Digital Elevation Model of the Central Washington Coast: Procedures, Data Sources, and Analysis

Prepared for the Pacific Marine Environmental Laboratory (PMEL), NOAA Center for Tsunami Research Program by the NOAA, National Centers for Environmental Information (NCEI)
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Summary

In June of 2015, NOAA's National Centers for Environmental Information (NCEI) developed an integrated bathymetric–topographic digital elevation model (DEM) of the Central Washington Coast for the Pacific Marine Environmental Laboratory (PMEL), NOAA Center for Tsunami Research Program. The DEM will be used to support modeling tsunami generation, propagation, and inundation. The DEM covers the Central Washington Coast including the communities of Pacific Beach, Taholah, La Push, and the Quinault, Quileute and Hoh Indian reservations. Extents of this DEM, procedures, data sources, and analysis are described below. The methodologies used by NCEI in developing DEM are described in the NOAA Technical Memorandum-52 for Central California and San Francisco Bay (Carignan et al., 2011).

DEM Specifications

The Central Washington Coast DEM was built to the specifications listed in Table 1. Figure 1 shows this 1/3 arc-second Central Washington Coast integrated topographic–bathymetric DEM boundary in red, the 2015 Juan de Fuca and the 2012 Astoria integrated topographic–bathymetric 1/3 arc-second DEMs in green.

Table 1. Specifications for the Central Washington Coast DEM.

Cell Size	1/3 arc-second
Coverage	124.10° to 125.25° W, 47.14° to 48.06° N
Coordinate System	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)
Vertical Datum	NAVD 88
Vertical Units	Meters
Grid Format	ASCII raster grid

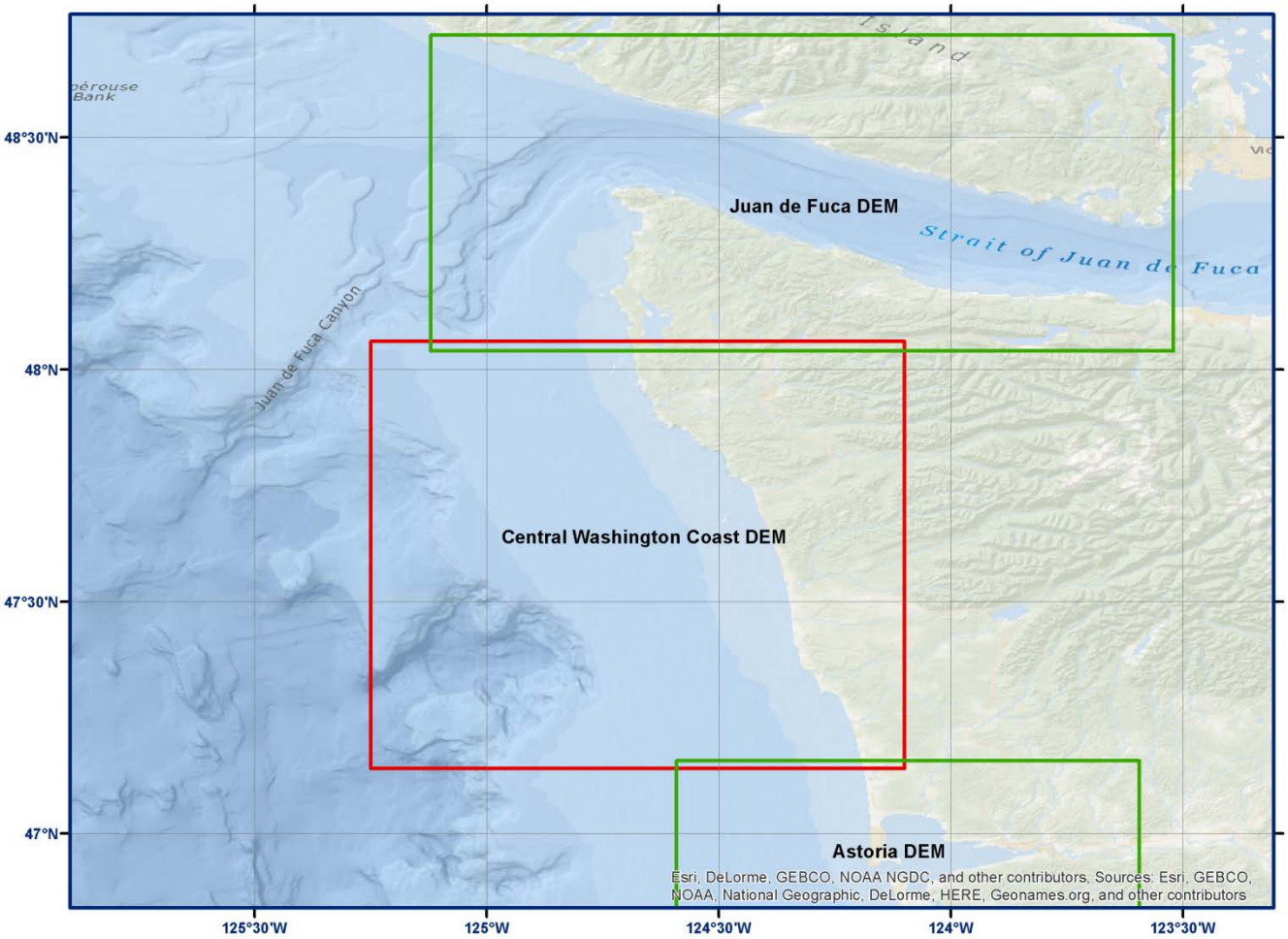

Figure 1. Map image of the boundaries for the 1/3 arc-second Central Washington Coast DEM in red and previously developed DEMs in green.

Data Sources and Processing

A section of the Continually Updated Shoreline (CUSP) was retrieved from NOAA's Shoreline Data Explorer (http://www.ngs.noaa.gov/NSDE/) and edited to match either recently acquired high resolution lidar data or imagery available via Google Earth and ESRI's World Imagery map service (http://www.arcgis.com/features/maps/imagery.html). Bathymetric and topographic data were downloaded from NOAA's Office for Coastal Management (OCM) and Office of Coast Survey (OCS), Puget Sound Lidar Consortium (PSLC), and the U.S. Geological Society (USGS), and NCEI. Figure 2 shows the source and coverage of the datasets used in developing the Central Washington Coast DEM.

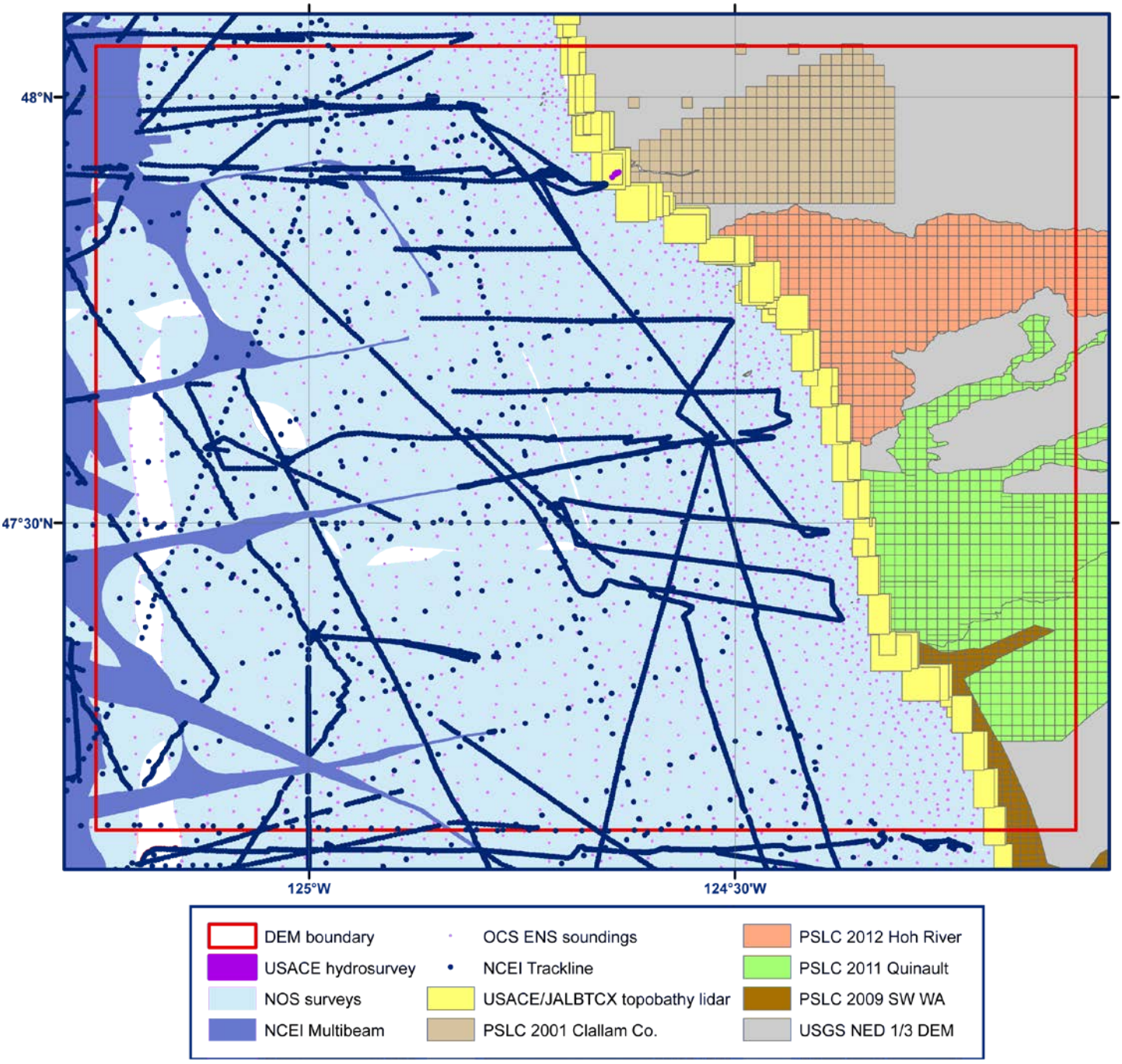

Figure 2. Source and coverage of the datasets used in compiling the Central Washington Coast DEM.

Table 2: Bathymetric data sources used in compiling the Central Washington Coast DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
NOAA NOS	1891 to 2010	Hydrographic survey soundings	< 1 meter to several kilometers	Unknown, NAD 1927 Projected Modified Transverse Mercator, or NAD 1983 Projected UTM Zone 10	Mean Lower Low Water (MLLW)
USACE	2006	Hydrographic survey profiles	Profiles 50 to 200 meters long, space 50 meters apart with point spacing < 1 meter	NAD 1983 Washington State Plane North	MLLW
NCEI	2000 to 2013	Multibeam bathymetry	10 meter grid	NAD 83 geographic	Assumed Mean Sea Level (MSL)
NOAA OCM	1997 to 2013	ENC soundings	1:20,000 to 1:300,000	WGS 84 geographic	MLLW
NCEI	1965 to 1999	Trackline bathymetry		NAD 83 geographic	Assumed MSL

Table 2 lists the bathymetry data used in the compilation of the Central Washington Coast DEM including NOS hydrographic surveys (Appendix A), multibeam surveys (Appendix B), and trackline bathymetry data. Bathymetric data were transformed to WGS 84 geographic and NAVD 88 using GDAL and NOAA's VDatum transformation tool. USACE harbor survey profiles were retrieved from NCEI archive and converted to NAVD 88 using a constant value of 2.43 meters (Taylor et al., 2008) and VDatum. The profile data were converted to TIN format to interpolate between survey lines and a denser point file was extracted from the resulting TIN surface. Where recent, higher resolution data exists, older data were superseded. Elevation values below 5 meters were filtered from the bathymetric-topographic lidar data and used along with the bathymetric data. These bathymetric data were converted to xyz format before combining with the coastline data to generate a bathymetric pre-surface at 1/3 arc-second. An upper limit of 4 meters was used to ensure consistent elevation along the coastline. The bathymetric surface grid was clipped to the coastline and converted to xyz format before incorporating in the final DEM.

Table 3: Topographic-Bathymetric data source used in compiling the Central Washington Coast DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
OCM - 2010-11 U.S. Army Corps of Engineers (USACE) JALBTCX Topobathy Lidar:	2010-2011	LAS	Nominal Point Spacing 2 meters	NAD 83 geographic	NAVD 88

Topographic-bathymetric data (Table 3) were processed to filter to only ground returns and transformed to WGS 84 geographic using LASTools and GDAL.

Table 4: Topographic data sources used in compiling the Central Washington Coast DEM.

Source - Title	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
2012 Puget Sound Lidar Consortium (PSLC) Lidar: Hoh River Watershed	2012	LAS and ASC	Average Ground Classified Density 0.745 points/m^2	NAD 83 (1991 HARN) WA SP South (FIPS 4602) (U.S. feet)	NAVD 88
2011 Puget Sound Lidar Consortium (PSLC) Lidar: Quinault	2011	LAS and ASC	Average Ground Classified Density 0.69 points/m^2	NAD 83 (1991 HARN) WA SP South (FIPS 4602) (U.S. feet)	NAVD 88
2009 Puget Sound Lidar Consortium (PSLC) Lidar: Southwest Washington	2009	LAS	Average Ground Classified Density 0.85 points/m^2	NAD 83 (1991 HARN) WA SP North (FIPS 4601) (U.S. feet)	NAVD 88
2001 Puget Sound Lidar Consortium (PSLC) Lidar: Clallam Co.	2001	File Raster Geodatabase (GDB)	6 feet	NAD 83 (1991 HARN) WA SP North (FIPS 4601) (U.S. feet)	NAVD 88
USGS NED	2013	Topographic DEM	1/3 arc-second	NAD 83 geographic	NAVD 88
OCS ENC	2002 to 2013	Land elevation points		WGS 84 geographic	MHW

Topographic data used in developing the Central Washington Coast DEM are listed in Table 4. LAS lidar files were processed to filter out non-ground returns then transformed to WGS 84 geographic using GDAL. The converted data files were clipped to the coastline to remove NoData values or filtered to remove returns over water. Elevation information from ENCs was used to provide topographic coverage for large off shore rocks not resolved in any of the topographic datasets. An 80 meter buffer was used to smooth the seam between the NED and OCM bathymetric-topographic lidar data. All topographic data were converted to xyz format for the final gridding process.

DEM Development

Development of the Central Washington Coast DEM followed procedures documented in NOAA Technical Memorandum NCEI-52 for Central California and San Francisco Bay (Carignan et al., 2011). Exceptions being the bathymetric pre-surface was generated at 1/3 arc-second. Gridding weight was modified to Table 5.

Table 5: Data hierarchy used to assign gridding weight in MB-System.

Dataset	*Relative Gridding Weight*
PSLC lidar	100
OCS ENC land elevations	100
NOS BAG hydrographic surveys	100
OCM - 2010-11 U.S. Army Corps of Engineers (USACE) JALBTCX Topo-bathy Lidar	10
USACE Hydrographic survey profiles	10
USGS NED DEM	10
NCEI multibeam surveys	1
Bathy surface	1
Coastline	1

MHW DEM Development

The MHW Central Washington Coast DEM was developed by generating a conversion grid based on VDatum software. The completed conversion grid was then applied to the NAVD 88 DEM.

DEM Analysis

The completed Central Washington Coast DEMs were compared to ENC charting data, topographic benchmarks, and high resolution imagery. Inconsistencies were evaluated and resolved based on most current or reliable data available.

Acknowledgement

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Appendix A: NOS Surveys

Survey ID	*Date*	*Scale*	*Original Horizontal Datum*	*Original Vertical Datum*
H02096	1891	40,000	unknown	undetermined
H04710	1927	20,000	unknown	undetermined
H04715	1927	20,000	unknown	MLLW
H04716	1927	20,000	unknown	MLLW
H04729	1927	40,000	unknown	MLLW
H04735	1927	80,000	unknown	MLLW
H04775	1927	120,000	unknown	MLLW
H05068	1930	40,000	unknown	MLLW
H05069	1930	20,000	unknown	MLLW
H05070	1930	20,000	unknown	MLLW
H05107	1930	20,000	unknown	MLLW
H05108	1930	20,000	unknown	MLLW
H05110	1930	40,000	unknown	MLLW
H05111	1930	40,000	unknown	MLLW
H05114	1930	120,000	unknown	MLLW
H05146	1931	20,000	unknown	MLLW
H08241	1955	5,000	unknown	MLLW
H08242	1955	10,000	unknown	MLLW
H09413	1974	80,000	NAD 1927	MLLW
H09418	1974	80,000	NAD 1927	MLLW
H12221	2010	20,000	NAD 1983 UTM 10 N	MLLW
H12222	2010	20,000	NAD 1983 UTM 10 N	MLLW
H12223	2010	20,000	NAD 1983 UTM 10 N	MLLW

Appendix B: NCEI Multibeam surveys

Survey ID	*Date*	*Ship*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
AT11L30	2005	Atlantis	AT11L30	NAD 1983 geographic	Assumed MSL
AVON09MV	1999	Melville	AVON09MV	NAD 1983 geographic	Assumed MSL
EX0801	2008	Okeanos Explorer	EX0801	NAD 1983 geographic	Assumed MSL
HLY11TA	2011	Healy	HLY11TA	NAD 1983 geographic	Assumed MSL
MGL1211	2012	Marcus G. Langseth	MGL1211	NAD 1983 geographic	Assumed MSL
REM-01MV	1993	Melville	REM-01MV	NAD 1983 geographic	Assumed MSL
SO108	1996	Sonne	SO108	NAD 1983 geographic	Assumed MSL
TN254	2010	Thomas G. Thompson	TN254	NAD 1983 geographic	Assumed MSL
TN265	2011	Thomas G. Thompson	TN265	NAD 1983 geographic	Assumed MSL
TN267	2011	Thomas G. Thompson	TN267	NAD 1983 geographic	Assumed MSL
TN268	2011	Thomas G. Thompson	TN268	NAD 1983 geographic	Assumed MSL
TN281	2012	Thomas G. Thompson	TN281	NAD 1983 geographic	Assumed MSL
TN283	2012	Thomas G. Thompson	TN283	NAD 1983 geographic	Assumed MSL
TN290B	2013	Thomas G. Thompson	TN290B	NAD 1983 geographic	Assumed MSL
TN296	2013	Thomas G. Thompson	TN296	NAD 1983 geographic	Assumed MSL
TN312	2014	Thomas G. Thompson	TN312	NAD 1983 geographic	Assumed MSL