Volume 4

Data Integration into a Geographic Information System (GIS)

By Tim Webster (Ph.D), Erin Marshall, Nathan Crowell, and Kate Collins
Applied Geomatics Research Group, Nova Scotia Community College, Middleton, NS

3/1/2013

4 March 2012

1. Introduction

This document summarizes the various input datasets that have been provided to the Applied Geomatics Research Group (AGRG) for the SW Nova Scotia Tidal Project. The data have been assembled in a Geographic Information System (GIS) and converted to a consistent vertical datum (the Canadian Geodetic Vertical Datum of 1928, CGVD28) and horizontal datum (North American Datum 1983, Universal Transverse Mercator Zone 20N). A list of data is provided in Table 1 and the vertical datum conversions are listed in Table 2.

Dataset	**Included in gdb**	Resolution	Vertical Datum Conversion	Notes	Coverage		
					Digby Gut	Petit Passage	Grand Passage
CHS Multibeam via Glen King	yes	10 m	CD2006 to CGVG28		Yes	Yes	Yes
CHS Multibeam via Greg Towse	no	10 m	Assumed CD2006 to CGVG28	Bathymetry values and extent of data different from other CHS multibeam data	Yes	Yes	Yes
CHS Multibeam via Jon Griffin.	no	2 m	CD2006 to CGVG28	2 sets (2006 and 2007) mainly covering offshore.	Yes	Less than 10 m res. CHS data	Yes
Olex Multibeam	Yes	Variable	CD2006 to CGVG28	2 copies of identical data received at different times.	No	Yes	No
GPS	yes	Variable	GRS80 ellipsoid to CGVD28		No	Yes	No
Acadia Grid	no	Varaible	none yet; Supposedly data are in MSL (CGVD28) but this claim is suspect	Positive values offshore, negative values near shore, some discrepancy with CHS charts and multibeam	Yes	Yes	Yes
CHS Digitized Chart	yes	Sparse	Assume in Chart Datum		No	Yes	Yes
GSC Backscatter	yes	10 m	N/A		Yes	Yes	Yes
Fundy 50 m Grid via Greg Towse.	yes	50 m	Unknown. Not yet converted. Seems to be in MSL.	Unknown origin	No	Yes	Yes

Table 1: Bathymetric Data Summary

Vertical Datum Conversion	Digby Gut	Petit Passage (Tiverton)	Grand Passage (Westport)
CD2000 to MSL (CGVD28)	4.39	no data	no data
CD2006 to MSL (CGVD28)	4.415	3.333	2.870

Table 2: Vertical Datum Conversions.

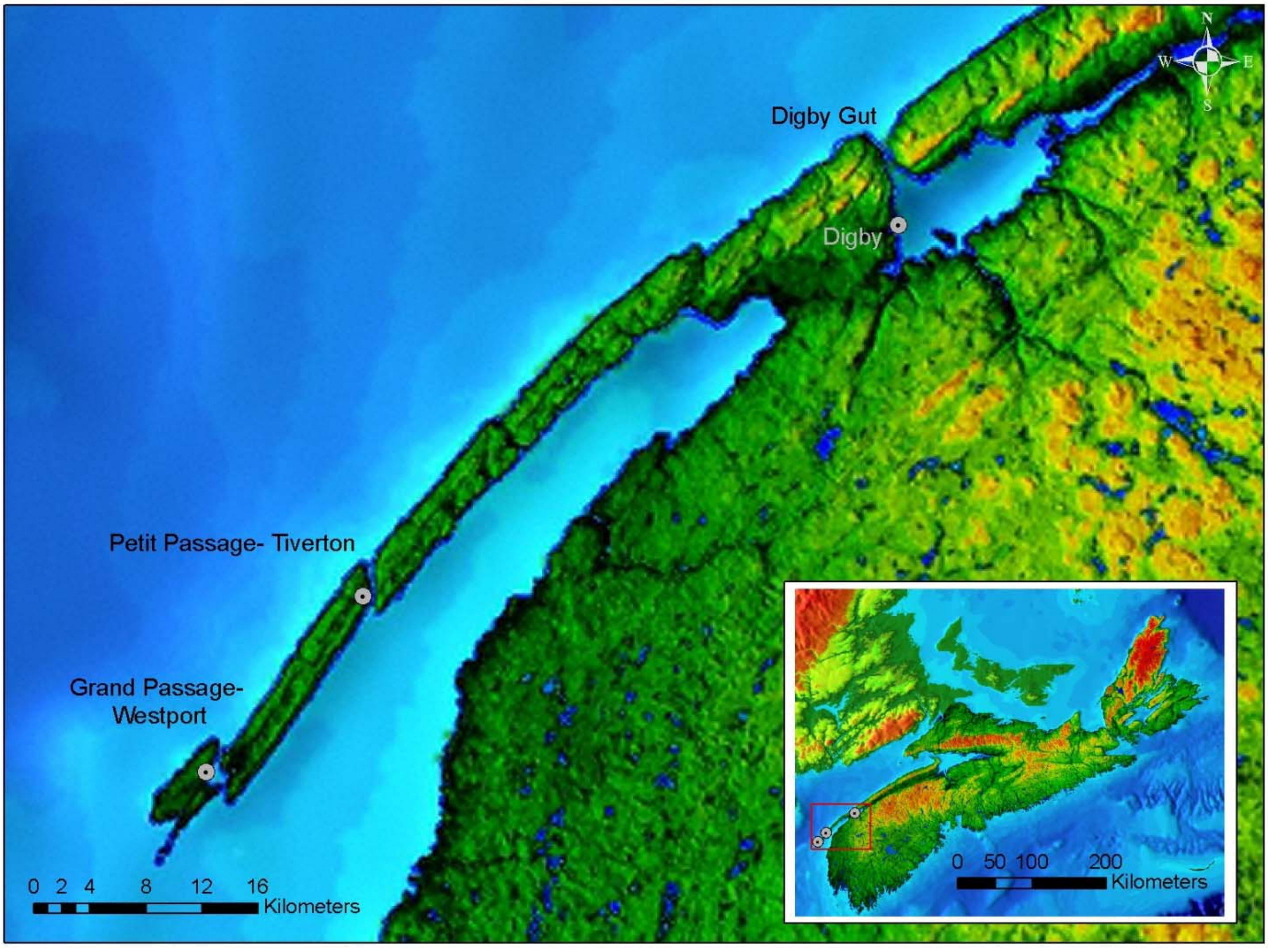

Figure 1: Map of study area showing Grand Passage and the town of Westport, Petit Passage and the town of Tiverton, Digby Gut and the town of Digby. Background image is a digital elevation model (DEM) of Nova Scotia.

2. Canadian Hydrographic Service Multibeam

We received three sets of multibeam data from CHS: two slightly different 10 m resolution datasets covering the passages and the gut, and one 2 m resolution dataset covering mainly the offshore region, with coverage in the passages less than or equal to the 10 m coverage.

2.1.CHS 10 m resolution

The first CHS 10 m resolution multibeam bathymetry dataset was provided by Glen King (CHS) and will be referred to in this report at CHS 10 m (1). The second dataset was provided by Greg Trowse (Dalhousie) and will be referred to as CHS 10 m (2).

2.1.1. Processing Procedures

The data for all three passages, for CHS 10 m (1) and (2), were provided as text files in xyz format, where the horizontal coordinates were latitude and longitude. Each file was imported into a GIS, where it was projected into UTM coordinates (Zone 20N). A TIN (Triangulated Irregular Network, a triangulated mesh of faces that describes a surface) was generated and clipped to fit the original data extent using a 50 m Maximum Edge Length and Perimeter Only processing method. The TIN was converted to a raster using Linear Interpolation and a Sampling Distance of cell size 10 m.

The original bathymetric data were referenced to Chart Datum 2006. CHS provided a conversion to CGVD28 for each passage (Table 2). The appropriate conversion value, $z_{conversion}$, was applied to the depths as follows:

$$\boxed{z_{CGVD28} = z_{CD} - z_{conversion}}$$

Equation 1: Conversion from Chart Datum elevation (z_{CD}) to CGVD28 (approximatel Mean Sea Level, z_{CGVD28}) using a conversion provided by CHS ($z_{conversion}$).

2.1.2. Coverage

Grand Passage

The CHS 10 m datasets have the same coverage in the Grand Passage channel, but CHS 10 m (1) extends ~1.3 km farther north than (2) (Figure 2, Figure 3) and contains depths ~20 m deeper than (2) as a result of the extension into the deeper water. The data consists of a narrow swath through the passage, coming to within ~20 m of the shoreline in a few places but not exceeding ~250 m in width within the passage. The datasets differ by up to 6.7 m (Figure 4); the greatest differences appear near the deep basin north of the passage, and within the channel.

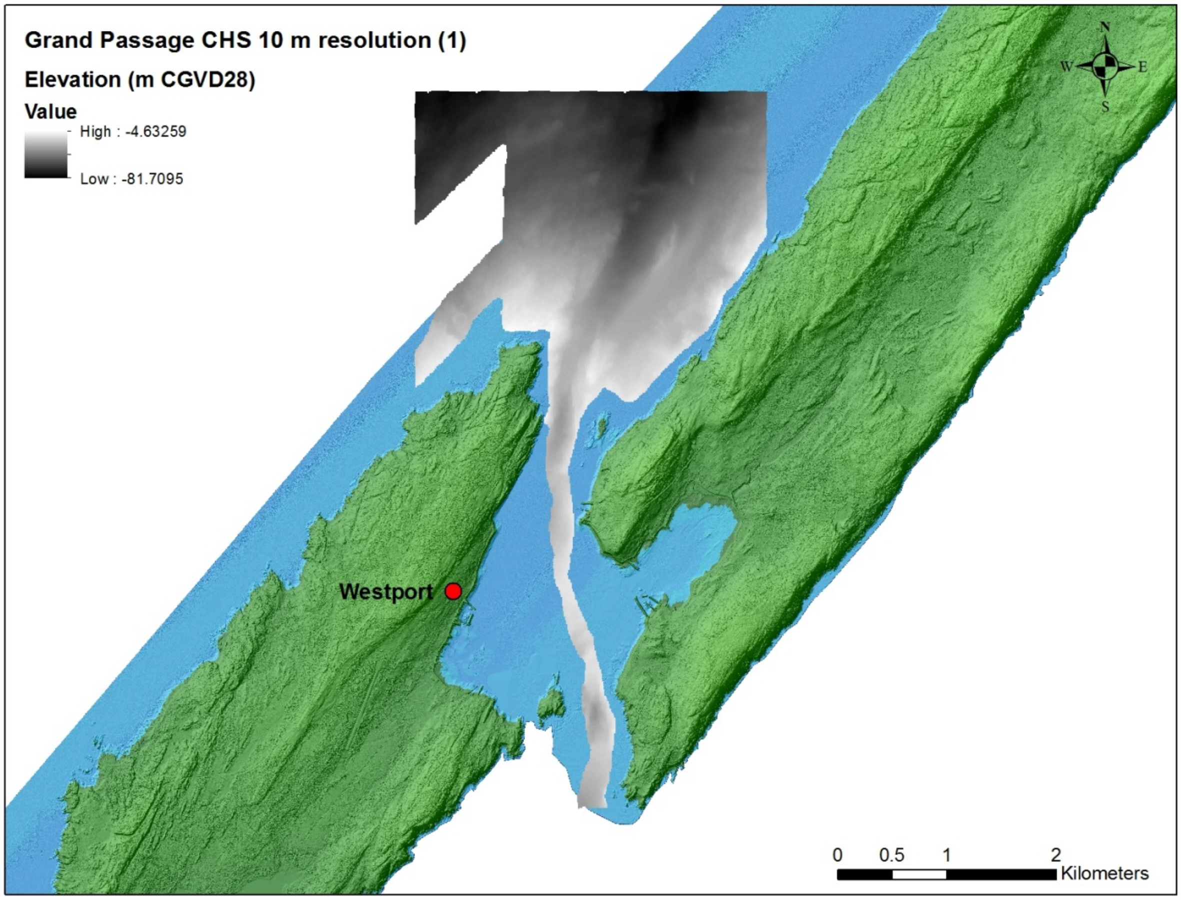

Figure 2: Grand Passage CHS 10 m multibeam bathymetry data, courtesy of Glen King (CHS).

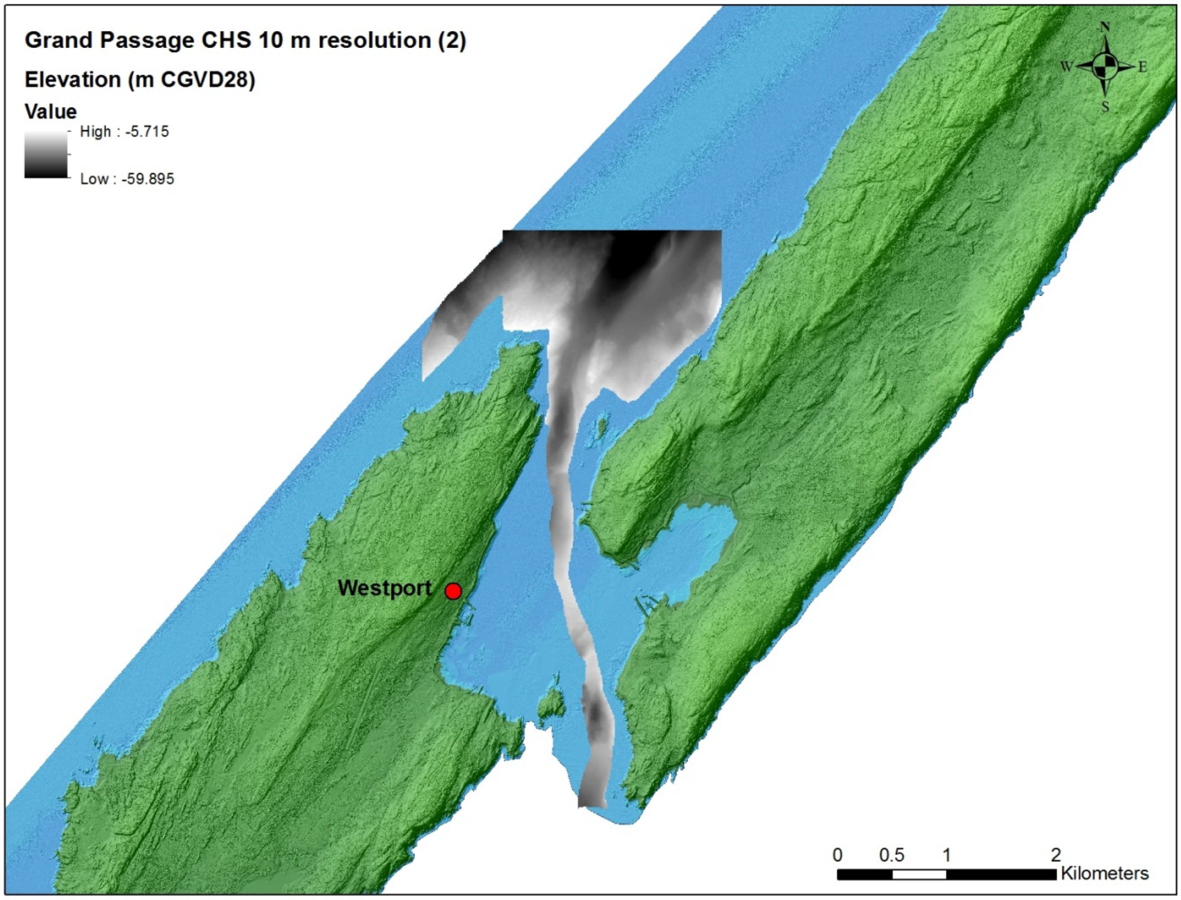

Figure 3: Grand Passage CHS 10 m multibeam bathymetry data, courtesy of Greg Towse.

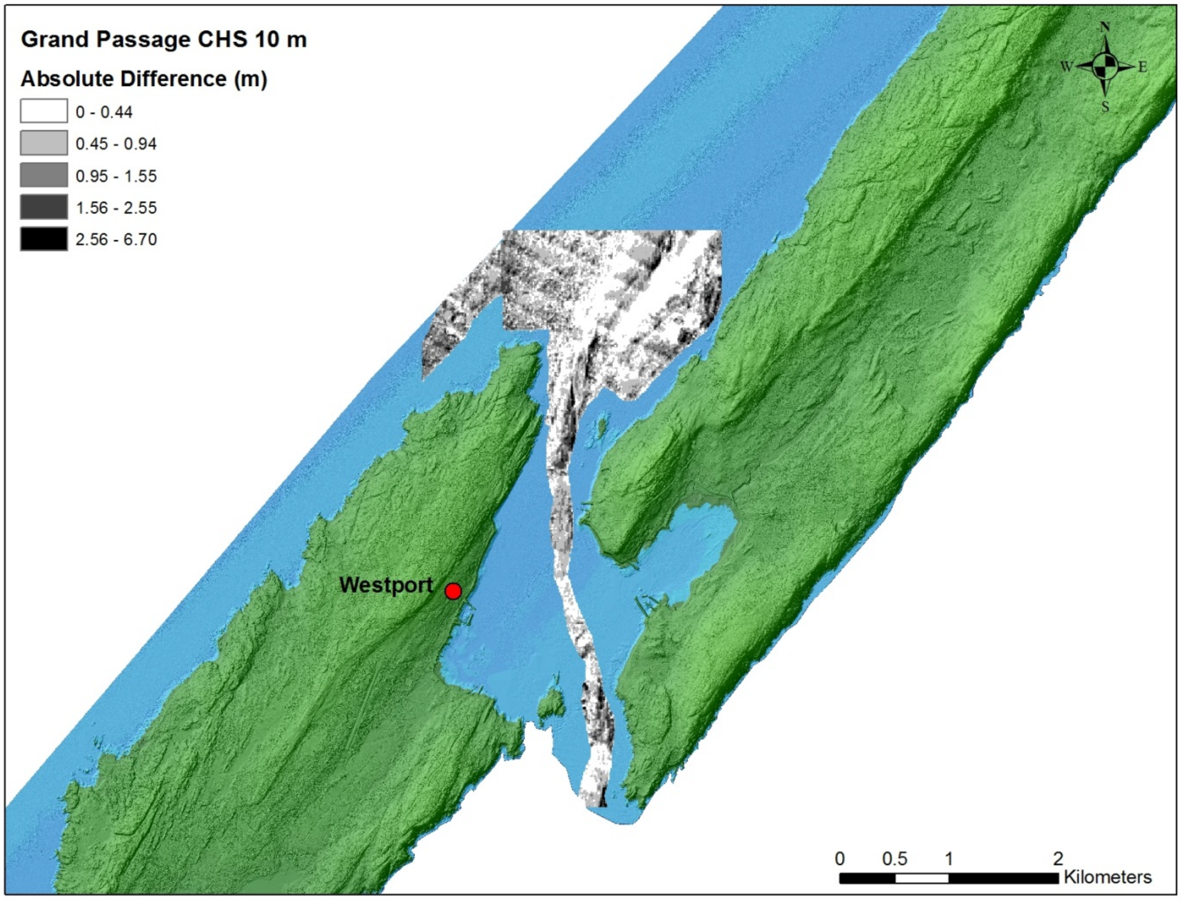

Figure 4: The absolute value of the difference between the two different CHS 10 m datasets at Grand Passage; maximum difference is 6.7 m.

Petit Passage

The CHS 10 m datasets have the same coverage in the Petite Passage channel (Figure 2, Figure 3). The data consists of a narrow swath through the passage, and continues to a larger area north in the Bay of Fundy. The datasets differ by up to 12.8 m (Figure 4); the greatest differences appear near the deepest part of the channel within the passage.

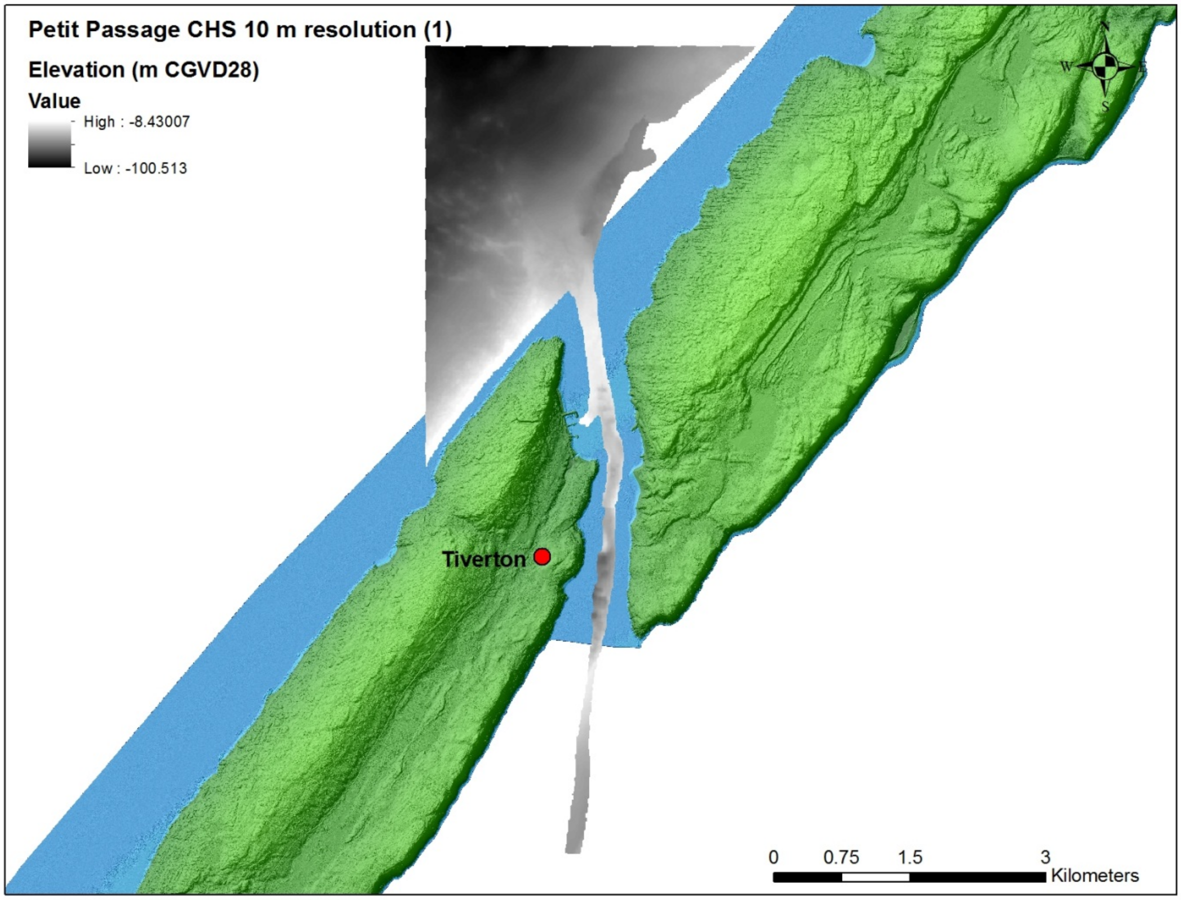

Figure 5: Petit Passage CHS 10 m multibeam bathymetry data, courtesy of Glen King (CHS).

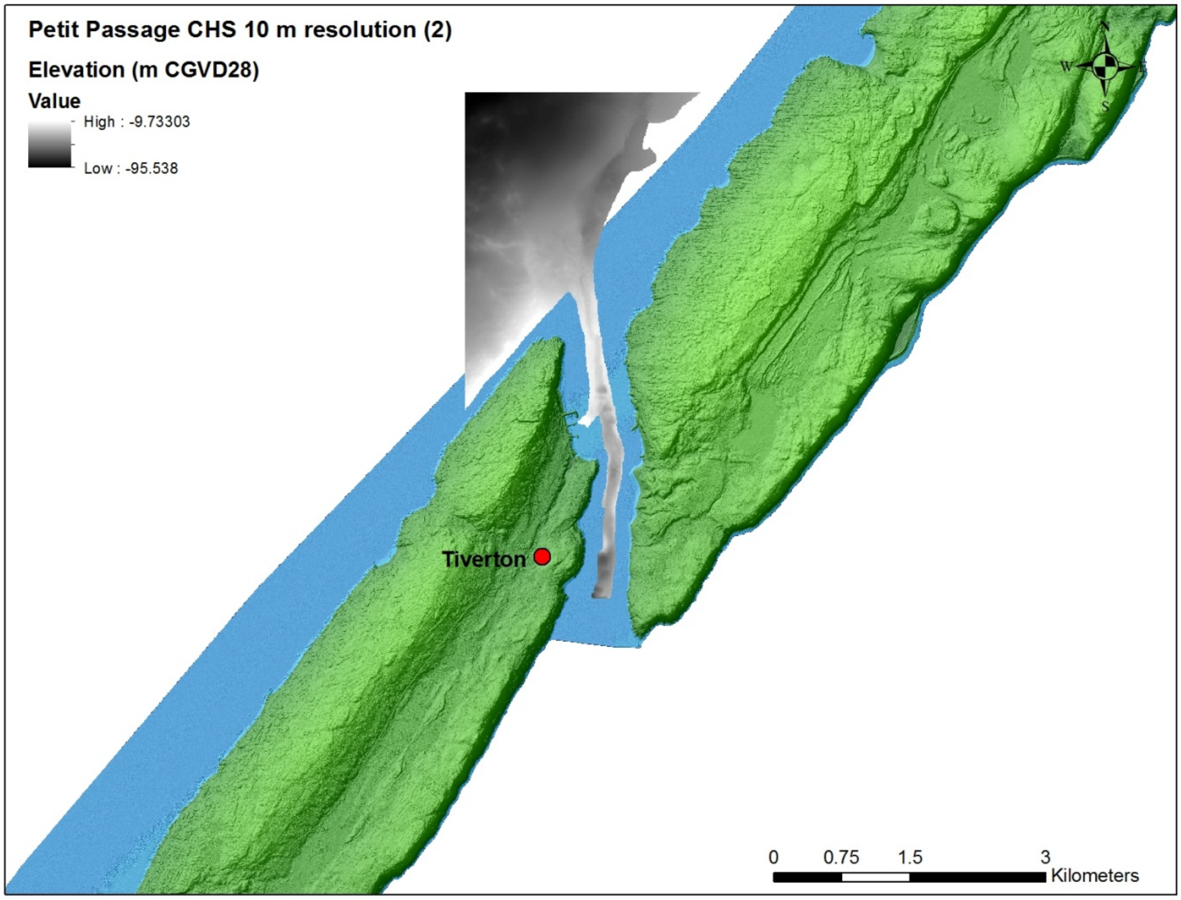

Figure 6: Petit Passage CHS 10 m multibeam bathymetry data, courtesy of Greg Towse.

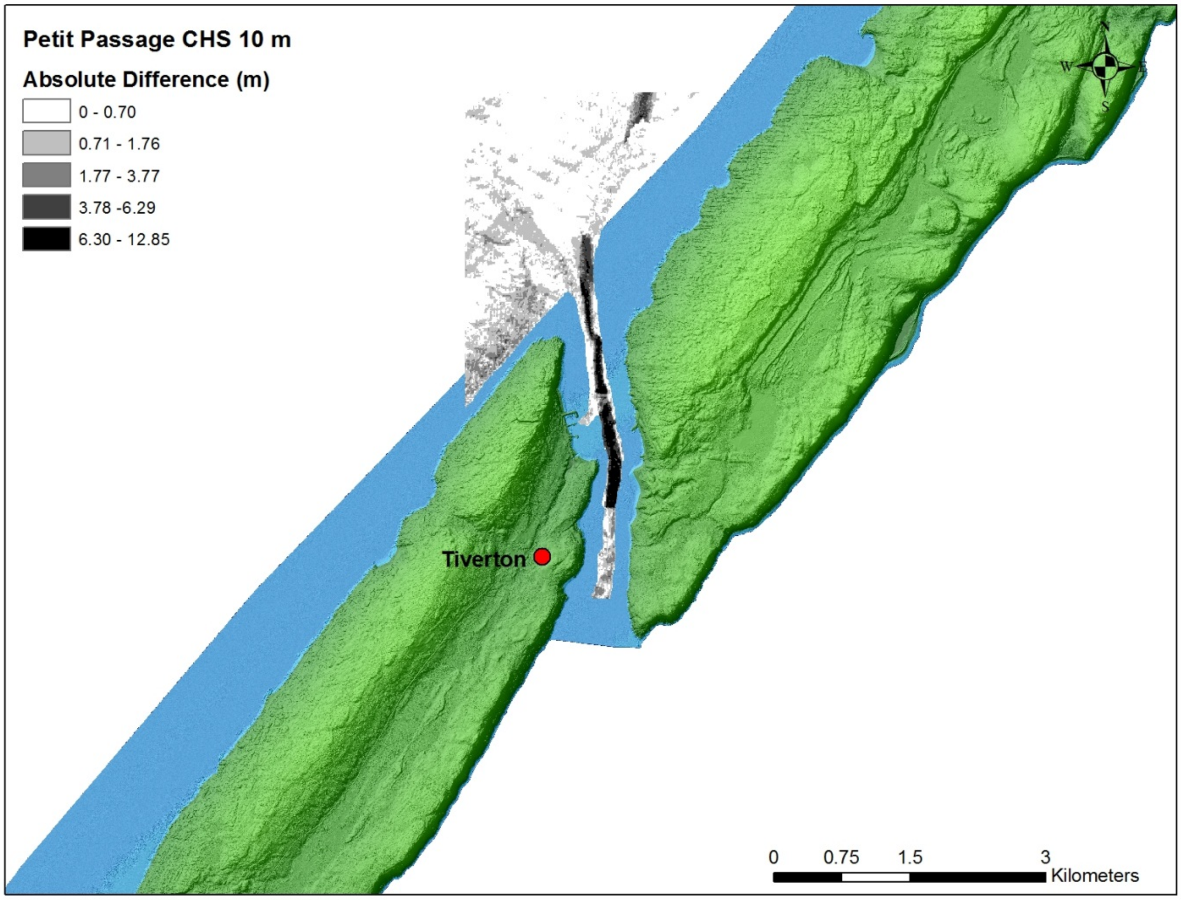

Figure 7: The absolute value of the difference between the two different CHS 10 m datasets at Petit Passage. Differences up to 12.85 m exist within the deep channel.

Digby Gut

Both CHS 10 m datasets provide good coverage of Digby Gut, getting to within 100 m of the coast in some areas and extending south to the town of Digby (Figure 8, Figure 9). CHS 10 m (1) extends up to 4 km north of the coast, while CHS 10 m (2) extends 1.3 km less, to only ~2.6 km offshore. The datasets have similar maximum and minimum depths; the deepest value is ~-98 m (CGVD28) in the center of the channel and the shallowest depth is ~-4 m near the eastern shore of the channel. In addition to their different extents, Figure 10 shows that CHS 10 m (1) and (2) have slightly different values, differing by up to 8 m near the slope of the deep channel. This suggests the original multibeam data was post-processed into 10 m grids slightly differently by CHS.

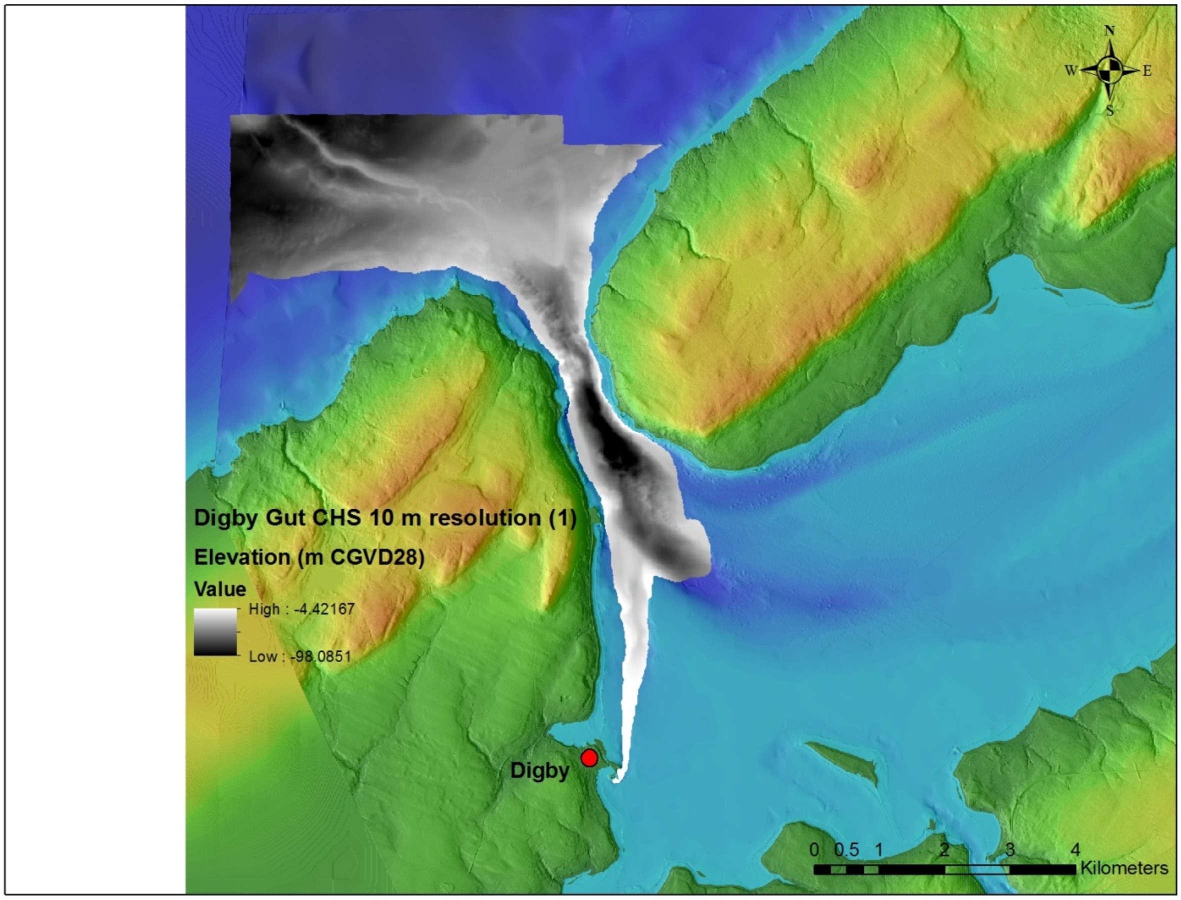

Figure 8: Digby Gut CHS 10 m multibeam bathymetry data, courtesy of Glen King (CHS).

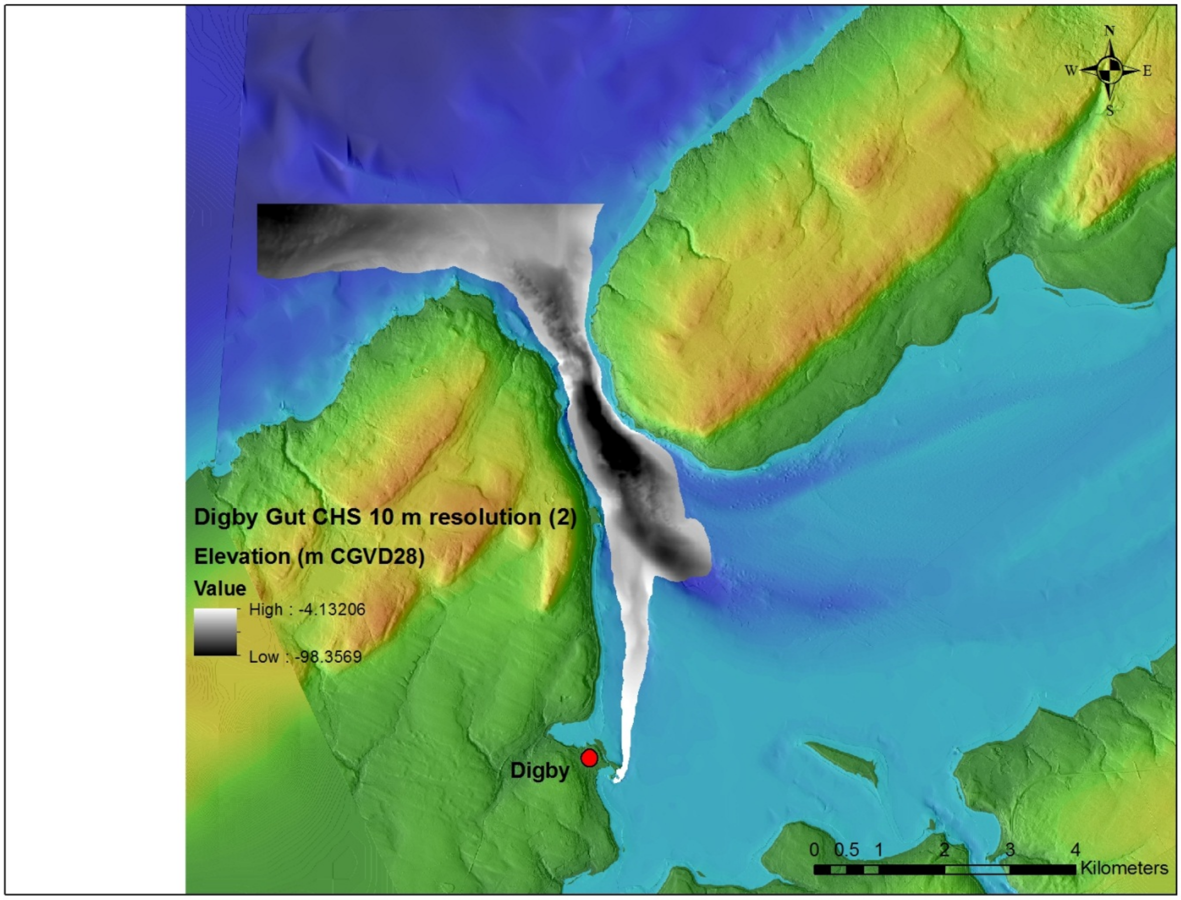

Figure 9: Digby Gut CHS 10 m multibeam bathymetry data, courtesy of Greg Towse.

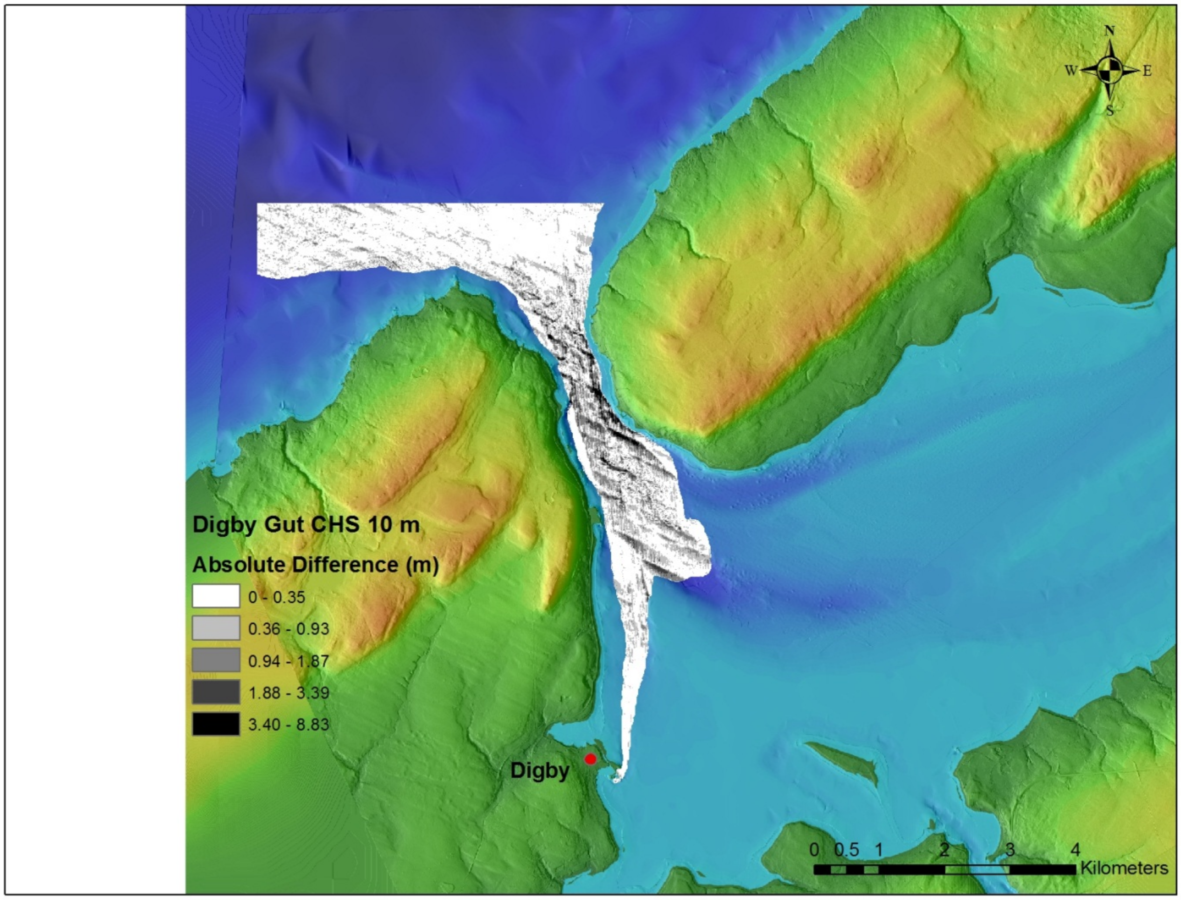

Figure 10: The absolute value of the difference between the two different CHS 10 m datasets at the Digby Gut. Differences up to 8.8 m exist along the edges of the deep channel.

2.2. CHS 2 m resolution

A set of bathymetric points with spacing of approximately 2 m was provided by Jon Griffin of CHS for the area of interest. These points were processed into a 2 m grid and converted from CD2006 to CGVD28.

2.2.1. Coverage

The data extends off shore northwest of Digby Gut and extends southwest past the tip of brier island in the Bay of Fundy. Each of the channels is covered with a similar extent as with the CHS 10 m bathymetry data (Figures 11-13).

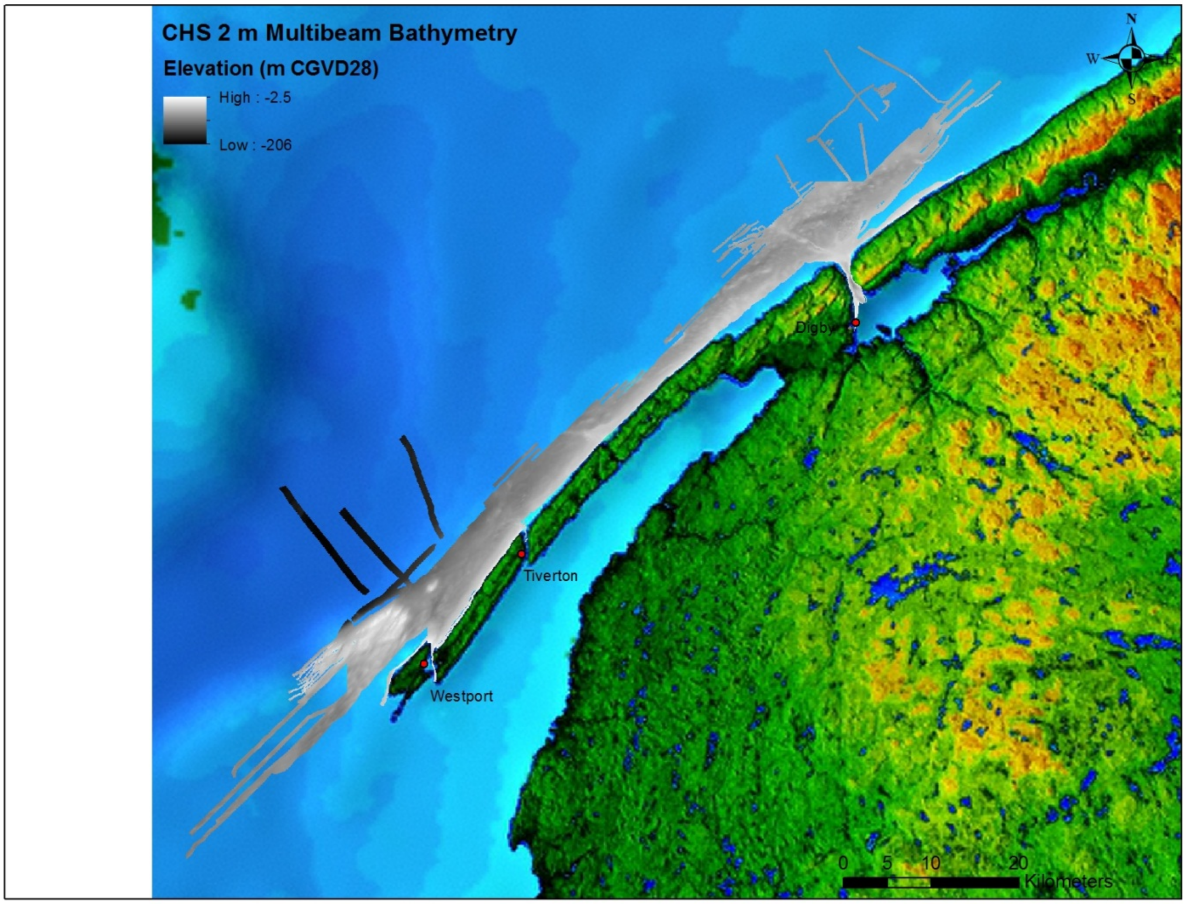

Figure 11: Complete extent of CHS 2 m resolution data.

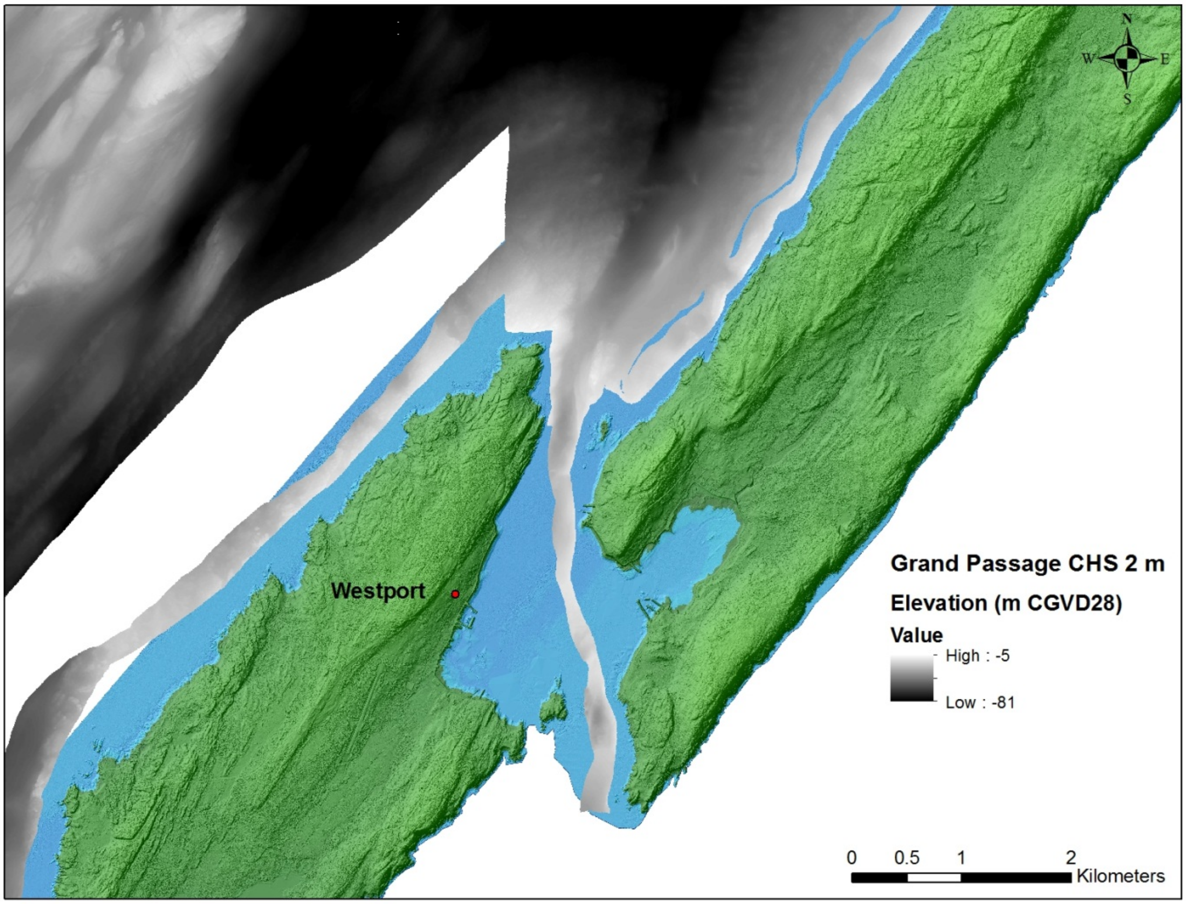

Figure 12: Grand Passage CHS 2 m grid.

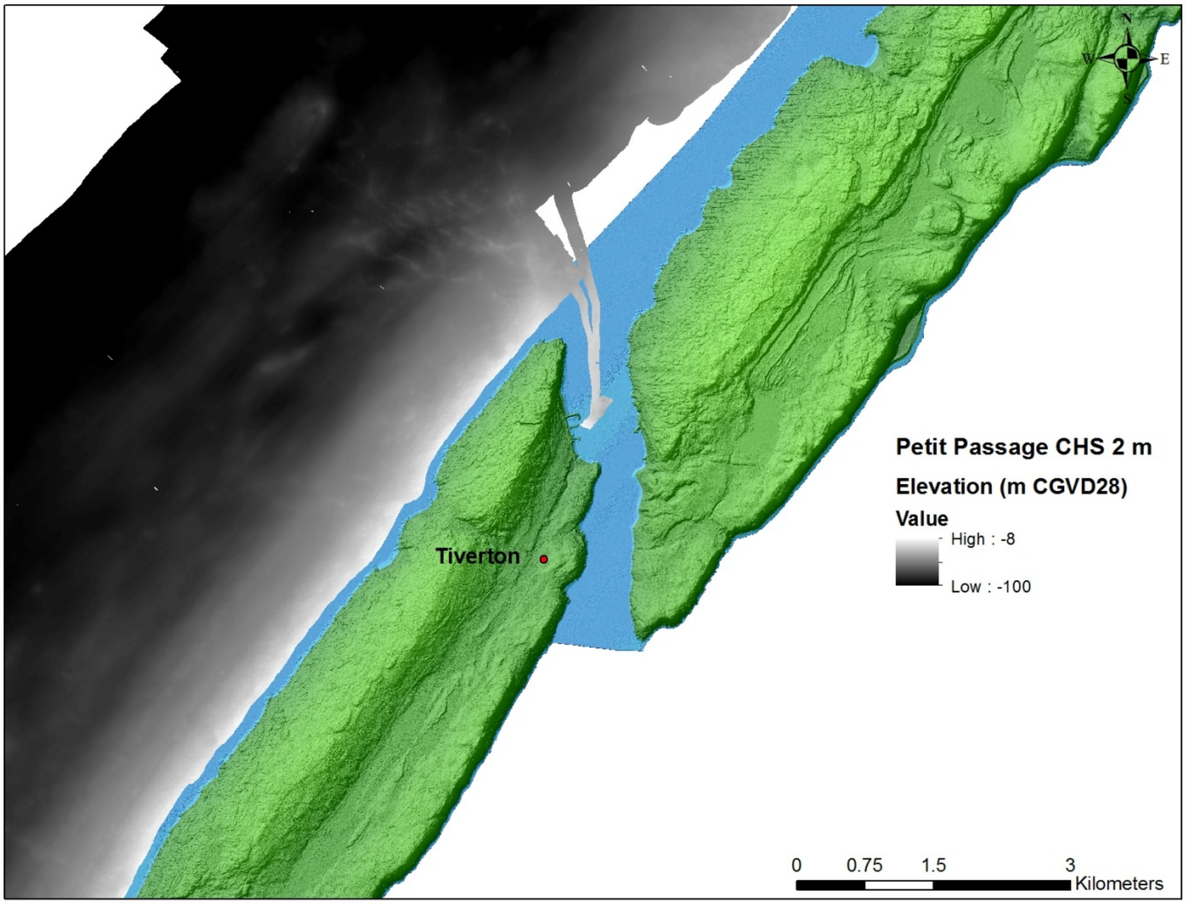

Figure 13: Petite Passage CHS 2 m grid.

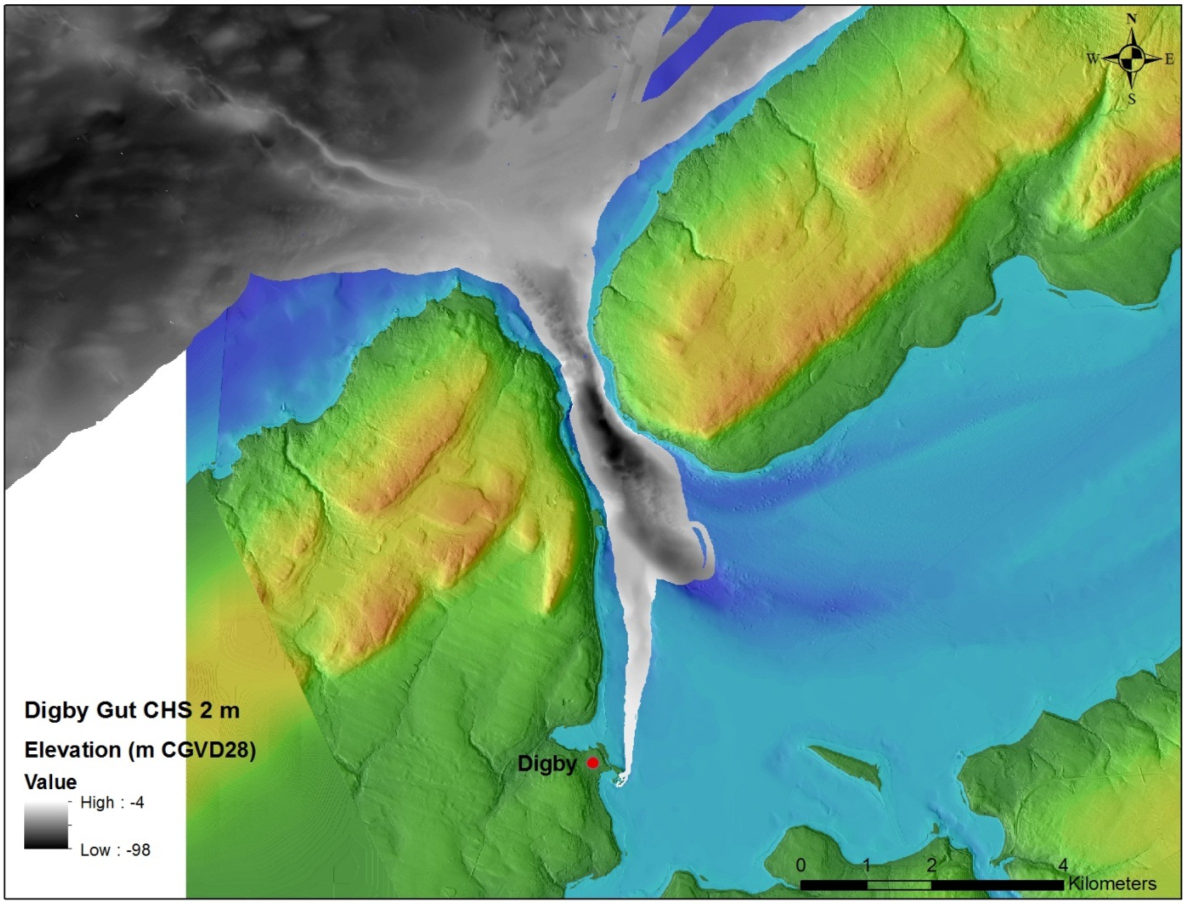

Figure 14: Digby Gut CHS 2 m grid.

3. Olex Multibeam

The Olex bathymetric survey uses a predicted tidal model to compensate for the vertical motion of the tide and uses a local chart datum for the vertical datum reference. Based on personal communications with Brian Sibly of CMC Electronics, it is believed that the Westport tidal station was used as a reference. The data were converted from CD2006 to CGVD28 using the values presented in Table 2. The Olex bathymetry referenced to CGVD28 was surveyed for Petite and Grand Passages (Figure 15, 16, 17). A survey grade GPS system was mounted on the vessel to measure the change in water elevation during the survey with the intent to compensate the data to a local vertical datum (Figure 18). However, the proprietary software that accompanies the Olex system did not allow for such integration.

3.1.Coverage

The Olex system was deployed to survey the channels in Petite Passage and Grand Passage.

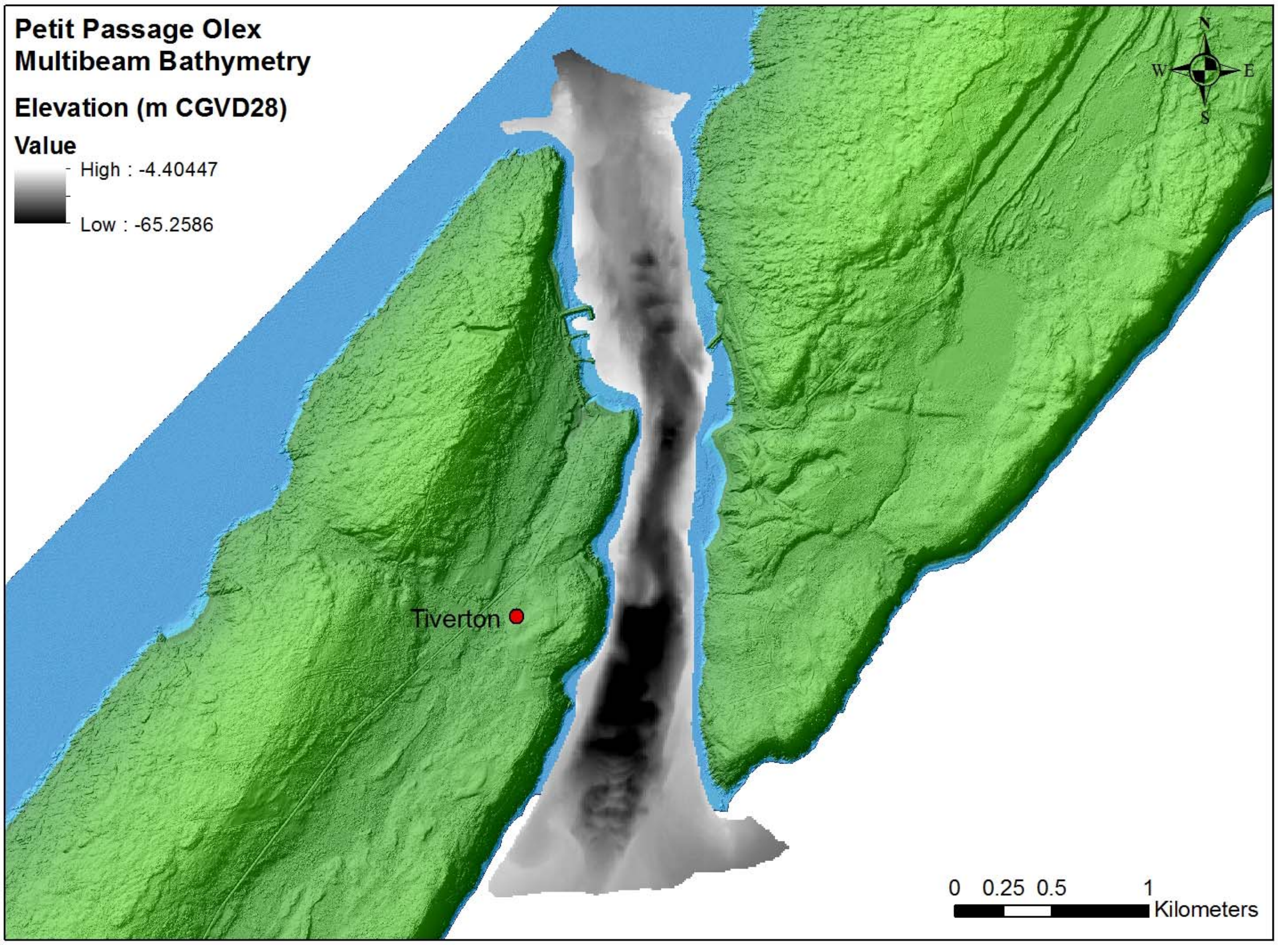

Figure 15: Olex multibeam coverage for Petite Passage.

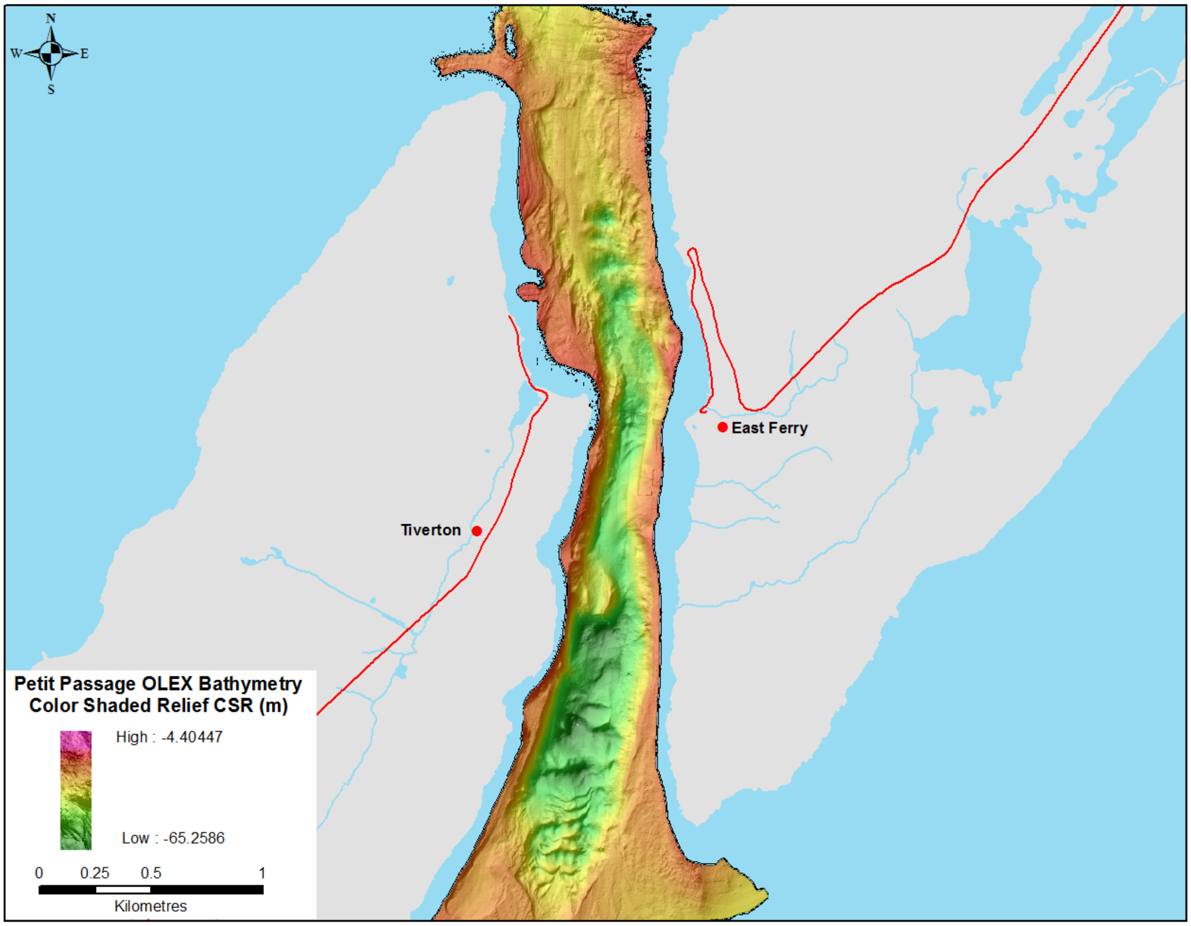

Figure 16: Olex multibeam coverage, color shaded relief (CSR) image for Petite Passage.

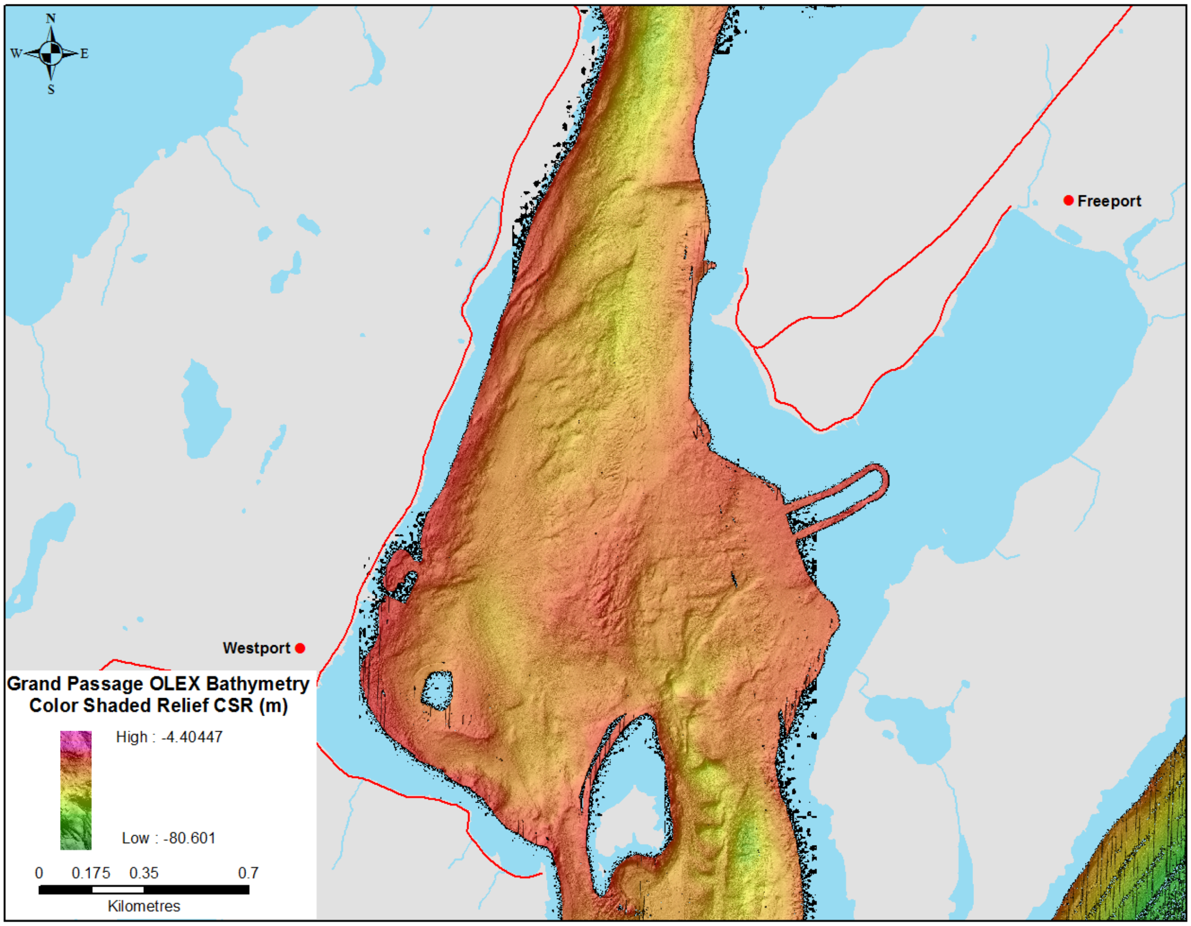

Figure 17: Olex multibeam coverage, color shaded relief (CSR) image for Grand Passage.

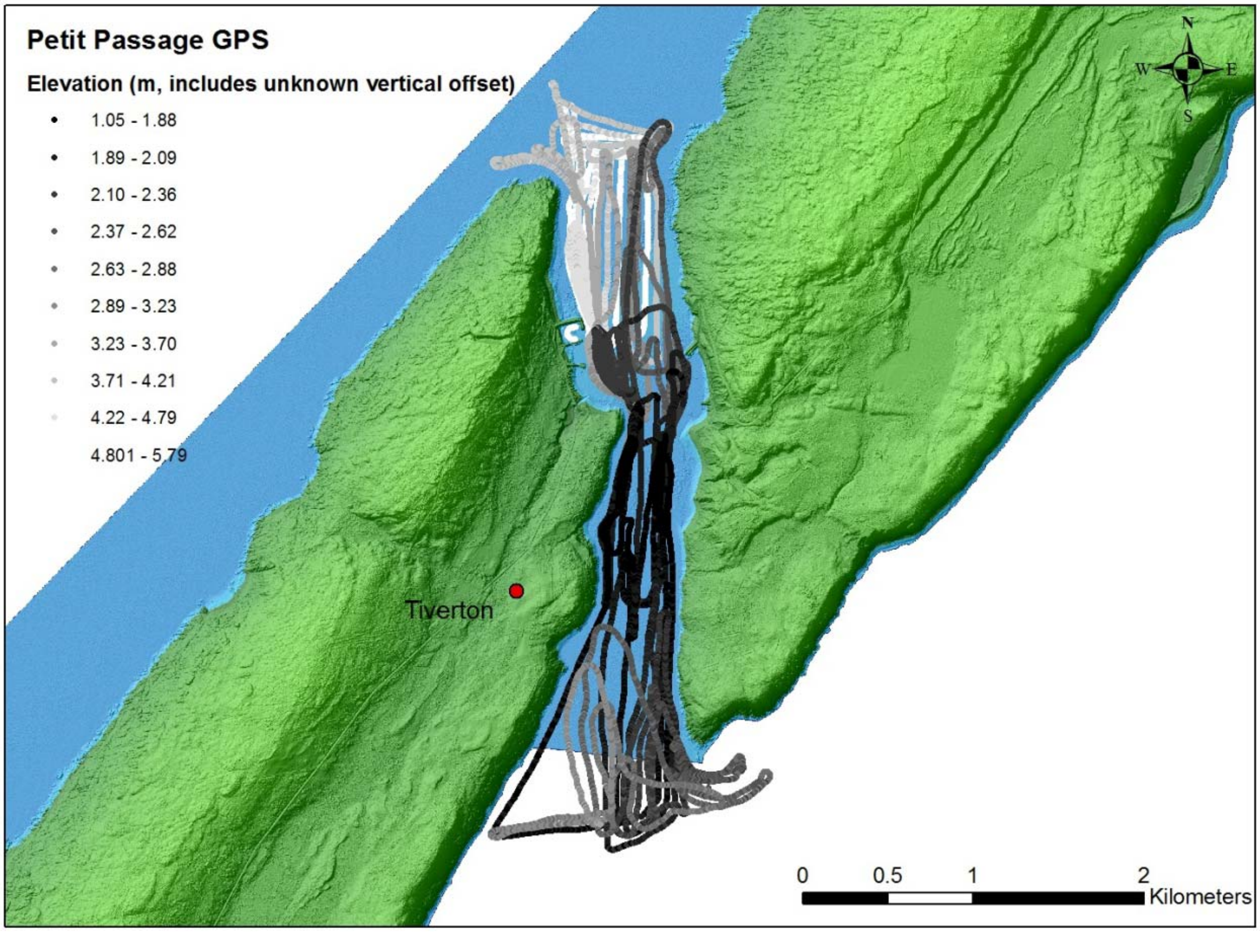

Figure 18: GPS track and elevation of the boat used in the Olex multibeam survey.

4. Acadia Bathymetric data for Modelling

The Acadia modelling was based on an irregular set of points representing the bathymetry from various sources. The vertical datum of these bathymetric points was summed to be mean sea-level. The point density increases significantly near the shore and in the channels (Figure 19).

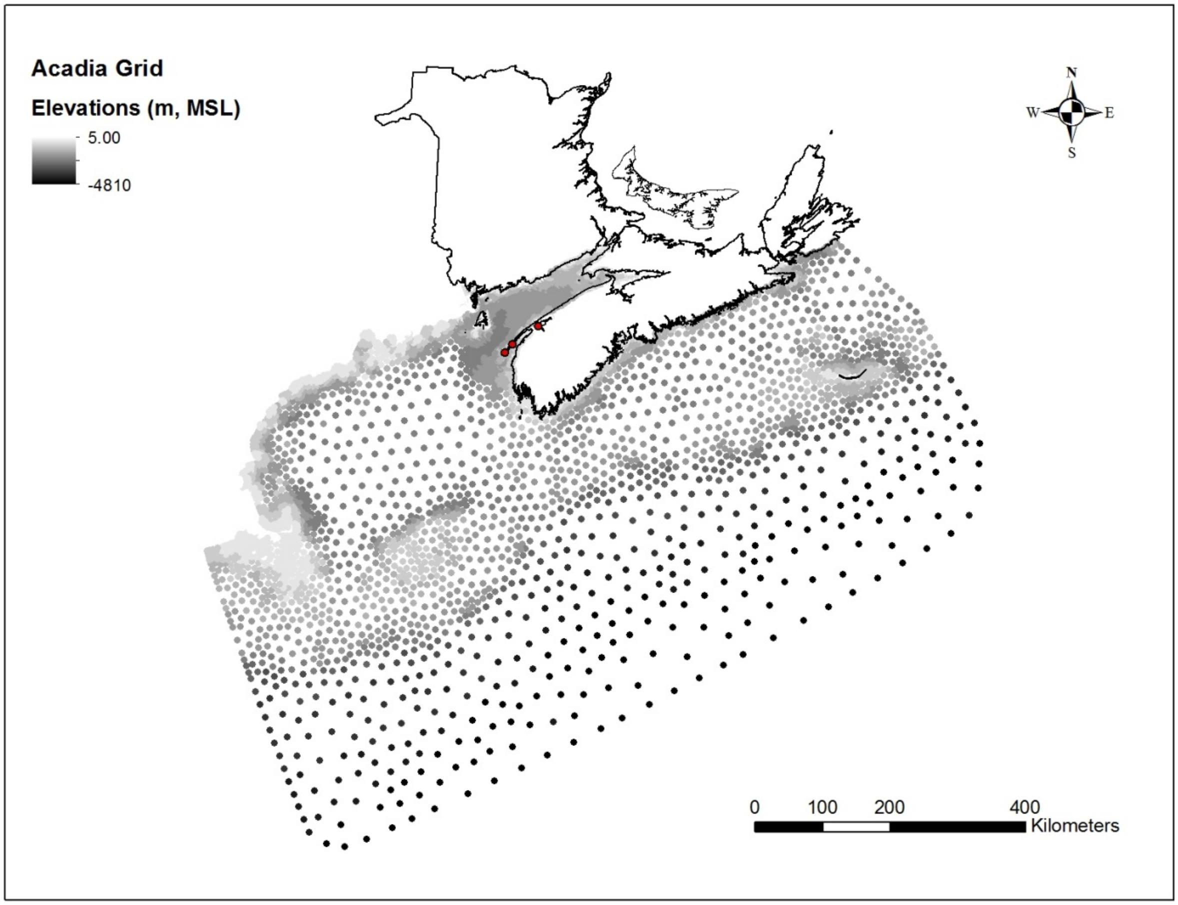

Figure 19: Acadia bathymetric points used in their modelling, referenced to MSL.

5. Digitized Chart

In addition to the multibeam and the bathymetric points used by Acadia a CHS chart was incorporated into the GIS database for Petite Passage. Depth contours and spot elevations are referenced to chart datum (Figure 20).

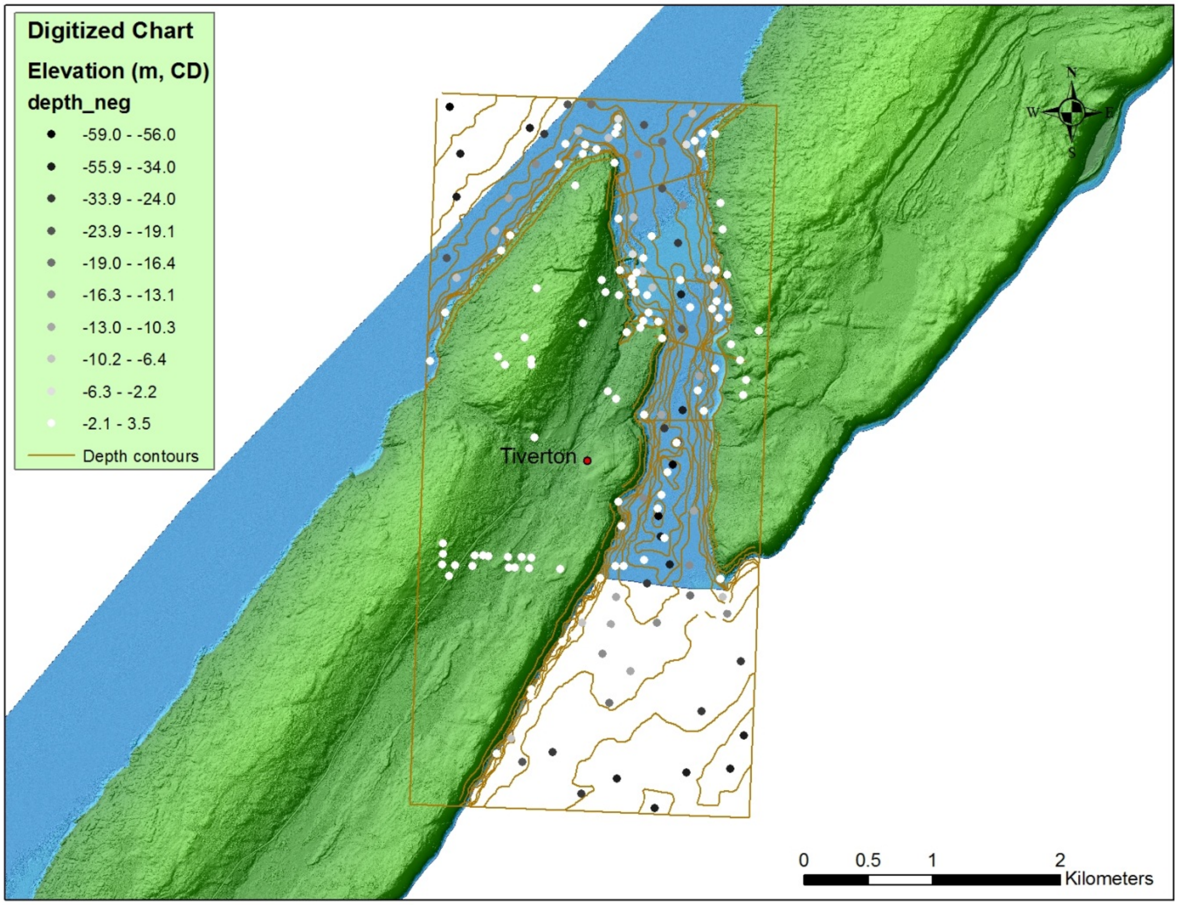

Figure 20: Digitized Chart for Petite Passage.

6. Acoustic Doppler Current Profiler (ACDP)

Acoustic Doppler Current Profiler (ACDP) positions where they were deployed data were provided to the Applied Geomatics Research Group (AGRG) for inclusion in the GIS. The data was assembled in the GIS and converted to a horizontal datum (North American Datum 1983, Universal Transverse Mercator Zone 20N). Only the locations of the ACDP were provided for inclusion in the GIS. In addition to location, the mean depth and start and end dates of the deployment are included.

The following figures show the deployment locations of the ACDP units deployed in Digby Gut (Figure 21), petite Passage (Figure 22), and Grand Passage (Figure 23).

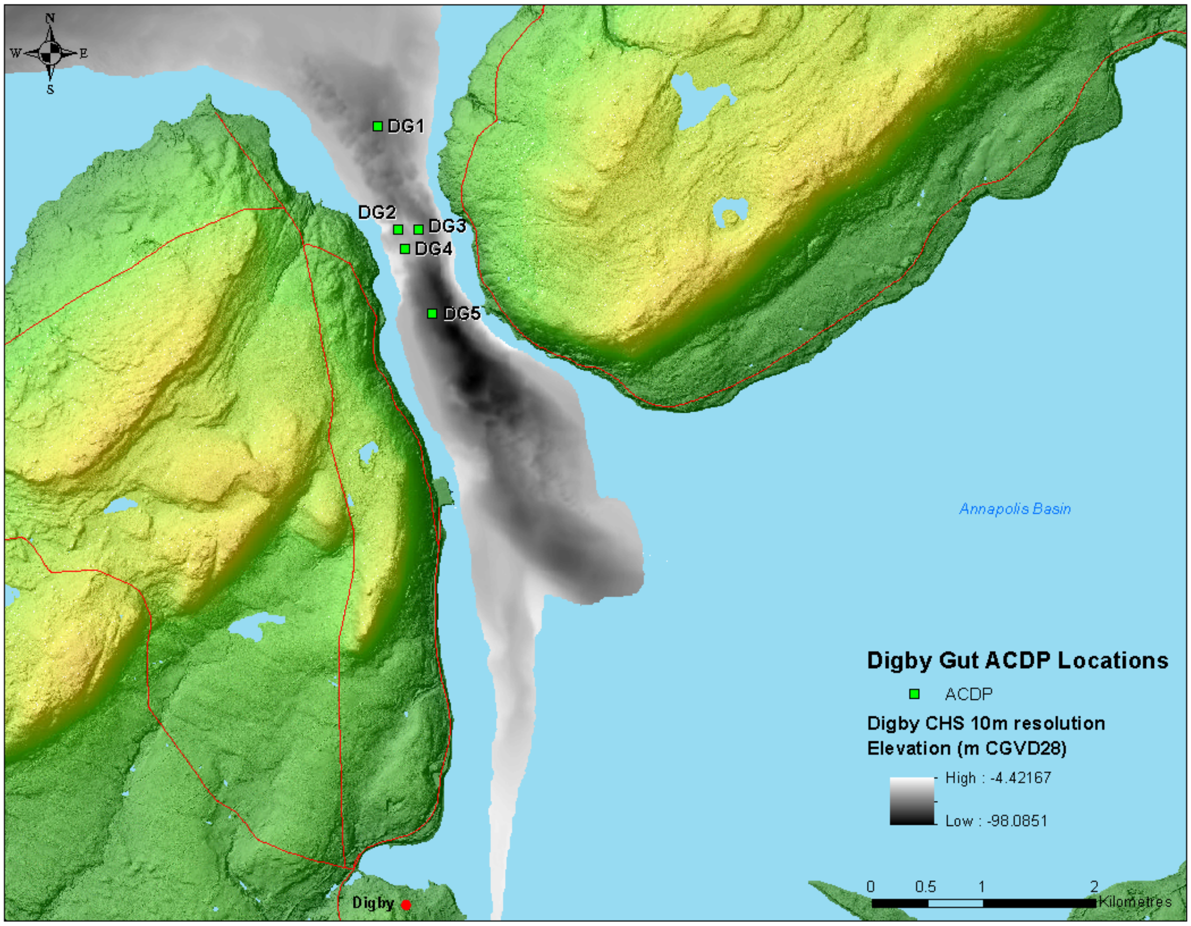

Figure 21: Location of ACDP deployment in Digby Gut.

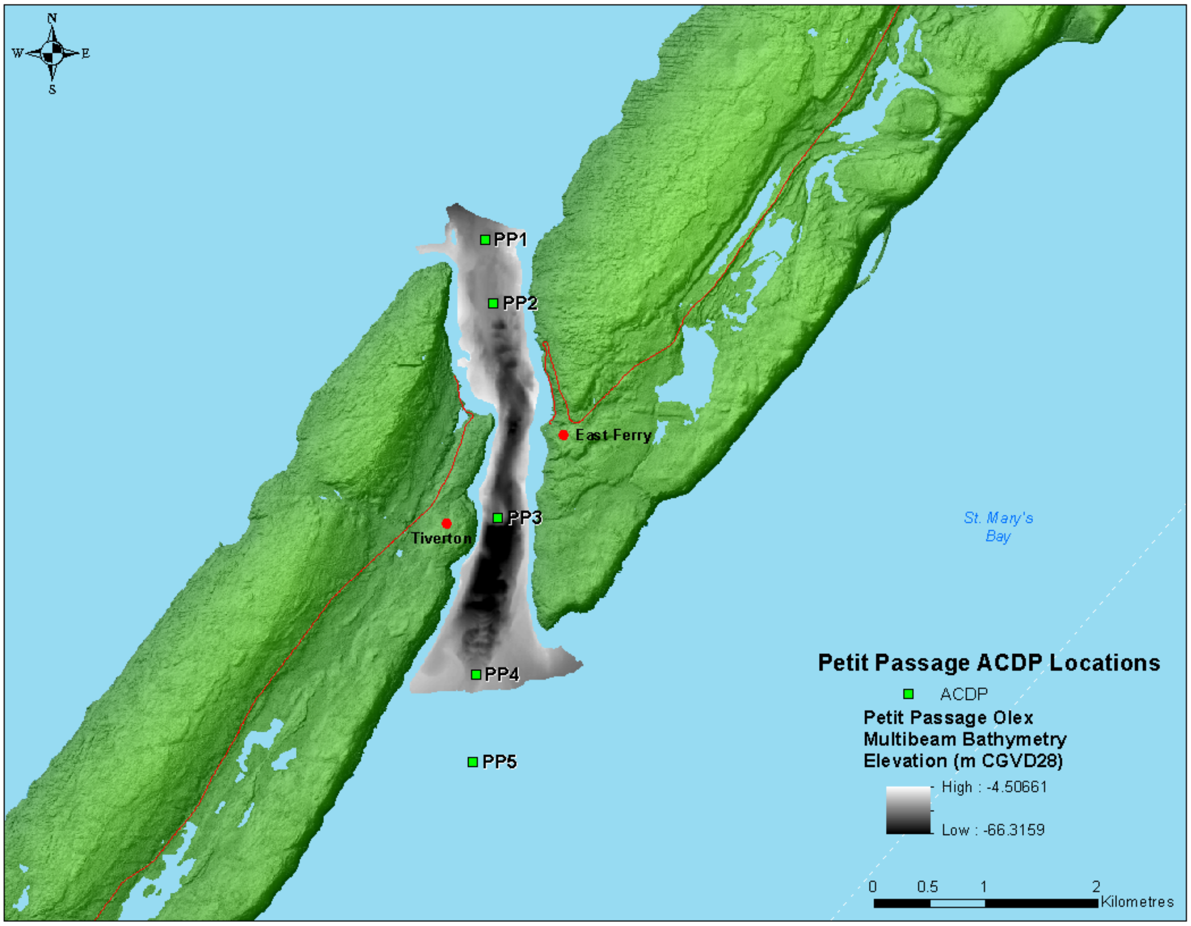

Figure 20: Location of ACDP deployment in Petit Passage.

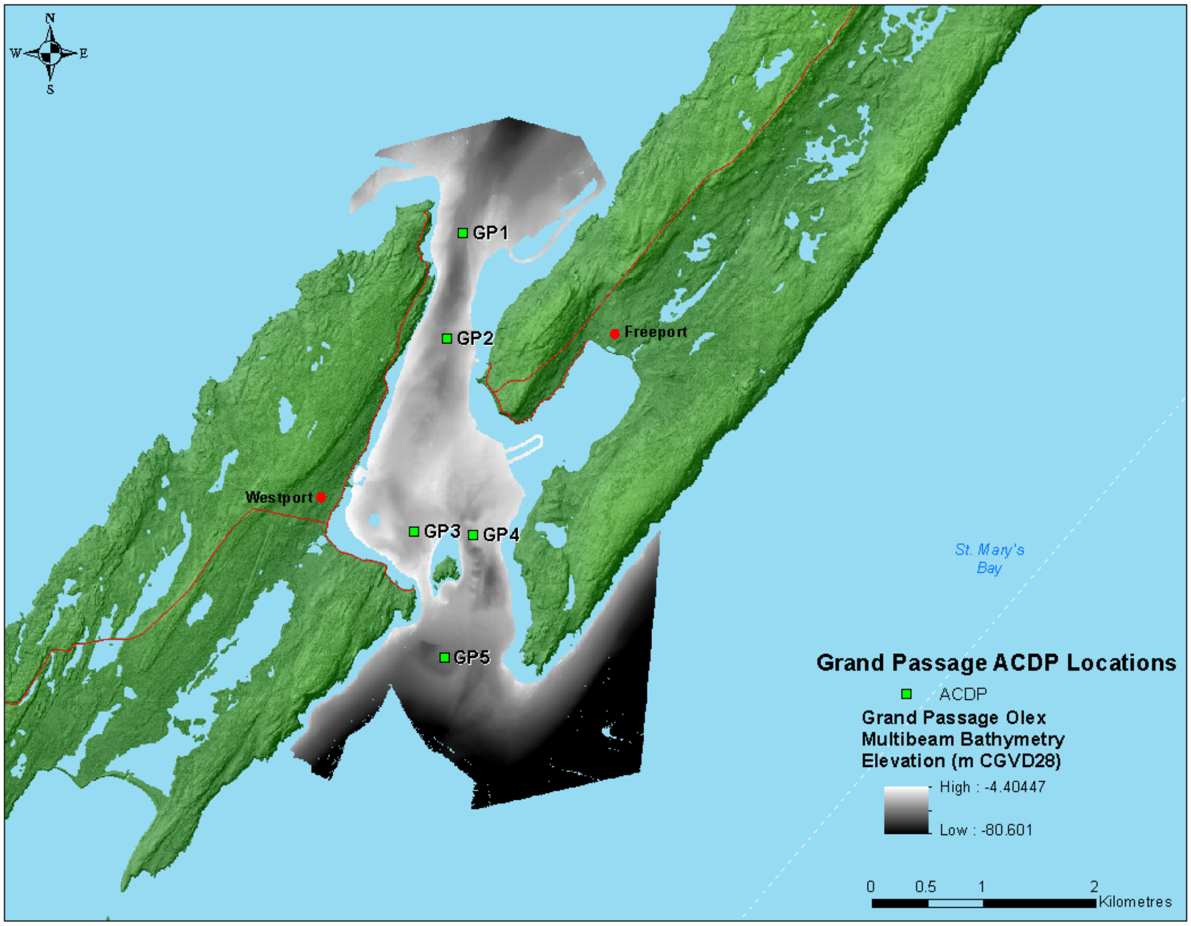

Figure 21: Location of ACDP deployment in Grand Passage.

7. Surface Drifters

Surface Drifter data were provided to the Applied Geomatics Research Group (AGRG) for inclusion in the GIS. The data has been assembled in a Geographic Information System (GIS) and converted to a horizontal datum (North American Datum 1983, Universal Transverse Mercator Zone 20N).

Surface drifters equipped with GPSZ were deployed in the following areas: Grand Passage; Petite Passage; "The Gap" south of Green Island off of Brier Island; channels west of Big Tusket Island; Indian Sluice; Tittle Channel west of Fox Island, Flat Island, Kings Island and Outer

Sheep Island; “The Sluice” east of Morris Island; the Cat Island Bridge channel; channel west of Lower East Pubnico; Port Clyde; and Port Herbert.

In the data assemblage the raw tabular point data was converted to ESRI point shape files. These files were further converted to raster and the Minimum, Maximum and Mean flow speed (m/s) of the tidal currents were calculated for Grand Passage and Petit Passage (Figure 24-29). In the other areas the speed is available in the point shape file.

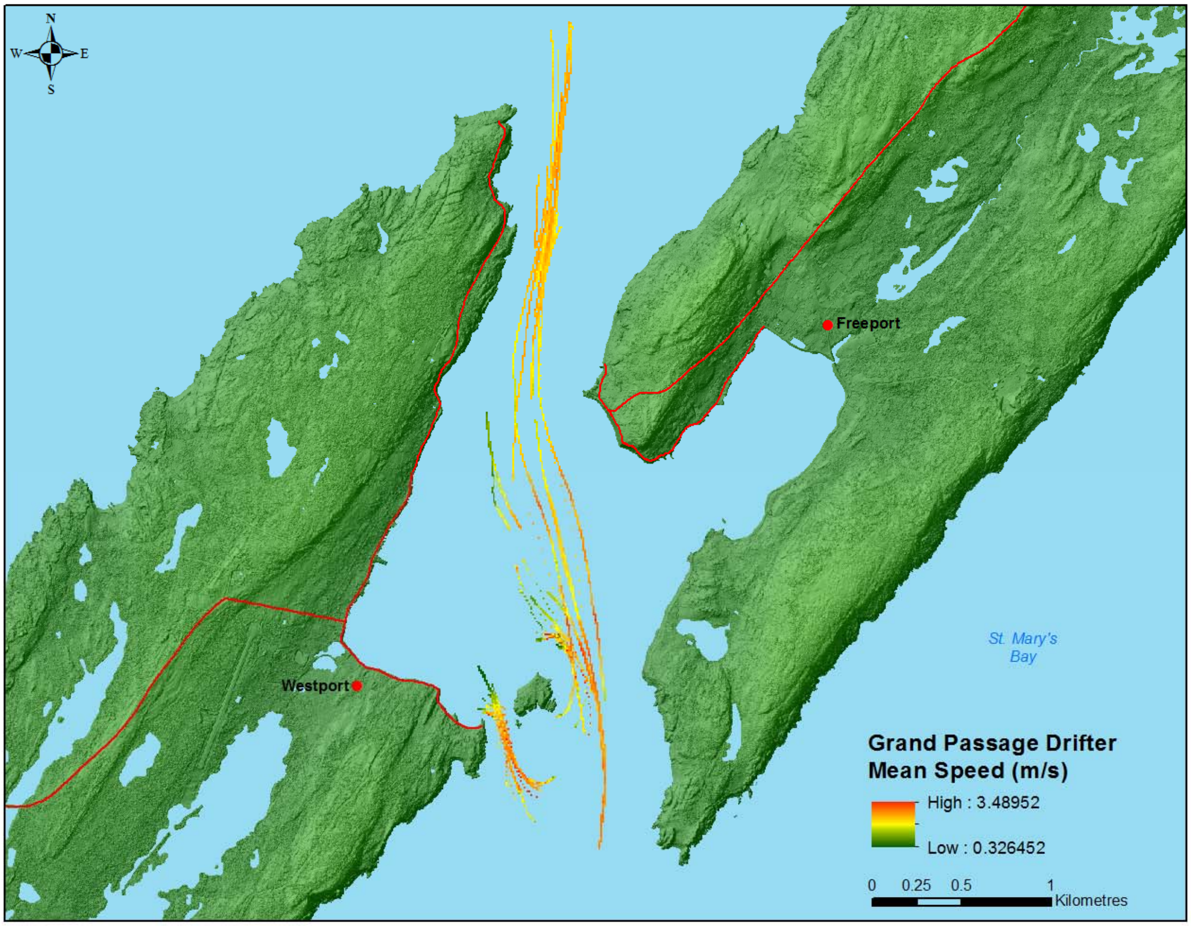

Figure 24: Drifter Mean Speed (m/s) in Grand Passage

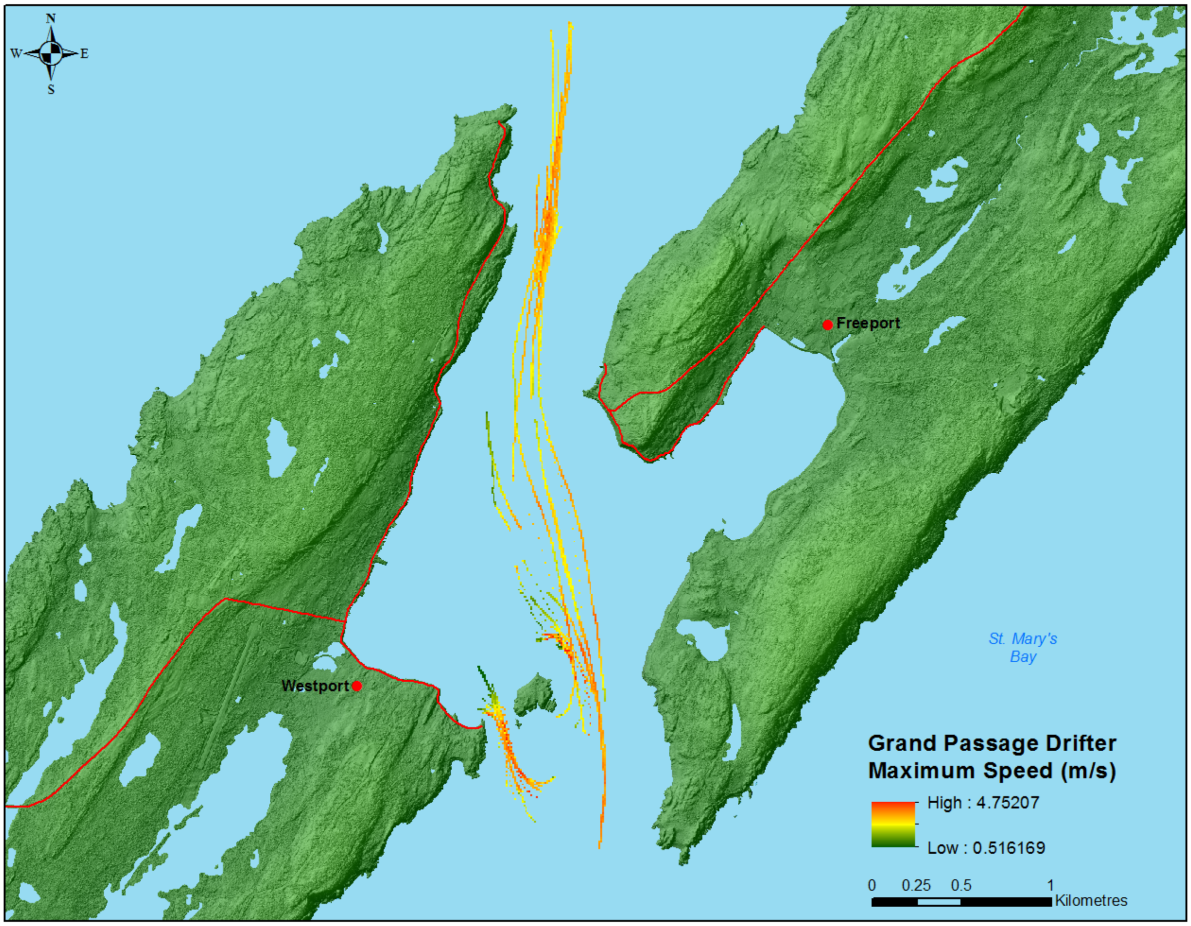

Figure 25: Drifter Maximum Speed (m/s) in Grand Passage.

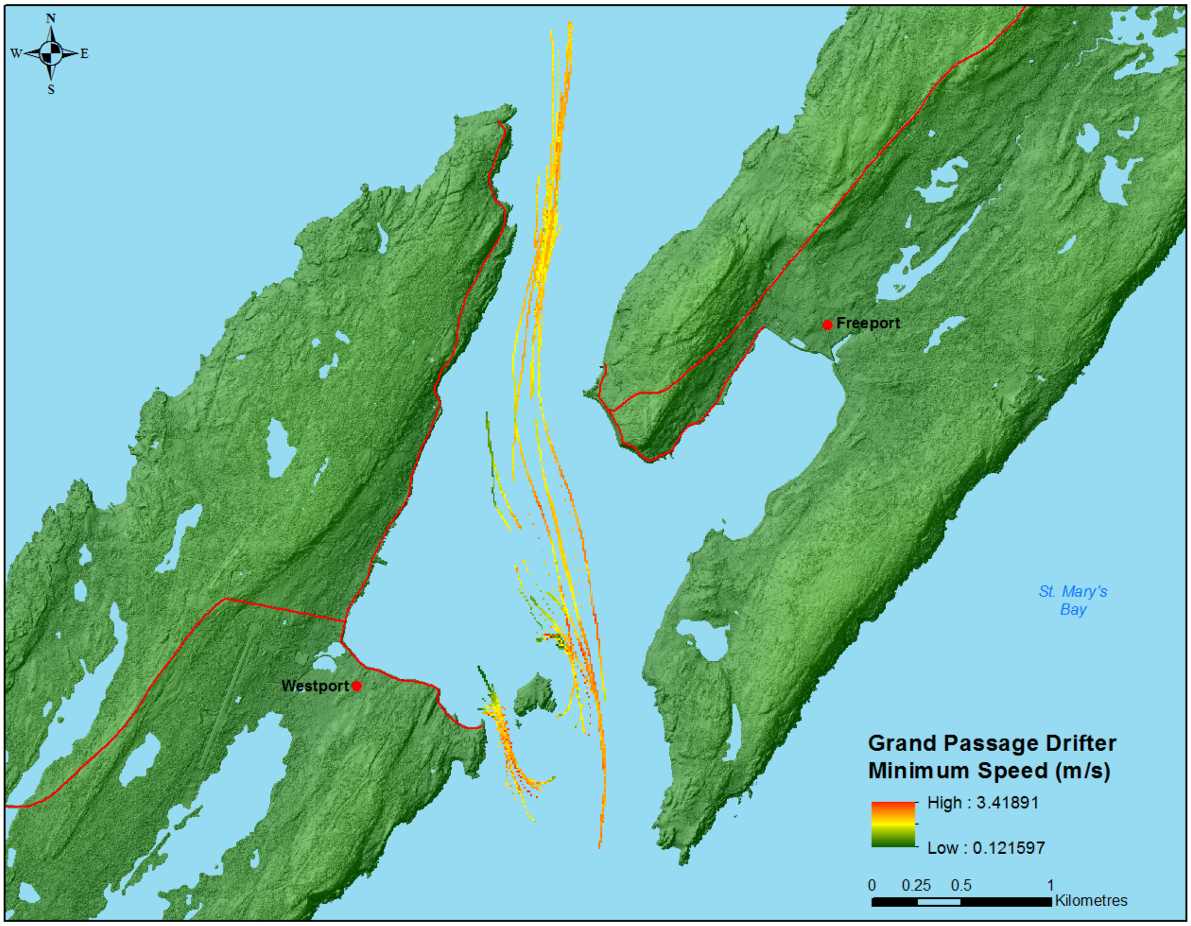

Figure 26: Drifter Minimum Speed (m/s) in Grand Passage.

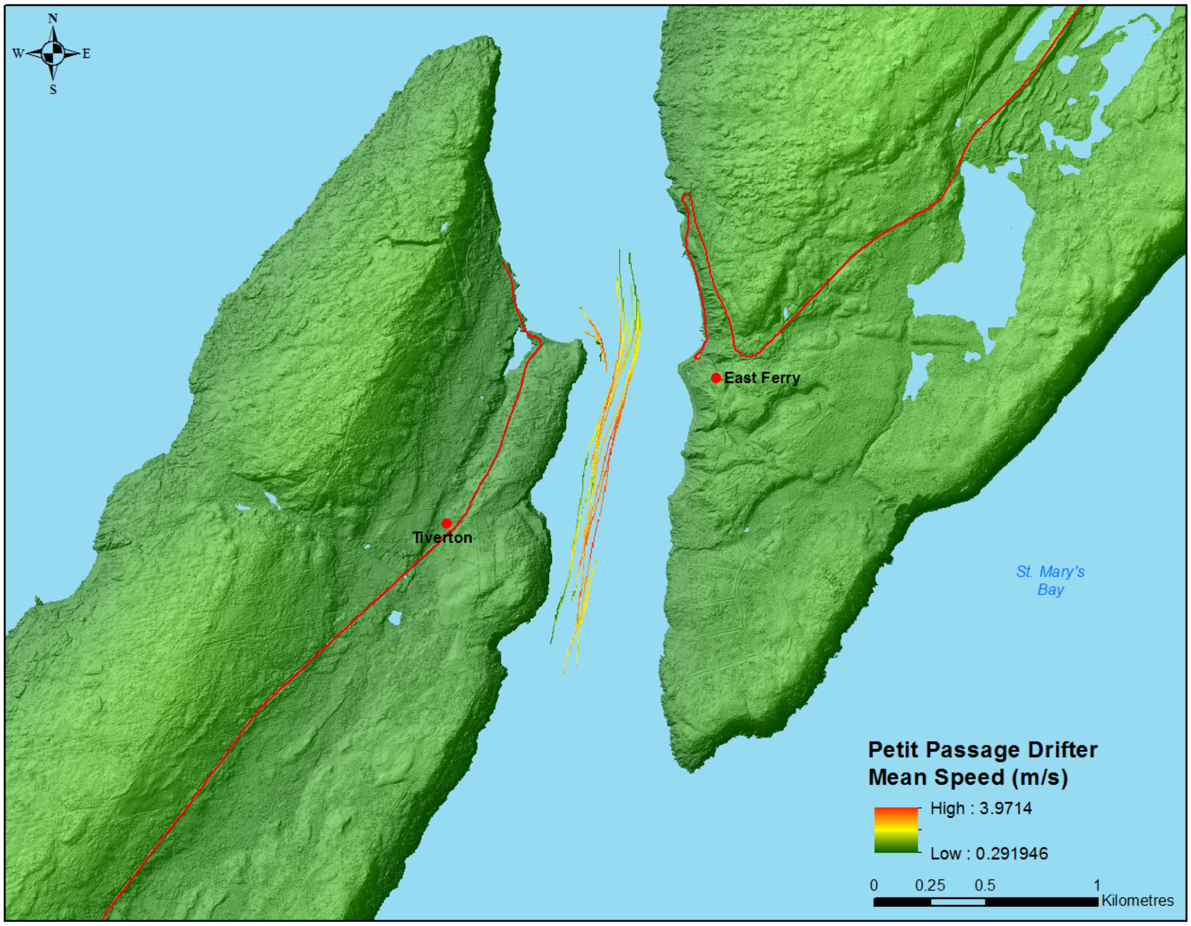

Figure 27: Drifter Mean Speed (m/s) in Petit Passage.

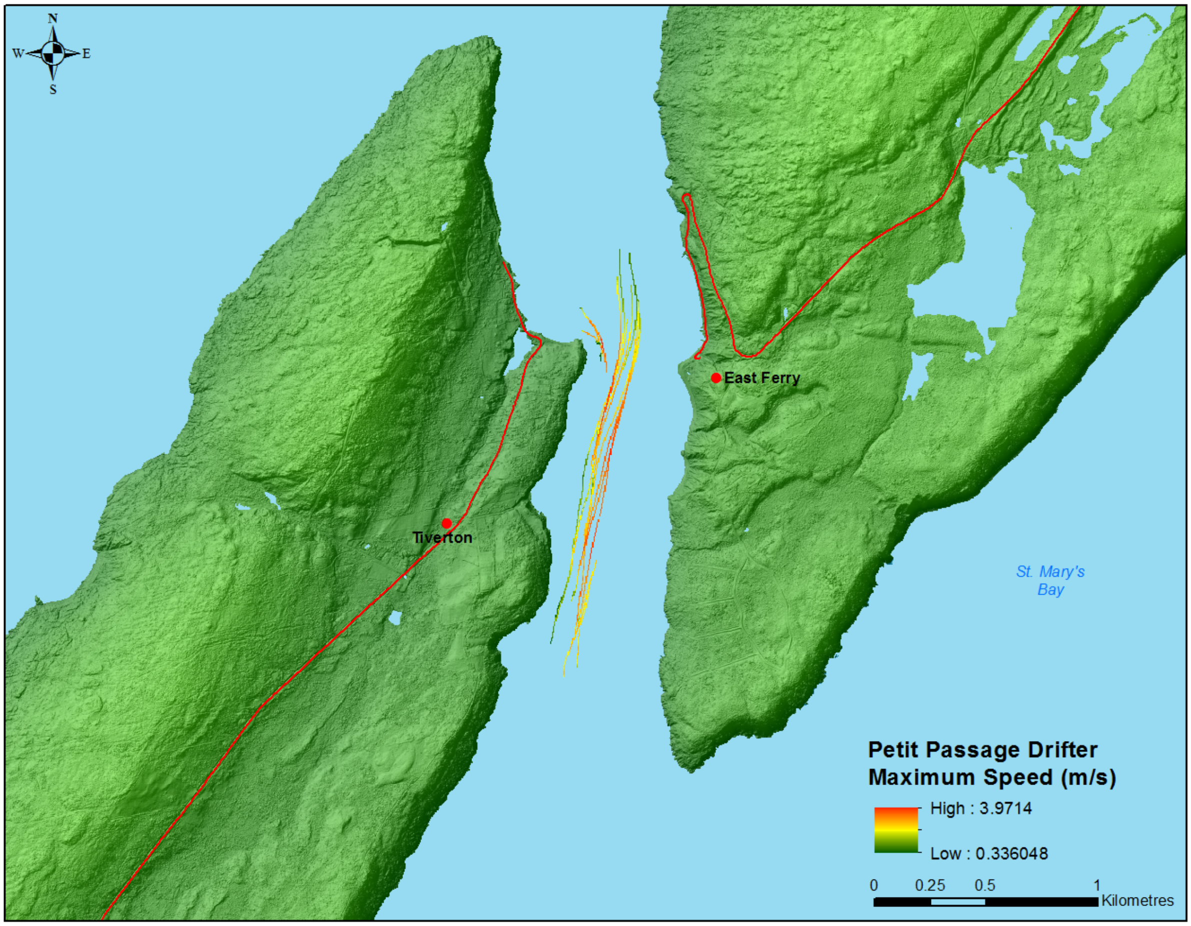

Figure 28: Drifter Maximum Speed (m/s) in Petit Passage

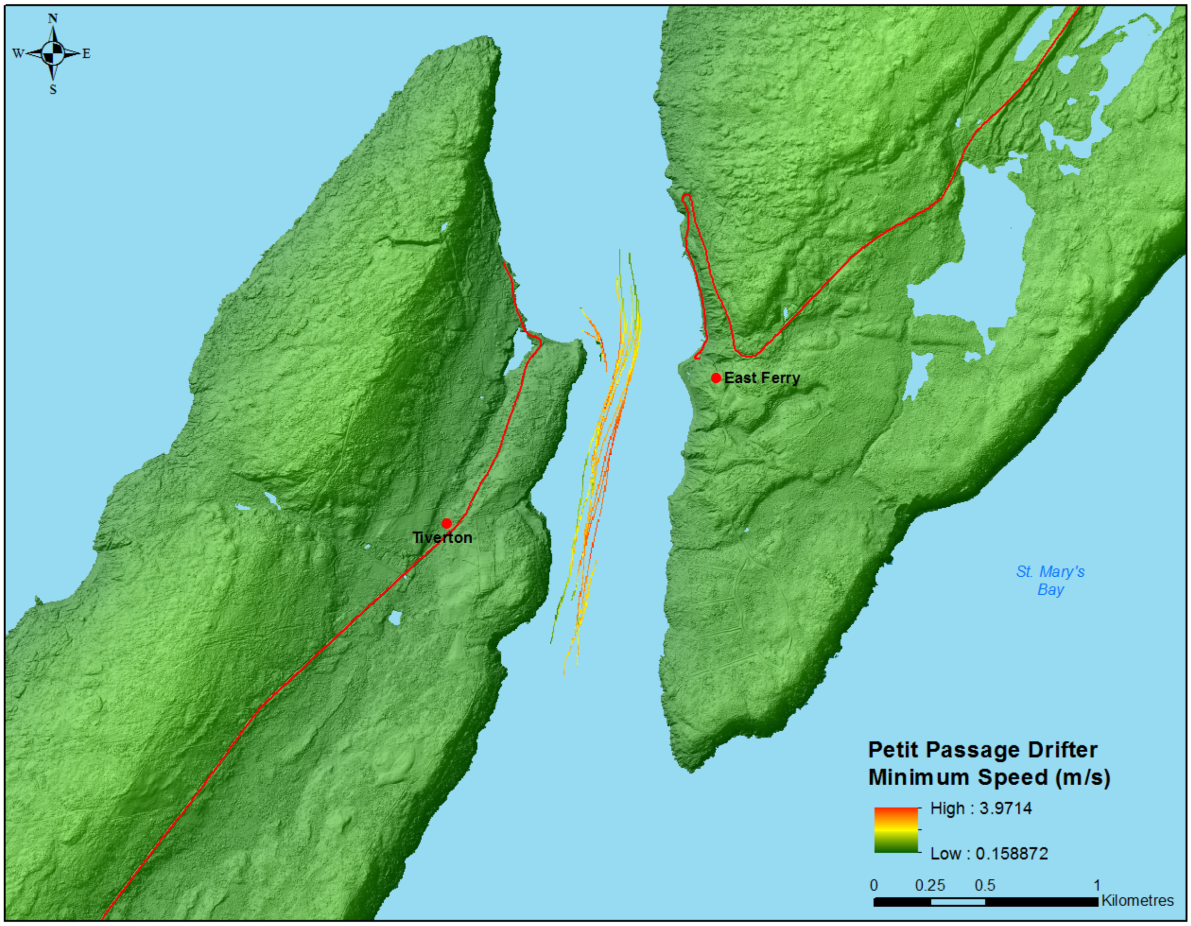

Figure 29: Drifter Minimum Speed (m/s) in Petit Passage

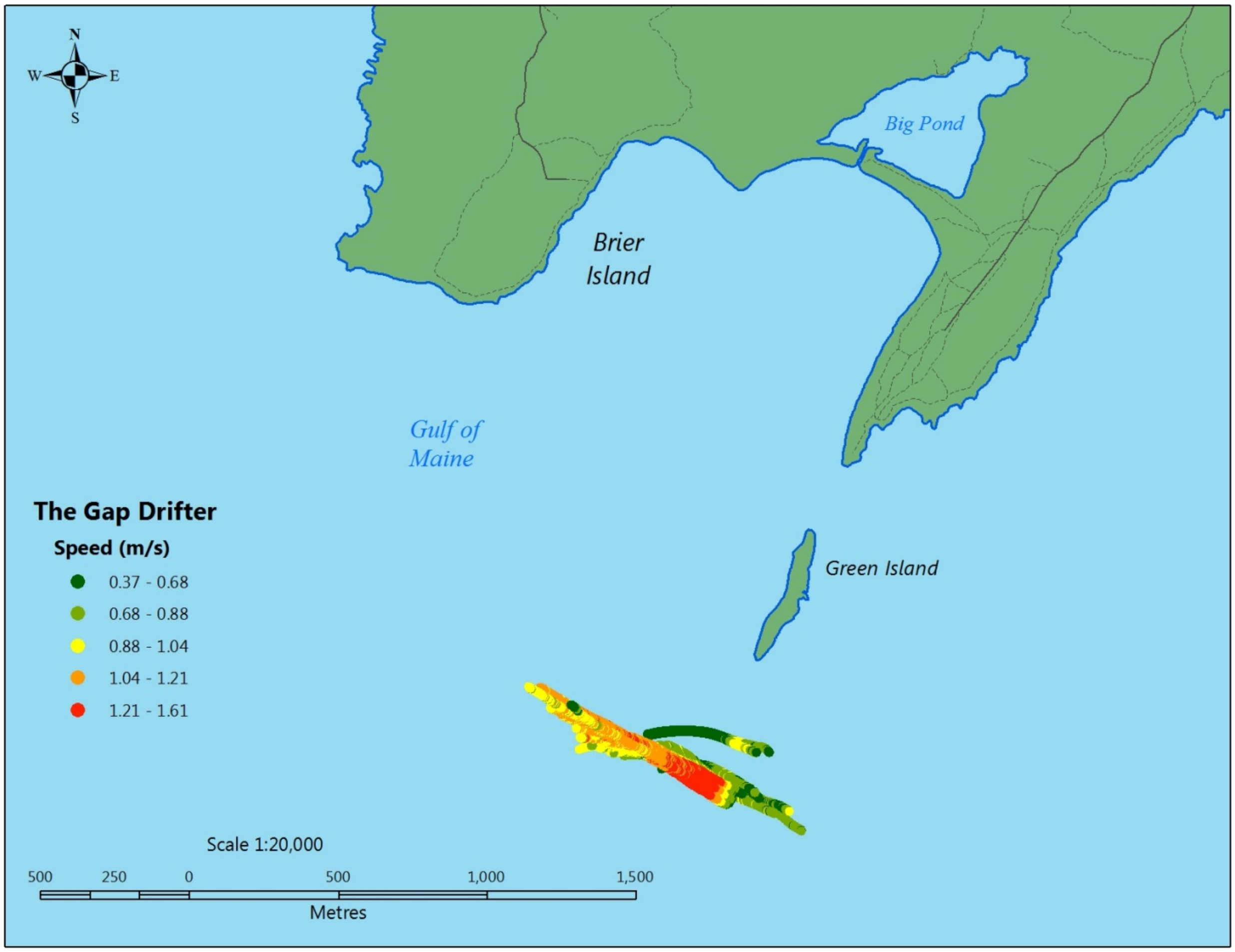

Figure 22 Drifter speed plot of "The Gap" near Green Island.

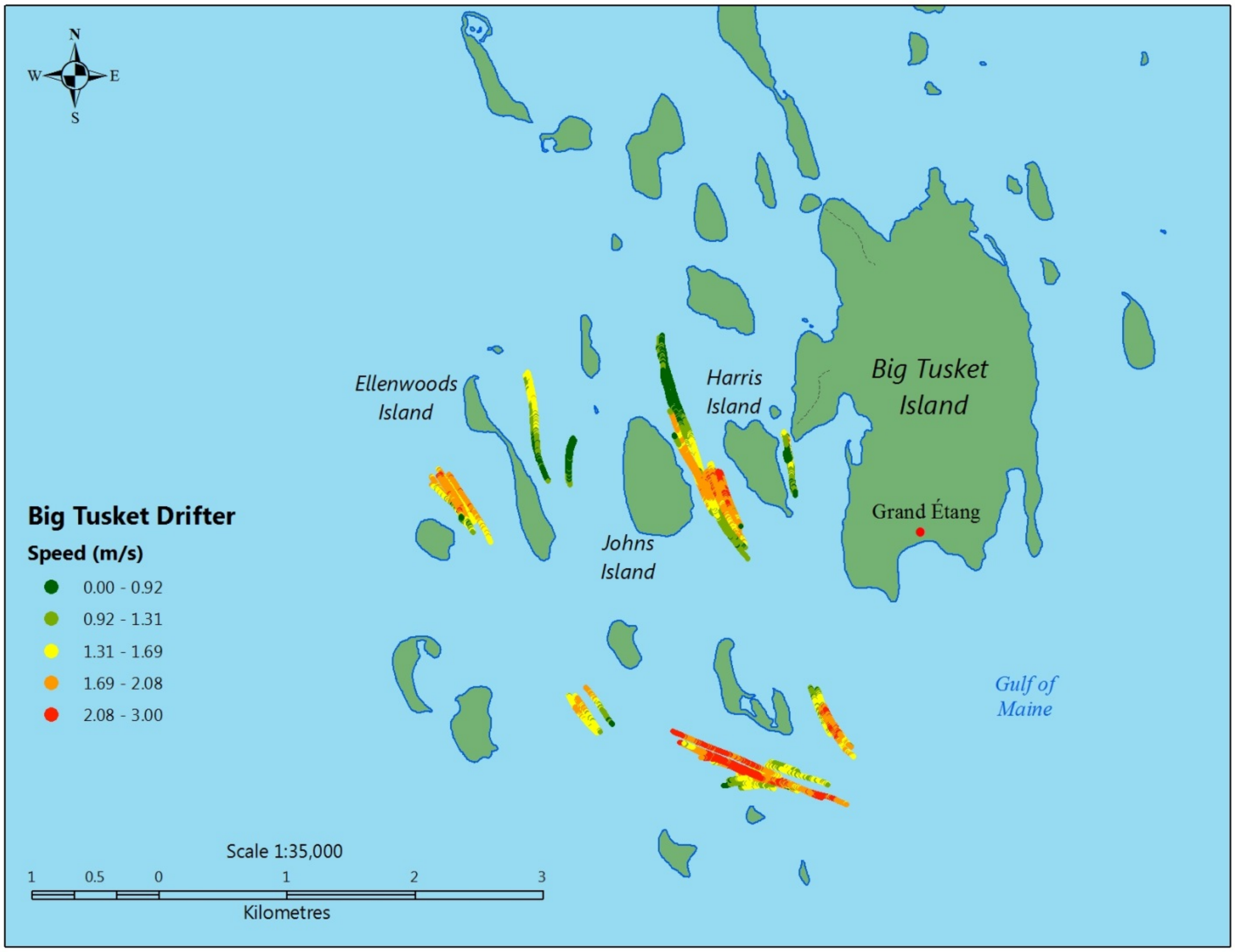

Figure 23 Drifter speed plot near Big Tusket Island.

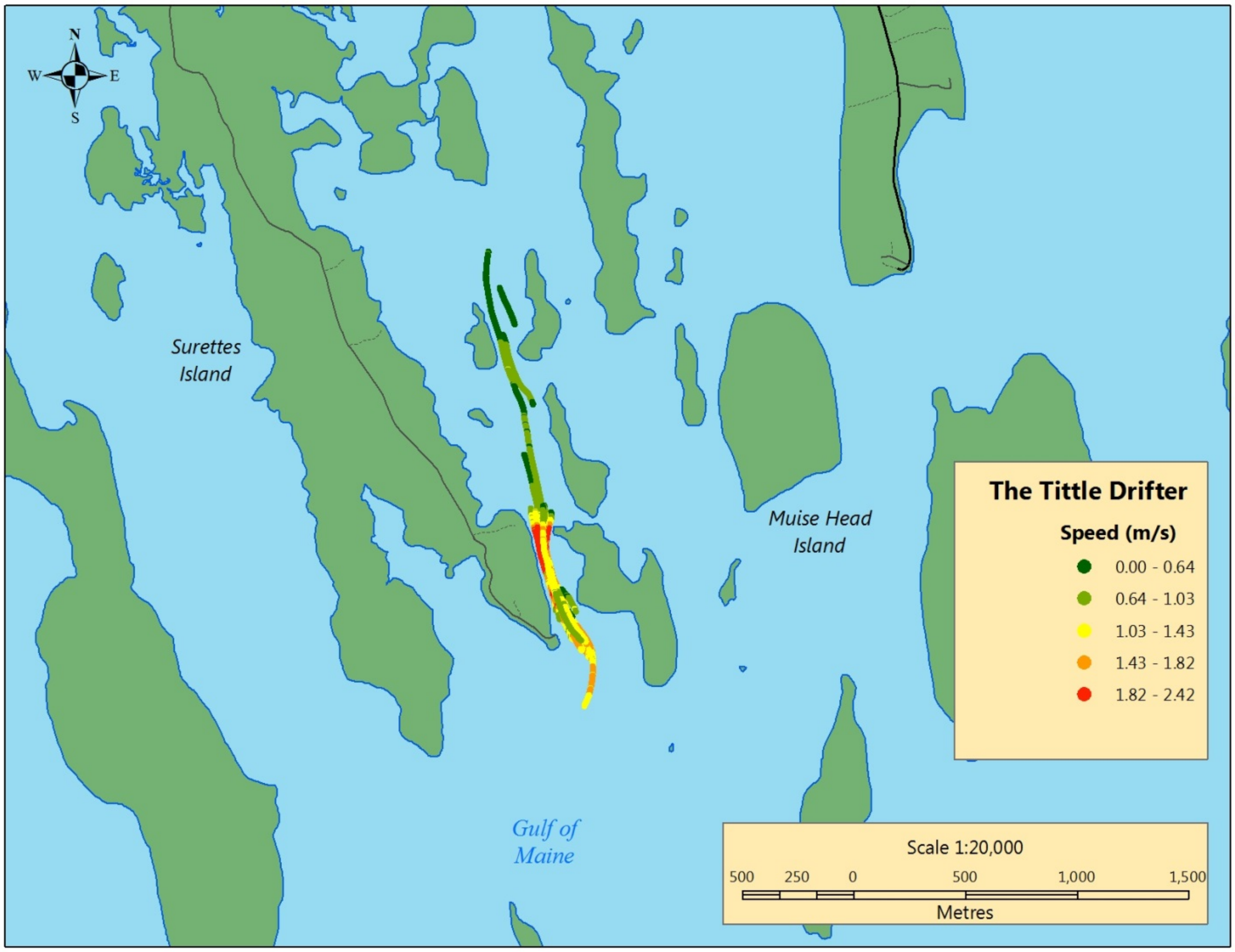

Figure 24 Drifter speed plot near the Tittle channel.

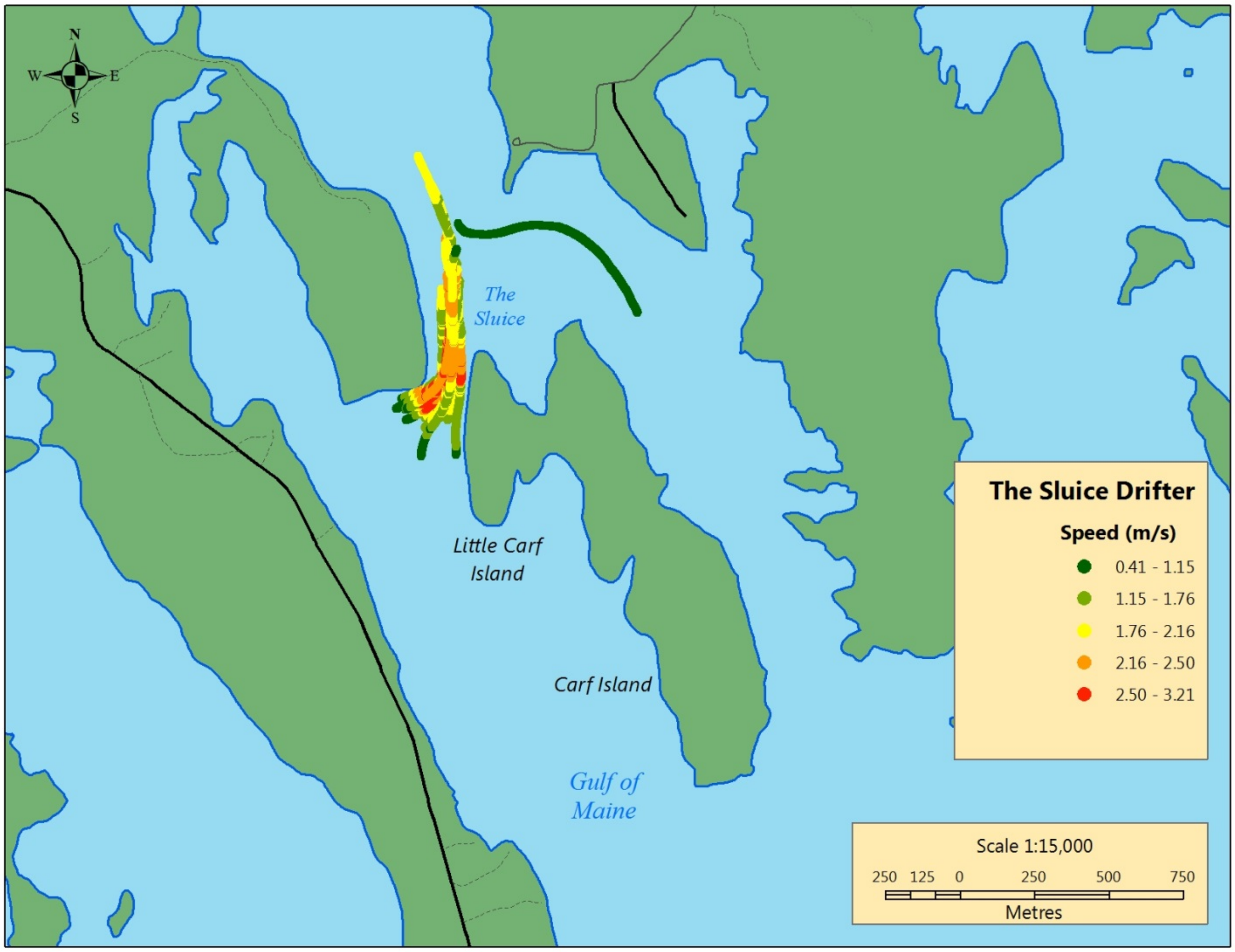

Figure 25 Drifter speed plot of “The Sluice”.

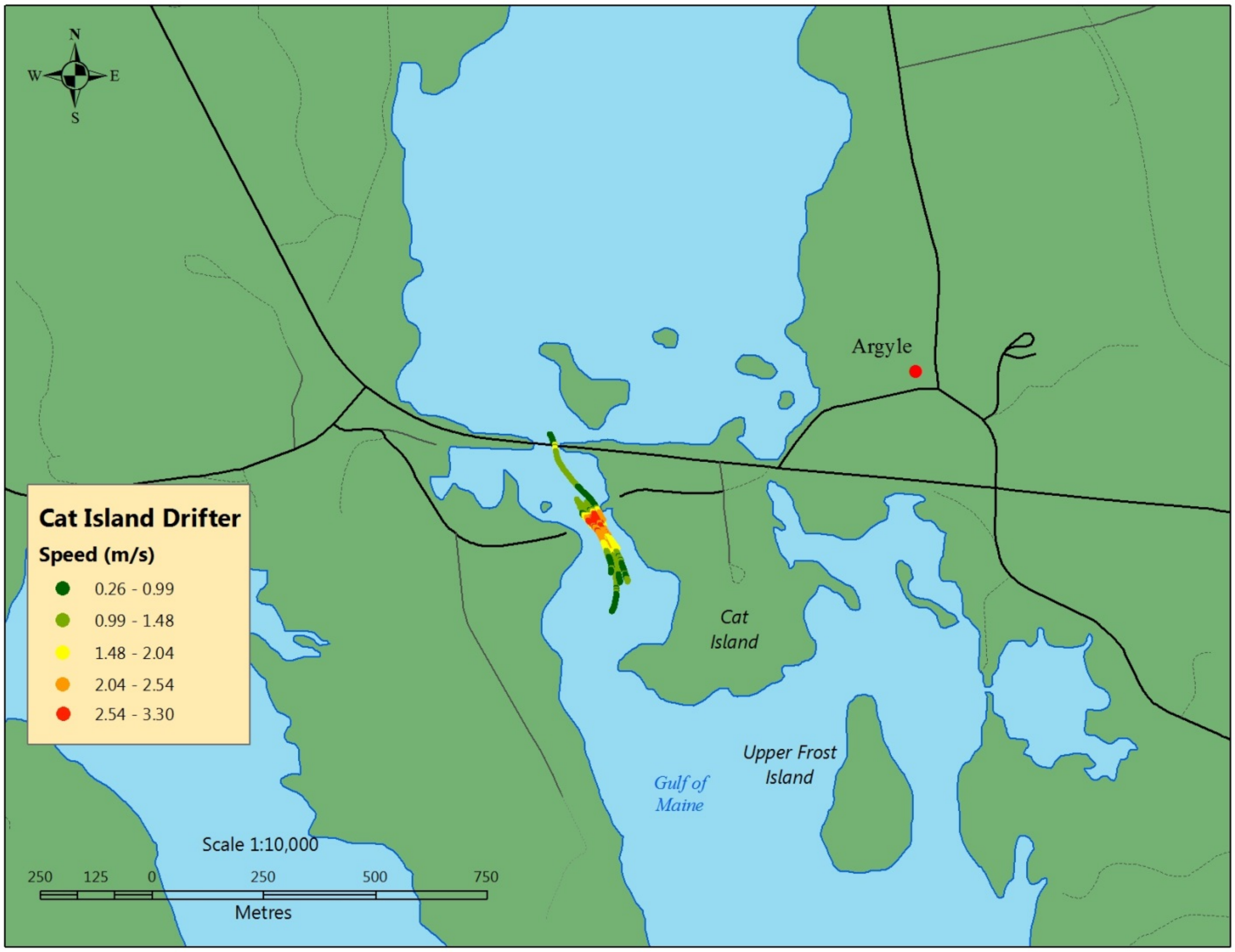

Figure 26 Drifter speed plot of the Cat Island channel.

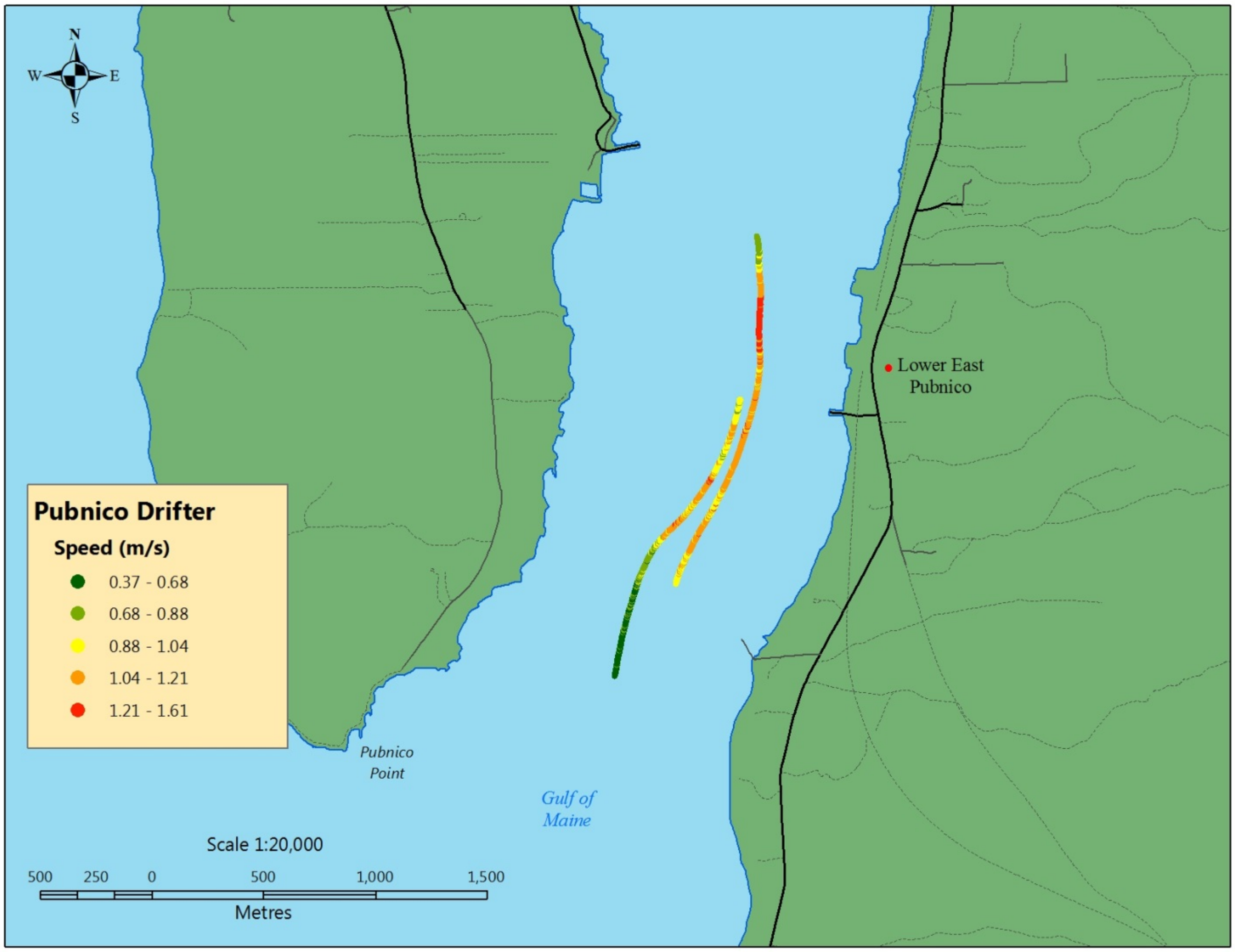

Figure 27 Drifter speed plot near Lower East Pubnico.

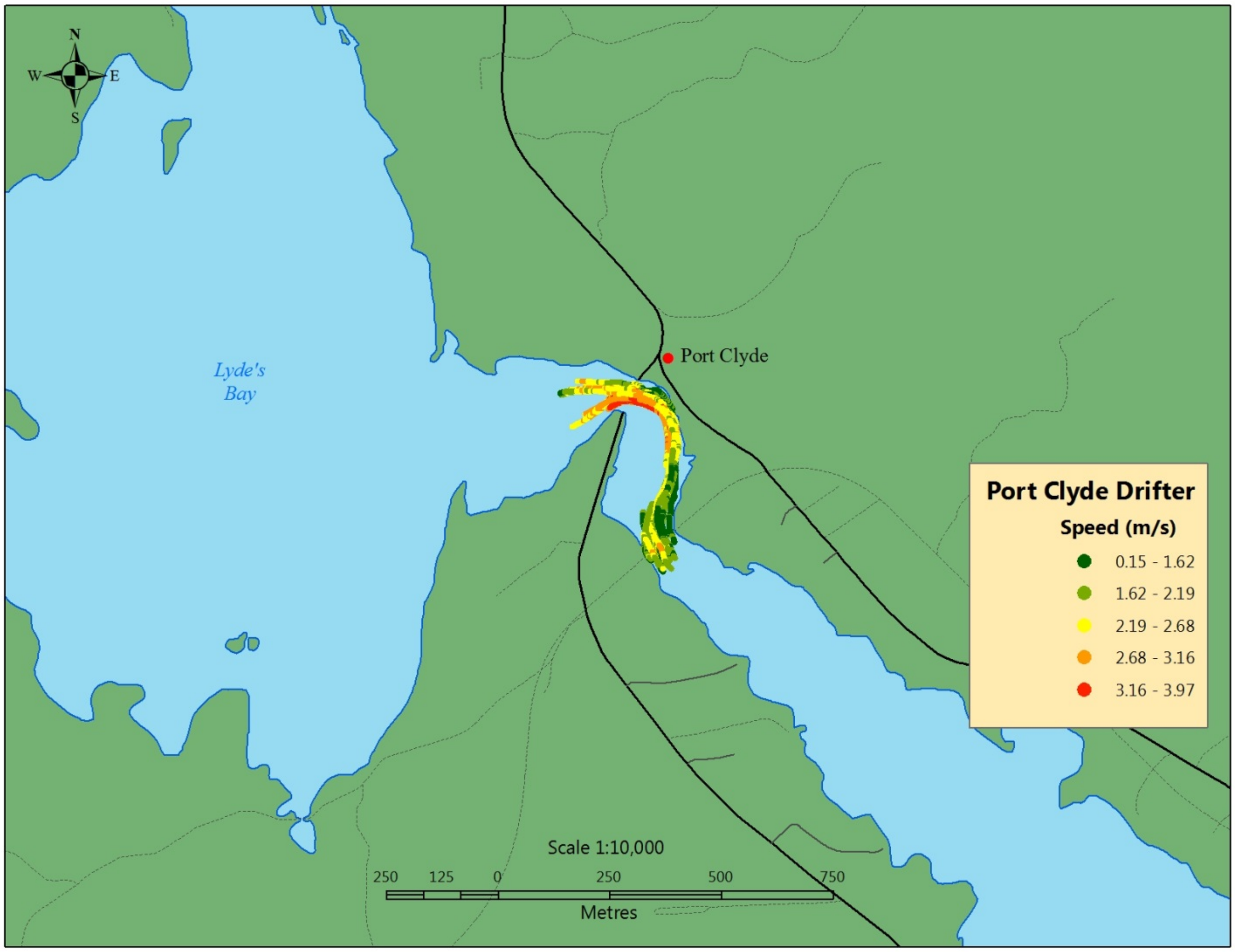

Figure 28 Drifter speed plot near port Clyde.

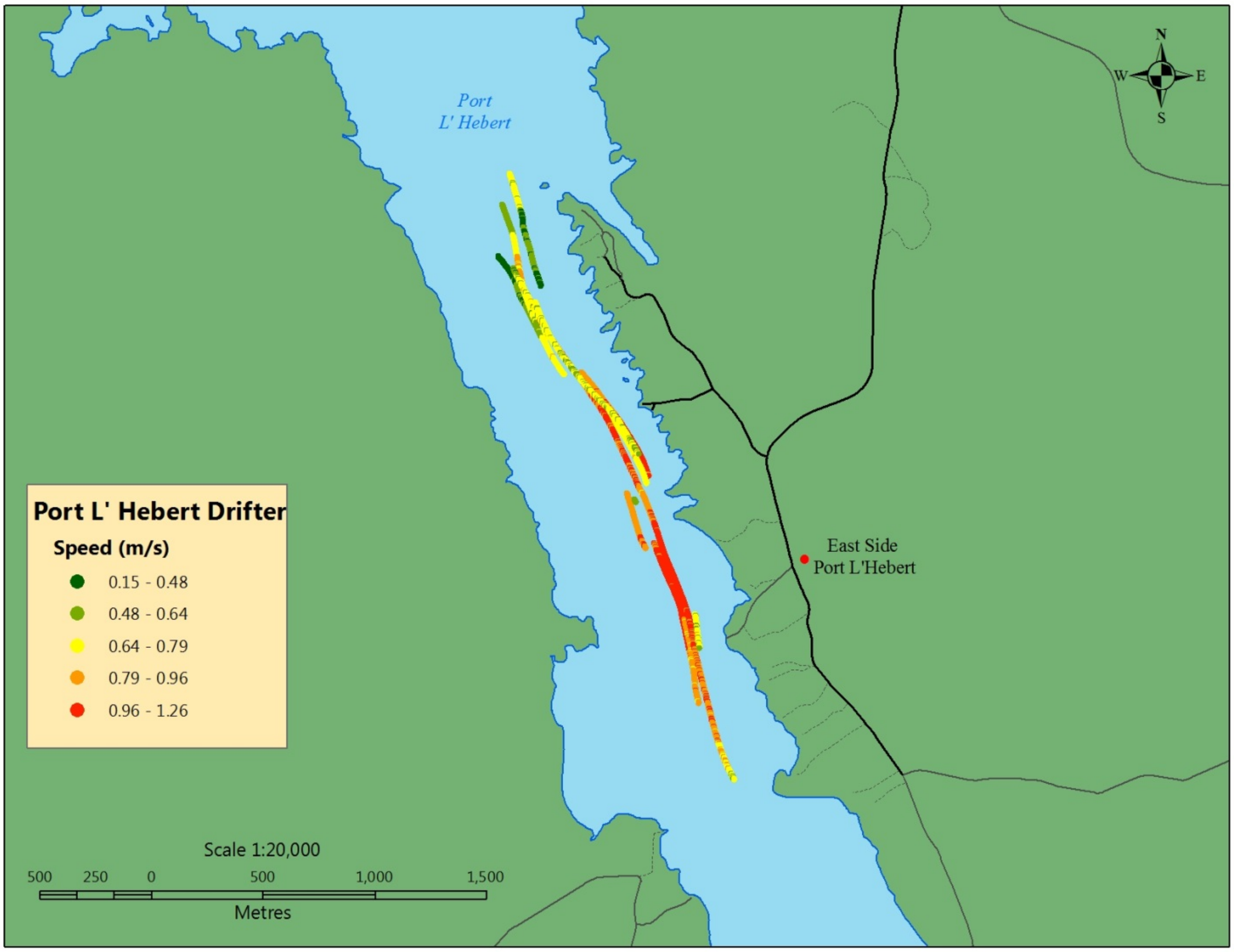

Figure 29 Drifter speed plot near Port Hebert.

8. Numerical Flow Modelling

Acadia used the bathymetric pointy data for a hydrodynamic model to calculate current velocities for the different channels. The model was run within the MatLab environment and time series files were exported in a NetCDF format. ESRI Arc GIS 10.1 supports NetCDF format files. However, the NetCDF files output from the numerical modelling were not compatible with ESRI implementation and as a result were not able to be georeferenced.

9. Lidar high-resolution elevation model

The Applied Geomatics Research Group, NSCC have supplied high resolution elevation models of the land areas near the channels of Digby Gut, Petite and Grand Passages. The lidar was flown in 2004 for the Digby Guy area and in 2006 for Petite and Grand Passages. The data have been processed to colour shaded relief models for visual interpretations as well as comma separated value files of the x,y,z points where the elevations (gridcode) are referenced to CGVD28.

10. Other GIS layers

Other GIS layers included in the database include the 1:50,0000 scale National Topographic Series map sheet, the 1;10,000 scale Nova Scotia Topographic Database of base layer information including the coastline, road and electric utility network and towers, streams as well as the ferry routes and wharf locations.

An additional 50 m bathymetric dataset was supplied as part of the Olex bathymetric data system. These data have been converted to CGVD28 vertical datum.

11. GIS Layout and Conclusions

The data has been organized in the GIS database to be viewed by users. An introductory Arc GIS map composition has been constructed (SW_Nova_Bathy_Overview.MXD file). This map displays data from the various Geodatabases which contain most of the spatial information supplied during the project. The Geodatabases consist of the overview: SW_Tidal_Overview.gdb and specific databases: Acadia.gdb, DibgyGut.gdb, Fundy_50m.dbg, GandPassage.gdb, and PetitePassage.gdb. Additional folders contain information in other formats compatible with the GIS (shape files, CSV or Jpeg2000 graphic files) for other data such as the ACDP, bathymetry colour shaded relief (CSR), drift files, lidar csv, and the scanned NTS map sheet. Other directories are related to documents, figures and predicted tides used during the project.

The GIS database captures all of the main inputs of data to the project, it does not fully capture the modelling output results or the actual ACDP data, the user will have to refer to the report and directly to the researcher involved to obtain access to those data.