NOAA Technical Memorandum NMFS-AFSC-250

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

May 2013

NOAA Technical Memorandum NMFS

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This document should be cited as follows:

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.

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Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle WA 98115

*www.afsc.noaa.gov*

**U.S. DEPARTMENT OF COMMERCE**
Rebecca M. Blank, Acting Secretary
**National Oceanic and Atmospheric Administration**
Kathryn D. Sullivan, Acting Under Secretary and Administrator
**National Marine Fisheries Service**
Samuel D. Rauch III, Acting Assistant Administrator for Fisheries

May 2013

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# ABSTRACT

We assembled 2.1 million National Ocean Service (NOS) bathymetric soundings extending 1,900 km along the Aleutian Islands from Unimak Island in the east to the Russian border in the west, and ranging approximately 500 km north of the central Aleutians to Petrel and Bowers Banks, and also the surrounding deep waters of the southeastern Bering Sea. These bathymetry data are available from the National Geophysical Data Center (NGDC: http://www.ngdc.noaa.gov), which archives and distributes data that were originally collected by the NOS and others. While various bathymetry data have been downloaded previously 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 Our editing included deleting erroneous and superseded values, digitizing missing values, and properly aligning all data sets to a common, modern datum. We also digitized 25,000 verbal surficial sediment descriptions from the smooth sheets, providing the largest single source of sediment information for the Aleutians.

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# INTRODUCTION

The bathymetry of the Aleutian Islands is poorly described and relatively unknown, considering that it and the rest of Alaska have been part of the United States since 1867. Part of the reason for this lack of information is that Russian and European navigators were late to explore and map the Aleutians, along with other parts of Alaska. Another reason is the vastness and complicated distribution of the Alaska mainland and island areas, with more shoreline than the continental U.S. (Jones 1918). Alaska, and especially the Aleutians, has remained relatively unpopulated and is remote from major population centers since this early period of exploration. Despite these negative factors, the Aleutian waters support important fisheries (Aleutian Islands Ecosystem Team 2007) and the Aleutian chain is crossed twice by about 3,100 commercial vessels each year (Nuka Research and Planning Group, LLC. 2006) while plying the great circle route between the Strait of Juan de Fuca and Asia (Jones 1918; Fig. 1).

The Dutch navigator Vitus Bering, sailing in 1741 for the Russians on his second expedition, is credited with the first charting of the Aleutian Islands, though the posthumously published chart showed the Aleutians as a peninsula (Hayes 2001). This led to the Russian colonization of Alaska and numerous Russian charting efforts, with the expeditions of Petr Krenitsyn and Mikhail Levashev (1766-1769) and Potap Zaikov (1774-1779) being especially fruitful for establishing the location and number of the Aleutian Islands (Hayes 2001). Early Spanish expeditions sailing from Mexico to the North Pacific in 1774, 1775, and 1779 did not reach the Aleutians (Olson 2004). The British explorer Captain James Cook used some of the Russian nautical knowledge during his third voyage and stopped at Unalaska Island in 1778, nearly shipwrecking in the eastern Aleutians because Bering's positions were incorrect (Hayes 2001). Cook's survey of what is now called English Bay, on eastern Unalaska Island, is reasonably accurate in terms of shoreline, depth and latitude, but the longitude places the bay about 18 km too far to the west. A Spanish expedition under the command of Esteban Martinez utilized the work of Bering and Cook to reach Unalaska in 1788 (Olson 2004). Other notable North Pacific scientific charting expeditions during this time period did not venture as far north and west as the Aleutians, such as a French effort led by Jean-Francois de Galaup, comte de LaPerouse (1785-1788), Spanish expeditions in 1790, 1791, and 1792 (Olson 2004), a British effort led by George Vancouver (1791-1795), and the U.S. Exploring Expedition (1838-1842) led by Charles Wilkes (Philbrick 2003). William Gibson, commanding the *Fenimore Cooper* as part of the U.S. North Pacific Exploring Expedition (1853-1856), surveyed some of the Aleutians in 1855 (McCormick 1906, Hayes 2001) but a formal publication never followed (Hayes 2001).

At the time of the U.S. purchase of Alaska in 1867, U.S. charts were based on these earlier, mostly foreign, explorations (Jones 1918) and significant details were still lacking. After the purchase, George Belknap, commanding the *Tuscarora* (1873-1874), discovered the Aleutian Trench, a major seafloor feature exceeding 7,000 m in depth, while trying to determine a submarine cable route between Japan and the United States (Belknap 1874). The first U.S. Coast Survey chart of the Aleutian Islands was published in 1875, incorporating the late 18th century and early 19th century work of the Russians, the 1850s work of Gibson, the recent work of Belknap, and Coast Survey work conducted by W.H. Dall in 1873 (Pierce 1875). While this chart is a relatively accurate depiction of the Aleutians Islands, the bathymetry surrounding the islands was almost entirely unknown. On the chart there are only 58 soundings scattered throughout the Aleutians, mostly from the *Tuscarora* cruise, and no contour lines. Bathymetric progress was slow because there was generally just one hydrographic survey vessel operating in Alaskan waters until 1880 (Jones 1918). The U.S. Fisheries Commission steamer *Albatross* made hundreds of soundings in the eastern Aleutians and southern Bering Sea area in the late 1880s (Tanner 1890) and early 1890s (Tanner 1891, Rathbun 1894), but just a few soundings were scattered throughout the rest of the Aleutian Chain.

The beginning of the modern hydrographic surveying of the Aleutians can be traced to U.S. Coast and Geodetic Survey Aid Owen B. French, who made a chronometric longitudinal and astronomic latitudinal observation in 1896 at the Village of Unalaska, on the shore of Iliuliuk Bay, Unalaska Island (Fig. 1) (Duffield 1897). This first Geodetic Triangulation station, called "Unalaska Astronomic Station", along with several others also established in the immediate vicinity in 1896, was the foundation for hydrographic surveyors to make accurate triangulation position estimates of their offshore soundings. It would take decades to establish independent triangulation stations along the rest of the Aleutian chain, and decades more to link the stations into a unified datum.

In 1918, E. Lester Jones, the superintendent of the U.S. Coast and Geodetic Survey (precursor agency to the National Ocean Service (NOS)), publicly lamented the need for bathymetric surveying funds for Alaskan waterways (Jones 1918). Jones estimated that only 9% of Alaskan waters were adequately surveyed and that his present resources were far outstripped by the vast needs for surveying. He considered the Aleutians completely unsurveyed even though some relatively formal, or geodetically controlled, surveys had been completed in the early 1900s. Jones (1918) cited the wreck of the U.S. Revenue Cutter *Tahoma* in 1914 (Orth 1967) on an uncharted Buldir Island area reef, which now bears the name of the vessel, as an argument that it is economically more rational to survey these obstacles prior to collisions rather than discovering them one at a time with shipwrecks.

From the early 1900s through the 1950s, most of the Aleutian Islands area was systematically surveyed for the first time by the U.S. Navy and the NOS for the purpose of creating smaller-scale navigational charts, which minimize details but maximize critical navigational information (such as shipping lanes, navigational buoys, etc.). While mariners have routinely used the small-scale navigational charts (1:300,000) for about a century, the source data - the original, detailed hydrographic surveys (1:20,000) - remained relatively unknown to those outside of the NOS. One reason for this lack of familiarity is that many of the Aleutian hydrographic surveys were classified as "Confidential" (Fig. 2) until a formal review following Executive Order 12356, signed by President Reagan in 1982, which set standards for declassifying government information. In 2005 the National Geophysical Data Center (NGDC) began hosting electronic copies of the hydrographic surveys. This project focused on working with the original survey bathymetric data available from NGDC and combining them into a single data set, along with digitizing the sediment information.

## METHODS

We downloaded and examined several hundred lead line and fathometer or single-beam hydrographic survey data sets, available in whole or in part from the NGDC (http://www.ngdc.noaa.gov), dating back to 1901, in order to create a bathymetry map of the Aleutian Islands. Many of these hydrographic surveys were superseded by more modern surveys and therefore not considered for further analysis, and yet most of the remaining "modern" surveys remaining would be considered old or antiquated anywhere else in the United States. If we had limited our analyses only to surveys conducted in recent decades, our resulting map would have been largely blank.

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 which have been digitized (Wong et al. 2007) from the smooth sheet. In general, there is no original text or data file of the soundings because most of these surveys predate the computer era where data can be entered and stored electronically. A paper smooth sheet with muslin backing was the final product of a hydrographic survey (Hawley 1931). 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 simplest to download and plot the digitized soundings in a Geographic Information System (GIS) in order to produce a continuous, interpolated, bathymetric surface, which can be accomplished in a matter of hours or days. This is the goal of most users. A generalized surface which 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 features (flats, bumps, and dips) that create the bathymetry, and we have found 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, correcting any errors, and producing 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, and making comparisons to the digitized text file provided by NGDC. Details of the methods are described in Zimmermann and Benson (2013).

Verbal sediment descriptions were also digitized from the smooth sheets. Short abbreviations such as "S" and "M" were translated into their full names of "Sand" and "Mud". Position of the sediment points were centered on the written description even though it is obvious that these descriptions were written off to the side of the sounding from where they were determined.

## RESULTS

Our efforts resulted in the inclusion of 290 more or less unique hydrographic surveys or data sets (Table 1; Fig. 3). Sixteen of these required full or partial digitization of missing soundings from the smooth sheets. Three of the smooth sheets images are missing and therefore no formal proofing was done. During the course of this project, three previously missing smooth sheets were scanned and provided for digitizing (Jeff Ferguson, Chief, Hydrographic Surveys Division, NOS, pers. comm.), which filled important gaps. Significant gaps remain, though, as discussed later in this manuscript. Altogether there were approximately 2.1 million soundings which we proofed, edited or digitized. Approximately 100 additional surveys were examined and rejected for inclusion, mostly because they were either superseded by more recent surveys, were wire-drags or pipe-drags and did not include soundings, or were freshwater surveys.

The combined soundings were used to create a continuous bathymetric surface (TIN: Triangulated Irregular Network) of the Aleutians, but some significant gaps in coverage, such as the Aleutian Trench, remained. Therefore, we supplemented these NOS hydrographic surveys with some other non-hydrographic surveys, such as a NOS *Surveyor* survey in 1963-64, a USGS (U.S. Geological Survey) *Rainier* survey in 1970, and USGS and UKNERC (United Kingdom

Natural Environment Research Council) *Farnella* surveys in 1986 and 1987 (Fig. 3), in order to fill gaps and provide a more complete TIN of the Aleutians (raster or grid version available at http://www.afsc.noaa.gov/maps/Bathymetry/default.htm; Fig. 4).

There were 25,274 verbal sediment descriptions digitized from 234 smooth sheets, resulting in 608 unique verbal descriptions (available by survey at http://www.afsc.noaa.gov/maps/Bathymetry/default.htm, Fig. 5). Thus, 56 or 19% of the smooth sheets did not have any verbal sediment descriptions on them, creating gaps in the sediment information. "Rocky" (n = 8,716), "Sand" (n = 5,192), "Mud" (n = 1,113), and "Sticky" (n = 945) were the most common descriptions. In addition there were descriptions which provided more detail about a sample, for example, aside from the simplistic description of "Sand", there were also numerous instances of "Fine Gray Sand" (n = 817), "Fine Black Sand" (n = 783), "Black Sand" (n = 699), and "Gray Sand" (n = 570). There were also numerous, complicated or specific sediment descriptions, with over 58% of the sediment description categories only having a single occurrence.

## Age

Antiquated best describes these Aleutian hydrographic surveys (Fig. 3). There were 89 surveys from the 1930s, 136 surveys from the 1940s (with a large concentration around World War II, probably as a response to the attack and invasion of some of the Aleutian Islands early in the war), 61 surveys from the 1950s, and 4 relatively recent surveys (1988 - 93). A limited number of more modern surveys utilizing multibeam hydrographic surveys have been conducted in small areas within the study area - these are discussed later in this manuscript but were not included in this bathymetry compilation.

## Datums

Antiquated and relatively unknown horizontal datums provided the surveying frame-work for the majority of these surveys (Fig. 6), due to the age of the surveys, and due to the remoteness of the Aleutian Islands from U.S. continental triangulation surveys (Tittmann 1903). The bulk of the early surveys were conducted in the Unalaska datum (n = 136) and various U.S. Navy or Independent datums (n = 50), none of which have known conversions to modern datums. Therefore each of these Unalaska and U.S. Navy datum smooth sheets were custom-shifted from the old datum to the North American Datum (NAD) of 1983 (HARN or High Accuracy Resolution Network), as described in Zimmermann and Benson (2013), so there was a common frame of reference for all surveys. The North American Datum of 1927 (NAD 1927), centered in Meades Ranch, Kansas (Robinson et al., 1995), which is approximately 5,000 km on a direct path from the eastern end of the Aleutians (perhaps twice as far on a land-based triangulation network), was not utilized in the Aleutians until after World War II - a two decade lag. One hundred surveys from 1947 to 1959 were conducted in NAD 1927, and almost three decades later there was a single additional NAD 1927 survey of Sweeper Cove, Adak Island (H10282: 1988), site of a naval air station until 1997. NAD 1927 is also antiquated but algorithms exist for conversion -- still we relied on custom datum-shifts for these surveys, not trusting that algorithmic conversions would be accurate for the Aleutians. Only the three most recent surveys from 1991 (n = 2) and 1993 were conducted in NAD 1983 and we did not convert them to NAD 1983 HARN. The two 1991 surveys were conducted in Dutch Harbor, Unalaska Island, the most important fishing port in the Aleutians, and the 1993 survey was conducted in Alcan Harbor, Shemya Island, site of Eareckson Air Force Station (Fig. 1).

Unalaska datum surveys cover the eastern end of the study area, Navy datum surveys cover the western end of the study area, other datum surveys cover very small areas, and NAD 1927 surveys cover the central part of the study area, Petrel and Bowers Banks on the north side of the Aleutians, and the surrounding deep of the Bering Sea (Fig. 6). Latitude and longitude shifts for converting the old surveys to NAD 1983 HARN were quite variable within the region covered by each datum and between datums.

## Datum Shifts

Most of the smooth sheets required unique datum shifts, which were quite variable in location and survey era (Fig. 7). The Unalaska datum surveys required decreasing amounts of latitudinal shifts to the south ranging from 225 m at Unimak Island, to about 168 m at Umnak Island, and to about 140 m at Amchitka Island. The longitudinal shifts for the Unalaska datum were much more complicated. There were western shifts of about 34 m at Amchitka Island at the western end of its range and western shifts of about 56 m at Sanak Island at the eastern end of its range, however, in the center of the Unalaska datum surveys used for this project, such as at Umnak Island, the surveys required a shift in the opposite direction (to the east) of about 55 m.

The two Atka 1925-1934 datum surveys required a shift of 609 m to the south and a shift of 213 m to the west. Despite being separated by a distance of about 800 km along the Aleutian chain, this Atka datum shift was very similar to that of the U.S. Navy *Gannet* 1934 datum surveys in the Near Islands, which required shifts of about 671 m to the south and about 288 m to the west. The U.S. Navy datums of 1933 and 1943, restricted to Tanaga and Adak Islands, both required shifts of about 160 m to the north and about 336 m to the east.

The single Astronomic Amchitka survey required a shift of 537 m to the north and 247 m to the west. The single Independent survey at Kiska Island required a shift of 300 m to the north and 25 m to the east.

The NAD 1927 surveys required shifts to the south of about 164 m, ranging from 140 m (at Atka Island) to 183 m (at Agattu Island), and shifts to the west of about 183 m, ranging from 163 m (at Atka Island) to 206 m (at Shemya Island).

## 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 on 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. Many 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 served the purpose of 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 H07182 was originally digitized

10 minutes (~11,600 m) to the west of its correct location, taking a bay from the east side of Adak Island and creating one on the north side of the island.

## Scale and Coverage

The majority of the surveys were conducted at a scale of 1:20,000 (n = 134) or larger scale (n = 59), ranging up to a scale of 1:480, generally covering the nearshore area in a detailed, narrow band throughout the Aleutian Island chain (Fig. 8). These large-scale surveys were generally surrounded by surveys of intermediate scale down to 1:100,000 (n = 78), with 1:40,000 (n = 42) and 1:80,000 (n = 19) the most common. Offshore surveys ranged as small a scale as 1:500,000. Numerous smooth sheets included insets but these were not counted separately from the main smooth sheet. The large-scale surveys covered only about 27,000 $km^2$ or < 3%, the intermediate surveys covered about 220,000 $km^2$ or 21%, and the small-scale surveys covered about 780,000 $km^2$ or 76% of total study area.

## Data Quality

Data quality appears to be high on many of these nearshore smooth sheets, despite the age of the surveys, the weird datums, the remoteness of the sites, and the paucity of hydrographic surveys over such a broad area. As mentioned above, the majority of the surveys are large scale and occurred in the nearshore area, where depths were relatively shallow and visual fixes of shore stations was possible. The greatest survey challenges were those too far offshore for visual fixes and too deep for simple technology to sound adequately.

Several of the 1930s-era U.S. Navy smooth sheets, such as H06883 (scale 1:10,000) for Shagdak Bay (now Shagak), Adak Island, are compiled so expertly they are practically works of art (Fig. 9A). The beautiful penmanship clearly depicts bathymetric soundings and sediments; marine features such as rocks, islets, kelp, tide rips, and shoreline (along with navigational notes); and land features such as topographic contours, mountain peak elevations, rivers, and hand-colored lakes. Currently these water and land map elements are split into two map series: hydrographic features appear on NOS Navigational Charts and land features appear on USGS topographic maps. USGS topographic maps are only available at a scale of 1:250,000 for the Aleutians. Shagak Bay has never been resurveyed but there is a newer 1:20,000 hydrographic survey covering the outside of the bay - thus, survey H06833 stands as the best bathymetric and topographic survey for this location, despite its age of nearly eight decades. Comparison of H06883 to Bing Maps Imagery (Fig. 9B) (© Microsoft Corporation and its data suppliers, available in ArcMap 10.0, ESRI, Redlands, CA) shows close shoreline alignment (Fig. 9C).

Offshore surveys are smaller scale, with fewer soundings, and long-distance visual sextant fixes on shore stations or dead-reckoning for navigation, all of which resulted in lower quality surveys. The Radio Acoustic Ranging (RAR) offshore navigational system, such as that mentioned in survey H06503 (1938) was a relatively complicated and dangerous navigation method - hydrographic vessels would drop bombs in the water, the sound from the explosion would cause shore-based hydrophones to send a radio signal back to the ship, so that time of the delay, and hence the distance offshore, could be calculated (Hawley 1931). Sonobuoys, first mentioned in survey H06478 (1939), were an advancement over RAR, and hydrophones could be offshore and unmanned. The SHORAN (Short Range Navigation) navigational system, based on radio waves, was first nationally tested and implemented in Aleutians survey H06871 (1945), allowing position fixes at distances of 40 to 50 miles from the SHORAN broadcasting stations, far exceeding the distance for making visual fixes on shore stations. SHORAN was used for navigation thru the 1959 survey H08823. Mini-ranger microwave positioning systems were used for the 1988 and 1991 surveys. Differential GPS (Global Positioning System) navigation was first mentioned for survey H10483 (1993), the last survey in this Aleutians data set.

Lead line soundings were the primary means of determining shallower depths for most of these Aleutian hydrographic surveys, but other more automated methods such as the fathometer and wire sounding machine supplemented the lead line soundings on the earliest (1934) of these surveys. Hawley (1931) provides an exact description of the various sounding equipment and methods used for these surveys. A lead line is a wire-core rope, measured and marked in fathom intervals, terminating into an 8 to 12 lb lead that is lowered and retrieved manually for measuring shallower depths. Wire soundings are conducted with narrow wire such as piano wire wrapped around a powered spool or drum and lowered with a heavier weight (30 to 40 lb) for deeper depths. Hollow tips in the sounding leads, or dedicated scoopers, provided sediment samples that could be viewed upon retrieval. Pressure tubes were also used in some of these surveys, but this type of equipment, which measures water pressure according to how far into the tube air is displaced, was unreliable. The fathometer (dating from 1925) or the echo sounder (a revised fathometer), in which sound waves are reflected off the seafloor back to a survey vessel, was a major advance over earlier sounding methods, but still required significant calibration and interpretation. Despite the antiquity of the lead line and the manual-labor aspect of the device, it was and still is the standard against which other sounding methods are measured. Even today, multibeam ships frequently test their equipment by conducting bar checks (sailing over horizontal bars suspended from the surface by ropes of known length), and a lead line was used to verify the multibeam data in survey H10483, the most recent (1993) survey used in this compilation.

# DISCUSSION

We consider this smooth sheet bathymetry and sediment compilation a first draft. Time did not allow for careful editing along shore where some bathymetric features such as rocks, islets and rocky reefs sometimes have depths (or elevations) associated with them. Digitization of kelp patches and comments about tide rips or strong currents also was not completed. Shorelines, defined as Mean High Water (MHW) tidal datum, could also be digitized, connecting the seafloor bathymetry with land topography and satellite imagery (Zimmermann and Benson 2013). Additionally, soundings from smaller scale surveys could be deleted in areas where they overlap soundings from larger scale surveys, in order to remove possible contradictions. As more bathymetry data becomes available, and as more time allows, additional bathymetry drafts will be completed.

Our slow method of data editing and compilation, which relied on comparing the digitized soundings (Wong et al. 2007) to the smooth sheets in a GIS, was vindicated by 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. Other compilation efforts have also encountered datum-shift errors, such as at Amchitka Island (Johnson and Stewart 2005) and the Akutan region (Lim et al. 2011), and had to resort to shifting bathymetry data sets manually to align with a coast line. A Dutch Harbor, Unalaska Island bathymetry compilation was facilitated by Dave Doyle providing the proper horizontal datum shift of older data sets (Taylor et al. 2006). We are not aware of any other bathymetry compilation effort which compared and corrected the digitized soundings to the original smooth sheets.

In general, if the Aleutian hydrographic survey coverage can be accepted as adequate, it should also be recognized as sparse or minimal. For comparison, while there have been about 400 surveys in the mostly unpopulated Aleutians covering its 1,900 km length, along with Petrel and Bowers Banks, and the Bering Sea deep, there have been about 1,000 hydrographic surveys in the highly populated Chesapeake Bay area covering its 300 km length, according to the survey map at NGDC.

Almost 100 years after E. Lester Jones identified the shortcomings in Alaska bathymetry (Jones 1918) he might not be too surprised that the work is still incomplete, although he might also be flattered to see that one of the hydrographic survey vessels bears his name (Table 1). Improvement can be made by filling in the gaps, such as in the central Aleutians, and superseding older, lower quality surveys with newer surveys, such as those executed with multibeam sonars and DGPS.

## Central Aleutians Bathymetry Gap

There is a significant gap in hydrographic survey data in the central Aleutians surrounding part of Atka Island, most of Amlia Island, and western Seguam Pass (Fig. 10). Comparing the available hydrographic surveys with the navigational and bathymetric charts for the area reveals some inconsistencies, but, in general, confirms areas of unknown bathymetry.

The nearshore area around the northeast end of Atka Island, ranging from the Korovin Bay survey (H06845, 1:20,000), which extends as far northeast as Cape Korovin, to the Nazan Bay surveys (H06851 and H05644, both 1:20,000), which extend as far northeast as Cape Kudugnak, has never been surveyed (Fig. 10). This unsurveyed nearshore area is bounded by the offshore surveys H06850 (1:60,000) on the west, H07973 (1:60,000) on the north, and H07995

(1:100,000) on the east. On NOS navigational Chart 16480 this area is left blank. On Bathymetric Map Amlia - 1810N-1 this same area is left blank with a notation reading "no surveys available".

The north and south sides of Amlia Island have never been surveyed. There is a significant gap on the north side of Amlia Island, extending approximately 4 to 7 km from the shore to offshore survey H07995 (1:100,000) (Fig. 10). The south side of Amlia Island has soundings from offshore survey H08823 (1:60,000) extending to within approximately 8 km of the southwest coast, but no other nearby surveys. NOS navigational Chart 16480 has soundings covering much of the offshore area, extending past H08823, up to about 30 fathoms in depth (within about 5 or 6 km of the south shore) but the source of these soundings is unknown. Chart 16480 also has an inset chart of tiny Sviechnikof Harbor on the south side of Amlia, at a scale of 1:20,000, without any information about the survey's origin. This same survey of Sviechnikof Harbor is repeated on NOS Chart 16464 (1976 ed.), Harbors and Anchorages Andreanof Islands, with the notation "Hydrography and topography by the National Ocean Survey (formerly the Coast and Geodetic Survey)". It also appears on the 1968 and 1972 editions of precursor chart 9121, but not on the earlier editions of 1944 and 1947 (it appears that during this time period users were directed to chart 8851 from editions of Amlia area Chart 8862, the precursor of Chart 16480). According to the Geographic Dictionary of Alaska (McCormick 1906), Sviechnikof Harbor was surveyed in 1832 by Ivan Chernof, a Russian American Company pilot, so perhaps the soundings come from his work. On bathymetric bap Amlia - 1810N-1 the north side of Amlia Island has a note "contours omitted from islands where topographic surveys are inadequate" and the south side has a note "no adequate hydrographic surveys available", while offshore soundings on the south side of Amlia appear to have come from a 1963-64 NOS *Surveyor* cruise (not shown in Fig. 10: available under Trackline Geophysics at NGDC).

The western side of Seguam Pass has also never been surveyed (Fig. 10). There are detailed surveys surrounding Seguam Island (H06696 and H06697 1:20,000, and H06723 1:40,000) but these end approximately 19 km from the eastern tip of Amlia Island. NOS Navigational Chart 16480 has a single line of soundings extending down the center of Seguam Pass but their origin is unknown.

The descriptive report for 1958 hydrographic surveys H08473, H08474, H08475 (Fig. 11) and the 1959 hydrographic survey H08476 from the ship *Explorer* has outlines for proposed surveys covering much of the Atka and Amlia unsurveyed areas for the 1959 field season, but the fate of these proposed surveys is unknown. Therefore it is not known if these areas were never surveyed, or if the surveys were completed but are not available.

## Multibeam Surveys

There is very little spatial coverage of multibeam hydrographic survey data for the Aleutian Islands, totaling only about 3% of the study area (Fig. 12). The largest single source is from a 2005 backarc mapping cruise on the RV *Thompson*, which mapped approximately 9,700 km$^2$, at nine sites, scattered through the central and western Aleutians, mostly in deeper water (Coombs et al. 2007). The second largest data set of approximately 8,900 km$^2$ is from the northeastern edge of Bowers Bank (Gardner 2003), from the U.S. Extended Continental Shelf Task Force (USECSTF), under the auspices of the United Nations Convention on the Law of the Sea (UNCLOS). Another substantial multibeam data set of 5,100 km$^2$ is from NOS which is currently mapping shallower areas of navigational importance in the Unimak Pass, Akutan Pass and Unalga Pass areas. There are 20 surveys presently available with more being completed annually, but only in the eastern Aleutians. A mapping transect from the *Revelle* covers about 3,400 $km^2$ in the eastern Aleutians. Another mapping effort of 2,700 $km^2$ was a cold-water corals research project funded by NPRB (North Pacific Research Board), on the RV *Davidson*, in 2003, which mapped 17 sites in narrow strips ranging from shallow to deep. There are other, isolated, small multibeam maps such as that covering about 59 $km^2$ by CRESP (Consortium for Risk Evaluation with Stakeholder Participation; Johnson and Stewart 2005) at Amchitka Island.

# ACKNOWLEDGMENTS

Funding for much of the work was provided by NOAA's Deep Sea Coral Research and Technology Program. D. Doyle and J. Benson 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. We also thank A. Greig and T. Vance for their reviews.

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Table 1. -- List of smooth sheet survey data sets used in Aleutian Islands bathymetry compilation.

| Survey | Scale | Year | Vessel | Datum |
|---|---|---|---|---|
| H05643 | 5,000 | 1934 | *Discoverer* | Atka 1925-1934 |
| H05644 | 20,000 | 1934 | *Westdahl* | Atka 1925-1934 |
| H05672 | 20,000 | 1934 | *Discoverer* and *Westdahl* | Unalaska |
| H05728 | 40,000 | 1934 | *Surveyor* | Unalaska |
| H05737 | 20,000 | 1934 | *Surveyor* | Unalaska |
| H05738 | 20,000 | 1934 | *Surveyor* | Unalaska |
| H05739 | 80,000 | 1934 | *Discoverer* | Unalaska |
| H05740 | 160,000 | 1934 | *Discoverer* | Unalaska |
| H05744 | 20,000 | 1934 | *Surveyor* | Unalaska |
| H05745 | 20,000 | 1934 | *Surveyor* | Unalaska |
| H05759 | 80,000 | 1934 | *Surveyor* | Unalaska |
| H05761 | 40,000 | 1934 | *Surveyor* | Unalaska |
| H05762 | 20,000 | 1934 | *Surveyor* | Unalaska |
| H05763 | 20,000 | 1934 | *Surveyor* | Unalaska |
| H05948 | 80,000 | 1935 | *Surveyor* | Unalaska |
| H05949 | 20,000 | 1935 | *Surveyor* | Unalaska |
| H05964 | 20,000 | 1935 | *Discoverer* | Unalaska |
| H05965 | 10,000 | 1935 | *Discoverer* | Unalaska |
| H05966 | 20,000 | 1935 | *Surveyor* | Unalaska |
| H05967 | 160,000 | 1935 | *Discoverer* | Unalaska |
| H05970 | 20,000 | 1935 | *Surveyor* | Unalaska |
| H05971 | 40,000 | 1935 | *Surveyor* | Unalaska |
| H05972 | 80,000 | 1935 | *Surveyor* | Unalaska |
| H05973 | 40,000 | 1935 | *Surveyor* | Unalaska |
| H05974 | 20,000 | 1935 | *Surveyor* | Unalaska |
| H05977 | 20,000 | 1935 | *Discoverer* | Unalaska |
| H05978 | 20,000 | 1935 | *Discoverer* | Unalaska |
| H05979 | 20,000 | 1935 | *Discoverer* | Unalaska |
| H05980 | 5,000 | 1935 | *Discoverer* | Unalaska |
| H06109 | 10,000 | 1935 | *Surveyor* | Unalaska |
| H06110 | 20,000 | 1935 | *Surveyor* | Unalaska |
| H06111 | 20,000 | 1935 | *Surveyor* | Unalaska |
| H06112 | 20,000 | 1935 | *Surveyor* | Unalaska |
| H06139 | 80,000 | 1936 | *Discoverer* | Unalaska |
| H06146 | 20,000 | 1936 | *Discoverer* | Unalaska |
| H06150 | 10,000 | 1936 | *Discoverer* | Unalaska |
| H06160 | 80,000 | 1936 | *Surveyor* | Unalaska |
| H06175 | 20,000 | 1936 | *Surveyor* | Unalaska |
| H06176 | 40,000 | 1936 | *Surveyor* | Unalaska |
| H06183 | 10,000 | 1936 | *Surveyor* | Unalaska |

Table 1. – Continued.

| | | | | |
|---|---|---|---|---|
| H06212 | 20,000 | 1936-37 | *Surveyor* | Unalaska |
| H06229 | 20,000 | 1936 | *Surveyor* | Unalaska |
| H06233 | 40,000 | 1936-37 | *Surveyor* | Unalaska |
| H06234 | 20,000 | 1937 | *Surveyor* | Unalaska |
| H06235 | 20,000 | 1937 | *Surveyor* | Unalaska |
| H06241 | 10,000 | 1937 | *Surveyor* | Unalaska |
| H06255 | 20,000 | 1936-37 | *Surveyor* | Unalaska |
| H06256 | 20,000 | 1935-37 | *Surveyor* | Unalaska |
| H06257 | 40,000 | 1936-38 | *Surveyor* | Unalaska |
| H06265 | 40,000 | 1936 | *Surveyor* | Unalaska |
| H06274 | 20,000 | 1937 | *Surveyor* | Unalaska |
| H06277 | 20,000 | 1935-37 | *Surveyor* | Unalaska |
| H06278 | 80,000 | 1937 | *Discoverer* | Unalaska |
| H06279 | 80,000 | 1937 | *Discoverer* | Unalaska |
| H06286 | 20,000 | 1937 | *Surveyor* | Unalaska |
| H06287 | 20,000 | 1937 | *Discoverer* | Unalaska |
| H06288 | 20,000 | 1937 | *Discoverer* | Unalaska |
| H06303 | 20,000 | 1936 | *Surveyor* | Unalaska |
| H06319 | 20,000 | 1937 | *Surveyor* | Unalaska |
| H06377 | 80,000 | 1936 | *Surveyor* | Unalaska |
| H06378 | 20,000 | 1937 | *Surveyor* | Unalaska |
| H06379 | 20,000 | 1938 | *Surveyor* | Unalaska |
| H06380 | 20,000 | 1938 | *Surveyor* | Unalaska |
| H06381 | 20,000 | 1938 | *Surveyor* | Unalaska |
| H06382 | 20,000 | 1938 | *Surveyor* | Unalaska |
| H06383 | 80,000 | 1937-38 | *Surveyor* | Unalaska |
| H06386 | 20,000 | 1938 | *Discoverer* | Unalaska |
| H06387 | 40,000 | 1938 | *Discoverer* | Unalaska |
| H06388 | 40,000 | 1938 | *Discoverer* | Unalaska |
| H06389 | 20,000 | 1938 | *Discoverer* | Unalaska |
| H06412 | 20,000 | 1938-39 | *Pioneer* | Unalaska |
| H06413 | 120,000 | 1938 | *Pioneer* | Unalaska |
| H06414 | 10,000 | 1937-39 | *Surveyor* | Unalaska |
| H06464 | 80,000 | 1939 | *Guide* | Unalaska |
| H06465 | 40,000 | 1939 | *Guide* | Unalaska |
| H06466 | 20,000 | 1939 | *Guide* | Unalaska |
| H06467 | 20,000 | 1939 | *Guide* | Unalaska |
| H06478 | 120,000 | 1939 | *Pioneer* | Unalaska |
| H06484 | 40,000 | 1938 | *Discoverer* | Unalaska |
| H06503 | 80,000 | 1938 | *Surveyor* | Unalaska |
| H06504 | 20,000 | 1939 | *Surveyor* | Unalaska |
| H06505 | 20,000 | 1938-39 | *Surveyor* | Unalaska |
| H06506 | 20,000 | 1937-39 | *Surveyor* | Unalaska |

Table 1. – Continued.

| | | | | |
|---|---|---|---|---|
| H06507 | 20,000 | 1938 | *Surveyor* | Unalaska |
| H06509 | 20,000 | 1938 | *Surveyor* | Unalaska |
| H06510 | 20,000 | 1939 | *Surveyor* | Unalaska |
| H06568 | 80,000 | 1940 | *Explorer* | Unalaska |
| H06569 | 20,000 | 1940 | *Explorer* | Unalaska |
| H06570 | 20,000 | 1940 | *Explorer* | Unalaska |
| H06571 | 20,000 | 1940 | *Explore*r and *E. Lester Jone*s | Unalaska |
| H06572 | 20,000 | 1940 | *Explorer* | Unalaska |
| H06573 | 160,000 | 1940 | *Pioneer* | Unalaska |
| H06610 | 20,000 | 1939-40 | *Surveyor* and *Explorer* | Unalaska |
| H06611 | 20,000 | 1939-40 | *Surveyor* and *Explorer* | Unalaska |
| H06695 | 20,000 | 1941 | *Explorer* | Unalaska |
| H06696 | 20,000 | 1940 | *Explorer* | Unalaska |
| H06697 | 20,000 | 1941 | *Explorer* | Unalaska |
| H06698 | 40,000 | 1941 | *Explorer* | Unalaska |
| H06700 | 80,000 | 1941, 1952 | *Explorer* | Unalaska |
| H06701 | 160,000 | 1941 | *Explorer* | Unalaska |
| H06701 | 160,000 | 1941 | *Explorer* | Unalaska |
| H06723 | 40,000 | 1941 | *Explorer* | Unalaska |
| H06845 | 20,000 | 1943 | *Surveyor, E. Lester Jones* and *Hydrographer* | Unalaska |
| H06846 | 20,000 | 1943 | *Surveyor* and *E. Lester Jones* | Unalaska |
| H06847 | 20,000 | 1943 | *Surveyor* and *E. Lester Jones* | Unalaska |
| H06848 | 20,000 | 1943 | *Surveyor* and *E. Lester Jones* | Unalaska |
| H06849 | 20,000 | 1943 | *Surveyor* and *E. Lester Jones* | Unalaska |
| H06850 | 60,000 | 1943 | *Surveyor* | Unalaska |
| H06851 | 20,000 | 1943 | *E. Lester Jones* | Unalaska |
| H06852 | 10,000 | 1943 | *E. Lester Jones* | Unalaska |
| H06864 | 20,000 | 1945-46 | *Explorer* | US Navy *Gannet* 1934 |
| H06865 | 10,000 | 1945 | *Explorer* | US Navy *Gannet* 1934 |
| H06866 | 20,000 | 1945 | *Explorer* | US Navy *Gannet* 1934 |
| H06867 | 20,000 | 1945 | *Explorer* | US Navy *Gannet* 1934 |
| H06868 | 20,000 | 1945 | *Surveyor* | US Navy *Gannet* 1934 |
| H06869 | 40,000 | 1945 | *Explorer* | US Navy *Gannet* 1934 |
| H06870 | 10,000 | 1945 | *Explorer* | US Navy *Gannet* 1934 |
| H06871 | 40,000 | 1945 | *Explorer* | US Navy *Gannet* 1934 |
| H06872 | 10,000 | 1945 | *Explorer* | US Navy *Gannet* 1934 |
| H06874 | 40,000 | 1945 | *Derickson* | US Navy *Gannet* 1934 |
| H06875 | 10,000 | 1945 | *Derickson* | US Navy *Gannet* 1934 |
| H06879 | 5,000 | 1943 | *Explorer* | Unalaska |
| H06883 | 10,000 | 1933-35 | US Navy | US Navy 1933 |
| H06910 | 10,000 | 1944 | *Patton* and *Explorer* | Unalaska |
| H06914 | 720 | 1944 | *Patton* | Unalaska |

Table 1. – Continued.

| | | | | |
|---|---|---|---|---|
| H06915 | 5,000 | 1943 | *Explorer* | Unalaska |
| H06916 | 4,800 | 1943 | *Patton* | Unalaska |
| H06917 | 10,000 | 1945 | *Patton* | Unalaska |
| H06918 | 20,000 | 1943 | *Patton* and *Explorer* | Unalaska |
| H06918b | 20,000 | 1956 | *Explorer* | NAD 1927 |
| H06920 | 10,000 | 1943 | *Surveyor* | Unalaska |
| H06924 | 5,000 | 1945 | *Patton* | US Navy 1943 |
| H06931 | 20,000 | 1943 | *Explorer* | US Navy 1943 |
| H06933 | 10,000 | 1943 | *Hydrographer* and *Explorer* | Independent |
| H06937 | 20,000 | 1943-44 | *Surveyor* | US Navy *Gannet* 1934 |
| H06939 | 20,000 | 1943 | *Hydrographer* and *Explorer* | US Navy *Gannet* 1934 |
| H06940 | 10,000 | 1944 | *Explorer* | US Navy *Gannet* 1934 |
| H06987 | 10,000 | 1944 | *Explorer* | US Navy *Gannet* 1934 |
| H06988 | 5,000 | 1944 | *Surveyor* | US Navy *Gannet* 1934 |
| H06990 | 10,000 | 1944 | *Surveyor* | US Navy *Gannet* 1934 |
| H06991 | 20,000 | 1944 | *Derickson* | US Navy *Gannet* 1934 |
| H06999 | 10,000 | 1944 | *Surveyor* | US Navy *Gannet* 1934 |
| H07000 | 20,000 | 1944 | *Surveyor* | US Navy *Gannet* 1934 |
| H07004 | 5,000 | 1944 | *Derickson* and *Patton* | Unalaska |
| H07005 | 10,000 | 1944 | *Derickson* and *Patton* | Unalaska |
| H07006 | 10,000 | 1944-45 | *Surveyor* and *Derickson* | Unalaska |
| H07007 | 5,000 | 1944 | *Derickson, E. Lester Jones* and *Surveyor* | Astronomic Amchitka |
| H07013 | 10,000 | 1944 | *Explorer* | US Navy *Gannet* 1934 |
| H07014 | 10,000 | 1944 | *Explorer* | US Navy *Gannet* 1934 |
| H07015 | 20,000 | 1944-45 | *Explorer* | US Navy *Gannet* 1934 |
| H07016 | 20,000 | 1944 | *Explorer* | US Navy *Gannet* 1934 |
| H07017 | 20,000 | 1944 | *Explorer* | US Navy *Gannet* 1934 |
| H07018 | 40,000 | 1944-45 | *Explorer* | US Navy *Gannet* 1934 |
| H07019 | 40,000 | 1944-45 | *Explorer* | US Navy *Gannet* 1934 |
| H07023 | 40,000 | 1944 | *Patton* | Unalaska |
| H07026 | 20,000 | 1944 | *Patton* | Unalaska |
| H07033 | 5,000 | 1944 | *Derickson* | Unalaska |
| H07038 | 40,000 | 1945 | *Surveyor* and *Patton* | Unalaska |
| H07039 | 20,000 | 1944-45 | *Surveyor* and *Derickson* | Unalaska |
| H07040 | 10,000 | 1945 | *Surveyor* | Unalaska |
| H07042 | 10,000 | 1945 | *Surveyor* | Unalaska |
| H07050 | 40,000 | 1945 | *Surveyor* and *Patton* | Unalaska |
| H07051 | 40,000 | 1944-45 | *Surveyor* and *Derickson* | Unalaska |
| H07052 | 20,000 | 1945 | *Surveyor* | Unalaska |
| H07053 | 20,000 | 1945 | *Surveyor* | Unalaska |
| H07067 | 2,500 | 1945 | *Derickson* | US Navy *Gannet* 1934 |
| H07068 | 5,000 | 1945 | *Derickson* | US Navy *Gannet* 1934 |

Table 1. – Continued.

| | | | | |
|---|---|---|---|---|
| H07078 | 10,000 | 1945 | *Patton* | Unalaska |
| H07079 | 10,000 | 1945 | *Patton* | Unalaska |
| H07081 | 20,000 | 1945 | *Surveyor* | Unalaska |
| H07084 | 5,000 | 1945 | *Patton* | Unalaska |
| H07088 | 20,000 | 1945 | *Derickson* | US Navy *Gannet* 1934 |
| H07134 | 100,000 | 1946 | *Surveyor* and *Explorer* | US Navy *Gannet* 1934 |
| H07135 | 80,000 | 1946 | *Explorer* | US Navy *Gannet* 1934 |
| H07136 | 60,000 | 1946 | *Surveyor* | US Navy *Gannet* 1934 |
| H07137 | 160,000 | 1946 | *Explorer* | US Navy *Gannet* 1934 |
| H07138 | 10,000 | 1946 | *Explorer* | US Navy *Gannet* 1934 |
| H07139 | 2,000 | 1946 | *Explorer* | US Navy *Gannet* 1934 |
| H07141 | 80,000 | 1946 | *Explorer* | US Navy *Gannet* 1934 |
| H07142 | 10,000 | 1946 | *Surveyor* | US Navy *Gannet* 1934 |
| H07143 | 120,000 | 1946 | *Surveyor* | US Navy *Gannet* 1934 |
| H07144 | 20,000 | 1946 | *Surveyor* | US Navy *Gannet* 1934 |
| H07145 | 20,000 | 1946 | *Surveyor* | US Navy *Gannet* 1934 |
| H07146 | 40,000 | 1946 | *Surveyor* and *Explorer* | US Navy *Gannet* 1934 |
| H07182 | 20,000 | 1946 | *Derickson* | Unalaska |
| H07183 | 5,000 | 1946 | *Derickson* | Unalaska |
| H07595 | 20,000 | 1947 | *Pioneer* | NAD 1927 |
| H07596 | 40,000 | 1947 | *Pioneer* | NAD 1927 |
| H07597 | 120,000 | 1947 | *Pioneer* | NAD 1927 |
| H07598 | 120,000 | 1947 | *Pioneer* | NAD 1927 |
| H07605 | 30,000 | 1946 | *Derickson* | Unalaska |
| H07624 | 40,000 | 1947 | *Explorer* | NAD 1927 |
| H07625 | 40,000 | 1947-48 | *Explorer* | NAD 1927 |
| H07626 | 100,000 | 1947 | *Explorer* | NAD 1927 |
| H07627 | 100,000 | 1947 | *Explorer* | NAD 1927 |
| H07634 | 5,000 | 1947 | *Explorer* | US Navy *Gannet* 1934 |
| H07644 | 20,000 | 1948-49 | *Pioneer* | NAD 1927 |
| H07645 | 20,000 | 1948 | *Pioneer* | NAD 1927 |
| H07646 | 20,000 | 1948-49 | *Pioneer* and *Explorer* | NAD 1927 |
| H07647 | 20,000 | 1948 | *Pioneer* | NAD 1927 |
| H07648 | 20,000 | 1948-49 | *Pioneer* | NAD 1927 |
| H07649 | 40,000 | 1948 | *Pioneer* | NAD 1927 |
| H07650 | 80,000 | 1948-49 | *Pioneer* | NAD 1927 |
| H07651 | 160,000 | 1948 | *Pioneer* | NAD 1927 |
| H07652 | 200,000 | 1948 | *Pioneer* | NAD 1927 |
| H07707 | 20,000 | 1947-49 | *Explorer* | NAD 1927 |
| H07708 | 20,000 | 1948 | *Explorer* | NAD 1927 |
| H07710 | 40,000 | 1948 | *Explorer* | NAD 1927 |
| H07711 | 100,000 | 1948 | *Explorer* | NAD 1927 |
| H07712 | 10,000 | 1948 | *Explorer* | NAD 1927 |

Table 1. – Continued.

| | | | | |
|---|---|---|---|---|
| H07713 | 10,000 | 1948 | *Explorer* | NAD 1927 |
| H07726 | 20,000 | 1949 | *Pioneer* | NAD 1927 |
| H07727 | 20,000 | 1949 | *Pioneer* | NAD 1927 |
| H07728 | 20,000 | 1949 | *Pioneer* | NAD 1927 |
| H07729 | 40,000 | 1949 | *Pioneer* | NAD 1927 |
| H07730 | 40,000 | 1949 | *Pioneer* | NAD 1927 |
| H07731 | 10,000 | 1949 | *Explorer* | NAD 1927 |
| H07733 | 20,000 | 1949 | *Explorer* | NAD 1927 |
| H07734 | 20,000 | 1949 | *Explorer* | NAD 1927 |
| H07735 | 20,000 | 1949 | *Explorer* | NAD 1927 |
| H07736 | 20,000 | 1949 | *Explorer* | NAD 1927 |
| H07737 | 20,000 | 1949-50 | *Explorer* | NAD 1927 |
| H07738 | 40,000 | 1949 | *Explorer* | NAD 1927 |
| H07739 | 40,000 | 1949 | *Explorer* | NAD 1927 |
| H07740 | 40,000 | 1949 | *Explorer* | NAD 1927 |
| H07741 | 100,000 | 1949 | *Explorer* | NAD 1927 |
| H07775 | 160,000 | 1948-49 | *Pioneer* | NAD 1927 |
| H07803 | 40,000 | 1950 | *Pioneer* | NAD 1927 |
| H07804 | 80,000 | 1950 | *Pioneer* | NAD 1927 |
| H07805 | 80,000 | 1950 | *Pioneer* | NAD 1927 |
| H07806 | 160,000 | 1950 | *Pioneer* | NAD 1927 |
| H07825 | 2,500 | 1951 | *Surveyor* | NAD 1927 |
| H07888 | 20,000 | 1950 | *Explorer* | NAD 1927 |
| H07889 | 20,000 | 1950 | *Explorer* | NAD 1927 |
| H07890 | 40,000 | 1950 | *Explorer* | NAD 1927 |
| H07891 | 100,000 | 1950 | *Explorer* | NAD 1927 |
| H07972 | 200,000 | 1952 | *Pathfinder* | NAD 1927 |
| H07973 | 500,000 | 1952 | *Pioneer* and *Pathfinder* | NAD 1927 |
| H07974 | 20,000 | 1952 | *Explorer* | NAD 1927 |
| H07975 | 20,000 | 1952 | *Explorer* | NAD 1927 |
| H07976 | 20,000 | 1952 | *Explorer* | NAD 1927 |
| H07977 | 100,000 | 1952 | *Explorer* | NAD 1927 |
| H07978 | 400,000 | 1952 | *Explorer* | NAD 1927 |
| H07992 | 200,000 | 1952 | *Pioneer* | NAD 1927 |
| H07993 | 500,000 | 1952 | *Pioneer* | NAD 1927 |
| H07995 | 100,000 | 1952 | *Explorer* | NAD 1927 |
| H08051 | 20,000 | 1953 | *Explorer* | NAD 1927 |
| H08052 | 20,000 | 1953 | *Explorer* | NAD 1927 |
| H08053 | 20,000 | 1953 | *Explorer* | NAD 1927 |
| H08054 | 20,000 | 1953 | *Explorer* | NAD 1927 |
| H08055 | 20,000 | 1953 | *Explorer* | NAD 1927 |
| H08056 | 60,000 | 1953 | *Explorer* | NAD 1927 |
| H08057 | 60,000 | 1953-54 | *Explorer* | NAD 1927 |

Table 1. – Continued.

| | | | | |
|---|---|---|---|---|
| H08070 | 10,000 | 1953 | *Pathfinder* | NAD 1927 |
| H08071 | 10,000 | 1956 | *Pathfinder* | NAD 1927 |
| H08139 | 40,000 | 1954 | *Explorer* | NAD 1927 |
| H08140 | 40,000 | 1954 | *Explorer* | NAD 1927 |
| H08141 | 20,000 | 1954 | *Explorer* | NAD 1927 |
| H08142 | 20,000 | 1954 | *Explorer* | NAD 1927 |
| H08143 | 20,000 | 1954 | *Explorer* | NAD 1927 |
| H08144 | 20,000 | 1954-55 | *Explorer* | NAD 1927 |
| H08145 | 20,000 | 1954 | *Explorer* | NAD 1927 |
| H08146 | 20,000 | 1954 | *Explorer* | NAD 1927 |
| H08147 | 10,000 | 1954 | *Explorer* | NAD 1927 |
| H08233 | 40,000 | 1955 | *Explorer* | NAD 1927 |
| H08234 | 40,000 | 1955 | *Explorer* | NAD 1927 |
| H08235 | 40,000 | 1955 | *Explorer* | NAD 1927 |
| H08236 | 20,000 | 1955 | *Explorer* | NAD 1927 |
| H08237 | 20,000 | 1955 | *Explorer* | NAD 1927 |
| H08238 | 20,000 | 1955 | *Explorer* | NAD 1927 |
| H08239 | 20,000 | 1955 | *Explorer* | NAD 1927 |
| H08240 | 25,000 | 1955 | *Explorer* | NAD 1927 |
| H08306 | 20,000 | 1956 | *Explorer* | NAD 1927 |
| H08307 | 20,000 | 1956 | *Explorer* | NAD 1927 |
| H08308 | 20,000 | 1956 | *Explorer* | NAD 1927 |
| H08309 | 60,000 | 1956 | *Explorer* | NAD 1927 |
| H08386 | 20,000 | 1957 | *Explorer* | NAD 1927 |
| H08387 | 40,000 | 1957 | *Explorer* | NAD 1927 |
| H08437 | 20,000 | 1957-58 | *Explorer* | NAD 1927 |
| H08438 | 20,000 | 1957-58 | *Explorer* | NAD 1927 |
| H08439 | 20,000 | 1958 | *Explorer* | NAD 1927 |
| H08454 | 480 | 1958 | *Explorer* | NAD 1927 |
| H08473 | 60,000 | 1958-59 | *Explorer* | NAD 1927 |
| H08474 | 20,000 | 1958-59 | *Explorer* | NAD 1927 |
| H08475 | 20,000 | 1958-59 | *Explorer* | NAD 1927 |
| H08476 | 10,000 | 1959 | *Explorer* | NAD 1927 |
| H08823 | 60,000 | 1959 | *Explorer* | NAD 1927 |
| H10282 | 5,000 | 1988 | *Davidson* | NAD 1927 |
| H10389 | 5,000 | 1991 | *Rainier* | NAD 1983 |
| H10391 | 5,000 | 1991 | *Rainier* | NAD 1983 |
| H10483 | 5,000 | 1993 | Launch *SeaArk* | NAD 1983 |

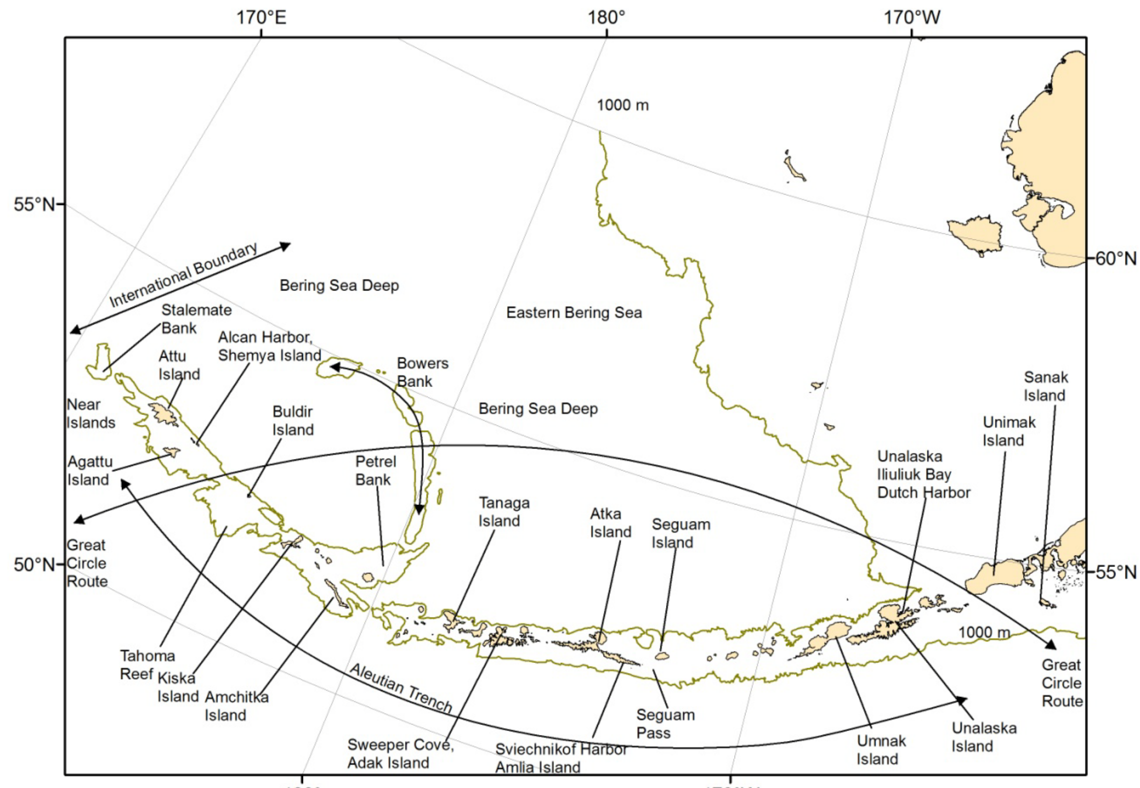


Figure 1. -- Place names in the Aleutian Islands.

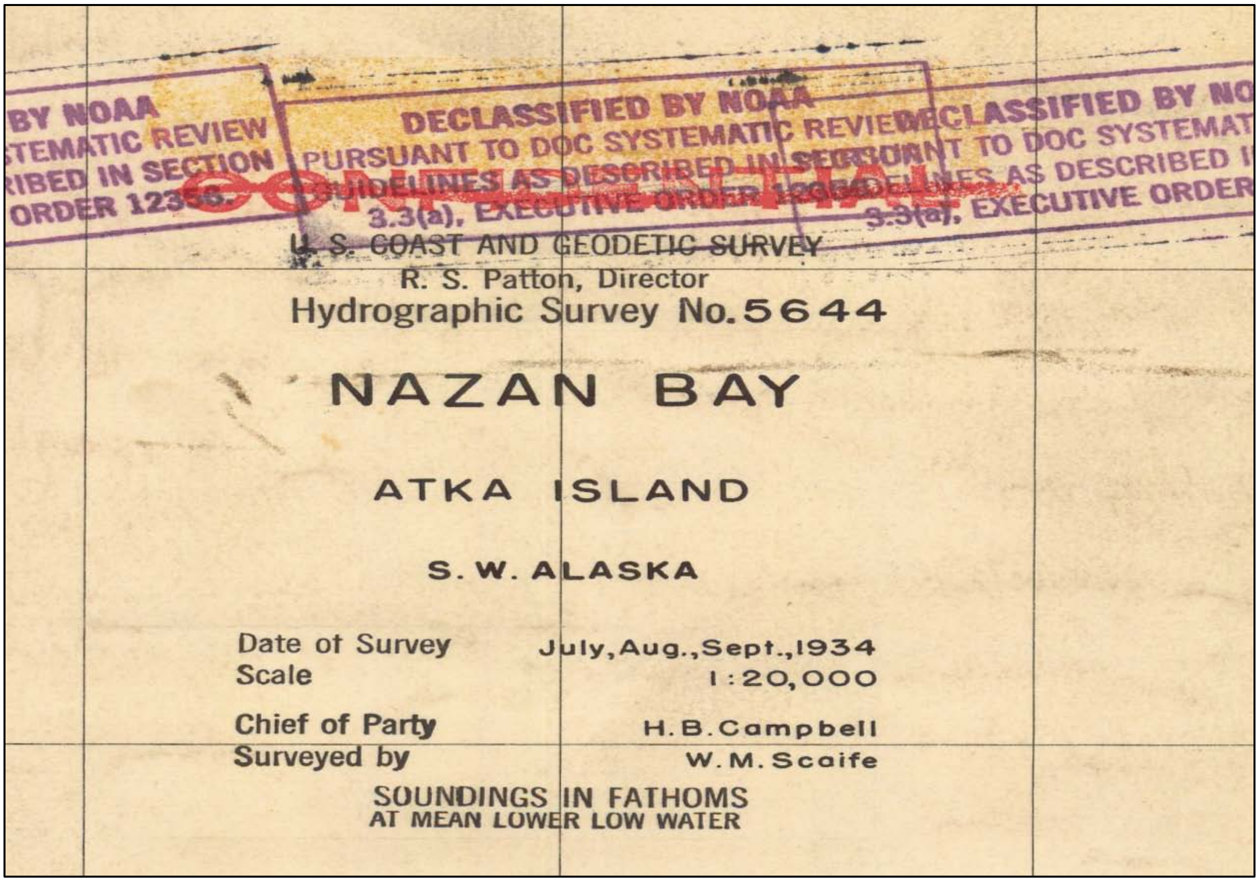


Figure 2. -- Confidential notation and declassification stamp on smooth sheet H05644.

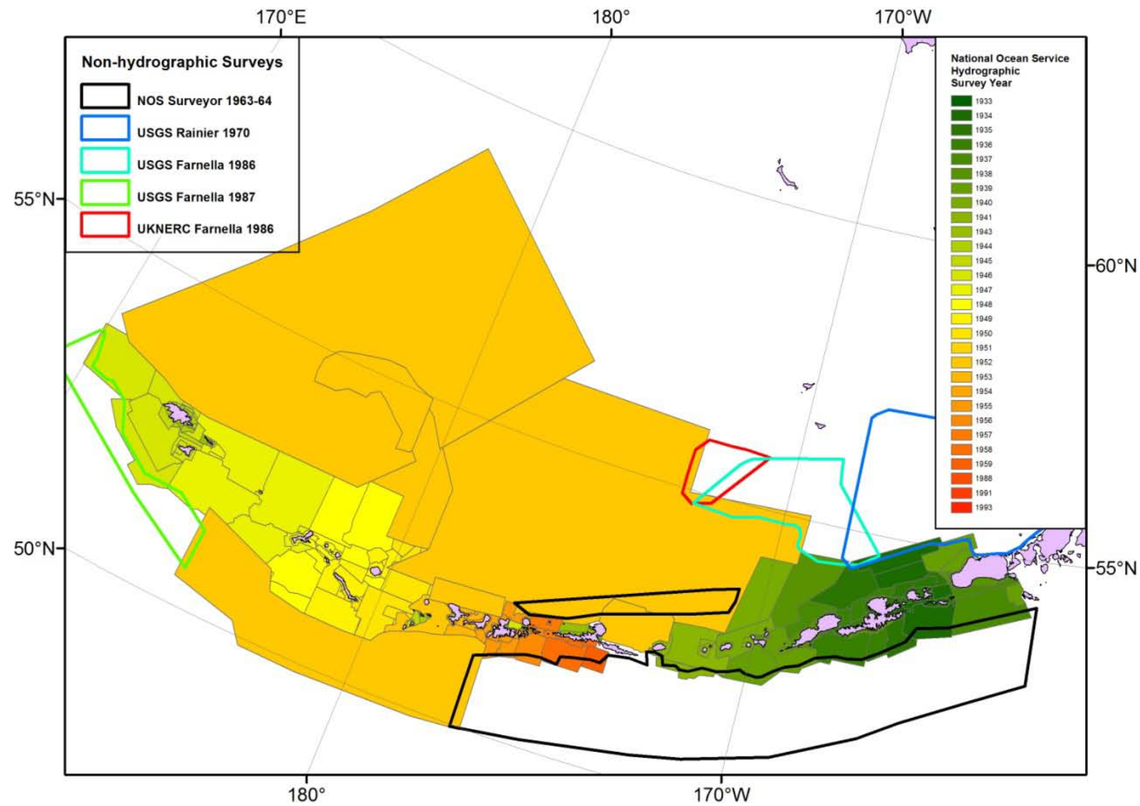


Figure 3. -- Age of Aleutian Island hydrographic surveys analyzed for this project and outlines of five supplemental surveys used for completing a bathymetric surface.

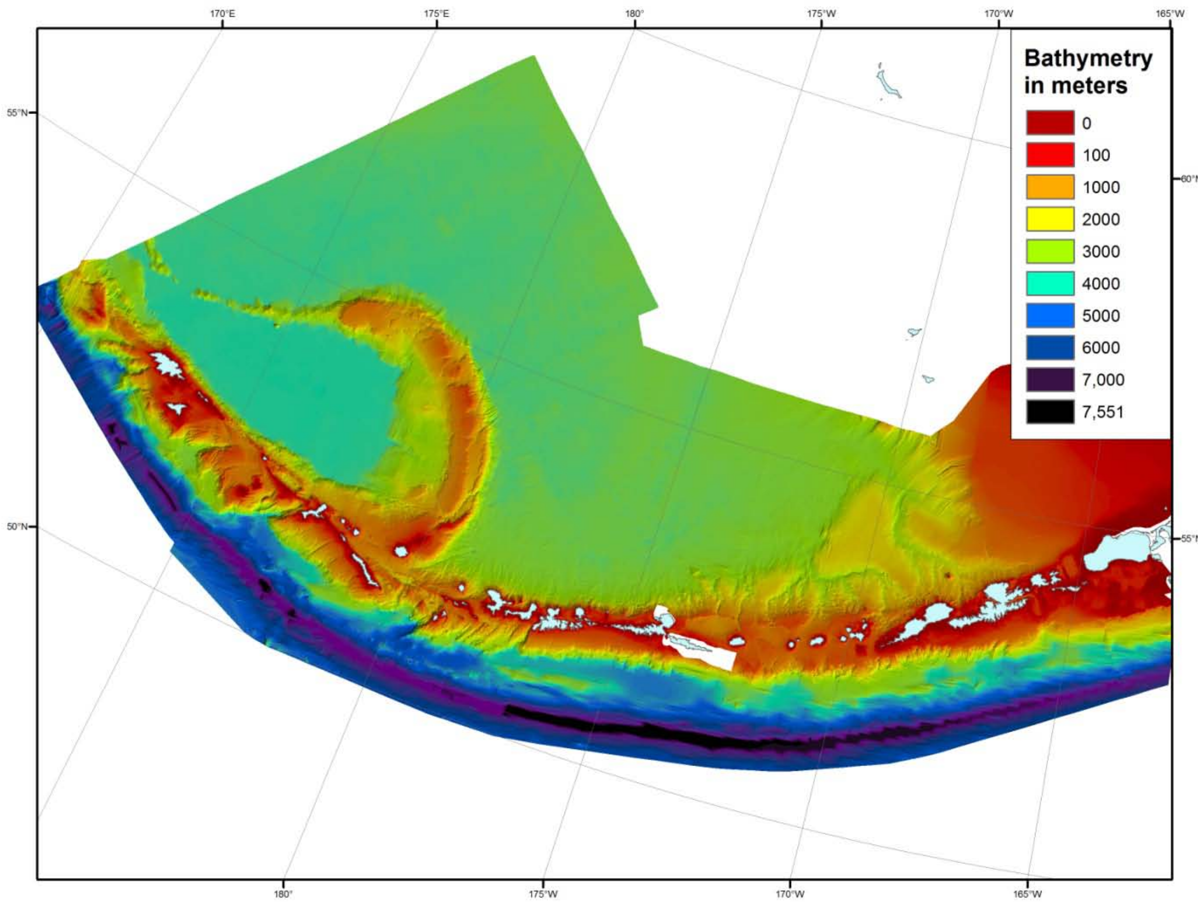


Figure 4. -- Bathymetric surface (TIN: Triangulated Irregular Network) of Aleutians compiled from National Ocean Service hydrographic surveys and supplemented with some non-hydrographic surveys.

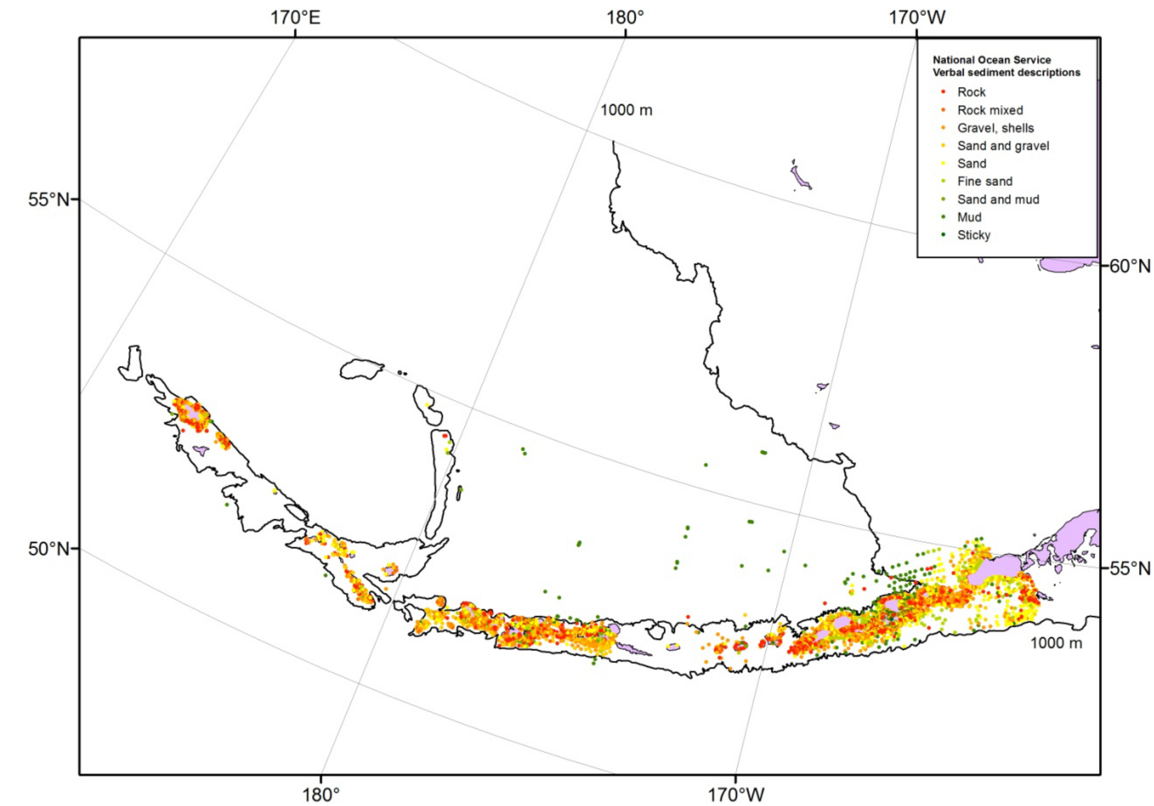


Figure 5. -- Distribution of sediment observations from National Ocean Service smooth sheets.

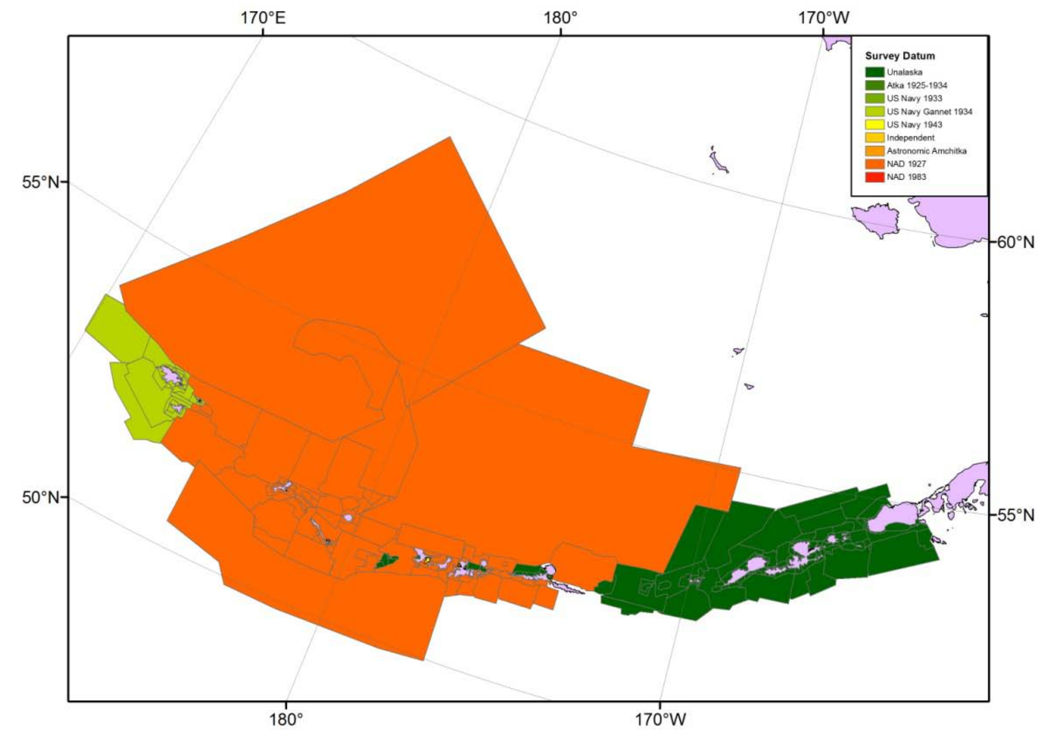


Figure 6. -- Horizontal datum of Aleutian Island hydrographic surveys.

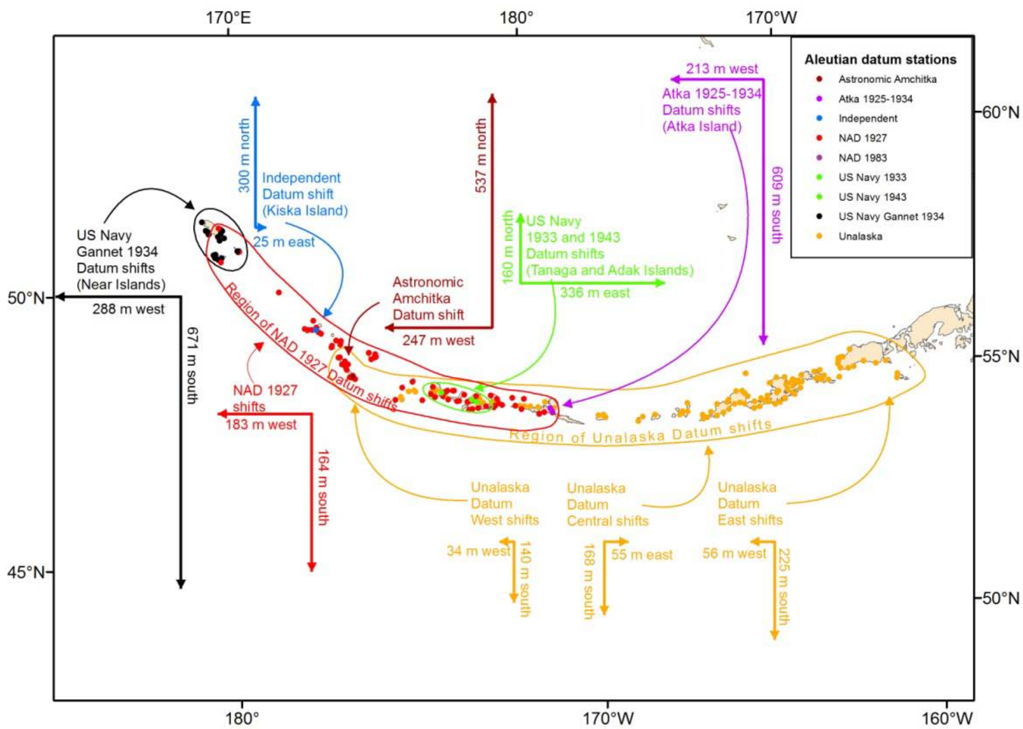


Figure 7. -- Triangulation stations and approximate latitudinal and longitudinal shift of each Aleutian Island datum in order convert it into North American Datum of 1983 High Accuracy Resolution Network (NAD 1983 HARN). Datum shifts in meters are exaggerated 1000× for illustration purposes.

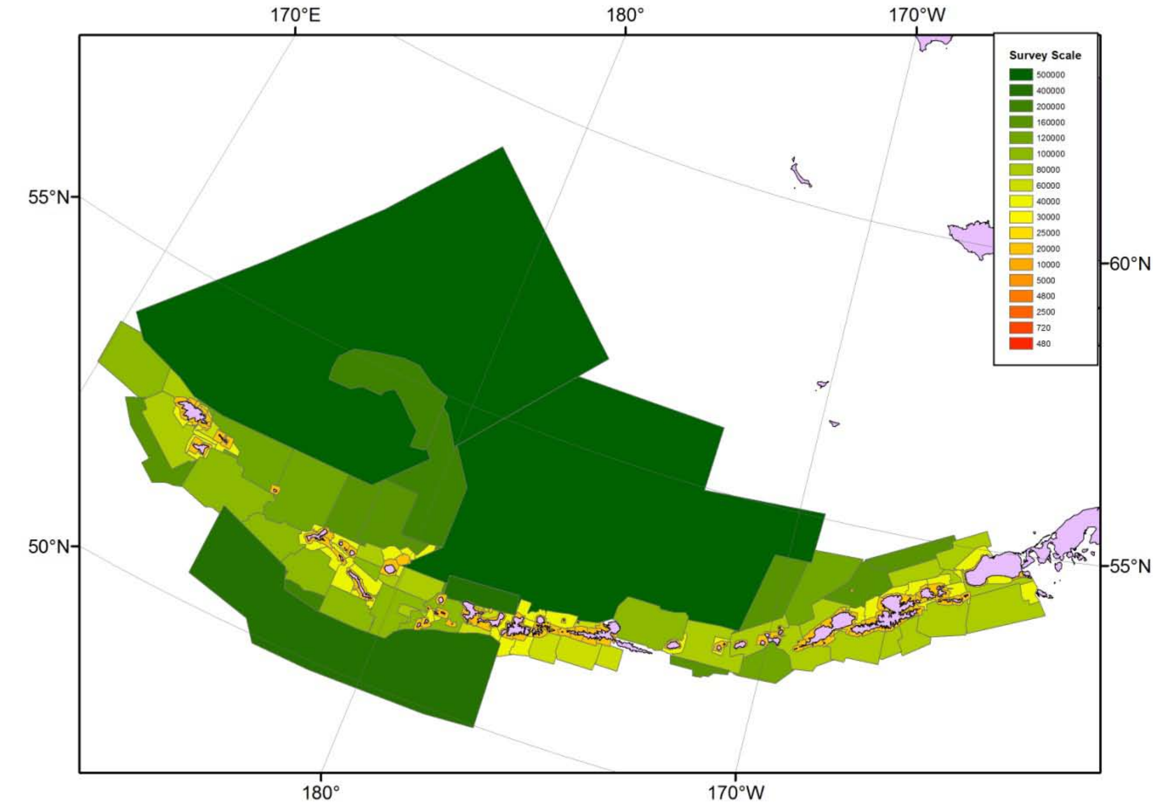


Figure 8. -- Scale of Aleutian Island hydrographic surveys.

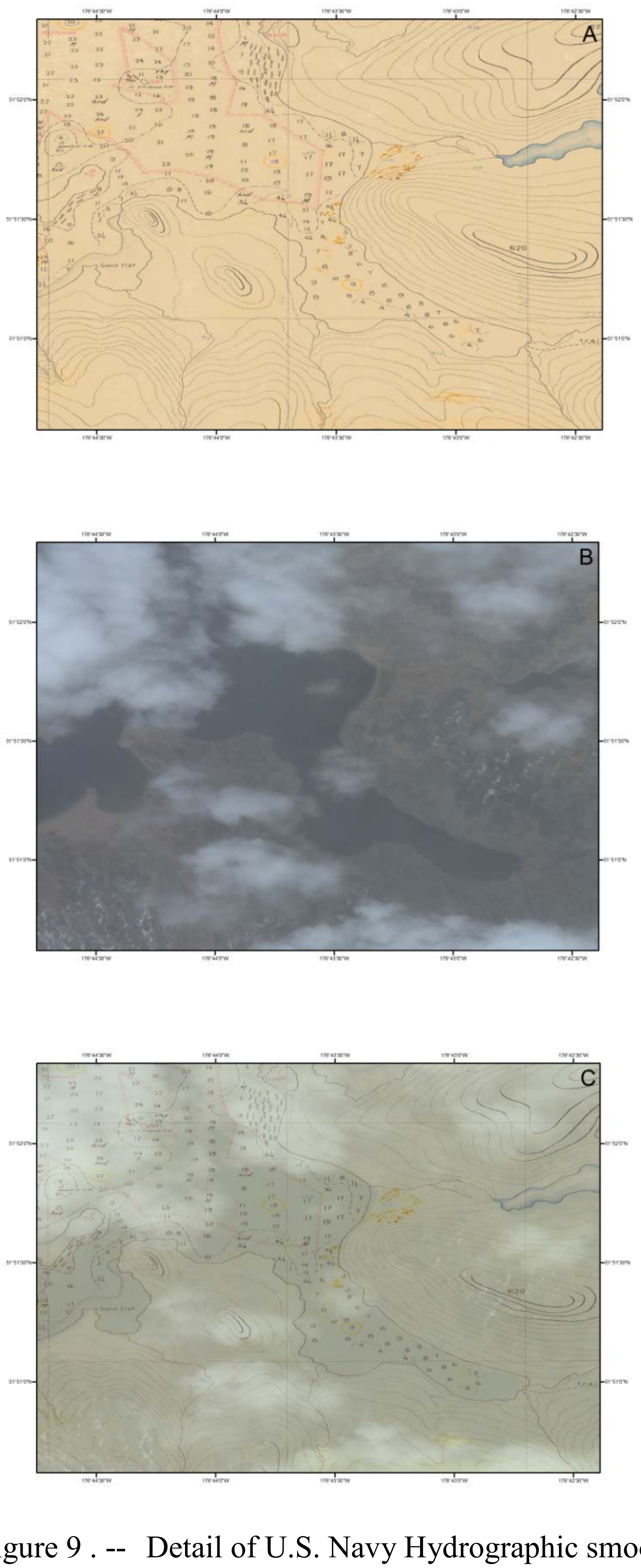


Figure 9 . -- Detail of U.S. Navy Hydrographic smooth sheet H06883 (1933-35) at (A) Shagak Bay, Adak Island; (B) corresponding aerial imagery; and (C) alignment between the two images.

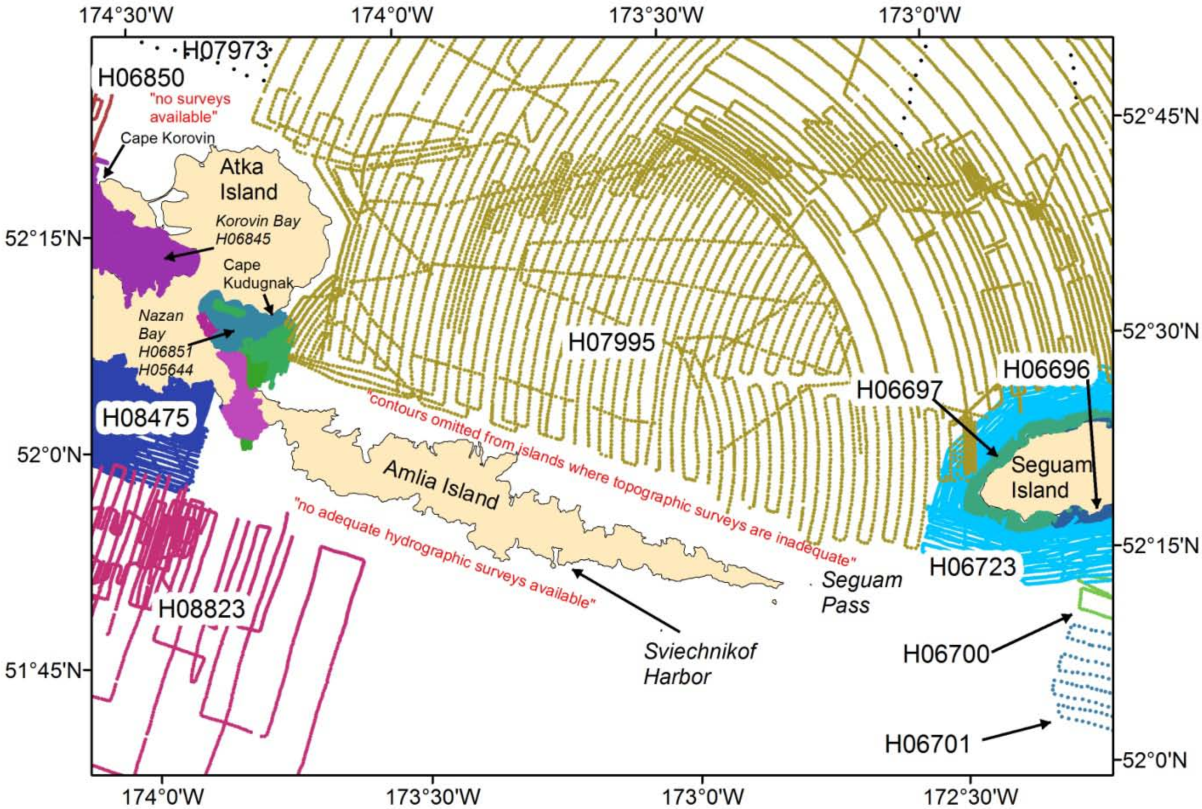


Figure 10. -- Bathymetry gap in the central Aleutians, with individual soundings shown as colored dots for available surveys. Solid-colored areas indicate crowded soundings.

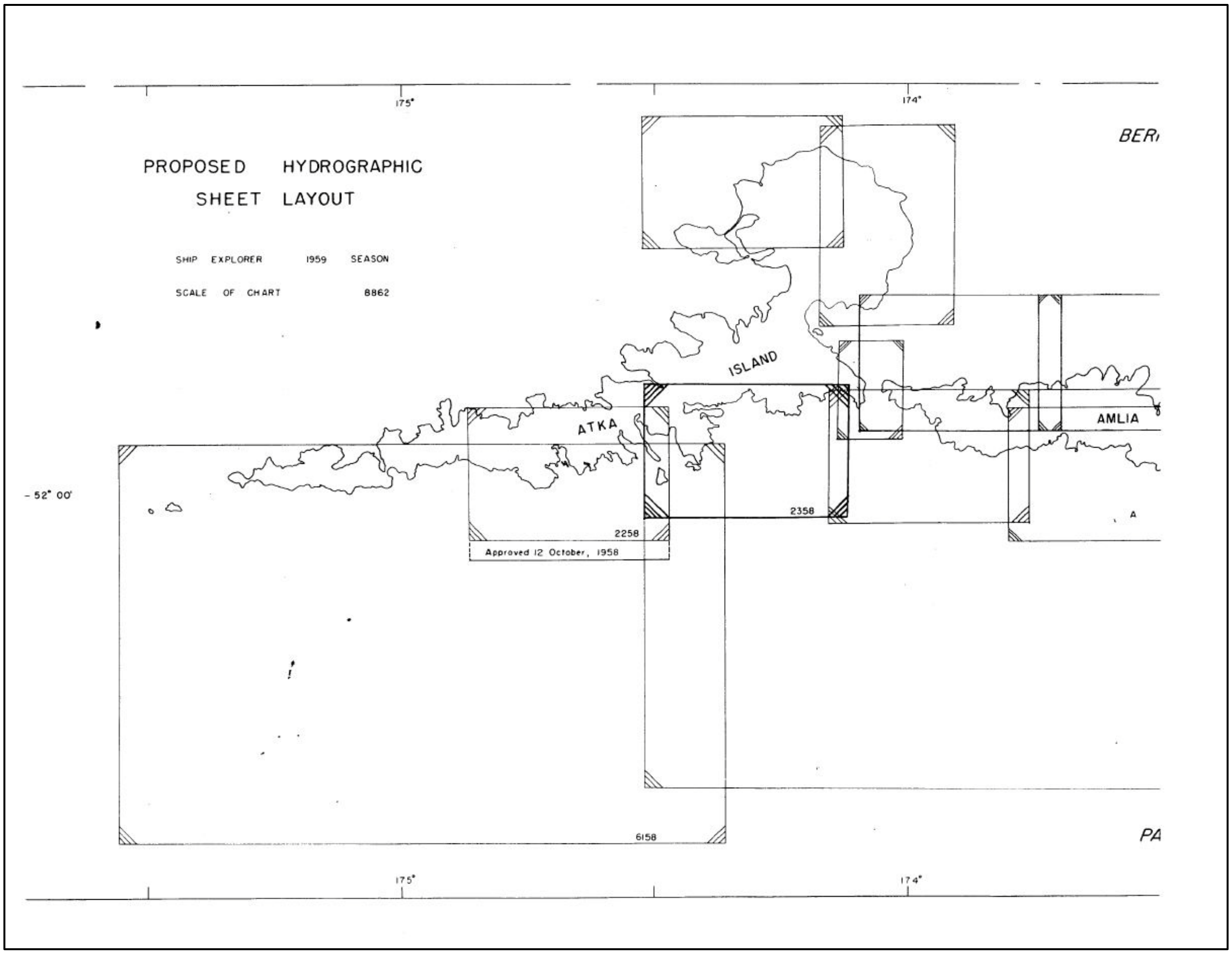


Figure 11. -- Page from H08475 descriptive report showing proposed hydrographic surveys at Atka and Amlia Islands by the *Explorer* during 1959.

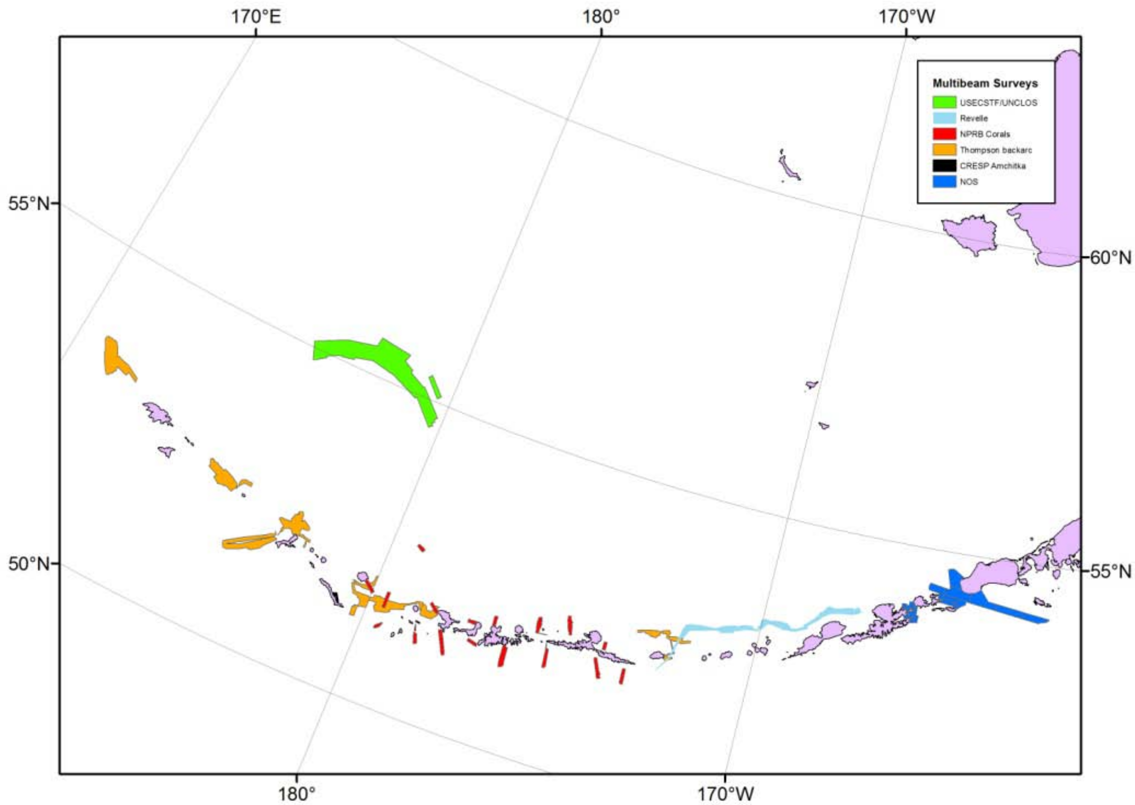


Figure 12. -- Regions of the Aleutian Islands surveyed by multibeam.

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