies **mutatis mutandis** to artificial islands, installations and structures on the continental shelf.

Article 81
Drilling on the continental shelf

The coastal State shall have the exclusive right to authorize and regulate drilling on the continental shelf for all purposes.

Article 82
Payments and contributions with respect to the exploitation of the continental shelf beyond 200 nautical miles

1. The coastal State shall make payments or contributions in kind in respect of the exploitation of the non-living resources of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

2. The payments and contributions shall be made annually with respect to all production at a site after the first five years of production at that site. For the sixth year, the rate of payment or contribution shall be 1 per cent of the value or volume of production at the site. The rate shall increase by 1 per cent for each subsequent year until the twelfth year and shall remain at 7 per cent thereafter. Production does not include resources used in connection with exploitation.

3. A developing State which is a net importer of a mineral resource produced from its continental shelf is exempt from making such payments or contributions in respect of that mineral resource.

4. The payments or contributions shall be made through the Authority, which shall distribute them to States parties to this Convention, on the basis of equitable sharing criteria, taking into account the interests and needs of developing States, particularly the least developed and the land-locked among them.

Article 83
Delimitation of the continental shelf between States with opposite or adjacent coasts

1. The delimitation of the continental shelf between States with opposite or adjacent coasts shall be effected by agreement on the basis of international law, as referred to in Article 38 of the Statute of the International Court of Justice, in order to achieve an equitable solution.

2. If no agreement can be reached within a reasonable period of time, the States concerned shall resort to the procedures provided for in Part XV.

3. Pending agreement as provided for in paragraph 1, the States concerned, in a spirit of understanding and co-operation, shall make every effort to enter into provisional arrangements of a practical nature and, during this transitional period, not to jeopardize or hamper the reaching of the final agreement. Such arrangements shall be without prejudice to the final delimitation.

4. Where there is an agreement in force between the States concerned, questions relating to the delimitation of the continental shelf shall be determined in accordance with the provisions of that agreement.

Article 84
Charts and lists of geographical co-ordinates

1. Subject to this Part, the outer limit lines of the continental shelf and the lines of delimitation drawn in accordance with article 83 shall be shown on charts of a scale or scales adequate for ascertaining their position. Where appropriate, lists of geographical co-ordinates of points, specifying the geodetic datum, may be substituted for such outer limit lines or lines of delimitation.

2. The coastal State shall give due publicity to such charts or lists of geographical co-ordinates and shall deposit a copy of each such chart or list with the Secretary-General of the United Nations and, in the case of those showing the outer limit lines of the continental shelf, with the Secretary-General of the Authority.

Article 85
Tunnelling

This Part does not prejudice the right of the coastal State to exploit the subsoil by means of tunnelling, irrespective of the depth of water above the subsoil.

PART VII

HIGH SEAS

SECTION 1. GENERAL PROVISIONS

Article 86
Application of the provisions of this Part

The provisions of this Part apply to all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State. This article does not entail any abridgement of the freedoms enjoyed by all States in the exclusive economic zone in accordance with article 58.

Article 87
Freedom of the high seas

1. The high seas are open to all States, whether coastal or land-locked. Freedom of the high seas is exercised under the conditions laid down by this Convention and by other rules of international law. It comprises, **inter alia**, both for coastal and land-locked States:

(a) freedom of navigation;

(b) freedom of over flight;

(c) freedom to lay submarine cables and pipelines, subject to Part VI;

(d) freedom to construct artificial islands and other installations permitted under international law, subject to Part VI;

(e) freedom of fishing, subject to the conditions laid down in section 2;

(f) freedom of scientific research, subject to Parts VI and XIII.

2. These freedoms shall be exercised by all States with due regard for the interests of other States in their exercise of the freedom of the high seas, and also with due regard for the rights under this Convention with respect to activities in the Area.

Article 88
Reservation of the high seas for peaceful purposes

The high seas shall be reserved for peaceful purposes.

Article 89
Invalidity of claims of sovereignty over the high seas

No State may validly purport to subject any part of the high seas to its sovereignty.

Article 90
Right of navigation

Every State, whether coastal or land-locked, has the right to sail ships flying its flag on the high seas.

Article 91
Nationality of ships

1. Every State shall fix the conditions for the grant of its nationality to ships, for the registration of ships in its territory, and for the right to fly its flag. Ships have the nationality of the State whose flag they are entitled to fly. There must exist a genuine link between the State and the ship.

2. Every State shall issue to ships to which it has granted the right to fly its flag documents to that effect.

Article 92
Status of ships

1. Ships shall sail under the flag of one State only and, save in exceptional cases expressly provided for in international treaties or in this Convention, shall be subject to its exclusive jurisdiction on the high seas. A ship may not change its flag during a voyage or while in a port of call, save in the case of a real transfer of ownership or change of registry.

2. A ship which sails under the flags of two or more States, using them according to convenience, may not claim any of the nationalities in question with respect to any other State, and may be assimilated to a ship without nationality.

Article 93
Ships flying the flag of the United Nations, its specialized agencies and the International Atomic Energy Agency

The preceding articles do not prejudice the question of ships employed on the official service of the United Nations, its specialized agencies or the International Atomic Energy Agency, flying the flag of the organization.

Article 94
Duties of the flag State

1. Every State shall effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag.

2. In particular every State shall:

   (a) maintain a register of ships containing the names and particulars of ships flying its flag, except those which are excluded from generally accepted international regulations on account of their small size; and

(b) assume jurisdiction under its internal law over each ship flying its flag and its master, officers and crew in respect of administrative, technical and social matters concerning the ship.

3. Every State shall take such measures for ships flying its flag as are necessary to ensure safety at sea with regard, **inter alia**, to:

(a) the construction, equipment and seaworthiness of ships;

(b) the manning of ships, labour conditions and the training of crews, taking into account the applicable international instruments;

(c) the use of signals, the maintenance of communications and the prevention of collisions.

4. Such measures shall include those necessary to ensure:

(a) that each ship, before registration and thereafter at appropriate intervals, is surveyed by a qualified surveyor of ships, and has on board such charts, nautical publications and navigational equipment and instruments as are appropriate for the safe navigation of the ship;

(b) that each ship is in the charge of a master and officers who possess appropriate qualifications, in particular in seamanship, navigation, communications and marine engineering, and that the crew is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship;

(c) that the master, officers and, to the extent appropriate, the crew are fully conversant with and required to observe the applicable international regulations concerning the safety of life at sea, the prevention of collisions, the prevention, reduction and control of marine pollution, and the maintenance of communications by radio.

5. In taking the measures called for in paragraphs 3 and 4 each State is required to conform to generally accepted international regulations, procedures and practices and to take any steps which may be necessary to secure their observance.

6. A State which has clear grounds to believe that proper jurisdiction and control with respect to a ship have not been exercised may report the facts to the flag State. Upon receiving such a report, the flag State shall investigate the matter and, if appropriate, take any action necessary to remedy the situation.

7. Each State shall cause an inquiry to be held by or before a suitably qualified person or persons into every marine casualty or incident of navigation on the high seas involving a ship flying its flag and causing loss of life or serious injury to nationals of another State or serious damage to ships or installations of another State or to the marine environment. The flag State and the other State shall co-operate in the conduct of any inquiry held by that other State into any such marine casualty or incident of navigation.

Article 95
Immunity of warships on the high seas

Warships on the high seas have complete immunity from the jurisdiction of any State other than the flag State.

Article 96
Immunity of ships used only on government non-commercial service

Ships owned or operated by a State and used only on government non-commercial service shall, on the high seas, have complete immunity from the jurisdiction of any State other than the flag State.

Article 97
Penal jurisdiction in matters of collision or any other incident of navigation

1. In the event of a collision or any other incident of navigation concerning a ship on the high seas, involving the penal or disciplinary responsibility of the master or of any other person in the service of the ship, no penal or disciplinary proceedings may be instituted against such person except before the judicial or administrative authorities either of the flag State or of the State of which such person is a national.

2. In disciplinary matters, the State which has issued a master's certificate or a certificate of competence or licence shall alone be competent, after due legal process, to pronounce the withdrawal of such certificates, even if the holder is not a national of the State which issued them.

3. No arrest or detention of the ship, even as a measure of investigation, shall be ordered by any authorities other than those of the flag State.

Article 98
Duty to render assistance

1. Every State shall require the master of a ship flying its flag, in so far as he can do so without serious danger to the ship, the crew or the passengers:

(a) to render assistance to any person found at sea in danger of being lost;

(b) to proceed with all possible speed to the rescue of persons in distress, if informed of their need of assistance, in so far as such action may reasonably be expected of him;

(c) after a collision, to render assistance to the other ship, its crew and its passengers and, where possible, to inform the other ship of the name of his own ship, its port of registry and the nearest port at which it will call.

2. Every coastal State shall promote the establishment, operation and maintenance of an adequate and effective search and rescue service regarding safety on and over the sea and,

where circumstances so require, by way of mutual regional arrangements co-operate with neighbouring States for this purpose.

Article 99
Prohibition of the transport of slaves

Every State shall take effective measures to prevent and punish the transport of slaves in ships authorized to fly its flag and to prevent the unlawful use of its flag for that purpose. Any slave taking refuge on board any ship, whatever its flag, shall **ipso facto** be free.

Article 100
Duty to co-operate in the repression of piracy

All States shall co-operate to the fullest possible extent in the repression of piracy on the high seas or in any other place outside the jurisdiction of any State.

Article 101
Definition of piracy

Piracy consists of any of the following acts:

(a) any illegal acts of violence or detention, or any act of depredation committed for private ends by the crew or the passengers of a private ship or a private aircraft, and directed:

(i) on the high seas, against another ship or aircraft, or against persons or property on board such ship or aircraft;

(ii) against a ship, aircraft, persons or property in a place outside the jurisdiction of any State;

(b) any act of voluntary participation in the operation of a ship, or an aircraft with knowledge of facts making it a pirate ship or aircraft;

(c) any act of inciting or of intentionally facilitating an act described in sub-paragraph (a) or (b).

Article 102
Piracy by a warship, government ship or government aircraft whose crew has mutinied

The acts of piracy, as defined in article 101, committed by a warship, government ship or government aircraft whose crew has mutinied and taken control of the ship or aircraft are assimilated to acts committed by a private ship or aircraft.

Article 103
Definition of a pirate ship or aircraft

A ship or aircraft is considered a pirate ship or aircraft if it is intended by the persons in dominant control to be used for the purpose of committing one of the acts referred to in article 101. The same applies if the ship or aircraft has been used to commit any such act, so long as it remains under the control of the persons guilty of that act.

Article 104
Retention or loss of the nationality of a pirate ship or aircraft

A ship or aircraft may retain its nationality although it has become a pirate ship or aircraft. The retention or loss of nationality is determined by the law of the State from which such nationality was derived.

Article 105
Seizure of a pirate ship or aircraft

On the high seas, or in any other place outside the jurisdiction of any State, every State may seize a pirate ship or aircraft, or a ship or aircraft taken by piracy and under the control of pirates, and arrest the persons and seize the property on board. The courts of the State which carried out the seizure may decide upon the penalties to be imposed, and may also determine the action to be taken with regard to the ships, aircraft or property, subject to the rights of third parties acting in good faith.

Article 106
Liability for seizure without adequate grounds

Where the seizure of a ship or aircraft on suspicion of piracy has been effected without adequate grounds, the State making the seizure shall be liable to the State the nationality of which is possessed by the ship or aircraft for any loss or damage caused by the seizure.

Article 107
Ships and aircraft which are entitled to seize on account of piracy

A seizure on account of piracy may be carried out only by warships or military aircraft, or other ships or aircraft clearly marked and identifiable as being on government service and authorized to that effect.

Article 108
Illicit traffic in narcotic drugs or psychotropic substances

1. All States shall co-operate in the suppression of illicit traffic in narcotic drugs and psychotropic substances engaged in by ships on the high seas contrary to international conventions.

2. Any State which has reasonable grounds for believing that a ship flying its flag is engaged in illicit traffic in narcotic drugs or psychotropic substances may request the co-operation of other States to suppress such traffic.

Article 109
Unauthorized broadcasting from the high seas

1. All States shall co-operate in the suppression of unauthorized broadcasting from the high seas.

2. For the purposes of this Convention, "unauthorized broadcasting" means the transmission of sound radio or television broadcasts from a ship or installation on the high seas intended for reception by the general public contrary to international regulations, but excluding the transmission of distress calls.

3. Any person engaged in unauthorized broadcasting may be prosecuted before the court of:

(a) the flag State of the ship;

(b) the State of registry of the installation;

(c) the State of which the person is a national;

(d) any State where the transmissions can be received; or

(e) any State where authorized radio communication is suffering interference.

4. On the high seas, a State having jurisdiction in accordance with paragraph 3 may, in conformity with article 110, arrest any person or ship engaged in unauthorized broadcasting and seize the broadcasting apparatus.

Article 110
Right of visit

1. Except where acts of interference derive from powers conferred by treaty, a warship which encounters on the high seas a foreign ship, other than a ship entitled to complete immunity in accordance with articles 95 and 96, is not justified in boarding it unless there is reasonable ground for suspecting that:

(a) the ship is engaged in piracy;

(b) the ship is engaged in the slave trade;

(c) the ship is engaged in unauthorized broadcasting and the flag State of the warship has jurisdiction under article 109;

(d) the ship is without nationality; or

(e) through flying a foreign flag or refusing to show its flag, the ship is, in reality, of the same nationality as the warship.

2. In the cases provided for in paragraph 1, the warship may proceed to verify the ship's right to fly its flag. To this end, it may send a boat under the command of an officer to the suspected ship. If suspicion remains after the documents have been checked, it may proceed to a further examination on board the ship, which must be carried out with all possible consideration.

3. If the suspicions prove to be unfounded, and provided that the ship boarded has not committed any act justifying them, it shall be compensated for any loss or damage that may have been sustained.

4. These provisions apply **mutatis mutandis** to military aircraft.

5. These provisions also apply to any other duly authorized ships or aircraft clearly marked and identifiable as being on government service.

Article 111
Right of hot pursuit

1. The hot pursuit of a foreign ship may be undertaken when the competent authorities of the coastal State have good reason to believe that the ship has violated the laws and regulations of that State. Such pursuit must be commenced when the foreign ship or one of its boats is within the internal waters, the archipelagic waters, the territorial sea or the contiguous zone of the pursuing State, and may only be continued outside the territorial sea or the contiguous zone if the pursuit has not been interrupted. It is not necessary that, at the time when the foreign ship within the territorial sea or the contiguous zone receives the order to stop, the ship giving the order should likewise be within the territorial sea or the contiguous zone. If the foreign ship is within a contiguous zone, as defined in article 33, the pursuit may only be undertaken if there has been a violation of the rights for the protection of which the zone was established.

2. The right of hot pursuit shall apply **mutatis mutandis** to violations in the exclusive economic zone or on the continental shelf, including safety zones around continental shelf installations, of the laws and regulations of the coastal State applicable in accordance with this Convention to the exclusive economic zone or the continental shelf, including such safety zones.

3. The right of hot pursuit ceases as soon as the ship pursued enters the territorial sea of its own State or of a third State.

4. Hot pursuit is not deemed to have begun unless the pursuing ship has satisfied itself by such practicable means as may be available that the ship pursued or one of its boats or other craft working as a team and using the ship pursued as a mother ship is within the limits of the territorial sea, or, as the case may be, within the contiguous zone or the exclusive economic zone or above the continental shelf. The pursuit may only be commenced after a visual or auditory signal to stop has been given at a distance which enables it to be seen or heard by the foreign ship.

5. The right of hot pursuit may be exercised only by warships or military aircraft, or other ships or aircraft clearly marked and identifiable as being on government service and authorized to that effect.

6. Where hot pursuit is effected by an aircraft;

(a) the provisions of paragraphs 1 to 4 shall apply **mutatis mutandis**;

(b) the aircraft giving the order to stop must itself actively pursue the ship until a ship or another aircraft of the coastal State, summoned by the aircraft, arrives to take over the pursuit, unless the aircraft is itself able to arrest the ship. It does not suffice to justify an arrest outside the territorial sea that the ship was merely sighted by the aircraft as an offender or suspected offender, if it was not both ordered to stop and pursued by the aircraft itself or other aircraft or ships which continue the pursuit without interruption.

7. The release of a ship arrested within the jurisdiction of a State and escorted to a port of that State for the purposes of an inquiry before the competent authorities may not be claimed solely on the ground that the ship, in the course of its voyage, was escorted across a portion of the exclusive economic zone or the high seas, if the circumstances rendered this necessary.

8. Where a ship has been stopped or arrested outside the territorial sea in circumstances which do not justify the exercise of the right of hot pursuit, it shall be compensated for any loss or damage that may have been thereby sustained.

Article 112
Right to lay submarine cables and pipelines

1. All States are entitled to lay submarine cables and pipelines on the bed of the high seas beyond the continental shelf.

2. Article 79, paragraph 5, applies to such cables and pipelines.

Article 113
Breaking or injury of a submarine cable or pipeline

Every State shall adopt the laws and regulations necessary to provide that the breaking or injury by a ship flying its flag or by a person subject to its jurisdiction of a submarine cable beneath the high seas done wilfully or through culpable negligence, in such a manner as to be liable to interrupt or obstruct telegraphic or telephonic communications, and similarly the breaking or injury of a submarine pipeline or high-voltage power cable, shall be a punishable offence. This provision shall apply also to conduct calculated or likely to result in such breaking or injury. However, it shall not apply to any break or injury caused by persons who acted merely with the legitimate object of saving their lives or their ships, after having taken all necessary precautions to avoid such break or injury.

Article 114
Breaking or injury by owners of a submarine cable or pipeline of another submarine cable or pipeline

Every State shall adopt the laws and regulations necessary to provide that, if persons subject to its jurisdiction who are the owners of a submarine cable or pipeline beneath the high seas, in laying or repairing that cable or pipeline, cause a break in or injury to another cable or pipeline, they shall bear the cost of the repairs.

Article 115
Indemnity for loss incurred in avoiding injury to a submarine cable or pipeline

Every State shall adopt the laws and regulations necessary to ensure that the owners of ships who can prove that they have sacrificed and anchor, a net or any other fishing gear, in order to avoid injuring a submarine cable or pipeline, shall be indemnified by the owner of the cable or pipeline, provided that the owner of the ship has taken all reasonable precautionary measures beforehand.

SECTION 2. CONSERVATION AND MANAGEMENT OF THE LIVING RESOURCES OF THE HIGH SEAS

Article 116
Right to fish on the high seas

All States have the right for their nationals to engage in fishing on the high seas subject to:

(a) their treaty obligations;

(b) the rights and duties as well as the interests of coastal States, provided for, **inter alia**, in article 63, paragraph 2, and articles 64 to 67; and

(c) the provisions of this section.

Article 117
Duty of States to adopt with respect to their nationals measures for the conservation of the living resources of the high seas

All States have the duty to take, or to co-operate with other States in taking, such measures for their respective nationals as may be necessary for the conservation of the living resources of the high seas.

Article 118
Co-operation of States in the conservation and management of living resources

States shall co-operate with each other in the conservation and management of living resources in the areas of the high seas. States whose nationals exploit identical living resources, or different living resources in the same area, shall enter into negotiations with a view to taking the measures necessary for the conservation of the living resources concerned. They shall, as appropriate, co-operate to establish sub regional or regional fisheries organizations to this end.

Article 119
Conservation of the living resources of the high seas

1. In determining the allowable catch and establishing other conservation measures for the living resources in the high seas, States shall:

   (a) take measures which are designed, on the best scientific evidence available to the States concerned, to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors, including the special requirements of developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether sub regional, regional or global;

   (b) take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.

2. Available scientific information, catch and fishing effort statistics, and other data relevant to the conservation of fish stocks shall be contributed and exchanged on a regular basis through competent international organizations, whether sub regional, regional or global, where appropriate and with participation by all States concerned.

3. States concerned shall ensure that conservation measures and their implementation do not discriminate in form or in fact against, the fishermen of any State.

Article 120
Marine mammals

Article 65 also applies to the conservation and management of marine mammals in the high seas.

PART VIII

REGIME OF ISLANDS

Article 121
Régime of islands

3. An island is a naturally formed area of land, surrounded by water, which is above water at high tide.

3. Except as provided for in paragraph 3, the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf of an island are determined in accordance with the provisions of this Convention applicable to other land territory.

3. Rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf.

PART IX

ENCLOSED OR SEMI-ENCLOSED SEAS

Article 122
Definition

For the purposes of this Convention, "enclosed or semi-enclosed sea" means a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States.

Article 123
Co-operation of States bordering enclosed or semi-enclosed seas

States bordering an enclosed or semi-enclosed sea should co-operate with each other in the exercise of their rights and in the performance of their duties under this Convention. To this end they shall endeavour, directly or through an appropriate regional organization:

(a) to co-ordinate the management, conservation, exploration and exploitation of the living resources of the sea;

(b) to co-ordinate the implementation of their rights and duties with respect to the protection and preservation of the marine environment;

(c) to co-ordinate their scientific research policies and undertake where appropriate joint programmes of scientific research in the area;

(d) to invite, as appropriate, other interested States or international organizations to co-operate with them in furtherance of the provisions of this article.

ANNEX II

COMMISSION ON THE LIMITS OF THE CONTINENTAL SHELF

Article 1

In accordance with the provisions of article 76, a Commission on the Limits of the Continental Shelf beyond 200 nautical miles shall be established in conformity with the following articles.

Article 2

1. The Commission shall consist of 21 members who shall be experts in the field of geology, geophysics or hydrography, elected by States Parties to this Convention from among their nationals, having due regard to the need to ensure equitable geographical representation, who shall serve in their personal capacities.

2. The initial election shall be held as soon as possible but in any case within 18 months after the date of entry into force of this Convention. At least three months before the date of each election, the Secretary-General of the United Nations shall address a letter to the States Parties, inviting the submission of nominations, after appropriate regional consultations, within three months. The Secretary-General shall prepare a list in alphabetical order of all persons thus nominated and shall submit it to all the States Parties.

3. Elections of the members of the Commission shall be held at a meeting of States Parties convened by the Secretary-General at United Nations Headquarters. At that meeting, for which two thirds of the States Parties shall constitute a quorum, the persons elected to the Commission shall be those nominees who obtain a two-thirds majority of the votes of the representatives of States Parties present and voting. Not less than three members shall be elected from each geographical region.

4. The members of the Commission shall be elected for a term of five years. They shall be eligible for re-election.

5. The State Party which submitted the nomination of a member of the Commission shall defray the expenses of that member while in performance of Commission duties. The coastal State concerned shall defray the expenses incurred in respect of the advice referred to in article 3, paragraph 1(b), of this Annex. The secretariat of the Commission shall be provided by the Secretary-General of the United Nations.

Article 3

1. The functions of the Commission shall be:

(a) to consider the data and other materials submitted by coastal States concerning the outer limits of the continental shelf in areas where those limits extend beyond 200 nautical miles, and to make recommendations in accordance with article 76 and the Statement of Understanding adopted on 29 August 1980 by the Third United Nations Conference on the Law of the Sea;

(b) To provide scientific and technical advice, if requested by the coastal State concerned during the preparation of the data referred to in subparagraph (a).

2. The Commission may co-operate, to the extent considered necessary and useful, with the Intergovernmental Oceanographic Commission of UNESCO, the International Hydrographic Organization and other competent international organizations with a view to exchanging scientific and technical information which might be of assistance in discharging the Commission's responsibilities.

Article 4

Where a coastal State intends to establish, in accordance with article 76, the outer limits of its continental shelf beyond 200 nautical miles, it shall submit particulars of such limits to the Commission along with supporting scientific and technical data as soon as possible but in any case within 10 years of the entry into force of this Convention for that State. The coastal State shall at the same time give the names of any Commission members who have provided it with scientific and technical advice.

Article 5

Unless the Commission decides otherwise, the Commission shall function by way of sub-commissions composed of seven members, appointed in a balanced manner taking into account the specific elements of each submission by a coastal State. Nationals of the coastal State making the submission who are members of the Commission and any Commission member who has assisted a coastal State by providing scientific and technical advice with respect to the delineation shall not be a member of the sub-commission dealing with that submission but has the right to participate as a member in the proceedings of the Commission concerning the said submission. The coastal State which has made a submission to the Commission may send its representatives to participate in the relevant proceedings without the right to vote.

Article 6

1. The sub-commission shall submit its recommendations to the Commission.

2. Approval by the Commission of the recommendations of the sub-commission shall be by a majority of two thirds of Commission members present and voting.

3. The recommendations of the Commission shall be submitted in writing to the coastal State which made the submission and to the Secretary-General of the United Nations.

Article 7

Coastal States shall establish the outer limits of the continental shelf in conformity with the provisions of article 76, paragraph 8, and in accordance with the appropriate national procedures.

Article 8

In the case of disagreement by the coastal State with the recommendations of the Commission, the coastal State shall, within a reasonable time, make a revised or new submission to the Commission.

Article 9

The actions of the Commission shall not prejudice matters relating to delimitation of boundaries between States with opposite or adjacent coasts.

APPENDIX 3

CITATIONS AND RECOMMENDED READINGS

This Bibliography represents a sampling of the literature that pertains to the topics addressed in the TALOS Manual. Entries are categorized according to the scope of their contents: General entries (designated with a G) consist among other things of: monographs; wide-ranging surveys and reviews; conference proceedings; collections of historical and technical topics; compendiums; and related subjects of broad interest. Chapter-specific entries (designated by relevant chapter numbers) refer to sections of the TALOS Manual where topics are considered in some detail; some of these entries also fit within the General category, and are so listed.

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APPENDIX 4

MEMBERSHIP OF THE TALOS WORKING GROUP

The following is a cumulative list of individuals who were members of the TALOS Group between 1985-2002, and who contributed to the preparation of Editions 1, 2, and 3 of the TALOS Manual, either by correspondence or by personally attending the meetings of the Group:

Rear Admiral A.A. YUNG .... Argentina
Lt. Cdr. E. RODRIGUEZ .... Argentina
Cdr. M.A. BOMPET .... Brazil
Capt. P.K. MUKERJEE .... Canada
LT. Cdr. H. GORZIGLIA .... Chile
Cdr. M. THAMSBORG .... Denmark
Ing. en Chef CAILLIAU .... France (1985/1989)
Ing. en Chef HABERT .... France (1988/1989)
Ing. General A. ROUBERTOU .... France (1990)
Rear Admiral G. PAPATHEOFANOUS .... Greece (1985-1989)
Captain I. PAPPAS .... Greece (1990)
Cdr. D. SENGUPTA .... India (1985-1989)
Commodore P.P. NANDI .... India (1990)
Rear Admiral A. CIVETTA .... Italy (1985-1987)
Captain F. SPANIO .... Italy (1988-1990)
Dr. Gian Petro FRANCALANCI .... Italy (1985-1990)
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Mr. Shigeru KATO .... Japan (1989-1990)
Mr. Mario C. MANASALA .... Philippines (1985-1987)
Mr. W.R. JIMENEZ .... Philippines (1987-1990)
Commodore N.R. GUY .... Republic of South Africa
Cdr. R.L.C. HALLIDAY .... U.K. (1985-1987)
Lt. Cdr. C.M. CARLETON .... U.K. (1987-1990)
Dr. R.W. SMITH .... U.S.A.
Captain S.V. VALTCHOUK .... U.S.S.R.
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Late Mr. A.J. KERR (Chairman) .... I.H.B. (1987-1990)
Cdr. N.N. SATHAYE (Secretary) .... I.H.B. (1985-1986)
Lt. Cdr. E.H. TORRES (Secretary) .... I.H.B. (1987-1988)
Lt. Cdr. F. BERMEJO-BARO (Secretary) .... I.H.B. (1988-1989)
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In addition to the above, the Directing Committee of the International Hydrographic Bureau also acknowledged the contribution made by Lt. Cdr. BEAZLEY of the United Kingdom in his capacity as the Bureau's consultant; and by the following members of the Special Study Group (SSG) of the International Association of Geodesy (IAG):

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Mr. Galo CARRERA .... Canada
Mr. Jack WEIGHTMAN .... U.K.

The Editorial Group formed in 2003 to prepare the 4th Edition comprised:

Ron MACNAB – Chairman .... Canada
Steve SHIPMAN – Secretary .... IHB
Lars SJOBERG .... Sweden
Carlo DARDENGO .... Italy
Chris CARLETON.. UK
Shin TANI .... Japan

A new Editorial Group was formed in 2010 and was augmented several times subsequently, with a mandate to prepare the Fifth Edition. It comprised the following members and associates of ABLOS:

Niels ANDERSEN.. Denmark
I Made Andi ARSANA .... Indonesia
Isabelle BELMONTE.. IHB
Sunil BISNATH.. Canada
Graeme BLICK... New Zealand
John BROWN... United Kingdom
Chris CARLETON – Chairman 2012-17 .... United Kingdom
Ron MACNAB – Chairman 2011-12 .... Canada
Chris RIZOS – Chairman 2010-11 .... Australia
Clive SCHOFIELD .... Australia
Steve SHIPMAN... IHB
Michael SIDERIS .... Canada
Sobar SUSTINA .... Indonesia
Shin TANI .... Japan
Asano USUI.. Japan
David WYATT .... IHB