NOAA Technical Memorandum NMFS-AFSC-287
doi:10.7289/V5GT5K4F

Smooth Sheet Bathymetry of the Central Gulf of Alaska

by
M. Zimmermann and M. M. Prescott

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

January 2015

NOAA Technical Memorandum NMFS

The National Marine Fisheries Service's Alaska Fisheries Science Center uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

The NMFS-AFSC Technical Memorandum series of the Alaska Fisheries Science Center continues the NMFS-F/NWC series established in 1970 by the Northwest Fisheries Center. The NMFS-NWFSC series is currently used by the Northwest Fisheries Science Center.

This document should be cited as follows:

Zimmermann, M., and M. M. Prescott. 2015. Smooth sheet bathymetry of the central Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-287, 54 p. doi:10.7289/V5GT5K4F.

Document available: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-287.pdf

NOAA Technical Memorandum NMFS-AFSC-287
doi:10.7289/V5GT5K4F

Smooth Sheet Bathymetry of the Central Gulf of Alaska

by
M. Zimmermann and M. M. Prescott

Alaska Fisheries Science Center
Resource Assessment and Conservation Engineering Division
7600 Sand Point Way NE
Seattle, WA 98115-6349

www.afsc.noaa.gov

U.S. DEPARTMENT OF COMMERCE
Penny. S. Pritzker, Secretary
National Oceanic and Atmospheric Administration
Kathryn D. Sullivan, Under Secretary and Administrator
National Marine Fisheries Service
Eileen Sobeck, Assistant Administrator for Fisheries

January 2015

This document is available to the public through:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

www.ntis.gov

Abstract

We assembled 1.75 million bathymetric soundings from 225 lead-line and single-beam echosounder hydrographic surveys conducted from 1901 to 1999 in the central Gulf of Alaska. These bathymetry data are available from the National Geophysical Data Center (NGDC: http://www.ngdc.noaa.gov), which archives and distributes data that were collected by the NOS (National Ocean Service), its predecessors, and others. While various bathymetry data have been previously downloaded from NGDC, compiled, and used for a variety of projects, our effort differed in that we compared and corrected the digital bathymetry by studying the original analog source documents - digital versions of the original survey maps, called smooth sheets. Our editing included deleting erroneous and superseded values, digitizing missing values, and properly aligning all data sets to a common, modern datum. There were several areas where these older surveys were superseded by more recent, higher quality multibeam surveys, mostly from the NOS (n = 106). Three of these were unprocessed NOS multibeam surveys in the Sitka area, which we edited and processed into final bathymetric surfaces. We reduced the resolution of these multibeam surveys to 100 m, since some may have sub-meter resolution and many exceed a million soundings, and added them to our bathymetry compilation. We proofed, edited, or digitized 96,000 cartographic features (mostly from the smooth sheets, some from the multibeam surveys), such as rocky reefs, kelp beds, rocks, and islets, creating the most thorough compilation of these typically shallow, inshore features. The depth surface and inshore features, intended for use in fisheries research, are available at the Alaska Fisheries Science Center (AFSC: http://www.afsc.noaa.gov), and were mostly produced at a map scale of 1:20,000.

Contents

Introduction

While the Alaska Fisheries Science Center (AFSC) has been conducting marine research for decades in Alaskan waters, a lot of basic information about the seafloor, such as depth, is generally not known beyond what is depicted on small scale (1:100,000) NOS (National Ocean Service) navigational charts. Therefore, we have been creating more detailed bathymetry and sediment maps in order to provide a better understanding of how studied animals interact with their environment. Our smooth sheet bathymetry compilation of the central Gulf of Alaska (CGOA) ranged geographically from the Trinity Islands in the west, across the southern coast of Kodiak Island, around the Barren Islands, along the southern Kenai coast, outside of Prince William Sound (PWS), and east and southeast along the coast to Cape Ommaney, including inlets such as Icy Bay, Yakutat Bay, Lituya Bay, Cross Sound, Salisbury Sound, and Sitka Sound, covering an arc of about 1,400 km of shelf (Fig. 1). The CGOA is a large area covering about 20 degrees of longitude and 4 degrees of latitude, with numerous geomorphic features such as islands, wide inlets, fjords, straits, banks, reefs, glacial troughs and moraines, active tidewater glaciers, fault lines, and shelves both broad and narrow. Our CGOA boundaries are somewhat arbitrary as the CGOA connects to other regions such as the western Gulf of Alaska (GOA), Shelikof Strait, Cook Inlet (Zimmermann and Prescott 2014), interior PWS, the inside waters of Southeast (SE) Alaska, the easternmost portion of the GOA ranging from Cape Ommaney to Dixon Entrance, as well as the open ocean. Our definition of the geographic boundaries was set to match the boundaries of the Gulf of Alaska Integrated Ecosystem Project (GOA-IERP), sponsored by the North Pacific Research Board (NPRB).

The CGOA bathymetry is unevenly and patchily described, with a majority of the smooth sheet surveys conducted prior to World War II (WWII), some shallow areas without any surveys, and some deep areas with detailed surveys. Therefore we combined numerous bathymetric data sources, including smooth sheet surveys, shallow- and deep-water multibeam surveys, and non-hydrographic surveys, to provide coverage across the entire area with as few contradictory overlaps as possible. Minimizing contradictions meant that differences in neighboring soundings could be attributed to seafloor features, several of which, such as the depressions in Kayak Trough, elevations associated with the Fairweather Fault Zone, relic marine terraces around Middleton Island, and fault scarps off Kodiak Island, were revealed in new detail.

The western portion of the study area is almost entirely banks and troughs (Fig. 2), while the only normal continental shelf area (shallow onshore and deep offshore) is in the eastern portion of the study area (Fig. 3). On the western side of the CGOA, extending along the south side of the Kodiak archipelago, Albatross Bank is divided into southern, middle, and northern regions by Barnabus and Chiniak Troughs, respectively (Fig. 2). Northern Albatross Bank is separated from Portlock Bank by Stevenson Trough, which extends between the Kodiak Archipelago and the Barren Islands. Kennedy Entrance divides the Barren Islands from the Kenai Peninsula and is loosely connected to Amatuli Trough, which bounds the north side of Portlock Bank. Small banks extending southerly from the Pye Islands, the Chiswell Islands, Cape Junken, and Montague Island are separated by troughs that are partially occluded with semi-circular arcs, presumably glacial moraines.

In the central portion of our study area, Tar Bank, which is capped by Wessels Reef, is defined on the west by Hinchinbrook Entrance, on the east by Kayak Trough, and by a very poorly defined trough on the north side. A bank surrounding Kayak Island is bounded on the east by Bering Trough. Pamplona Spur occurs about 65 km off of Icy Bay and rises to a depth of about 123 m.

In the eastern portion of our study area, Yakutat Canyon trends parallel to shore outside of Yakutat Bay to where it bends south and extends to the shelf break (Fig. 3). Alsek Canyon trends straight offshore outside of Dry Bay. Fairweather Ground has many shallow points, including a 23.8 m (13 fathoms or fm) summit or pinnacle at a distance of about 67 km offshore. South of Yakobi Strath, a broad and flat sea valley that extends into Cross Sound, the bathymetry exhibits a normal continental shelf, with a gentle gradation from shallower water onshore to deeper water offshore. Just south of Cape Ommaney, the deep waters of Chatham Strait extend through Christian Sound and far offshore, truncating the southern end of the normal shelf physiography.

History of Nautical Charting in the CGOA

The major European discovery and charting expeditions of the CGOA spanned half a century, starting with Vitus Bering's famous 1741 voyage and ending with George Vancouver's 1794 voyage. This period included Russian, British, Spanish, and French naval expeditions, and exacted a terrible toll on the captains and crew through inclement weather, violence, accidents, and disease, especially scurvy. Captain Vitus Bering, a Danish officer sailing for the Russian Navy; Captain James Cook, sailing for the British Admiralty; and Captain Jean-Francois de Galaup, comte de LaPerouse of the French Navy, all died during their fateful North Pacific voyages (Hayes 2001). Captain George Vancouver, sick and weakened after his three North Pacific cruises, made it home but faced legal difficulties directly related to his cruises, was physically assaulted in the street, and died in obscurity less than three years after returning home (Anderson 1960). The Spanish fared more safely with their seven expeditions to Alaska, perhaps because of their policy of secretly taking possession of lands and not publishing their findings and charts, although Alejandro Malaspina was imprisoned for treason for suggesting changes in these colonial policies (Olson 2004).

The 1741 expedition of Vitus Bering, commanding the *St. Peter*, and Alexi Chirikov, commanding the *St. Paul*, was the first European charting of the Gulf of Alaska (Hayes 2001). The ships having been separated at sea, Chirikov was the first to sight land — an island in SE Alaska — from where he turned north and sailed past the future location of Sitka (Baranof Island) in an attempt to find suitable anchorage along the steep shoreline (Hayes 2001). After first losing his longboat with 11 men and then losing his final small boat with 4 more men to unknown causes, he turned for home after only 12 days in SE Alaska, never being able to obtain any drinking water nor even approaching land during the return trip (Hayes 2001). Along the way home he sighted the Kenai Peninsula, sounded out Albatross Bank, and sighted Kodiak Island (Hayes 2001). Just two days after Chirikov sighted land, Bering sighted Mt. St. Elias, and some of his crew, including the scientist Georg Steller, later made a very brief visit to Kayak Island before turning back towards Russia, charting the Shumagin Islands in the western GOA, and purposefully shipwrecking on Bering Island because with 12 men already dead and 34 completely disabled from scurvy, the ship was too difficult to operate (Hayes 2001). After over-wintering on Bering Island and suffering several more deaths, including that of Bering, the survivors built a smaller craft out of the wreckage of the *St. Peter* and sailed home (Hayes 2001). Numerous Russian fur traders and explorers followed in the wake of Bering and Chirikov.

In 1774 the Spanish began sending expeditions from Mexico toward the Gulf of Alaska, out of concern for an expanding Russian presence (Olson 2004). The first expedition under Juan Perez (in 1774) ranged only as far north as Dixon Entrance, and only one of the two boats in a

1775 expedition, the *Sonora* under the command of Juan Francisco Bodega y Quadra, made it as far north as the Sitka area, overlapping with the discoveries of Chirikov (Olson 2004).

On his third voyage in 1778, James Cook mapped much of the SE offshore coast of Alaska before discovering PWS and Cook Inlet (Hayes 2001). He missed Kodiak Island, not being able to distinguish it from the Alaskan Peninsula, although he sighted and named the Trinity Islands, thinking they were a single island (Beaglehole 1974), prior to sailing through the Aleutians to the Arctic, and then to his violent death in Hawaii (Hayes 2001). Because Cook was officially searching for the fabled Northwest Passage above a certain latitude, he did not explore the inlets in the eastern GOA nor distinguish the coastline as belonging to islands or the mainland, leaving much discovery for future expeditions (Hayes 2001).

The Spanish expedition of 1779, under Ignacio Arteaga, which was sent partially as a response to Cook's voyage but also to scout for Russian settlements, reached PWS and the Kenai Peninsula (Olson 2004).

Jean-Francois de Galaup, comte de LaPerouse, France's answer to Cook, landed on the Alaska coast in 1786 near Mt. St. Elias and surveyed south along the coast all the way to Monterey (now in California) (Hayes 2001). LaPerouse was an admirer of Cook, utilized his published journals and charts, and improved upon Cook's charting by investigating inlets (Hayes 2001). While surveying Lituya Bay he lost a boat and 21 of his men in the rough tidal currents near the mouth of the bay (Hayes 2001). Later in 1786, after leaving port in Australia, LaPerouse and his entire expedition disappeared in the south Pacific.

Using copies of Cook's journals and charts, Esteben Martinez explored PWS, the Trinity Islands, and Unalaska in 1788 (Olson 2004). In 1790 Salvador Fidalgo traded with the natives in PWS and visited with Russian fur traders in Cook Inlet and Kodiak (Olson 2004). Alejandro

Malaspina mounted a scientific expedition in 1792 as a Spanish answer to Cook's expedition, exploring Yakutat Bay, PWS, and Middleton Island (Olson 2004). The last northern Spanish cruise was commanded by Jacinto Caamano in 1792 but mostly explored today's coastal British Columbia (Olson 2004).

Both Nathanial Portlock and George Dixon returned to the eastern GOA in 1786 as fur traders, after having sailed with Cook on his third voyage, but also continued in their roles as explorers for several years (Hayes 1999). For example, Dixon determined that the Queen Charlotte Islands were islands, naming the body of water that separates them from southeast Alaska after himself, and naming the islands after his ship (Hayes 1999).

George Vancouver, who also had sailed with Cook, started the Alaska explorations of his third voyage in 1794 in Cook Inlet. He then continued to the east and south, mapping many of the major islands and inlets of SE Alaska near the end of his time in Alaska (Hayes 1999).

Russia won the colonial race in Alaska and had created compilation charts of their own surveys and that of other explorers by the time Alaska was sold to the United States in 1867, but E. Lester Jones (1918), Superintendent of the U.S. Coast and Geodetic Survey (USCGS), later called the NOS, contended that "No accurate surveys had been made by any of them, and their charts were more or less crude sketches, giving a general idea only of the configuration of the coast and harbors." (p. 12, Jones 1918). The first Alaskan hydrographic surveys started in the interior southeast in 1867, and proceeded slowly, with some contributions from the U.S. Navy and the U.S. Fisheries Commission, later to become the National Marine Fisheries Service (Jones 1918). For example, the Fisheries Commission steamer *Albatross*, operated by U.S. Naval Officers and normally stationed in Woods Hole, Massachusetts, conducted research cruises in the North Pacific from 1888 to 1896, some of them in Alaska waters. In 1888 the *Albatross* took some soundings in the deep sea off of SE Alaska and numerous shallow soundings on Portlock and Albatross Banks, naming the former for Mr. Portlock and latter for the vessel *Albatross*. A fairly thorough map of the central and western GOA was produced (Tanner 1890) though the troughs separating the banks were not discovered at the time. In 1890 the *Albatross* skirted the south edge of the GOA, mostly at 56°N latitude and south, on its way to work in the eastern Bering Sea. In 1892 it collected a few more soundings on Portlock Bank, outside of PWS and Icy Bay. In 1893 it sounded across the GOA just north of 57°N latitude and also made three more soundings on Albatross Bank. After these *Albatross* cruises, hydrographic surveys by the USCGS became the standard for charting in the GOA. For our compilation of CGOA bathymetry, we included several USCGS surveys from the early 1900s.

While mariners have routinely used the small-scale navigational charts (1:100,000) for about a century, the source data — the original, detailed hydrographic surveys (1:20,000) — remained relatively unknown to those outside of the NOS. In 2005, the National Geophysical Data Center (NGDC: http://www.ngdc.noaa.gov) began hosting electronic copies of the hydrographic surveys. This project focused on working with the original bathymetric survey data available from NGDC, combining them into a single data set, and adding and correcting various cartographic features. In the CGOA these surveys date back to the early 1900s because they are the best, and sometimes the only, surveys available. These data are not to be used for navigation because they were assembled for research purposes only.

Methods

We downloaded and examined single-beam and lead line hydrographic survey smooth sheet data sets available in whole or in part from the NGDC, to create a bathymetry map of the CGOA. Due to the vast area and numerous individual data sets, and for purposes of proofing and editing, we divided the region into three work areas: the Kenai area (the southern side of Kodiak Island to the Kenai Peninsula), offshore of PWS, and the Yakutat area (ranging from Kayak Island in the north to Cape Ommaney in the south). Despite hundreds of hydrographic surveys containing thousands of bathymetric soundings, there remain significant gaps in seafloor coverage; therefore other non-standardized surveys were added to provide a more complete bathymetric map (shown as green dots on Fig. 4). Noteworthy gaps include a triangular area northeast of the city of Kodiak, Portlock Bank, south of Montague Island, the area between Kayak Island and Dry Bay, and south of Sitka to Cape Ommaney; there is also very sparse coverage near the Copper River delta. Numerous shallow and deep-water multibeam surveys were also included to supplement or supersede the older smooth sheet surveys.

Each data set provided by NGDC generally consists of three parts: a typed or hand-written document called the Descriptive Report, which contains much of the survey metadata; a nautical chart called the smooth sheet, which depicts the geographical placement of the soundings written as numerals; and a text file of the soundings (Wong et al. 2007) from the smooth sheet. A paper smooth sheet with muslin backing was the final product of each hydrographic survey (Hawley 1931). Numerous different cartographic features, such as rocky reefs, kelp beds, rocks, and islets, were drawn on the smooth sheets as symbols, and many were also digitized along with the soundings. For example, individual rocks were drawn on the smooth sheets as the "+" (if always under water) or "*" (if awash at any tide) symbols (Hawley 1931), and these were also digitized, each having a null depth, a real depth, or an elevation. Older surveys that predated the computer era did not have a digital file. The text file of soundings is a modern interpretation of the smooth sheet, produced in a vast and expensive digitizing effort to salvage millions of hydrographic soundings from thousands of aging paper smooth sheets in U.S. waters, done largely without any error-proofing (Wong et al. 2007).

It is fairly straightforward to download and plot the digitized soundings in a geographic information system (GIS) to produce a continuous, interpolated, and bathymetric surface. This task can be accomplished in a matter of hours or days. This is the goal of most users of bathymetric data. A generalized surface that shows the central bathymetric tendency is a valuable product in the relatively unknown and unexplored Alaskan waters, but such efforts have limited value in that they tend to smooth errors and blur seafloor features. Our goal is to describe the individual geomorphologic features (flats, mounds, and depressions) that create the bathymetry, and we have found in doing this that there are too many errors in the digitization process to ignore. Therefore, over the course of several years, we made very careful comparisons between the smooth sheet soundings and the digitized soundings, corrected any errors and produced an edited version of the NGDC bathymetry. We accomplished this error-proofing in a GIS by georeferencing the smooth sheets, custom datum-shifting them into a common, modern datum (the North American Datum of 1983 or NAD83), and making comparisons to the digitized text file provided by NGDC. Details of the methods are described in Zimmermann and Benson (2013).

In the Kenai area, the smooth sheet data sets were supplemented by a U.S. Geological Survey (USGS) cruise on the *Growler* documenting the bathymetry in McCarty Fjord following the melting of the glacier (Post 1980) which had limited the work of survey H04760 (Table 1). We also included an offshore single-beam survey entitled CONMALAS (NOAA ship *Surveyor* 1972) and another offshore single-beam survey (LSSALE46) that was digitized from materials provided by NGDC. Multibeam surveys were obtained from colleagues at the Auke Bay

Laboratories (ABL) of the AFSC, by the NOS at Kodiak and Seward, and from the German research vessel *Sonne* (Table 2).

In the Prince William Sound area, the smooth sheet data sets were supplemented with information from NOS Chart 16723: bathymetry west of Kanak Island and cartographic features around Kayak Island (Table 3). There were single beam surveys conducted by the *Growler* for the USGS in 1977, *Thompson* for the USGS in 1974, survey number G-1-75-EG (*Cecil H. Green*, 1975) for USGS, and *Farnella* 1986 and 1989 (GLORIA surveys). In addition we added 22 deep-water multibeam surveys conducted by the NOAA ship *Surveyor* and numerous NOS shallow water multibeam surveys conducted outside of Hinchinbrook Entrance, and inside of Hinchinbrook Entrance, Patton Bay, and Port Bainbridge (Table 4).

In the Yakutat area, we digitized soundings outside of Yakutat Bay from smooth sheet H07100, which was not a true survey, but rather a compilation of various, unproofed single-beam soundings, because the shelf outside of Dry Bay, Yakutat Bay, Icy Bay and up to Cape Suckling has not been surveyed (Table 5). An offshore USCGS survey of this area from 1903 (H02665, scale 1: 600,000) was not utilized due to datum-shifting issues as the smooth sheet covered an area with multiple old datums and there were few landmarks and triangulation stations for calculating and assessing datum shifts. The upper reaches of Yakutat Bay have a few, narrow tracks of multibeam data, but we did not include these data in our compilation because the spatial coverage is too sparse. Near the shelf edge we utilized ABL multibeam surveys at Pamplona Spur and South Yakutat. A large (20 million soundings), deep-water multibeam survey off the edge of the continental shelf conducted by the University of New Hampshire Center for Coastal & Ocean Mapping/Joint Hydrographic Center (UNH/CCOM-JHC) was also added (Gardner and Mayer 2005). A USGS survey conducted on the *Growler* in 1981 provided bathymetry in the upper reaches of Icy Bay where several glaciers had receded (Post 1983) since the 1976 smooth sheet survey (H09469) was conducted. In the Sitka area and south we superseded smooth sheet bathymetry with multibeam data from NOS, ABL, and NOAA's Pacific Hydrographic Branch (PHB) (Table 6). Additional cartographic features were digitized from NOS chart 17326 for an area of Sitka Sound that had multibeam coverage but not features. Bathymetry and cartographic features were digitized from NOS charts 17328 and 17330 from Whale Bay to Cape Ommaney, a linear expanse of about 60 km of coast, because smooth sheets H04395, H04429, and H04430, along with any digitized bathymetry, are missing at NGDC (Table 5).

Cartographic features such as rocky reefs, kelp beds, rocks, and islets were proofed, edited, and digitized along with the soundings. All of these features, except for the kelp beds, sometimes have depths associated with them, and these were added to the bathymetric data set. Rocky reefs, kelp beds, rocks and islets might all be considered as rock or hard bottom and added to compilations of unconsolidated sediments.

Results

Our efforts resulted in the inclusion of 225 smooth sheet surveys (Table 1; Fig. 4) from which we proofed, edited, or digitized 1.75 million soundings and features: 1.7 million had depth and 96,000 represented cartographic features (some of which also have a depth). There were 95 smooth sheets from the Kenai area containing about 827,000 soundings and features, 56 smooth sheets from the PWS containing about 325,000 soundings and features, and 74 smooth sheets from the Yakutat area containing about 602,000 soundings and features. We digitized five full or partial smooth sheets in the Kenai area, 14 in the PWS area, and eight in the Yakutat area.

Numerous smooth sheets required the editing or digitizing of features. Proofing and digitizing were hampered in the Kenai area by H05080 missing its eastern half, and H05260 missing entirely; in the PWS area where H03018 and H09228 were missing; and in the Yakutat area where surveys H04395, H04429 and H04430 were missing. Several additional surveys were examined and rejected for inclusion, because they were superseded by more recent surveys.

Proofing and editing was quite variable among smooth sheet data sets. We encountered most of the characteristic and random errors described in Zimmermann and Benson (2013), but each smooth sheet needed to be read and individually interpreted. For example, in survey H09957, as originally downloaded from NGDC, a group of 39 soundings was repeated 141 or 142 times; these repetitions had to be deleted. It was also missing 4,137 soundings, and missing many islets, kelp beds, and rocks, while several of the digitized rocks had incorrect elevations. Survey H05100 was missing the western half of its soundings, which we digitized. Rock elevations from several surveys such as H10033 were 10x too high. Survey H04842 was digitized as if it were in feet rather than meters (Zimmermann and Benson 2013).

In a few instances we digitized features from multibeam surveys that had smooth sheets available, instead of relying on the older lead-line and single-beam survey smooth sheets. In the Kenai area we digitized 768 features from the Seward multibeam smooth sheets and in the Yakutat area we digitized 8,451 features from the Sitka multibeam smooth sheets.

The raw data for three multibeam surveys, H11114, H11118, and H11354, was acquired from NGDC and required full processing because the NOS never finalized and published these data sets. Tide files, sound velocity files, and vessel files all had to be created or reformatted from the raw data, and the notes available in the Data Acquisition and Processing Report (DAPR) filed with the unprocessed data. Tide station information was listed in the survey DAPR files and the corresponding data was downloaded from the NOAA Tides and Currents website (http://tidesandcurrents.noaa.gov/). Vessel and hardware information was located in the DAPR file. Sound velocity data profiles were included with the data, but needed to be reformatted. Once these files were compiled and formatted, the multibeam data could be read, processed, and edited in a computer aided resource information system (CARIS), hydrographic information processing system (HIPS) and sonar information processing system (SIPS; version 7.1). The DAPR files contained detailed flowcharts for processing methods, and the Office of Coast Survey field procedures manual website (OCS 2010) provided additional guidance for data processing. Bathymetry associated with statistical error (BASE) surfaces were created in CARIS at varying resolutions following guidelines found in the DAPR, as well as resolution guidelines outlined in the OCS technical paper "U.S. Office of Coast Survey's Re-Engineered Process for Application of Hydrographic Survey Data to NOAA Charts" (Barry et al. 2005). The bathymetric data were then exported as text files with easting, northing, and depth attributes, then brought into ArcMap v. 10.0 (ESRI: Environmental Systems Research Institute, Redlands, CA), and finally converted into raster format.

Features

About 96,000 cartographic features such as rocky reefs, kelp beds, rocks, islets and others were proofed, edited, and digitized from the smooth sheets and charts, mostly in the Kenai and Yakutat areas (available at AFSC: http://www.afsc.noaa.gov). The most common feature was kelp beds, with the majority of the 29,000 occurrences in the Kenai area (it should be noted that kelp beds are seasonal and their size and location are variable from year to year). The second-most common feature was rocks, at just less than 29,000, with the majority occurring in the Kenai and Yakutat areas. Rocky reefs were third in occurrence, with most of the 22,000 occurring in the Kenai and Yakutat areas. There were 15,000 islets almost equally split between Kenai and Yakutat. Altogether there were almost 95,000 features indicating rock or hard seafloor areas. Over 9,000 of these features had a depth associated with them that we added to the bathymetry data set, generally adding more information in the nearshore area where soundings are typically sparse.

Bathymetric Surface

The edited smooth sheet bathymetry points, along with the features with elevations, and superseding multibeam data set points, were processed into a solid surface of variably-sized triangles (triangular irregular network or TIN) which utilized the points as corners of the triangles. The TIN was then converted by area-weighted interpolation into a continuous surface of 100 x 100 m squares, which is commonly also called a raster surface, or a grid in ArcMap. Those grid cells that appeared on land, or outside of the area covered by the smooth sheets, were eliminated and a new grid was made that covered only the water (available at AFSC: http://www.afsc.noaa.gov, Figs. 2 and 3).

Age of Surveys

Most of the bathymetry surveys utilized for this project were quite old. Dating back to 1907 in the Kenai area, 1902 in the PWS area, and 1901 in the Yakutat area, some of these old smooth sheets qualify as antiques, and yet they remain the best authority of bathymetry and features in some of these areas. The majority of the smooth sheet surveys in the Kenai (81%) and Yakutat areas (62%) predated WWII, while only 44% did in the PWS area, as numerous modern surveys mapped the oil tanker travel corridor to Valdez in PWS. In the Kenai area, most of the newer smooth sheet surveys occurred in the Barren Islands and Kennedy Entrance while in Yakutat the newest surveys were in Icy Bay, Yakutat Bay, Lituya Bay, and Cross Sound.

Datums

All of the pre-WWII surveys in the Kenai and PWS areas used the Valdez datum, or an unknown, possibly earlier datum. There were two surveys (H04854 and H04855) in the Kenai area that may have been in the Port Hobron datum, as they differed significantly from neighboring surveys. In the PWS area, H02613 and H02669 also differed from their Valdez datum neighbors and may have been in a PWS datum. In the Yakutat area, most of the early datums are unknown, except for H04524, which references Quillian's triangle, and H04608 which references southeast Alaska datum. Following WWII all the surveys used NAD27 (North American Datum of 1927) through the 1980s. The first NAD83 surveys in the Kenai and PWS areas occurred in 1999 and in the Yakutat area in 1991.

Datum Shifts

We calculated unique datum shifts for each smooth sheet, aligning them with NAD83 HARN (High Accuracy Resolution Network) triangulation stations (http://www.ngs.noaa.gov/cgi-bin/sf_archive.prl), so that the original datum, even if it was unknown, did not matter (Zimmermann and Benson 2013). In the Kenai area, the older (Valdez and unknown datums) surveys were shifted about 300 m to the east and about 250 m to the north, with the exception of the possible Port Hobron surveys, which were shifted about 120 m east and about 525 m north. In the PWS area, the older surveys needed a shift of about 320 m to the east and about 250 m to the north except for H02613 and H02669, which needed shifts of about 2,700 m to the west and about 250 m north. In the Yakutat area the datum shifts were more variable, ranging from about 60 to 180 m to the west, and about 145 to 235 m to the north - an exception was H04643, which was shifted 420 m to the east and 55 m to the north. The NAD27 surveys in the Kenai area needed shifts of about 130 m to the east and 80 m to the south, in the PWS area shifts of about

110 m to the west and about 65 m to the south were needed, and in the Yakutat area shifts of about 100 m to the west and about 40 m to the south were made.

Soundings

The soundings downloaded from NGDC were plotted in a GIS to determine if their positions corresponded to the sounding numerals written on the georeferenced and datum-shifted smooth sheets. We defined agreement between the digital soundings and the soundings of the smooth sheet to be when the digital soundings were "on or near" the written soundings on the smooth sheet. In general, there were numerous substantial differences between many of the sounding data sets, which required shifting the soundings as a group to align with the smooth sheets. Some of these shifts corresponded to the difference between the original smooth sheet datum and NAD 1983 HARN (a few hundred meters). However, some data sets aligned perfectly. Each data set needed to be checked individually.

This comparison between the soundings and the smooth sheets also allowed checking for errors or incompleteness in the soundings files. Errors in the soundings such as those misplaced, missing, incorrectly entered, or otherwise in disagreement, were corrected (Zimmermann and Benson 2013). Sometimes there was little or nothing to correct. Other times there were numerous or significant errors to correct, which made this tedious and time-intensive error-checking process seem worthwhile. For example, survey H5100 was available as a smooth sheet, but only the eastern half of the soundings were available in the digital file - this gap might not have been noticed without making the comparison between the two. Many surveys were missing some of the cartographic features.

Scale and Coverage

The majority of the smooth sheet surveys were conducted at a scale of 1:20,000 (n = 105) or larger scale (n = 62), ranging up to a scale of 1:2000, generally covering the nearshore area and major islands. These large-scale surveys were most frequent in the Yakutat area (82%) and least common in the PWS area (44%). There were 66 medium-scale surveys (1:40,000) accounting for about 25% of the total surveys. The remaining 10% of the smooth sheets are at a scale of 1:60,000 or smaller scale, ranging down to 1:200,000.

Data Quality

Data quality appears to be quite variable on these smooth sheets. Some are barely legible and the inshore area is a confusing array of amorphous islands, sparse cartographic features and isolated soundings in otherwise blank water. Others appear crisp, clean, and well-organized, and reveal surprising details that the smooth sheet makers never noticed.

Geological Features

Our bathymetry editing resulted in the “discovery” of several noteworthy geological features not previously visible in the smooth sheets, although they may have been known from other data and investigations. We are presenting them to demonstrate that some of the seemingly slight errors in the bathymetry are in fact existing seafloor features, and also to help refine these known features with georeferenced and tidally corrected soundings. The Kayak Trough depressions, Fairweather Fault Zone, relic submerged marine terraces around Middleton Island, and faults off Kodiak Island are all interesting examples.

The depressions within Kayak Trough, a glacial feature composed of a flat floor bordered by steep edges along its inland margins, were initially investigated as part of routine bathymetry checking, since the eastern depression or channel (~70 m deep) formed an obvious, nearly straight line, which often indicates a vertical disagreement between two neighboring bathymetry data sets (Fig. 5). After finding no such disagreement, another less-pronounced (~20 m deep) and less-linear depression was found approximately parallel, and to the west, of the first depression. Sean Gulick (Univ. Texas, Inst. for Geosciences, personal communication, 2012; Worthington et al. 2008) recognized these depressions as the edges of the Kayak Trough, a remnant ice-scoured valley from the Bering Glacier. The two depressions are separated by a flat floor and bulge about 20 km across that becomes smaller to the south until the bulge disappears and the trough becomes part of a larger U-shaped depression. According to Sean Gulick (personal communication, 2012), the depressions are remnants of a deeper Kayak Trough, the center of which has been filled with sediment (Jaeger et al., 1998). Currents may play an important role in forming (scouring) and maintaining these depressions (Sean Gulick, personal communication, 2012).

A trace of the Fairweather Fault Zone was found in the soundings from survey H04529, a 1925 small-scale (1:100,000) smooth sheet. The fault zone was located off of Yakobi and Chichagof Islands, just south of Cross Sound, and consisted of an east-facing scarp and a western uplifted structural block (Fig. 6A). Soundings from this survey are about 500 to 700 m apart west to east and about 1,000 m apart north to south, making such a discovery seem very unlikely. The fault zone was not mentioned in the Descriptive Report even though there is a concentration of soundings on the north section of it, peaking at depths of 48 and 49 fm (88 and 90 m), which were about 30 fm (55 m) shallower than the adjacent soundings (Fig. 6B). In the central part of the structural block there is an isolated sounding of 43 fm (79 m), which is 23 to 35 fm (42 to 64 m) shallower than its neighbors (Fig. 6C). Near the south end of the fault zone there is a linear ridge of soundings (defining the uplifted structural block) about 13 fm (24 m) shallower than the adjacent ones (Fig. 6D). The fault zone as imaged is a linear fault scarp and ridge about 25 km long. Again these oddly shallow soundings seemed like errors, especially the isolated 43 fm (79 m) sounding, but the explanation of the Fairweather Fault Zone's presence in the area, provided by Peter Haeussler (USGS, personal communication, 2011), is corroborated by single-beam echosounder passes across the structure, such as shown in Figure 6E collected during the 2005 GOA trawl survey (Raring 2007).

The discovery of the Middleton Island submerged marine terraces, which were not previously imaged, proves the benefit of carefully editing and plotting the bathymetry data (Fig 7). The initial plot of all soundings results in a bathymetry surface that is mostly a contradiction between three 1933, pre-1964 earthquake surveys and three 1969 post-quake surveys, with a few soundings from a 1909 small-scale survey in the northwest corner (Fig. 7A). The seafloor looks pockmarked, which is due to isolated vertical and horizontal disagreements between the pre- and post-quake surveys, and there are also horizontal stripes along the south side of the island due to closer placement of soundings. If we simply remove the 1933 surveys, edit and shift the 1969 surveys, and ignore the 1909 survey, a very different picture appears (Fig. 7B). The first thing to notice is that the general bathymetry does not change much - the island is still surrounded by a shallow platform with shallower areas to the northwest and west, and a deep area to the southeast. The second thing to notice is that the individual features that comprise the bathymetry changed markedly. For example, the shallow area to the northwest is clearly defined, but the most striking changes are the series of parallel lines visible mostly to the southwest of the island. These are the relic marine terraces (George Plafker, USGS, personal communication, 2012), perhaps 20 of them, never previously imaged, similar in size and orientation to those on the island described by Plafker and Rubin (1978).

Some of the linear faults on Albatross bank, such as the Kodiak Fault Zone (KFZ), as reported by von Huene et al. (1980) and Carver et al. (2008, see Plate 1), are clearly visible in the bathymetry, especially when represented as slope (Fig. 8). This was confirmed by georeferencing von Huene et al.'s (1980) chart and Carver's (2008) Plate 1, and plotting them with the slope data in ArcMap. The longest fault strand trends southeast from offshore Sitkinak Island, crosses outer Sitkalidak Strait, southern Albatross Bank, disappears in Barnabus Trough, reappears on Middle Albatross Bank, and runs to the edge of Chiniak Trough, a total distance of about 190 km. Other, shorter faults are visible in this area too, such as the Narrow Cape Fault that trends parallel to, and inboard of, the KFZ.

Discussion

We consider this smooth sheet bathymetry and cartographic feature compilation for the central GOA a rough first draft. This project, approximating the size of our Aleutian Islands compilation (Zimmermann et al. 2013), but with fewer available data, is quite extensive, with multiple surveys covering a large portion of the region. We were able to supersede data from some areas with more modern and detailed multibeam data, something we did not have time to do in the Aleutians project, but we also needed to make patches with non-hydrographic surveys over large areas, which are still incomplete.

Our slow but detailed, methodical process of data editing and compilation, which relied on comparing the digitized soundings (Wong et al. 2007) to the smooth sheets in a GIS, was critical to the discovery and elimination of numerous errors, such as incorrect, misplaced, and missing soundings. Properly accounting for the horizontal shift from the original datum to NAD 1983 HARN was the most important part of our error checking.

Multibeam Surveys

Our project was improved by adding multibeam data that superseded older, less-comprehensive single-beam echosounder data. As more multibeam data sets become available, and more time permits, we may update the bathymetry surface.

It is important to note that just because some seafloor mapping data comes from advanced technology sources does not mean that it is perfect. Each multibeam and LIDAR data set needs to be proofed and potentially edited too. For example, both the 1 m resolution (7,178 out of 6,707,055) and 2 m resolution (1,305 out of 1,228,646) portions of multibeam survey H11115 had incorrect soundings that needed to be deleted. The 3 m resolution portion of the LIDAR data set H11427 had 1,162 incorrect soundings out of 931,442 recorded, but the 5 m resolution portion of the data set appeared to be free of errors. The LIDAR data set H11429 had 1,046 bad soundings out of 777,406 recorded.

We were surprised to find that there were three fully completed NOS multibeam surveys in the Sitka area that had never been processed. By processing them in CARIS software we were able to plug significant gaps in the bathymetry of that area. The result is a large, contiguous area of detailed multibeam and LIDAR coverage in Sitka Sound and surrounding areas compiled from 45 surveys.

Seafloor Changes

An added difficulty in describing bathymetry across the vast area of the CGOA is that it is changing faster than it is being surveyed. Therefore, bathymetric maps can always be subject to change. The best known example of seafloor change is the great Alaska earthquake of 1964 (magnitude 9.2), centered near Valdez, which abruptly altered the seascape across a large distance of the CGOA (National Research Council 1972). A comparison of smooth sheet surveys conducted before and after the 1964 earthquake showed subsidence of 0.2 to 9.8 m in Resurrection Bay, elevation (uplift) of 6.1 m at Cape Clear, and elevation of 1.6 to 4.2 m at Middleton Island (Fig. 9). We attempted to construct our own earthquake-related vertical depth corrections, but found that depth changes within and among locations were too variable for us to be able to interpolate a surface of differences across the entire study area. Therefore our bathymetry is unfortunately a mix of neighboring pre- and post-earthquake surveys, but we avoided the worst contradictions by deleting overlaps of pre- and post-earthquake surveys.

Other significant bathymetry changes are more localized. For example, a shoreline accretion of about 600-800 m in Katalla Bay, near the Copper River delta (Fig. 2), occurred between the 1905 (H02768) and 1971 (H09207) surveys (Fig. 10), perhaps as a result of heavy sediment deposition in this area (Jaeger et al., 1998). In Lituya Bay (Fig. 3), a 1958 earthquake (magnitude 8.3) and resultant mega-tsunami of 524 m (1,720 ft), the largest known historical tsunami in the world (Miller 1961), caused shoreline accretion of as much as 120 m and shoaling of up to 55 m (Descriptive Report H08492). The melting of glaciers in McCarty Fjord (Post 1980) on the Kenai Peninsula and Icy Bay (Post 1983; Fig. 2) opened new waters following the NOS surveys, which had never before been mapped. At Taylor Bay, just inside of Cross Sound, a survey conducted in 1992 found shoaling of 10-15 m since the previous survey (H02558, 1901) following retreat of the Brady Glacier (Descriptive Report H10425; Fig. 11). The shoaling is so great that Taylor Island is now connected to the mainland, making it a peninsula. Our analysis shows a 26 fm (47.6 m) sounding from the 1901 survey on the 0 depth contour of the 1992 survey, indicating significant possible sedimentation (Jeff Freymueller, Univ. Alaska at Fairbanks, personal communication 2014) in addition to the local uplift of about 20 mm/year

(Freymueller et al. 2008). This exceptional point value is probably taken from underneath the former extent of the glacier, rather than the surrounding landscape, where most studies are done.

Fisheries Research

This CGOA bathymetry compilation is part of a GAP (Groundfish Assessment Program) effort to create more detailed bathymetry and sediment maps in order to provide a better understanding of how studied animals interact with their environment. This information is being used by NOAA's Deep Sea Coral Research and Technology Program to predict the presence/absence and abundance of corals and sponges (Rooper et al., 2014). GAP scientists who conduct stock assessment bottom trawl surveys are also using the information to delimit areas that cannot be sampled effectively with bottom trawls. The results from this project may result in a separate survey conducted by another method, such as underwater cameras or acoustics, to assess the abundance of fish in the untrawlable areas. The GOA-IERP, sponsored by NPRB, is using the detailed bathymetry and sediment information to predict the preferred settlement habitat of juveniles of five important groundfish species. Results from GOA-IERP will be used towards developing a better understanding of the ecosystem processes that regulate stock recruitment. The Alaska Regional Office will investigate use of the bathymetry and sediment information to oversee sustainable fisheries, conduct Essential Fish Habitat (EFH) reviews, and manage protected species.

Acknowledgments

Funding for much of the work was provided by NOAA's Essential Fish Habitat (EFH), Habitat and Ecological Processes Research (HEPR) through the NMFS Alaska Regional Office. B. McMahon, G. Nelson (retired) and especially C. Barry (Pacific Hydrographic Branch of the NOS) provided assistance with interpreting smooth sheets, bathymetric sounding files, and descriptive reports. D. Doyle (National Geodetic Survey, retired) and J. Benson (AFSC) provided valuable datum and GIS advice, respectively. D. Fischman, G. Glover, J. A. Bunn, J. Campagnoli, M. Frydrych, and M. Cole from the National Geophysical Data Center helped with accessing smooth sheets on the NGDC web site. Thanks to K. Shotwell (AFSC) for helping to edit smooth sheet bathymetry inside of Yakutat Bay. Thanks to several geologists, including Jeff Freymueller (University of Alaska Fairbanks), Sean Gulick (University of Texas Austin), Peter Haeussler (U.S. Geological Survey), George Plafker (U.S. Geological Survey), and Jennifer Reynolds (University of Alaska Fairbanks), for helpful consultations about seafloor features. Thanks to Stephen L. Copps, Curt E. Whitmire, H. Gary Greene and Wayne Palsson for reviews.

Citations

Anderson, B. 1960. The life and voyages of Captain George Vancouver: Surveyor of the sea. University of Washington Press, Seattle, Washington. 274 p.

Barry, C., S. Legeer, G. Parker, and K. VanSant. 2005. U.S. Office of Coast Survey's re-engineered process for application of hydrographic survey data to NOAA charts (http://www.nauticalcharts.noaa.gov/hsd/docs/SW_techpaper_barry.pdf).

Beaglehole, J. C. 1974. The life of Captain James Cook. Stanford University Press, Stanford, California, 760 p.

Carver, G., J. Sauber, W. Lettis, R. Witter, and B. Whitney. 2008. Active faults on northeastern Kodiak Island, Alaska, pp. 167-184. *In* J. T. Freymueller, P. J. Haeussler, R. L. Wesson and G. Ekström (editors), Active Tectonics and Seismic Potential of Alaska, American Geophysical Union, Washington, D. C.

Freymueller, J. T., H. Woodard, S. C. Cohen, R. Cross, J. Elliot, C. F. Larsen, S. Hreinsdottir, and C. Zweck. 2008. Active deformation processes in Alaska, based on 15 years of GPS measurements. Active Tectonics and Seismic Potential of Alaska, Geophysical Monograph Series 179. American Geophysical Union.

Gardner, J. V. and L. A. Mayer. 2005. U.S. law of the sea cruise to map the foot of the slope and 2500-m isobath of the Gulf of Alaska continental margin. Cruise Report, University of New Hampshire (UNH), Center for Coastal and Ocean Mapping (CCOM)/Joint Hydrographic Center (JHC).

Hawley, J. H. 1931. Hydrographic manual. U.S. Department of Commerce, U.S. Coast and Geodetic Survey, Special Publication No. 143. U.S. Gov. Print. Office, 170 p.

Hayes, D. 1999. Historical atlas of the Pacific Northwest: Maps of exploration and discovery: British Columbia, Washington, Oregon, Alaska, Yukon. Sasquatch Books, Seattle, Washington. 208 p.

Hayes, D. 2001. Historical atlas of the North Pacific Ocean: Maps of discovery and scientific exploration 1500-2000. Sasquatch Books, Seattle, Washington. 224 p.

Jaeger, J. M., C. A. Nittrouer, N. D. Scott, and J. D. Milliman. 1998. Sediment accumulation along a glacially impacted mountainous coastline: north-east Gulf of Alaska. Basin Res. 10:155-173.

Jones, E. L. 1918. Safeguard the gateways of Alaska: her waterways. U.S. Dep. of Commer., U.S. Coast and Geodetic Survey, Special Publication No. 50. Government Printing Office, 41 p.

Miller, D. J. 1961. Giant waves in Lituya Bay, p. 51-86. *In* Shorter Contributions to General Geology 1959. Geological Survey Professional Paper 354, U.S. Government Printing Office, Washington.

National Research Council. 1972. The great Alaska earthquake of 1964: Seismology and geodesy. National Academy of Sciences, Washington, D.C., 596 p.

Office of Coast Survey. 2010. Field procedures manual. NOAA. 326 p.

Olson, W. M. 2004. The Spanish exploration of Alaska, 1774-1792. Heritage Research, Alaska, 48 p.

Plafker, G., and M. Rubin. 1978. Uplift history and earthquake recurrence as deduced from marine terraces on Middleton Island, Alaska. *In* Proceedings of Conference VI, Methodology for identifying seismic gaps and soon-to-break gaps: U.S. Geological Survey Open-File Report 78-943, p. 687-721.

Post, A. 1980. Preliminary bathymetry of McCarty Fiord and neoglacial changes of McCarty Glacier, Alaska: USGS Open-File Report 80-424, 4 maps; 89 x 67 cm.

Post, A. 1983. Preliminary bathymetry of upper Icy Bay, Alaska: USGS Open-File Report: 83-256, 1 map; 135 x 107 cm.

Raring, N. W. 2007. Report to industry: Fishing log for the 2005 bottom trawl survey of the Gulf of Alaska. AFSC Processed Rep. 2007-03, 211 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar, Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Rooper, C. N., M. Zimmermann, M. M. Prescott, and A. J. Hermann. 2014. Predictive models of coral and sponge distribution, abundance and diversity in bottom trawl surveys of the Aleutian Islands, Alaska. Mar. Ecol. Prog. Ser. 503:157-176.

Tanner, Z. L. 1890. Explorations of the fishing grounds of Alaska, Washington Territory, and Oregon, during 1888, by the U.S. Fish Commission Steamer Albatross. *In* Bulletin of the United States Fish Commission Vol. VIII, for 1888. Government Printing Office.

von Huene, R., M. A. Hampton, M. A. Fisher, D. J. Varchol, and G. R. Cochrane. 1980. Near-surface geologic structures, Kodiak Shelf, Alaska. 1:500,000, Map MF-1200, U.S. Geol. Survey, Misc. Field Stud.

Wong, A. M., J. G. Campagnoli, and M. A Cole. 2007. Assessing 155 years of hydrographic survey data for high resolution bathymetry grids, p. 1-8. *In* Proceedings of Oceans 2007, Vancouver, B.C., Canada.

Worthington, L., Gulick, S., Pavlis, T., Bruns, R., and Mann, P. 2008. Localized deformation zones in the offshore leading edge of the Yakutat microplate. *In* J. T. Freymueller, P. J. Haeussler, R. L. Wesson, G. Ekström (editors) Gulf of Alaska Active Tectonics and Seismic Potential of Alaska, Geophysical Monograph Series, Volume 179, 350 pp., ISBN 978-0-87590-444-3, 2008.

Zimmermann, M., and M. M. Prescott. 2014. Smooth sheet bathymetry of Cook Inlet, Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-275, 32 p.

Zimmermann, M., and J. L. Benson. 2013. Smooth sheets: How to work with them in a GIS to derive bathymetry, features and substrates. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-249, 52 p.

Zimmermann, M., M. M. Prescott, and C. N. Rooper. 2013. Smooth sheet bathymetry of the Aleutian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-250, 43 p.

Table 1. -- List of smooth sheet bathymetry data sets for the Kenai area.

Survey	Scale	Year	Vessel	Datum
H02922	20,000	1907	*Patterson*	Valdez
H02926	20,000	1907	*Patterson*	Unknown
H02929	20,000	1907	*Patterson*	Unknown
H03013	20,000	1909	*Yukon*	Unknown
H03014	20,000	1909	*Yukon*	Unknown
H03015	20,000	1909	*Yukon*	Unknown
H03802	60,000	1915	*Explorer*	Unknown
H03803	20,000	1915	*Explorer*	Unknown
H04721	20,000	1927	*Surveyor*	Unknown
H04731	80,000	1927-28	*Surveyor*	Unknown
H04759	20,000	1927-28	*Surveyor*	Unknown
H04760	20,000	1927-28	*Surveyor*	Unknown
H04824	20,000	1928	*Surveyor*	Valdez
H04825	20,000	1928	*Surveyor*	Unknown
H04836	40,000	1928	*Surveyor*	Unknown
H04838	20,000	1928	*Surveyor*	Unknown
H04854	20,000	1928	*Surveyor*	Port Hobron?
H04855	20,000	1928	*Surveyor*	Port Hobron?
H04856	200,000	1928	*Surveyor*	Unknown
H04922	10,000	1929	*Surveyor*	Unknown
H05080	20,000	1930-31	*Surveyor*, *Wildcat* & *Helianthus*	Unknown
H05082	20,000	1930	*Discoverer* & *Westdahl*	Unknown
H05083	40,000	1930	*Discoverer*	Unknown
H05085	40,000	1930	*Westdahl* & *Discoverer*	Unknown
H05086	20,000	1930	*Wildcat* & *Helianthus*	Unknown
H05087	160,000	1930	*Discoverer*	Unknown
H05091	40,000	1930	*Westdahl*	Unknown
H05092	40,000	1930	*Discoverer* & *Westdahl*	Unknown
H05093	20,000	1930	*Discoverer* & *Westdahl*	Unknown
H05099	20,000	1930	*Discoverer*	Unknown
H05100	80,000	1930	*Discoverer*	Unknown
H05101	20,000	1930	*Discoverer* & *Westdahl*	Unknown
H05151	20,000	1931	*Surveyor* & *Wildcat*	Valdez
H05152	20,000	1931, 1933	*Surveyor*	Valdez
H05161	20,000	1931	*Surveyor* & *Wildcat*	Unknown
H05166	20,000	1931	*Surveyor*	Unknown
H05177	160,000	1931-32	*Surveyor*	Valdez

Table 1. -- Cont'd.

Survey	Scale	Year	Vessel	Datum
H05178	20,000	1931	*Wildcat*	Valdez
H05180	20,000	1931	*Helianthus*	Unknown
H05182	40,000	1931	*Surveyor*	Unknown
H05183	40,000	1931	*Surveyor*	Valdez
H05184	20,000	1931	*Wildcat* & *Surveyor*	Unknown
H05186	20,000	1931	*Westdahl*	Unknown
H05187	20,000	1931	*Westdahl*	Valdez
H05190	20,000	1931	*Westdahl*	Valdez
H05191	40,000	1931	*Discoverer*	Unknown
H05192	40,000	1931	*Discoverer*	Unknown
H05193	40,000	1931	*Discoverer*	Unknown
H05194	120,000	1931	*Discoverer*	Unknown
H05226a	10,000	1932	*Surveyor* & *Wildcat*	Valdez
H05226b	20,000	1932	*Surveyor* & *Wildcat*	Valdez
H05231	20,000	1932	*Surveyor*	Valdez
H05232	40,000	1932	*Surveyor*	Valdez
H05250	40,000	1932	*Surveyor*	Valdez
H05251	20,000	1932	*Wildcat*	Valdez
H05252	20,000	1932	*Surveyor*	Valdez
H05253	40,000	1932	*Surveyor*	Valdez
H05254	20,000	1932	*Wildcat*	Valdez
H05255	20,000	1932	*Discoverer* & *Westdahl*	Valdez
H05256	20,000	1932	*Discoverer* & *Westdahl*	Valdez
H05257	20,000	1932-33	*Discoverer*	Valdez
H05258	40,000	1932	*Discoverer*	Valdez approx.
H05259	160,000	1932	*Discoverer*	Valdez
H05260	20,000	1932	*Discoverer* & *Westdahl*	Valdez
H05261	40,000	1932	*Discoverer* & *Westdahl*	Valdez
H05265	20,000	1932	*Discoverer* & *Westdahl*	Valdez
H05280	20,000	1932	*Surveyor*	Valdez
H05437	20,000	1933	*Discoverer* & *Westdahl*	Valdez
H05438	20,000	1933	*Discoverer* & *Westdahl*	Valdez
H05439	20,000	1933	*Discoverer* & *Westdahl*	Valdez
H05440	20,000	1933	*Discoverer* & *Westdahl*	Valdez
H05441A	10,000	1933	*Discoverer* & *Westdahl*	Valdez
H05442	40,000	1933	*Discoverer*	Valdez
H05443	40,000	1933	*Discoverer* & *Westdahl*	Unknown
H05444	160,000	1933	*Discoverer*	Valdez

Table 1. -- Cont'd.

Survey	Scale	Year	Vessel	Datum
H06479	5,000	1939	*Discoverer*	Valdez
H06481	10,000	1939	*Discoverer*	Valdez
H08118	10,000	1954	*Pathfinder*	NAD27
H09003	5,000	1968	*Pathfinder*	NAD27
H09302	10,000	1972	*Rainier*	NAD27
H09762	5,000	1978	*Rainier*	NAD27
H09763	5,000	1978	*Rainier*	NAD27
H09822	100,000	1979	*Surveyor*	NAD27
H09823	100,000	1979	*Surveyor*	NAD27
H09890	20,000	1980	*Fairweather*	NAD27
H09949	10,000	1981	*Davidson*	NAD27
H09957	10,000	1981	*Davidson*	NAD27
H10030	10,000	1982	*Rainier*	NAD27
H10032	5,000	1982-83	*Fairweather*	NAD27
H10033	20,000	1982, 1984	*Rainier*	NAD27
H10137	20,000	1984	*Rainier*	NAD27
H10143	40,000	1984	*Rainier*	NAD27
H10149	20,000	1984	*Rainier*	NAD27
H10912	5,000	1999	*Rainier*	NAD83
H10913	10,000	1999	*Rainier*	NAD83
Non-smooth sheet surveys added as patches				
USGS	20,000	1978	*Growler*	NAD27
CONMALAS	unknown	1972	*Surveyor*	Unknown
LSSALE46	96,000	1976	Multiple	Unknown

Table 2. -- List of multibeam data sets used in Kenai area bathymetry compilation. Each survey was available at a single or multiple resolutions, and then grouped together at the lowest resolution. Then all neighboring surveys were grouped together at the lowest common resolution (10, 15, or 16 m) then subsetted to a resolution of 100 m.

Survey	Resolution	Year	Vessel
Fathom 49	10 m	2003	*Davidson*
Portlock Bank	10 m	2001	*Davidson*
Spruce Island (Combined at 16 m resolution)			
H12317	16 m	2011	*Fairweather*
H12320	16 m	2011	*Fairweather*
Seward area (Combined at 15 m resolution)			
H10968*	10 m	2000	*Quicksilver, Sea Ducer*
H10969*	10 m	2000	*Quicksilver, Sea Ducer*
H11010*	10 m	2000	*Quicksilver, Sea Ducer*
H11072*	15 m	2001	*Rainier*
H11073*	15 m	2001	*Rainier*
H11074*	15 m	2001	*Rainier*
H11075*	15 m	2001	*Rainier*
*Sonne*** (Combined at 100 m resolution)			
SO 96/1	variable	1994	*Sonne*
SO 96/2	variable	1994	*Sonne*
SO 97/1	variable	1994	*Sonne*

* Features digitized from smooth sheets.
** *Sonne* bathymetry data provided by Volkmar Leimer, Bundesamt für Seeschifffahrt und Hydrographie (BSH), the Hydrographic Office of the Federal Republic of Germany.

Table 3. -- List of smooth sheet bathymetry data sets for the Prince William Sound area.

Survey	Scale	Year	Vessel	Datum
H02613	20,000	1902	*McArthur*	PWS?
H02669	20,000	1903	*Patterson*	PWS?
H02848	10,000	1906	*McArthur*	Unknown
H02971	40,000	1908	*Taku*	Valdez
H03017	20,000	1909	*Patterson*	Unknown
H03019	20,000	1909	*Patterson*	Unknown
H03020	10,000	1909	*Patterson*	Unknown
H03021	10,000	1909	*Patterson*	Unknown
H03024	200,000	1909	*Patterson*	Valdez
H03953	20,000	1916	*Taku*	Unknown
H03954	20,000	1916	*Taku*	Valdez
H03955	20,000	1916	*Taku*	Valdez
H03957	20,000	1916	Unknown	Valdez
H03958	80,000	1916	*Taku*	Valdez
H03959	10,000	1916	*Taku*	Unknown
H04677	20,000	1927	*Surveyor*	Unknown
H04692*	20,000	1927, 1934	*Surveyor*	Unknown
H04693	20,000	1927	*Surveyor*	Unknown
H04722	200,000	1927	*Surveyor*	Unknown
H04727	20,000	1927-28	*Surveyor*	Unknown
H04730	60,000	1927-28	*Surveyor*	Unknown
H05447	200,000	1933	*Surveyor*	Valdez
H05454	80,000	1933	*Surveyor*	Valdez
H05460	20,000	1933	*Surveyor*	Valdez
H05461	20,000	1933	*Surveyor*	Valdez
H08312	20,000	1956-57	*Pathfinder*	NAD27
H08534	20,000	1960	*Pathfinder*	NAD27
H08875	40,000	1965	*Surveyor*	NAD27
H09047	10,000	1969	*Fairweather*	NAD27
H09049	20,000	1969	*Fairweather*	NAD27
H09053	20,000	1969	*Fairweather*	NAD27
H09205	40,000	1971	*Fairweather*	NAD27
H09206	40,000	1971	*Fairweather*	NAD27
H09207	10,000	1971	*Fairweather*	NAD27
H09208	10,000	1971	*Fairweather*	NAD27
H09227	20,000	1971	*Fairweather*	NAD27
H09228	10,000	1971	*Fairweather*	Unknown
H09383	10,000	1973	*Davidson*	NAD27

Table 3. -- Cont'd.

Survey	Scale	Year	Vessel	Datum
H09385	20,000	1973	*Davidson*	NAD27
H09386	20,000	1973	*Davidson*	NAD27
H09387	20,000	1973	*Davidson*	NAD27
H09425	20,000	1974	*Davidson*	NAD27
H09624	40,000	1976	*Davidson*	NAD27
H09625	40,000	1976	*Davidson*	NAD27
H09626	40,000	1976	*Davidson*	NAD27
H09713	10,000	1977	*Fairweather*	NAD27
H09829	40,000	1979	*Davidson*	NAD27
H09830	40,000	1979	*Davidson*	NAD27
H09831	40,000	1979	*Davidson*	NAD27
H10029	10,000	1982	*Davidson*	NAD27
H10038	2,000	1983	*Davidson*	NAD27
H10090	20,000	1983-84	*Davidson*	NAD27
H10139	40,000	1984	*Davidson*	NAD27
H10920**	10,000	1999	*Rainier*	NAD83
H10921**	10,000	1999	*Rainier*	NAD83
F00252	2,500	1983	*Davidson*	NAD27
Non-smooth sheet surveys added as patches				
Chart 16723*	100,000	2000 edition	Various	NAD83
USGS	20,000	1978	*Growler*	assumed NAD27
USGS	unknown	1974	*Thompson*	assumed NAD27
USGS	unknown	1975	*Cecil H. Green*	assumed NAD27
USGS	unknown	1986	*Farnella*	assumed NAD27
USGS	unknown	1989	*Farnella*	assumed NAD27

* Used for features only.
** Multibeam survey but only lower resolution data used.

Table 4. -- List of multibeam data sets used in the Prince William Sound area bathymetry compilation. Each survey was available at a single or multiple resolutions, and then grouped together at the lowest resolution. Then all neighboring surveys were grouped together at the lowest common resolution (5, 10, 16 or 20 m) then subsetted to a resolution of 100

Survey	Resolution	Year	Vessel
Inside Hinchinbrook Entrance (Combined at 10 m resolution)			
H11200	10 m	2003	*Davidson, Quicksilver*
H11201	5 m	2003	*Davidson*
H11202	5 m	2003	*Davidson, Quicksilver*
H11203	5 m	2003	*Davidson, Quicksilver*
H11204	5 m	2003	*Davidson, Quicksilver*
Outside Hinchinbrook Entrance (Combined at 16 m resolution)			
H10925	10 m	1999	*Rainier*
H11752	10 m	2008	*Fairweather*
H11987	16 m	2009	*Fairweather*
Patton Bay (Combined at 5 m resolution)			
H11333	5 m	2004	*Davidson*
H11630	5 m	2007	*Fairweather*
Port Bainbridge (Combined at 20 m resolution)			
H11007	15 m	2000	*Rainier*
H11008	10 m	2002	*Rainier*
H11166	10 m	2002	*Rainier*
H11167	10 m	2002	*Rainier*
H11168	10 m	2002	*Rainier*
H11172	15 m	2002	*Rainier*
H11390	10 m	2004	*Davidson*
H11391	20 m	2004	*Davidson*
H11392	10 m	2004	*Davidson*
H11393	5 m	2004	*Davidson*
B00xxx (Combined at original resolution)			
B00106	var.	1987	*Surveyor*

Table 4. -- Cont'd.

Survey	Resolution	Year	Vessel
B00108	var.	1987	*Surveyor*
B00110	var.	1987	*Surveyor*
B00111	var.	1987	*Surveyor*
B00113	var.	1987	*Surveyor*
B00140	var.	1988	*Surveyor*
B00141	var.	1988	*Surveyor*
B00142	var.	1988	*Surveyor*
B00143	var.	1988	*Surveyor*
B00144	var.	1988	*Surveyor*
B00145	var.	1988	*Surveyor*
B00146	var.	1988	*Surveyor*
B00147	var.	1988	*Surveyor*
B00148	var.	1988	*Surveyor*
B00149	var.	1988	*Surveyor*
B00150	var.	1988	*Surveyor*
B00151	var.	1988	*Surveyor*
B00152	var.	1988	*Surveyor*
B00153	var.	1988	*Surveyor*
B00154	var.	1988	*Surveyor*
B00155	var.	1988	*Surveyor*
B00156	var.	1988	*Surveyor*

Table 5. -- List of smooth sheet bathymetry data sets for the Yakutat area.

Survey	Scale	Year	Vessel	Datum
H02558	40,000	1901	*Patterson*	Unknown
H02558A	2,000	1901	*Patterson*	Unknown
H02762	10,000	1905	*McArthur*	Unknown
H02857	10,000	1906	*Gedney*	Unknown
H02858	20,000	1906	*Gedney*	Unknown
H02859	10,000	1906	*Gedney*	Unknown
H04001	10,000	1917	*Patterson*	Unknown
H04002	20,000	1917	*Launch Delta*	Unknown
H04003	20,000	1917	*Patterson*	Unknown
H04261A	120,000	1922-23	*Surveyor*	Unknown
H04261B	60,000	1922-23	*Surveyor*	Unknown
H04331	30,000	1923	*Cosmos*	Unknown
H04431	20,000	1924	*Surveyor*	Unknown
H04432	80,000	1924	*Surveyor*	Unknown
H04524	20,000	1925	*Surveyor*	Quillian's triangle
H04525A	10,000	1925	*Surveyor*	Unknown
H04526	10,000	1925	*Surveyor*	Unknown
H04527	10,000	1925	*Surveyor*	Unknown
H04528	80,000	1925	*Surveyor*	Unknown
H04529	100,000	1925	*Surveyor*	Unknown
H04539	20,000	1925	*Surveyor*	Unknown
H04601	10,000	1926	*Surveyor*	Unknown
H04602	20,000	1926	*Surveyor*	Unknown
H04603	20,000	1926	*Surveyor*	Unknown
H04608	20,000	1926	*Surveyor*	SE Alaska
H04640	20,000	1926	*Surveyor*	Unknown
H04641	20,000	1926	*Surveyor*	Unknown
H04642	20,000	1926	*Surveyor*	Unknown
H04643	200,000	1926	*Surveyor*	Unknown
H04648	100,000	1926	*Surveyor*	Unknown
H04842	20,000	1928	*Explorer*	Unknown
H04843	20,000	1928	*Explorer*	Unknown
H04846	20,000	1928	*Explorer*	Unknown
H04847	20,000	1928	*Explorer*	Unknown
H06355*	10,000	1938, 1947	*Explorer*	NAD27
H06578	40,000	1940	*Surveyor*	NAD27
H06579	200,000	1940	*Surveyor*	NAD27
H06580	40,000	1940	*Surveyor*	NAD27

Table 5. -- Cont'd.

Survey	Scale	Year	Vessel	Datum
H06581	100,000	1940	*Surveyor*	NAD27
H06582	20,000	1940	*Surveyor*	NAD27
H06583	20,000	1940	*Surveyor*	NAD27
H06584	20,000	1940	*Surveyor*	NAD27
H06585	20,000	1940	*Surveyor*	NAD27
H06655*	20,000	1940-41	*E. Lester Jones*	NAD27
H06667*	20,000	1941	*Westdahl*	NAD27
H06743	40,000	1941	*Westdahl*	NAD27
H07100	Unknown	Various	Various	assumed NAD27
H07189*	10,000	1947	*Patton*	NAD27
H07190*	10,000	1947	*Patton*	NAD27
H07191*	10,000	1947	*Patton*	NAD27
H08492	10,000	1959	*Bowie*	NAD27
H09630	10,000	1976	*Rainier*	NAD27
H09634	10,000	1976	*Rainier*	NAD27
H09635	20,000	1976	*Rainier*	NAD27
H09649	20,000	1976	*Rainier*	NAD27
H09686	10,000	1977-78	*Davidson*	NAD27
H09687	20,000	1977	*Davidson*	NAD27
H09688	20,000	1977	*Davidson*	NAD27
H09694	20,000	1978	*Davidson*	NAD27
H09695	20,000	1977	*Davidson*	NAD27
H09778	20,000	1978	*Davidson*	NAD27
H09779	20,000	1978	*Davidson*	NAD27
H10316	5,000	1989	*Rainier*	NAD27
H10370	5,000	1991	*Rainier*	NAD83
H10371	10,000	1991	*Rainier*	NAD83
H10374	20,000	1991	*Rainier*	NAD83
H10376	10,000	1991-92	*Rainier*	NAD83
H10377	10,000	1991-92	*Rainier*	NAD83
H10407	10,000	1991	*Rainier*	NAD83
H10408	10,000	1991	*Rainier*	NAD83
H10419	10,000	1992	*Rainier*	NAD83
H10420	10,000	1992	*Rainier*	NAD83
H10425	10,000	1992	*Rainier*	NAD83

Table 5. -- Cont'd.

Survey	Scale	Year	Vessel	Datum
H10426	10,000	1992	*Rainier*	NAD83
Non-smooth sheet surveys added as patches				
Chart 17326*	40,000	2000 edition	Various	NAD83
Chart 17328	40,000	2003 edition	Various	NAD83
Chart 17330	20,000	1990 edition	Various	NAD83
USGS	20,000	1981	*Growler*	Unknown

* Used for features only.

Table 6. --List of multibeam data sets used in Yakutat bathymetry compilation. Each survey was available at a single or multiple resolutions, and then grouped together at the lowest resolution. Then all neighboring surveys were grouped together at the lowest common resolution (10 m) then subsetted to a resolution of 100 m.

Survey	Resolution	Year	Vessel
Pamplona spur	5 m	2002	*Davidson*
South Yakutat	5 m	2002	*Davidson*
Sitka area (Combined at 10 m resolution)			
H11105	10 m	2002	*Rainier*
H11106	5 m	2002	*Rainier*
H11107	5 m	2002	*Rainier*
H11108	5 m	2002	*Rainier*
H11109	10 m	2002	*Rainier*
H11110	5 m	2002	*Rainier*
H11111	10 m	2003	*Rainier*
H11112	5 m	2003	*Rainier*
H11113	5 m	2003	*Rainier*
H11114**	5 m	2004	*Rainier*
H11115	5 m	2004	*Rainier*
H11116	5 m	2004	*Rainier*
H11117*	5 m	2003	*Rainier*
H11118**	5 m	2004	*Rainier*
H11119*	10 m	2004	*Rainier*
H11120*	5 m	2003	*Rainier*
H11121*	2 m	2002	*Rainier*
H11122	10 m	2005	*Rainier*
H11123	5 m	2004	*Davidson*
H11124	5 m	2004	*Davidson*
H11126	5 m	2006	*Rainier*
H11127	5 m	2006	*Rainier*
H11128	10 m	2006	*Rainier*
H11130	5 m	2004	*Davidson*
H11131	10 m	2002	*Rainier*
H11134*	10 m	2003	*Rainier*
H11135	10 m	2005	*Rainier*
H11270	10 m	2005	*Rainier*

Table 6. -- Cont'd.

Survey	Resolution	Year	Vessel
H11271	10 m	2005	*Rainier*
H11272	10 m	2005	*Rainier*
H11354**	5 m	2004	*Quicksilver, Kvichak Surveyor*
H11427	5 m	2005	LIDAR
H11428*	5 m	2005	LIDAR
H11429*	5 m	2005	LIDAR
H11538	3 m	2006	LIDAR
H11539	3 m	2006	LIDAR
H11540	3 m	2006	LIDAR
H11586	10 m	2007	*Rainier*
H11677	10 m	2007	*Rainier*
H11678	5 m	2007	*Rainier*
H11679	10 m	2007	*Rainier*
H11844	8 m	2008	*Rainier*
H11845	8 m	2008	*Rainier*
H11846	4 m	2008	*Rainier*
H11847	8 m	2008	*Rainier*
Cape Ommaney			
W00035	10 m	2001	*Davidson*
Hazy Island			
W00036	10 m	2001	*Davidson*
Gulf of Alaska continental margin			
UNH/CCOM-JHC	~100 m	2005	*Kilo Moana*

* Features digitized from multibeam smooth sheet.
** Raw multibeam data processed into final surfaces by Megan Prescott, AFSC. Features also digitized from multibeam smooth sheets.

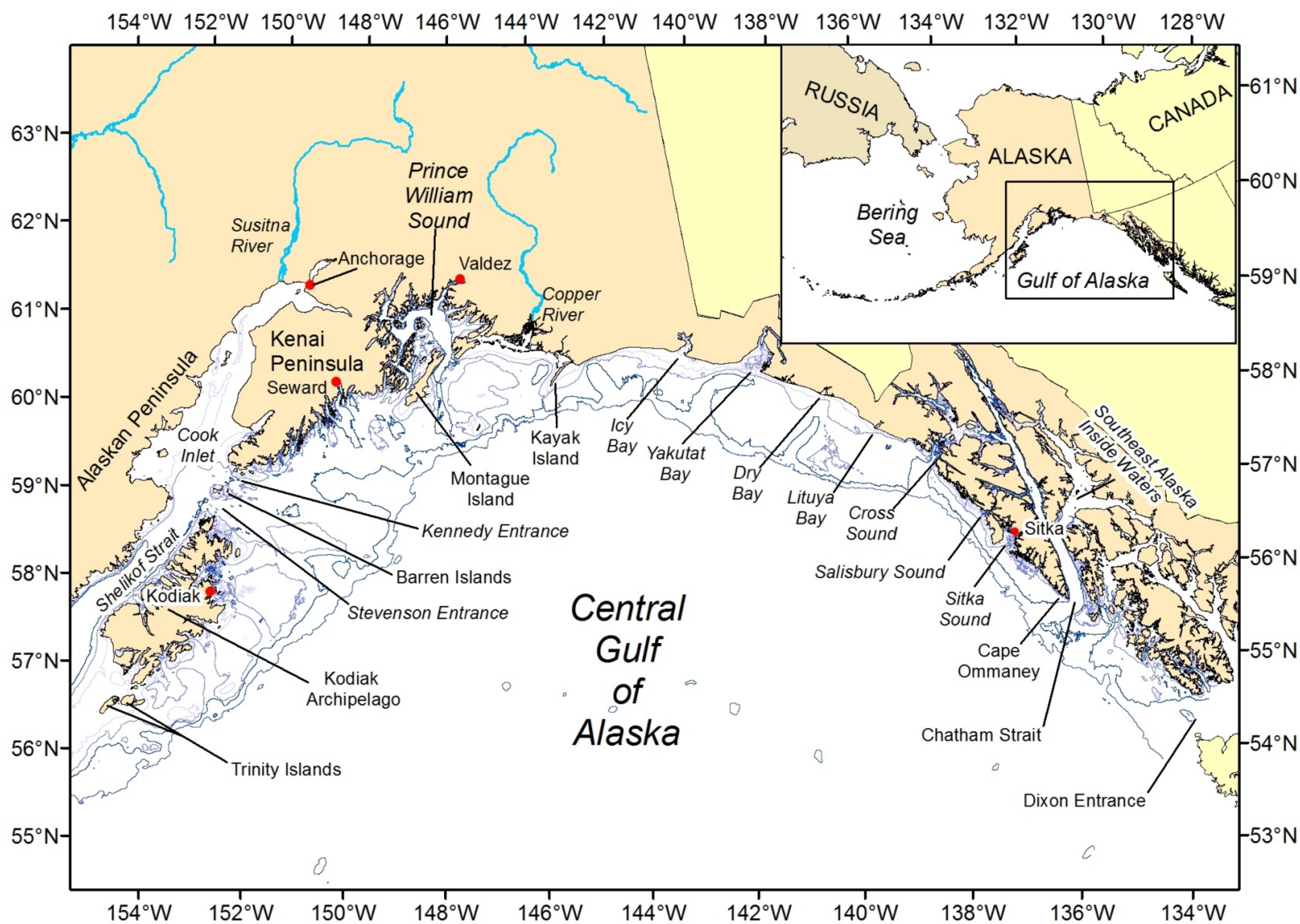

Figure 1. -- Bathymetry compilation in the central Gulf of Alaska ranges from the Trinity Islands in the west to Cape Ommaney in the east.

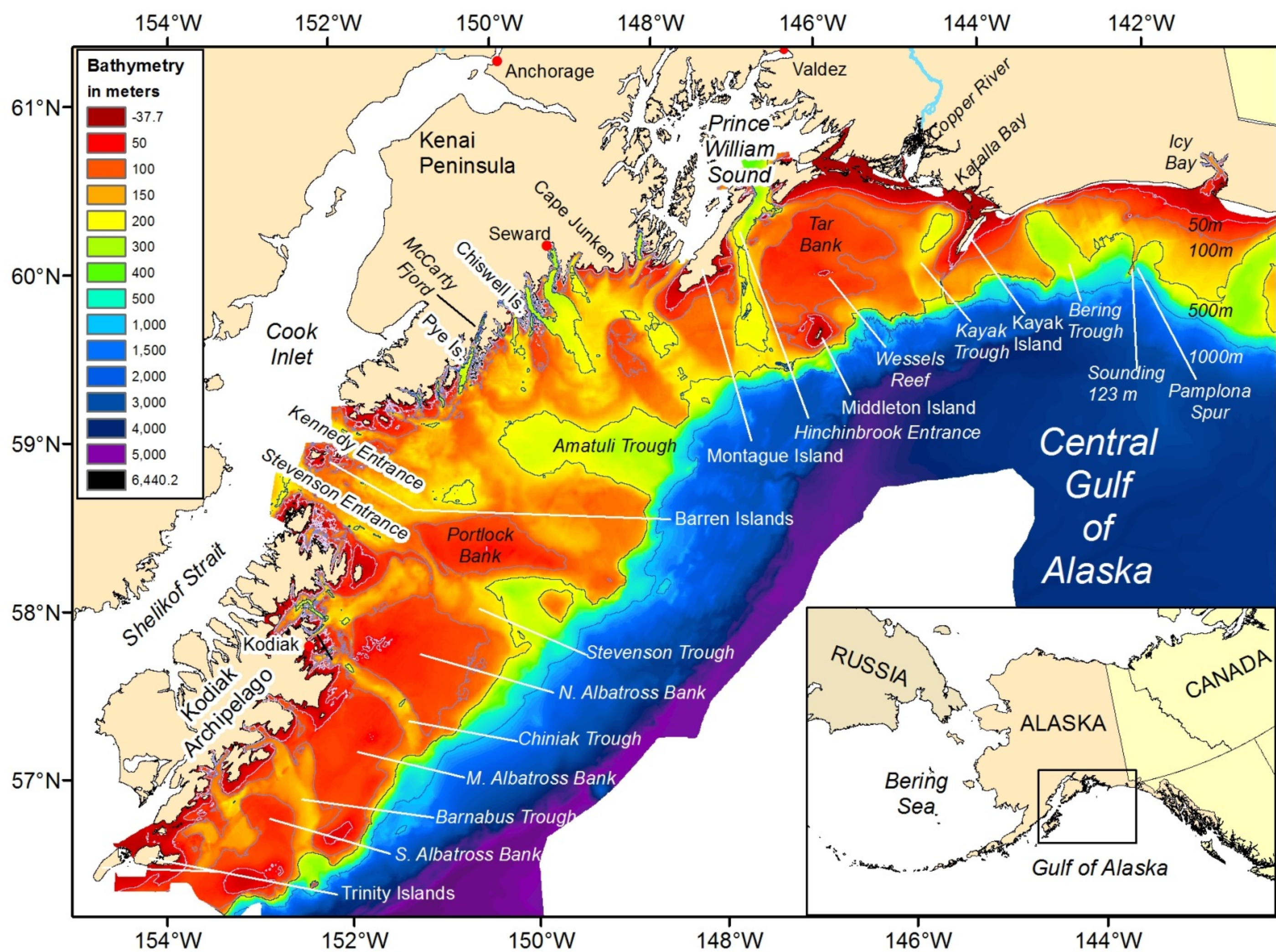

Figure 2. -- Prominent seafloor features in the western portion of the study area include Albatross and Portlock Banks, Amatuli Trough, Tar Bank, Kayak and Bering Troughs, and Pamplona Spur.

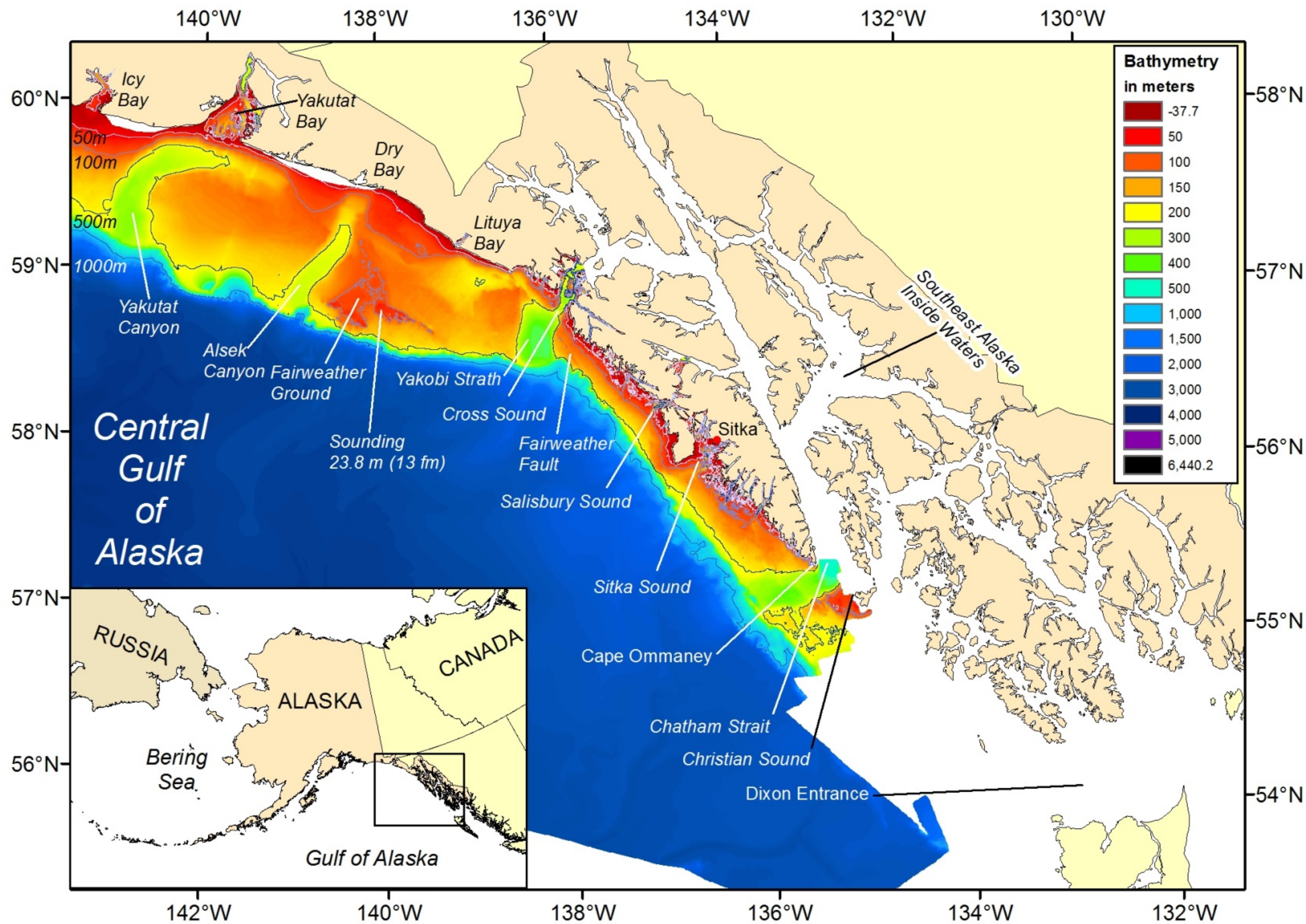

Figure 3. -- Prominent seafloor features in the eastern portion of the study area include Yakutat and Alsek Canyon, Fairweather Ground, Cross Sound, the Fairweather Fault Zone, Sitka Sound, Cape Ommaney and Chatham Strait.

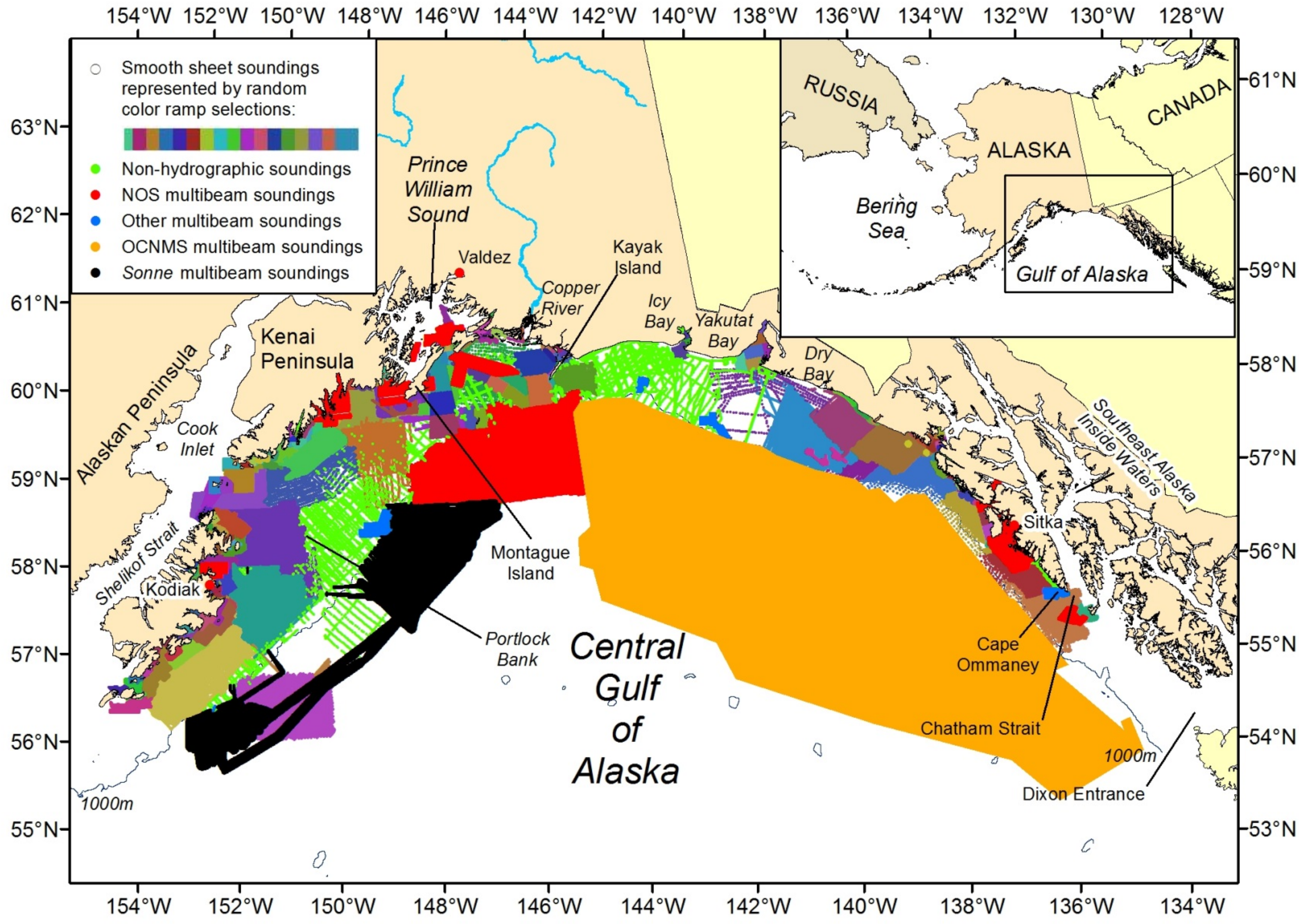

Figure 4. -- Areas of individual soundings from various data sources. Bright green soundings are patches made from various non-smooth sheet surveys, often non-hydrographic surveys.

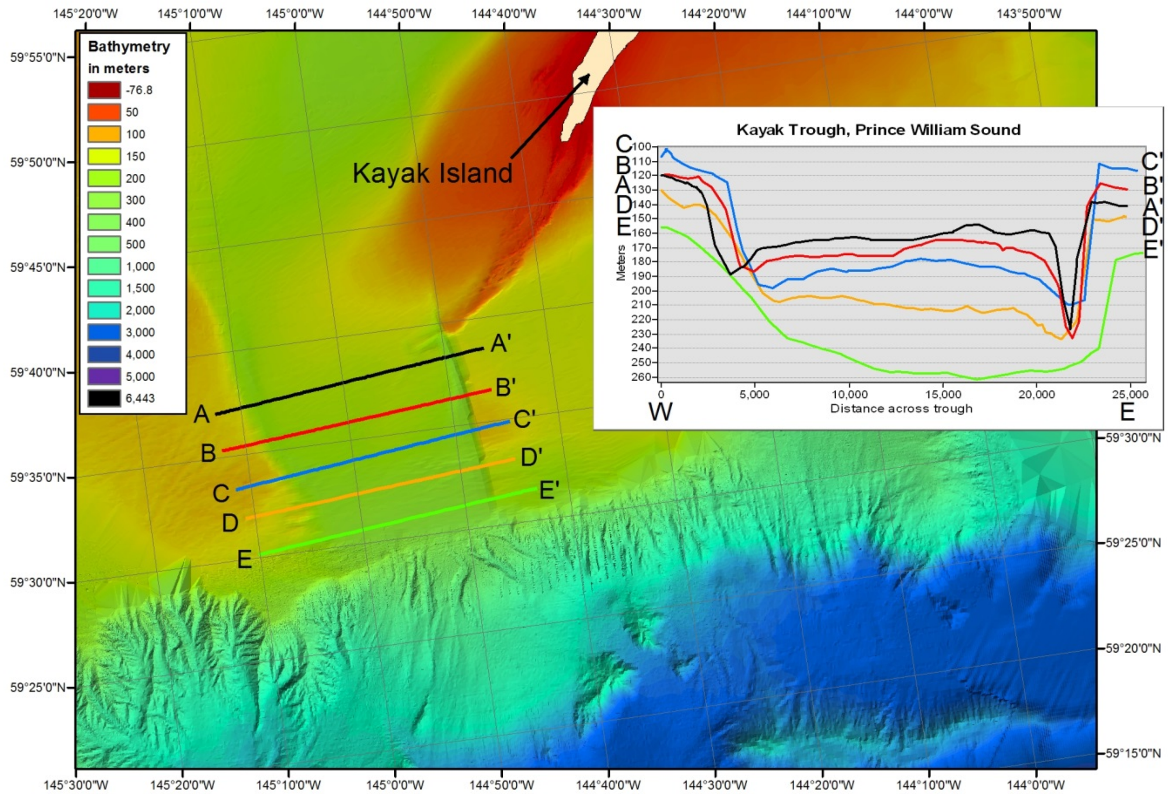

Figure 5. -- Kayak Trough, a generally flat-floored to humped trough with an eastern depression about 70 m deep and a western depression about 20 m deep at the cross-section drawn in black (A-A'). Successive cross-sections drawn progressively closer to the shelf (B-B', C-C' and D-D') edge show a smaller hump in the center of the trough and a consequential loss of eastern and western depressions. The green cross-section (E-E') shows complete loss of central hump and both depressions. Extra seafloor details and shading are visible in this TIN (Triangular Irregular Network) version of the bathymetry.

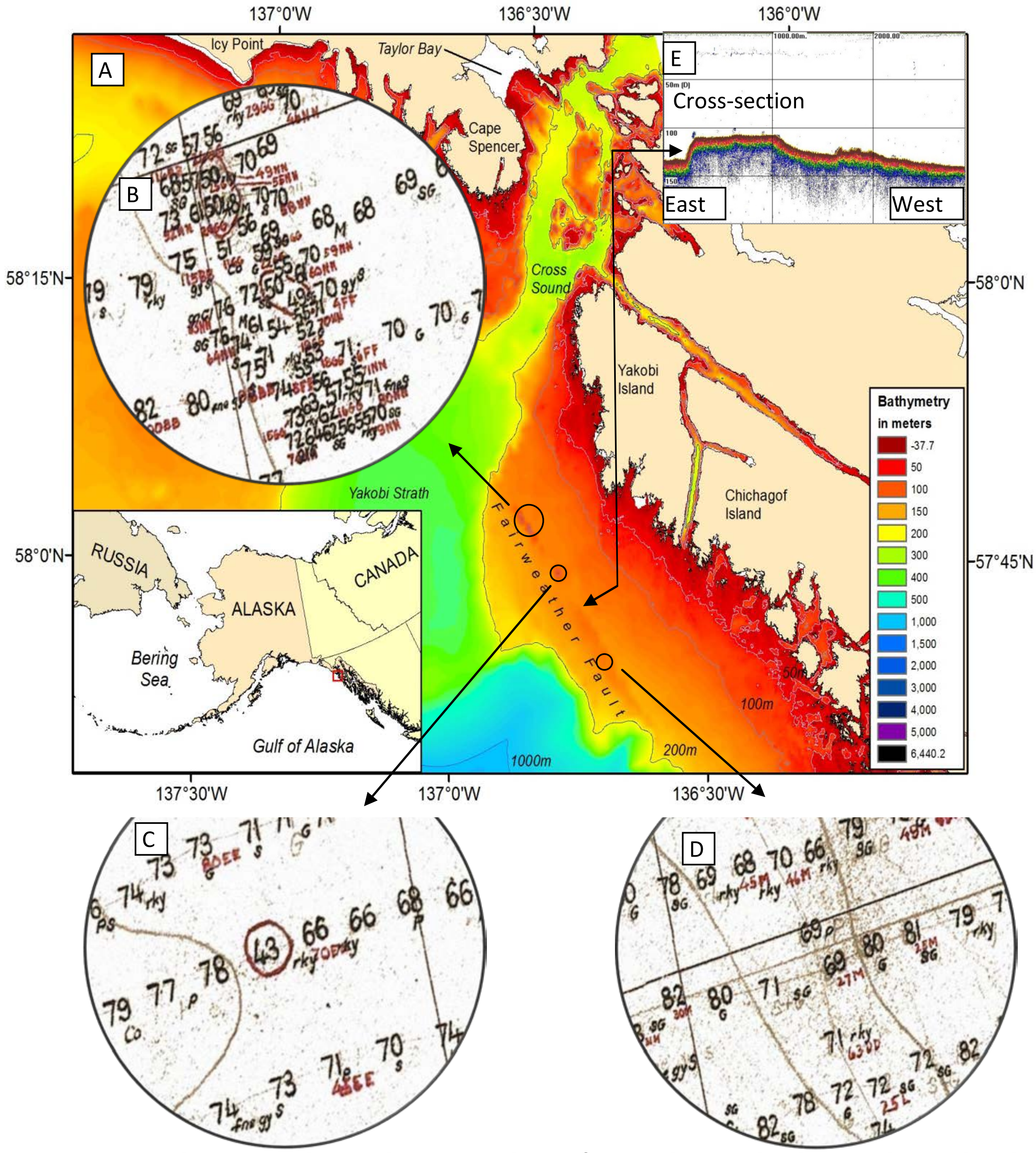

Figure 6. -- A) The Fairweather Fault Zone is a linear feature about 25 km long as depicted in the edited smooth sheet bathymetry from H04529 (Scale 1:100,000, Year 1925). On the smooth sheet, the fault is described by: B) A concentration of soundings as shallow as 48 fm (88 m) in the north end, C) a single sounding of 43 fm (79 m) in the middle, and D) soundings about 13 fm (24 m) shallower than the surounding soundings in the south end. E) A single-beam echsounder profile (from east to west) across the fault scarp depicts an east-facing scarp and a western uplifted block structure.

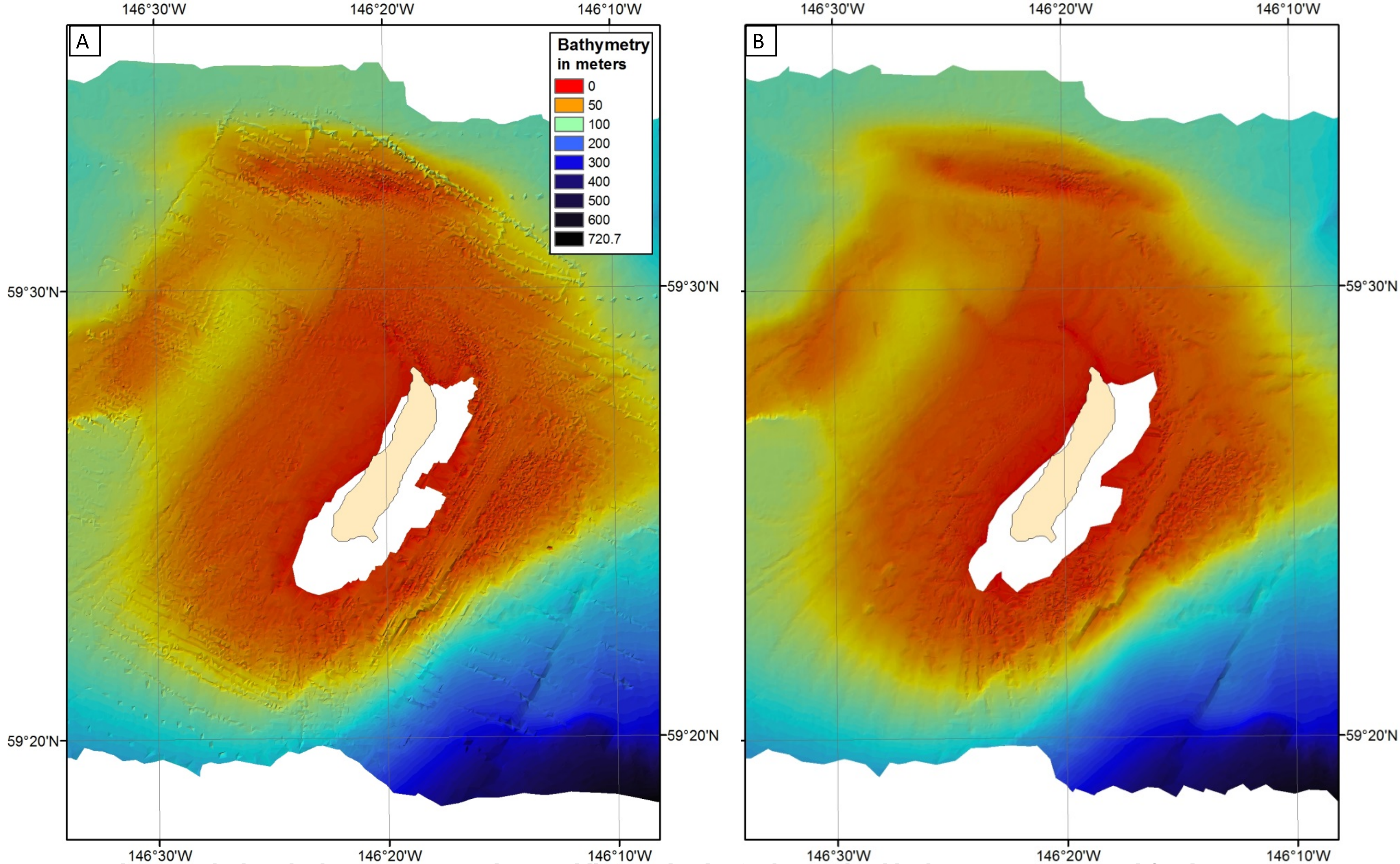

Figure 7. -- The smooth sheet bathymetry surrounding Middleton Island. A) The unedited bathymetry, uncorrected for digitization and datum errors, is a mixture of pre- and post-1964 earthquake soundings, which produces numerous confusing artifacts. B) The edited, post-quake bathymetry produces a much cleaner surface, even though it uses fewer soundings, revealing submerged marine terraces, which generally lie parallel to the island's coastline.

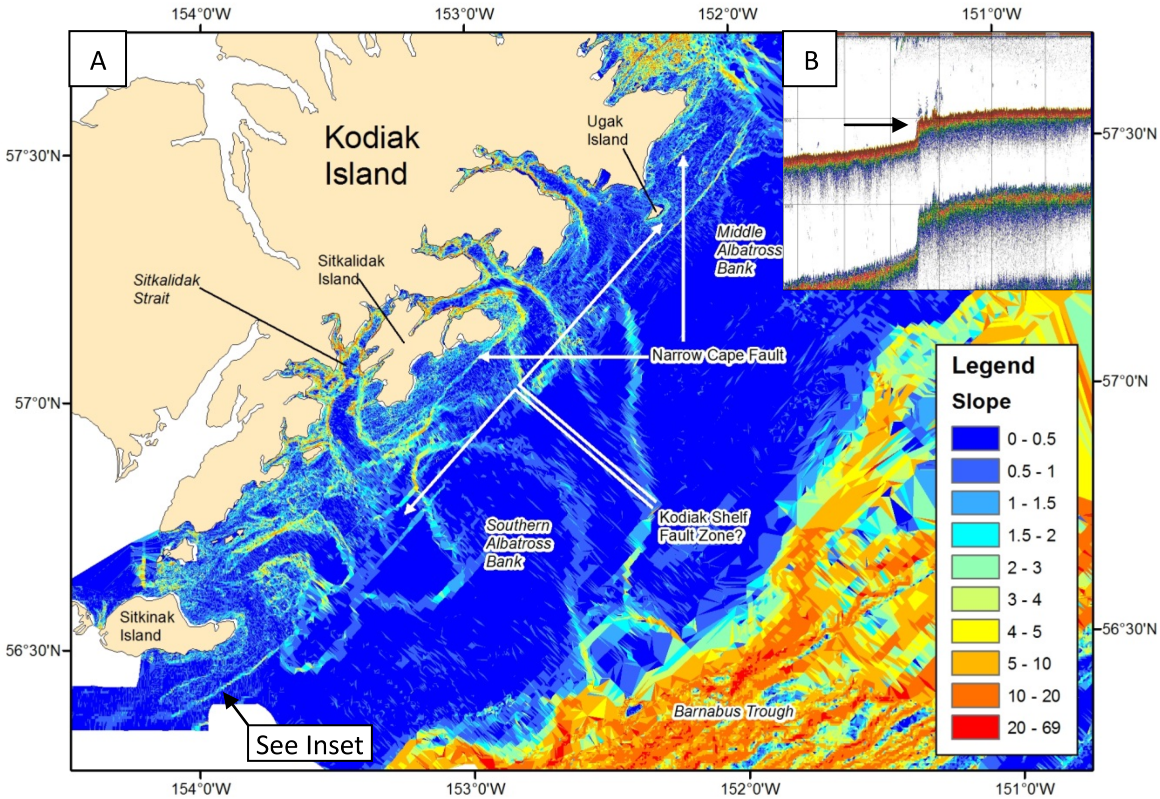

Figure 8. -- A) Narrow Cape Fault and the Kodiak Fault Zone (KFZ) on Southern and Middle Albatross Banks, south of Kodiak Island, as depicted by slope, or depth change. The KFZ appears to consist of an elevated platform and a steep south-facing scarp in our bathymetry data. B) The inset of a single-beam echogram shows a depth change from 62 to 50 m over a distance of about 200 m as the KFZ is approached from the south (indicated with black arrow), south of Sitkinak Island, which images a south-facing scarp and associated uplifted northern platform.

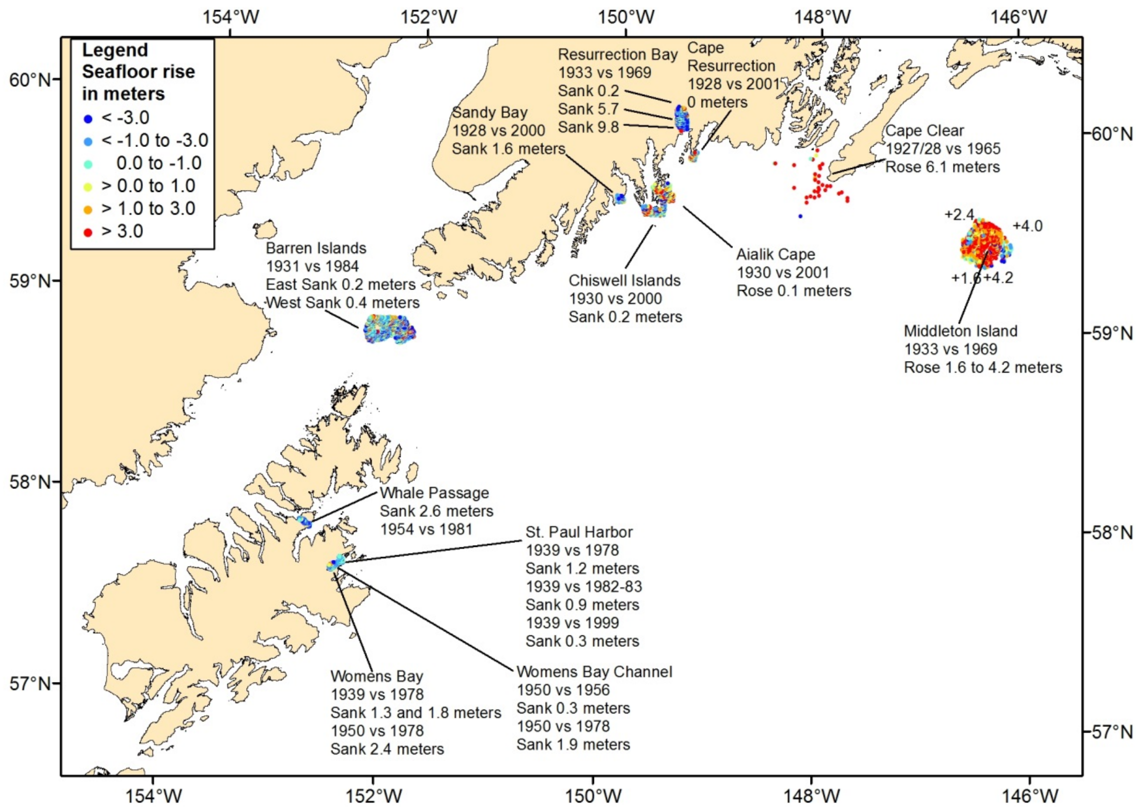

Figure 9. -- Comparison of National Ocean Service (NOS) hydrographic surveys before and after the Great Earthquake of 1964. Sites chosen based on data availability - not many areas resurveyed. Surveys prior to 2000 not multibeam. Each comparison based on pairs of before/after soundings only if within 25 meters. Hot colors indicate elevation (red/orange/yellow) and cold colors indicate subsidence (blues).

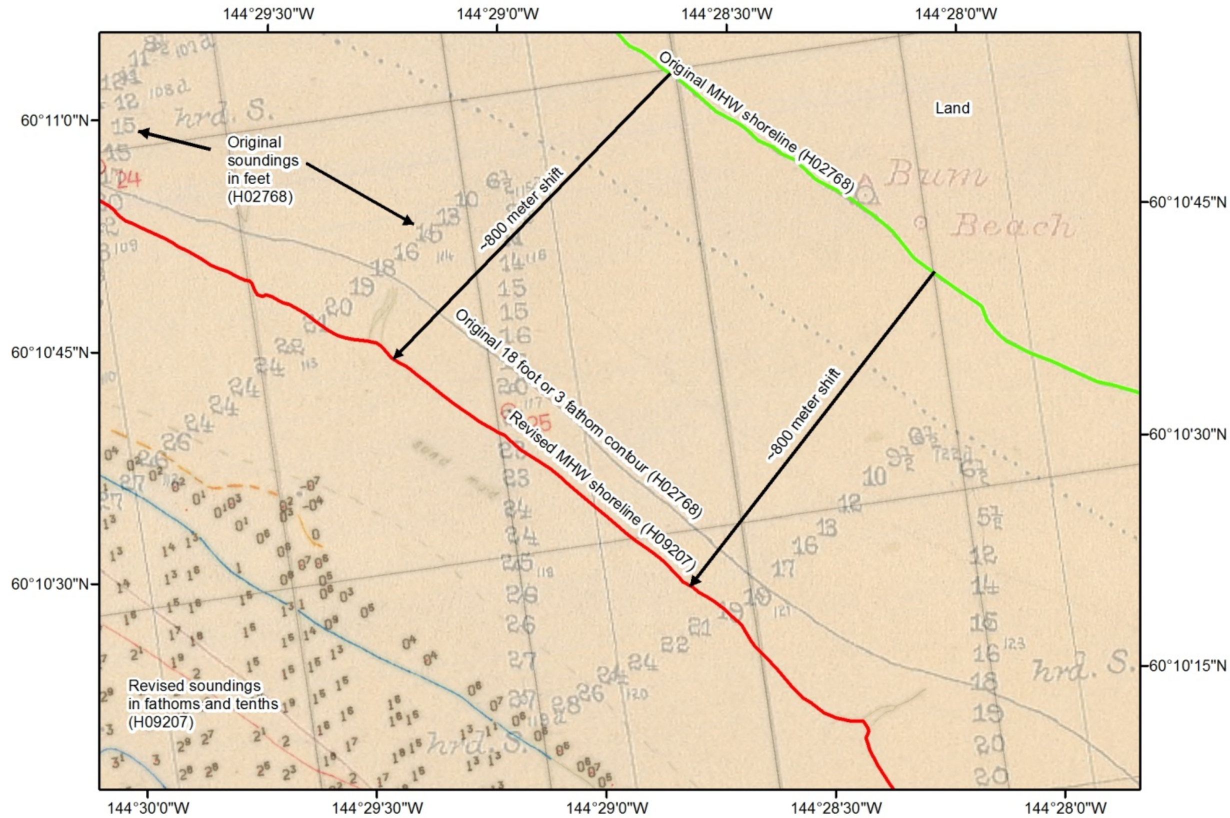

Figure 10. -- There was approximately 600-800 m change in the MHW shoreline of Katalla Bay between the 1905 survey of H02768 (green) and the 1971 survey of H09207 (red). This figure was created by plotting the partially transparent smooth sheet of the newer survey on top of the smooth sheet of the older survey, resulting in some imagery faintness. The shoreline has shifted about 800 m to the southwest in this section of the bay The shallowest soundings of the newer survey occur in places where soundings were about 27 feet deep in the original survey.

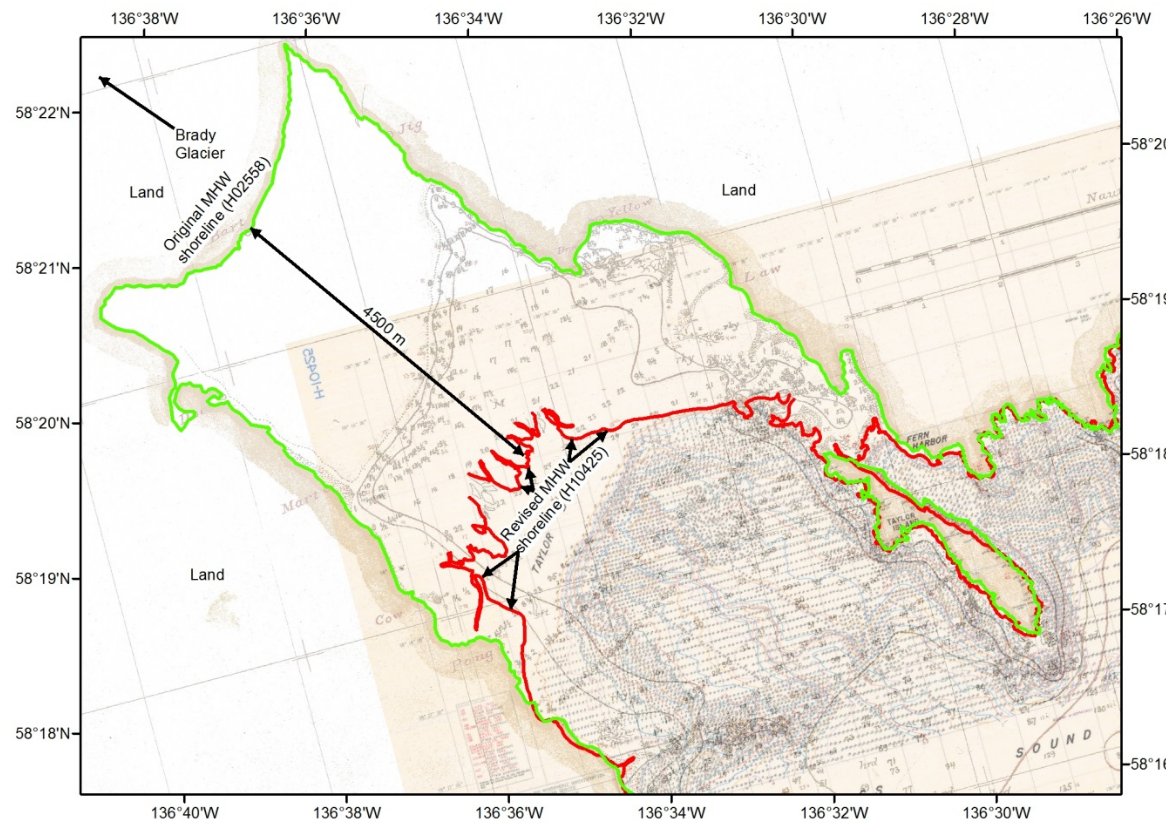

Figure 11. -- There was approximately 4500 m change in the MHW shoreline of Taylor Bay between the 1901 survey of H02558 (green) and the 1992 survey of H10425 (red). This figure was created by plotting the partially transparent smooth sheet of the older survey on top of the smooth sheet of the newer survey, resulting in some imagery faintness. The shallowest modern soundings occur on top of 26 fathom soundings from the old survey.

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167 (web site: *www.ntis.gov)*. Paper and electronic (.pdf) copies vary in price.

AFSC-

286 CAHALAN, J., J. GASPER, and J. MONDRAGON. 2014. Catch sampling and estimation in the feder al groundfish fisheries off Alaska, 2015 edition, 46 p. NTIS number pending.

285 GUYON, J. R., C.M. GUTHRIE III, A. R. MUNRO, J. JASPER, and W. D. TEMPLIN. 2014. Extension of genetic stock composition analysis to the Chinook salmon bycatch in the Gulf of Alaska walleye pollock (*Gadus chalcogrammus*) trawl fisheries, 2012, 26 p. NTIS number pending.

284 HIMES-CORNELL, A., and K. KENT. 2014. Involving fishing communities in data collection: a summary and description of the Alaska Community Survey 2011, 171 p. NTIS number pending.

283 GARVIN, M. R., M. M. MASUDA, J. J. PELLA, P. D. BARRY, S. A. FULLER, R. J. RILEY, R. L. WILMOT, V. BRYKOV, and A. J. GHARRETT. 2014. A Bayesian cross-validation approach to evaluate genetic baselines and forecast the necessary number of informative single nucleotide polymorphisms, 59 p. NTIS number pending.

282 DALY, B. J., C. E. ARMISTEAD, and R. J. FOY. 2014. The 2014 eastern Bering Sea continental shelf bottom trawl survey: Results for commercial crab species, 167 p. NTIS No. PB2015-101255.

281 FAUNCE, C., J. CAHALAN, J. GASPER, T. A'MAR, S. LOWE, F. WALLACE, and R. WEBSTER. 2014. Deployment performance review of the 2013 North Pacific Groundfish and Halibut Observer Program, 74 p. NTIS No .PB2015-100579.

280 HIMES-CORNELL, A., and K. KENT. 2014. Involving fishing communities in data collection: a summary and description of the Alaska Community survey, 2010, 170 p. NTIS No PB2015-100578.

279 FISSEL, B. E. 2014. Economic indices for the North Pacific groundfish fisheries: Calculation and visualization, 47 p. NTIS No. PB2015-100577.

278 GODDARD, P., R. LAUTH, and C. ARMISTEAD. 2014. Results of the 2012 Chukchi Sea bottom trawl survey of bottomfishes, crabs, and other demersal macrofauna, 110 p. NTIS No.PB2015-100576.

277 ALLEN, B. M., and R. P. ANGLISS. Alaska marine mammal stock assessments, 2013, 294 p. NTIS No. PB2015-100575.

276 LOEFFLAD, M. R., F. R. WALLACE, J. MONDRAGON, J. WATSON, and G. A. HARRINGTON. 2014. Strategic plan for electronic monitoring and electronic reporting in the North Pacific, 52 p. NTIS No. PB2014-106286.

275 ZIMMERMANN, M., and M. M. PRESCOTT. 2014. Smooth sheet bathymetry of Cook Inlet, Alaska, 32 p. NTIS number pending.

274 ALLEN, B. M., V. T. HELKER, and L. A. JEMISON. 2014. Human-caused injury and mortality of NMFS-managed Alaska marine mammal stocks, 2007-2011, 84 p. NTIS number pending.

273 SMITH, K. R., and C. E. ARMISTEAD. 2014. Benthic invertebrates of the Eastern Bering Sea: a synopsis of the life history and ecology of the sea star *Asterias amurensis*, 60 p. NTIS number pending.

272 DE ROBERTIS, A., D. MCKELVEY, K. TAYLOR, and T. HONKALEHTO. 2014. Development of acoustic-trawl survey methods to estimate the abundance of age-0 walleye pollock in the eastern Bering Sea shelf during the Bering Arctic subarctic survey, 46 p. NTIS number pending.

271 VULSTEK, S. C., C. M. KONDZELA, C. T. MARVIN, J. WHITTLE, and J. R. GUYON. 2014. Genetic stock composition analysis of chum salmon bycatch and excluder device samples from the 2012 Bering Sea walleye pollock trawl fishery, 35 p. NTIS No. PB2014-105096.