REDUCING CONTENTIOUS ISSUES OF BASELINES AND MARITIME LIMITS THROUGH THE USE OF AN INTERNATIONAL DATA STANDARD FOR THE SUBMISSION OF LAW OF THE SEA DATA

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Abstract:
This paper highlights new technical developments which can reduce the difficulties coastal States experience in interpreting articles 16, 47.8, 47.9, 75 and 84 of UNCLOS for submission of their territorial sea or archipelagic baseline models and maritime limits. All of these articles relate to the submission of this data in the form of nautical charts or as series of points. The use of nautical charts can introduce variable interpretation in the process, especially in the case of normal baselines, which may lead to contention. A standard digital format to exchange national baselines and maritime limits could help reduce uncertainties, potential disputes as well as improve law of the sea (LOS) data management.

Work on establishing an international standard for exchange of LOS data is under way as an extension first to the existing IHO S-57 standard, and then to its successor, the S-100 standard. This is perceived as a step in the right direction for more clearly defined national baselines and maritime limits. New law of the sea objects with new mandatory legal and technical attributes can become part of extended S-57 catalogues. Existing geospatial database software that can manage electronic chart data using these same IHO standards can then easily provide supporting tools for geodetic calculation and maintenance of LOS data such as territorial sea baseline models, maritime limits and international boundaries.

1. Introduction:

Law of the sea (LOS) data covers a large spectrum of legal maritime geographical data, such as: territorial sea baselines, maritime limits delineating the Territorial Sea, the Contiguous Zone, the Exclusive Economic Zone or the Outer Limit of the Continental Shelf, as well as boundaries between countries where these different maritime zones overlap and meet[1]. The delineation of some of these maritime limits and boundaries (MLB) has a long history that predates the present United Nations Convention on the Law Of the Sea (UNCLOS). It is therefore not surprising that in spite of recent advances in GPS surveying, GIS and geospatial software, the delineation or delimitation of many of these limits and boundaries are still deeply affected by surveying methods, treaties and nautical charts from the past. Although newer technologies, GIS, geospatial software and advances in hydrographic surveying allow a reduction of the uncertainties in the definition and display of LOS data, there is still a lot of potential for contentious issues. This paper describes the foreseen benefits of the use of an extension to the existing IHO S-57 data exchange standard for support of law of the sea data that can then be managed within geospatial software. This standardization of LOS data along with supporting geodetic geospatial tools can help reduce sources of uncertainty and contention as well as make this data more readily available to marine users.

2. Lists of points and uncertainties:

The Territorial Sea Baseline (TSB) model is an essential component in the delineation or delimitation of maritime limits and boundaries. It's two components, the normal baseline points and the straight baselines are usually extracted from official nautical charts. Normal baseline points are associated with the low water line coinciding with the vertical datum of these charts. Straight baselines are used to preserve the natural trend of the coastline and may use capes and headlands as well as fringing islands. The straight baselines are technically described as either loxodromes or geodesics that can be used for example to close legal Bays and mouths of rivers, or define archipelagic baselines enclosing islands forming an archipelago. Murphy et al (1999)[2] note the discrepancy between the technical requirements of the legislation on TSB and the actual reality:

> "An examination of straight, closing and archipelagic baseline legislation promulgated by coastal States will reveal that the definition of the geometric properties of straight lines is very much the exception rather than the rule. In the great majority of cases, the legislation simply refers to straight lines joining named coastal features defined by geographical coordinates, or by lines joining points on the normal baseline defined by geographical coordinates, or by a combination of both of these methods."

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[1] United Nations (1983) - The Law of the Sea, United Nations Convention on the Law of the Sea (UNCLOS).

[2] Murphy, Brian, P. Collier, D. Mitchell and W. Hirst,- Maritime Zone Boundary Generation from Straight Baselines as Geodesics.- in Proceedings of the International Conference on Technical Aspects of Maritime Boundary Delineation and Delimitation. Monaco, 9-10 September, 1999.

Pratt (2007)[3], also supports this statement in the case of boundary agreements, "*nearly a third do not define the nature of the line segments*". Both of these practices lead to uncertainties and potential causes of contention.

Another serious matter, related to datum, was mentioned by Pratt (2007)[3] concerning boundary delimitation. According to him, *"nearly half of all boundary agreements to date fail to specify a reference datum"***.**

Articles 16, 47.8, 47.9, 75 and 84 refer to the submission of baselines, territorial sea, exclusive economic zone and outer limit of the continental shelf. All of these contain two common statements:

1. The [legal baseline, limit or boundary being delimited] shall be shown on charts of a scale or scales adequate for ascertaining their position. Alternatively, a list of geographical coordinates of points, specifying the geodetic datum, may be substituted.
2. The coastal State shall give due publicity to such charts or lists of geographical coordinates and shall deposit a copy of each such chart or list with the Secretary-General of the United Nations.

As described in these Articles, the present media for depositing, submitting and depicting TSB models, sovereign maritime limits and boundaries under the United Nations Convention for the Law Of the Sea (UNCLOS) are either nautical charts updated with TSB information and/or MLB or lists of points of these. More information would be needed to better describe the legal and technical attributes of this data and make it more readily useful. These attributes are discussed in a later section of this paper.

3. Nautical Charts and Sources of Uncertainties

As stated in TALOS ed. 4.0[4], "*in almost all countries at present, the nautical chart is the only type of chart (or map) which 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*"

Nautical charts have several associated properties that are normally meant to resolve, yet sometime lead to uncertainty and then to contention. One of these properties is the horizontal datum. The theoretical model of the earth as an ellipsoid used for nautical charts often includes different parameters used regionally to best fit the shape of the earth. In order to accurately transfer geographic coordinates between these different datums, these coordinates must be properly transformed. Failure to do so may cause a

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[3] Pratt, M.- Maritime Boundary Delimitation; in: Lines in the Sea, Hydro International, V.11, no. 4, April 2007.
http://www.hydro-international.com/issues/articles/id772-Lines_in_the_Sea.html downloaded in July 2009

[4] ABLOS**.-** A manual on the technical aspects of the United Nations Convention on the Law of the Sea - 1982. IHO Special Publication 51, 4th edition, 2006. Published by the International Hydrographic Bureau, Monaco.

geodetic displacement of the latitudes and longitudes by values of the order of up to 200 to 400 m (e.g. NAD27 to WGS84).

In areas where the TSB is ambulatory, the frequency of update of charts may affect the data available for baseline definition[5]. Two countries may also use different charts from different charting agencies that they recognize as official. These charts will have various scales and although a large enough scale is required, this may be restricted by the availability of the charts. There may be areas that are crucial for a national baseline definition that are only covered by small scale charts. The baseline's point resolution will vary with the line thickness from each paper chart according to its scale.

Examples of some of the contentious issues associated with nautical charts count delimitation of maritime boundaries from charts with unknown datum such as in the Cameroon vs Nigeria ICJ judgment. As mentioned by Pratt (2007)[6], uncertainties associated with such a boundary delimitation creates additional complexity for future use of this maritime space.

Another recent example of datum uncertainty was found in the revision of the 1973 Indonesia-Singapore maritime boundary treaty where the boundary was based on two charts, one from the British Admiralty and a Japanese one pre-dating the reclamation project[7]. In this case, the geographic points from the treaty established on charts with non-WGS datum had to be reconciled with the operational navigation use of GPS on the WGS84 datum in the straights between the two countries. Initial analysis showed discrepancies of the order of 200 m with a more recent chart from 2005 on the WGS84 datum. A multi-disciplinary team of experts had to be consulted to resolve satisfactorily the uncertainty of the geographic coordinates of the treaty[7].

Since the WGS84 datum is recommended by the IHO for use in nautical charts and since most modern GPS positioning equipment function by default on this datum, its use is viewed as a means of reducing the uncertainty in LOS data. Sets of archipelagic baseline points were deposited with the Secretary General of the United Nations on this datum by Indonesia, the Philippines and Trinidad and Tobago. Trinidad and Tobago had previously deposited their archipelagic baselines on a regional datum[8] but re-deposited them on WGS84 in 2004[9]. In the case of the extension of the continental shelf under article 76 of UNCLOS, the Scientific Guidelines of the CLCS designate WGS84 and its equivalent

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[5] Hirst, W. and D. Robertson,- GIS, Charts and UNCLOS – Can they live Together, in: Proceedings from ABLOS 2003.

[6] See footnote 3 above.

[7] F.Adm Sugeng Supriyanto, Capt. Trismadi, LC, dr. Muhammad Yazid and Leut. M. Qisthi A..- Geodetic and chart datum problem arising from the map annexure of the maritime boundary treaties in non-WGS datum (Lesson learned from Indonesia –Singapore case), in: Proceedings of the International Seminar on the Technical Aspects of the Law Of the Sea: *Problems and Challenges with Maritime Boundary Delimitation and the Role of Geospatial Data in UNCLOS*, Nusa Dua, Bali, Indonesia , 3-5 August, 2009.

[8] United Nations, LOS Legislation and treaties.-Archipelagic Baselines of Trinidad and Tobago Order, 1988, Notice no 206 of 31 October 1988
http://www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/TTO_1988_Order.pdf

[9] United Nations, DOALOS.- Law of the Sea Bulletin, No 55, p. 29-30.

datum ITRF94 as requirements in the submission of claims. The need to remove as much uncertainty from these data as possible is leading DOALOS towards requiring submitted and deposited coordinates on the WGS84 datum[10].

In this perspective, the use of a WGS84-based standard international digital format able to provide the nautical chart elements required by LOS practitioners and the necessary LOS data attributed with the proper legal information would help reduce contention associated with uncertainty. The IHO's S-57 ENC exchange format does fulfill many of these requirements and is already in operational use worldwide.

4. S-57 and LOS standard

The IHO S-57 exchange standard was developed first to support Electronic Navigational Charts which once integrated with navigation systems in ship-borne ECDIS (Electronic Chart Display and Information System) improve the safety of navigation. The S-57 standard was designed to apply to more digital marine products than just the S-57 ENC, however. Recent expansions to the S-57 standard have been done in the form of MIOs (Marine Information Overlays). These cover different marine domains such as Sea Ice Coverage and Marine Protected Areas. As Maritime limits and boundaries are often associated with possible fishing and marine policing incidents, they would seem a likely addition to the data described as S-57 objects.

Based on recommendations from ABLOS and IHO, an ENC can be considered as a valid nautical chart [11]. The Netherlands Navy has taken this a step further and can produce updates to its normal territorial sea baseline from recent editions of its national S-57 ENCs[12]. Interpreting Articles 16, 47.8, 47.9, 75 and 84 of UNCLOS along these lines would make feasible a deposition or submission of law of the sea data as part of an official ENC on the condition that the S-57 standard could provide appropriate object and attribute support for this field of application.

The IHO's S-57 standard offers several advantages for a LOS extension. In addition to a single reference geodetic datum, WGS84, data is stored as decimal latitudes and longitudes which renders the information independent from map projections. As the format is used worldwide to transfer ENC information in vector format, it provides the coastline and low water line data relevant to the delimitation of the TSB model. The horizontal data resolution maintained for geographic coordinates in this format ensures that data from a large range of scale bands used in nautical charts are supported within

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[10] United Nations (1999). *Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf*, from the Fifth Session of the Commission on the Limits of the Continental Shelf (CLCS), New York May 13-14, 65 p.

[11] ABLOS, Section 3.2 of "A manual on the technical aspects of the United Nations Convention on the Law of the Sea – 1982". IHO Special Publication 51, 4th edition, 2006. Published by the International Hydrographic Bureau, Monaco.

[12] Dorst , L and I Elema,- *THE EFFECTS OF CHANGING BASELINES ON THE LIMITS OF THE NETHERLANDS IN THE NORTH SEA*.- Proceedings from ABLOS 2008 scientific conference, October 2008.

1.5 cm on the ground or 1x 10^{-7} degrees on the ellipsoid (which corresponds roughly to a paper chart scale of 1:300).

Work is under way to make a LOS addition to the S-100 standard (Universal Hydrographic Data Model) which will eventually replace the S-57 standard for ENCs. The United Nations' DOALOS has been tasked by the IHO with developing specifications for an S-100 compliant product for the Law of the Sea. TSMAD is assisting DOALOS in this endeavour. DOALOS attended the first meeting of the IHO Hydrographic Services and Standards Committee (HSSC) in Singapore, 22-24 October 2009.[13] This meeting was an important landmark in the establishment of the S-100 standard since its final text was approved. DOALOS is now listed as one of the users of the S-100 standard[14].

From the assumption that LOS objects could transition through an S-57 stage before becoming part of the S-100 standard, CARIS developed a tentative LOS catalogue as part of a pilot project with the UKHO LOS division. This required several additions compared to what is present in the S-57 standard.

5. Limitations of the S-57 Standard w.r.t. Law of the Sea

The present S-57 standard is limiting when the use of LOS objects is concerned. Only a few LOS related objects already exist in the S-57 ENC standard[15]. These objects are enumerated below and sorted by their data type.

- Line
  - STSLNE : Straight Territorial Sea Baseline
- Area
  - ADMARE: Administration Area
  - TESARE : Territorial Sea Area (Territorial Sea Baseline to 12 M)
  - CONZNE : Contiguous Zone (12 M to 24 M)
  - EXZNE : Exclusive Economic Zone (12 M to 200 M)
  - FSHZNE: Fishery Zone (variable, many countries use 200 M)
  - COSARE: Continental Shelf Area (12 M to Outer Limit of the CS)

These objects are used for representation of maritime limits and zones on an S-57 ENC. Most of these are however, only available as areas. The geodetic tools that generate the maritime limits and boundaries will generate lines. In order to easily maintain these legal limits and boundaries, they should be created as lines in the geospatial software.

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[13] IHO Circular Letters, CL04, 2010). Downloaded on Aug, 20, 2010 http://www.iho-ohi.net/mtg_docs/circular_letters/english/2010/Cl04e.pdf

[14] Ward, Robert, *IHO S-100, 21st century Framework Data Standard for Hydrographic and Related Data*- Session 3 - Interoperability and Standards in Marine Data Management, International Conference on Marine Data and Information Systems, Paris, 2010 http://wwz.ifremer.fr/imdis2010/content/download/69490/487549/version/1/file/IMDIS2010_oral3_05_Ward.pdf)

[15] Note that there are some overlaps between the S-57 ENC 3.1 standard and the AML standard for LOS objects. An effort at consolidating these definitions and objects may be required in the future.

Even in the case of the existing line object for straight territorial sea baselines (STSLNE), additional attributes are required to better qualify and track the information. Since the LOS objects are not part of the S-57 standard, a new reworked object, "strbln", was added to the catalogue to support the new definition of a straight baseline without interfering with the standard.

New proposed line-type LOS objects targeted by an extended catalogue:

- Normal baseline (territorial sea baseline model)
- Straight baselines (territorial sea baseline model)
- Maritime limits: 12M (Territorial Sea), 24M (Contiguous Zone), 200M (EEZ), Outer Limit of the Continental Shelf and other relevant limits
- Maritime boundaries
- Article 76 components: Formulae and Constraints

It is important to note that although straight TSBs or new maritime limits and boundaries are often published as a series of turning points, their true representation on a chart will be shown by lines that are either geodesics, loxodromes or envelope of arcs. The nature of the line should be maintained as part of the data. One possibility for this will be mentioned in a later section of this paper.

New proposed point objects would carry their own identification and legal information as per claims, legislations, judgments or awards.

- Baseline points
- Maritime Boundary points
- Maritime Limits points
- Foot of the slope markers
- Sediment 1% markers
- Outer continental shelf points

New proposed area objects would include marine areas not presently covered by S-57 ENC objects[16] :

- Marine areas: Joint development areas, marine sanctuaries, environment protected areas, joint fishing zones, …
- Internal waters

Lévesque et al (2009)[17] indicated that the new LOS objects must be supported by new attributes to characterize their legal and temporal aspects. Some proposed attributes are listed below.

[16] Some of these areas are covered by MIO features.

[17] Lévesque, S., S. Cockburn and O. Büchsenschütz-Nothdurft.- SOFTWARE FOR DELINEATION AND MANAGEMENT OF MARITIME BOUNDARIES – POST MAY 13, 2009 CHALLENGES,- in: Proceedings of the International Seminar on the Technical Aspects of the Law Of the Sea: Problems and Challenges with Maritime Boundary Delimitation and the Role of Geospatial Data in UNCLOS, Nusa Dua, Bali, Indonesia , 3-5 August, 2009

- Categories of limits and boundaries
- Data source
- Legal source
- Legal status
- Date of change in legal status
- National ownership or neighbours sharing the limit or boundary
- Source document, associated legal documents or reports
- Nautical chart reference
- Date of publication or entry into force
- Dependence on other features in the database

The S-57 compatible LOS catalogue created by CARIS currently counts 30 new objects and 35 new attributes to use for law of the sea. Access to this catalogue as an internet resource (see Figure 1) was provided to DOALOS to assist them in their endeavour with the S-100 product specification for law of the sea.

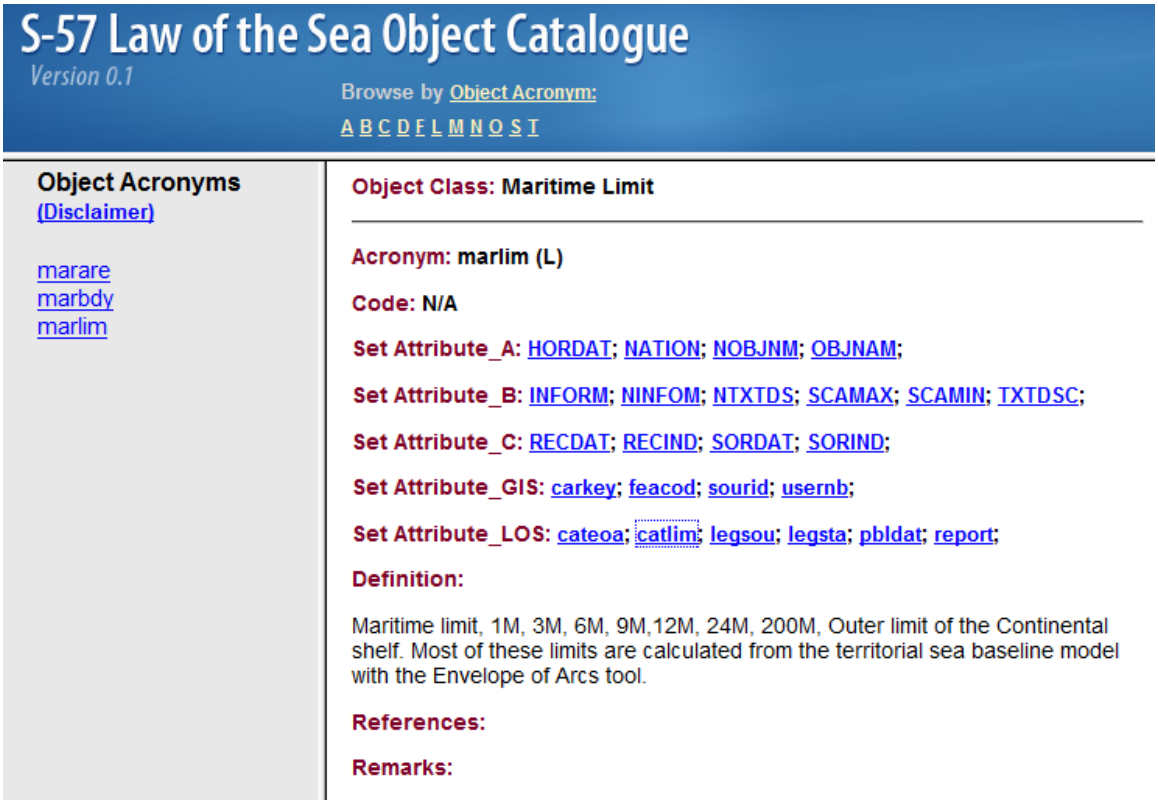
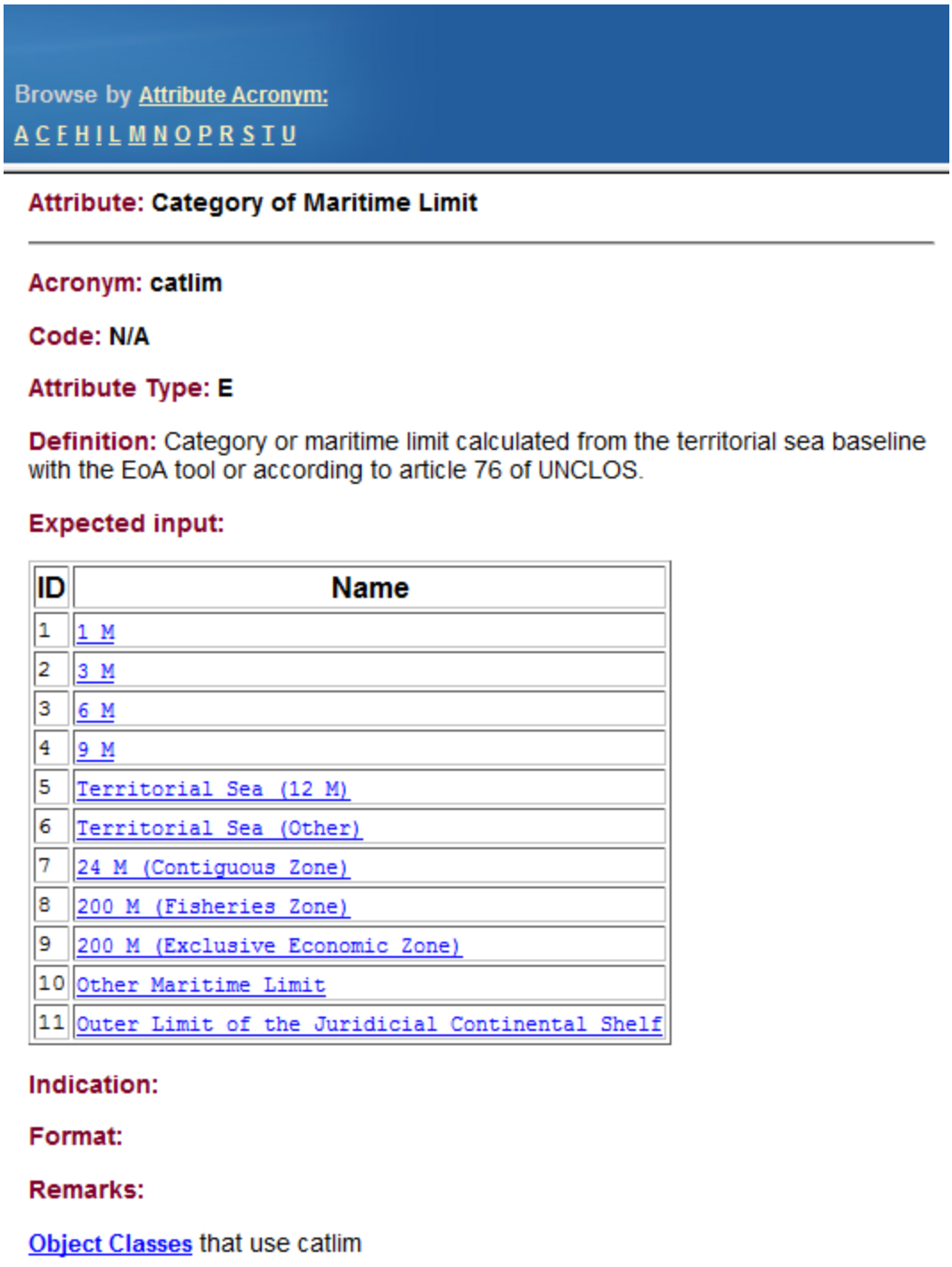


Figure 1: S-57 LOS catalogue CARIS resource: marlim object



Browse by Attribute Acronym:

A C F H I L M N O P R S T U

Attribute: Category of Maritime Limit

Acronym: catlim

Code: N/A

Attribute Type: E

Definition: Category or maritime limit calculated from the territorial sea baseline with the EoA tool or according to article 76 of UNCLOS.

Expected input:

ID	Name
1	1 M
2	3 M
3	6 M
4	9 M
5	Territorial Sea (12 M)
6	Territorial Sea (Other)
7	24 M (Contiguous Zone)
8	200 M (Fisheries Zone)
9	200 M (Exclusive Economic Zone)
10	Other Maritime Limit
11	Outer Limit of the Juridicial Continental Shelf

Indication:

Format:

Remarks:

Object Classes that use catlim

Figure 2: S-57 LOS catalogue CARIS resource: catlim attribute

The use of the LOS catalogue as part of a geospatial database was foreseen as a solution to reducing the volume of file-based GIS data with various horizontal resolutions accumulated through the years from desktop LOS applications and other GIS software. Regrouping this data as part of a seamless S-57 compatible geospatial database reduces

duplication and provides concurrent access to source TSB vector data used in nautical charting and other hydrographic products.

6. Geospatial software and database

To use efficiently LOS data in such a standard format as S-57, the geospatial software and database of choice need to support this format and provide the geodetic tools necessary to maintain the data and create maritime limits and boundaries from the TSB model. A database with an S-57 compatible data model is recommended to facilitate the management of this LOS data.

Advantages of this database approach were given in Lévesque et al (2009)[18] but will be repeated and expanded here:

- Compliance with OGC standards
- Native support of state of the art data models (S57/VPF)
- Future support of S-100 standard as it matures[19].
- An expandable catalogue of objects and attributes to include relevant LOS objects that are easily maintainable and updatable.
- Maintenance of the TSB directly from source hydrographic data used to produce nautical charts and other navigation products.
- A set of geodetic tools to generate LOS limits and boundary objects from validated TSB data.
- Catalogue-independent tools (catalogues can be changed without affecting the geodetic tools)
- Increase in speed when updating official nautical charts or other nautical products of a coastal State with up-to-date maritime limits and boundaries
- History tracking of changes made to maritime limits and boundary data on an object by object basis.
- Flexible rules mapping import allowing loading of existing data into the proper objects with appropriate attributes.

With the expert advice of the UKHO LOS division, a pilot project was begun in 2007 to demonstrate the feasibility of using the CARIS HPD software to manage LOS data using the S-57 data model. This concept and the initial results from this pilot project were introduced by Lévesque, Cockburn and McLeay (2008)[20]. The support of LOS data in a hydrographic production database and its potential application to marine cadastre were shown. Once imported in the database, the data is stored as decimal latitudes and longitudes on the WGS84 datum thus addressing one of the factors creating uncertainty in the process of depositing or submitting LOS limits and boundary data. Because the coastline and low water line source data needed to produce the TSB is stored once in the hydrographic production database at the best resolution possible, the maintenance of the

[18] See footnote 17 above.
[19] International Hydrographic Organisation, "*S-100 IHO Geospatial Standard For Hydrographic Data - Draft*", January 2008
[20] Lévesque, S, S. Cockburn and C. McLeay.-Modern developments in geospatial management in the field of marine cadastre, ABLOS 2008, Monaco, October 2008

TSB model can be simplified and become synchronized with the chart update process. The LOS data associated with maritime limits and boundaries can now coexist in digital form with its source data without being limited to the area of a small scale chart that shows all the extent of the national limits and boundaries, but causes a reduction in accuracy of the positioning of the baseline data. Within the database, the straight baseline data can be stored attributed with the proper line-type: loxodrome, geodesic or planimetric line. This line-type is a technical description of the line segment and will affect the display representation of the line defined by its turning points, how it intersects with other features and how it can be sub-sampled.

As mentioned in an earlier section, new objects and attributes are required in the catalogue to better represent the LOS data in a geospatial database. The data coming from file-based law of the sea software and GIS sources will often have a large range of different attributions and information. The migration of this data into a geospatial database using an S-57 compatible data model becomes a data mapping and structuring exercise.

For maintenance of this data within the database, Maritime Limits and Boundary (MLB) calculation tools are being added to the CARIS HPD Source Editor software. These tools were originally found in the CARIS LOTS software[21]. Their migration to a database application will provide the following geodetic MLB tools:

- Equidistant/Median Line
- Envelope of Arcs from normal baseline points
- Envelope of Arcs from straight baselines
- Wagon Wheel Filter
- Interactive Baseline Digitizing
- Legal Bay Closing evaluation tool
- Geodetic line intersection

Future development will address the inclusion of database tools to create, support and analyze law of the sea data related to Article 76 of UNCLOS

7. Conclusions

This paper uses an S-57 compatible catalogue for law of the sea developed independently as a proof of concept. It emphasizes that the use of a standard format for LOS data requires expansions to existing S-57 (or S-100) data catalogues for both new objects and new attributes. Efforts in developing definite specifications for the international standard format are already under way, spearheaded by IHO and DOALOS.

[21] Cárdenas J. A. P. and S. Lévesque (2008), "Marine geospatial software: Generating Economic Benefits from Hydrographic Data and Calculation of Maritime Boundaries." In *The Journal of Ocean Technology, Ocean Sovereignty*, Vol. 3, No. 1, 2008

The use of an international standard vector data format for depositing or submitting law of the sea baselines, limits and boundary data with the Secretary General of the United Nations would potentially make it easier for DOALOS to manage this data. For international maritime boundaries court cases, the exchange of data between technical experts would also be simplified.

The use of geospatial database software supporting an S-57 compatible (or S-100) data model is seen as a very good solution to optimally use this standardized LOS data. All possibilities of error are not prevented, but this approach should reduce their incidence and promote the maintenance of this type of data in a geospatial database. This solution, as well as the growing acceptance of ENCs as legal alternates to officially recognized paper nautical charts[22], is perceived as a means of reducing contentious issues related to Articles 16, 47.8, 47.9, 75 and 84 of UNCLOS.

The combination of LOS data inclusion in ENCs and the coexistence of hydrographic and LOS data in geospatial databases used for the production of nautical charts must eventually lead to a greater availability of official maritime limits and boundary data to marine users who need it. The associated reduction of the uncertainty in these maritime limits and boundaries also makes them more readily useable by marine space stakeholders. The availability of database geodetic tools in COTS software will support and promote this worldwide increase in production, use and sharing of up-to-date LOS data.

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9. Biographies

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Cameron McLeay is an Senior Cartographic Consultant for CARIS USA in Alexandria, Virginia, USA. He started his hydrographic career at the New Zealand Hydrographic Office before joining CARIS Canada in 2003. His fields of expertise at CARIS are in electronic chart production and the development of related international standards. He is

[22] Note that by 2016 all ships must carry ENCs.

the Product Manager of CARIS's desktop electronic charting application, and also provides training and consulting for CARIS clients focused on chart production workflows and the development of speciality electronic products.

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