Combined High-Resolution LIDAR Topography and Multibeam Bathymetry for Northern Resurrection Bay, Seward, Alaska

Data Series 374

This page intentionally left blank

Combined High-Resolution LIDAR Topography and Multibeam Bathymetry for Northern Resurrection Bay, Seward, Alaska

By Keith A. Labay and Peter J. Haeussler

Data Series 374

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia: 2008

Contents

Figures

Conversion Factors and Datums

Conversion Factors

Multiply	By	To obtain
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)

Datums

Vertical coordinate information is referenced to the tidal datum of Mean High Water (MHW).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Elevation, as used in this report, refers to distance above or below the vertical datum.

This page intentionally left blank

Combined High-Resolution LIDAR Topography and Multibeam Bathymetry for Northern Resurrection Bay, Seward, Alaska

By Keith A. Labay and Peter J. Haeussler

Abstract

A new Digital Elevation Model was created using the best available high-resolution topography and multibeam bathymetry surrounding the area of Seward, Alaska. Datasets of (1) LIDAR topography collected for the Kenai Watershed Forum, (2) Seward harbor soundings from the U.S. Army Corp of Engineers, and (3) multibeam bathymetry from the National Oceanic and Atmospheric Administration contributed to the final combined product. These datasets were placed into a common coordinate system, horizontal datum, vertical datum, and data format prior to being combined. The projected coordinate system of Universal Transverse Mercator Zone 6 North American Datum of 1927 was used for the horizontal coordinates. Z-values in meters were referenced to the tidal datum of Mean High Water. Gaps between the datasets were interpolated to create the final seamless 5-meter grid covering the area of interest around Seward, Alaska.

Introduction

The small coastal town of Seward, Alaska, lies at the north end of Resurrection Bay—a spectacular fiord adjacent to Kenai Fjords National Park that faces south to the Pacific Ocean (fig. 1). Seward is an important port city, with numerous cruise ship landings in the summer, and is a significant fishing port year round.

A new seamless Digital Elevation Model (DEM) covering the northern portion of Resurrection Bay was created using the best available high-resolution topography and multibeam bathymetry (fig. 2). This DEM was developed for studying submarine landslides and tsunamis produced by the M9.2 1964 earthquake (Lee and others, 2006; Haeussler and others, 2007), and for developing computer models of tsunami wave propagation and inundation as part of the National Tsunami Hazards Mitigation Program (Suleimani and others, 2006). With higher quality topography and bathymetry data becoming more commonly available, seamless datasets like this DEM should become more routinely used for studying physical processes in coastal areas.

Data Sources and Processing

The elevations, or Z-values, in this DEM are a composite of three sources (fig. 3). The topographic data are from a previously unpublished dataset collected in January 2006 for the Kenai Watershed Forum. Snow cover at Seward at the time of the survey was discontinuous and ranged from 0 to approximately 1 inch in some areas, although there likely was more snow at higher elevations. The detail of the topographic data indicates that the small amount of snow did not significantly smooth out topography. The U.S. Army Corp of Engineers (USACE) collected soundings for the recently expanded Seward small boat harbor in June 2006. Bathymetric data outside the harbor are from a National Oceanographic and Atmospheric Administration (NOAA) multibeam dataset collected from August to September 2001. Prior to combining the datasets, the three sources were modified to place them into a common coordinate system, horizontal datum, and vertical datum. The projected coordinate system of Universal Transverse Mercator (UTM) Zone 6 North American Datum of 1927 (NAD27) was used for the horizontal coordinates to meet the requirements of the tsunami modeling project. Vertical units converted to meters were referenced to the tidal datum of Mean High Water (MHW). By using MHW as the datum, an inundation model can reproduce the effects of a tsunami occurring at high tide when the risk to coastal areas would be greatest.
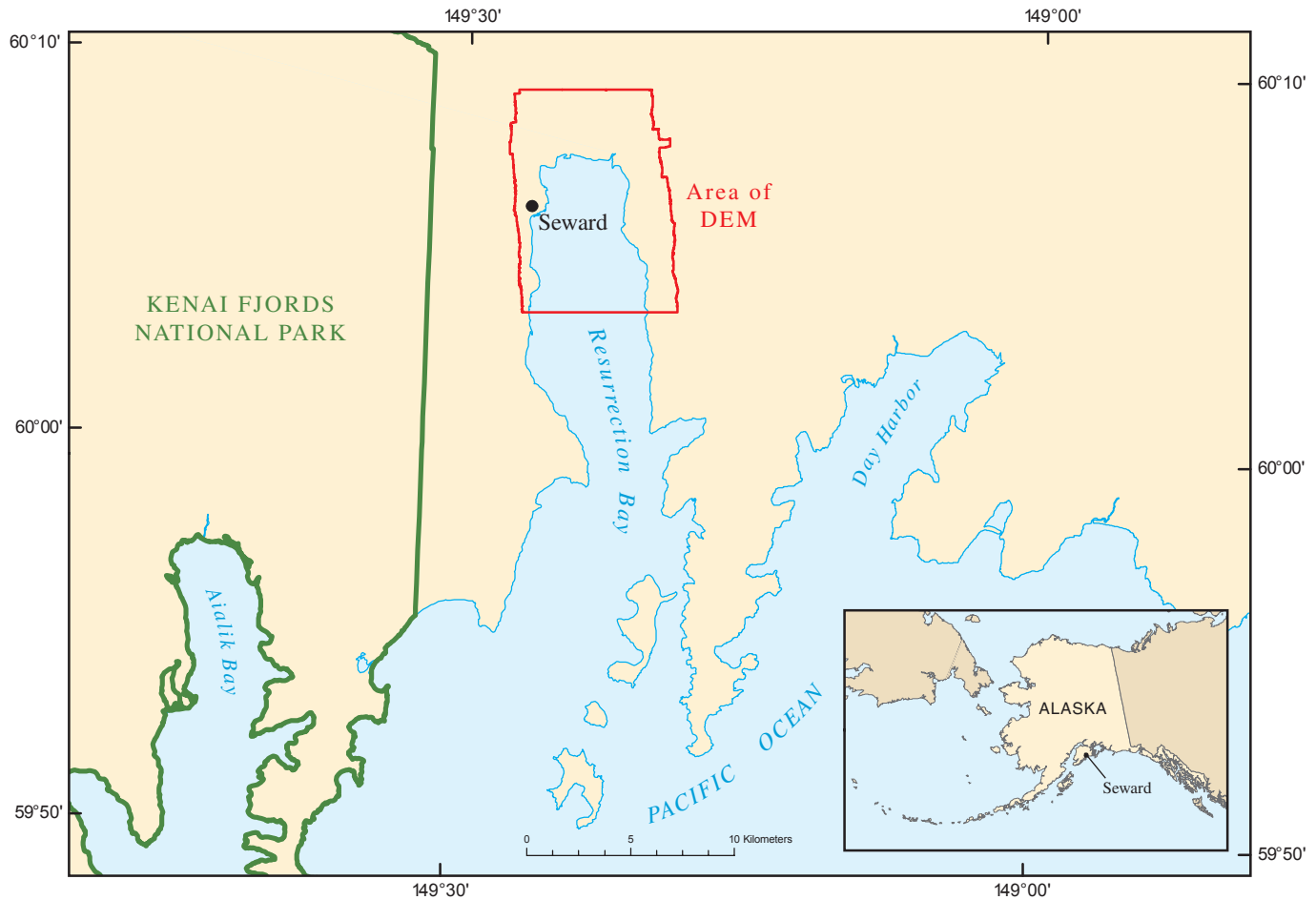
Figure 1.   Coastline around Seward, Alaska, showing the extent of the combined high-resolution LIDAR topography and multibeam bathymetry DEM.

High-Resolution Topography

The topography of most areas of Alaska is known only roughly. The USGS produced 1:63,360-scale topographic maps of most of the State, as well as derivative about 45-meter DEMs. These DEMs, based on the topographic maps produced in the last 50 years, are of moderate quality and are most useful for small-scale regional mapping. One of the recent tools-of-choice for high-resolution large-scale mapping of topography is Airborne Laser Swath Mapping (ALSM), also known as LIDAR (Light Detection and Ranging). With proper data acquisition and processing, a 'bare earth' image can be produced from LIDAR data that removes overlying vegetation and buildings. This allows the ground surface to be shown in greater detail even in forested areas.

The Kenai Watershed Forum (http://www.kenaiwatershed.org) organized a coalition of partners to acquire a public domain LIDAR survey of the Seward area. With their permission, a subset of the survey is being

published for the first time in this report. Due to processing constraints and the needs of this project, the entire survey could not be used; there is additional coverage north of the dataset presented here (fig. 2).

The bare earth LIDAR data were obtained as an ARC/INFO® grid. Projection of the grid was Alaska State Plane FIPS 5004 North American Datum of 1983 (NAD83). Elevation values were in feet. The vertical datum of the Z-values was North American Vertical Datum of 1988 (NAVD 88).

This grid was reprojected into UTM zone 6 NAD27. Z-values were converted from feet to meters. The vertical datum was adjusted from NAVD88 to MHW by adding -2.9 meters to the Z-values. The difference between the geodetic and tidal datums was determined relative to several tidal benchmarks in the Seward area. Information about the geodetic and tidal datum elevations at these benchmarks was provided by NOAA National Ocean Service (NOS).
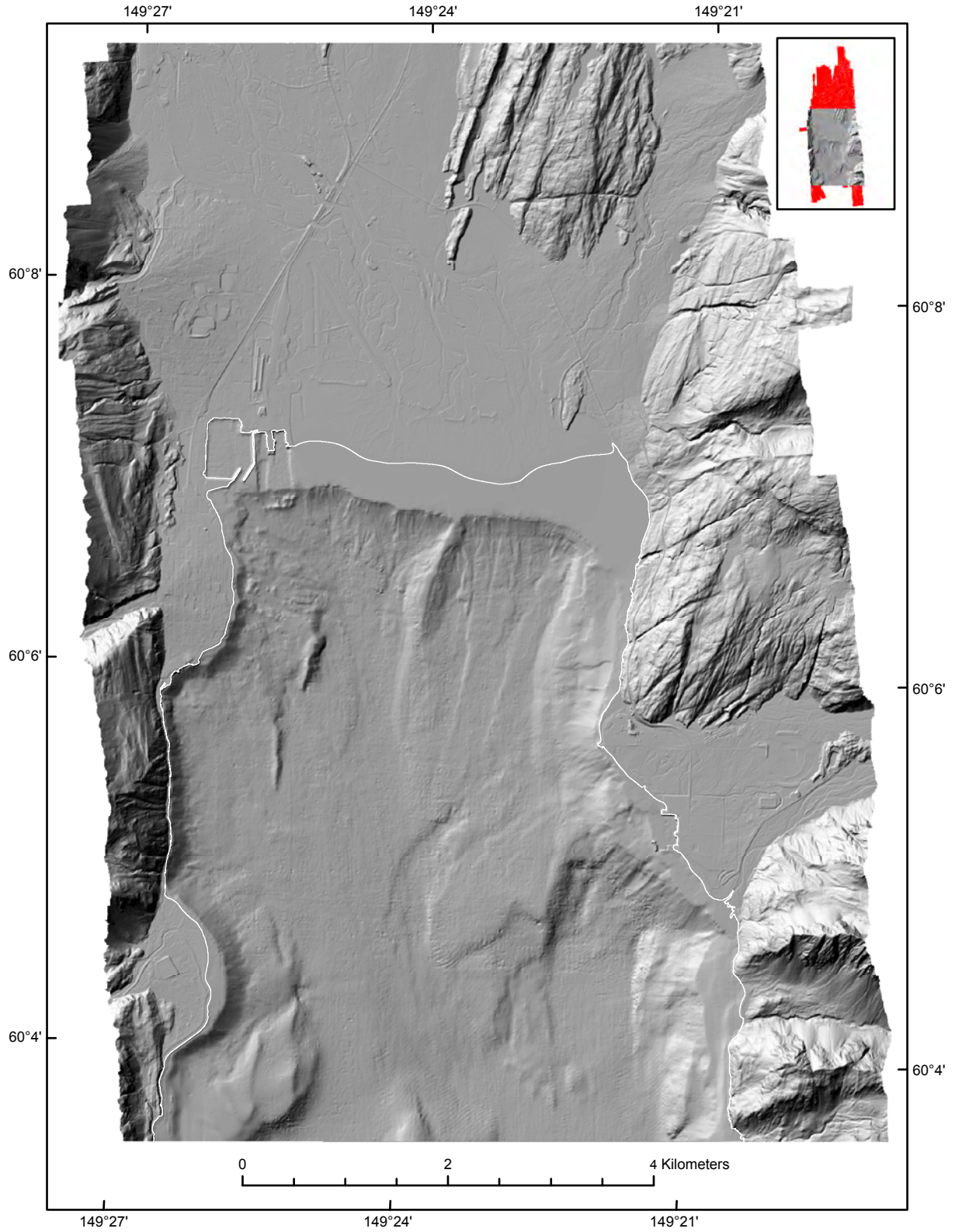
Figure 2.   Shaded relief image showing combined high-resolution LIDAR topography and multibeam bathymetry DEM.
Artificial sun angle is from the northwest. White line defines boundary between LIDAR and bathymetry data.
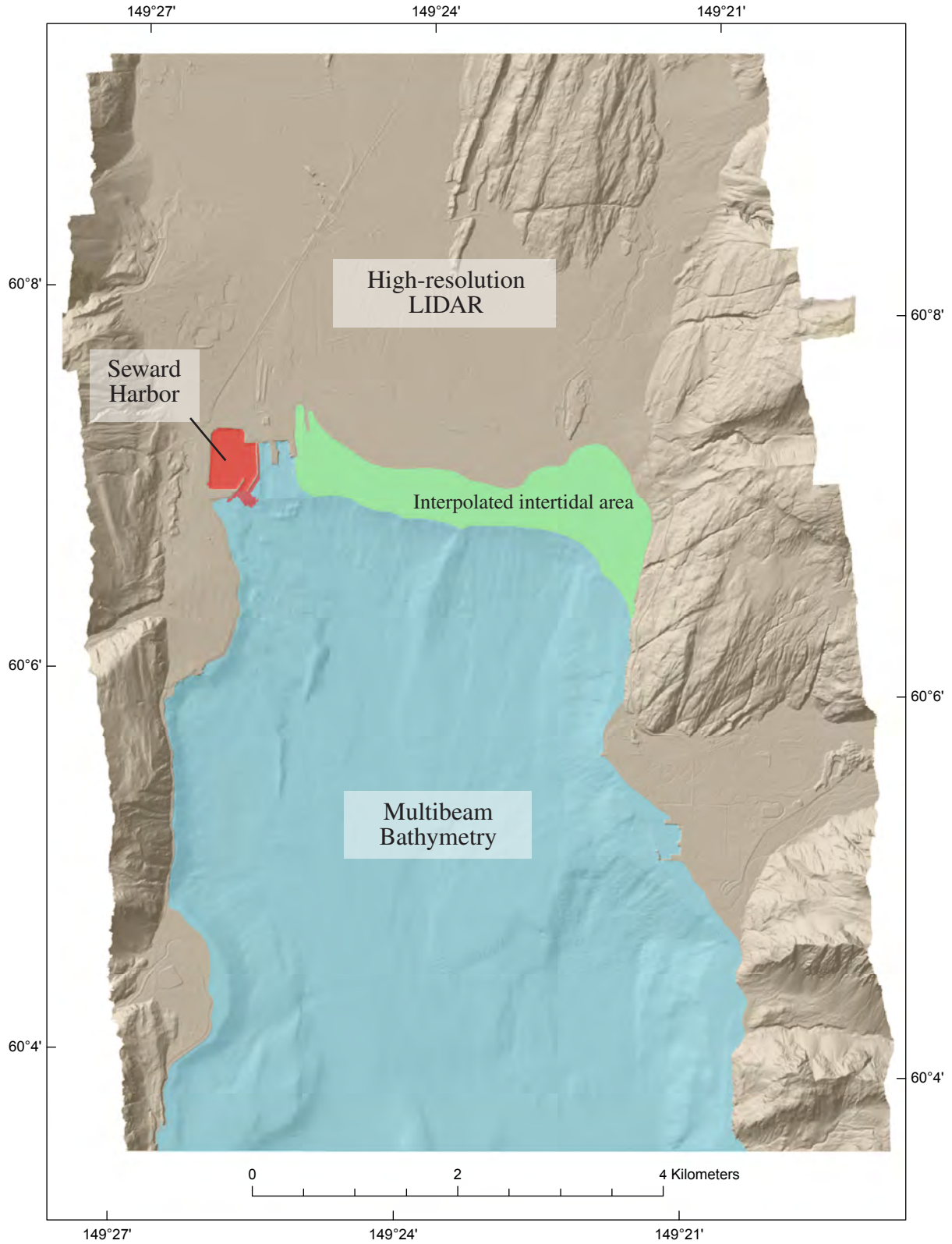Inset shows original larger extent of LIDAR data.

Figure 3.   Data extents for the combined high-resolution LIDAR topography, Seward harbor soundings, and multibeam bathymetry DEM.

The grid was then resampled from the original 0.9144-meter cell size to 5-meter cells, and converted to a GIS point feature class. The extent of the LIDAR survey included a portion of the ocean's surface near the coast on which water waves could be seen. This allowed a line to be digitized that defined the waters edge at the time the LIDAR survey was collected. The elevation of the waters edge varies due to changing tide levels while the aircraft collecting the data was flying overhead. Using this line as the shoreward extent of LIDAR data, data points returned from the ocean's surface were eliminated. The LIDAR data collected over the ocean was adequate to image wave trains with peak to trough amplitudes of 0.5–1.5 meters.

Seward Harbor

The eastern edge of the Seward harbor was moved seaward in 2004–06 as part of an expansion project by the USACE. Upon completion, the USACE surveyed the condition of the harbor and harbor entrance area. This condition survey collected 5,062 depth soundings. These soundings were obtained from the USACE as an ASCII XYZ file. Projection of the data was Alaska State Plane FIPS 5004 NAD83. Depth values were in feet. The tidal datum of the depths was MLLW.

A GIS point feature class was created from these points and reprojected into UTM Zone 6 NAD27. Depth values were converted to meters instead of feet. Z-values greater than or equal to zero were eliminated. The tidal datum was adjusted from MLLW to MHW by adding the value of -2.96 meters determined from the Seward tidal benchmarks. Using the remaining Seward harbor points, together with the Seward LIDAR data as a guide, a polygon was created to define the area where depths would be determined from the Seward harbor points in the final DEM.

Multibeam Bathymetry

As part of a program to improve the bathymetry of areas with extensive vessel traffic, NOAA used a multibeam echosounder system to map the floor of the entire fiord, up to the level of MLLW. This bathymetry was downloaded over the Internet using the NOS Hydrographic Survey Viewer http://map.ngdc.noaa.gov/website/mgg/nos_hydro/ (accessed October 3, 2007) as an ASCII YXZ file gridded to 15-meter cells. Projection of the coordinates was UTM Zone 6 NAD83, and the depths were in positive meters. The tidal datum of the depths was MLLW.

A GIS point feature class was created from these coordinates, and the depths were changed to negative values. These points were then reprojected into UTM Zone 6 NAD27. The tidal datum of the depths was adjusted to MHW by adding

a value of -2.96 meters. Using the waters edge defined from the Seward LIDAR data, any points that fell outside of this polygon were eliminated. Points that overlapped with the area covered by the Seward harbor polygon also were eliminated.

Combined Dataset

The three modified point datasets were combined to create a single point dataset. Gaps between the three datasets in the intertidal zone were filled by interpolated data points to create a seamless transition. Along the steep sides of Resurrection Bay, the separation between the LIDAR data and multibeam bathymetry was minimal, and required little to no interpolation. A shallow intertidal area at the head of the bay represented the only large gap within the DEM, which was filled during the interpolation process (fig. 3). Grid cells outside of the area of interest appear as NODATA. Final projection of the combined DEM was UTM Zone 6 NAD27, Z-values were in meters, and the grid cell size was 5 meters.

Summary

This report presented a new DEM for the area surrounding the coastal town of Seward, Alaska. Using a combination of three data sources a DEM was created that seamlessly represented the topography from the seafloor to the surrounding mountains. These sources included high resolution LIDAR topography, soundings collected in the Seward harbor, and multibeam bathymetry. The steps used to modify and then combine the individual datasets are provided.

References Cited

Haeussler, P.J., Lee, H.J., Ryan, H.F., Kayen, R.E., Labay, Keith, Suleimani, Elena, and Hampton, M.A., 2007, Submarine slope failures near Seward, Alaska, during the M9.2 1964 earthquake: 3rd International Symposium on Submarine Mass Failures and Their Consequences, Springer Verlag.

Lee, Homa, Ryan, Holly, Kayen, R.E., Haeussler, P.J., Dartnell, Peter, and Hampton, M.A., 2006, Varieties of submarine failure morphologies of seismically-induced landslides in Alaskan fjords: Norwegian Journal of Geology, v. 86, p. 221-230. ISSN 029-196X.

Suleimani, Elena, Lee, H.J., Haeussler, P.J., and Hansen, R.A., 2006, Numerical modeling of submarine landslide-generated tsunamis as a component of the Alaska Tsunami Inundation Mapping Project: Eos Trans. AGU, v. 87, no. 52, fall meeting supplement, Abstract OS33E-01.

This page intentionally left blank

USGS