Digital Elevation Models of Nikolski, Alaska: Procedures, Data Sources, and Analysis

Prepared for the National Tsunami Hazard Mitigation Program (NTHMP) and the University of Alaska at Fairbanks (UAF) by the NOAA National Geophysical Data Center (NGDC)
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Summary

In July of 2014, NOAA's National Geophysical Data Center (NGDC) developed two updated integrated bathymetric–topographic digital elevation models (DEMs) of Nikolski, Alaska for the National Tsunami Hazard Mitigation Program (NTHMP) and for the Geophysical Institute at the University of Alaska, Fairbanks (UAF). The nested DEMs will be used to support modeling tsunami generation, propagation, and inundation. Nikolski, Alaska is located at 52º56'29"N 168º51'39"W, on Umnak Island in the Aleutian Islands. The island covers an area of 133 square miles and has a total population of 39. On a clear day, the horizon is dominated by Mount Vsevidof, a strato-volcano with the highest point on Umnak Island. Mount Vsevidof is approximately 10 kilometers wide at the base and steepens from 15 degrees to 30 degrees near the peak. A circular crater, 1.2 kilometers in diameter, is present at the summit. Its most recent eruption was caused by an earthquake on March 11, 1957. DEM Specifications for the Nikolski DEMs are listed in Table 1. Figure 1 shows the DEM extents.

Table 1. Specifications for the nested Nikolski, Alaska DEMs.

	Coverage
Cell Size	Nikolski, AK
1/3 arc-second	168.99° to 168.73° W, 52.89° to 53.02° N
1 arc-second	169.66° to 168.08° W, 52.09° to 53.19° N
Coordinate System	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)
Vertical Datum	Mean Higher High Water (MHHW)
Vertical Units	Meters
Grid Format	ASCII raster grid

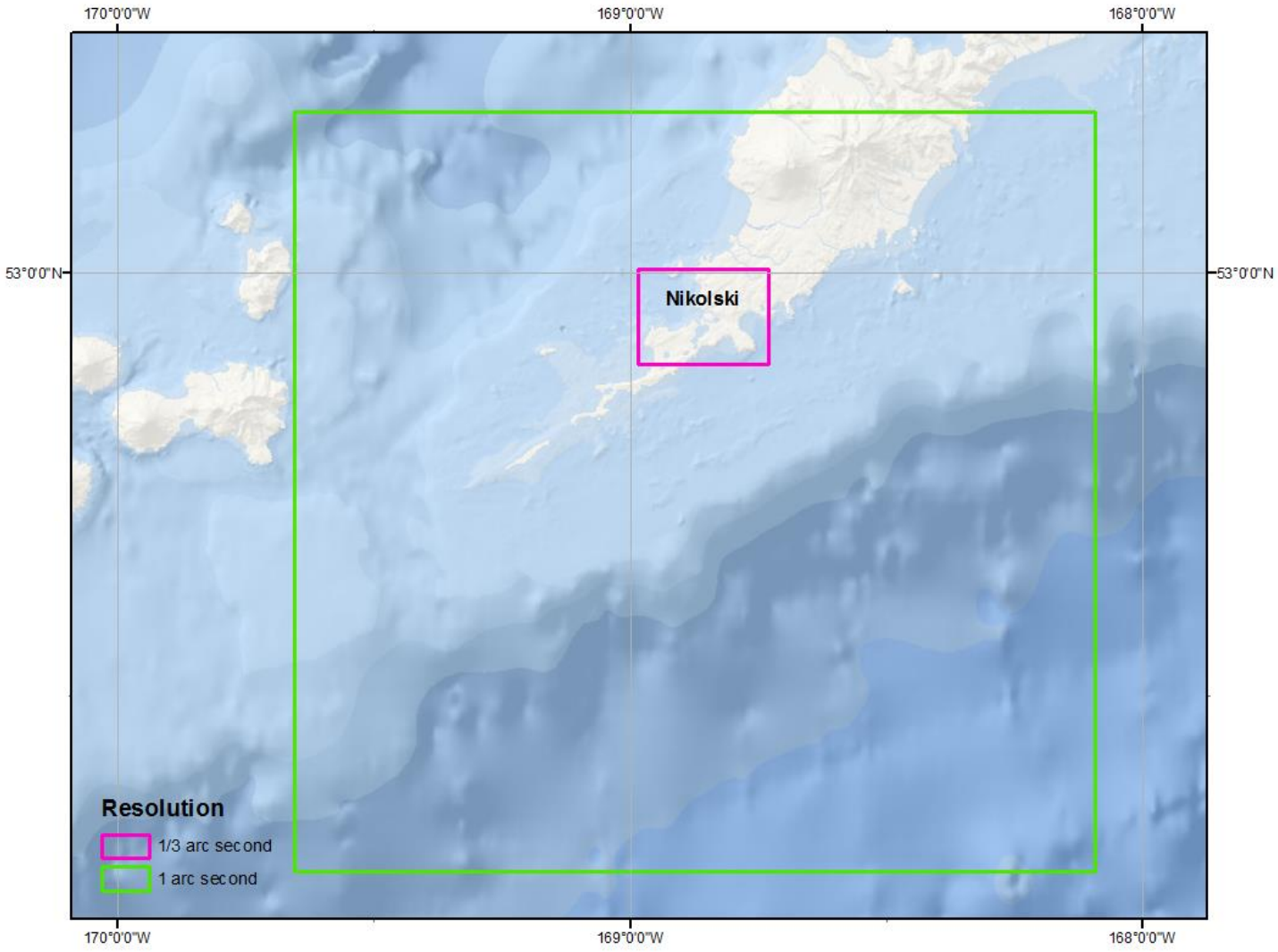

Figure 1. Map image of the boundaries for the 1/3 arc-second Nikolski DEM in pink and the 1 arc-second Nikolski DEM in green.

Data Sources and Processing

Shoreline, bathymetric, and topographic digital datasets were obtained from several U.S. federal and academic agencies, including: NOAA's National Ocean Service (NOS), and NGDC; the U.S. Fish and Wildlife Service (USFWS); the National Aeronautic Space Administration (NASA), and the U.S. Geological Survey (USGS). Figure 2 illustrates the source data coverage for both bathymetric and topographic data used in developing the Nikolski DEMs.

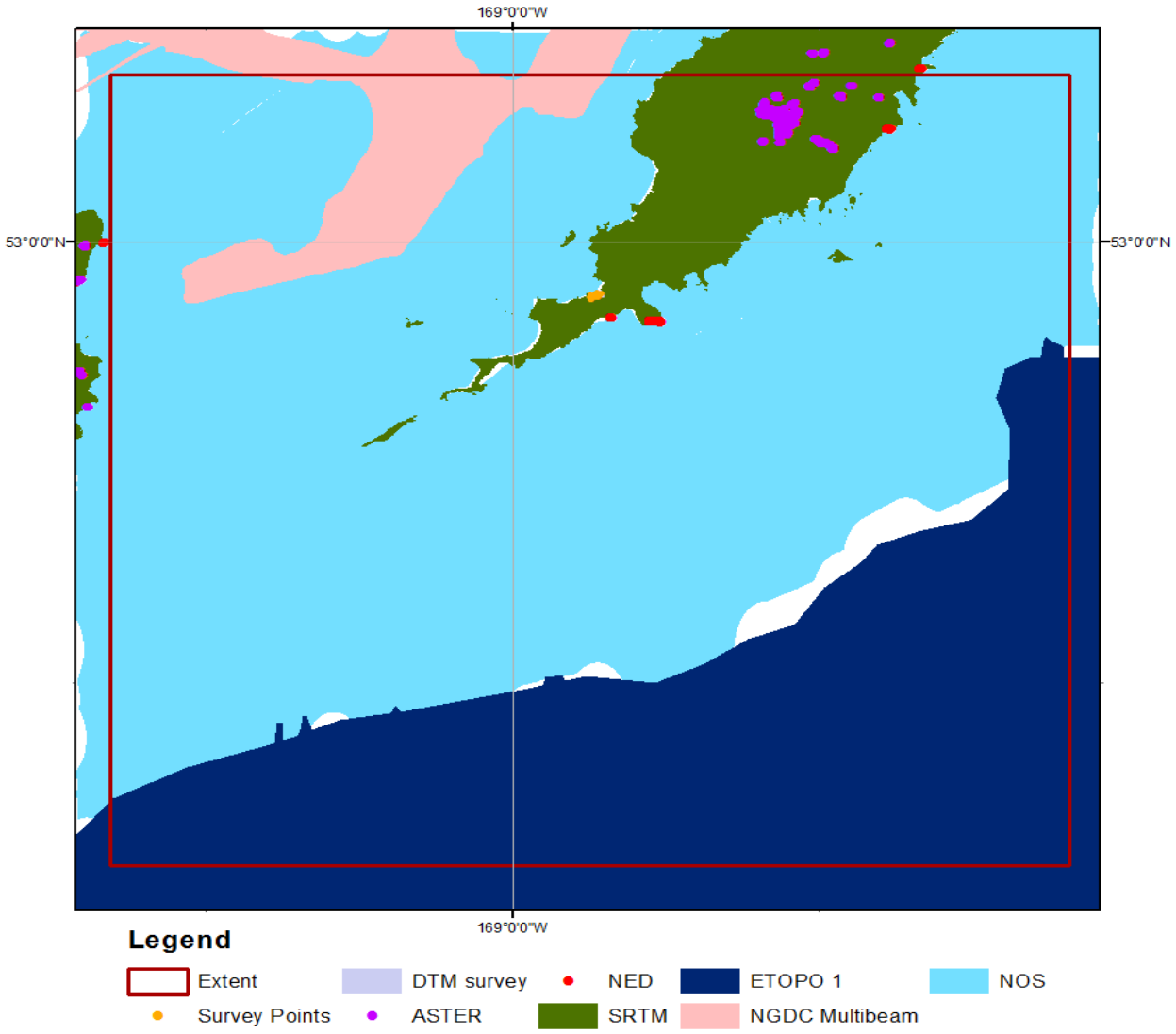

Figure 2. Source and coverage of the datasets used in compiling the Nikolski DEMs.

Digital coastlines were extracted from NOAA's Office of Coast Survey (OCS) ENC Direct to GIS online extraction service (http://nauticalcharts.noaa.gov/csdl/ctp/encdirect_new.htm). The coastlines were merged and edited to match ESRI's World Imagery map service (http://www.arcgis.com/features/maps/imagery.html), and topographic data. Figure 3 shows a comparison of the available coastlines used in developing the Nikolski DEMs.

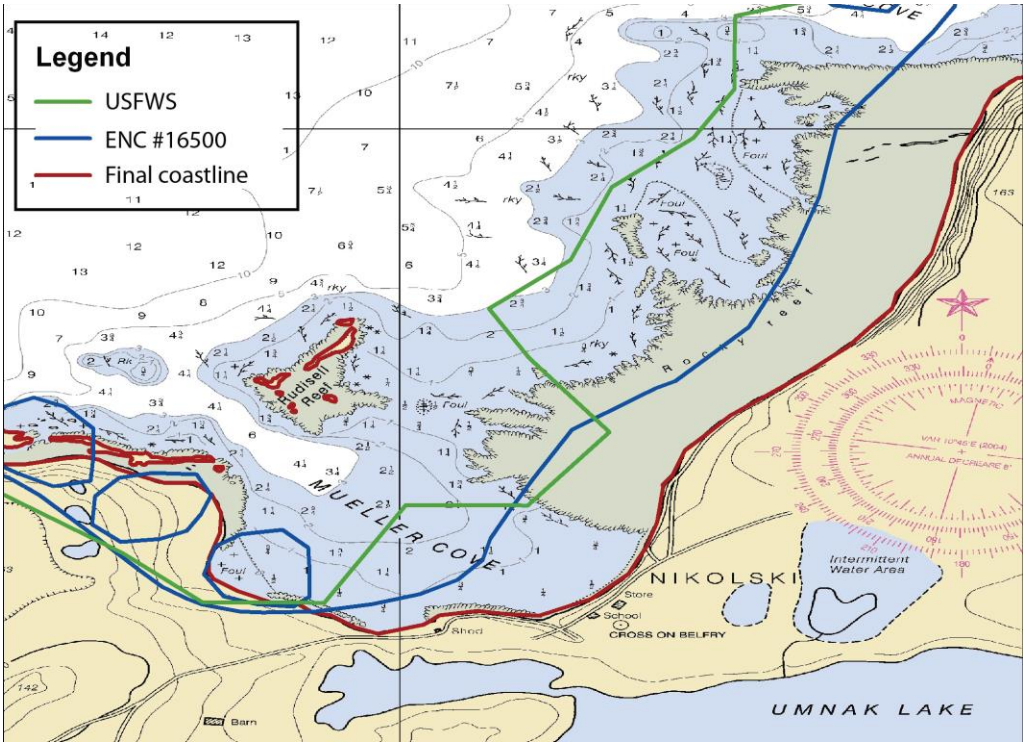

Figure 3. Digital coastlines used in developing the Nikolski DEMs.

Bathymetric datasets used in the compilation of the Nikolski DEM included NOS hydrographic surveys, NGDC multibeam swath sonar surveys and the ETOPO1 Global Relief Model (Table 2). Datasets were originally referenced to mean lower low water (MLLW) or mean sea level (MSL).

Safe Software's FME data translation tool package was used to shift datasets to WGS 1984 horizontal datum and to convert into ESRI ArcGIS shapefiles. The shapefiles were then displayed with ArcGIS to assess data quality and manually edit datasets. Vertical datum transformations to MHHW were also accomplished using FME and GDAL based upon data from the NOAA Nikolski tide station.

Table 2: Bathymetric data sources used in compiling the Nikolski DEMs.

Source	***Date***	***Data Type***	***Spatial Resolution***	***Horizontal Datum***	***Vertical Datum***
NOAA NOS	1910 to 1940	Hydrographic survey soundings	1 meter to several kilometers	Unknown, Early Alaska Datums, NAD 1927, NAD 83, or NAD 83 UTM Zone 4	Mean Lower Low Water (MLLW)
NGDC ETOPO 1	2008	Global Relief Model	1 Arc Minute	WGS 84 geographic	Assumed MSL
NGDC multibeam	1988 to 2005	Multibeam swath sonar	Gridded to 1 arc-second	WGS 84 geographic	Assumed MSL

Bathymetric data were transformed to WGS 84 and MHHW as needed and where recent, higher resolution data exists, older data were deleted. Vertical datum transformations were calculated based on the Nikolski, AK tidal gauge (Table 3).

Table 3: Relationship between MHHW and other vertical datums at regional tide gauge.

Vertical Datum	***Elevations of tidal datums (meters)***		***Difference to MHHW (meters)***
Mean higher high water	1.224		
Mean high water	1.21	MHW to MHHW	-0.014
Mean tide level	0.701	MTL to MHHW	-0.523
Mean sea level	0.695	MSL to MHHW	-0.529
Mean low water	0.281	MLW to MHHW	-0.943
Mean lower low water	0.000	MLLW to MHHW	-1.224

The bathymetric data were converted to xyz format before combining with the coastline data to generate bathymetric pre-surfaces at 1/3 arc-second and 1 arc-second. These bathymetric surface grids were converted to xyz format before incorporating in their respective final DEMs.

Five topographic datasets were obtained for the Nikolski region. The SRTM DEM provided full topographic coverage at 1 arc-second. USGS's NED provides full 2 arc second coverage for Alaska. The NED and ASTER datasets were used to fill gaps on the coast where SRTM data was sparse. Along with these data, used were GPS points acquired through the University of Alaska Fairbanks and survey grade CAD points near the town of Nikolski. Vertical datum transformations were based on the NOAA tide stations (Table 3). All topographic data were converted to xyz format for the final gridding process.

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

Source	***year***	***Data Type***	***Spatial Resolution***	***Original Horizontal Datum/coordinate system***	***Original Vertical Datum***	***URL***
USGS NED	2006	Topographic DEM	2 arc second grid	NAD27 geographic	NGVD29 (meters)	http://ned.usgs.gov
NASA SRTM	2000	Topographic DEM	1 arc second grid	WGS84 geographic	WGS84/EGM96 Geoid (meters)	http://srtm.usgs.gov
ASTER	2009	Topographic DEM	1 arc second grid	WGS84 geographic	WGS 84/EGM96 Geoid (meters)	http://asterweb.jpl.nasa.gov
DCRA	2014	Survey data		NAD 83 Alaska State Plane, Zone 10 (feet)	Geoid 99 (feet)	
UAF GPS Points	2014	GPS points		WGS 84 geographic	MHHW	

DEM Development

MB-System was used to create both the 1 and 1/3 arc-second DEMs of Nikolski, Alaska. The MB-System tool "mbgrid" applied a tight spline tension to the xyz data, and interpolated values for cells without data. The data hierarchy used in the "mbgrid" gridding algorithm, as relative gridding weights, is listed in Table 5. Greatest weight was given to the NGDC swath sonar multi-beam. Least weight was given to the pre-surfaced 1 arc-second bathymetric grid. A small area was updated manually near Umnak lake to show a lake depth of -3 meters.

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

Dataset	***Relative Gridding Weight***
NGDC hydrographic sonar multi-beam	100
SRTM topographic DEM	10
NOS hydrographic surveys	10
DCRA survey data	1
UAF GPS Points	1
USGS NED topographic DEM	1
ASTER topographic DEM	1
ETOPO1 Global Relief Model	1
Final Coastline at 0 meters	1
Pre-surfaced bathymetric grid	0.01

DEM Analysis

The completed Nikolski DEM was compared to nautical charts, topographic maps, and high resolution imagery. Inconsistencies were evaluated and resolved based on most reliable data available.

Acknowledgement

The creation of this DEM was funded by the National Tsunami Hazard Mitigation Program.

Reference

Electronic Navigational Chart #16500, 4th Edition, 2009. Unalaska Island to Amukta Island. Scale 1:300,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Electronic Navigational Chart #16501, 2nd Edition, 2007. Islands of Four Mountains. Scale 1:80,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Raster Nautical Chart # 16511, 7th Edition, 2004. Inanudak and Nikolski Bays. Scale 1:40,000. U.S. Department of Commerce, NOAA, National Ocean Service, Coast Survey.

Appendix A: NOS Surveys

NOS Survey ID	*Year of Survey*	*Original Vertical Datum*	*Original Horizontal Datum of Digital records*
H03124	1910	MLLW	Undetermined
H06265	1937	MLLW	Early Alaska
H06274	1937	MLLW	Early Alaska
H06286	1937	MLLW	Early Alaska
H06303	1937	MLLW	Early Alaska
H06377	1938	MLLW	Early Alaska
H06379	1938	MLLW	Early Alaska
H06380	1938	MLLW	Early Alaska
H06381	1938	MLLW	Early Alaska
H06382	1938	MLLW	Early Alaska
H06383	1938	MLLW	Early Alaska
H06412	1938	MLLW	Early Alaska
H06413	1938	MLLW	Early Alaska
H06478	1939	MLLW	Early Alaska
H06503	1940	MLLW	Early Alaska
H06504	1940	MLLW	Early Alaska
H06505	1940	MLLW	Early Alaska
H06526	1940	MLLW	Early Alaska
H06527	1940	MLLW	Early Alaska
H06568	1940	MLLW	Early Alaska
H06569	1940	MLLW	Early Alaska
H06570	1940	MLLW	Early Alaska
H06610	1940	MLLW	Early Alaska
H06611	1940	MLLW	Early Alaska

Appendix B: NGDC Multi-beam Surveys

Survey ID	*Date*	*Ship*	*Source*
EW0204	2002	Maurice Ewing	UNOLS R2R
FOCI95	1995	Surveyor	UNOLS R2R
TNI182	2005	Thomas Thompson	UNOLS R2R
RNDB06WT	1988	Thomas Washington	UNOLS R2R