

MODERN DEVELOPMENTS IN GEOSPATIAL MANAGEMENT IN THE FIELD OF MARINE CADASTRE

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Abstract:

There is growing world-wide use of modern geospatial software to calculate maritime limits and boundaries both as part of work on the Article 76 of UNCLOS and for maintenance or delimitation of other limits. In the very dynamic and rapidly changing coastal environment, the territorial sea baseline model will evolve and thus impact dependent maritime limits. Juridical maritime limits and boundaries also play an important role in marine cadastres, defining the Sovereign rights and responsibilities in the territories they delimit. It is therefore essential that they be updated and managed efficiently in order to affect marine cadastres appropriately.

Since new baseline models, maritime limits and boundaries must typically be published before they become official, it is a common practice to incorporate them in official nautical charts. In a common hydrographic production database environment, where they can be easily combined with hydrographic data, they become available and traceable for effective management. The resulting integration with recent and relevant marine information about the coastline, shipping lanes, marine protected areas and territorial sea baselines also allows fast updating of relevant nautical charts.

The use of a hydrographic production database offers interesting advantages in the management and updating of marine boundaries. The transfer of existing geospatial maritime limits and boundaries data to a hydrographic database environment does require that a compatible data model be adopted. One international standard, S-57, offers distinct benefits to marine data managers. For instance, new custom object and attribute acronyms may be added to allow better flexibility and management of legal maritime data. For variants on marine cadastre applications, the catalog of object and attribute acronyms can also be expanded.

This paper examines the possibilities of a hydrographic production database solution to allow more effective management of maritime limits and boundaries.

1. Introduction

In the field of marine cadastres, maritime boundaries and limits play a crucial role in delimiting the rights and responsibilities of the sovereign state as well as those of different levels of government: federal, state/province or municipal, for example. Maritime boundaries may also outline extents of individual or group rights – i.e., the use, exploitation and management of the maritime space is also shared by different user communities and stakeholders whose rights must be considered, weighed, adjudicated and preserved.

A clear representation of a border, legal boundary or limit is difficult without a map or chart to display it clearly. By providing easy-to-use tools and geographic visualization of this type of data, modern geospatial software and GIS tools can enhance the efficiency of maritime boundary delimitation¹. Long time geospatial software² users have accumulated large archives of maritime boundary and limits data. This data may reside in data files with different datums, different projections or different resolutions. These files may also follow the extent of existing nautical charts and thus have overlapping redundant information that needs to be kept up-to-date, doubling the work where redundancies occur. The desktop GIS software approach, despite its efficiency, is confronted with limitations that make the management of a large number of digital maritime limits and boundaries a serious challenge.

The technology available to acquire geo-referenced datasets keeps pace with the evolution of geospatial software. The world is also rapidly going digital with massive volumes of geospatial data generated each year. These developments call for a database solution that can handle geographic data while allowing geographic display. As mentioned above, in the case of maritime limits and boundaries, the marine sector is not spared in this need for better data management tools but has some specific requirements due to the 3- or 4-dimensional nature of rights in the water column and sub-surface, and the lack of physical boundary markers over the possible in the ocean and seas. A modern geospatial technology, known as a hydrographic production database, addresses some of these special needs and offers increased value for marine cadastre managers.

¹ Gent R. (2001). "The use of GIS in the Law of the Sea" In *Proceedings of the Advisory Board on the Law of the Sea to the International Hydrographic Organization (ABLOS) Conference "Accuracies and Uncertainties in Maritime Boundaries and Outer Limits."* Presented at the International Hydrographic Bureau, Monaco, October 2001.

² CARIS LOTS is one such software which was specifically developed to provide maritime limits and boundaries geodetic calculation tools complying with the United Nations Convention on the Law Of the Sea (UNCLOS). CARIS LOTS is a GIS-type desktop software that can be used to calculate and visualize the marine limits and boundaries thus allowing the illustration of problem areas and display of alternative scenarios. Since 1999, this software is being used by many countries for maritime limits and boundaries delineation work as well as for the delimitation of the outer continental shelf under Article 76 of UNCLOS.

2. Territorial Sea baseline management

2.1. Demarcation versus delineation

Whereas on land, the borders and cadastral areas can be indicated physically through the means of surveyed markers, monuments, walls and geographic features such as a river, mountain range or the crest line of watershed divides, in the marine environment, the means of demarcation are much more limited or not viable. Therefore, delimitation on charts or in a marine cadastre is the alternate means to make seafarers and others aware of maritime limits and boundaries.

2.2. The importance of the Territorial Sea baseline model in UNCLOS

In the case of UNCLOS, of course, one primary basis for the delimitation of maritime limits is the Territorial Sea baseline (TSB)³. The baseline model can be composed of several types of baselines. In the case of normal baselines, it can be drawn from the coastline depicted as the “low-water line along the coast as marked on large-scale charts officially recognized by the coastal State”⁴ and/or, in the case of Straight or Archipelagic baseline applications, where all other conditions set by UNCLOS are met, from “low-tide elevations, where lighthouses or similar installations which are permanently above sea level have been built on them”.⁵ Low tide elevations may also be used in some cases under Article 13 of UNCLOS for normal baseline creation. These are depicted by the vertical datum (or tide datum) on appropriate charts. Due to the increasingly dynamic coastal environment, some parts of this Territorial Sea baseline may be ambulatory over time.⁶

³“Territorial Sea Baseline refers to the line from which the seaward limits of ...Maritime Zones are measured” Geoscience Australia (2008). Retrieved from the World Wide Web September 8, 2008 <http://www.ga.gov.au/nmd/mapping/marbound/bndrs.jsp> Commonwealth of Australia 2008. See also Commission on the Limits of the Continental Shelf, Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf, CLCS 11, Adopted 13 May 1999. Retrieved from the World Wide Web September 11, 2008. http://www.un.org/Depts/los/clcs_new/documents/CLCS_11.htm

⁴ Article 5, 1982 LOS Convention opened for signature 10 December 1982, UN Doc. A/Conf. 62/122 reprinted in United Nations, Official Text of the United Nations Convention on the Law of the Sea with Annexes and Index (New York: UN Sales No. E83.V.5, 1983). This applies to “Normal Baselines” for information on “Straight Baselines” or “Archipelagic Baselines”, see Articles 7 and 47, respectively (same convention).

⁵ See Articles 7.4 and 47.4, 1982 LOS Convention opened for signature 10 December 1982, UN Doc. A/Conf. 62/122 reprinted in United Nations, Official Text of the United Nations Convention on the Law of the Sea with Annexes and Index (New York: UN Sales No. E83.V.5, 1983) for more specifics.

⁶ Caron, D. (2008) “Climate Change, Sea Level Rise And The Coming Uncertainty In Oceanic Boundaries: A Proposal To Avoid Conflict” In *Maritime Boundary Disputes, Settlement Processes, And The Law Of The Sea* (2008). Retrieved from the World Wide Web September 8, 2008 http://works.bepress.com/cgi/viewcontent.cgi?article=1038&context=david_caron

2.3. Ambulatory boundaries: an example of the need for baseline model maintenance

Considering global warming, increases in the occurrence of strong storms or hurricanes and sea level rise, which some predict will be as much as 95 cm by the year 2100⁷, it is expected that coastlines globally may change drastically in the coming years. As the coastline evolves, there may be a need to update its accurate representation on nautical charts with increasing frequency.

The changes in the territorial sea baseline models, of course, also have a direct impact on the limits and boundaries derived from them. An example was considered in the aftermath of a 2005 earthquake off Sumatra where a piece of uplifted continental basement became emergent thus potentially being viable for inclusion in the country's territorial sea baseline model, and possibly pushing Indonesia's maritime limits seaward.⁸ Changes such as these pose challenges for marine cadastre managers, who must update not only the changing limits themselves, but possibly their relationships to other delineated rights.

3. Marine Cadastre

There are several advantages of geospatial data management tools (such as a hydrographic production database) for marine cadastre management. If we examine a definition of marine cadastre used in Australia, for example: "In essence, the marine cadastre would aim to provide a means for delineating, managing and administering legally definable offshore boundaries and associated rights, restrictions and responsibilities."⁹ we note that many different types of marine boundaries may overlap one another in marine space. Updating these boundaries and limits is important to account for their potentially ambulatory nature, but when it comes to dispute resolution, it is equally important to maintain a historic, reproducible record of where boundaries and limits were at the time the dispute arose. To begin, it is important to examine the ways in which marine limits and boundaries have historically been handled in GIS software.¹⁰ Many maritime limits and boundaries have been calculated in standalone desktop software, which already offers several advantages.

⁷ Food and Agriculture Organization of the United Nations (1998). *FAO Guidelines: Integrated Coastal Area Management and Agriculture, Forestry and Fisheries*. Publishing Management Group, FAO Information Division, Rome.

⁸ O'Keefe, Brendan (2005). "Indonesia Gets Bigger –Sumatra Quake: The Aftermath" In *The Weekend Australian*, Ed. 1, P. 9, 02 April 2005

⁹ Binns, A., A. Rajabifard, P. Collier, And I. Williamson (2004). "Developing the Concept of a Marine Cadastre: An Australian Case Study", Retrieved from the World Wide Web September 10, 2008 [http://www.sli.unimelb.edu.au/maritime/publications/Binns%20et%20al%20\(2004\).pdf](http://www.sli.unimelb.edu.au/maritime/publications/Binns%20et%20al%20(2004).pdf)

¹⁰ In order to demonstrate some of the advantages of a hydrographic production database used in conjunction with desktop Law of the Sea GIS technology, the authors will reference work completed using CARIS LOTS and CARIS HPD. These technologies were chosen due to their easy availability, the much appreciated collaboration of outside experts using the technology, and their interoperability.

4. Advantages of standalone GIS packages in marine boundary and limit delineation

With the advent of UNCLOS in 1982¹¹, common definitions were established for the maritime boundaries and limits of ratifying nations. These definitions were scientifically based, or formulaic¹². The convention equally expressed the specific rights each limit contained, thus helping to define the extent of a coastal nation's potential sovereignty. It soon became apparent that the amplitude of tasks such as maritime boundary delineation or the definition of the outer limit of the continental shelf would benefit from well adapted geospatial software tools to calculate and maintain the new maritime limits. The use of such software reduces the length of time required in the production of these limits and boundaries significantly and makes the overall legal picture more easily understandable and communicable¹³. The use of geospatial software can therefore help coastal nations achieve the economic benefits associated with clearly defined maritime boundaries and limits faster than would otherwise be possible¹⁴. The studies described below both made use of CARIS LOTS to produce desktop studies of the areas in question.

5. The Arctic IBRU and UKHO Caribbean Examples: Accurate Representations as an Aid to Decision-Makers

The recently published IBRU map of the legal boundaries and disputed areas in the Arctic¹⁵ brings into focus the need to accurately calculate and represent the legal maritime limits and boundary data in a geographically referenced framework. This type of data is vital to professionals and experts in this field both for reference purposes and for guidance in decision making. By bringing all of this information into a common map, the exercise undertaken by IBRU cleared up many inaccuracies being circulated in the media and provided a new perspective on the international territorial issues that are being faced by Arctic nations.

¹¹ 1982 LOS Convention opened for signature 10 December 1982, UN Doc. A/Conf. 62/122 reprinted in United Nations, Official Text of the United Nations Convention on the Law of the Sea with Annexes and Index (New York: UN Sales No. E83.V.5, 1983).

¹² Cockburn, S., S. Nichols, and D. Monahan (2003). "UNCLOS' Potential Influence on a Marine Cadastre: Depth, Breadth, and Sovereign Rights." In Proceedings of the Advisory Board on the Law of the Sea to the International Hydrographic Organization (ABLOS) Conference "Addressing Difficult Issues in UNCLOS." Presented at the International Hydrographic Bureau, Monaco, October 2003.
<http://www.gmat.unsw.edu.au/ablos/ABLOS03Folder/PAPER1-1.PDF>

¹³ See footnote 1, above.

¹⁴ 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

¹⁵ IBRU (2008), "Map of maritime jurisdiction and boundaries in the Arctic region" published by the International Boundaries Research Unit, Durham University, August 2008:
<http://www.dur.ac.uk/ibru/resources/arctic>.

Law of the Sea software¹⁶ can be used to delimit the areas of extended continental shelf under Article 76 of UNCLOS as well as disputed areas. All of these new boundaries and limits need to be included and considered in the framework of a marine cadastre, because they show the limits of particular rights in the water column or the sea bed.

New boundary and limit data can be created and submitted using standalone geospatial software specially designed¹⁷ for accurate calculation of maritime limits and boundaries complying with UNCLOS. This software must be able to import and display data coming from different sources in different formats, to facilitate comparisons and allow the user easy access to the best source of data.

To go into more detail, we can examine an example data set from the Caribbean¹⁸ that is used by the UKHO Law of the Sea Division to display the published and calculated maritime boundaries and limits for this area. Many of the maritime boundaries and most of the maritime limits calculations require geodetic tools for an accurate representation independent from the map projection.

The CARIS LOTS envelope of arcs¹⁹ tool was used to calculate the following maritime limits from the territorial sea baseline (TSB) model: 3 M, 6 M, 12 M (territorial sea), 24 M (contiguous zone), and the 200 M (exclusive economic zone). All the salient points of the territorial sea baseline model were used to generate geodetic arcs at the desired geodetic distance. The outer envelope of these overlapping arcs formed the maritime limit of interest. Articles 5 and 7 of UNCLOS outline the two types of baselines that can be part of the territorial sea baseline model for non-archipelagic baselines: the normal baseline tied to low tide elevations (at a distance of not more than 12 M from the mainland or an island)²⁰ and the straight baseline. The general concept of the envelope of arcs tool is shown in the diagram below in the perspective of these two types of baselines:

¹⁶ CARIS LOTS was used in this case.

¹⁷ 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

¹⁸ The UKHO Law of the Sea Division has assembled a global dataset of maritime boundary and limits data. The Caribbean dataset presented in this paper is only a small portion of the data they have in their archives. This data is presented with their permission – please see Acknowledgement, below.

¹⁹ For more on this principle, see Shalowitz, A. L. "Shore and Sea Boundaries: with Special Reference to the Interpretation and Use of Coast and Geodetic Survey Data. Volume 1, Boundary Problems and the submerged Lands Acts, D.C. U.S. Department of Commerce, Coast and Geodetic Survey, pp. 171-172, 1962

²⁰ Article 13 of UNCLOS states: "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." 1982 LOS Convention opened for signature 10 December 1982, UN Doc. A/Conf. 62/122 reprinted in United Nations, Official Text of the United Nations Convention on the Law of the Sea with Annexes and Index (New York: UN Sales No. E83.V.5, 1983).

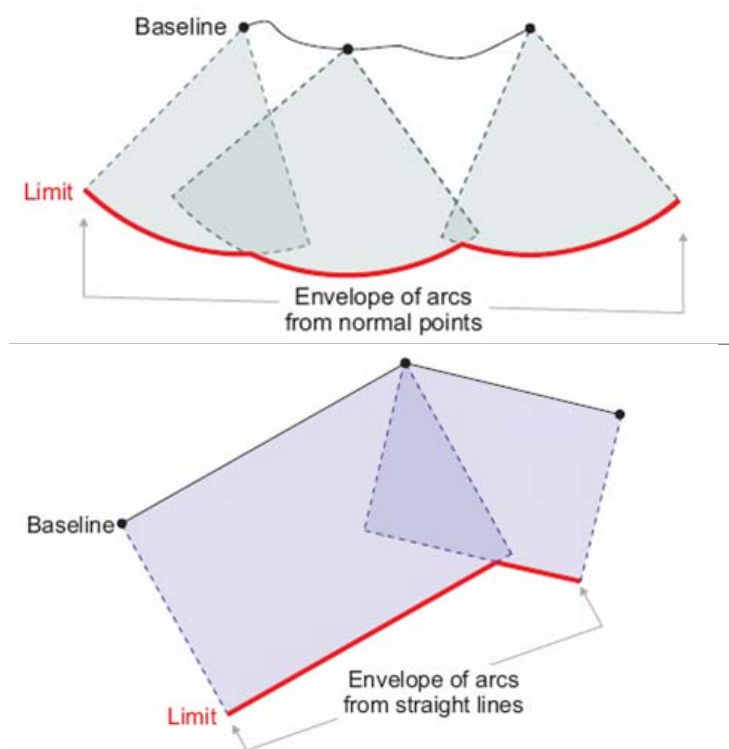


Figure 1: Diagram of the envelope of arcs calculated from a normal baseline and from a straight baseline. Two separate tools are needed to handle each separate case.

Another important geodetic tool for boundary delimitation is the median/equidistant line tool, which is often used as a starting point for negotiations of a fair bilateral boundary between two coastal or island States. In the case shown below a median line was calculated between Barbados and St-Lucia. The construction lines shown below link each of the points forming the median line to their contributing points on each Territorial Sea baseline.

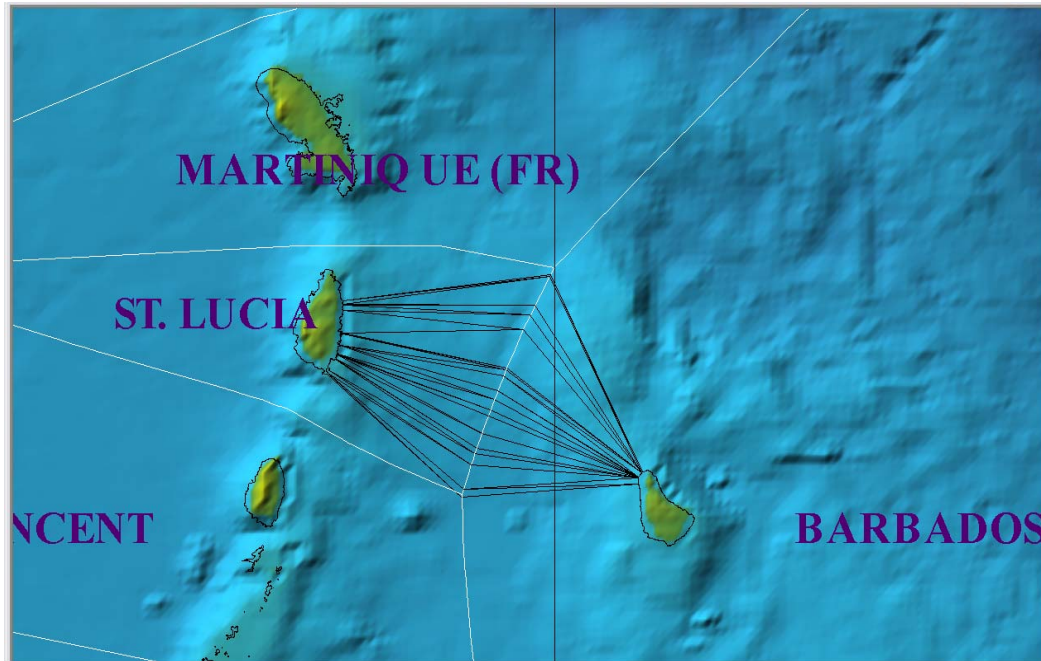


Figure 2: Median line calculation between Barbados and St Lucia. Construction lines are shown.

These tools and other geodetic functionality in CARIS LOTS were used by the UKHO in the production of boundaries and limits in the Caribbean.

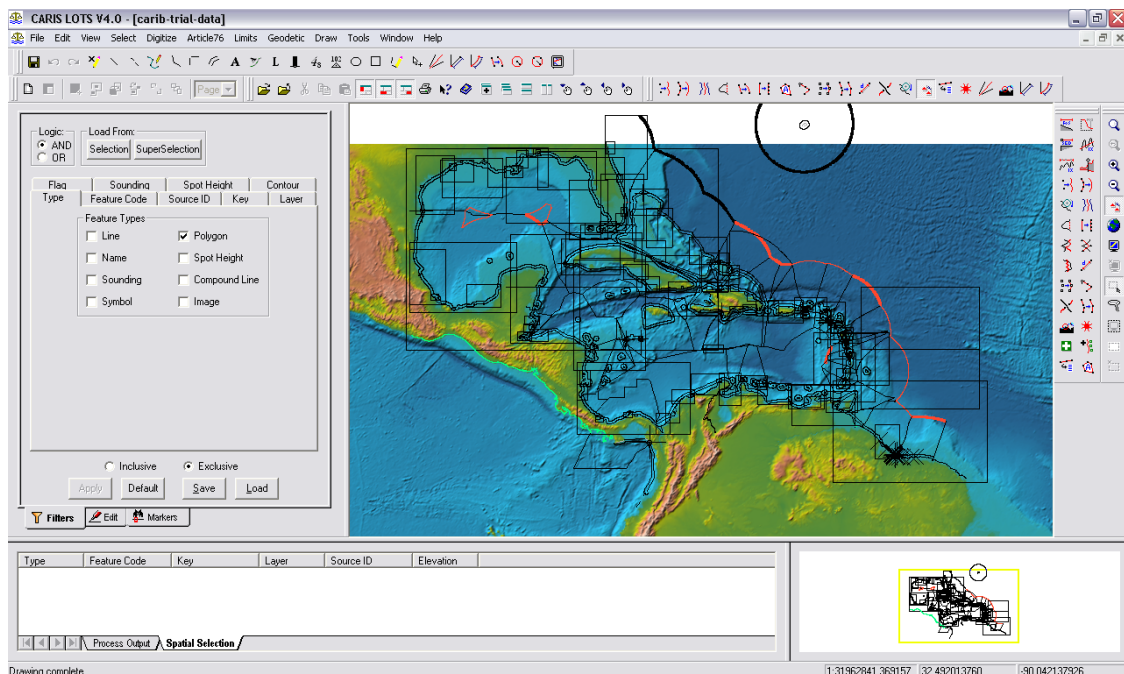


Figure 3: Maritime limits and boundaries dataset in the Caribbean over a backdrop of ETOPO2 bathymetry displayed in the geospatial software CARIS LOTS.

The data set shown above displays the 12 nautical mile Territorial Sea limits and the 200 nautical miles Exclusive Economic Zone for many of the sovereign States in the Caribbean. Bilateral boundaries are also represented. The display is dominated by the polygons marking the extent of the official nautical charts from the United Kingdom Hydrographic Office (UKHO) which was the source of official data for the territorial sea baseline models' definition. These charts come in different scales and are used for the safety of navigation. The largest scales which will show harbour approaches and the detail of ports and harbours are preferred for depiction of the coastline and the low tide elevations²¹ which will become part of the territorial sea baseline model. In this particular data set, the chart polygons hold additional information and attributes which are tracked for reference and documentation of the source data used for the coastline and therefore for the territorial sea baseline. Such information as the horizontal datum of the chart, the date of publication, the tide datum used, the projection and the scale are all important information constraining the baseline data derived from these charts.

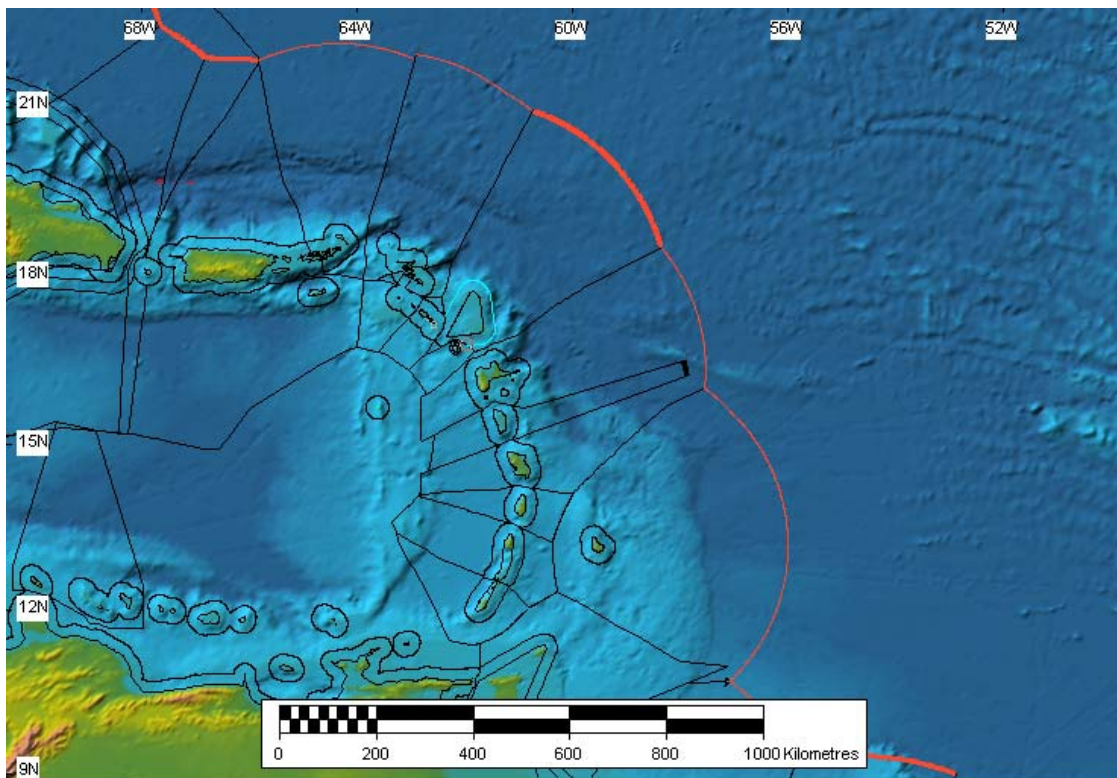


Figure 4: Detail of the maritime boundaries and limits in the Lesser Antilles. The 12 M and 200 M limits are shown as well as the median lines, treaty lines, some coastlines and the territorial sea baseline models.

Also represented in this data set are potential and disputed boundaries and limits claims. A more detailed representation of the maritime limits and boundaries is also shown in Figure 4. The 200 M EEZ is shown in red. The 12 M Territorial Sea is shown as a black

²¹ See note 20, above.

envelope surrounding each island. One of the CARIS attributes controls the symbology, colour and line thickness of the line objects displayed.

For management purposes, this data has to be associated to the different respective nations with national interests in the local limits and boundaries. It is also helpful, for marine cadastre managers, if the relevant information helps to track the time when court rulings, treaties and their accompanying delimitations came into force. Similarly, it can be useful if accessing the data gives the user access to information on the jurisdictional authority or authorities in charge of the rights contained in each limit or boundary. The maritime boundaries of this area were documented in this fashion by Sutherland in the *Journal of Ocean Technology* this year²². For the Caribbean states, the delineation of their maritime boundaries must often use a mathematical solution such as the median line to produce a fair result. Where the boundaries were unknown in the data set shown above, a theoretical median or equidistance solution was calculated.

6. Advantages of a Hydrographic database for a marine cadastral application

The kinds of data attributes described above, which can assist in marine cadastre management, can be handled easily in conjunction with other kinds of data in a hydrographic production database such as CARIS HPD. For example, as shown above, hydrographic data and the territorial sea baseline model are extremely important information to manage within the framework of a marine cadastre application since they have a direct effect on maritime limits and may evolve over time. The limits and boundaries themselves are also very useful information for mariners and other marine user communities. It is desirable to maintain them in a way that allows nautical charts to reflect the current delimitation situation as the charts have legal status. Therefore, having maritime boundaries printed on charts is likely to give more weight to the location of the boundary²³. It is equally important to allow charts and the TSB to be easily updated.

A hydrographic production database can help a nation manage and maintain its hydrographic data while reducing the time from survey to chart or to S-57 ENC production by storing the data directly in S-57 ready format and by allowing a single change to the source data stored only once to be reflected in all the nautical products that share this area and feature. As was mentioned by Bundesamt für Seeschifffahrt und Hydrographie (BSH) recently in a news article in *Hydro International*, “as one of the major benefits, HPD technology ends the laborious segregated processing and storing of source data for individual products. Instead, HPD offers a single consistent and up to date database as “the” source for all products”.²⁴ CARIS HPD also allows change tracking, keeping a record of who made each specific change and when and the rapid updating of marine products. For the purposes of reviewing historical records of rights and responsibilities, it also provides the user with the ability to view older versions of the data

²² Sutherland, M. (2008). “Law of the Sea and Maritime Limits and Boundary Delineation in the Caribbean”. In *Journal of Ocean Technology, Ocean Sovereignty*, vol. 3, June 2008.

²³ Hirst, B. and D. Robertson (2003). “GIS, Charts and UNCLOS- Can they live together?” ABLOS Scientific conference: Addressing Difficult Issues in UNCLOS, Monaco, October 29, 2003

²⁴ BSH, “Full Digital Workflow for Chart Production”. In *Hydro International*, News, August 26th, 2008

it contains. These are dated in historical database records to allow for accurate representations of past data. Rapid new updates to paper charts, S-57 ENC's or other marine products are now possible within such an environment. Further, other types of data can be stored in a hydrographic production database besides limits and boundaries. Examples include objects such as joint development areas, offshore leasing blocks for energy-related offshore exploration and exploitation, polygons representing fishing zones, marine protected areas, marine parks or aquaculture sites, shipping lanes, buoys for shipping lanes, navigation aids and lights, danger areas, government lighthouses, soundings and contours. This enables the user to view their limits and boundaries in relation to other features representing juxtaposed rights in the same area. This type of database also calculates the geodetic area of area objects on-the-fly based on the datum used for displaying the data. This information is always available when querying such objects. Therefore, such a database can be used as a cornerstone for building and managing marine cadastre features.

As shown above, a hydrographic production database already can include several components important in a marine cadastre and caters to a potentially large community of marine users. All of these users could obtain access to updated data in a shared version of the database, even if that data was maintained by another party.

The general workflow of CARIS HPD is shown below.

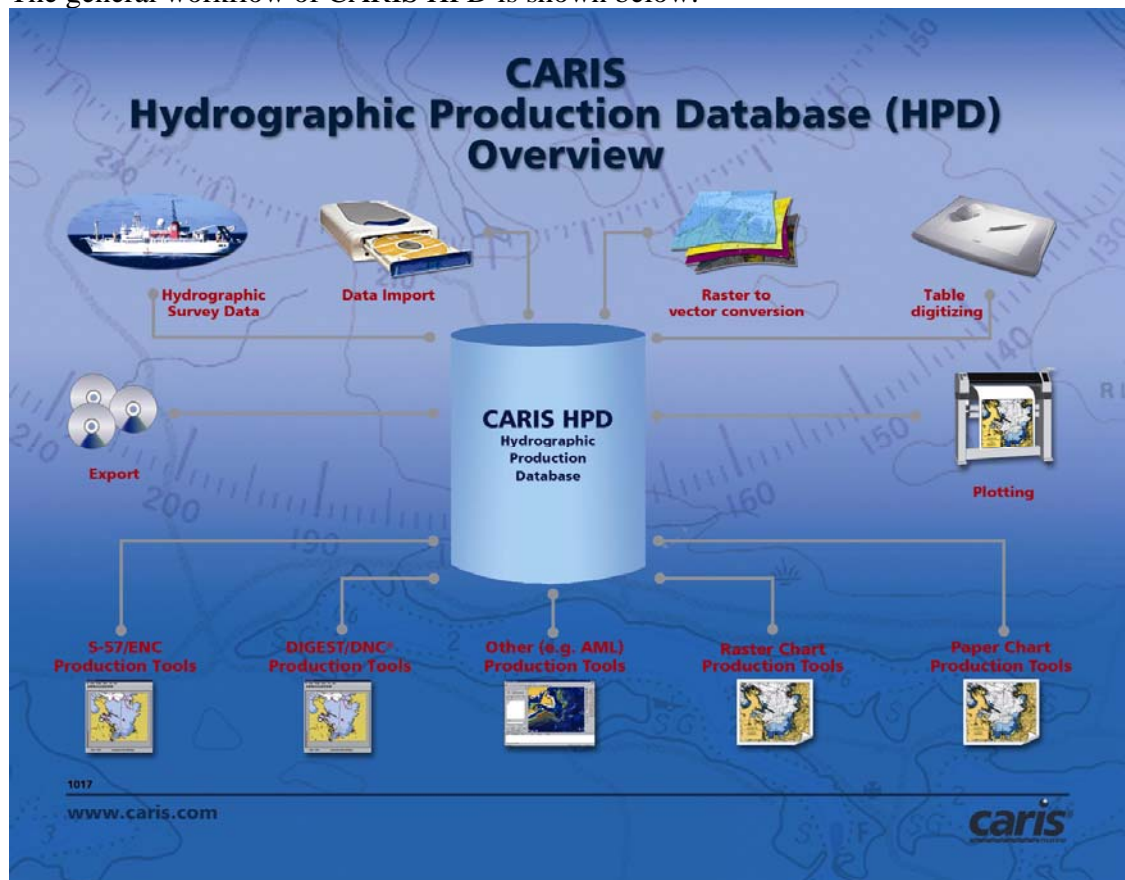


Figure 5: Overview of the hydrographic production database's basic workflow.

The hydrographic production database is further divided into a source database and a product database as shown below. The source data is maintained and stored in one location and eliminates duplicates, and therefore duplication of effort. This source data is used in the generation of various marine products.

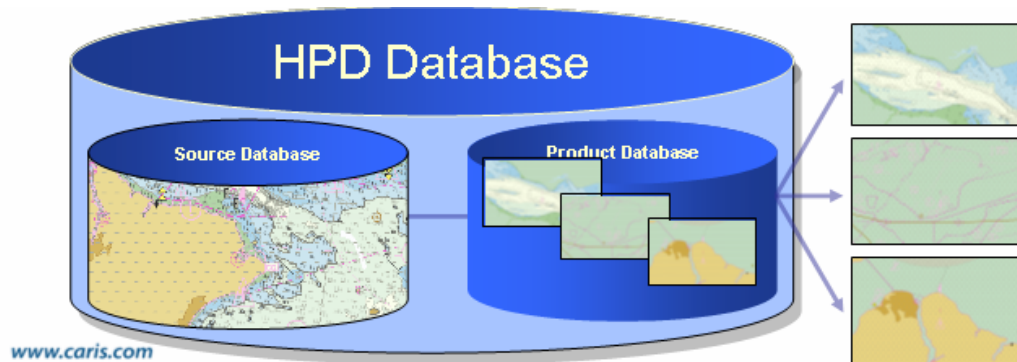


Figure 6: Division of the hydrographic database into a source and a product database.

This seamless hydrographic production database provides the advantages of an S-57 compatible data structure, storage of geographic information, history tracking, single storage of objects, production of INT1 and INT2 compatible chart products as well as validated ENC's and other marine products from a single digital source.

A hydrographic production database already caters to the needs of hydrographic offices and mariners by producing marine products such as S-57 ENC's and paper charts. As described above, official nautical chart information is the base data from which the Territorial Sea baseline model is determined. It is only after publication of updated charts that new hydrographic survey data results can become official. The coastline and relevant low tide elevations²⁵ can all be included in the database as part of the nautical charts and marine products data sets. These can then become readily available for the production of nautical charts depicting law of the sea maritime boundaries and limits.

²⁵ See note 20, above.

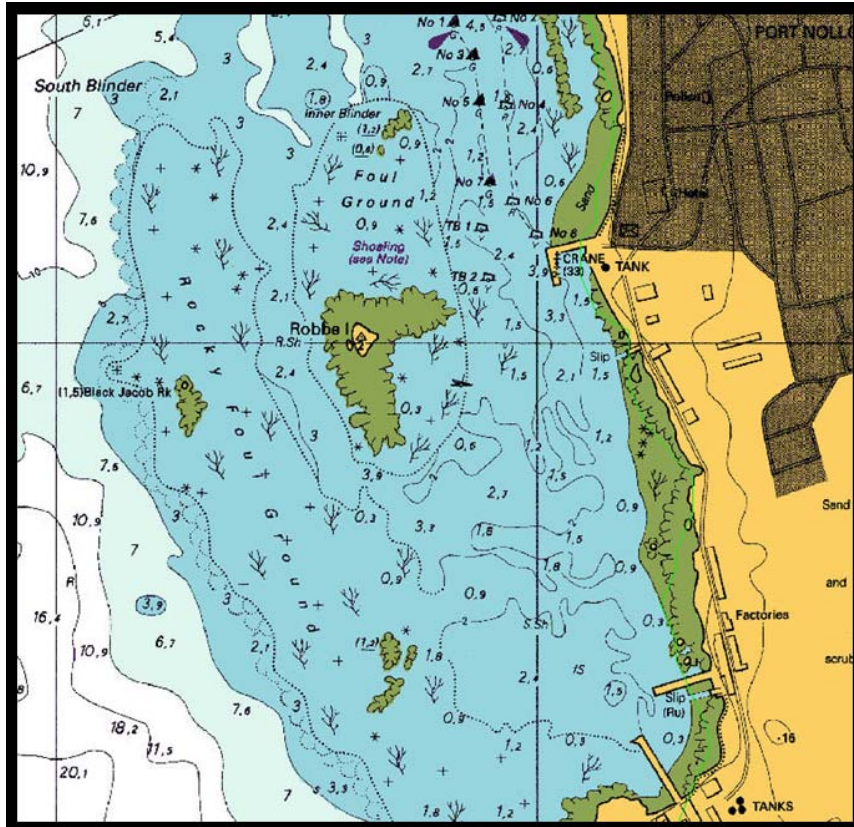


Figure 7: Area of a nautical chart showing low tide elevations in green which can be included in the territorial sea baseline model as normal baseline points.

7. Expanding the S-57 ENC catalogue for marine cadastre objects

The S-57 standard is used for exchanging ENC data products between hydrographic offices and the electronic navigation systems (ECDIS) users.²⁶ CARIS HPD takes advantage of the S-57 catalogue because this standard already encompasses a large number of objects and attributes which are of great value to hydrographic and maritime cadastral applications. However, for the purpose of managing the legal aspects of maritime limits and boundaries, there is room for enhancement. The following standard maritime limit objects are available in the S-57 ENC catalogue: the straight territorial sea baseline (STSLNE), the 12 M Territorial Sea area (TESARE), the 24 M Contiguous Zone (CONZNE), the exclusive Fishery Zone (FSHZNE), the 200 M Exclusive Economic Zone (EXEZNE) and the Continental Shelf area (COSARE). These area objects are not easily manageable, however, as most of these limits are originally created as lines in most geospatial law of the sea software. These lines may also be formed of several segments with different object acronyms and attributes. Making them part of a standard area object loses some of the flexibility of the line data type, limits the available attributes to attach to the object and may be more difficult to maintain. It may therefore

²⁶ International Hydrographic Organisation, “S-57 IHO Transfer Standard for Digital Hydrographic Data, Edition 3.1”, November 2000

be necessary to expand the catalogue to better accommodate these and other additional maritime limit objects. Adding specialized attributes can provide more flexibility to the maritime limits and boundaries practitioners.

Fortunately, taking advantage of an open catalogue and customizability of the hydrographic production database, several custom objects and attributes can be designed specifically for the purpose of managing the legal limits and boundaries related to the law of the sea. Page: 14

This type of customization does not require any coding changes to the application and can be performed by users as their needs or product folio evolves.

As part of managing the legal aspect of the maritime limits and boundaries in a marine cadastre setting, several questions can be answered by proper attribution and new objects. Some of these questions are the following: What is the maritime limit or boundary in question? Under which nation's and/or administrative body's jurisdiction does this maritime limit fall? When did it come in force? Is it in dispute? If it is a resolved arbitration or court ruling, which legal authority produced the ruling? When did the limit become legal? If several nations were involved, which nations were they? What were the suggested boundaries proposed by each side of the boundary dispute? Is there a point in time when a maritime boundary (such as a fishing zone) expires? These and several other customized objects and attributes may be required in order to provide the best flexibility and quick information access to the boundary expert. CARIS HPD, for example, includes catalogue editing tools allowing the expansion of the basic S-57 ENC catalogue. A much larger number of attributes are available in the HPD database than may have been possible in a file-based standalone desktop application.

For future development in this field, the new objects and attributes for UNCLOS and maritime limits and boundaries need to be standardized for dissemination and data sharing purposes. Making them part of a Product Specification for a Marine Information Overlay (MIO) product would promote a standards-based approach.²⁷ The upcoming IHO S-100 standard will provide support for a greater variety of marine or hydrographic-related digital data, products and customers, and thus will be able to incorporate any new feature additions such as UNCLOS. This is based on ISO standards to promote and enable wider use of hydrographic data within the GIS community.²⁸

Mapping rules between the data and attributes of maritime limits and boundary data can be established in advance after inspection of the information content of the data. The new maritime limits and boundaries data can then be opened as a backdrop to the database to allow selection and copying to the database while automatically mapping its attribution.

²⁷ International Hydrographic Organisation, <http://www.iho-ohi.net/english/committees-wg/hgmio.html>, Retrieved from the World Wide Web September 5, 2008

²⁸ International Hydrographic Organisation, "S-100 IHO Geospatial Standard For Hydrographic Data - Draft", January 2008

8. Standalone Law of the Sea Software and Hydrographic Production Database Interoperability

As described above, maritime limits and boundaries can currently be calculated in standalone desktop software (in this case CARIS LOTS). The visual representation of these maritime limits and boundaries already exists in the software where they are part of a larger symbol set shared by CARIS digital chart production software. The nautical symbols also already follow the IHO INT1 standard. This commonality of symbols makes the inclusion of the LOTS maritime limits in nautical charts much easier.

Interoperability between CARIS LOTS and CARIS HPD is achieved through the workflow shown in Figure 8. This makes many of the advantages of a hydrographic production database available to those responsible for maritime limits and boundaries.

The present workflow for maritime limits and boundary delineation will be modified and enhanced when the CARIS LOTS limits and boundaries geodetic tools are ported to CARIS HPD, which is planned by 2010.

Law of the Sea (LOS) Information – CARIS Workflow

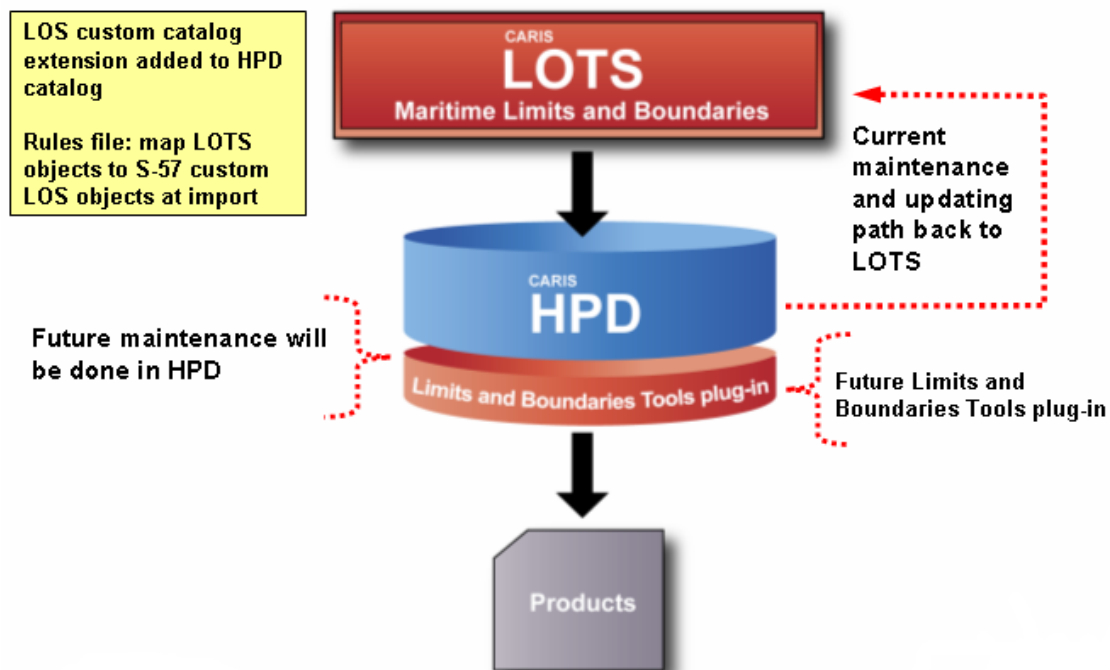


Figure 8: Workflow diagram for LOTS to HPD and HPD to LOTS

The present workflow consists of calculating and maintaining the maritime limits and boundaries in the desktop geospatial software LOTS. The limits and boundary data is then imported into the CARIS HPD database for warehousing and management.

A mapping file based on equivalence rules is used to immediately populate some of the attributes based on the original values of the data attributes. Depending on the effort invested in the mapping rules, data can be imported fully attributed or partially attributed. The exercise of importing the maritime limits and boundaries objects in the database is in itself an exercise in data structuring facilitated by the rules file.

A stage of data review can follow to properly populate the extended attribution in the database. Using the HPD standard import tools, a similar import path can be easily designed for other GIS domain data formats.

Since the hydrographic production database used in this paper's case maintains scrupulous records of all changes, the history of change of the coastal country's law of the sea maritime boundary and limit data is preserved. This will therefore allow reverting to a previous limit or boundary delineation if a new calculation or ruling overrules the existing maritime limit or boundary. Intermediate proposed boundaries with court case studies can also be input and maintained in the database until the boundary dispute is resolved and the new boundary is delimited. As long as a new editing of the data does not require special geodetic tools, corrections, deletions and additions can be realized within the hydrographic production database.

Whenever a change in the coastline or TSB impacts the calculation of the maritime limits and boundaries, a maintenance step is currently required. This calls for a return path to LOTS from HPD. The relevant baseline data is exported back to the desktop software for maintenance and update of the limits or boundaries affected. Once updated, this limit or boundary data is then re-imported into HPD. At this point, the update functionality in HPD allows any changes made in LOTS to be ported back to HPD without affecting the expanded attribution of the object contained in the database.

To provide a continuity in the representation of these maritime legal objects in the CARIS HPD database, the same symbology as that used in CARIS LOTS has been used. The graphic representation of the new law of the sea S-57 objects can be done with the cartographic INT1 standard expanded to cover new maritime boundaries and limits.

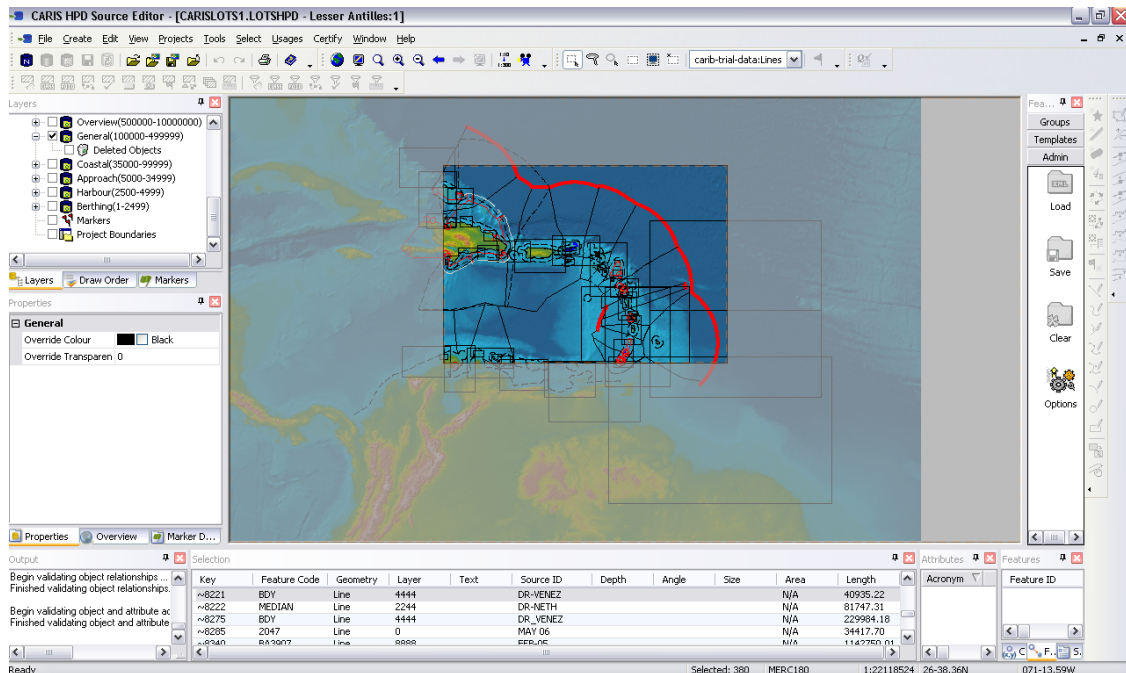


Figure 9: CARIS LOTS Limits and Boundaries Data imported into the CARIS HPD database shown with an INT1 standard cartographic representation of the data.

This data can be filtered on different layers using different rules. These layers still reference the common data in the source database and can be used to discriminate between different attributes and their values.

One such filtering exercise was done by the authors²⁹ based on the nation's name attached to the different limits and boundaries. The results of this exercise are depicted below.

²⁹ The data for this exercise was kindly provided by the UKHO Law of the Sea Division.

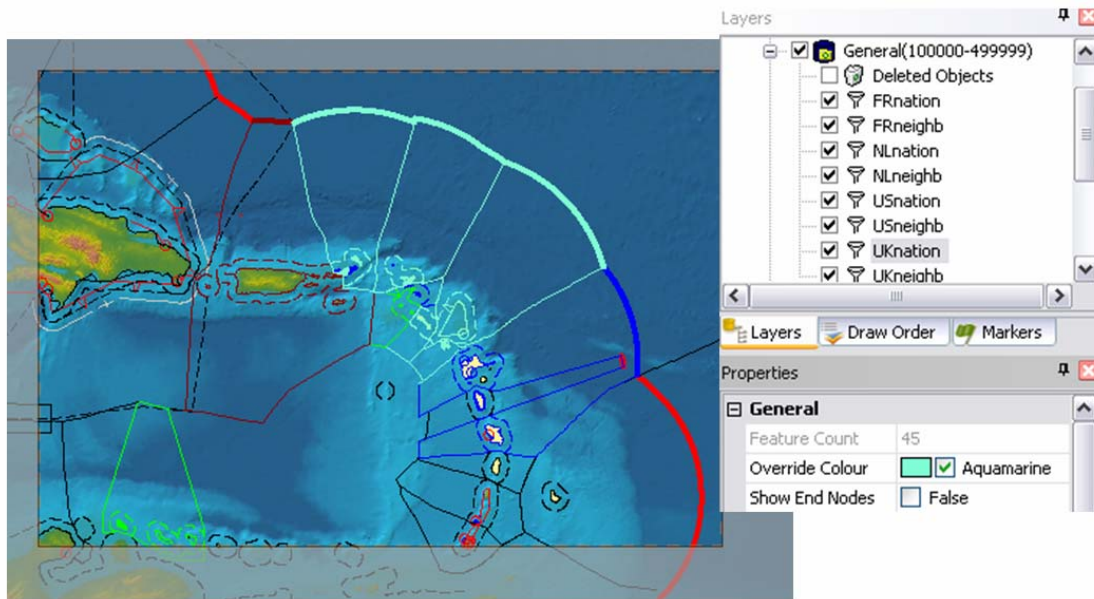


Figure 10: Several filter layers were created based on the national attributes of France (Blue), The United Kingdom (Pale Blue), The US Virgin Islands and Puerto Rico (Dark Red), and the Netherlands (Green)

Colours were attached to the filters to better differentiate the different limits and associate them visually with a country. The full data set is still contained in the main parent layer. Making changes on a filter sub-layer affects the data in the main layer since it is stored only once in the source database.

9. Future Workflow

In the near future, the porting of the limits and boundaries geodetic tools to the database software used in the case study will allow such data to be produced, maintained and managed directly inside a hydrographic production database (see figure 8). Additional cadastral functionality can then be added as needed.

10. Data Distribution

The distribution of relevant information to the end user is a necessary part of a marine cadastral application. The viewing of the maritime limits and boundary data results as well as the hydrographic data in the HPD database can be made available through HPD Web publishing. As an additional step in the LOTS-HPD workflow, this is seen as a viable means of making marine cadastral information available to a large community of marine users.

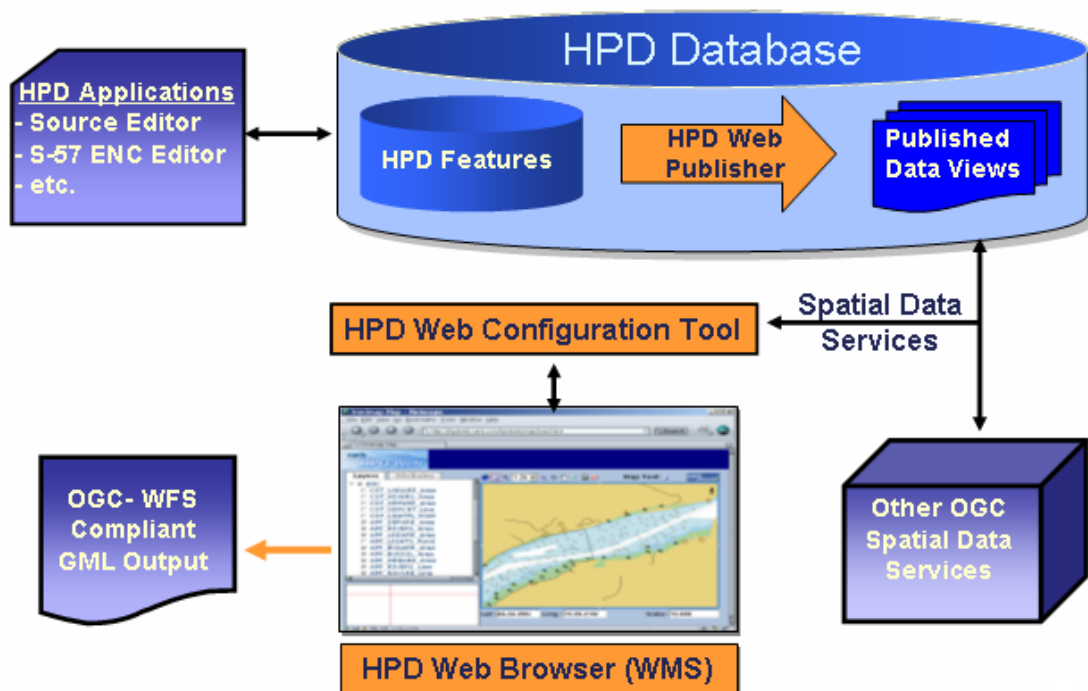


Figure 11: Data Distribution from CARIS HPD

11. Conclusions

This paper examined the use of a hydrographic production database to manage law of the sea-related cadastral information. As shown, there are several advantages of using such a database for marine cadastre applications. The use of a hydrographic production database allows increased control in the management of boundary and limits objects related to the law of the sea. Flexibility and adaptability are also achieved with the addition of new customized objects and attributes to address the specific needs of different marine space users. Paper charts, S-57 ENCs and other marine products can be created easily from a single seamless hydrographic production database with the added advantage of providing easier updates and publishing of new maritime limits and boundaries. Due to these facts, the IHO standards-based data model used by CARIS HPD is ideally suited for a marine cadastre application, and can be easily used with CARIS LOTS to provide the calculation of UNCLOS and other marine limits and boundaries.

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