# Digital Elevation Model of Port Alberni, Canada: Procedures, Data Sources, and Analysis

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Love, M.R.[1], K.S. Carignan[1], B.W. Eakins[1], M.G. Sutherland[1], L. Beasley[1], and S.J. McLean[2]

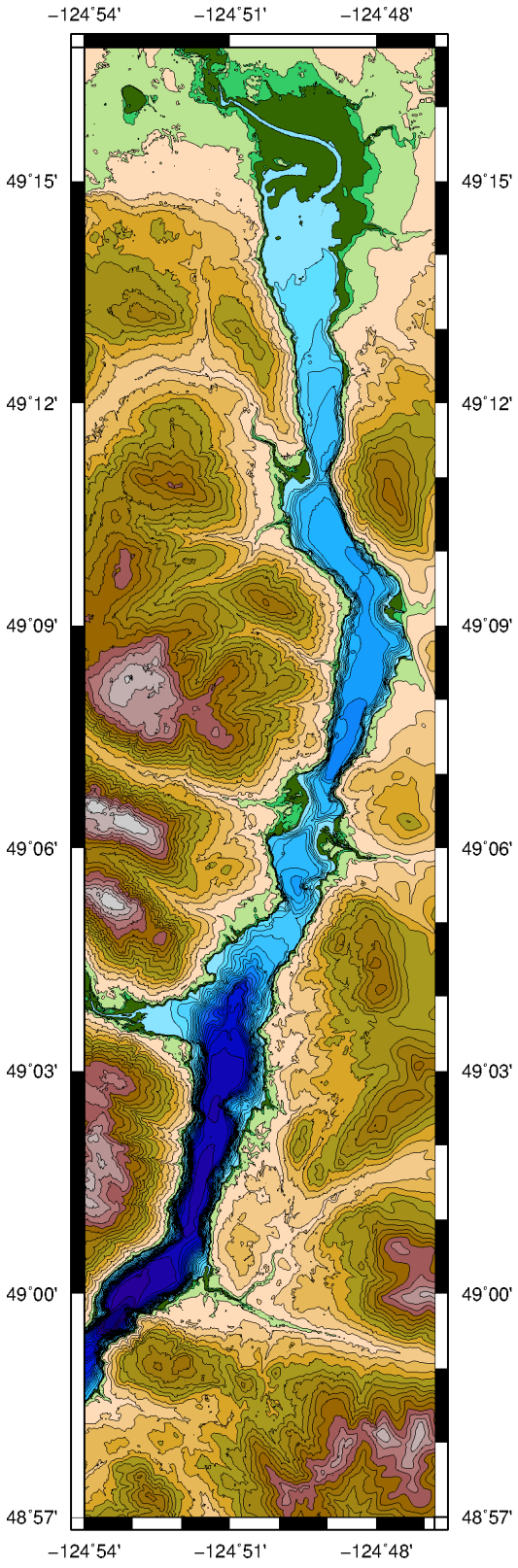
[1]Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder
[2]NOAA, National Geophysical Data Center

## Summary

In December of 2015, NOAA's National Centers for Environmental Information (NCEI) developed a topographic-bathymetric digital elevation model (DEM) of Port Alberni, Canada (Figure 1) for the National Tsunami Hazards Mitigation Project (NTHMP). The 1/3 arc-second DEM will be used to support improving the coastal tsunami inundation forecasts, storm surge modeling, community preparedness and hazard mitigation. This DEM covers the coastal area of Port Alberni, Canada. The extents of this DEM, procedures, data sources, and analysis are described below.

The Port Alberni DEM covers the area surrounding the city of Port Alberni, British Columbia, Canada (Fig. 2). The city of Port Alberni is within the Alberni Valley at the head of the Alberni Inlet, the longest inlet on Vancouver Island.

**Figure 1. Port Alberni, Canada Digital Elevation Model**



# DEM Specifications

The Port Alberni DEM was built to the specifications listed in Table 1. Figure 2 shows the 1/3 arc-second boundary in red. The best available digital data were obtained by NGDC and shifted to common horizontal and vertical datums: World Geodetic System of 1984 (WGS 84) and Canadian Geographic Vertical Datum of 2013 (CGVD). Data were gathered in an area slightly larger (~5%) than the DEM extents. This data "buffer" ensures that gridding occurs across rather than along the DEM boundaries to prevent edge effects. Data processing and evaluation, and the DEM assembly and assessment are described in the following subsections.

**Table 1. Specifications for the Port Alberni, Canada DEM.**

| | |
|---|---|
| **Grid Area** | Port Alberni, Canada |
| **Coverage Area** | -124.9° to -124.78° W, 48.95° to 49.28° N |
| **Coordinate System** | Geographic decimal degrees |
| **Horizontal Datum** | World Geodetic System 1984 (WGS 84) |
| **Vertical Datum** | Canadian Geodetic Vertical Datum of 2013 (CGVD2013) & North American Vertical Datum of 1988 (NAVD88) |
| **Vertical Units** | Meters |
| **Cell Size** | 1/3 arc-seconds |
| **Grid Format** | ASCII raster grid |

**Figure 2. Map image of the DEM boundary for the Port Alberni, Canada DEM in red.**

# Data Sources and Processing

The digital coastline used in developing the Port Alberni DEM was generated by editing the Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG) shoreline based on the Google satellite imagery layer. The digital coastline was converted into a polygon for use in masking topography and eliminating interpolated data.

Bathymetric data (Fig. 3) used in the compilation of the Port Alberni DEM included sounding data from the Canadian Hydrographic Survey (CHS) as well as completed datasets from NCEI (Table 2).

Topographic data (Fig. 4) used in the compilation of the Port Alberni DEM included lidar data provided by the Alberni-Clayoquot Regional District, high-resolution topographic data from GeoBC and the Canadian Digital Surface Model (CDSM) from National Resources Canada (NRC).

**Table 2: Bathymetric and Topographic Data Sources used in compiling the Port Alberni DEM.**

| Source/Title | Date | Data Type | Resolution | Horizontal Datum | Vertical Datum |
|---|---|---|---|---|---|
| Port Alberni Lidar | 2004 | Topographic Lidar | < 1 meter | UTM Zone 10N | CGVD |
| GeoBC | 2013 | Topographic Lidar | < 1 meter | UTM Zone 10N | CGVD |
| CHS Multibeam | 2001 | Bathymetric Soundings | ~ 1 meter | UTM Zone 10N | Chart Datum (CD) |
| ENC | 2012 - 2014 | Bathymetric Soundings | 1 – 10 meter | WGS84 Geographic | CD |
| CDSM | 1995 - 2011 | Topographic Surface Model | 30 meter | WGS84 Geographic | CGVD |
| BC Bathy | 2011 | Bathymetric Surface | 50 meter | WGS84 Geographic | CD |

The bathymetric data were transformed from their original datums to a horizontal datum of WGS 84 and a vertical datum CGVD prior to DEM development using a vertical transformation offset provided by CHS benchmarks (Table 3). Topographic data were transformed from their original horizontal datums to a horizontal datum of WGS 84. All topographic data originated in CGVD2013 prior to development, so no added vertical transformations were needed.

**Table 3: CHS Benchmark M09C9019 (Port Alberni, B.C.).**

| Datum Name | Elevation (meters) | Offset to CGVD2013 |
|---|---|---|
| CD | 6.241 | -1.614 |
| CGVD28(HTv2)2010 | 4.461 | 0.166 |
| NAD83(CSRS)2010 | -11.127 | 6.5 |
| NAVD88 | 5.6807 | -1.0537 |
| CGVD2013 | 4.627* | 0 |

* result calculated using the GPS-H tool provided by the Canadian Geodetic Survey.

**Figure 3. Bathymetric data sources used in the Port Alberni, Canada DEM.**

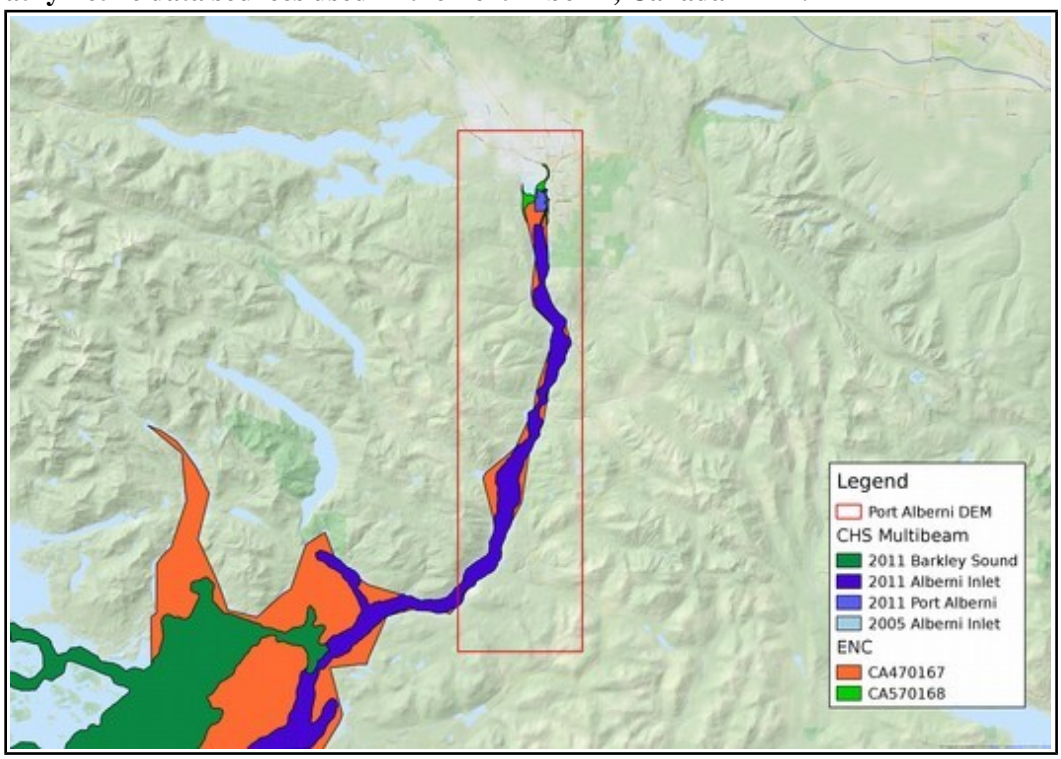
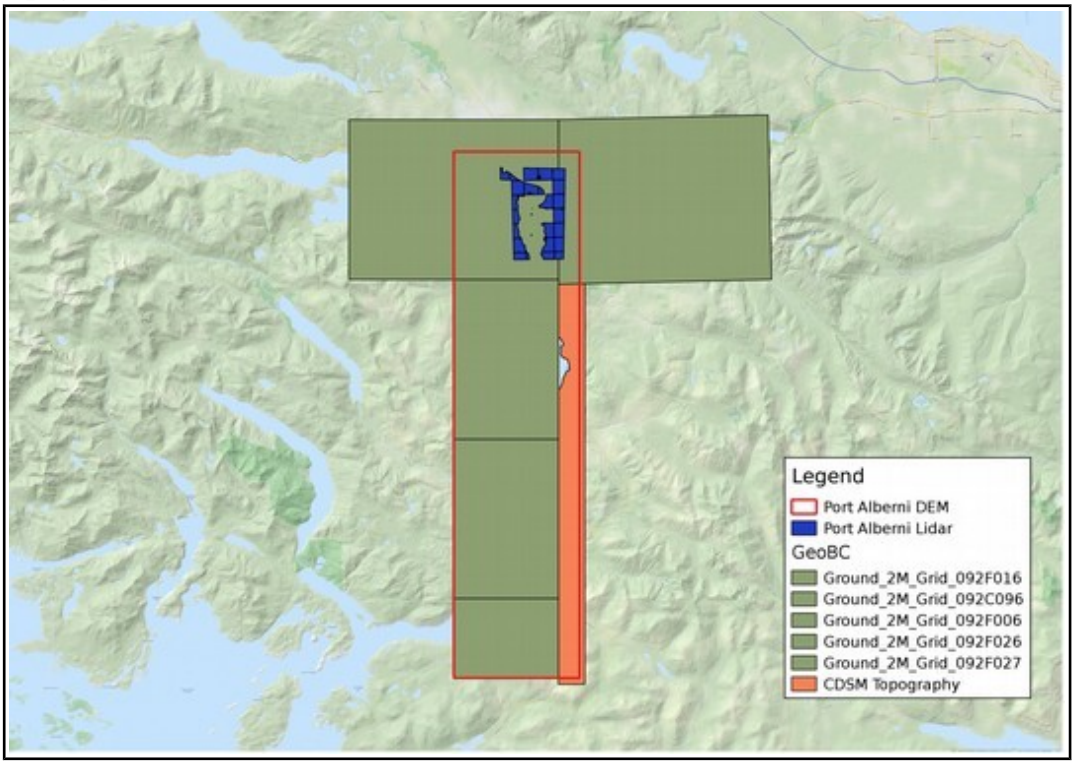



**Figure 4. Topographic data sources used in the Port Alberni, Canada DEM.**



# DEM Development

After the bathymetric data were transformed to common horizontal and vertical datums, they were visually reviewed for consistency and errors. Where more recent, higher resolution bathymetric data existed, older data were superseded. The edited and evaluated bathymetric data were then converted to ASCII xyz format using GDAL then gridded at 1/3 arc-second using Generic Mapping Tools (GMT). The GMT 'surface' tool was used to generate a bathymetric surface which provided full data coverage of the DEM area. The surface was then clipped using the digital coastline to create the final bathymetric DEM. The final bathymetric DEM was then converted to ASCII xyz format for use as input in generating the final DEM.

After the topographic data were transformed to common horizontal datums, the areas of overlap were visually reviewed for consistency and errors. Upon inspection the Port Alberni Lidar data and the GeoBC topographic data were further processed to remove all erroneous data points which were located over water bodies using custom lidar processing tools, after which, due to differences in data collection and filtering, edge effects between the Port Alberni Lidar data and the GeoBC topographic data were noticeable. To minimize the edge effects, the Port Alberni Lidar data was clipped to make use of the higher resolution near-shore regions of the Port Alberni regions, the data was then converted to ASCII xyz format using GDAL and combined into one data-set. The combined data-set was gridded at 1/3 arc-second using GMT's 'surface' tool to generate a topographic surface which provided full data coverage of the DEM area. The topographic surface was then clipped to the digital coastline to create a final topographic DEM. The final topographic DEM was then converted to ASCII xyz format for use as input in the generating the final DEM.

MB-System was used to create the 1/3 arc-second Port Alberni DEM. MB-System is an NSF-funded open source software application specifically designed to manipulate submarine multibeam sonar data, though it can utilize a wide variety of data types, including generic xyz data. The MB-System tool 'mbgrid' was used to apply a tight spline tension to the xyz data, and interpolate values for cells without data. The data hierarchy used in the 'mbgrid' gridding algorithm, as relative gridding weights, is listed in Table 4. The resulting binary grid was converted to an Arc ASCII grid using the GMT tool 'grdreformat' to create the final 1/3 arc-second Port Alberni DEM.

**Table 4: Data hierarchy used to assign gridding weight in MB-System**

| Data-set | Relative Gridding Weight |
|---|---|
| Generated Surfaces | 100 |
| Port Alberni Lidar | 10 |
| Geo BC | 10 |
| CHS Multibeam | 10 |
| ENC | .1 |

# Generating NAVD88 DEM

The Port Alberni 1/3 arc-second NAVD88 DEM was generated using constant offsets provided by CHS benchmarks (Table 3) and transformation parameters provided by NOAAs VDatum software. The final CGVD2013 DEM was transformed to a NAD83 Ellipsoidal datum using a constant offset. The NAD83 Ellipsoidal DEM was then transformed to NAVD88 using a constant offset generated using VDatum software.

# Recommendations

Recommendations to improve the Port Alberni, Canada 1/3 arc-second DEM are listed below:

- Conduct bathymetric lidar surveys of near-shore coastal areas.
- Conduct topographic lidar surveys in the area surrounding Port Alberni.

# Acknowledgments

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# References

Carignan, K.S, B.W. Eakins, M.R. Love, M.G. Sutherland, and S.J. McLean, 2013. Digital Elevation Model of British Columbia, Canada: Procedures, Data Sources and Analysis, NOAA Technical Memorandum NESDIS NGDC-13, National Geophysical Data Center, Boulder, CO, 8 pp.

Wessel, P., and W. H. F. Smith, A Global Self-consistent, Hierarchical, High-resolution Shoreline Database, J. Geophys. Res., 101, #B4, pp. 8741-8743, 1996.