

IN SEARCH OF NEW BRUNSWICK'S MARINE ADMINISTRATIVE BOUNDARIES

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1. Introduction

Good governance of Canada's oceans is a provincial as well as a federal affair. This paper is about New Brunswick's recent attempt to delineate the possible maximum spatial extent of its administration to support provincial marine policies and the good governance of its marine resources.

Manning et al [1998] state: "good governance is essential for all societies to ensure the provision of public services and the control of behaviours which affect the common good." Good governance of marine spaces, more often than not a common good, is therefore of vital importance and requires the management of a range of information. This includes information on living and non-living resources, bathymetry, spatial extents (boundaries), shoreline changes, marine contaminants, seabed characteristics, water quality, and property rights among other things [Nichols, Monahan and Sutherland, 2000; Nichols and Monahan, 1999; Payoyo, 1994; Lutz and Munasinghe, 1994; Gomes, 1998; Crowe, 2000]. For instance, the governance of a volume of marine space can involve the management of any number of overlapping property rights (figure 1) with each right itself tied to a spatial extent.

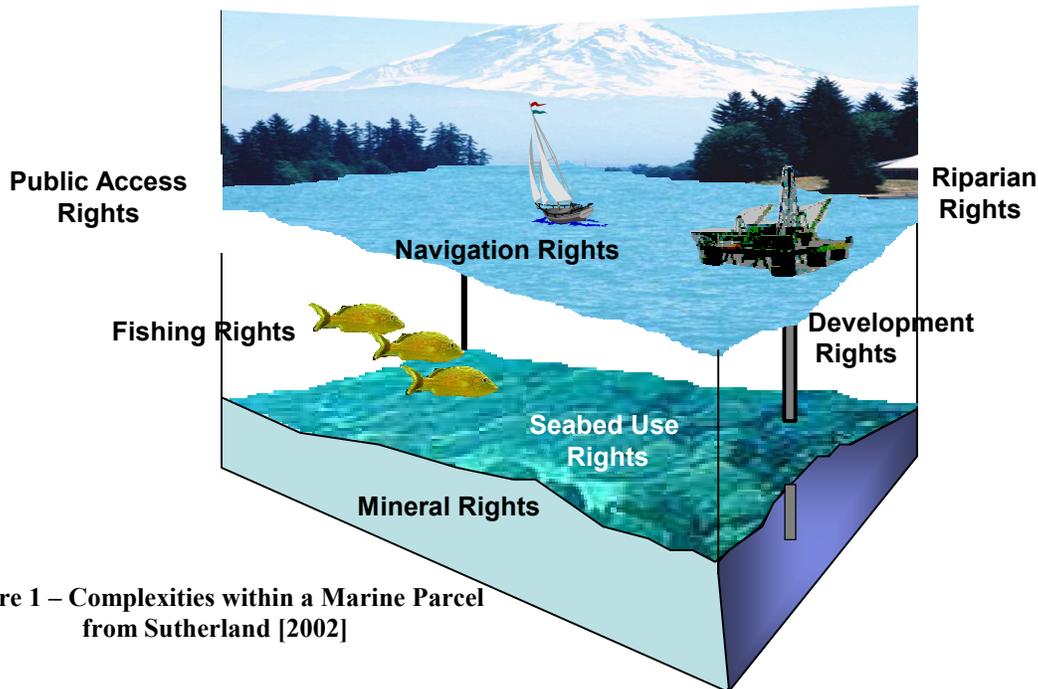


Figure 1 – Complexities within a Marine Parcel from Sutherland [2002]

However, in order for a jurisdiction to implement good governance of its marine spaces it must first know the maximum spatial extent of the marine space over which it desires to exercise jurisdiction and administration. As a first step towards securing this knowledge Service New Brunswick (SNB) formed a partnership with the Department of Geodesy and Geomatics Engineering of the University of New Brunswick, supported by the Geomatics for Informed Decisions (GEOIDE) Centres of Excellence, to delineate one possible maximum spatial extent of its marine administrative area. Using GIS technology supported by some legal research, the outcome of this process was two polygons representing a delineation of the potential maximum spatial extent of New Brunswick’s submerged lands.

In order to complete the process of creating the polygons it was necessary to secure data representing coastlines opposite to the shores of New Brunswick (to calculate midpoints), as well as inter-provincial and international boundary coordinates to complete the polygons. The databases used in the model were chosen because of their immediate availability. The chosen databases are of varying scales and positional accuracies. The databases are also in various projections and referenced to various datums. However they were the best available data at the time. The model workflow process for creating the polygons (that can only be described as “a model for delineating New Brunswick’s submerged lands from best available data”) is graphically described in Figure 2. The confidence placed in each database is outlined in the “hierarchy of confidence” set out in Table 1.

This paper outlines on the process of creating the two polygons that potentially delineate New Brunswick’s maximum marine administrative boundaries (i.e. in the Bay of Fundy–Gulf of Maine geographic region, and in the geographic region encompassing Northumberland Strait, the Bay of Saint Lawrence and the Restigouche River). The technical and governance implications of the process and the product are then discussed.

Table 1 - Hierarchy of Confidence in Imported Data Sources

Database	Hierarchical Position	Rationale
CTDB98	1	This is SNB’s Coastal Topographic Database, the database to which the final product must fit. The data has been subjected to known quality control. This data took precedence over all other data representing the same geographic extent.
International Boundary Commission (IBC) coordinates	1	These are published coordinates downloaded from NRCan (http://www.geocan.nrcan.gc.ca/ibc/ibccoord-nad83.htm). This data took precedence over all other data where international boundaries are represented except where gaps may exist.
Prince Edward Island’s Enhanced topographic Base (PEI ETB)	1-2	Apparently quality checked and reported to have a positional accuracy of ± 2.5m. This data took precedence all other data for the geographic area it represents (i.e. the south coast of PEI)
Proposed DNRE Mineral Lines and Shore Points	1-2	These data were supplied by the New Brunswick Department of Natural Resources and Energy (DNRE). They represent coordinates that were the result of a field survey exercise for proposed mineral sharing lines between the Maritime Provinces done in 1968.
Other International Boundary Coordinates from Department of Fisheries and Oceans (DFO)	2 - 3	These coordinates were obtained from DFO via email. This data took precedence over other data representing international boundaries where gaps exist.
Natural Resources Canada (NRCan) National Topographic Database (NTDB)	4	Positional accuracy range from 10 metres (urban areas) to 125 metres (isolated areas). This data was used in those geographic regions where no other data had been acquired by UNB.
SNB Digital Property Map (DPM)	5	Without another source, this database was the only available source of digital coordinates representing the inter-provincial boundaries between New Brunswick and the provinces of Nova Scotia and Quebec.

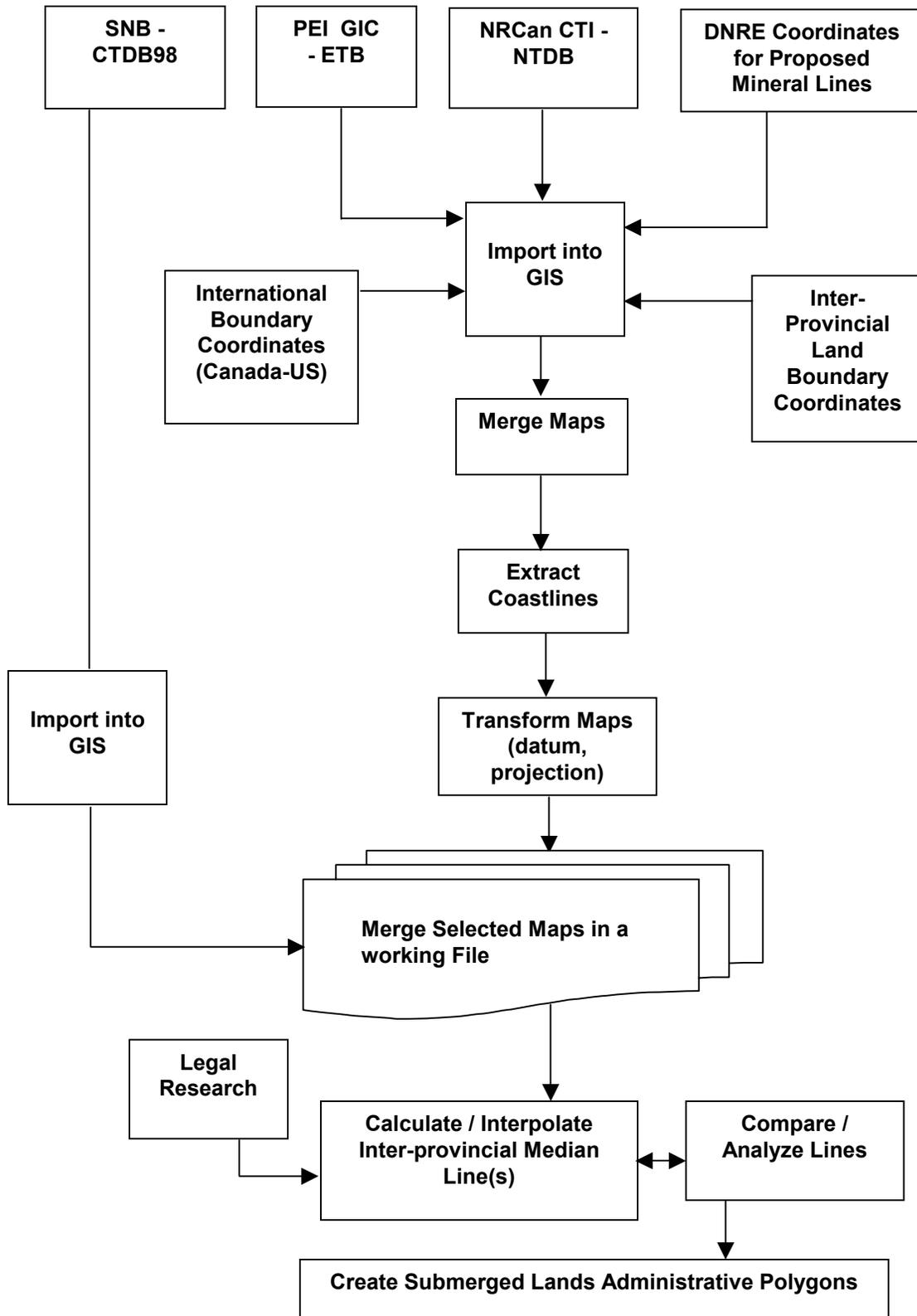


Figure 2 – The General Process of Creating New Brunswick’s Submerged Lands Polygons

2. Importing the Database Files

In general terms, this section describes the execution of the process model described in figure 2. The process of importing each set of database files into the working file through to the process of visual and spatial analysis and manipulation to produce the submerged lands polygons are described. Processing of the spatial files was accomplished with CARIS GIS and CARIS LOTSTM. The databases referred to herein were previously described in table 1.

2.1 Processing the CTDB98 Files

Any polygon created had to fit with the CTDB98 database (i.e. the created polygon lines have to intersect with CTDB98 coastlines to complete the polygon representing the submerged lands of New Brunswick. The CTDB98 was obtained in CARIS GIS format (specifically, a continuous database of 1895 files). The x and y resolution of this data is 1.0 metre. The CTDB98 continuous database was loaded in CARIS GIS and the appropriate coastline features were extracted to a working file of the same projection (New Brunswick Double Stereographic), resolution, scale (1:10000) and datum (NAD83 CSRS).

2.2 Processing the NRCAN NTDB Files

Data from 90 NRCAN NTDB files were acquired in order to provide the relevant parts of provincial coastlines not covered by the other databases. These datasets are in geographic projection and referenced to the NAD83 datum, and NRCAN's hydrographic layer were provided in DXF format. The appropriate coastline features were extracted, merged, transformed to the New Brunswick stereographic projection and NAD83 datum, and then incorporated into the working file.

2.3 Processing the PEI ETB Files

A portion of Prince Edward Island's ETB was acquired in order to provide relevant parts of PEI's coastline. This dataset is in stereographic projection and referenced to the AT77 datum and was provided in CARIS ASCII format. The x and y resolution of this data is 0.05 metre with a stated positional accuracy of ± 2.5 m. The appropriate coastline features were extracted, merged, transformed to the New Brunswick stereographic projection and NAD83 datum, and then incorporated into the working file.

2.4 Processing the SNB DPM Files

The SNB DPM files were chosen as the best available source of inter-provincial boundaries relevant to this process. The maps are in New Brunswick's double stereographic projection and referenced to the NAD83 datum. The x and y resolution of this data is 0.05 metres. The files were provided in CARIS ASCII format. The appropriate coastline features were extracted, merged, transformed (in terms of x and y resolution), and then incorporated into the working file.

2.5 Importing NRCAN-IBC and DFO Land and Marine Boundary Coordinates

The NRCAN-IBC and DFO coordinates were obtained in order to provide the international boundary portions of the submerged lands polygons. These coordinates were acquired via files downloaded from an NRCAN website [NRCAN, 2002] and via email from DFO. These data are in geographic projection and referenced to the NAD83 datum. These coordinates were imported into CARIS GIS in order to produce point-to-point lines. The imported lines were then merged in to a single file and appropriately transformed to the New Brunswick stereographic projection. The transformed file was then merged into the working file.

2.6 Importing DNRE Proposed Mineral Lines Coordinates

In 1968 the Premiers of the Atlantic Provinces agreed to division line for the sharing of offshore mineral resources. The coordinates for shore points and the resulting midpoints were recorded and stored with the New Brunswick Department of Natural Resources and Energy (DNRE). Although the 1968 process measured midpoints from "low water", it was thought useful to incorporate this data as a means of facilitating comparison between other produced midpoints, and possible incorporation into the final product. These coordinates are referenced to the NAD27 datum and were obtained in hard copy [McLaughlin, 1968]. The coordinates were first imported into CARIS GIS as point-to-point lines referenced to the NAD27 datum. They were then transformed to NAD83 and incorporated into the working file.

2.7 Processing the Working File

The manner in which the working file was processed to produce the submerged lands polygons is detailed in the following sub-sections. The general steps include:

- Compare/analyze the imported DNRE mineral lines and the lines generated by using imported DNRE shore points
- Analyze the inter-provincial boundaries from the SNB's Digital Property Map Database

- Compare the imported coastline segments from the integrated sources
- Generate median lines in the working file using integrated data
- Generate the final median lines in the working file
- Create the final submerged lands polygons

2.7.1 Comparing Lines Generated from Both Imported DNRE Mineral Lines coordinates and Shore Coordinates

In this section a comparison is made between the coordinates used to recreate the DNRE mineral lines in the working file and the median line coordinates generated from the use of the imported DNRE shore coordinates described in Section 2.6. Both sets of coordinates were subjected to identical processing in terms of how they were imported into the GIS, transformed and merged into the working file. This exercise was done to test the accuracy of the coordinates for the centre points used to construct the DNRE mineral lines, which was taken into consideration when delineating the submerged lands polygons.

The DNRE shore points were not able to be duplicated in totality for any other exercise described in Section 2.7.3 as it seems that the surveyor(s) had access to a landmass (Dead Man's Island in the Bay of Saint Lawrence, West of Isle de Madeleine) which does not appear in any of the other databases used in this model experiment. The resulting median lines points generated from the shore points were then compared with the imported DNRE median points. The points were found to differ by an average of 11.2 metres in the Restigouche region, by an average of 10.3 metres in the Northumberland Strait region, and by an average of 49.43 metres in the Bay of Fundy region. The larger average in the Bay of Fundy region is caused by one point that was calculated to be approximately 292 metres from the corresponding median point in the DNRE mineral line. These differences were taken into consideration when producing the final polygons.

2.7.2 Analyzing the Inter-Provincial Boundary Line Segments Imported from SNB's DPM

The inter-provincial boundary line segments imported from SNB's DPM were investigated to see how well they fit with the CTDB98 since both databases are maintained by the same agency. This exercise also has the potential to determine whether the digital data maintained by SNB reflects that agency's understanding of the outer land bounds of its scope of jurisdiction, administration or title.

The inter-provincial line segments were needed in order to close the submerged lands polygons at intersections with the CTDB98. Legal research indicates that the boundary runs the middle (between banks) of the Tidnish and Missequash rivers, and the Bay of Fundy. It was decided to accept the DPM data if the representation of the inter-provincial borders ran at least within the line segments representing both shores of the Restigouche River (in the case of the New Brunswick-Quebec border), and ran at least within the line segments representing the shores of the Missequash and Tidnish Rivers (in the case of the New Brunswick-Nova Scotia border) since legal research seems to support this depiction. Observation of the New Brunswick-Quebec boundary proved to be at least visually satisfactory though it was not proven to be a valid legal representation. The DPM New Brunswick-Nova Scotia boundary, however, does not always fall within the line segments of the Missequash River. These problems were addressed by creating median lines with CARIS LOTS™ where they did not occur. Then these created median lines were appropriately joined with the DPM boundary segments, and then finally those DPM line segments that did not fit the criterion of a midline were deleted.

2.7.3 Comparing the coastline Segments from the Integrated Sources

In order to understand what impact the imported coastline segments was going to have on the final output of the delineation of the submerged lands, they were compared. It was fully understood at the outset that the types of comparisons possible were limited by the fact that there was no way of knowing if the line segments represented the same vertical datum (i.e. ordinary high water, ordinary low water etc.), or even if the same coastal feature were mapped. Also, since there were data captured at more than one scale there was bound to be some generalizations in the smaller scale mapping exercise. The only "useful" comparisons and analysis was to determine which coastline was more seaward and possibly to determine some measure of distances between the line segments.

Observation of the working file revealed that no one coastline was always more seaward than another. However when comparing the CTDB98 and the NTDB it was found that the NTDB was more often more seaward. When comparing the NTDB and PEI's ETB it was found that the NTDB was more often seaward. As there is no obvious pattern to the manner or number of times in which the coastlines overlapped and intersected, no useful sample of distances between coastlines could be gained. Random measurements using CARIS GIS distance measurement tool revealed distance differences as small as 0m (obviously) and as

much as approximately 530m.

2.7.4 Generating Median Lines in the working File Using Integrated Data

In this section the process of using the working file to generate median lines from the integration of data from various sources is described. The result from this process was later compared with other solutions in order to produce the desired delineation of New Brunswick's submerged lands. The number of baseline points chosen in this exercise is greater than those used for creating the DNRE median lines, and was performed in this manner so as to produce lines that would better (subjectively speaking) represent medians as dictated by the sinuosity of the coastlines used to choose baseline points. A sample of the resulting line is depicted in Figure 3.

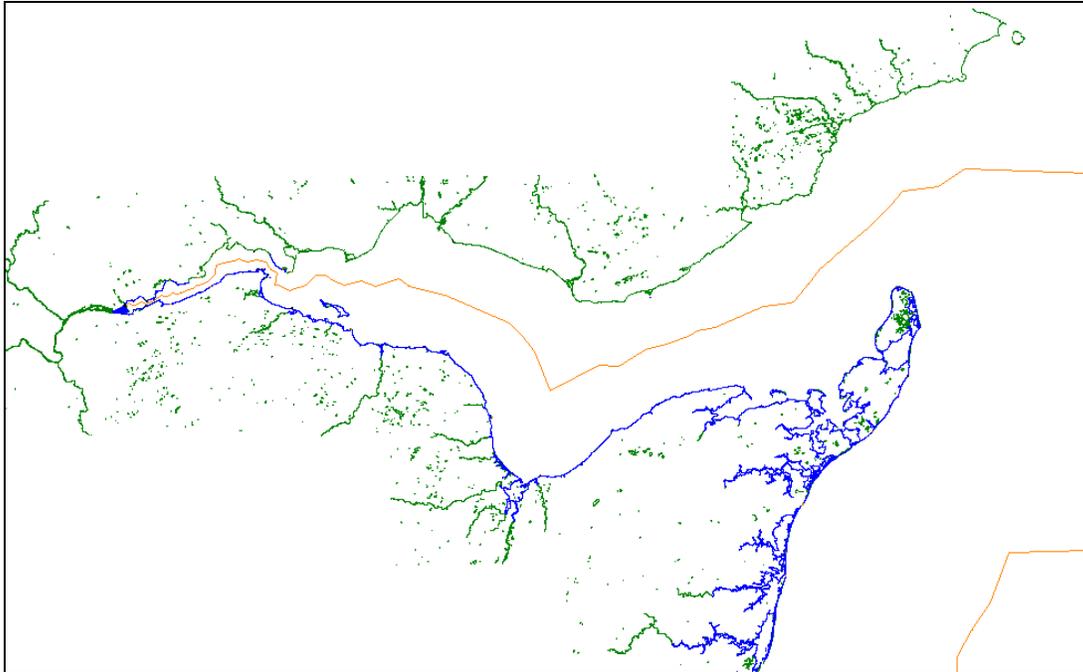


Figure 3 – Median Line Created From the Integrated Databases

2.7.5 Generating Composite Median Lines in the Working File

After all the various median lines were generated it was left to either choose one set of lines, or to create a set of lines being a composite of a number of lines. Figure 4 shows the various median lines generated.

There are distinct variations among the lines in terms of position and dimensions. This is due to a number of factors. These include (among other things) the number of baseline points chosen, the positions of the chosen baseline points, and the shoreline data used to position the baseline points. The median lines generated from the integrated data has more midpoints and therefore more closely reflects median lines reflective of the sinuosity of the coastlines used. These lines also, especially in the Bay of Saint Lawrence and the area of the mouth of the Tidal River, are affected by baseline points not apparently used in the DNRE lines. For example, in the Bay of Saint Lawrence baseline points on Anticosti Island and Isle de Madeleine were taken into consideration in constructing the median line from integrated data and this action is reflected in its difference with the DNRE line in that area. For all the reasons outlined in the immediately preceding paragraph (and sections) two criteria were developed to determine the choice of median points and line segments used to generate the final median lines. These criteria are:

- The median points generated from the integrated data would be of highest priority.
- Median points from the DNRE lines will be used only when they appear to represent median points between the median points as described at (a).

The immediately foregoing criteria were put into effect and a final set of combined median lines were created.

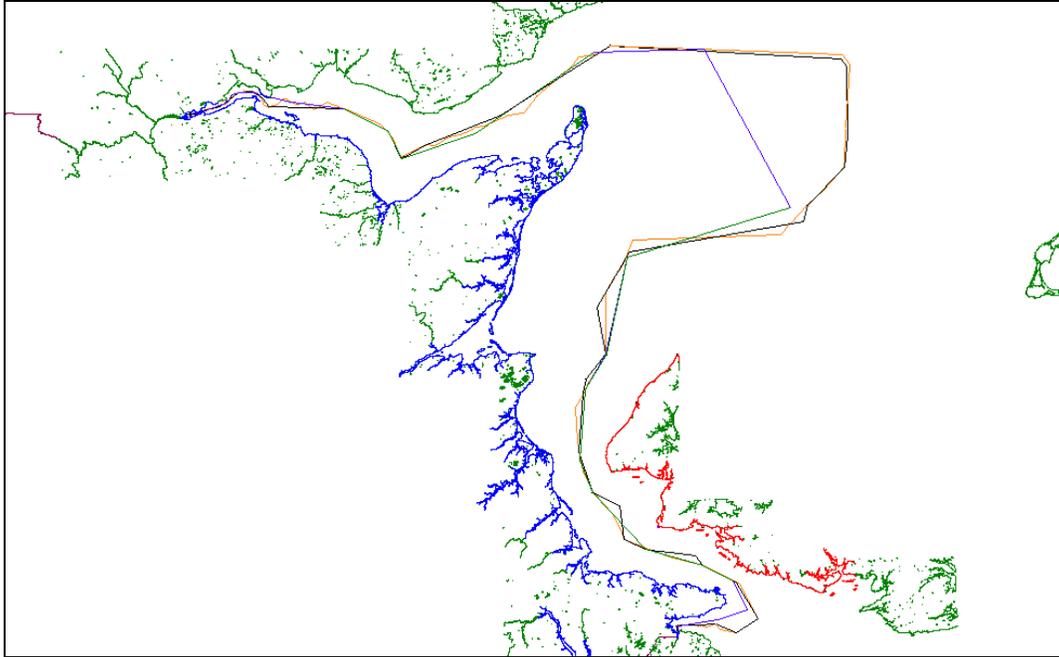


Figure 4 – A Sample of the Various Median Lines

2.7.6 Creating the Final Potential Submerged Lands Polygons

At this stage in the experiment the final median lines have been created. There remains the exercise of locating the relevant intersections of these lines with the appropriate line segments of the CTDB98 so as to enclose areas representative of New Brunswick's submerged lands. Steps, according to the criteria set out in Section 2.7.5, and using CARIS GIS and LOTSTTM where appropriate, were undertaken in order to produce the final polygons. The final product is graphically depicted in Figure 5.

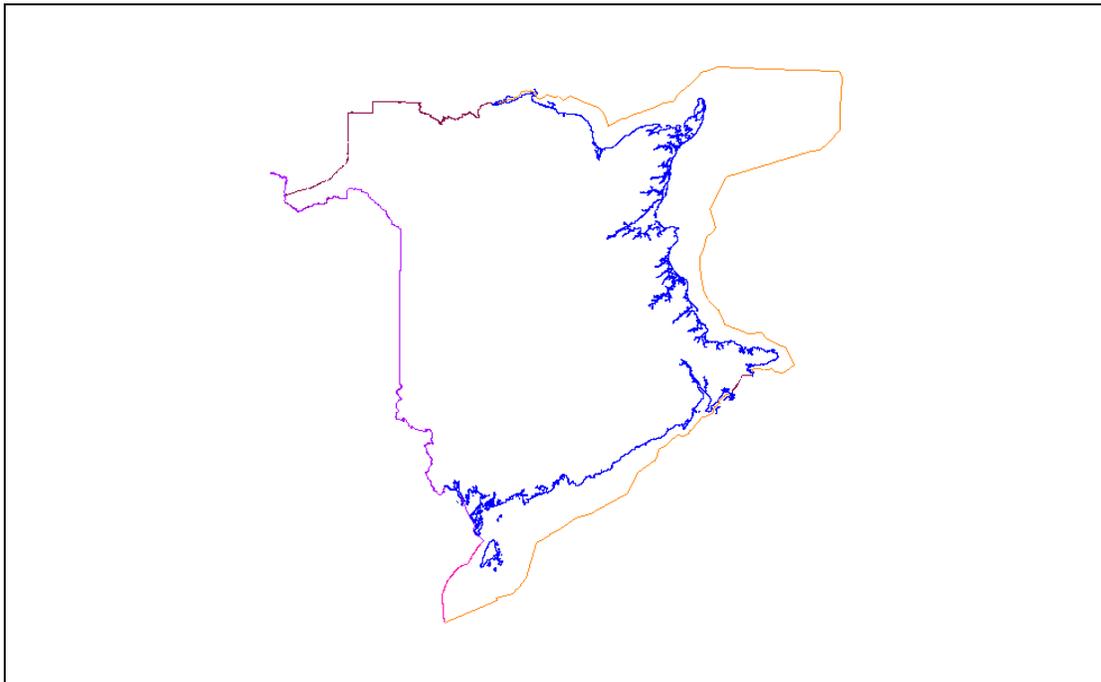


Figure 5 – The Final Polygons

3.0 Conclusions

Technically, the model described in this paper can satisfactorily allow for the production of polygons representative of New Brunswick's submerged lands from "best available data". However, the ideal situation would be to produce the polygons from data (whether integrated from various databases or from a database maintained by one entity) that all contain the same degree of positional accuracy, and preferably a high degree of positional accuracy. Also, if integrated databases are used it would be ideal if the same coastal features were represented. It would also be ideal if all physical features were represented for the geographic area represented by each database.

It is prudent to note that any graphic representation of New Brunswick's submerged lands that were created via this experiment has no binding effect in law as only binding legal agreements, or decisions of a court of law can give that effect. The produced polygons serve only as the fulfillment of the user's (i.e. SNB's) need to have "a" digital representation of these boundaries. It is also pertinent to note that if different baseline points or digital data etc. were utilized, the dimensions of these boundaries would be different. Also, the polygons represent only one *possible potential maximum dimension* of New Brunswick's submerged lands.

There are a number of errors associated with the production of the final polygons. These include (among other things):

- a. Errors introduced due to the original capture of the coordinates by owners of the data sources.
- b. Errors introduced due to the recording of the coordinates by the original surveyor.
- c. Errors introduced due to the digital re-recording of the coordinates for importation into the GIS that were obtained from hard copy.
- d. Errors related to importing the coordinates into the GIS.
- e. Errors related to transformation functions performed by the GIS.
- f. Errors related to the choice and number of baseline point locations.
- g. Errors related to accuracy of digitizing the baseline points.

With regard to the inter-provincial boundaries between New Brunswick and the contiguous provinces of Nova Scotia and Quebec, La Forest [1959 and 1973] offers the opinion that the New Brunswick-Quebec boundary in the Restigouche River runs along the centre of the Restigouche River to the mouth of the Baie des Chaleurs (but encompassing the islands where the river narrows inland, in favor of New Brunswick). There are also a number of sources that describe the New Brunswick-Nova Scotia boundary. These include La Forest [1959 and 1973], March [1954] and correspondence held by DNRE [Noël, 1991]. March [1954] contains a metes and bounds description of the inter-provincial boundary as agreed to by both New Brunswick and Nova Scotia. The sources indicate that the boundary generally runs the middle (between banks) of the Tidnish and Missequash rivers, and the Bay of Fundy. The ideal governance scenario is to maintain spatial information that adequately represents stakeholders' perception of reality.

SNB maintains a number of spatial databases including the CTDB98 (coastlines) and the DPM (inter-provincial boundaries) that were used in this experiment. When the DPM inter-provincial boundaries were integrated with the CTDB98, the New Brunswick-Quebec inter-provincial boundary segments apparently reflected the understanding gained from La Forest [1959 and 1973]. This was not the case with the New Brunswick-Nova Scotia provincial boundary segments that (in a number of instances) intersected with the CTDB98 segments representing the banks of the Missequash River instead of altogether being between the segments representing the banks. The general understanding expressed in the immediately preceding paragraph was taken into consideration when editing the digital data representing the inter-provincial boundaries as part of the process of creating the final submerged lands polygons. The outcome of this process, however, is that these digital representations of the inter-provincial boundaries are approximations. Furthermore, any digital representation of a boundary is only a model that can support further modeling, and management and administrative decision-making. Ground truth always takes precedence. Recent governance research supports the relevance of imprecise boundaries if the existence of these boundaries is not a catalyst for dispute [Nichols, Monahan and Sutherland, 2001]. The precise delimitation of boundaries usually become important in relation to the need to allocate equitable resources perceived to be dissected by the potential boundary. Such is the case with the boundary dispute between Nova Scotia and Newfoundland [Arbitration Tribunal, Nova Scotia-Newfoundland Dispute, 2002].

Governance research also indicates that stakeholders with common interests should form relationships of information sharing (i.e. collaboration, cooperation, integration etc.) that is beneficial to all concerned [Paquet, 1999a and 1999b; Lane 2000; Charette and Graham, 1999; Hoogsteden, Robertson and Benwell; 1999]. This is especially true in terms of information sharing in situations where each shareholder is in need of information held and maintained by another and each stakeholder desires the best available quality data. The federal government, and the provinces of New Brunswick, Nova Scotia and Quebec all have an

interest (obviously for different reasons) in the inter-provincial land boundaries between New Brunswick and Nova Scotia, and between New Brunswick and Quebec. Decisions have been handed down by tribunals and in law that indicate the spatial dimensions of these boundaries, and the Federal government of Canada along with the named provincial governments should all maintain the same digital representations of these boundaries. The same situation applies to international boundaries that form part of the spatial extent of provinces.

Explicit information sharing between these stakeholder entities would at least facilitate the desirable situation where stakeholders have access to the best quality data in which they all have an interest, but are not necessarily the primary collectors. The fact that there is not yet an *explicit* governance mechanism to facilitate the updating of all these stakeholders' databases when one party comes into possession of more accurate digital data is a governance problem and a source of duplication of effort and desynchronized databases. This type of governance problem will continue until all stakeholders cease to maintain data only according to its narrow mandate.

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