

A TECHNICAL METHOD ON CALCULATING THE LENGTH OF COASTLINE FOR COMPARISON PURPOSES

Laurent LOUVART

(Eng. Corps & Hydrograph., SHOM - FRANCE)
on behalf of the IHO Correspondence Group

Abstract

A quick web search illustrates the wide variation in the quoted lengths of the coastline of a unique State, with ratios from 1 to 100 and in some examples, even more. This illustrates the need for a common measuring method. The length of a coastline, for the purpose of comparison between States, can be calculated according to the guidance and specifications described in this paper.

This specification describes a harmonized approach to determining the length of a coastline. It may only be relevant for comparison purposes and should not be regarded as definitive nor suitable for all purposes. Based on official ENC datasets, the advantage of this method is that it gives comparable results that can be easily verified.

Background

Following a request from the European Commission, the 20th IHO CHRIS Meeting (November 2008) encouraged the creation of a Correspondence Group (CG) aimed at harmonizing the way Member States define and measure the length of their national coastlines.

France volunteered to coordinate such a CG to study the feasibility of such standardization and members were invited to join the group. The HSSC-2 meeting in October 2010 invited the CG on the Definition and Length of Coastline to complete its work by HSSC-3.

The CG met on 30-31 March 2011 in Brest, France, with participation from Germany, Finland, Spain, Cyprus, USA, Slovenia and France. A first draft method was proposed to HSSC-3 in 2011. This last version clarified the aspects related to determinations between S-57 Usage Band ENC's.

Users' need and purposes for length of coastline

The CG found that there are no clear legal, or other obligations to define how the length of coastline is determined. It is possible to define the length for various different purposes such as, administrative and comparison purposes (allocating fishing quotas, referencing aquaculture production statistics, coastal zone management, defining "hydrographic interest", etc.), environmental protection (for example, evaluating response capacity requirements) and scientific purposes.

It was found that there are often several lengths available for the calculated or estimated length of coastlines, but only few metadata is associated with these values. There are many worldwide digital source data sets available. There also exist several GIS software tools available to make the calculations.

The CG recognized that the coastline is by nature a fractal object, so it is not possible to provide an unambiguous length. The length may be calculated in as much detail as is desired and the length may therefore grow to infinity. There is never one simple solution (see Appendix 1).

However, the CG noted that there are often requirements to be able to compare the length of coastlines between States for certain administrative purposes. Thus a standardised method for calculating these lengths is required.

General requirements

The CG noted that in order to develop a harmonised approach, there are many issues that must be clarified before the length of a coastline can be calculated for a given purpose. Among these are:

- Requirements on the level of detail
- Sources to be used
- Scale of the sources
- Method to be used
- Generalisation
- What to be included (islands, inland waters, artificial structures...)
- How far do we measure river mouths
- Dynamic aspects and evolution of coastline

The CG identified some general requirements, specifications and guidance for those who may need to calculate the length of a coastline:

- Have a common definition of what is used in calculations
- Sufficient metadata should be associated with the calculated length. These include information on the methods used, source data, purpose of the calculation, what is included in the calculation, specifications used, expected use of the results
- The calculated results should be repeatable
- The results should be auditable

Coastline Length calculation for comparison purposes based on ENCs

The CG has developed a specification on a harmonised approach to define the length of a coastline for comparison purposes, based on official, standardised and available data: S-57 Electronic Navigational Charts (ENC).

The ENC coverage at Navigation Purpose code 1 (Overview), which is almost complete, is recommended as the basis for the calculation. Where this coverage is not available or suited for comparison purposes, Navigation Purpose code 2 or largest existing scales should be used. The key concept here is that the initial selection of equivalent scale products is fundamental to appropriately comparing lengths of coastline between two or more States.

The CG noted the following benefits of using ENC as the basis for the calculations:

- ENCs are officially produced under the authority of national Hydrographic Offices (HOs).
- The coverage of small scale ENCs is effectively complete.
- The ENC product specification does not allow overlaps in the same navigation purpose code – hence a single unambiguous source of data should normally be available.
- It is possible to identify the Producer State from the ENC data for each coastline segment.
- Data is already in a consistent structure and in a uniform format and associated with a unique geodetic datum
- There are tools to extract coastlines from unencrypted ENC data sets.

The following specification identifies the sources to be used for the calculation, what elements should be included and the metadata to be associated with the results. **Appendix 1** provides examples of calculated lengths together with relevant metadata.

Calculation details

1. For the purposes of this method, the coastline is defined as the High Water Line as represented by the Coastline, Shoreline Construction and Causeway object classes of the applicable Electronic Navigational Charts (ENC).

2. The length of the coastline between two points is the sum of the lengths of the three Coastline, Shoreline Construction and Causeway object classes between those points.
3. Equivalent scale and vintage products are recommended for the calculation to support comparative analysis. The following approaches are recommended:
 - The relevant lengths obtained from Navigation Purpose code 1 (overview) ENC cells should be considered first for the calculation.
 - If Navigation Purpose code X ENC cells have not been published or are not suited for comparison purposes, data from Navigation Purpose code X+1 ENC cells (largest scales) should be used.
 - In cases where data from Navigation Purpose code X ENC cells is supplemented by data from Navigation Purpose code X+1 ENC cells, the latter is counted from the vertex closest to the last vertex of the code X ENC corresponding curve (see **Appendix 2**).
4. River mouths should be included in the calculation to the point where they become a line feature in the ENC band that is used for the calculation. When the chart ends first or when there is no greatest ENC scale to complete the river, a straight line is drawn across the mouth and included in the measurement of the length of coastline.
5. Water bodies, such as inland lakes, which may be upstream of a river line should not be included in the calculation of coastline (for example: in the case of inland water linked to the sea by a canal).
6. The end of each State coastline will be at the agreed or declared border line.

Data and descriptive metadata

Whatever the way of calculation of the length of coastline, the results should at least include the following metadata:

- Country name
- Two-letter Country code (IHO S-62)
- Length
- Unit of Measure (UoM)

Some metadata should be also included with the result of the calculation.

Note: elements marked * are repeatable.

- Any comments
- Point of contact of the organisation responsible for the calculation (such as the postal address or web addresses of the HO)
- Method of calculation (e.g. International Hydrographic Review reference)
- Date of calculation (YYYY/mm/dd)
- Identifier of the ENC cell(s) used for the calculation *
- Edition date of the ENC(s) *
- Producer code of the ENC(s) (IHO S-62) *
- Scale of the line segment(s) used *
- Object Classes included in the calculation *

Conclusions

France achieved some tests to validate this method and results are shown in **Appendix 3**. Now, it is up to nations or interested readers to complete it.

Biography of the Author**Laurent LOUVART**

He is currently deputy director of research & innovation department, SHOM Headquarters. Amongst other duties, he is responsible for managing the survey fleet renewal project and representing SHOM at the IHO's Hydrographic Services & Standards Committee (HSCC).

e-mail : laurent.louvar@shom.fr

Appendix 1 - Examples of different calculations for the same State

This example is based on a quick web search. It illustrates the wide variation in the quoted lengths of the coastline of Finland - from 1,100 km to 314,604 km, thus illustrating the need for a common metric and minimum metadata.

Length [km]	What is included	Metadata	Source
1100	Only sea border line.	No metadata available	Unspecified document
1250		No metadata available	CIA World Fact book: Worldwide list of lengths of coastlines
2774	Shoreline only.	Based on 1:4.5M. No other metadata available	Unspecified document
4600		No metadata available	Unspecified document
6299	Coastal shorelines.	No metadata available	Finnish Environmental Centre
31119		No metadata available	NGA World Vector Shoreline
39125		Basic topographic map 1:10.000. No other metadata available	Unspecified document
46198	Coastal shorelines includ- ing shorelines of islands and of lakes on islands.	No metadata available	Finnish Environmental Centre
314604	Coastal shorelines and shorelines of lakes includ- ing shorelines of islands and of lakes on islands.	No metadata available	Finnish Environmental Centre

Appendix 2 - An Example of how incorporate rivers using Navigation Purpose codes 1 and 2 ENC cells

Below is an illustrated example on how Navigation Purpose codes 1 and 2 ENC cells should be handled so that the latter supplement the former.

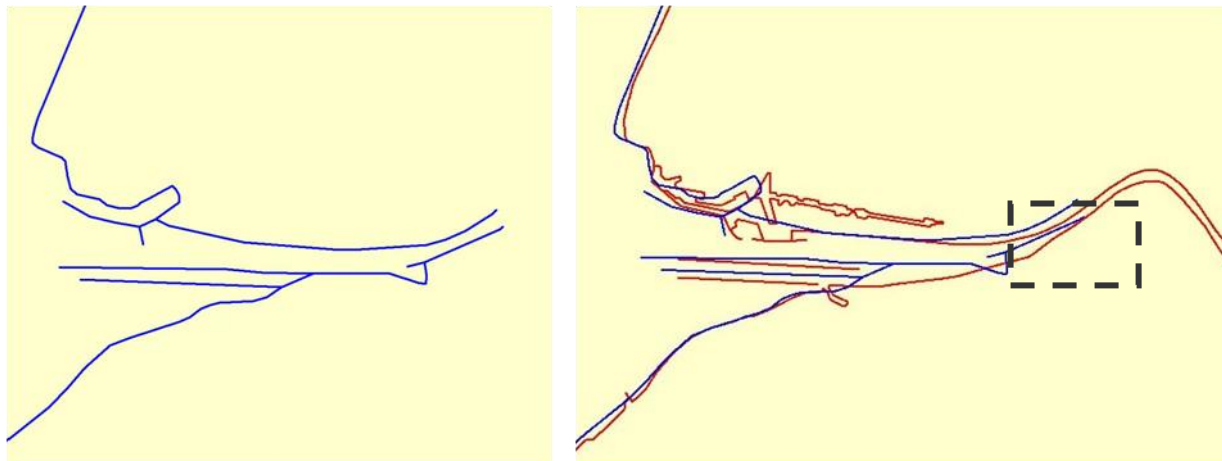


Fig.1 : Navigation Purpose code 1 ENC (blue), classes Coastline, Shoreline construction and Causeway. The line presents a discontinuity that can be supplemented by Navigation Purpose code 2 ENC data (red). The next figure displays the cropped area (dashed box).

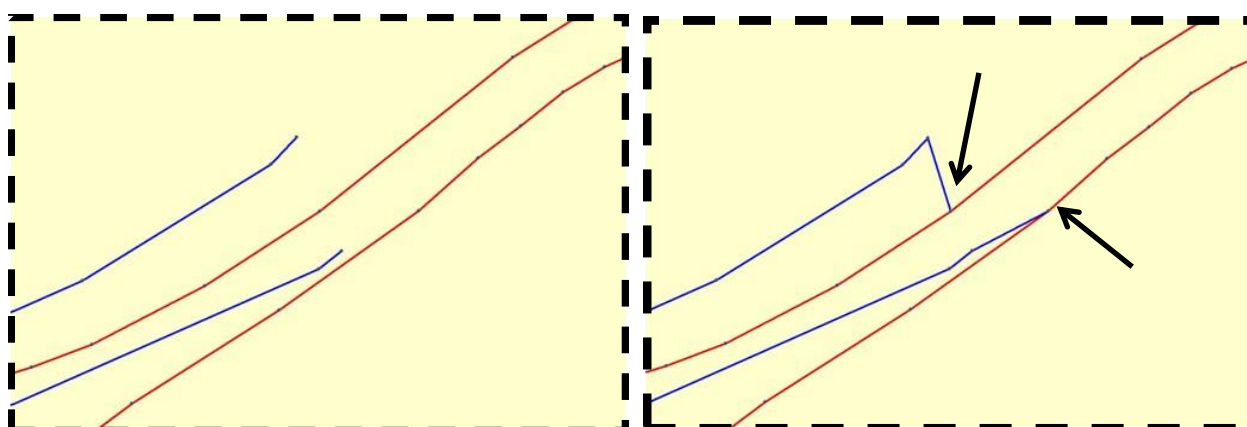


Fig.2 : Crop on the discontinuity. Navigation Purpose code 1 data is supplemented by Navigation Purpose code 2 data from the vertex closest to the last vertex of the code 1 ENC curve (arrows).

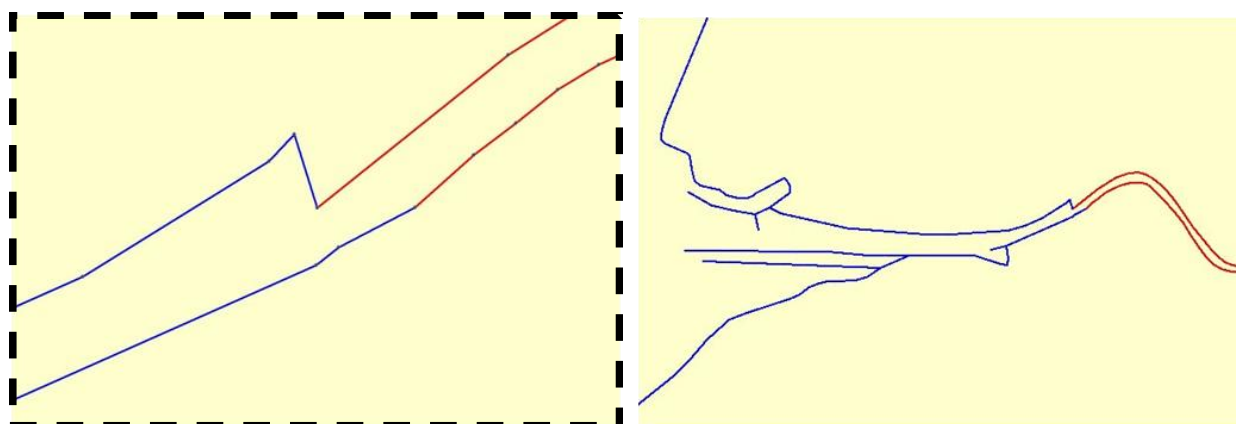


Fig.3 : Calculation can now be based on the composite coastline.

Appendix 3 - Lengths of coastlines for comparison purposes

Note : Figures are not official. It was carried out as an illustration of the ENC based method.

Country name	Code	Length	UoM	Comments	Point of Contact for calculation	Method of calculation	Date of calculation	ENCs Ids	ENCs Edition Date	Producer Code	Scale of line segments	Classes included
France	FR	5 077	Km	Mainland France and Corsica Island. Geodetic length, calculated using Global Mapper Software V12.01	www.shom.fr	IHR may 2013	2012/06/18	FR166230	2007/11/10	FR	1500000	COALNE; SLCONS
								IT100340	2004/10/04	IT	1500000	COALNE; SLCONS
								GB100160	2012/05/31	GB	1500000	COALNE; SLCONS
								FR200010	2010/07/31	FR	700000	COALNE
								GB202675	2011/04/13	GB	350000	COALNE
Italy	IT	6 387	Km	Unofficial. Calculation made by France for test	N/A	IHR may 2013	N/A	IT100340	2004/10/04	IT	1500000	COALNE; SLCONS
Monaco	MC	4	Km	Unofficial. Calculation made by France for test	N/A	IHR may 2013	N/A	IT100340	2004/10/04	IT	1500000	COALNE; SLCONS

Page intentionally left blank