The Evolution of Scientific and Technical Methodologies in the Delimitation of Maritime Spaces

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Introduction

The most important modern theoretical contribution made to ocean boundary-making is the recognition that establishing maritime boundaries and outer limits of national maritime spaces has a functional role.¹ Under this theory, boundaries and limits are not regarded as separate jurisdic tional or geometric entities, but rather they are important elements for sustainable development of the oceans. The theory of ocean boundary-making has been the subject of intense interdisciplinary research.² The value of the contributions made by any particular discipline towards the delimitation of a maritime boundary is largely measured by its ability to support more effective ocean governance.

Contemporary international practice recognizes the fundamentally interdisciplinary nature of the delimitation of maritime spaces. The roles of technical and scientific experts has evolved from simple technical tasks of depicting a geometric line or area on a nautical chart to developing a wide set of creative boundary scenarios and proposals. The boundary scenarios are developed in view of all the legal, historic, economic, strategic, technical, and scientific data and information available for the particular maritime region and are depicted in a variety of formats. Flexibility to accommodate any intrinsically special and relevant circumstances of each maritime boundary seems to be one of the key factors for success.

This essay cannot provide a full description of the evolution of ocean boundary-making methodologies. Instead it highlights the evolution of the scientific methodology employed in the delimitation of international maritime spaces, which comprises two components: the determination of the outer limits of

¹ D.M. Johnston, The Theory and History of Ocean Boundary-Making (Kingston: McGill-Queen's University Press, 1988).
² United Nations, Handbook on the Delimitation of Maritime Boundaries (New York, 2000).
maritime spaces under national jurisdiction and the delimitation of international maritime boundaries.

Whereas the outer limits of maritime spaces under national jurisdiction are determined by states as a result of unilateral actions by the coastal state, international maritime boundaries between claimant states are either created as a result of (i) international legal agreements reached through bilateral or multilateral negotiations and diplomacy, or (ii) third-party interventions such as enquiry, mediation, conciliation, arbitration, judicial settlement, resort to regional agencies or arrangements, or other peaceful means in accordance with Article 33 of the Charter of the United Nations.3

Some of the methodologies described here are applied by national organizations worldwide in support of routine operations. Other methods, however, are the result of analyses of boundaries determined by international courts and tribunals. For example, one of the most important recent developments in the delimitation of the outer limits of the continental shelf are presented in the Scientific and Technical Guidelines produced by the Commission on the Limits of the Continental Shelf (CLCS).4

**Early Methods and Pioneers**

A review of the evolution of methodology in the delimitation of maritime spaces must consider both national legislation and the work of international law conferences and the resulting conventions. The League of Nations Codification Conference of 1930 and the First and Third United Nations Conferences on the Law of the Sea are as much a *tour de force* as the corpus of *codified international law* produced by the latter two conferences, such as the 1958 Geneva Conventions on the Territorial Sea and the Contiguous Zone 5 and the Continental Shelf,6 and the 1982 United Nations Convention on the Law of the Sea (*UNCLOS*).7

Various scientific and technical scholars have made important contributions to the discussion of the delimitation of maritime spaces in the context

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3 The Charter of the United Nations was signed, in San Francisco, on 26 June 1945, at the conclusion of the United Nations Conference on International Organization, and came into force on 24 October 1945. The Statute of the International Court of Justice is an integral part of the Charter. See Part XV of the United Nations Convention on the Law of the Sea.
4 Commission on the Limits of the Continental Shelf (CLCS), Doc. CLCS/11 (13 May 1999); Doc. CLCS/11/Add.1 (3 September 1999).
5 Geneva, 29 April 1958, 516 *U.N.T.S.* 205.
6 Geneva, 29 April 1958, 499 *U.N.T.S.* 311.
7 Montego Bay, 10 December 1982, 1833 *U.N.T.S.* 3.
of national legislation and international law conferences and conventions. For example, Shalowitz’s study provides an excellent example of the evolution and development of methods and techniques for the delimitation of maritime spaces in the influential national legislation of the United States. Similarly, Boggs has described the seminal contributions made on scientific and technical aspects relating to the determination of the outer limit of the territorial sea and the determination of international maritime boundaries during the 1930 Codification Conference. The technique used to determine the offshore limits of the territorial sea from a selection of points along baselines was originally defined by Boggs as the method of envelopes of arcs first introduced as a proposal for codification in international law by the US delegation at the 1930 Hague Conference. This method provides an offshore limit every point of which is located at a prescribed distance from the nearest point on the coast. Shalowitz advanced a more elegant definition of this method where the offshore limit “is the locus of the centre of a circle the circumference of which is always in contact with the coastline, that is, with the low water line or the seaward limits of inland waters.”

The legal evolution of the determination of outer limits from straight lines has been reviewed elsewhere. From the technical standpoint, the difficult task of determining offshore limits from straight or archipelagic baselines is compounded by the fact that neither of these has ever been rigorously defined in the legal literature from a geodetic perspective. The existing literature only speculates as to what the nature of these lines might be.

The vast body of work by Alexander and many others describes methods for the determination of all baselines, the delimitation of maritime spaces,
and their evolving breadth over time, and the interpretation of a wide range of scientific and technical provisions and terms discussed during the Third Conference on the Law of the Sea and codified in UNCLOS. The development and analyses of international maritime boundary delimitation methods in state practice and judicial settlements has been extensively studied and scrutinized in international scientific and legal literature. The description of equidistance, simplified or modified equidistance, half- or partial-effect, bisectors, equi-ratio, parallel and meridian, and enclave methods for the delimitation of international maritime boundaries in the exclusive economic zone and the continental shelf in order to achieve an equitable solution are beyond the space and scope allocated to this essay. In particular, key elements of the modern methodology established by the International Court of Justice, the International Tribunal for the Law of the Sea, and other tribunals in case law, are important. However, a number of objective and subjective factors, which underlie this methodology, remain to be discussed and clarified.

As a corollary to this section, it will suffice to quote Alexander in order to gain an appreciation of the enormous progress and advancement made in the introduction of science and technology in the delimitation of maritime spaces and the ability to develop and present perceptual information to courts and tribunals since 1985:

> The third point is that we had with us at The Hague what I felt was a spectacular display of specially prepared maps, illustrating graphically the injustice which would be wrought on the people of Guinea, should the Court rule in favor of Guinea-Bissau’s boundary claim. Many of the maps were transparent overlays and I personally believe that our cartographic materials, some of which we managed to leave on display even after our

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14 For example, C. Lathrop, ed., *International Maritime Boundaries*, Vol. 1–vii (Brill Nijhoff and the American Society of International Law).

15 For example, United Nations, *supra* note 2.

16 Various decisions from these tribunals propose a three-step methodology to implement the equitable principles/relevant circumstances approach for delimiting the exclusive economic zone and the continental shelf: (i) draw provisional delimitation line; (ii) consider whether the line should be adjusted by the consideration of relevant circumstances; and (iii) apply a proportionality test.
presentations, may have helped our cause considerably. Guinea-Bissau, I might note, had no special maps whatever.\textsuperscript{17}

The Impact of New Technologies on Ocean Boundary-making

Developments in data gathering and processing technologies have in turn significantly impacted the development and application of methodologies for the delimitation of maritime spaces. For example, the availability of global navigation satellite systems (GNSS) in geodesy, multi-beam echo-sounding, and light detection and ranging (LIDAR) in coastal hydrography, satellite imagery and remote sensing designed to detect and classify vast amounts of information in cartography, and marine, land, air, and space techniques in geophysics, provide high-quality data in volumes unprecedented in the history of science.

Modern GNSS in geodesy such as global positioning systems (GPS)\textsuperscript{18} and its augmentation systems, the Russian Global Navigation Satellite System (GLONASS),\textsuperscript{19} and the soon to be operational Galileo\textsuperscript{20} and BeiDou-2\textsuperscript{21} systems, allow not only for highly accurate positioning of baselines from which the breadth of the territorial sea is measured, but also monitoring of changes over time. These positioning systems provide worldwide kinematic positioning of vessels at sea and their spatial relationships with respect to outer limits and international maritime boundaries. Further, they are accurate enough to describe the attitude (heave, roll, and pitch rotations) and deformations of vessels in real-time.

The challenges posed by the need to process and derive useful information from large amounts of high-quality data have, in turn, been met by exponential developments in computer hardware and software technologies. While the availability of geographic information systems and large database storage architectures\textsuperscript{22} have become standard tools for technical experts, specialized

\textsuperscript{17} L.M. Alexander, “Guinea/Guinea-Bissau Case Study: Maritime Boundary Maps,” in \textit{The Continental Shelf: Resources, Boundaries and Management}, eds., T.A. Grigalunas and L.C. Hanson (Kingston, RI: COMS, URI, 1986), 74.

\textsuperscript{18} See, “GPS Advanced Control Segment (OCX),” Los Angeles Air Force Base (25 October 2011), http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/343736/gps-advanced-control-segment-ocx/.

\textsuperscript{19} See GLONASS website, https://www.glonass-iac.ru/en/.

\textsuperscript{20} See “Galileo Status: Fact Sheet,” European Space Agency (last updated July 2017), https://esamultimedia.esa.int/docs/galileo/GalileoFactsheet2017.pdf.

\textsuperscript{21} See “China will make BeiDou Navigation Satellite System available to global users by 2020,” Next Big Future (28 June 2016), https://www.nextbigruture.com/2016/06/china-will-make-beidou-navigation.html.

\textsuperscript{22} Multi-user relational geodatabases of unlimited size.
software has also been developed to address specific needs in the delimitation of maritime spaces. Some of these maritime delimitation software products are available as commercial products. The ability to process big data is now, for example, explored as a user-behavior analytics tool in various applications relating to worldwide legal and illegal fisheries monitoring.

Important advances in the production and visualization of large digital elevation models, large amounts of high- and super-resolution air and satellite imagery, and digital charts and maps have been achieved over the last two decades. Multi-media technologies used to display such information are part of the current practice in international maritime boundary diplomatic negotiations and any other third-party intervention dispute settlement processes, including the preparation of materials in judicial processes, particularly oral hearings. These technologies have become evident in the preparation of submissions to the CLCS and presentations that states make in the process of their consideration.

Special mention must be made of the nautical technology that makes use of all national maritime limits and international maritime boundaries for modern marine navigation purposes: the Electronic Chart Display and Information System (ECDIS). ECDIS is an operational navigation display, an interpreter of sensors, and a source of real-time information designed for route planning, positioning, and collision and grounding avoidance. It is an important tool in maritime transportation, marine natural resources exploration and exploitation, and the enforcement of maritime boundaries and limits. New standards for the depiction and deposit of limits of maritime spaces and maritime boundaries in digital format are currently being developed.

The development of these new technologies interact with the process of delimiting maritime spaces in a symbiotic manner: Technology provides indispensable information for the determination of outer limits and international boundaries. In turn, new technologies may impose requirements on the methodology employed in the delimitation of international maritime spaces.

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23 Volumes of data so large and complex that are impossible to process with common hardware and software tools.
24 See, for example, the Global Fishing Watch website, http://globalfishingwatch.org/.
25 W.B.F. Ryan et al., “Global Multi-Resolution Topography Synthesis,” Geochemistry, Geophysics, Geosystems 10, no. 3 (2009), doi.org/10.1029/2008GC002332.
26 The International Hydrographic Organization maintains a set of standards related to ECDIS in the form of Special Publications, see their website at http://iho.int.
27 See “Main Page (S-121),” International Hydrographic Organization (last updated 16 March 2018), http://www.s-121.com/w/index.php/Main_Page.