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Calculation of the Geographic Area Sizes Used to Create Population Indices for the Alaska Fisheries Science Center Longline Survey

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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

Geographic area sizes (km^2) are used for computing abundance indices for sablefish and other groundfish species caught in the Alaska Fisheries Science Center's annual longline survey. These areas were devised before geographic information systems (GIS) and accurate bathymetric maps were available. In addition, there was poor documentation for how the currently used area measurements were determined. With new technology, area sizes can be defined using GIS to ground truth the area sizes currently being used for computing abundance indices. Additionally, because the survey was originally intended for sablefish, and their habitat is primarily in depths from 200 to1,000 m, area sizes were not determined for areas shallower than 200 m. A substantial amount of survey effort is placed in the 151-200 m depth range and several species of interest are commonly caught in these depths. Using ArcView GIS 9.3 and GEBCO_08 bathymetry source, geographic area sizes were recalculated and compared with existing values. In addition, area sizes for shallow stratum, consisting of depths between 151 and 200 m, were created, and documentation is provided for how the currently used area measurements were determined. Recalculated area sizes and geographic area sizes utilized in the AFSC longline and RACE trawl surveys were generally similar across the WGOA and CGOA, with larger differences occurring in the EGOA and in the gullies where boundary lines were hard to decipher. Where differences occurred, recalculated values were generally smaller.

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Alaska Fisheries Science Center	AFSC
Auke Bay Laboratories	ABL
Central Gulf of Alaska	CGOA
Eastern Bering Sea	EBS
Eastern Gulf of Alaska	EGOA
Geographic Information System	GIS
Gulf of Alaska	GOA
International North Pacific Fisheries Commission	INPFC
National Marine Fisheries Service	NMFS
National Ocean Service	NOS
North Pacific Fishery Management Council	NPFMC
Relative Population Numbers	RPN
Relative Population Weights	RPW
Resource Assessment and Conservation Engineering	RACE
Western Gulf of Alaska	WGOA

INTRODUCTION

The Alaska Fisheries Science Center's (AFSC) annual longline survey has sampled 80 fixed stations along the continental slope and select gullies in the Gulf of Alaska (GOA), the Aleutian Islands (AI), and the eastern Bering Sea (EBS; Fig. 1) since 1996. This survey is primarily directed at sablefish, *Anoplopoma fimbria*, but many other groundfish species are also sampled. Stations are placed throughout the survey area using a systematic sampling design of approximately 30-miles between stations (Sasaki 1983). The longline at each station is set perpendicular to the depth contours; however, gear is not commonly set in a straight line and is often zigzagged to ensure adequate effort is allocated in all depth strata. Depths usually range from ~100 to 1,000 m and are broken down by predetermined depth stratum into 100 m increments at depths < 400 m and 200 m increments in deeper depths (Table 1). Data are recorded for each depth stratum (e.g., catch, fish lengths, and tagged fish) within each area. Geographic areas are defined by the depth stratum and longitude and latitude boundaries defined by the North Pacific Fishery Management Council (NPFMC), which are based on the original International North Pacific Fisheries Commission (INPFC) areas. Relative population numbers (RPN) and weights (RPW) are relative indices of abundance that are calculated for all species within each depth stratum and geographic area. RPNs are calculated by multiplying the catch rate (CPUE equals the number of fish per skate) by the area size. RPWs are calculated by multiplying the RPN by the average weight of the species. These depth-stratified indices can be added together to provide RPNs and RPWs for all stratum within the geographic areas or summed for larger management areas (e.g., GOA, AI, or EBS; Sasaki 1981, 1983).

The current geographic area measurements were devised in the 1980s before digitized versions of bathymetric maps and geographic information system (GIS) technology were readily available. With the advent of this new technology it is possible to re-evaluate the geographic area sizes used in computing abundance indices in order to ground truth and ensure accuracy. Additionally, because the longline survey was originally intended to sample adult sablefish habitat, area sizes of depths < 200 m and gullies outside of typical adult sablefish habitat were previously not calculated. Therefore, no RPNs and RPWs are available for these areas. A substantial amount of survey effort has occurred in the 100-200 m range at many survey stations in gullies and on the slope (Table 2), and several species of interest are commonly caught in these depths (e.g., arrowtooth flounder, *Atheresthes stomias*; Pacific cod, *Gadus macrocephalus*; Pacific halibut, *Hippoglossus stenolepsis*; spiny dogfish, *Squalus suckleyi*; sablefish; and walleye pollock, *Theragra chalcogramma*). RPNs and RPWs could be calculated for the 100-200 m stratum if area sizes for this shallow stratum are available.

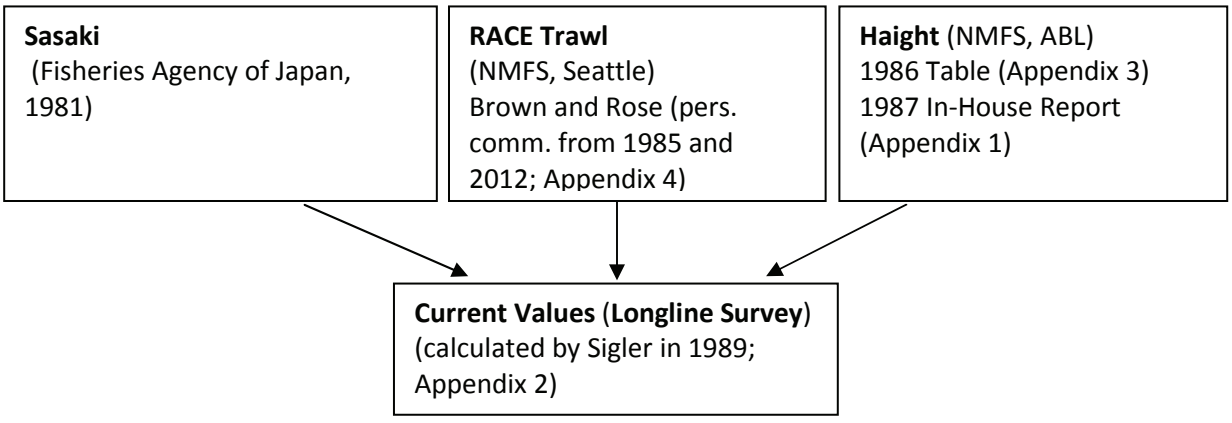
The purpose of this document is to 1) provide a historical accounting of previous methods used to generate the current geographic area measurements, 2) provide comparable geographic area measurements for the full extent of the AFSC longline survey using modern GIS technology and more recent bathymetric data and 3) calculate area sizes for the shallow stratum 151-200 m, where sizes are not currently available. We present methodology used to create new area

measurements using a single source of bathymetric data and ArcGIS® software. Results from these calculations are presented with the historical estimates for comparison. Finally, we include a series of maps for each of the management areas highlighting areas where definitions of area boundaries were difficult to interpret and redefine, such as gullies and passes.

HISTORICAL ACCOUNTING OF THE CURRENT GEOGRAPHIC AREA SIZES

The geographic area sizes used to calculate RPNs and RPWs for the AFSC longline survey have varied over time and have been poorly documented. Thus, a history of the evolution of the currently used area sizes within each geographic area and stratum is warranted. This accounting also helps to identify geographic areas where decisions on stratum boundaries were not based on bathymetry or gully habitat alone (e.g., entrances or passes). This information is important for stratum boundary re-evaluation and developing new boundaries for shallow stratum.

Initial strata area sizes were calculated by Sasaki (1981) for the Japan-U.S. Cooperative Longline Survey, the predecessor to the AFSC longline survey, and were recalculated by Mike Sigler in 1989 (Auke Bay Laboratories, ABL, pers. comm.; Appendix 2) using a combination of Sasaki's (1981) work, unpublished RACE trawl survey estimates calculated by Brown and Rose in 1985 (C. Rose, AFSC, pers. comm. from 1984 and 2012; Appendix 4), Richard Haight's unpublished planimeter work in 1986 (NMFS, ABL; Appendix 3), and Haight's unpublished 1987 in-house technical report (Appendix 1). The purpose of this section is to briefly summarize the methods that were used for calculating stratum area sizes, in chronological order, from each of these sources. Further details of Haight's unpublished 1987 in-house technical report, Sigler's 1989 calculations, Haight's 1986 unpublished table, and Brown and Rose's 1985 unpublished table are in Appendices 1, 2, 3, and 4, respectively. The simplified schematic below illustrates the flow of information between the four sources.



Sasaki's Methods

Sasaki (1981) calculated the area of survey grounds with a planimeter, a measuring instrument designed to determine the area of a two-dimensional shape using the Bathymetric Atlas of the

northeastern Pacific Ocean (U.S. Naval Oceanographic Office 1971) for depth zones deeper than 100 fathoms (fm) and U.S. charts for the zone from 50 to 100 fathoms. The area of the depth zones from 100 to 600 fathoms was calculated in units of 100 fathoms. The area sizes in fathoms^2 were converted into nine, 100 m increment stratum from 100 to 1,000 m. The Aleutian Region was subdivided into an eastern and western area with a border at 180° longitude (Amchitka Pass), designated as West and East Aleutians (Table 1b). The Eastern Bering Sea Area was divided into the Bering Region I, II, III, and IV (Table 1c), and the GOA was divided into the five INPFC geographic areas which match the NPFMC areas currently used, including: Shumagin, Chirikof, Kodiak, West Yakutat, and Southeast Outside (Table 1a). The area with a 101-145 m depth range situated in the EBS, except in Region I, was excluded by Sasaki because of inadequate survey efforts in the area as well as an extremely low density of sablefish. The area north of 59°N in the EBS, Bowers Bank in the AI, Shelikof Strait, Cook Inlet, Prince William Sound, and the inside waters of the Southeast part of the GOA were also not included in the calculation of the surveyed area because surveys were not conducted in those areas.

Unfortunately, Sasaki (1981) did not define any gully areas; that is, Sasaki did not indicate any separation between gullies and slope habitat. In addition, large areas that were not well surveyed by the Japan-U.S. Cooperative Longline Survey and extended far onto the shelf were included in the size calculations.

Brown and Rose, GOA RACE Trawl Survey Methods

All documentation and references of the work of Brown and Rose are "personal communications" from 1985 and 2012, and the only documents available include an unpublished table (Appendix 4). Since 1989, when Sigler used this source to help calculate stratum area sizes for the AFSC longline survey, Martin and Clausen (1995), among others, have published data reports documenting the RACE trawl survey methodology more thoroughly. For these reasons, we will refer to the Brown and Rose source as "RACE trawl survey" from here on.

The main requirements motivating the efforts by RACE for creating GOA depth boundaries and strata were as follows: 1) dividing the area into strata that could be expected to contain more similar fish densities within them than between them (therefore allowing more efficient allocation of survey stations than an unstratified survey and 2) to estimate total areas of these strata to allow extrapolation of survey results. In summary, the RACE stratum lines were delineated based on geographic area, habitat, and depth, and then by hand digitizing paper National Ocean Services (NOS) charts for the Western GOA (WGOA) and Central GOA (CGOA) and between 147°00'W and 144°00'W in the Eastern GOA (EGOA). This process involved taping down the paper map, georegistering several corners, and then click-dragging the mouse along contour lines. The charts originally had 50 fm (91 m), 100 fm (183 m), and 1,000 fm (1,829 m) contours which were colored to aid with tracing. No 10 fm (18 m) and 300 fm (549 m) lines existed; therefore, these lines were estimated and drawn in by hand based on the available soundings. Exact line location was necessarily subjective. Goals were to place

the lines between soundings that were above and below the target depths of 55, 109, 164, 273, 383, 547 fathoms and proportionately nearer to soundings nearer to the target depths. Broad decisions were pretty straightforward, while exact line placement was subjective. The specific technology for that step was colored pencils on broad-scale charts. While smaller-scale charts were available for smaller areas, the wide-scale charts (1:300,000) had to be used to achieve a comprehensive set of lines. There was no good way to accurately and precisely register between charts, therefore some finer details were lost. The finer-scale charts were referred to in making line placement choices on the larger-scale charts.

Once a set of depth contours had been established, the strata were delineated. The outer depth ranges (301-500 m, 501-700 m and 701-1,000 m) were straightforward to delineate because they are very narrow strips along the continental slope. Divisions were made by what were the major INPFC regions (Southeast Outside, West Yakutat, Kodiak, Chirikof, and Shumagin), and are now the NPFMC regions. Large flat areas on the continental shelf were separated from the steep areas of similar depths along the continental slope. The 101-200 m depth range had many more shelf areas. Each of those (Brown and Rose termed them gullies) that were contiguous with the slope required a subjective division between it and the adjacent slope stratum. With the basic goal of separating steep, slope areas from flatter shelf areas, a straight line was established across the mouth of each gully (as well as the deeper flats, like Shelikof Trough west of Kodiak Island). These were necessarily subjective, so they were kept simple. The 1-100 m depth zone was broadly separated into areas directly adjacent to the coastline and offshore banks (e.g., Albatross Banks south and east of Kodiak). Some similar arbitrary division lines had to be established to separate these strata. Other arbitrary choices included division lines for large areas of similar depths or joining similar smaller areas into a single stratum. All of these decisions were made with the overall goal of enclosing areas of similar expected fish catches (hence habitats), within the depth ranges (the best habitat indicator available on a wide scale). Regional boundaries were accommodated as well as possible.

Haight's Methods

Originally, Haight produced an unpublished in-house table in 1986 (Appendix 3) with calculated area sizes (km^2) for INPFC areas (now NPFMC areas) in the eastern Gulf of Alaska (EGOA) on the continental shelf, slope, and within gullies. These areas were computed for 200 m depth intervals from 200 to 1,000 m, in 30 minute increments for latitudes between 54° 00'N and 58° 30'N and for longitudes between 137° 00'W and 144° 30'W. These locations correspond to part of the areas within Southeast Outside and West Yakutat. The following year in 1987, Haight produced an in-house technical report (Appendix 1) documenting the calculation of the area for several distinct geographic sites in the EGOA, from the Canadian border at Dixon Entrance north and west to 144° 30'W at Cape St. Elias, based on depth zone and by 30 minute increments. This report was prepared for the 1987 triennial GOA trawl survey for assessing the abundance of groundfish in the EGOA. Geographic sites included within this area were Dixon Entrance, Christian Sound (or commonly referred to as Ommaney Trench), Cross Sound,

Fairweather Ground, Alsek Strath, Yakutat Valley, W-Grounds (area around Pamplona Spur and Bering Valley), the shelf between all of these sites, and the slope between and below all of these sites. The main difference from Haight's similar analysis in 1986 was that area data in 1987 were given for the following depth zones: 0-100 m, 101-200 m, 201-300 m, 301-500 m, 501-700 m, and 701-1,000 m, which correspond to the standard sampling strata for AFSC trawl surveys in the GOA.

Haight's 1987 in-house technical report is the only documentation giving a detailed description of where and why boundary lines were drawn between areas on the slope, shelf, and within gullies in the EGOA. We include the report in order to provide a more detailed description of these methods in Appendix 1 of this document. Generally, five NOAA, NOS charts were used, including four nautical charts (16016, 16760, 17320, and 17400) and one bathymetric chart (1513N-10). Contour lines were drawn on the nautical charts in intervals of 100 m, beginning with 100 m and ending with 1,000 m. At times, contours were drawn every 50 m to better depict the ocean floor. Even though areas were measured on this fine of a scale, the larger depth zones described above were used for groundfish assessment in the trawl surveys. A compensating polar planimeter was used to calculate area measurements in square nautical miles, which were then converted to square kilometers. Several boundaries, especially at the mouth of a gully, were determined by Haight and drawn as an arbitrary line. Please refer to Appendix 1 for more details.

Sigler's Methods for the AFSC Longline Survey

The present calculated area sizes used to estimate RPNs and RPWs for sablefish in the AFSC longline survey were done by Mike Sigler in 1989 (NMFS, ABL; Appendix 2). These calculations were based on the sources described above: Sasaki (1981), Haight (Appendices 1, 3), and RACE trawl survey area estimates (Appendix 4). EGOA area size estimates were a combination of Haight (Appendices 1, 3) and RACE trawl survey estimates (Appendix 4). Central Gulf of Alaska (CGOA) and western Gulf of Alaska (WGOA) were based on the RACE trawl survey estimates, while most of the AI and EBS were from Sasaki (1981). GOA gullies were based on a mixture of the Haight (Appendix 3) 1986 unpublished table and the Haight (Appendix 1) 1987 in-house technical report. A closer look at the development and origination of the current area sizes determined by Sigler in 1989 is attached (Appendix 2).

In a note in his files in 1987, Sigler defined the classification scheme of habitats in the GOA region for area size estimation of depths 101-1,000 m (Fig. 2). Areas between 101 and 200 m depth were classified as continental shelf. Bottom areas between 201 and 1,000 m were classified by topography into three types: continental slope, "deep" gullies, and "shallow" gullies. The continental slope is defined as the area between the continental shelf and the abyssal depths. Gully areas are defined as valleys within the shelf or slope areas. Gullies, which include depths greater than 400 m, were classified as "deep" gullies. If none of the gully bottom exceeded 400 m, then the gully was classified as a "shallow" gully. Areas of gullies which

extend into inside waters were not included in the area size estimation. “Inside waters” refer to waters within the Alexander Archipelago. Lines were drawn to define boundaries between inside and outside waters (Table 3). “Deep” gully areas are Spencer Gully, Ommaney Trench, and Dixon Entrance. “Shallow” gully areas are Shelikof Trough, Amatuli Trough and four smaller, nearby gullies, W-Grounds, Yakutat Valley, Alsek Valley, and Iphigenia Gully. No area sizes were calculated for gullies in the AI and EBS since no gullies are sampled by the longline survey in these areas.

METHODS FOR NEW GEOGRAPHIC AREA SIZE CALCULATIONS FOR THE LONGLINE SURVEY

In addition to inconsistent values among the historical sources used to calculate our current stratum area sizes (Table 1), no shallow stratum area sizes (i.e., < 200 m) had been calculated for the longline survey, although area sizes for < 200 m have been computed for the RACE trawl survey. We addressed three major issues before defining the extent of the shallow stratum. These were: 1) whether the shallow stratum should include the entire 101-200 m area or just 151-200 m area where most of the longline survey effort occurs; 2) alternatively, whether varying stratum widths, such as the average distance of set gear within 101-200 m in the geographic area, should be used; and 3) how to address areas with a wide shelf (101-200 m) but where sampling only occurs within a small portion, such as on the West Yakutat Shelf (Fig. 3, Table 5).

Within the sampled depth range of 101-200 m, the majority of the effort is from 151 to 200 m in most of the geographic areas (Table 2). We calculated the average distance sampled within the 151-200 m stratum by geographic area based on the average number of skates set in this stratum (a skate is a 100 m length of longline gear consisting of 45 hooks), and compared this to the widest shelf distance within the 151-200 m strata (Table 5). On average, this is the maximum distance that could be sampled if the gear was set perpendicular to the slope in a straight line. This is a conservative estimate of the proportion of the stratum that has been sampled on average. This exercise reiterated the fact that while the 151-200 m stratum in all geographic areas is not sampled in its entirety (conservatively estimated at the shelf’s widest distance; Table 5), we cannot justify the inclusion of the 101-150 m depths in the shallow stratum because the longline survey does not sample this depth stratum extensively. Because most of the effort within 100 to 200 m was only within the 151-200 m depth stratum and on average the survey sampled the 151-200 m stratum fairly well, we defined the shallow stratum as 151 to 200 m.

In addition to calculating the area of the shallow stratum, we defined boundaries and calculated area sizes for gullies within the GOA. Boundaries for gullies were created based on a combination of methods recorded by Haight (Appendix 1) and Sigler (Appendix 2), decisions based on the bathymetry and habitat data, and where longline survey sampling effort had occurred. Haight (Appendix 1) and Sigler (Appendix 2) delineated pre-defined gullies as areas

where depth contours turn in toward the shelf and away from slope, and arbitrary lines were drawn as boundaries inside some gullies to separate "inside" and "outside" waters (Table 3), as several gullies in the Southeast geographic area continue as straits within the Alexander Archipelago and "inside waters" were not sampled by the longline survey. "Inside waters" refer to waters within the Alexander Archipelago, and "outside waters" are not within the Alexander Archipelago. However, Haight and Sigler did not define boundaries within the gully itself where there were habitat differences or where areas within the gully were not sampled. Yakutat Valley is an example of this scenario. To help delineate areas within gullies in which there were habitat differences or where sampling on the longline survey doesn't take place, such as in the Yakutat Valley, we mapped NMFS RACE trawl survey catch data for species of interest to the longline survey. The RACE trawl survey has extensively sampled the GOA shelf (areas not sampled by the longline survey), providing a better idea of the distribution, abundance, and composition of various species, hence varying habitat types, to aid in this decision-making process. Areas showing substantial sampling effort but low CPUE (e.g., sablefish), as well as a change in species composition, were determined different habitat/stratification and were removed from the area calculation. In addition, we looked closely at maps with detailed bathymetry and oceanographic features in order to ascertain parts of Yakutat Valley containing habitat features dissimilar to parts of Yakutat Valley in which longline survey sampling occurs.

The GEBCO (General Bathymetric Chart of the Oceans) 08 Grid was used to extract depth contours using the contour surface analysis tools in ArcView GIS 9.3. The GEBCO_08 Grid is a global 30 arc-second grid generated by combining quality-controlled ship depth soundings with interpolation between sounding points guided by satellite-derived gravity data (http://www.gebco.net/data_and_products/gridded_bathymetry_data/, retrieved 8 February 2012). Using the 150 and 200 m depth contours and the geographic area boundaries, the shallow strata were created and area sizes calculated in ArcView GIS 9.3. New calculations of the following strata were also calculated for all geographic areas: 151-200 m, 201-300 m, 301-400 m, 401-600 m, 601-800 m, and 801-1,000 m. New calculations of the 151-200 m stratum within gullies were calculated, in addition to all other strata within the gullies (201-300 m, 301-400 m, and 401-600 m).

RESULTS AND DISCUSSION

A comparison of each of these historical sources shows that there are large differences between some of the estimated stratum area sizes (Tables 1, 4). The geographic area sizes utilized in the AFSC longline and RACE trawl surveys were similar across the WGOA and CGOA with some large differences in the EGOA (Table 4). These discrepancies could be explained by differences in interpolating the location of the 300 m contour line. Estimates by Sasaki (1981) were considerably different from other methods in the CGOA and EGOA; however, Sasaki's estimates were used by Sigler only in the AI and EBS regions. For example, the amount of area within the 300-1,000 m slope habitat depth zone in the CGOA is

approximately 14,500 km^2 for both RACE trawl survey and Sigler (Table 4), and again the amount of total area within the 200-300 m depth zone in the CGOA is roughly similar between RACE trawl survey estimates at 23,036 km^2 and Sigler at 22,115 km^2 (Table 4).

In the EGOA there are also differences among the sources for the amount of total area estimated in the 300-1,000 m depth stratum (Table 4). Sigler primarily used Haight (Appendix 1) for area sizes in the EGOA with some modifications of gully boundaries. Generally, Sigler's measurements in the EGOA have higher values for the slope and lower values for the gullies in comparison to Haight (Appendix 1). This is because Haight (Appendix 1) did not include measurements at the mouth of gullies in the slope measurements. For example, at 200-300 m in the W-Grounds, Haight (Appendix 1) measured the entire W-Grounds area up to the 300 m curve; there is no measurement for the slope area at 200-300 m at the mouth of the gully. As a result, all of the transition zones at the entrance of gullies that would be most appropriately allocated to the slope were instead included as portions of the gully measurements (Table 1d).

Recalculated area sizes compared to those currently used (Appendix 2) are generally similar in size when looking at comparisons by entire management area (Table 4), but there are exceptions for specific stratum in some geographic areas (Tables 1a, 1b, 1c, 1d, 1e). The majority of the strata size estimates for the Shumagin Slope down to 800 m, the Kodiak Slope, the Southeast Outside Slope deeper than 400 m, and Region I of the EBS were similar in size to the values currently used. Some substantial differences are in the GOA gullies, as boundary lines were sometimes difficult to determine, and past documentation of the creation of gully areas was minimal. These discrepancies could be a result of different bathymetry data being used and differences in the delineation of gully boundary lines. Other large differences are in Region III of the EBS and in the western AI.

Direct comparisons of recalculated area sizes were made with the currently used RACE trawl survey area sizes (Tables 6, 7). Differences between the recalculated values for the GOA from this document and the RACE trawl survey values are generally similar across the WGOA and CGOA, with larger differences occurring in the EGOA. On average, there was a 21% difference between the two sources. The largest differences are seen in the 201-300 m stratum, likely due to differences in gully measurements that would be included in this value (Table 7). Recalculated area sizes are generally smaller in comparison to RACE trawl survey values (Tables 4, 6, 7).

The decision to use the entire 151-200 m depth zone for the creation of the shallow stratum appears to appropriately represent sampled waters that are < 200 m in all GOA geographic areas, except West Yakutat (Table 5). The West Yakutat shelf (between depths 151-200 m) in some areas is much wider than in other geographic areas. The widest shelf distance in the 151-200 m stratum is approximately 8,100 m, and approximately 12% of that area is sampled on the longline survey (Table 5). In addition, mapping of RACE trawl survey catch data shows that sablefish catches are primarily concentrated to the outer edge (near the 200 m isobath) within the 151-200 m stratum, questioning the methods for shallow stratum creation for this area.

Much of the 151-200 m shelf in the AI and EBS is large as well, especially in comparison to the average amount of area sampled in this shallow stratum (Table 5).

Overall, the use of more accurate and updated bathymetry data, in addition to more advanced mapping technology, has resulted in more accurate stratum area sizes. As stated in the methods section, we recommend that the shallow stratum consists of the entire 151-200 m shelf area. The amount of sampling effort within the 151-200 m stratum was substantial in the longline survey, while the lack of sampling effort in the 101-150 m stratum does not justify its use for RPNs and RPWs (Table 2). There were no previous calculations of the 151-200 m stratum for comparison since Sasaki and RACE trawl survey estimates include the entire 101-200 m shelf in their calculations of area size. In addition, it is also suggested that potential users of these data explore the use of the new stratum estimates generated from this analysis for depths 201-1,000 m for future RPN and RPW calculations. With advances in GIS technology and additional depth data available, calculated area sizes reported in this study should be more accurate and would therefore be more applicable use than current stratum values. However, potential users of these data should take into consideration that changing the status quo calculations of RPNs could have impacts on fishermen in different areas. Those considerations would have to be analyzed and discussed before proceeding with a change in the values of RPN calculations.

Area Delineation

The following are the results of the delineation of each of the geographic areas and the gullies within. The boundaries that we followed for our newly created gully area calculations are described, as are a list of stations within each gully, and a list of stations that sample the shallow stratum of each geographic area.

Southeast Outside Geographic Area

Many gully stations and slope station 103 regularly sample depths within the 151-200 m depth stratum (Fig. 4). Other slope stations in this area do not regularly sample the shallow stratum. Depth strata area sizes were recalculated (Table 1a), the shallow stratum (151-200 m) was created (Table 1a), and depth strata within gullies within the Southeast Outside geographic area were recalculated (Table 1d). A description of the gullies within the Southeast Outside Area follows below.

Dixon Entrance -- When delineating Dixon Entrance (Fig. 5), we followed the boundary lines as closely as possible to those created by Haight (Appendix 1). The mouth, approximately 17 nmi west of Graham Island, is bound by the 300 m depth contour. The southern boundary is defined by the U.S. Exclusive Economic Zone (EEZ) (boundary between U.S. and Canadian waters) and the western boundary consists of a line (created by Sigler, Table 3) within the trench drawn from Cape Muzon to Langara Island. This boundary within the trench separates Dixon Entrance from inside Southeast Alaska waters that are not sampled by the longline survey. The northern boundary of Dixon Entrance runs along the 150 m depth contour until 134° W longitude, and from there due west on the 54°40 N latitude until intersecting the 300 m depth contour. The 151-200 m stratum that we created was not originally included in this area measurement. Stations sampled within Dixon Entrance include stations 148 and 149.

Iphigenia Gully -- Iphigenia Gully (Fig. 6) was not defined by Haight (Appendix 1) so ours is the first area size calculation. The gully is bound at the mouth (creating the western boundary) by a line connecting the two 200 m depth contours where they turn sharply inward away from the slope. The inside boundary of the gully (separating the gully from inside Southeast Alaska waters) consists of a line drawn from Helm Point to Cape Addington. The 150 and 200 m depth contours bound the two sides of the gully where the contours turn abruptly into the shelf and away from the slope. The 151-200 m stratum was created for this area measurement. Stations in this area were sampled by the Japan-U.S. cooperative longline survey but are no longer sampled.

Ommaney Trench -- Ommaney Trench (Fig. 7) is considered an extension of Chatham Strait, extending 27 nmi offshore. Following methods by Sigler (Appendix 2), we defined the eastern boundary inside the trench by a line running from Cape Ommaney to the Hazy Islands, where the gully moves to inside waters that are not sampled by the longline survey. The western boundary, at the mouth of the gully, is defined by where the 200, 300, and 400 m strata meet the slope. Northern and southern boundary lines follow the 150 and 200 m depth contours, respectively, where these contours leave the slope abruptly. Our delineation differs from Haight (Appendix 1), who used the 300 m contour line following 56° N latitude for the southern boundary, and did not include any depths shallower than 200 m. Stations 144 and 145 are sampled within Ommaney Trench.

Spencer Gully Southeast -- The management boundary between the Southeast Outside and the West Yakutat Areas (137°W) bisects Spencer Gully. Spencer Gully, is therefore split between the two areas (Fig. 8) and runs about 23 nautical miles (nmi) from Cape Spencer south west, and then south to its mouth located approximately 18 nmi due west of Chichagof Island. We discuss the area size of the portion of Spencer Gully in the Southeast Outside (SE) Area here and the other portion in the "West Yakutat Geographic Area" section. Spencer Gully SE is bound on its western side by 137° W longitude (SE/YAK Area divider). The northern boundary starts at 137° W longitude and follows the 150 m depth contour to the inside boundary of the gully. We followed Sigler's (Appendix 2) methods and drew a line from Cape Spencer to Cape Bingham (Table 3) creating the boundary separating the gully from inside Southeast Alaska waters. The eastern boundary is defined by the 150 m depth contour that heads towards the slope. The southern border consists of line drawn from the 137° W longitude area boundary to the 200 m contour, where this contour turns away from the slope. The 151-200 m stratum was created for this area measurement. There are no stations sampled in Spencer Gully SE.

West Yakutat Geographic Area

Many gully stations and slope stations 89, 90, 91, 92, 93, and 97 sample depths within the 101-200 m depth stratum in this area (Fig. 9). Other slope stations in this area do not regularly sample this shallow stratum. Depth stratum area sizes were recalculated (Table 1a), the shallow stratum (151-200 m) was created (Table 1a), and depth stratum within gullies in the West Yakutat Area were recalculated (Table 1d). A description of the gullies within the West Yakutat Area follows below.

Spencer Gully Yakutat -- Spencer Gully Yakutat (YAK; Fig. 10) is the portion of Spencer Gully that lies within the Yakutat Geographic Area. This area is bound on the eastern side by the Yakutat/Southeast Geographic Area boundary (137°W longitude). The western boundary is defined by both the 150 and 200 m depth contours, where each of these contours turn away from the slope. The mouth of the gully on the southern side is bound by a line drawn from the 137° W longitude area boundary to the 300 m contour where it turns away from the slope. The 151-200 m stratum was created for this area measurement. Stations 142 and 143 are sampled within Spencer Gully YAK.

Alsek Strath -- The mouth of Alsek Strath (sometimes called Alsek Valley; Fig. 11) is defined by a line through the 200-300 m depth stratum separating the gully from the slope. This line begins at approximately 58° 29' 5.9994" N × 139° 20' 24" W and heads west on latitude 58° 29' 5.9994" N until 58° 29' 5.9994" N × 139° 44' 13.1994" W. The east and north are defined by the 150 m depth contour. On the west, the 150-200 m depth stratum was divided where the depth stratum started to widen and become part of the shelf. The remainder of the west boundary is defined by the 200 m depth contour. The 151-200 m stratum was created for this area measurement. There are no stations sampled within Alsek Strath.

Yakutat Valley -- Yakutat Valley (Fig. 12) boundaries on the east and northwest are defined by where the 150 and 200 m depth contours leave the slope and shelf and enter the valley. The mouth is bound by dividing the 200-300 m and 300-400 m depth stratum from the slope. The non-colored areas of Yakutat Valley (Fig. 12) between 151-200 m and 201-300 m were excluded from the Yakutat Valley area calculation determined by the methods described above. By comparing RACE trawl survey catch rates from the removed northeastern area (the "finger") to the newly defined Yakutat Valley Area, we determined the northeastern area to be a different habitat than the section eventually included within the gully. Removal of the northeastern section reduced the area size of stratum 201-300 within Yakutat Valley by approximately 54% (in comparison to Sigler's calculation; Appendix 2). The 151-200 m stratum we created was not originally included in this area measurement. Stations 138 and 139 are sampled within Yakutat Valley.

W-Grounds -- When creating W-Grounds (Fig. 13), we modified the boundary lines of those created by Haight (Appendix 1) and that are used in the current longline survey area measurements. Haight's (Appendix 1) definition of the W-Grounds consisted of two geographic formations: the Pamplona Spur and the Bering Valley. The Pamplona Spur is a sharp lateral extension of the continental shelf, a narrow isthmus 250 m deep projecting less than 2 nmi from the shelf. The western part of the W-Grounds contains the Bering Valley, a large shallow valley that extends onto the shelf from the slope. Our newly defined W-Grounds consist only of the Bering Valley. We determined that the Pamplona Spur and areas in between were more similar to slope habitat, and included this section within the West Yakutat slope habitat instead of the W-Grounds gully habitat. The eastern boundary for the W-Grounds is the 200 m contour, where the Bering Valley pushes into the shelf, until intersecting the 150 m bathymetry which then continues as the eastern boundary. The western boundary is defined by the 150 and 200 m contours where they turn into the shelf. The entire mouth of the W-Grounds is bound by a line connecting the two 200 m contours which bounds the eastern and western sides of the gully. The 151-200 m stratum was created for this area measurement. Stations 136 and 137 are sampled within the W-Grounds.

Kodiak Geographic Area

Many gully stations and slope stations 80, 82, and 84 sample depths within the 101-200 m depth stratum (Fig. 14). Other slope stations in this area do not regularly sample this shallow stratum. Depth stratum area sizes were recalculated (Table 1a), the shallow stratum (151-200 m) was created (Table 1a), and depth stratum within gullies in the Kodiak Area were recalculated (Table 1d). A description of the gullies in the Kodiak Area follows below.

Amatuli Gully -- Amatuli Gully and three associated unnamed "gullies" (Fig. 15) are all bound in their entirety by the 150 m depth contour where this contour turns abruptly inshore, and either the 200 or 300 m contour at the mouth. There were no previous instructions on the boundaries of this gully, or why this designation consists of four gullies lumped together. The most

northeastern gully is divided between West Yakutat and Kodiak Areas (147° W longitude), however, previous Amatuli Gully area calculations were all designated to the Kodiak Area where nearly all the gully is located and we did the same. The 151-200 m stratum was created for this area measurement. Stations sampled within Amatuli Gully include the following: 87, 128, 129, 130, 131, 132, 133, 134, and 135.

Chirikof Geographic Area

Many gully stations and slope stations 72, 73, 74, 75, and 76 sample depths within the 101-200 m depth stratum (Fig. 16). Other slope stations in this area do not regularly sample this shallow stratum. Depth stratum area sizes were recalculated (Table 1a), the shallow stratum (151-200 m) was created (Table 1a), and depth stratum within gullies in the Chirikof Area were recalculated (Table 1d). A description of the gullies within the Chirikof Area follows below.

Shelikof Trough -- The majority of the Shelikof Trough (Fig. 17) is in the Chirikof Area (previously referred to as South Shelikof Trough), but a small portion is included in the Kodiak Area (previously referred to as North Shelikof Trough; divided by 154° W longitude). North Shelikof Trough was previously reported in Sigler's area calculations (Appendix 2); we, however, chose to remove this section from the Shelikof Trough Area due to a lack of sampling and very small catches in this area. Shelikof Trough is bound by the 150 m depth contours turning abruptly into the trough, and by the 300 m contour at the mouth. The Chirikof Area boundary line (154° W longitude) defines the inner Trough. There were no previous instructions on the boundaries of this trough. The 151-200 m stratum was created for this area measurement. Stations sampled within Shelikof Trough include the following: 120, 121, 122, 123, 124, 125, 126, and 127.

Shumagin Gully -- Shumagin Gully (Fig. 18) is bound by the natural inward turn of the 150 m depth contours away from the slope. The majority of Shumagin Gully is within the Chirikof Area; however, a small portion of the 151-200 m depth stratum crosses into the Shumagin Area (divided by 159° W longitude). We chose to remove the section of Shumagin Gully from the Shumagin Gully Area due to lack of sampling and insufficient catch in this area. There were no previous instructions on the boundaries of this gully. The 151-200 m stratum was created for this area measurement. There are no stations sampled within Shumagin Gully.

Shumagin Geographic Area

Slope stations 62, 63, 65, 66, 67, 68, 70, and 71 sample depths within the 101- 200 m depth stratum (Fig. 19). Other slope stations in this area do not regularly sample this shallow stratum. Depth stratum area sizes were recalculated (Table 1a) and the shallow stratum (151-200 m) was created (Table 1a). There are no defined gullies within the Shumagin Area that are sampled on the longline survey.

Aleutian Islands Area

Slope stations 35, 37, 38, 39, 40, 42, 53, 54, 55, 57, 58, 59, and 60 sample depths within the 101-200 m depth stratum (Figs. 20, 21). Other slope stations in this area do not regularly sample this shallow stratum. Depth stratum area sizes were recalculated (Table 1b) and the shallow stratum (151- 200 m) was created (Table 1b). There are no defined gullies within the Aleutian Islands Area that are sampled on the longline survey.

Eastern Bering Sea Area

Slope stations 1, 2, 4, 6, 8, 12, 13, 15, 17, 18, 22, 32, and 33 sample depths within the 101-200 m depth stratum (Figs. 22, 23). Other slope stations in this area do not regularly sample this shallow stratum. Depth stratum area sizes were recalculated (Table 1c) and the shallow stratum (151-200 m) was created (Table 1c). There are no defined gullies within the Eastern Bering Sea Area that are sampled on the longline survey.

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TABLES

Table 1a.-- Calculated area sizes by depth stratum and source for slope habitat within the Gulf of Alaska. Area size values are in square kilometers. The RACE trawl survey values are from the 2009 Gulf of Alaska Bottom Trawl Survey report (von Szalay et al. 2010), and the Haight values are from an unpublished table in 1986 (Appendix 3). The percent change (% Change) from Sigler's 1989 calculations (Appendix 2) estimates to the updated estimates calculated in this study (Echave) are noted.

Area (shelf, slope)	Depth (m)	Sasaki (1981)	RACE trawl survey	Haight (App. 3)	Haight (App. 1)	Sigler (current values; App. 2)	Echave	% Change
Shumagin	151 – 200						2,487	
	201 – 300	2,090	2,788			2,737	2,411	-12
	301 – 400	1,780	2,531[2]			1,264	1,266	.2
	401 – 600	2,250	2,006[3]			2,269	1,939	-15
	601 – 800	1,940	1,937[4]			1,629	1,744	7
	801 – 1,000	1,680				1,248	1,615	29
Chirikof	151 – 200						1,462	
	201 – 300	9,740	1,528			1,533	1,240	-19
	301 – 400	6,700	1,604[2]			817	729	-11
	401 – 600	1,620	1,953[3]			1,766	1,417	-20
	601 – 800	2,150	3,066[4]			1,955	1,522	-22
	801 – 1,000	2,450				2,012	2,750	37
Kodiak	151 – 200						1,658	
	201 – 300	9,380	1,623			1,626	1,956	20
	301 – 400	6,810	2,912[2]			1,480	1,209	-18
	401 – 600	3,270	1,745[3]			2,255	2,019	-10
	601 – 800	2,300	3,494[4]			1,923	1,977	3
	801 – 1,000	2,300				2,296	1,868	19
W. Yakutat	151 – 200						7,697	
	201 – 300	5,610	2,127	2,392[1]	2,841	1,494	2,193	47
	301 – 400	4,130	1,521[2]		859[2]	1,494	893	-40
	401 – 600	2,240	1,469[3]	1,462	1,333[3]	1,666	1,390	-17
	601 – 800	1,420	1,887[4]	1,253	1,819[4]	1,470	1,303	-11
	801 – 1,000	1,350		1,195		1,489	1,131	-24
Southeast	151 – 200						2,742	
Outside	201 – 300	4,360	5,052	1,909[1]	4,915	891	1,582	78
	301 – 400	3,130	773[2]		801[2]	891	537	-40
	401 – 600	1,340	1,033[3]	1,048	982[3]	822	935	14
	601 – 800	990	1,206[4]	1,218	1,954[4]	1,006	986	-2
	801 – 1,000	1,260		1,370		1,165	1,146	-2

[1]The calculation is for depth strata 200-400 m. [2]The calculation is for depth strata 301-500 m. [3]The calculation is for depth strata 501-700 m. [4]The calculation is for depth strata 701-1,000 m.

Table 1b.-- Calculated geographic area sizes by depth stratum and source for slope habitat within the Northwest (NW), Southwest (SW), Northeast (NE), and Southeast (SE) Aleutian Islands. Area sizes are in square kilometers. The percent change (% Change) from Sigler's (Appendix 2) estimates to the updated estimates in this study (Echave) are noted.

Area	Stratum	Depth (m)	Sasaki (1981)	Sigler (current values; Appendix 2)	Echave	% Change
NW Aleutian	shallow	151 – 200			545	
	3	201 – 300	1,130	1,130	1,052	-7
	4	301 – 400	1,300	1,300	880	-32
	5	401 – 600	3,100	3,100	1,459	-53
	6	601 – 800	2,640	2,640	1,763	-33
	7	801 – 1,000	2,210	2,210	1,151	-48
SW Aleutian	shallow	151 – 200			1,368	
	3	201 – 300	1,440	1,440	2,784	93
	4	301 – 400	1,570	1,570	1,700	8
	5	401 – 600	3,480	3,480	3,296	5
	6	601 – 800	2,820	2,820	3,899	38
	7	801 – 1,000	2,130	2,130	1,930	-9
NE Aleutian	shallow	151 – 200			1,596	
	3	201 – 300	2,260	2,141	2,179	2
	4	301 – 400	2,200	2,085	1,779	-15
	5	401 – 600	4,010	3,800	3,607	-5
	6	601 – 800	3,430	3,250	2,740	-16
	7	801 – 1,000	2,940	2,786	2,219	-20
SE Aleutian	shallow	151 – 200			2,202	
	3	201 – 300	3,030	2,530	3,740	48
	4	301 – 400	2,510	2,096	2,295	9
	5	401 – 600	2,870	2,396	3,007	26
	6	601 – 800	2,370	1,978	1,944	-2
	7	801 – 1,000	1,880	1,570	1,542	-2

Table 1c.-- Calculated geographic area sizes by depth stratum and source for slope habitat within Regions I, II, III, and IV of the Eastern Bering Sea. Area sizes are in square kilometers. The percent change (% Change) from Sigler's (Appendix 2) estimates to the updated estimates in this study (Echave) are noted.

Area	Stratum	Depth (m)	Sasaki (1981)	Sigler (current values; Appendix 2)	Echave	% Change
Region –I	shallow	151 – 200			548	
	3	201 – 300	770	770	940	22
	4	301 – 400	730	730	669	-8
	5	401 – 600	1,270	1,270	1,143	-10
	6	601 – 800	1,160	1,160	1,160	0
	7	801 – 1,000	1,130	1,130	1,018	-10
Region - II	shallow	151 – 200			3,672	
	3	201 – 300	2,440	2,440	2,877	18
	4	301 – 400	2,090	2,090	2,307	10
	5	401 – 600	3,010	3,010	4,127	37
	6	601 – 800	3,150	3,150	2,098	-33
	7	801 – 1,000	1,700	1,700	1,736	2
Region - III	shallow	151 – 200			1,846	
	3	201 – 300	600	600	2,270	278
	4	301 – 400	520	520	1,345	159
	5	401 – 600	890	891	1,144	28
	6	601 – 800	1,160	1,160	913	-21
	7	801 – 1,000	900	900	935	4
Region - IV	shallow	151 – 200			1,675	
	3	201 – 300	1,030	1,030	1,044	1
	4	301 – 400	840	840	511	-39
	5	401 – 600	960	960	857	-11
	6	601 – 800	920	920	785	-15
	7	801 – 1,000	1,050	1,050	849	-19

Table 1d.-- Calculated area sizes by depth stratum and source for defined gullies within the Gulf of Alaska. Area sizes are in square kilometers. The percent change (% Change) from Sigler's (Appendix 2) estimates to the updated estimates in this study (Echave) are noted. The Haight (Appendix 3) values are from an unpublished table in 1986.

Area	Stratum	Depth (m)	Description	Haight (App. 3)	Haight (App.1)	Sigler (current values; App. 2)	Echave	% Change
Chirikof	shallow	151 – 200	Shumagin Gully				2,505	
	3	201 – 300	Shumagin Gully			665	860	29
		150 – 200	S. Shelikof				4,066	
	3	201 – 300	S. Shelikof			12,610	12,156	-4
Kodiak	shallow	151 – 200	Amatuli Gully				5,168	
	3	201 – 300	Amatuli Gully			6,346	5,840	-8
W. Yakutat	shallow	151 – 200	W-Grounds				218	
	3	201 – 300	W-Grounds	845	1,366	1,008	828	-18
	4	301 – 400	W-Grounds	845	514[1]	302	137	-55
	shallow	151 – 200	Yakutat Valley				726	
	3	201 – 300	Yakutat Valley	1,315	1,268	1,268	578	-54
	4	301 – 400	Yakutat Valley	1,315	902[1]	768	656	-15
	shallow	151 – 200	Alsek Strath				604	
	3	201 – 300	Alsek Strath	565	964	565	804	42
	shallow	151 – 200	Spencer Gully				93	
	3	201 – 300	Spencer Gully	14		14	128	814
	4	301 – 400	Spencer Gully	14		14	175	1,150
	5	401 – 600	Spencer Gully	50	323[1]	50	134	168
	6	601 – 800	Spencer Gully	50		50		
Southeast	shallow	151 – 200	Spencer Gully				142	
Outside	3	201 – 300	Spencer Gully	175		175	193	10
	4	301 – 400	Spencer Gully	175	374[1]	175	211	21
	5	401 – 600	Spencer Gully	250		250	155	-38
	shallow	151 – 200	Ommaney Trench				250	
	3	201 – 300	Ommaney Trench			521	657	26
	4	301 – 400	Ommaney Trench		850[1]	610	625	2
	5	401 – 600	Ommaney Trench	122		122	296	143
	shallow	151 – 200	Iphigenia Gully				336	
	3	201 – 300	Iphigenia Gully	959		1,918	969	-49
	4	301 – 400	Iphigenia Gully				12	
	shallow	151 – 200	Dixon Entrance				362	
	3	201 – 300	Dixon Entrance	961		1,130	1,375	22
	4	301 – 400	Dixon Entrance	961	850[1]	793	759	-4
	5	401 – 600	Dixon Entrance	58		58	41	-29

[1]The calculation is for depth strata 301-500 m.

Table 1e.-- Calculated geographic area sizes by depth stratum and source for slope habitat within East (E) and West (W) Yakutat. Area sizes are in square kilometers. The percent change (% Change) from Sigler's (Appendix 2) estimates to the updated estimates in this study (Echave) are noted.

Area	Stratum	Depth (m)	Description	Sigler (current values; Appendix 2)	Echave	% Change
W. Yakutat	shallow	151 – 200	shallow		5,116	
	3	201 – 300	Slope	992	1,745	76
	4	301 – 400		992	720	-27
	5	401 – 600		1,271	1,132	-11
	6	601 – 800		1,245	1,059	-15
	7	801 – 1,000		1,282	920	-28
E. Yakutat	shallow	151 – 200	shallow		2,581	
	3	201 – 300	Slope	502	448	-11
	4	301 – 400		502	173	-66
	5	401 – 600		395	258	-35
	6	601 – 800		225	244	8
	7	801 – 1,000		207	211	2

Table 2.-- The total number of stations per geographic area, the number of stations with consistent effort in depths < 200 m (85% of years had sampling in the < 200 m depths), and the average percentage of effort (i.e., number of skates of gear set at the station) in each depth stratum (e.g., 100-200 m) from 1996 to 2011 on the AFSC longline survey. Aleutian Islands and Eastern Bering Sea sampling in the U.S. longline survey began in 1996 and occurs every other year, EBS in odd years and AI in even. For consistency, data from 1996 to 2011 is used for all areas. Stratum 101-200 m is broken into two strata (101-150 m and 151-200 m).

Area	Stations sampled 85% of years	Total stations	**101-150**	**151-200**	**100-200**	201-300	301-400	401-600	601-800	801-1000
Bering 1 Slope	2	3	**6%**	**4%**	**10%**	6%	7%	26%	45%	6%
Bering 2 Slope	3	4	**0%**	**17%**	**17%**	17%	12%	21%	31%	3%
Bering 3 Slope	3	5	**6%**	**10%**	**16%**	12%	12%	35%	24%	2%
Bering 4 Slope	3	4	**3%**	**21%**	**24%**	20%	11%	22%	21%	3%
NE Aleutians Slope	6	6	**8%**	**14%**	**22%**	10%	8%	27%	31%	2%
SE Aleutians Slope	7	8	**8%**	**10%**	**18%**	22%	9%	31%	14%	3%
Shumagin Slope	9	10	**13%**	**10%**	**23%**	21%	20%	25%	9%	2%
Kodiak Slope	2	9	**0%**	**2%**	**2%**	13%	12%	35%	30%	8%
Chirikof Slope	4	7	**1%**	**9%**	**10%**	26%	21%	23%	14%	5%
Shelikof Trough	1	8	**0%**	**4%**	**4%**	96%	0%	0%	0%	0%
W Yakutat Slope	4	8	**1%**	**3%**	**4%**	8%	10%	40%	31%	6%
W Grounds	1	2	**0%**	**22%**	**22%**	40%	37%	0%	0%	0%
Yakutat Valley	0	2	**0%**	**0%**	**0%**	50%	50%	0%	0%	0%
E Yakutat Slope	1	3	**0%**	**1%**	**1%**	5%	8%	39%	40%	7%
Southeast Slope	0	8	**0%**	**0%**	**0%**	5%	7%	30%	40%	17%
Southeast Shelf	1	1	**4%**	**75%**	**79%**	21%	0%	0%	0%	0%
Amatuli Gully	3	9	**0%**	**19%**	**19%**	77%	4%	0%	0%	0%
Spencer Gully	0	2	**0%**	**0%**	**0%**	7%	36%	56%	0%	0%
Dixon Entrance	1	2	**3%**	**11%**	**14%**	7%	31%	48%	0%	0%

Table 3.-- Boundaries delineating ”outside” versus “inside” areas (gullies) defined by Sigler in 1989 (Appendix 2).

Area	Boundary
Spencer Gully	Cape Spencer to Cape Bingham
Ommaney Trench	Cape Ommaney to Hazy Islands to Helm Point
Dixon Entrance	Cape Muzon to Langara Island

Table 4.-- Calculated area sizes by depth stratum and source. Values are in square kilometers. RACE trawl survey estimates are from the 2009 Gulf of Alaska bottom trawl survey report (von Szalay et al. 2010). Area sizes include gully, shelf, and slope habitat type.

Area	Stratum	Depth	Sasaki (1981)	Haight (App. 1)	RACE trawl survey	Sigler (current values; App. 2)	Echave
WGOA	3	201-300	2,090		2,788	2,737	2,411
WGOA	4, 5, 6, 7	301-1,000	7,650		6,474	6,410	6,564
CGOA	3	201-300	19,120		23,036	22,115	22,052
CGOA	4, 5, 6, 7	301-1,000	27,600		14,774	14,504	13,491
EGOA	3	201-300	9,970	11,354	10,222	8,984	9,307
EGOA	4, 5, 6, 7	301-1,000	15,860	11,561	11,340	13,195	10,784

Table 5.-- The average number and length of skates set in each geographic area within the 151-200 m stratum from 1996 to 2011. The approximate widest distance of the shelf within the 151-200 m stratum of each respective geographic area is also included, as is the average percentage of the shelf within the 151-200 m stratum that is sampled.

Geographic Area	Avg. # of skates within the 151-200 m stratum	Avg. skate distance (m) in the 151-200 m stratum	Widest shelf distance (m) in the 151-200 m stratum	% of the widest shelf in the 151-200 m stratum sampled on average
Bering I Slope	6.3	630	1,415	44.5%
Bering II Slope	30.3	3,030	27,190	11.1%
Bering III Slope	18.1	1,810	12,285	14.7%
Bering IV Slope	38.6	3,860	19,030	20.3%
NE Aleutians Slope	20.2	2,020	9,865	20.5%
SE Aleutians Slope	15.7	1,570	16,265	9.7%
Shumagin Slope	16.5	1,650	2,800	58.9%
Chirikof Slope	15.3	1,530	3,380	45.2%
Kodiak Slope	3	300	2,740	10.9%
W Yakutat Slope	10	1,000	8,186	12.2%
Southeast Outside Slope	120	12,000	13,880	86.4%

Table 6.-- A comparison of the current area sizes designated as slope habitat used by the RACE trawl survey (von Szalay et al. 2010; appendix table A-1) to the new area sizes calculated by this study (Echave). Values are in square kilometers.

Area name	Depth range (m)	RACE trawl survey	Echave
Shumagin	201 – 300	2,788	2,411
	301 – 500	2,531	2,307
	501 – 700	2,006	1,794
	701 – 1,000	1,937	2,463
Chirikof	201 – 300	1,528	1,240
	301 – 500	1,604	1,307
	501 – 700	1,953	1,573
	701 – 1,000	3,066	3,538
Kodiak	201 – 300	1,623	1,956
	301 – 500	2,912	2,215
	501 – 700	1,745	2,054
	701 – 1,000	3,494	2,804
W. Yakutat	201 – 300	2,127	2,193
	301 – 500	1,521	893
	501 – 700	1,469	1,346
	701 – 1,000	1,887	1,758
Southeast Outside	201 – 300		1,582
	301 – 500	773	993
	501 – 700	1,033	911
	701 – 1,000	1,206	1,682

Table 7.-- A comparison of all the current area sizes used by the RACE trawl survey (von Szalay et al. 2010; appendix table A-1) to the new area sizes calculated by this study (Echave). These areas include habitat designated as gullies, shelf, and slope. Values are in square kilometers.

Area name	Depth range (m)	RACE trawl survey	Echave
Shumagin	201 – 300	2,788	2,411
	301 – 500	2,531	2,307
	501 – 700	2,006	1,794
	701 – 1,000	1,937	2,463
Chirikof	201 – 300	11,546	14,256
	301 – 500	1,604	1,307
	501 – 700	1,953	1,573
	701 – 1,000	3,066	3,538
Kodiak	201 – 300	11,490	7,796
	301 – 500	2,912	2,215
	501 – 700	1,745	2,054
	701 – 1,000	3,494	2,804
W. Yakutat	201 – 300	5,170	4,531
	301 – 500	2,628	1,995
	501 – 700	1,469	1,346
	701 – 1,000	1,887	1,758
Southeast Outside	201 – 300	5,052	4,776
	301 – 500	3,117	3,041
	501 – 700	1,033	962
	701 – 1,000	1,206	1,682

Figure 1.-- Map of the Alaska Fisheries Science Center's annual longline survey stations (represented by triangles) and sablefish management areas. Slope station numbers by longline survey area are in parentheses.

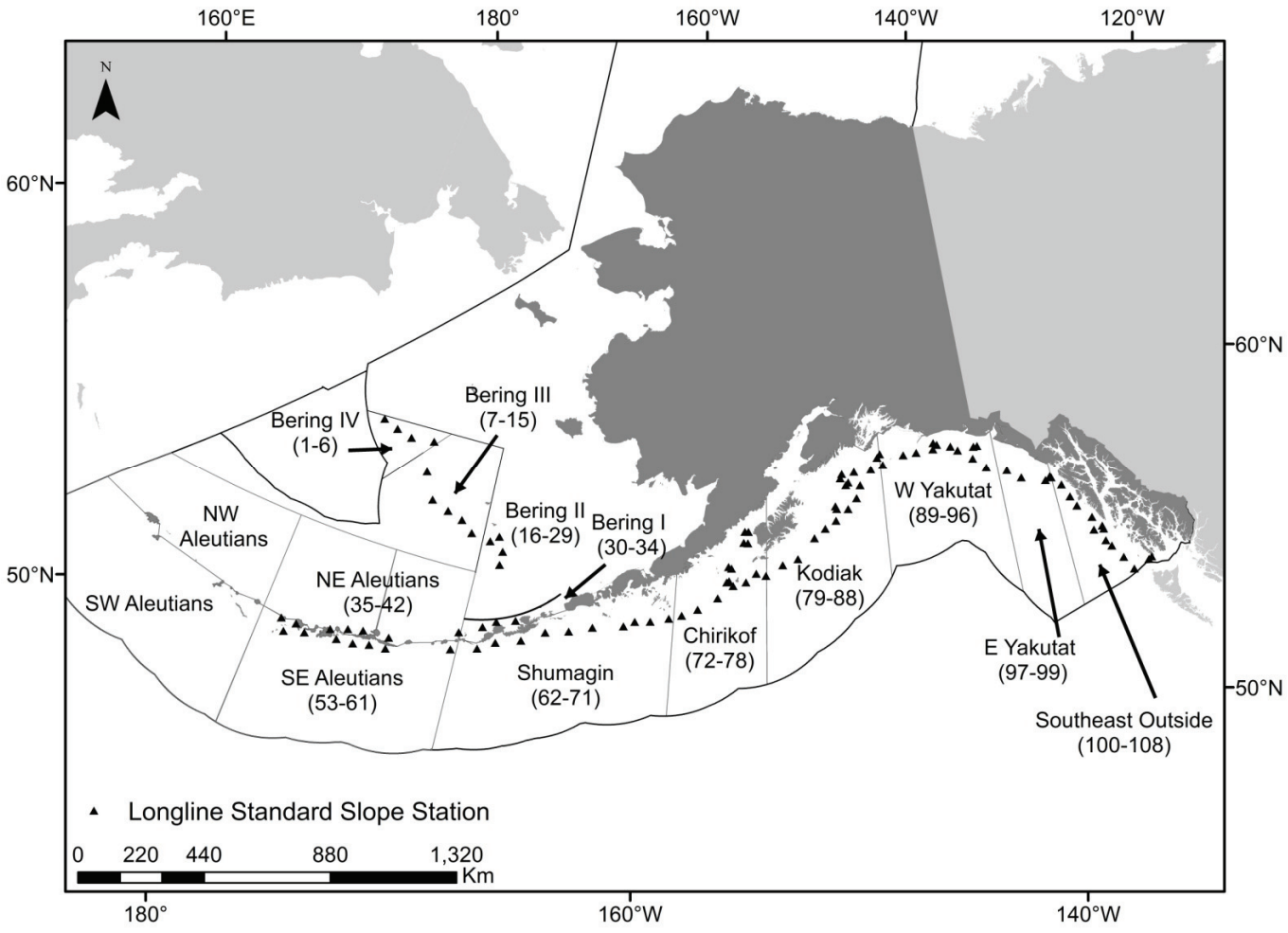


Figure 2.-- Defined “inside” and “outside” waters and labeled gullies as defined by Sigler (Appendix 2) in1989.

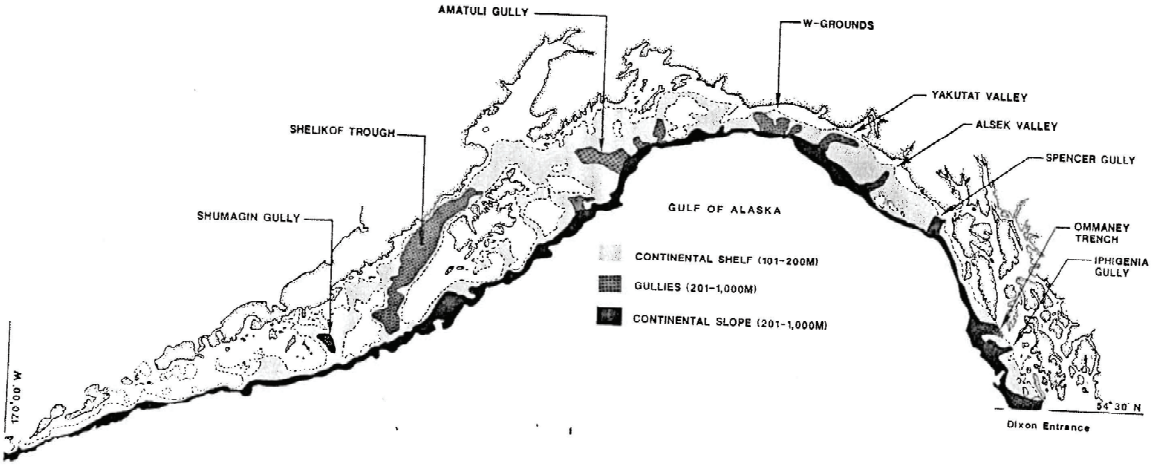


Figure 3.-- A drawing depicting three sampling scenarios in one geographic area and their various methods of shallow strata calculation. Blue lines are hypothetical track lines (where the longline was set) for Stations 1, 2, and 3 within a single geographic area. Station 1 consists of sampling that begins in the 101-150 m stratum, in an area where the shelf consisting of 151-200 m is very narrow. Station 2 sampling begins in the 151-200 m stratum, but in an area of the shelf that is much larger. Station 3 sampling begins in the 151-200 m stratum as well, but this area on the shelf is much larger than Stations 1 and 2. A skate of longline gear is 100 m in length.

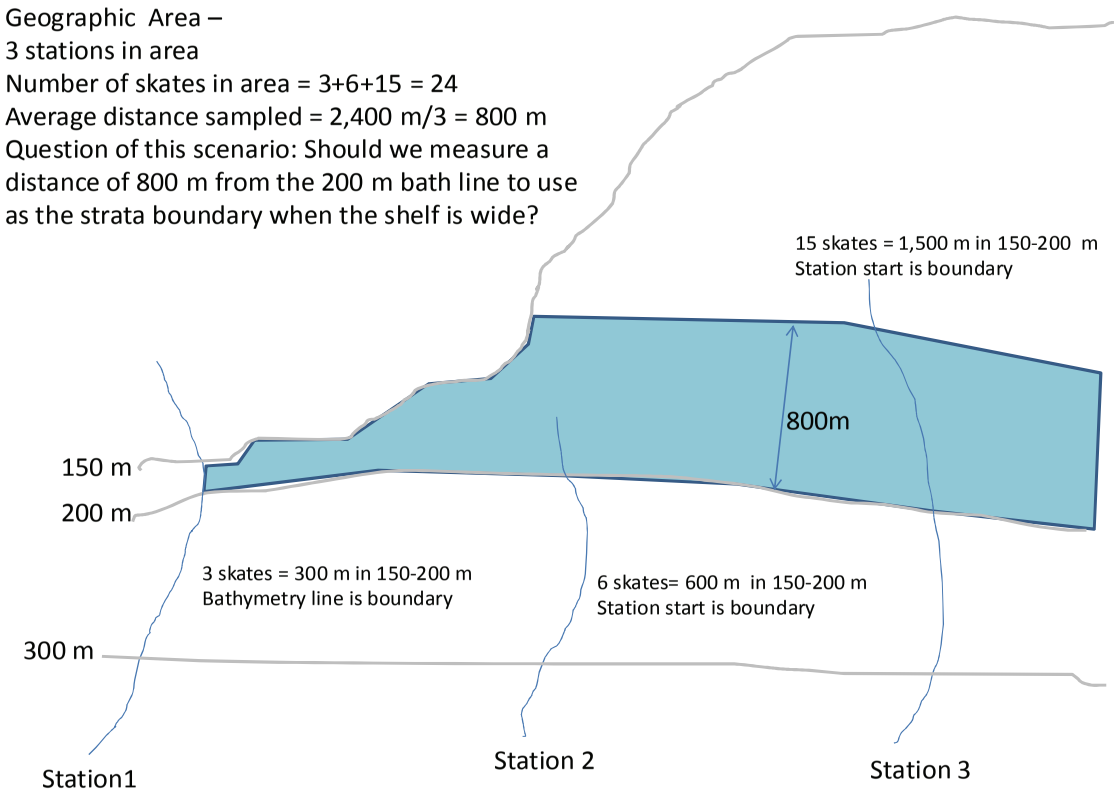


Figure 4.-- Longline survey stations and gullies within the Southeast Outside Area. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.

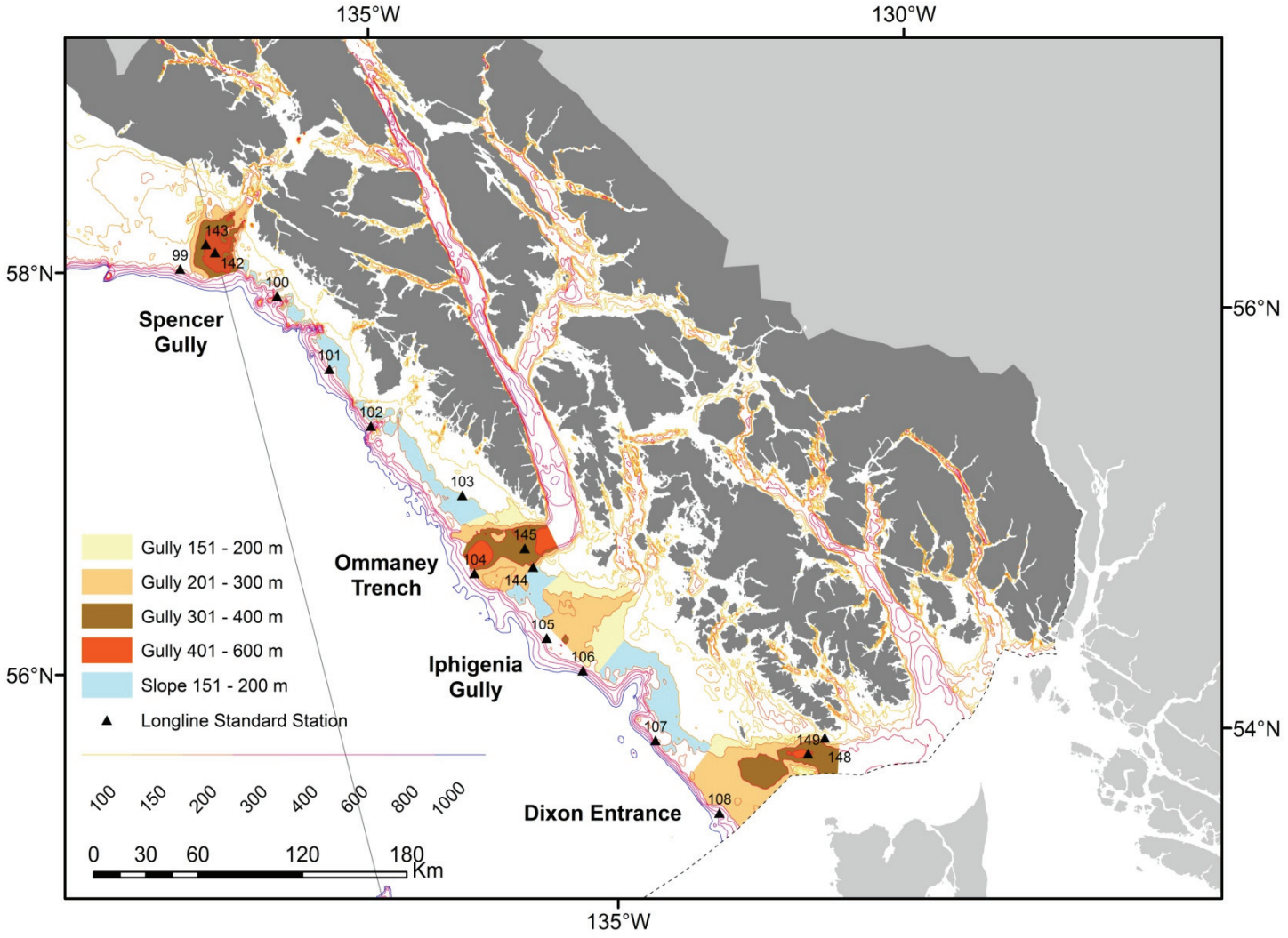


Figure 5.-- Dixon Entrance. Stations 148 and 149 are sampled within Dixon Entrance. The track lines for these stations are shown within the gully in black. Please note that these track lines may not accurately depict how the longline actually lays on the ocean floor while fished. The thin dashed black line is the U.S. Exclusive Economic Zone (EEZ).

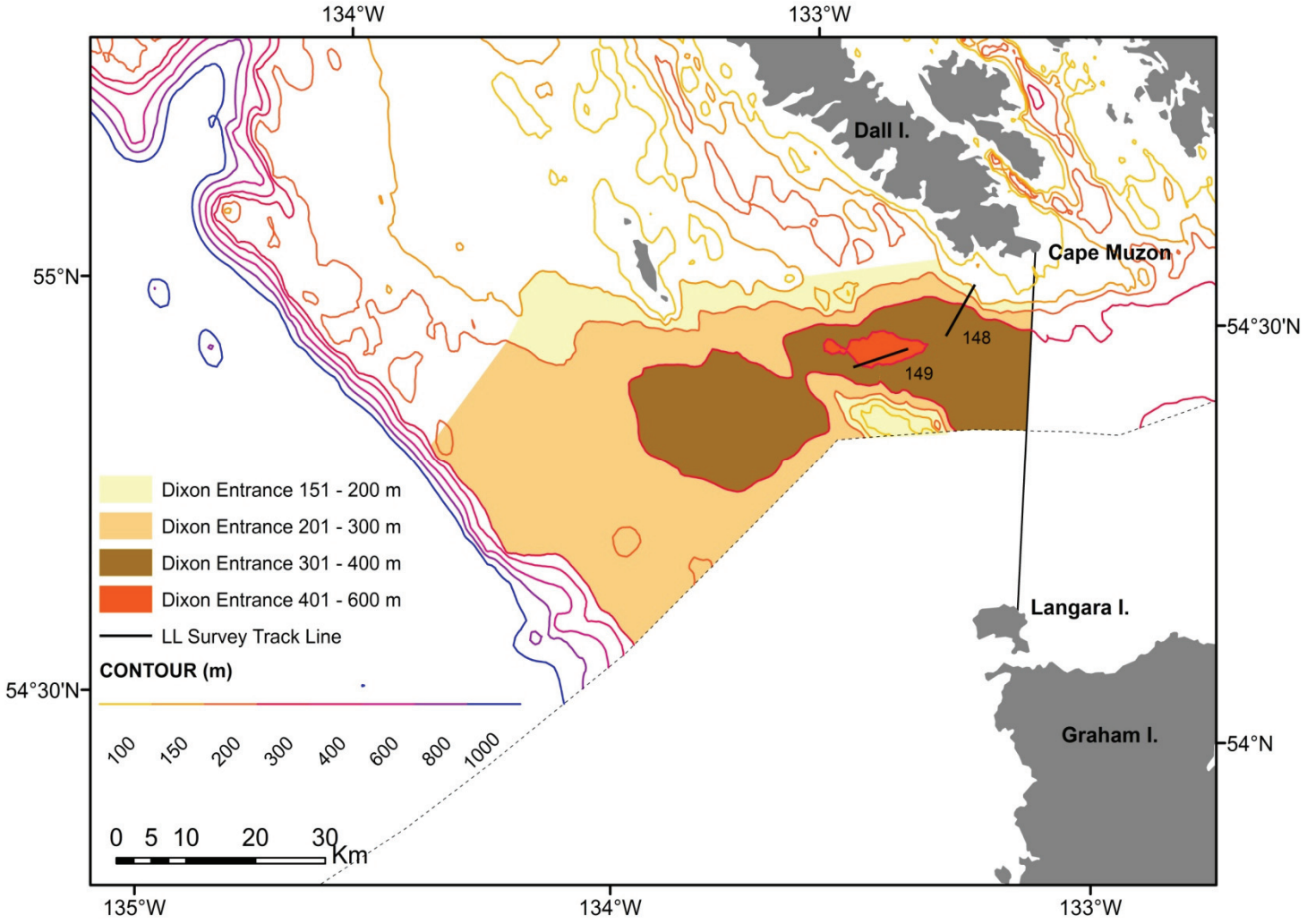


Figure 6.-- Iphigenia Gully.

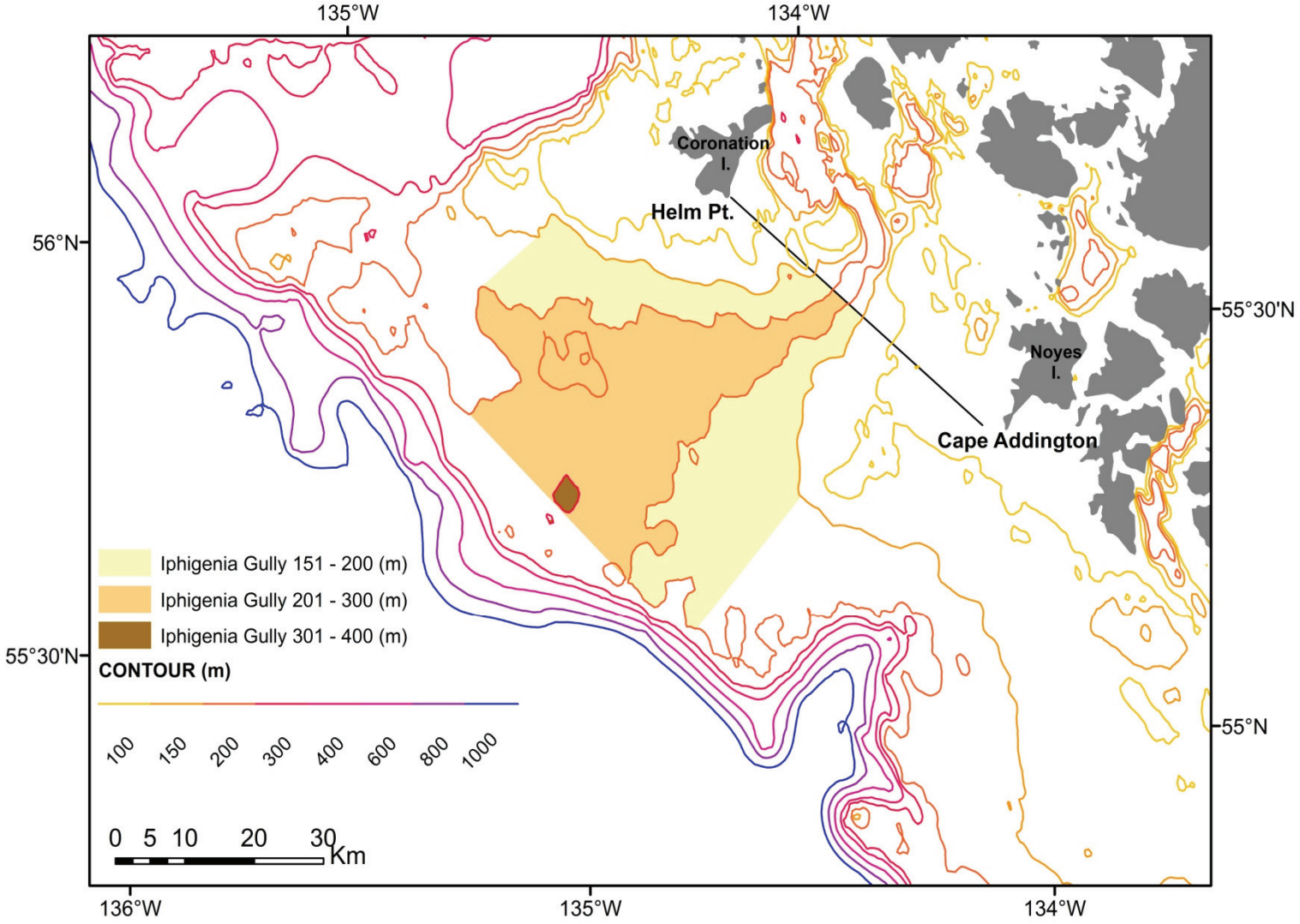


Figure 7.-- Ommaney Trench. Stations 144 and 145 are sampled within Ommaney Trench. The track lines for these stations are shown within the gully in black. Please note that these track lines may not accurately depict how the longline actually lays on the ocean floor while fished.

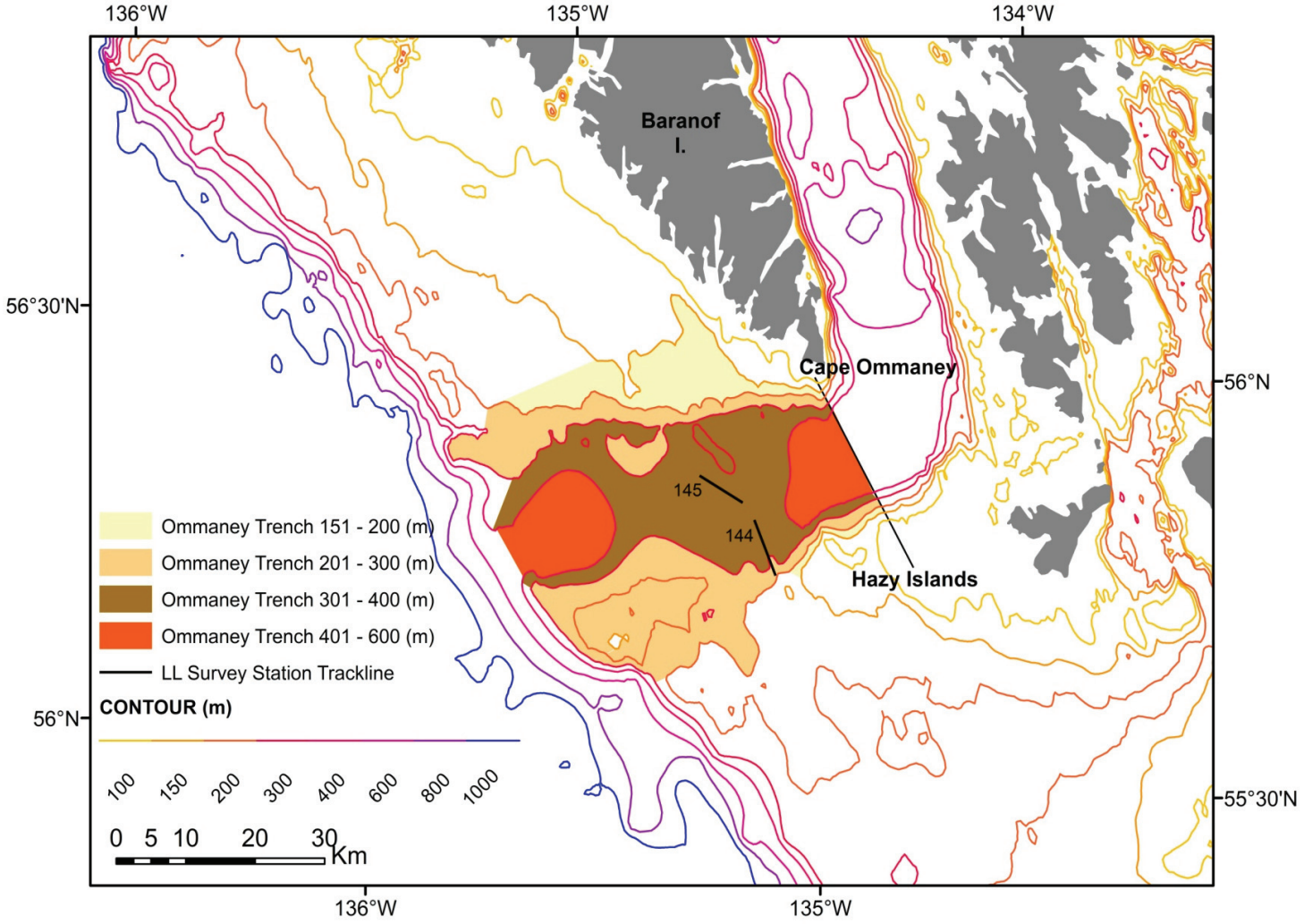


Figure 8.-- Spencer Gully Southeast (SE). Longitude 137° W is the boundary line between West Yakutat and Southeast Outside Areas.

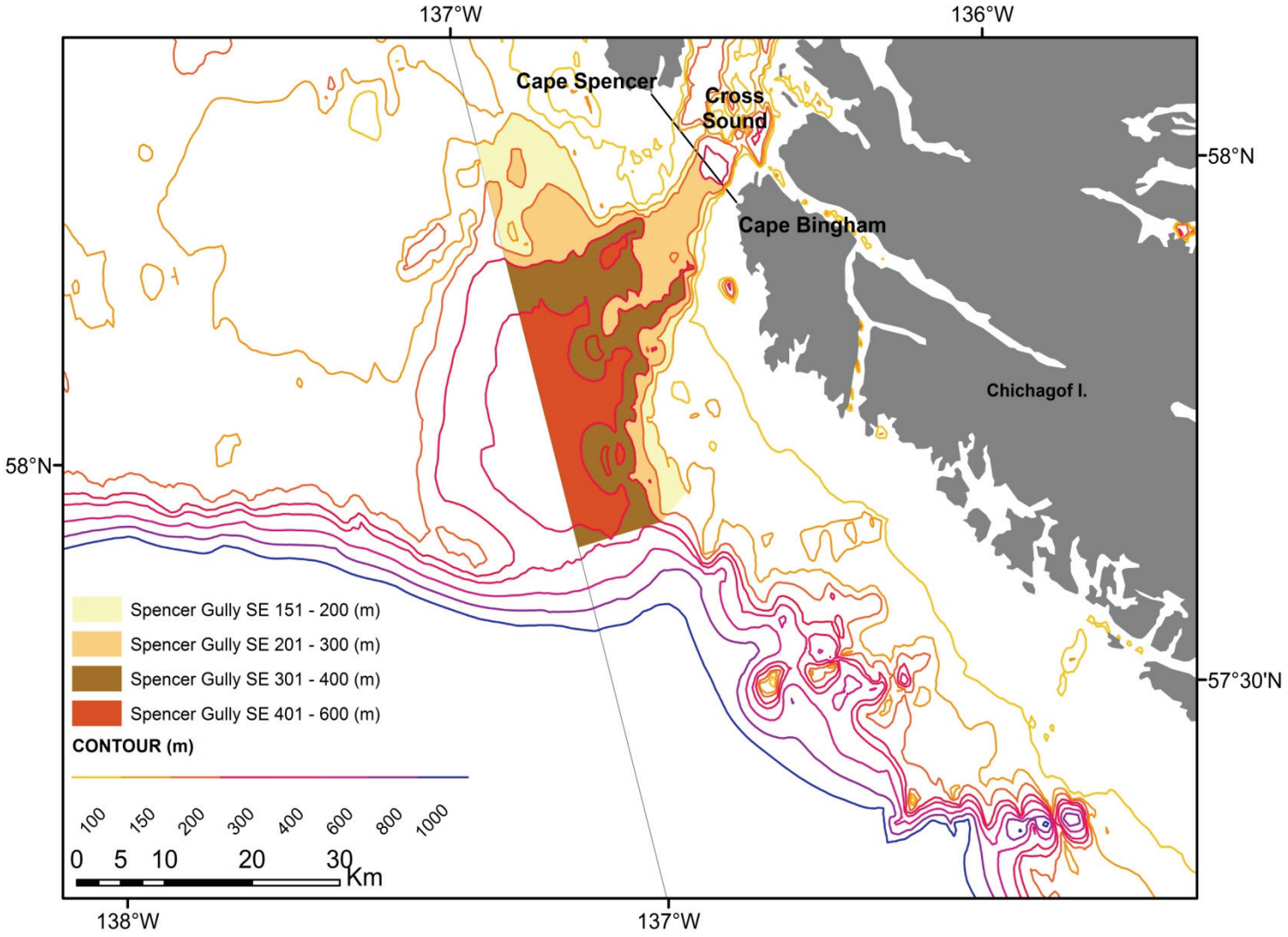


Figure 9.-- Longline survey stations and gullies within the West Yakutat Area. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters. The 140° W longitude separates West and East Yakutat.

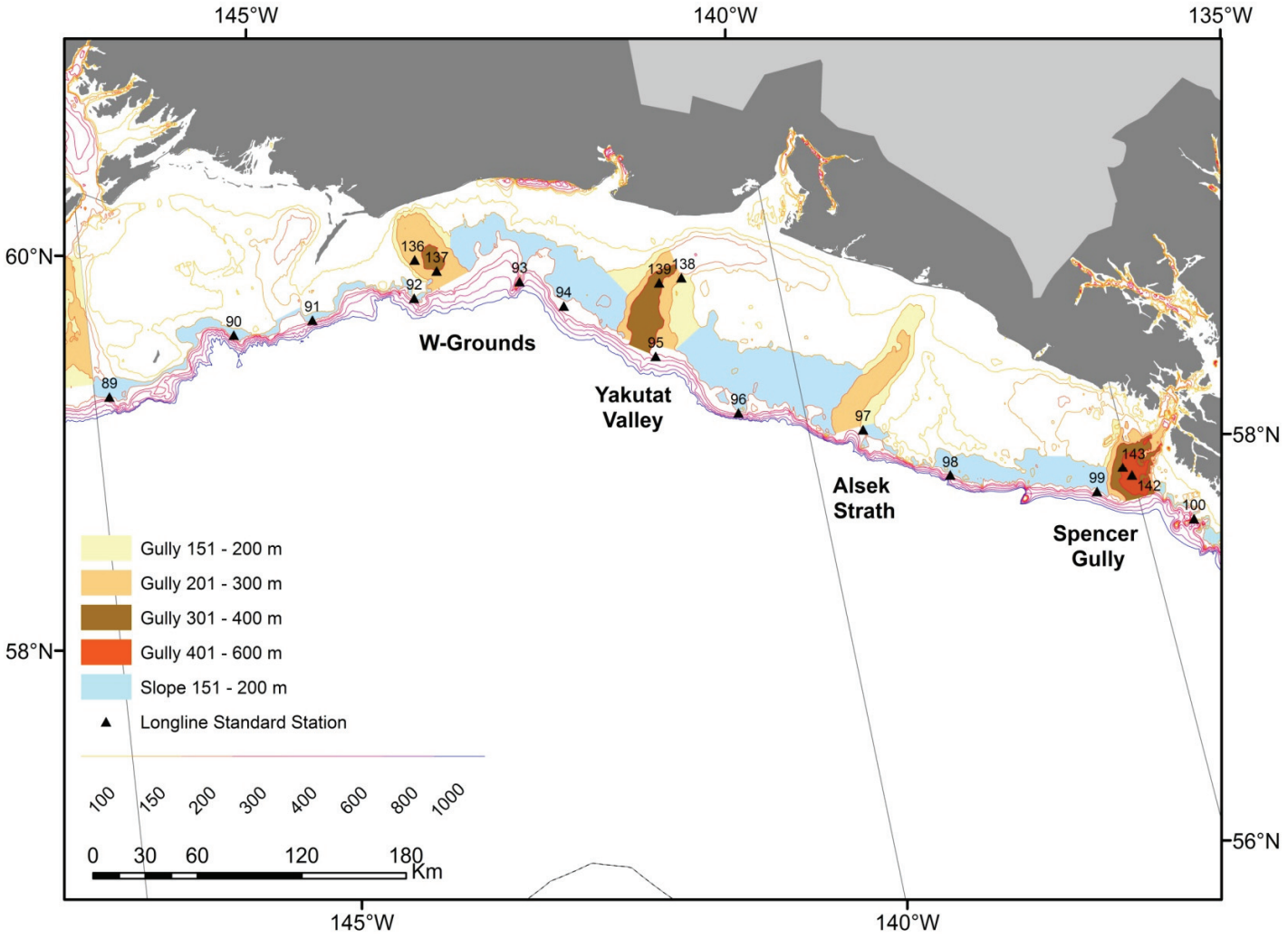


Figure 10.-- Spencer Gully Yakutat (YAK). Stations 142 and 143 are sampled within Spencer Gully YAK. The track lines for these stations are shown within the gully in black. Please note that these track lines may not accurately depict how the longline actually lays on the ocean floor while fished. Longitude 137° W is the boundary line between West Yakutat and Southeast Outside Areas.

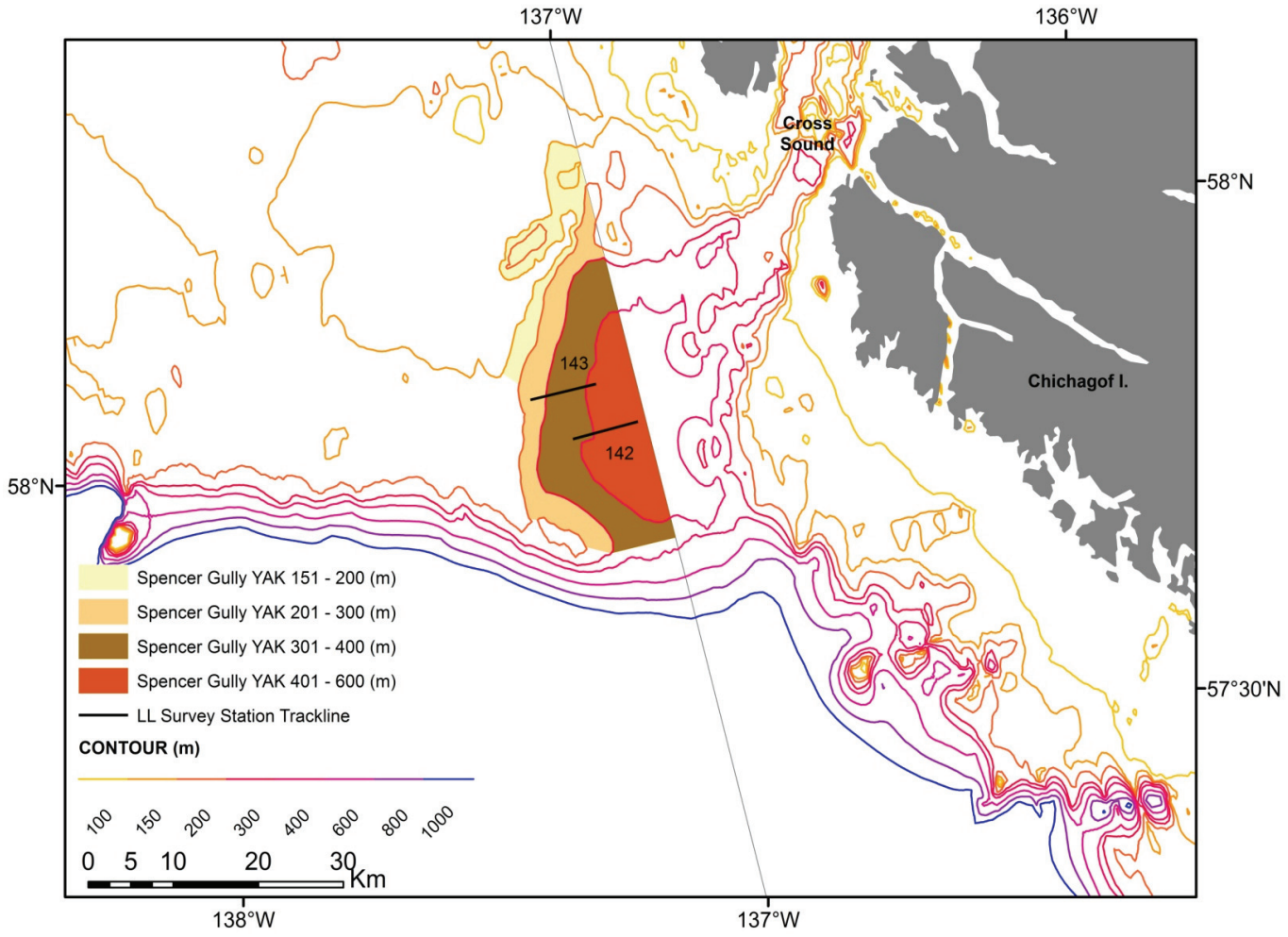


Figure 11.-- Alsek Strath. Longitude 140° W is the boundary line between West Yakutat and East Yakutat.

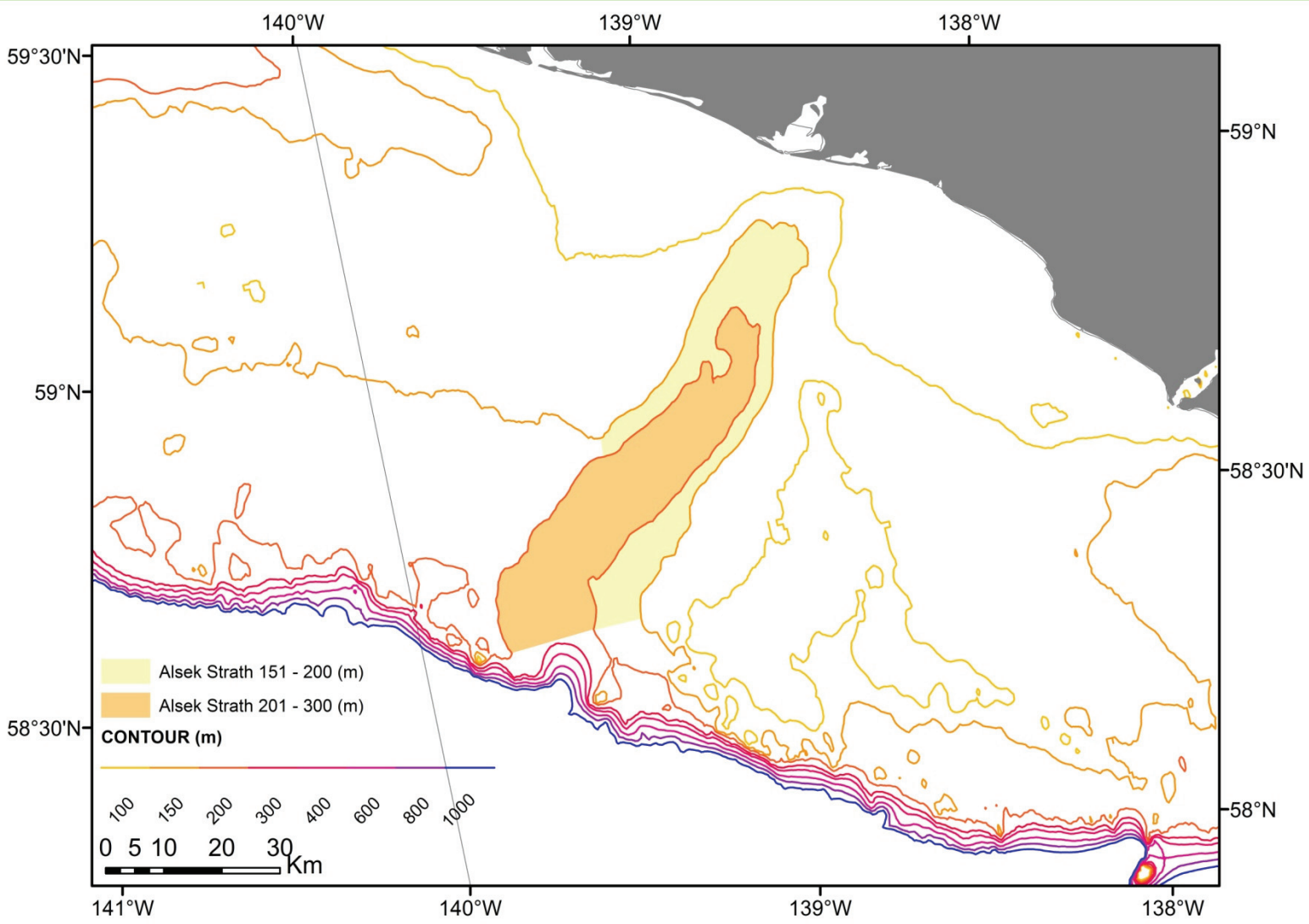


Figure 12.-- Yakutat Valley. Stations 138 and 139 are sampled within Yakutat Valley. The track lines for these stations are shown within the gully in black. Please note that these track lines may not accurately depict how the longline actually lays on the ocean floor while fished. Longitude 140° W is the boundary line between West Yakutat and East Yakutat.

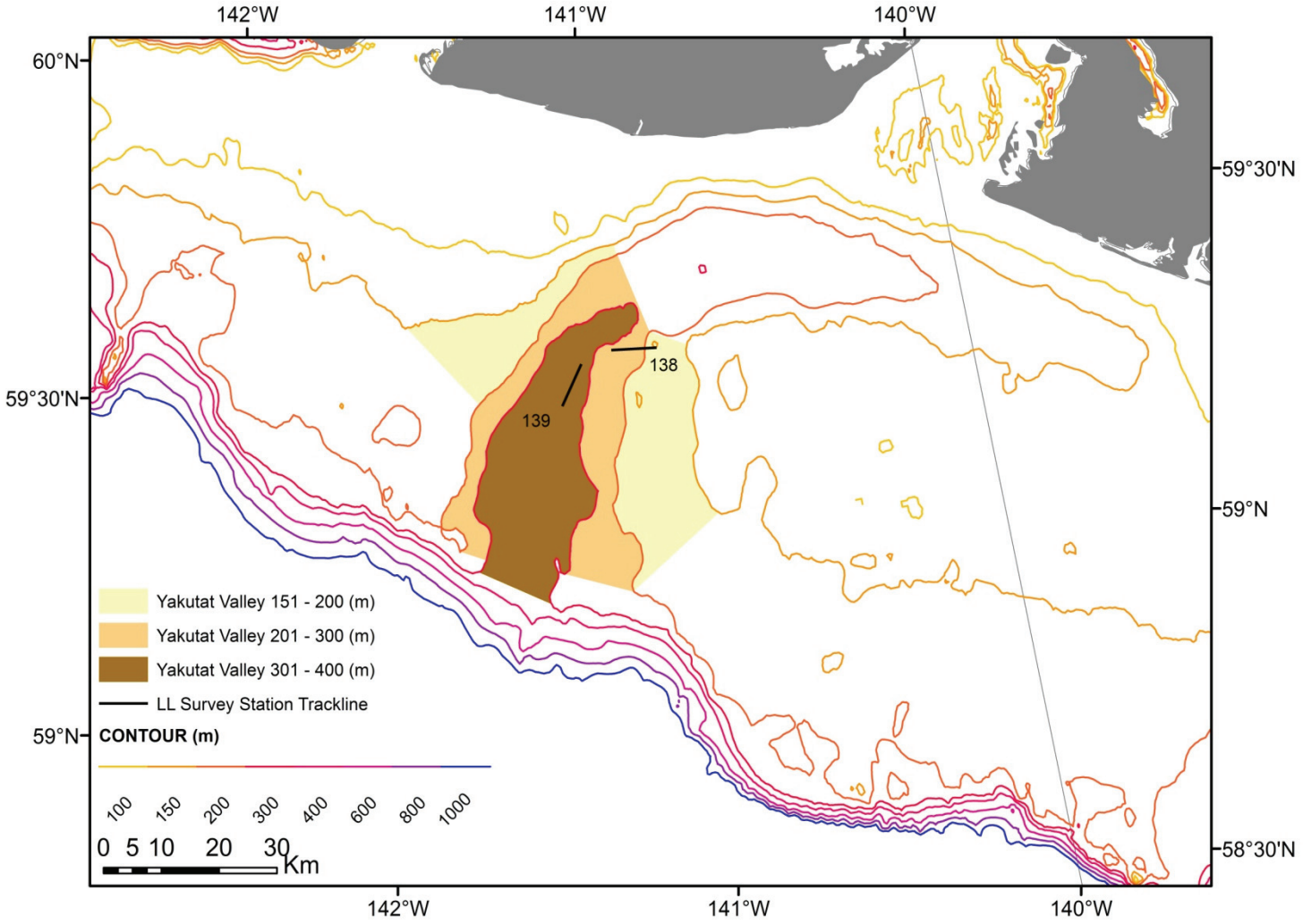


Figure 13.-- W-Grounds. Stations 136 and 137 are sampled within the W-Grounds. The track lines for these stations are shown within the gully in black. Please note that these track lines may not accurately depict how the longline actually lays on the ocean floor while fished.

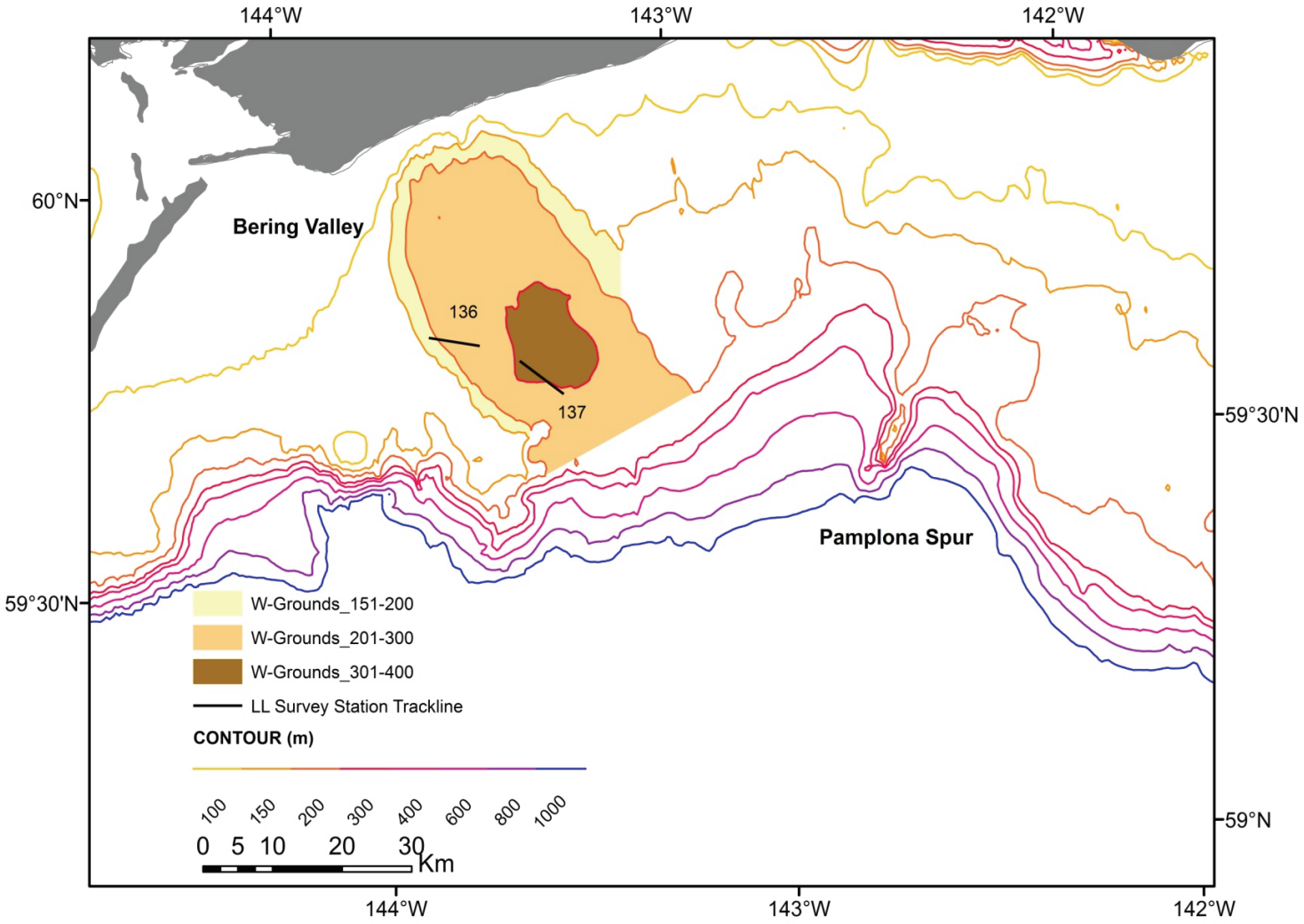


Figure 14.-- Longline survey stations and gullies within the Kodiak Area. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.

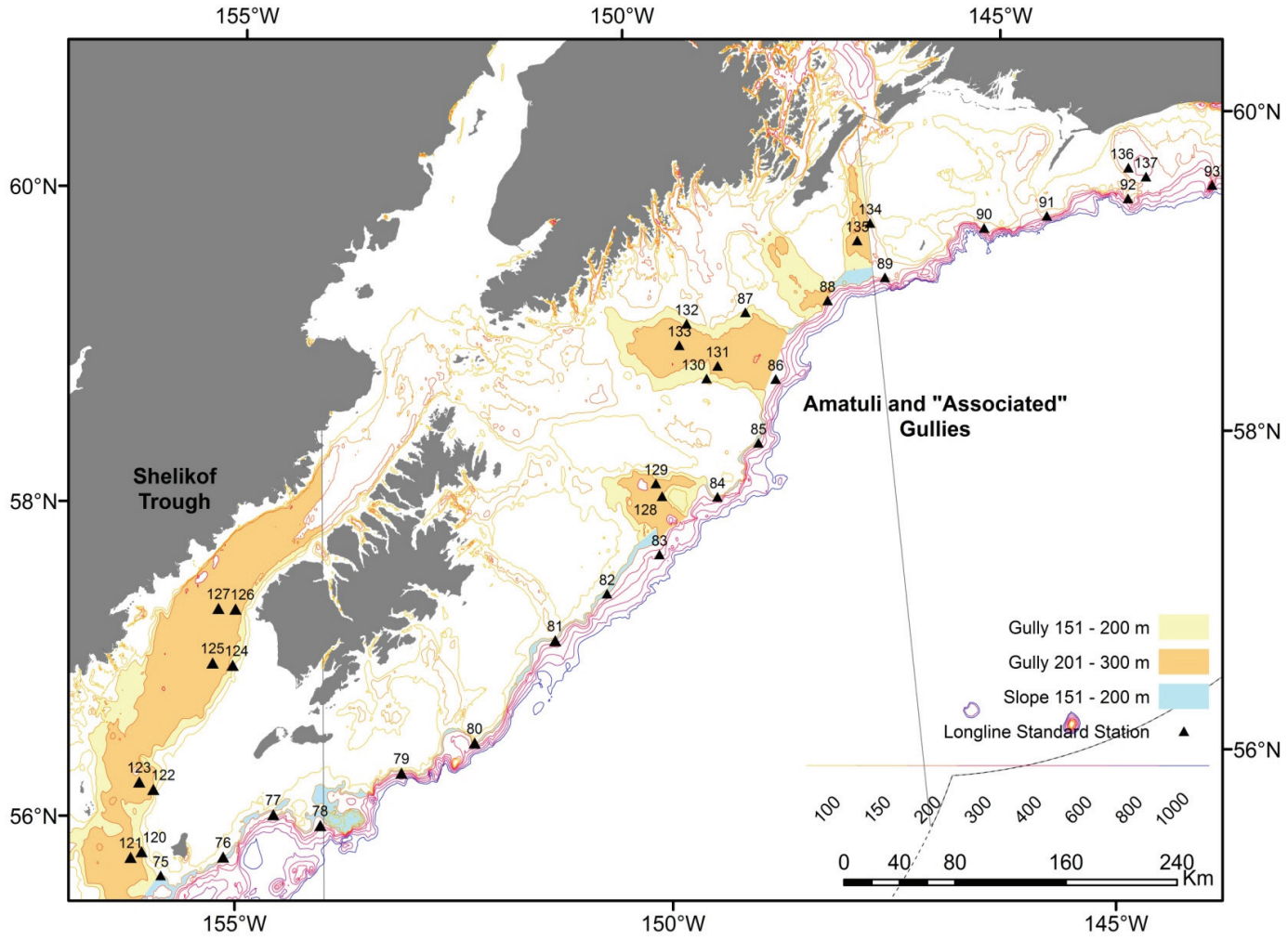


Figure 15.-- Amatuli Gully and associated gullies. Stations sampled within Amatuli Gully include the following: 87, 128, 129, 130, 131, 132,133, 134, and 135. The track lines for these stations are labeled by station number and shown within the gully in black. Please note that these track lines may not accurately depict how the longline actually lays on the ocean floor while fished. Longitude 147° W is the boundary line between West Yakutat and Kodiak Areas.

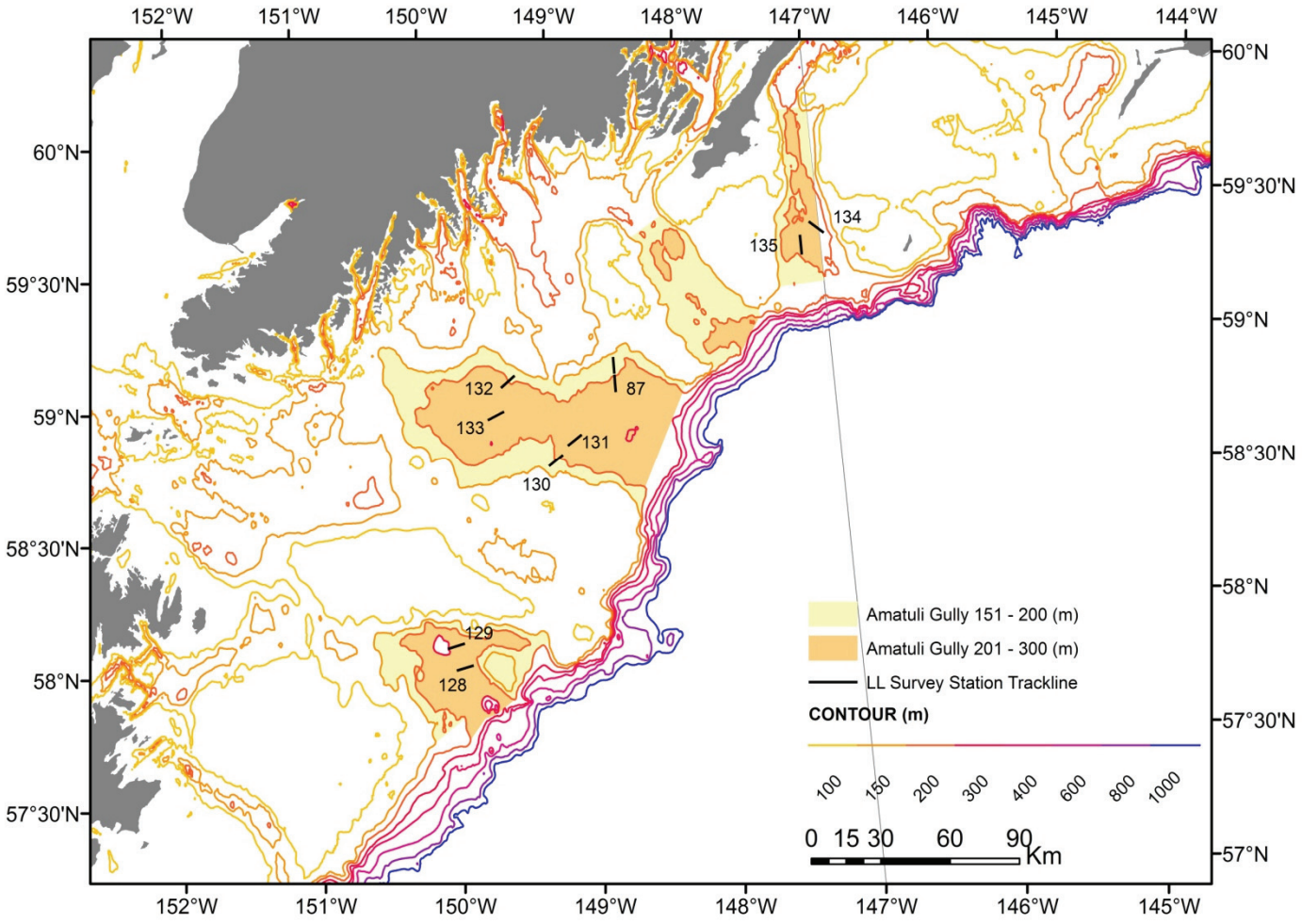


Figure 16.-- Longline survey stations and gullies within the Chirikof Area. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.

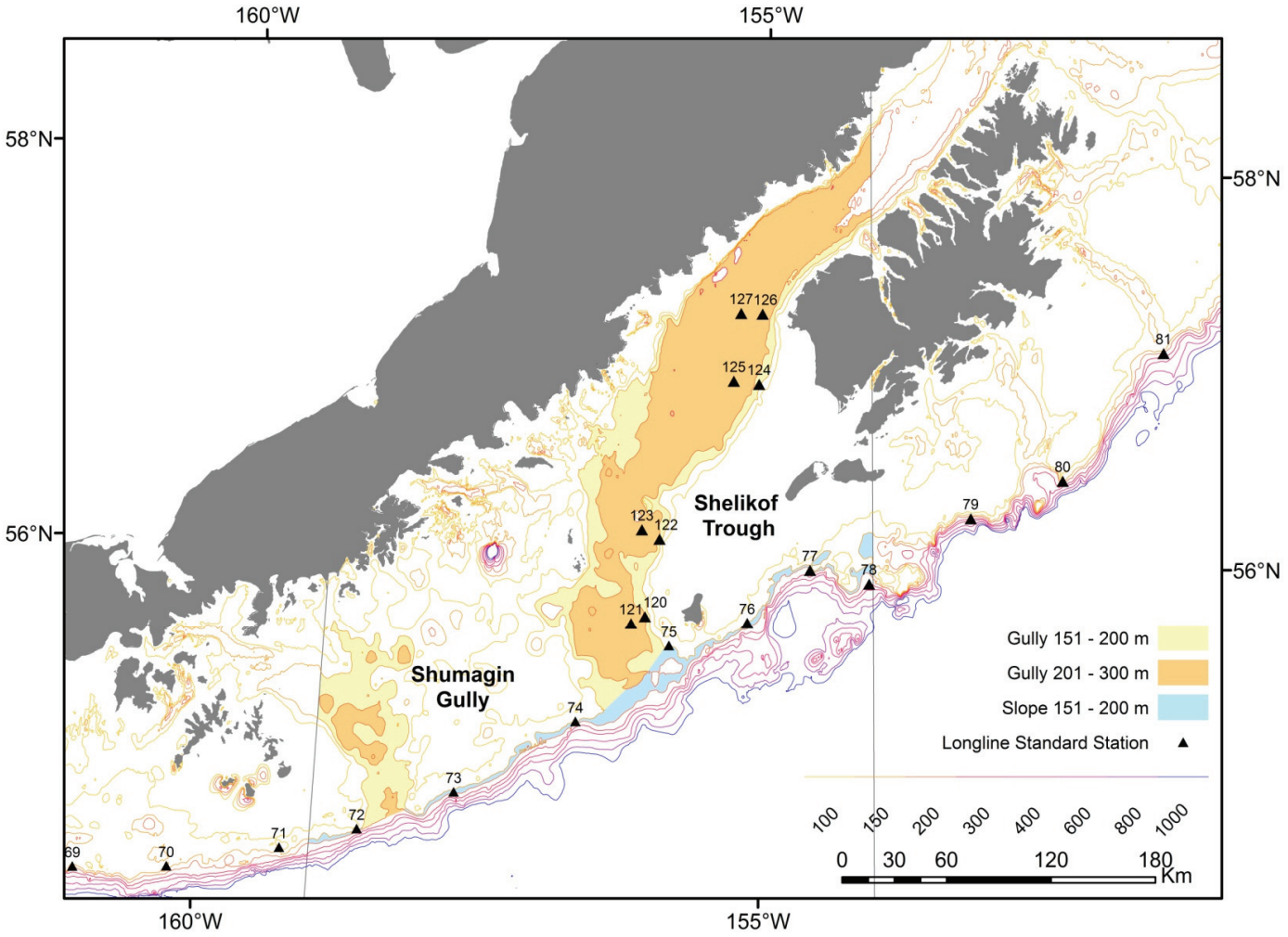


Figure 17.-- Shelikof Trough. Stations sampled within Shelikof Trough include the following: 120, 121, 122, 123, 124, 125,126, and 127. The track lines for these stations are labeled with station number and are shown within the gully in black. Please note that these track lines may not accurately depict how the longline actually lays on the ocean floor while fished. Longitude 154° W is the boundary line between Kodiak and Chirikof Areas.

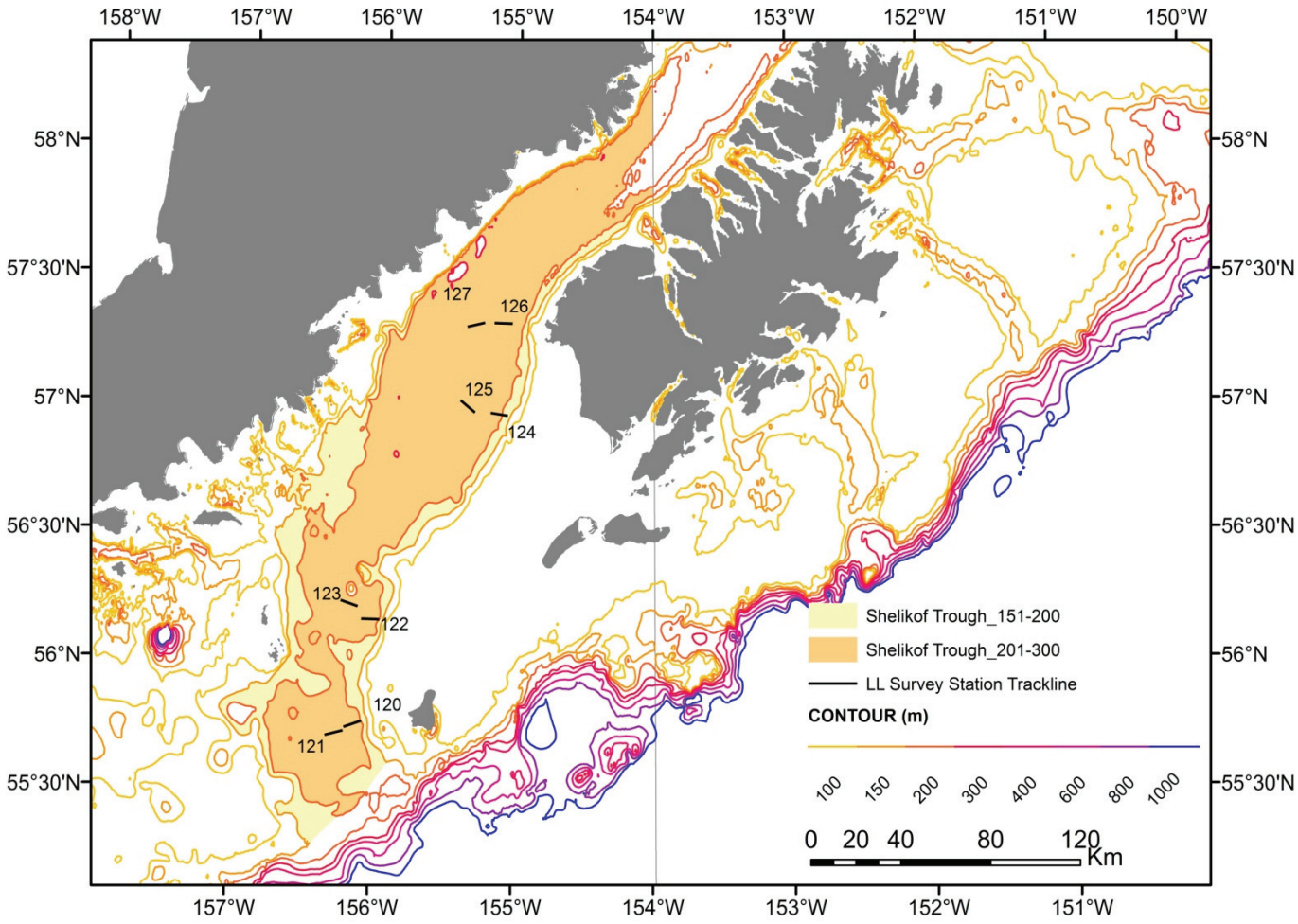


Figure 18.-- Shumagin Gully. Longitude 159° W is the boundary line between Chirikof and Shumagin Areas.

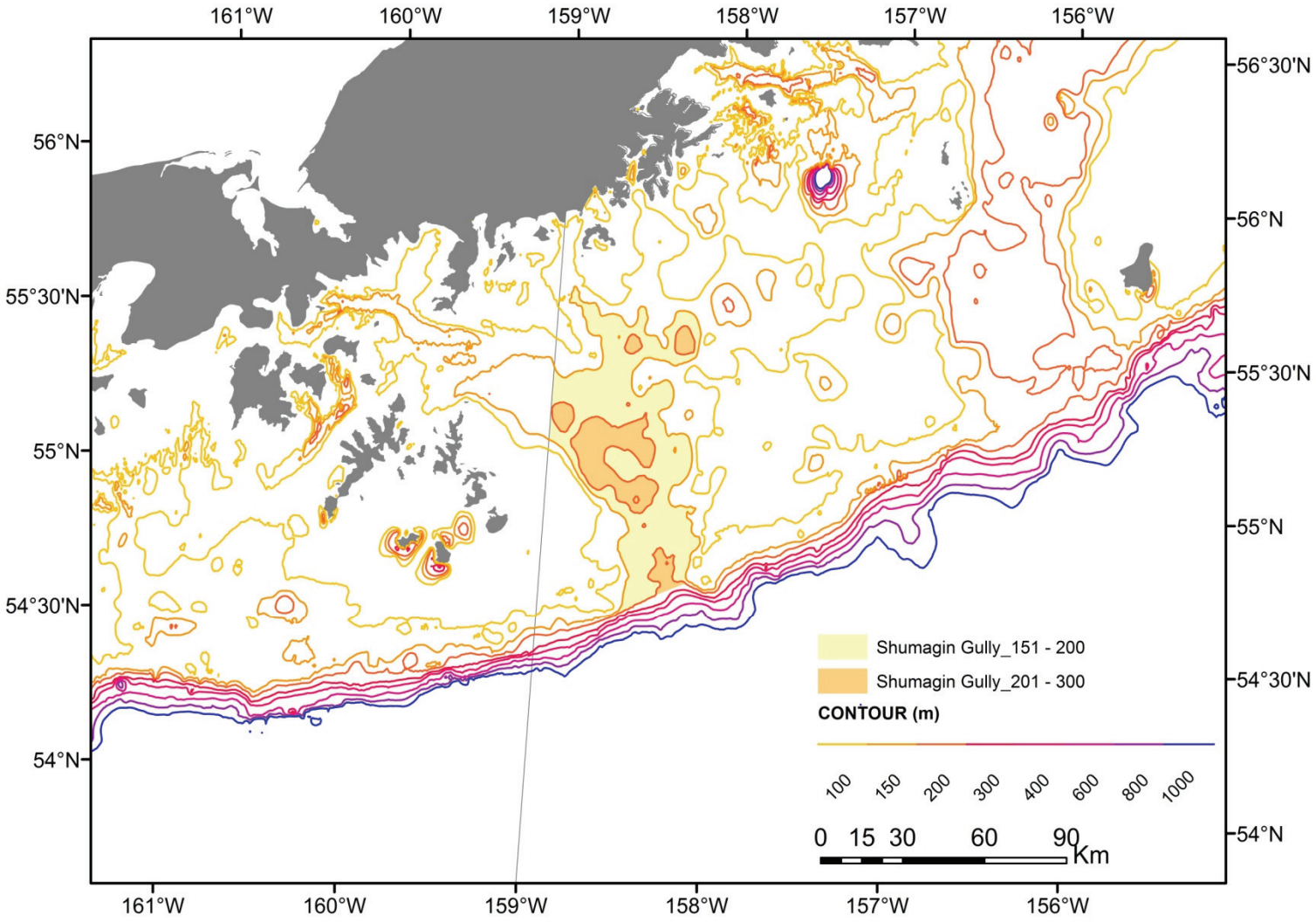


Figure 19.-- Longline survey stations and gullies within the Shumagin Area. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.

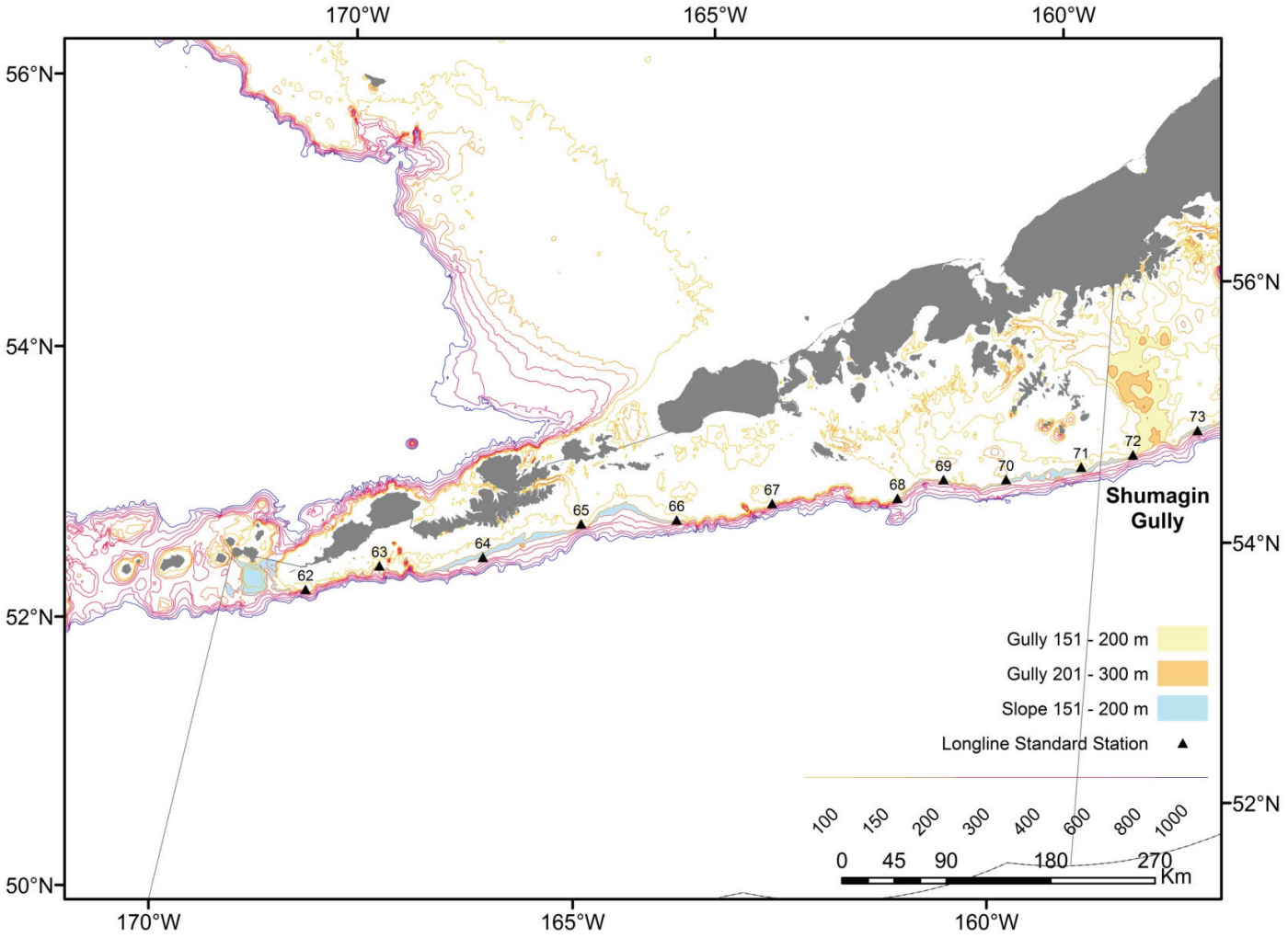


Figure 20.-- Longline survey stations within the East Aleutian Islands Area. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.

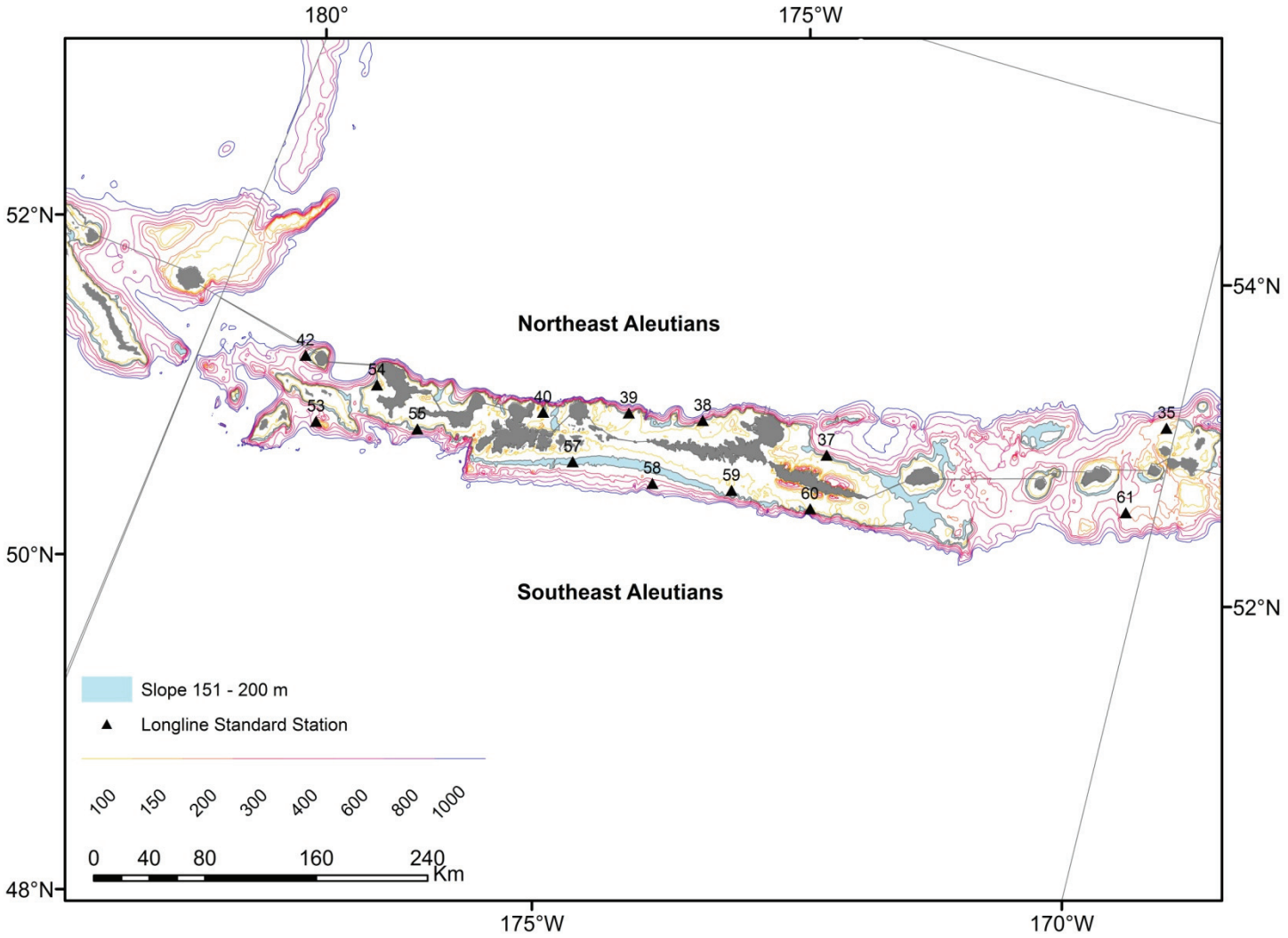


Figure 21.-- Longline survey stations within the West Aleutian Islands Geographic Area. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.

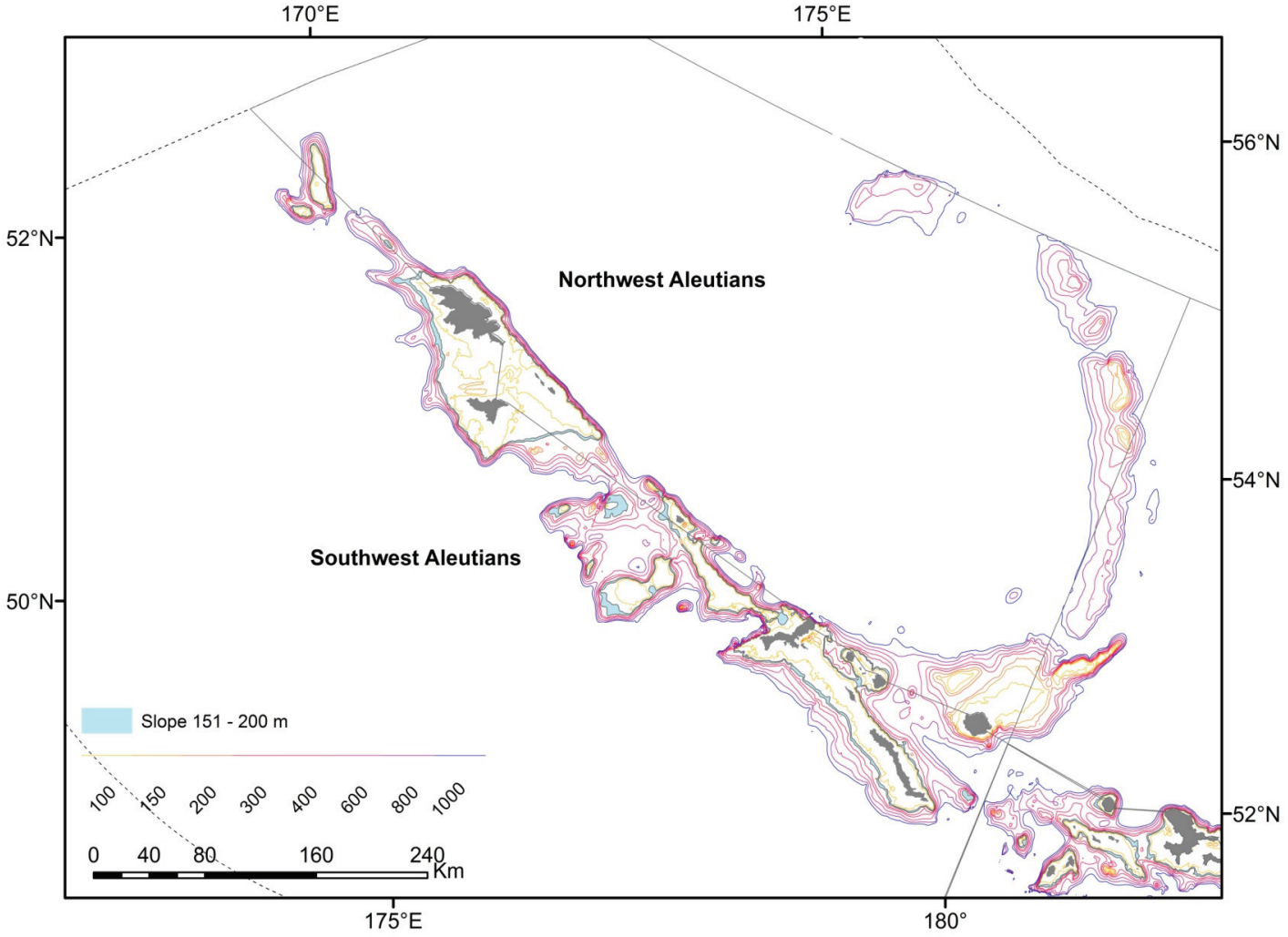


Figure 22.-- Longline survey stations within the Eastern Bering Sea Regions I and II. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.

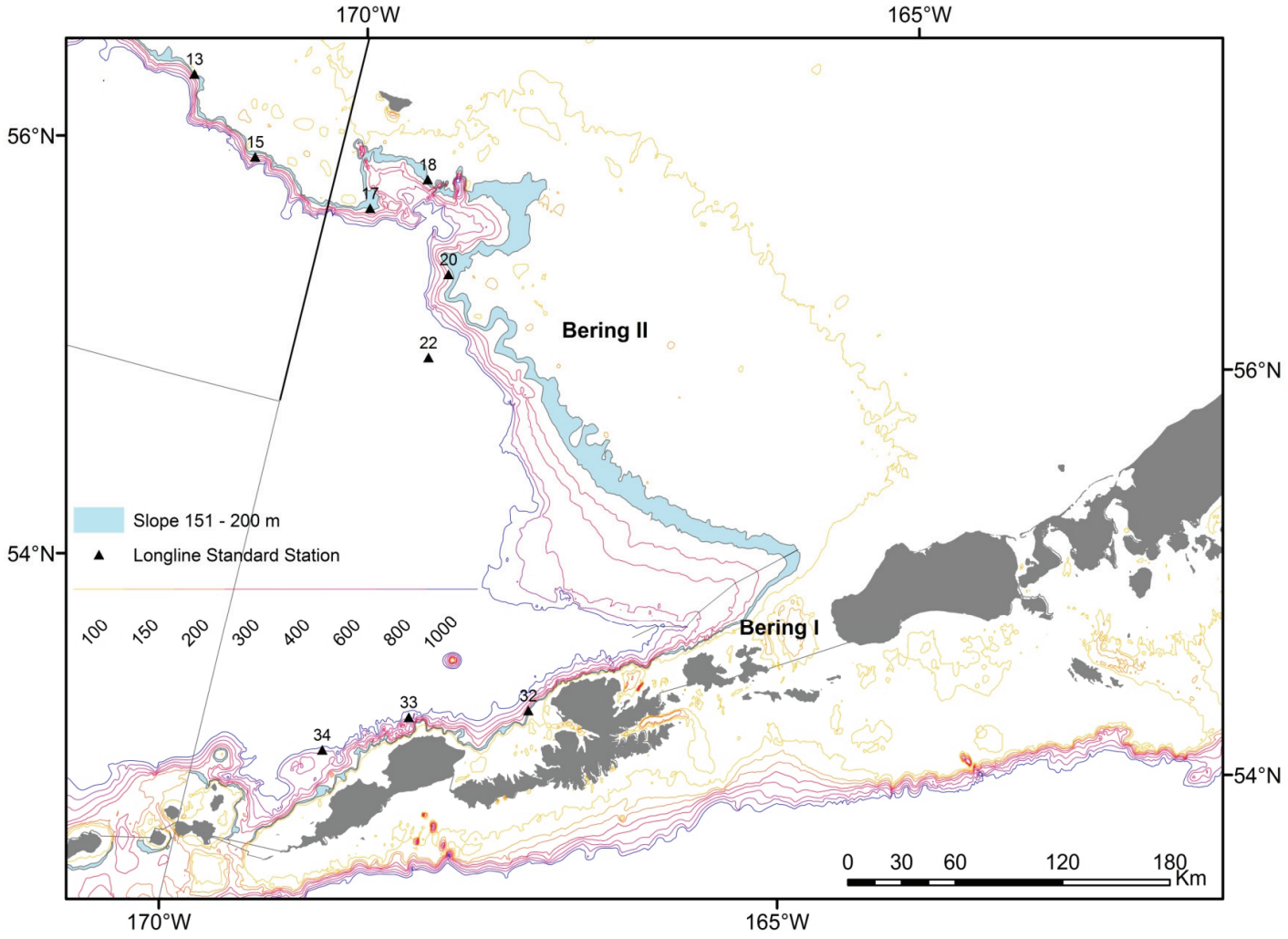
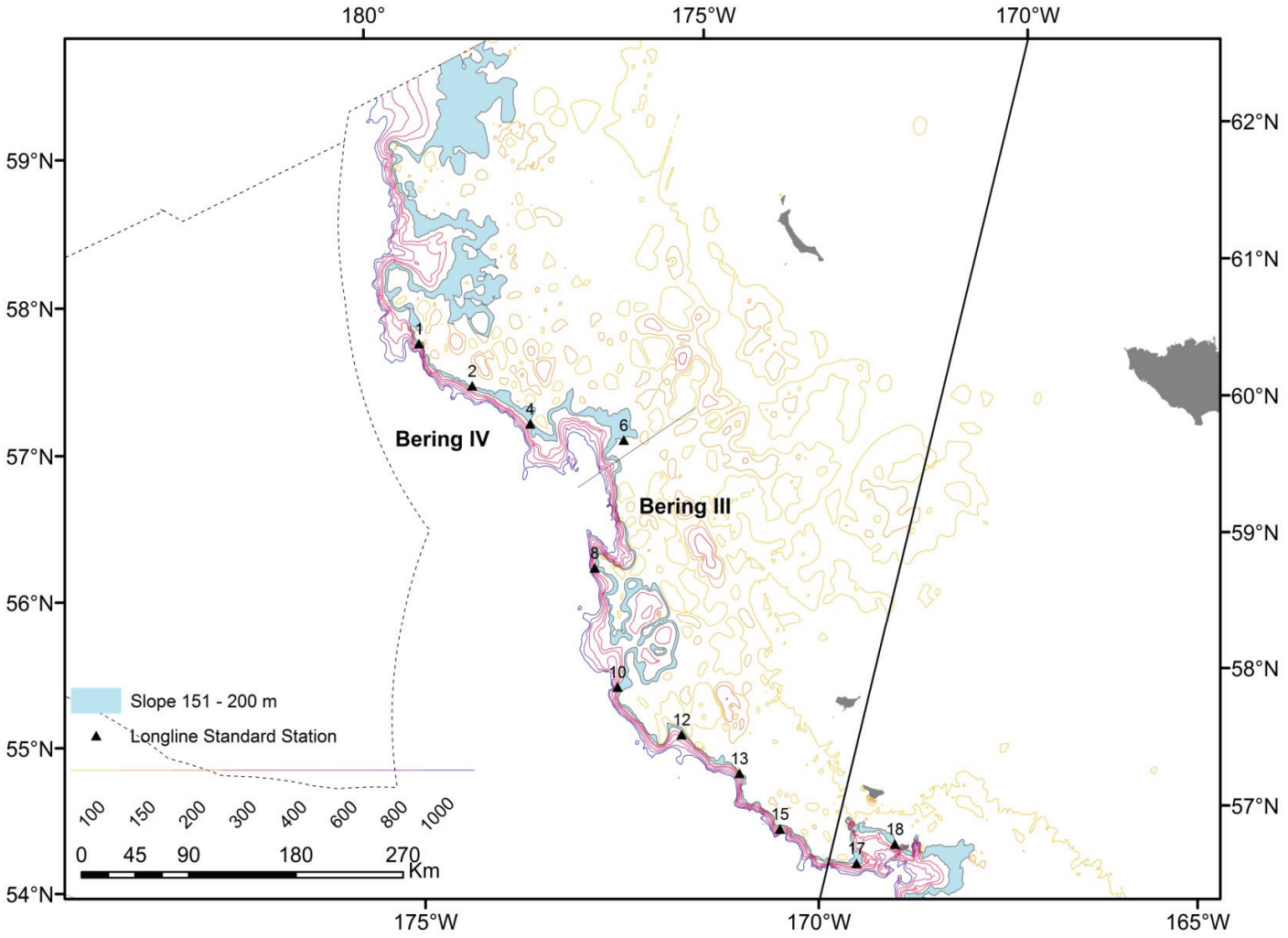


Figure 23.-- Longline survey stations within the Eastern Bering Sea Regions III and IV. The blue shaded area designated as Slope 151-200 m is the newly created shallow stratum. Depth contours are in meters.



APPENDIX 1

HAIGHT'S 1987 IN-HOUSE TECHNICAL REPORT

In 1987, Richard E. Haight, a researcher with the Auke Bay Laboratory, produced an in-house technical report documenting the calculation of the area for several distinct geographic sites in the Eastern Gulf of Alaska, from the Canadian border at Dixon Entrance north and west to 144°30' W at Cape St. Elias, based on depth zone and by 30 minute increments. This report was prepared for the 1987 triennial GOA trawl survey for assessing the abundance of groundfish in the Eastern Gulf of Alaska. The following appendix presents the report in its entirety. Original page numbers are in parentheses in the upper right of each page.

ABL MARINE INVESTIGATIONS

In House Technical Report

Square Nautical Miles and Kilometers Within Depth Zones of Geographic Sites In The Eastern Half of the Gulf of Alaska

Richard E. Haight

U.S. DEPARTMENT OF CCM1ERCE

National Oceanic and Atmospheric Administration

National Marine Fisheries Service

Auke Bay Laboratory

This report will appear later as part of a Technical Memorandum.

JUNE 1987

TABLE OF CONTENTS

INTRODUCTION

This material was prepared specifically for the 1987 triennial for assessing the abundance of groundfish in the eastern Gulf of Alaska. It gives the area, in square nautical miles and square kilometers, of several distinct geographic sites.

That part of the Gulf covered is from Dixon Entrance, in the Southern most part of Southeast Alaska, north then west to 144 30' W longitude at cape St. Elias located on Kayak Island.

The geographic sites considered are, from south to north: Dixon Entrance, Christian Sound, Cross Sound, Fairweather Ground, Alsek Strath, Yakutat Valley, the area around the Pamplona Searidge and Bering Valley (collectively called the W Ground), the shelf between all of these sites, and the slope between and below all of these sites.

Area data is given for these depth zones: 0-100 mm, 100-200 mm, 200-300 mm, 300-500 mm, 500-700 mm, and 700-1000 mm.

METHODS AND MATERIALS

Five NOAA, NOS charts, with coverage of the eastern half of the Gulf of Alaska, were selected to work from. Four were nautical charts: 16016, 16760, 17320, and 17400. The fifth was a bathymetric map, 1513N-10, already done in meters.

Contour lines were drawn, on the nautical charts, in intervals of 100 meters beginning with 100 m and ending with 1000 m. When necessary, to better depict the ocean floor, contours were drawn every 50 meters.

Square nautical miles (nmi ^{2}) were taken from the charts using a compensating polar planimeter. The planimeter gives area readings in square inches, which are converted to square nautical miles. This was done by finding the square inches in 100 nmi^2 on the charts and using the ratio between the two to convert the planimeter readings into square miles.

Square nautical miles were converted into square kilometers, using the following formula:

$$km^2 = nmi^2 \times 3.43$$

Square miles and kilometers are presented, in the Southeastern INPFC area, for each 30 minutes of latitude. In the Yakutat area, areas are determined for increments of 30 minutes of longitude. The terms: "INPFC Section, statistical section, section, lat. section, or long. section", are used to identify these 30 minute increments.

DIXON ENTRANCE - NORTH OF 54°30' N LAT.

The mouth, of the broad trench that forms Dixon Entrance, is 17 nautical miles west of Graham Island (Figure 1). Here, the 350 m contour turns in to form the entrance and create the floor of the shelf located in the mouth of the entrance. The 400 m depth contour passes in front of the entrance, but in Dixon Entrance, east of the 350 m deep shelf, are 400 m deep basins located on either side of Learmont Bank. The entrance into Dixon Entrance, on the south side, is clearly marked. All of the depths contours turn abruptly into the entrance within a few miles of each other, and from the outset, the sides are quite steep.

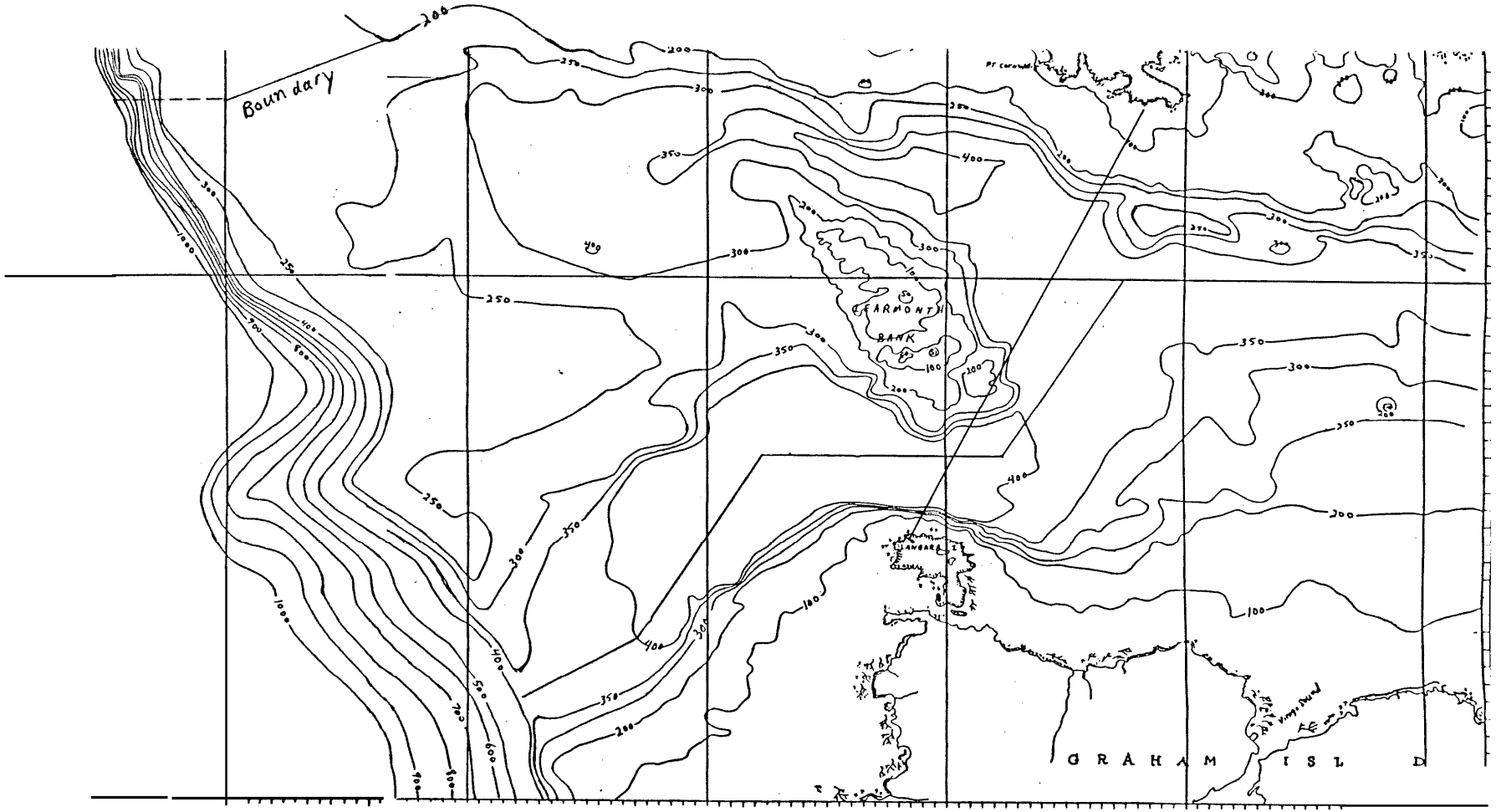


Figure 1. Dixon Entrance. The area considered is north of 54°30', and west of the line from Cape Muzon to Langara Island. The northern boundary of Dixon Entrance runs along the 200m depth contour, then on- a line over to 1349 W longitude and from there on the dotted line on 54°40' N latitude.

On the north side of Dixon Entrance, the 200 m depth contour forms a distinct boundary between shelf and the northern side of the trench. At 54°43.5'N lat. × 133°46.4'W long., this contour makes an abrupt turn to the north. However, the 200-300 m depth zone forms a broad band west and south of this area, and there is no distinct transition between trench and shelf or slope. The slope begins at about the 250 m contour. I arbitrarily drew a line from the demarcation point on the 200 m contour, to 54° 40' N lat. × 134° W long, then due west. Anything north of this line is shelf or slope and anything south of the line is in Dixon Entrance.

North of 54° 30', the area in Dixon Entrance between 300-500 m is 247.94 nmi^2 or 854.97 km^2 (Table 1). Of the 247.94, 6.78 nmi^2 is on the slope.

Table 1. Square nautical miles and kilometers in basin of Dixon Entrance north of latitude 54°30' and west of a line from Cape Muzon to Langara Island.

Latitude section	Area in 300-500 m depth zone	
	nmi^2	km^2
54°30’-55°00’	247.94	850.43

SLOPE AND SHELF FROM DIXON ENTRANCE TO CHRISTIAN SOUND

Four statistical sections are involved on this stretch of the coast line (Table 2). For the section, 54°30'-55°00', most of the 300-500 m depth zone was included in Dixon Entrance. A 14.43 nmi^2 area is on the slope.

All of section 55°00' - 55°30' is in this area. Part of the northern end of section 55°30'-56°00' is in Christian Sound, principally more than half of the 300-500 m depth zone (Figure 2).

Table 2a. Square nautical miles within depth zones located on the Continental shelf and slope between Christian Sound and Dixon Entrance. Not included are the 300-500 m depth zones in Christian Sound and Dixon Entrance that form the basins in both submarine valleys.

Latitude	Square nautical miles in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
54°30' - 55°00'	85.97	538.84	451.02	14.43	62.67	22.84
55°00' - 55°30'	165.15	646.70	180.48	48.51	46.83	104.48
55°30' - 56°00'	186.46	496.83	534.99	43.84	50.82	114.52
56°00' - 56°30'	0	0	1.22	7.06	7.53	12.36
Total	437.58	1682.37	1167.71	113.84	167.85	254.20

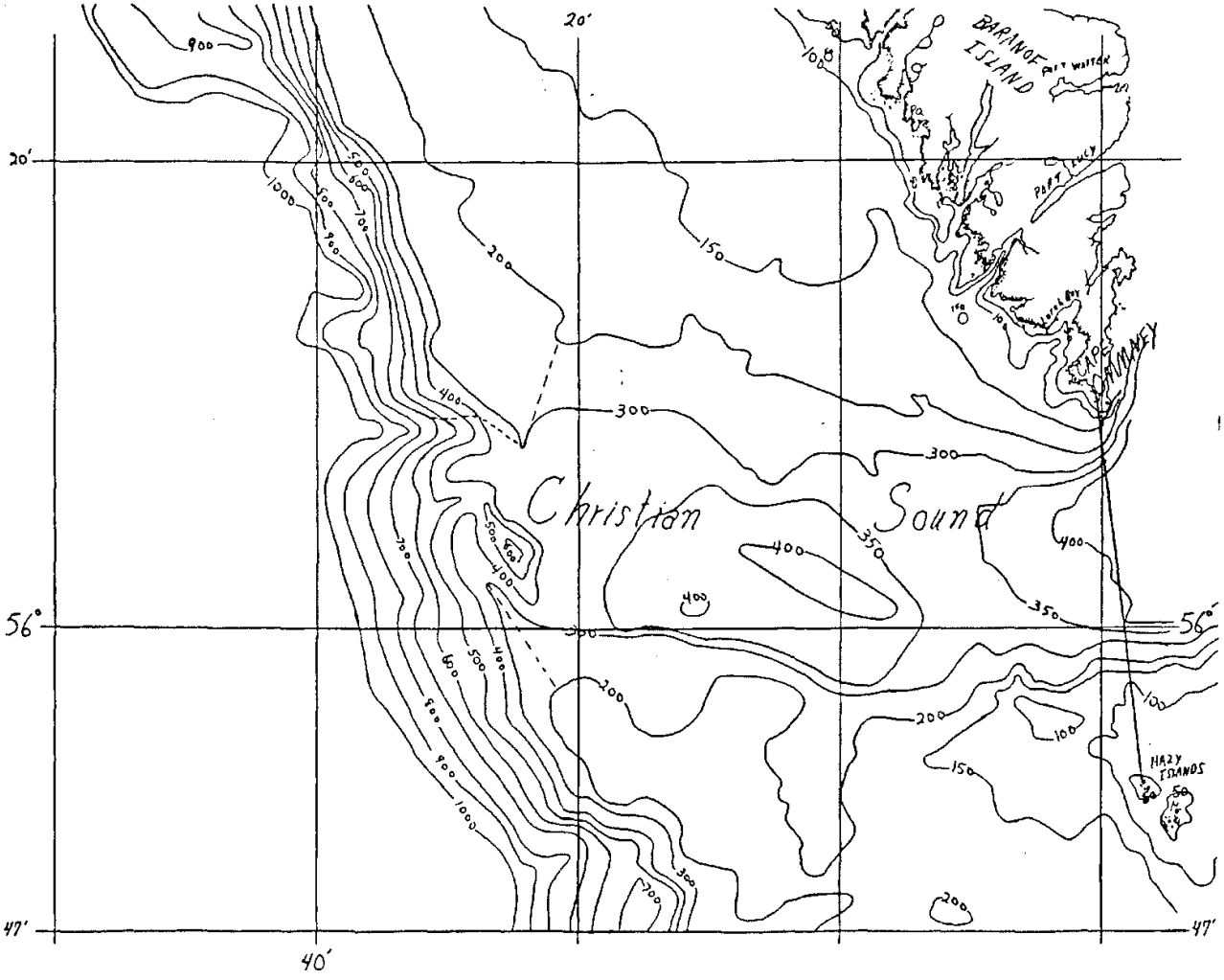
Table 2b. Square kilometers within depth zones located on the Continental shelf and slope between Christian Sound and Dixon Entrance. Not included are the 300-500 m depth zones in Christian Sound and Dixon Entrance that form the basins in both submarine valleys.

Latitude	Square kilometers in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
54°30' - 55°00'	294.88	1848.22	1547.00	49.49	214.96	78.34
55°00' - 55°30'	566.46	2218.18	619.05	166.39	160.63	358.37
55°30' - 56°00'	639.56	1704.13	1835.02	150.37	174.31	392.80
56°00' - 56°30'	0	0	4.18	24.22	25.83	42.39
Total	1500.90	5770.53	4005.25	390.47	575.73	871.91

CHRISTIAN SOUND

The trench or valley, beneath Christian Sound, is an extention of Chatham Strait (Figure 2). It extends 27 nautical miles off shore, and here, interrupts the shelf as all of the depth zones above 300 m turn towards shore and enter Chatham Strait. There are a couple of depressions in the center of the trench in the 400-500 m depth zone, otherwise the basin of the trench is in the 300-400 m depth zone. At the mouth of the trench is a small depression that drops to a little more than 600 m.

Figure 2. Christian Sound. The southern boundary, over the slope for the 300-500m depth zone, is, 56 N latitude. The northern boundary is marked by the dotted line.



A dotted line, in Figure 2, on the north side of the trench, shows what part of the 300-500 m depth zone, on the slope, is included as a part of Christian Sound. All of the 300-500 m zone, along 56°N latitude is included into the trench.

The area measurements stopped on the east end of the trench by a line running from cape Ommaney to the Hazy Islands. The latter are located about 8 miles west of Coronation Island.

Table 3. Square nautical miles and kilometers in basin of Christian Sound.

Latitude section	Area in 300-500 m depth zone	
	nmi^2	km^2
55°30'-56°00'	31.49	108.01
56°00'-56°30'	216.35	742.08
Total	247.84	850.09

SHELF AND SLOPE FROM CHRISTIAN SOUND TO CROSS SOUND

Five INPFC sections make up this part of the coast off Baranof and Chichagof Islands (Table 4). Most of the 300-500 m depth zone of section 56°00' - 56°30', is in Christian Sound. The remainder, in Table 4, is located, on the slope, north of the Sound.

All of the coast, from 56°30' to 57°30' is shelf or slope and appear as two sections in Table 4.

Part of the 300-500 m depth zone of section 57°30'- 58°00' is in the gully in Cross Sound. All of this depth zone, in section 58°00' - 58°30', is in Cross Sound.

Table 4a. Square nautical miles on the shelf and slope between Christian Sound to Cross Sound.

Latitude	Square nautical miles in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
56°00' - 56°30'	42.18	367.22	106.79	33.59	31.45	77.65
56°30' - 57°00'	221.74	324.76	87.77	32.33	30.92	69.37
57°00' - 57°30'	212.46	224.45	35.49	30.00	27.18	54.28
57°30' - 58°00'	129.16	198.92	21.65	24.80	28.98	48.87
58°00' - 58°30'	9.98	7.89	13.63	--	0	0
Total	615.52	1123.24	265.33	120.72	118.53	250.17

Table 4b. Square kilometers on the shelf and slope between Christian Sound to Cross Sound.

Latitude	Square kilometers in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
56°00' - 56°30'	144.68	1259.56	366.29	115.21	107.87	266.34
56°30' - 57°00'	760.57	1113.93	301.05	110.89	106.06	237.94
57°00' - 57°30'	728.74	769.86	121.73	102.90	93.23	186.18
57°30' - 58°00'	443.02	682.30	74.26	85.06	99.40	167.62
58°00' - 58°30'	34.23	27.06	46.75	--	0	0
Total	2111.23	3852.71	910.08	414.07	406.56	858.08

CROSS SOUND

Cross Sound separates INPFC Southeastern Area from the Yakutat Area (Figure 3). It takes in the two northernmost latitude sections of Southeastern and longitude section 137°00'- 137°30', the most eastern section of the Yakutat Area.

The gully, forming Cross Sound, runs about 23 nmi from cape Spencer south west, then south to its mouth located about 18 nmi due west of Chichagof Island (20 miles from Hill Island). The 500 m depth contour crosses the mouth of the gully, but the 400 m contour turns in to form the deepest part of Cross Sound. The 200 m depth contours form the sides of the sound.

The 300-500 m depth zone forming the basin, in Cross Sound, occupies all three sections and is 203 nmmi2 in area (Table 5).

Table 5. Square nautical miles and kilometers in the 300-500 m depth zone in the basin of Cross Sound. The areas given for sections 57°30'-58°00' and 58°00'-58°30' go west to and stop at l37°W long.

Latitude section	Area in 300-500 m depth zone	
	nmi^2	km^2
57°30’-58°00’	67.00	229.81
58°00’-58°30’	41.99	144.03
137°00’-137°30’	94.12	322.83
Total	203.11	696.67

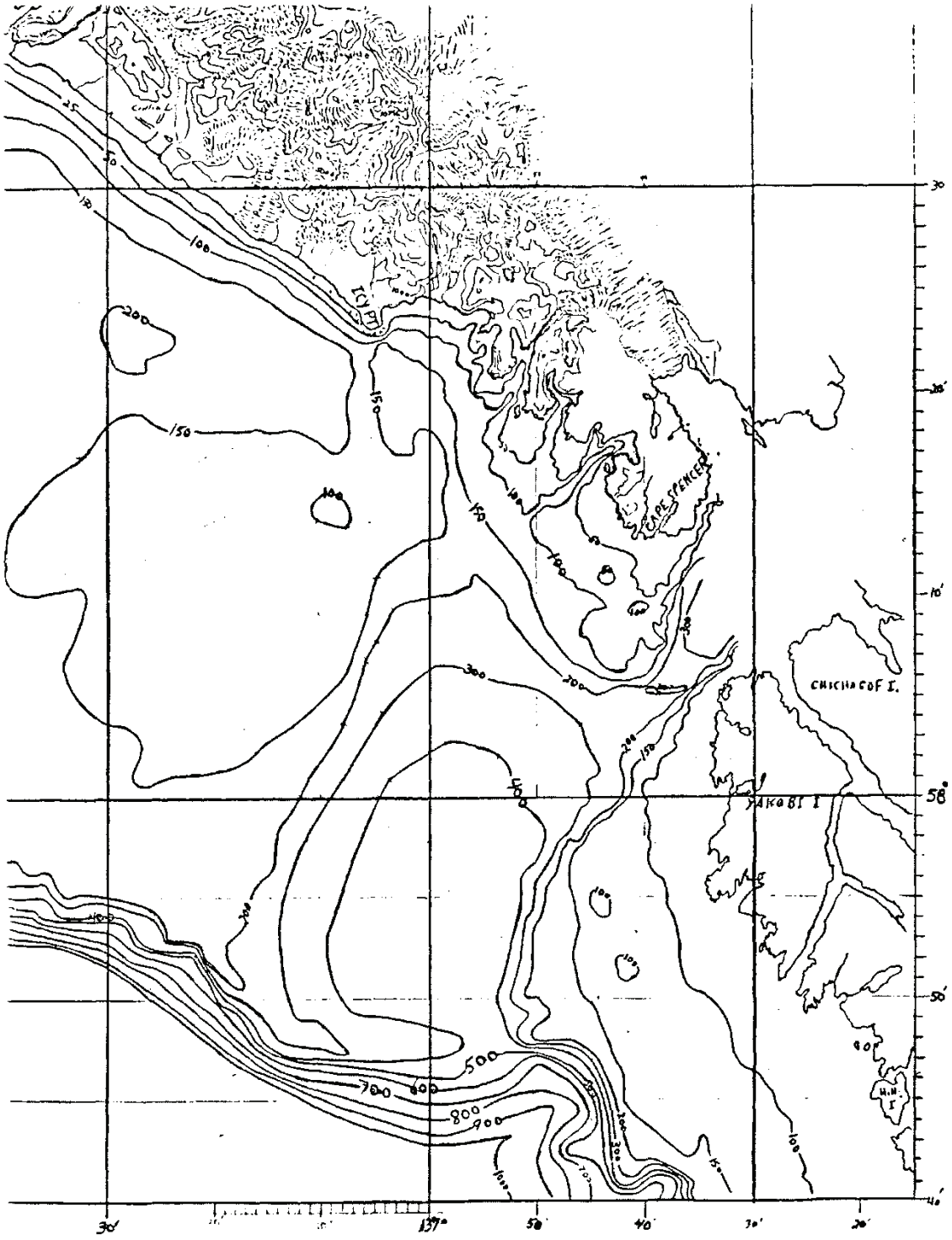


Figure 3. Cross Sound. The Sound separates Southeastern Alaska from the Yakutat Area.

SHELF AND SLOPE FROM CROSS SOUND TO ALSEK STRATH

This part of the Gulf takes in seven sections; two in Southeastern and five from Yakutat (Figures 3 and 4, and Table 6). The 300 to 1000 m depths in section 57°30 - 58°00', of Table 6, are on the slope west of Cross Sound. That part of 58°00' - 58°30' in the 300-500 m depth zone, is all in the basin of Cross Sound.

The Fairweather Ground is located in this geographic site, and the area in the 0-100 m depth zone, on the ground, is not included in this table.

Two of the sections are part of the Alsek Strath.

Table 6a. Square nautical miles on the shelf and slope between Cross Sound and Alsek Strath. The Fairweather Ground lies in this area, from 138°00' to 139°30', and the 0-100 m depth zone, on the Ground, is not included in this table. The total area of the 0-100 m zone, is the sum of Tables 6 and 7.

Latitude	Square nautical miles in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
57°30' - 58°00'	0	0	0	1.89	6.44	7.56
58°00' - 58°30'	45.34	72.33	35.04	--	0	0
137°00' - 137°30'	33.37	423.98	56.36	16.50	15.81	25.29
137°30' - 138°00'	122.07	574.91	14.27	13.61	11.75	16.67
138°00' - 138°30'	317.76	590.32	25.90	9.29	9.58	11.06
138°30' - 139°00'	56.44	420.27	15.11	11.91	10.96	12.43
139°00' - 139°30'	--	203.41	30.24	13.79	9.18	10.90
Total	574.98	2285.22	176.92	66.99	63.72	83.91

Table 6b. Square kilometers on the shelf and slope between Cross Sound and Alsek Strath. The Fairweather Ground lies in this area, from 138°00' to 139°30', and the 0-100 m depth zone, on the Ground, is not included in this table. The total area of the 0-100 m zone, is the sum of Tables 6 and 7.

Latitude	Square kilometers in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
57°30' - 58°00'	0	0	0	6.48	22.09	25.93
58°00' - 58°30'	155.52	248.09	120.19	--	0	0
137°00' - 137°30'	114.46	1454.25	1971.94	56.60	54.23	86.84
137°30' - 138°00'	418.70	1971.94	48.95	46.68	40.30	57.18
138°00' - 138°30'	1089.92	2024.80	88.84	31.86	32.86	37.94
138°30' - 139°00'	193.59	1441.53	51.83	40.85	37.59	42.63
139°00' - 139°30'	--	697.70	103.72	47.30	31.49	37.39
Total	1972.18	7838.30	2385.46	229.78	218.56	287.81

FAIRWEATHER GROUND

The 0-100 m depth zone, of the ground covers 276.77 nmi^2 and stretches across three longitudinal sections (Figure 4 and Table 7).

Table 7. The area of the 0-100 m depth zone on the Fairweather Ground.

Latitude section	Area in 0-100 m depth zone	
	nmi^2	km^2
138°00' - 138°30'	18.09	62.38
138°30' - 139°00'	195.95	675.69
139°00' - 139°30'	62.73	216.31
Total	276.77	954.38

ALSEK STRATH

The Alsek Strath (or Valley) covers three sections (Figure 4). The 200 m depth contour makes an abrupt turn into the valley, on both sides of the mouth, and is the deepest continuous contour in the strath. There is a 250 m deep basin in the strath. The 300 m depth contour passes across the mouth of the valley, approximately 50 nmi from Dry Bay. The area of the 200-300 m basin, in the strath for each of the sections, is found in Table 8.

Table 8. Square nautical miles and kilometers in the basin of the Alsek Strath.

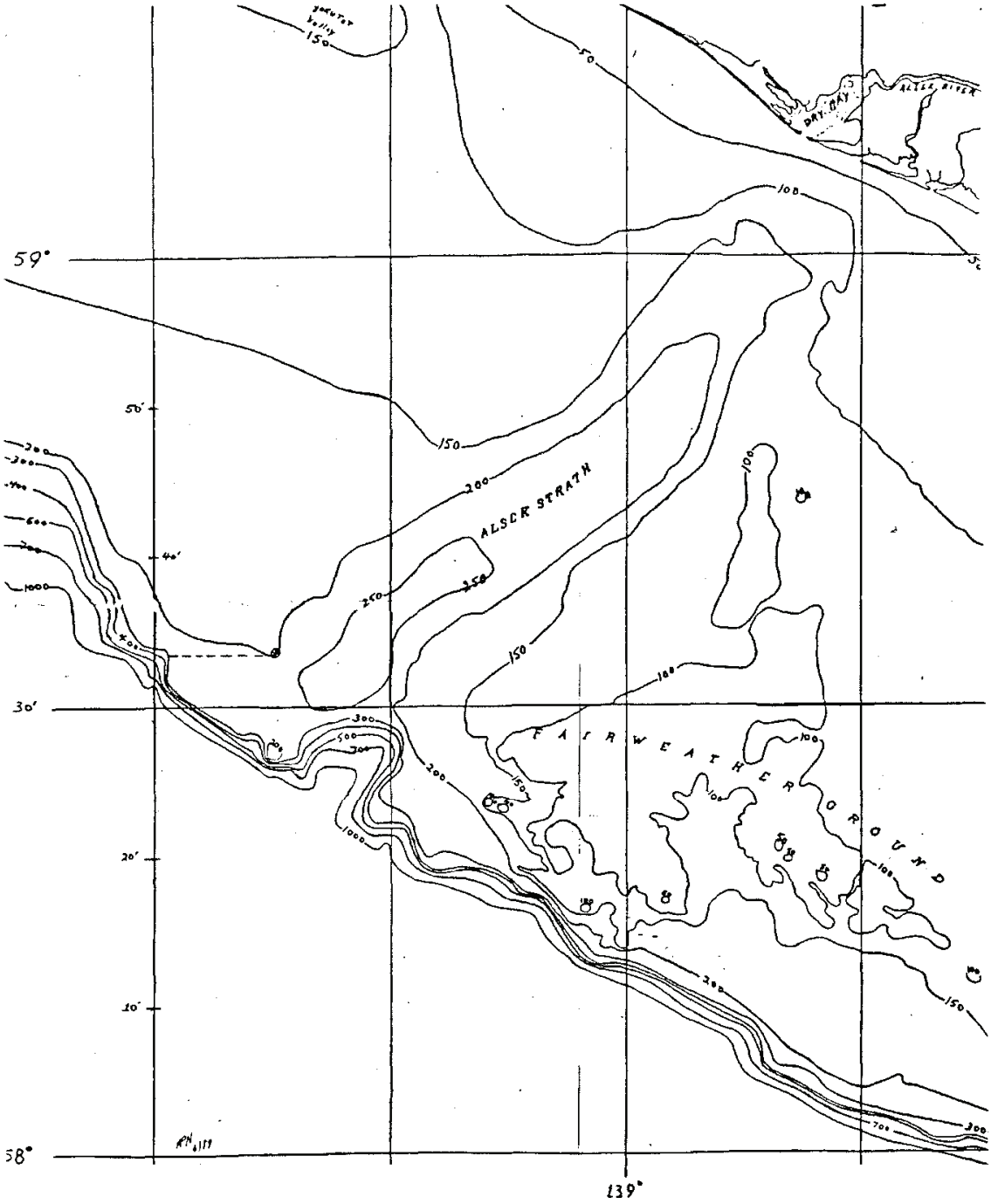
Latitude section	Area in 200-300 m depth zone	
	nmi^2	km^2
138°30' - 139°00'	43.74	150.03
139°00' - 139°30'	132.89	455.81
139°30' - 140°00'	104.43	358.19
Total	281.06	964.04

SHELF AND SLOPE FROM THE ALSEK STRATH TO YAKUTAT VALLEY

Six sections, from 138°30' to 141°30' W long., make up this portion of the shelf and slope (Figures 4, 5 and 6). It begins on the north side of the Alsek Strath at Dry Bay.

Yakutat Valley turns east, as it approaches shore, then parallels shore for some distance. Longitude 140°30' was made the east-west boundary on the shoreward side of the valley where the 0-100 and a portion of the 100-200 m depth zones pass.

Figure 4. Fairweather Ground and Alsek Strath. The mouth of Alsek Strath, for the 200-300m depth zone, is longitude 139 30', on the eastern side, and on the western side, the dotted line.



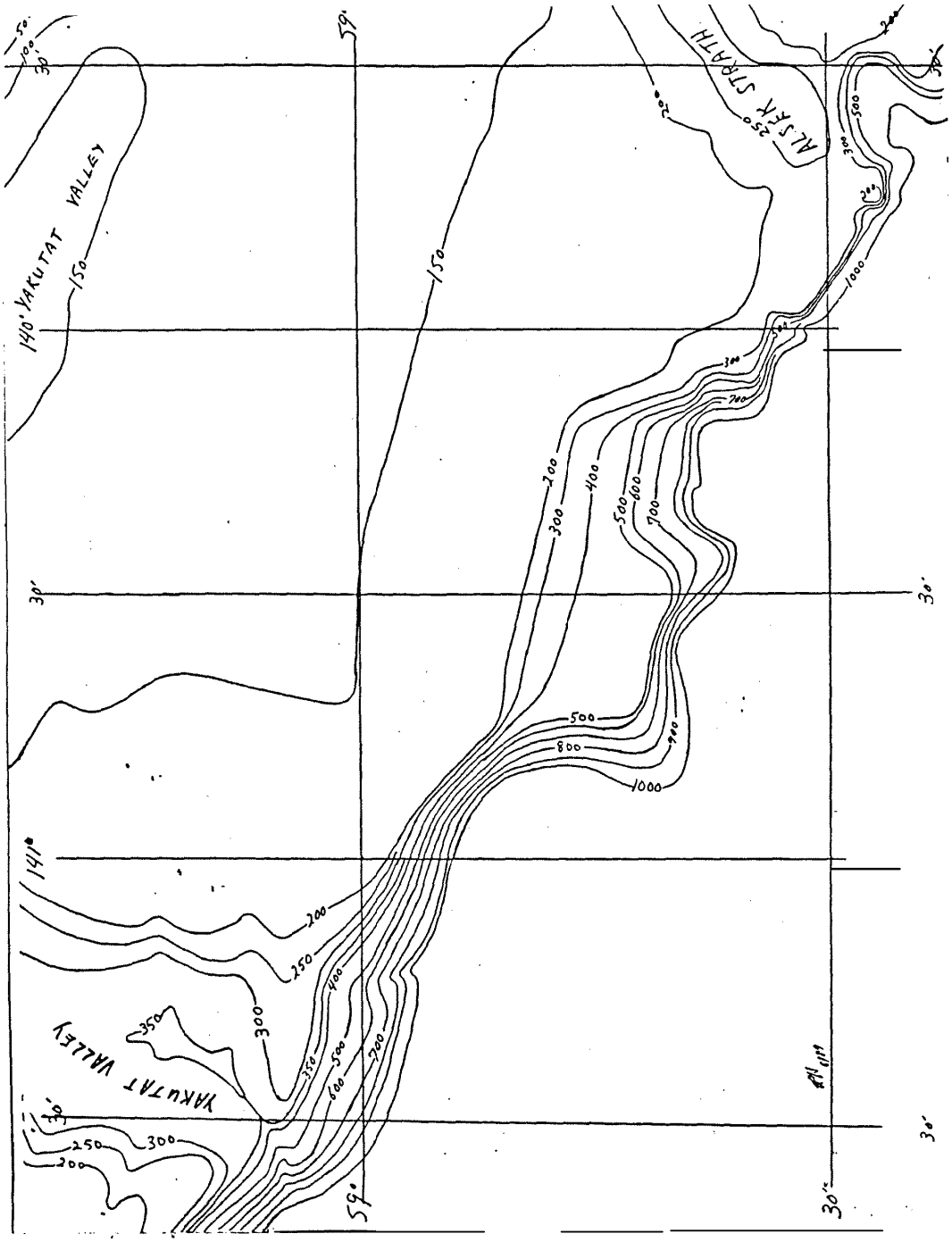


Figure 5. The slope between Alsek Strath and Yakutat Valley.

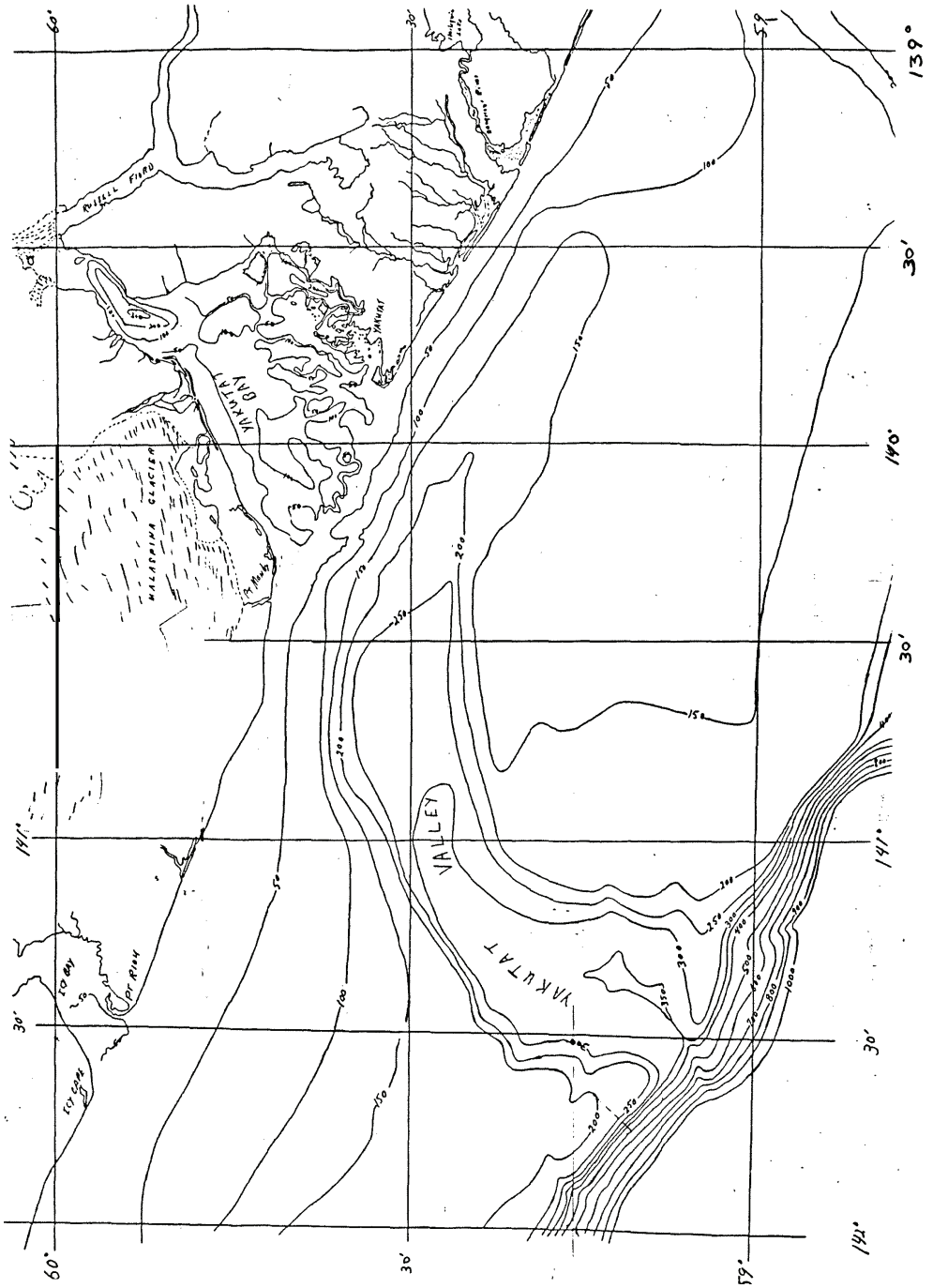


Figure 6. Yakutat Valley.

Table 9a. Square nautical miles on the slope and shelf between the Alsek Strath and Yakutat Valley. Areas in the 200-300 and 300-500 m depth zones in either the strath or valley are not included in this table.

Latitude section	Square nautical miles in depth zones					
	0-100	100-200	200-300	300-500	500-700	700-1000
138°30' - 139°00'	125.05	90.56	--	0	0	0
139°00' - 139°30'	200.30	331.60	--	0	0	0
139°30' - 140°00'	65.29	766.09	9.06	16.07	13.87	14.12
140°00' - 140°30'	85.77	674.85	13.61	22.34	11.70	12.59
140°30' - 141°00'	0	497.82	13.26	41.91	57.31	45.61
141°00' - 141°30'	0	80.06	--	--	28.33	28.45
Total	476.41	2440.98	35.93	80.32	111.21	100.77

Table 9b. Square kilometers on the slope and shelf between the Alsek Strath and Yakutat Valley. Areas in the 200-300 and 300- 500 m depth zones in either the strath or valley are not included in this table.

Latitude section	Square kilometers in depth zones					
	0-100	100-200	200-300	300-500	500-700	700-1000
138°30' - 139°00'	428.92	310.62	--	0	0	0
139°00' - 139°30'	687.03	1137.39	--	0	0	0
139°30' - 140°00'	223.94	2627.69	31.08	55.12	47.57	48.43
140°00' - 140°30'	294.19	2314.74	46.68	76.63	40.13	43.18
140°30' - 141°00'	0	1707.52	45.48	143.75	196.57	156.44
141°00' - 141°30'	0	274.61	--	--	97.17	97.58
Total	1634.09	8372.56	123.24	275.50	381.45	345.64

YAKUTAT VALLEY

Using the 200 m depth contour as its boundary, Yakutat Valley takes in four sections (Figure 6 and Table 10). The location where this contour leaves the slope and enters the valley, on the east side, is so close to longitude 141°W. This line is made the boundary.

On the west side, the 200 m contour turns sharply into the valley. The dotted line, shown in Figure 6, shows the slope-valley boundary on this side of the valley.

Table 10. Square nautical miles and kilometers in the 200-300 and 300-500 m depth zones of the basin in Yakutat Valley.

Latitude section	nmi^2		km^2	
	200-300	300-500	200-300	300-500
140°00' - 140°30'	70.40	0	241.47	0
140°30' - 141°00'	124.59	1.84	427.34	6.31
141°00' - 141°30'	130.08	227.29	446.17	779.60
141°30' - 142°00'	44.52	33.78	152.70	115.87
Total	369.59	262.91	1267.69	901.78

YAKUTAT VALLEY TO BERING VALLEY

For the 0-100 m depth zone, and that part of the 100-200 m zone, on the north side of Yakutat Valley, longitude 140 ° 30' is the eastern boundary for this vicinity of the slope (Figure 5). Together, six sections carry it to the Bering Valley. Longitude 143°30' forms a good western boundary line at the head of Bering Valley (Figure 6).

In section 142°30' - 143°00', 7.14 and 12.73 nmi^2 are located on top of the Pamplona Searidge, in the 0-100 and 100-200 m depth zones respectively. These are included in the 107.12 and 229.28 square mile areas listed in Table 11 for this section.

Table 11a. Square nautical miles of shelf and slope from Yakutat Valley to Bering Valley. The Bering Valley is the western half of the so-called "W Ground." The slashes (-) indicate the area is in either Yakutat Valley (140°-141°30') or the W Ground (142°30'-143°30').

Latitude	Square nautical miles in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
140°30' - 141°00'	109.06	35.40	--	--	0	0
141°00' - 141°30'	213.55	116.45	--	--	0	0
141°30' - 142°00'	248.89	353.15	30.84	13.60	26.05	39.20
142°00' - 142°30'	213.00	239.20	46.84	23.13	25.97	49.00
142°30' - 143°00'	107.12	229.28	--	--	36.29	36.01
143°00' - 143°30'	19.72	216.60	--	--	29.44	35.77
Total	911.34	1190.08	77.68	36.73	117.75	159.98

Table 11b. Square kilometers of shelf and slope from Yakutat Valley to Bering Valley. The Bering Valley is the western half of the so-called "W Ground." The slashes (-) indicate the area is in either Yakutat Valley (140° - 141°30') or the W Ground (142°30' - 143°30').

Latitude	Square kilometers in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
140°30' - 141°00'	374.08	121.42	--	--	0	0
141°00' - 141°30'	732.48	399.42	--	--	0	0
141°30' - 142°00'	853.69	1211.30	105.78	46.65	89.35	134.46
142°00' - 142°30'	730.59	820.46	160.66	79.34	89.08	168.07
142°30' - 143°00'	367.42	786.43	--	--	124.47	123.51
143°00' - 143°30'	67.64	742.94	--	--	100.98	122.69
Total	3125.90	4081.97	266.44	125.98	403.88	548.73

W GROUND

The name "W Ground," is used in this report for an area from 142° to 144°W longitude that, on NOS Chart 16016, has a W or M shape depending upon imagination. The entire area, in itself, is not a single geographic site. Rather, two independent earth formations exist, and each is here described independent of the other. These are the Pamplona Spur and a marine valley I have named, for this report, Bering Valley.

PAMPLONA SPUR

The Pamplona Spur is a sharp lateral extension of the continental shelf sticking into the Pacific Ocean. A narrow isthmus 250 m deep, projects less than 2 nmi from the shelf onto the ridge (Figure 7). The ridge raises to 130 m before plummeting down the slope on its south side. According to NOS bathymetric chart 1513N-10, there is no 100 fa (183 m) sweep off of the shelf around the spur as depicted in chart 16016. The shallowest depth contour passing from the shelf around the spur, is the 250 m (137 fa) contour.

The broadly indented portion of the shelf around the spur, is due to three gullys that cane up the slope. Their effect is visible as an indentation of the shelf along the 200 m depth contour. The eastern boundary for the Pamplona Spur Site, on the 200 m contour, is shown as a dotted line in Figure 7 where the gully east of the spur pushes into the shelf. The western boundary is also shown with a dotted line near West longitude 143°. This line canes off a ridge formed between the westernmost gully and the entrance into Bering Valley.

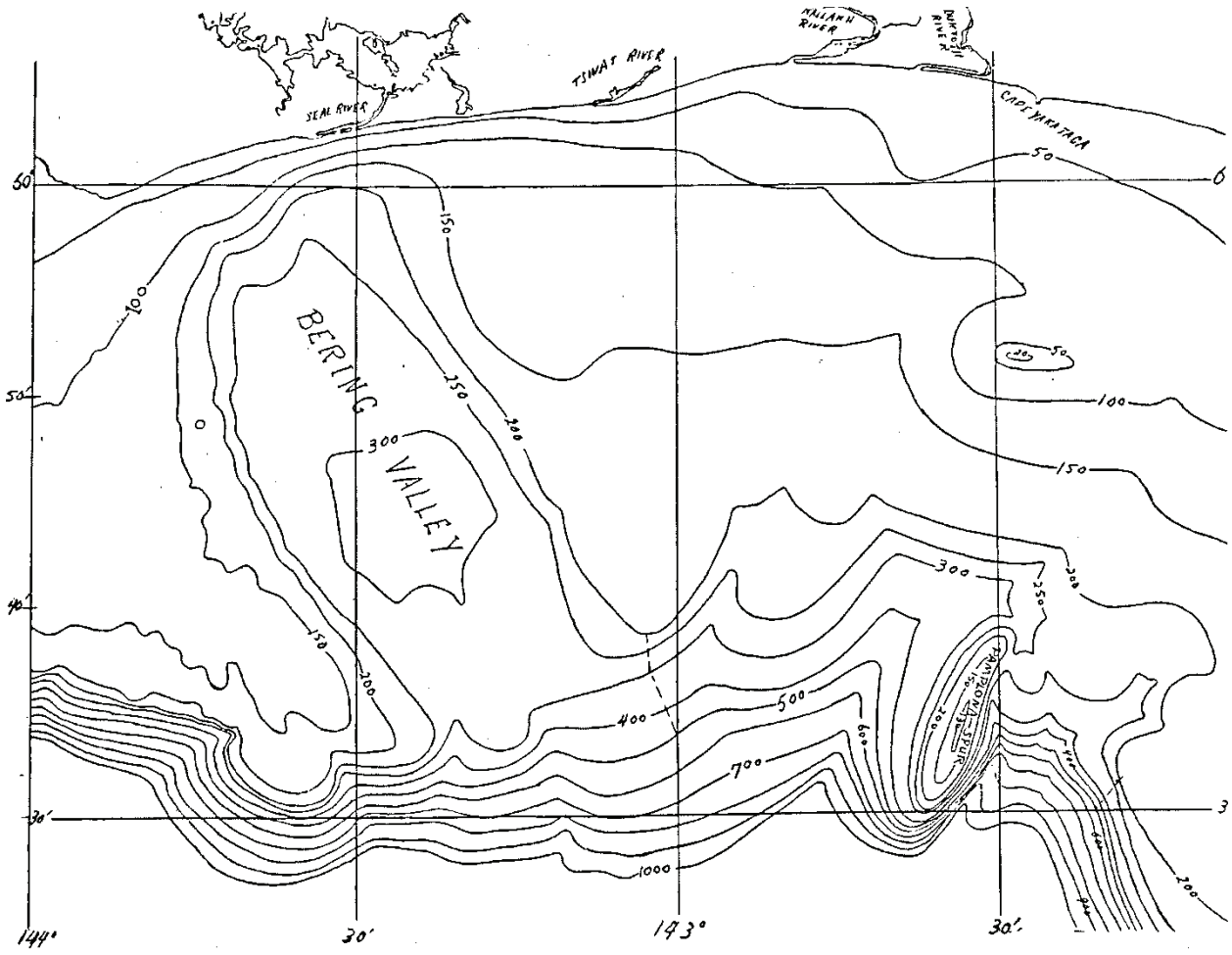


Figure 7. Pamplona Spur and Bering Valley. Dotted lines show the eastern and western boundaries for the Spur. The western boundary, for the valley, is 143°30'.

Three sections form the Pamplona Spur site and involve 141 and 72 nmi^2 of the 200-300 and 300-500 m depth zones respectively (Table 12).

Table 12. Square nautical miles and kilometers of the upper slope surrounding the Pamplona Spur. This region is the east leg of the W Ground.

Latitude	nmi^2		km^2	
section	200-300	300-500	200-300	300-500
142°00' - 142°30'	66.30	5.76	227.41	19.76
142°30' - 143°00'	72.68	64.49	249.29	221.20
143°00' - 143°30'	2.34	1.64	8.03	5.63
Total	141.32	71.89	484.73	246.58

BERING VALLEY

Figure 7 shows where the 200 mm depth contour leaves the shelf edge and enters Bering Valley. The dotted line is the east boundary and longitude 143°30' was made the western boundary although it is almost 2 nmi west of where this contour comes out of the valley and back onto the slope. The 300 m depth contour passes across the mouth of Bering Valley, but there is a 300 m deep basin inside the valley itself.

Bering Valley is in two sections and the area occupied by depth zones 200-300 and 300-500 m is given in Table 13.

Table 13. Square nautical miles and kilometers in basin and upper slope of Bering Valley in the 200-300 and 300-500 m depth zones. This valley forms the west leg of the so called W Ground.

Latitude	nmi^2		km^2	
section	200-300	300-500	200-300	300-500
143°00' - 143°30'	154.75	72.47	530.79	248.57
143°30' - 144°00'	102.20	5.46	350.55	18.73
Total	256.95	77.93	881.34	267.30

SHELF AND SLOPE FROM BERING VALLEY TO CAPE ST ELIAS

Longitude 143°30' is a perfect boundary line for measuring the area west of Bering Valley because of the southwesterly angle of the northern end of the valley, and the western location of the valley's mouth. The only area east of this longitude is a small 4.22 nmi^2, 100-200 m area at the mouth of Bering Valley (Figure 6 and Table 14).

Cape St. Elias is on the southern tip of Kayak Island. It is also so close to longitude 144°30', that this longitude is made the western boundary.

Table 14a. Square nautical miles on shelf and slope west of Bering Valley to 144°30' at Cape St. Elias. The slashes (-) indicate the area was included in Tables 11, 12, and/or 13.

Latitude	Square nautical miles in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
143°00' - 143°30'		4.22				
143°30' - 144°00'	63.77	229.58	14.49	15.87	16.85	27.39
144°00' - 144°30'	179.59	142.04	4.69	50.50	79.12	158.24
Total	243.36	375.84	19.18	66.37	95.97	185.63

Table 14b. Square kilometers on shelf and slope west of Bering Valley to 144°30' at Cape St. Elias. The slashes (-) indicate the area was included in Tables 11, 12, and/or 13.

Latitude	Square kilometers in depth zones					
Section	0-100	100-200	200-300	300-500	500-700	700-1000
143°00' - 143°30'		14.47				
143°30' - 144°00'	218.73	787.46	49.70	54.43	57.80	93.95
144°00' - 144°30'	615.99	487.20	16.09	173.22	271.38	542.76
Total	834.72	1289.13	65.79	227.65	329.18	636.71

SUMMARY TABLES

Table 15 (a and b) presents the total of the areas of the shelf and slope depth zones in the INPFC Southeastern Statistical Area.

Table 15a. The sum of the nmi^2 within each depth zone on the shelf and slope in Southeast Alaska excluding the 300-500 m zones in Dixon Entrance, Christian Sound and Cross Sound.

Geographic	Square nautical miles in depth zones					
Site	0-100	100-200	200-300	300-500	500-700	700-1000
Dixon Entrance to Christian Sound	437.58	1682.37	1167.71	113.84	167.85	319.49
Christian Sound to Cross Sound	615.52	1123.24	265.33	119.72	118.53	250.17
Total	1053.10	2805.61	1433.04	233.56	286.38	569.66

Table 15b. The sum of the square kilometers within each depth zone on the shelf and slope in Southeast Alaska excluding the 300-500 m zones in Dixon Entrance, Christian Sound and Cross Sound.

Geographic Site	Square kilometers in depth zones					
	0-100	100-200	200-300	300-500	500-700	700-1000
Dixon Entrance to Christian Sound	1500.90	5770.53	4005.53	390.47	575.73	1095.85
Christian Sound to Cross Sound	2111.23	3852.71	910.08	410.64	406.56	858.08
Total	3612.13	9623.24	4915.33	801.11	982.28	1953.93

Table 16 gives the three valleys in the Southeastern Area. Cross Sound is included here although part of its western half is in the Yakutat Area. Refer to Table 5 to determine the area in Yakutat and Southeastern.

Table 16. Square nautical miles and kilometers of three major geographic sites on the shelf and slope of Southeastern Alaska. The area in Cross Sound includes section 137°00' - 137°30' of Yakutat Area.

Geographic Site	Area in 300-500 m depth zone	
	nmi^2	km^2
Dixon Entrance	247.94	850.43
Christian Sound	247.84	850.09
Cross Sound	203.11	696.67

Table 17 (a and b) gives the area for the four segments of the shelf and slope in the Yakutat area. They are separated by the Alsek Strath, Yakutat Valley and Bering Valley. The Fairweather Ground is on the shelf between Cross Sound and the Alsek Strath and the area it occupies, in the 0-100 mm depth zone, is not part of the 700.03 nmi^2 (2401.10 km^2) in the table. Similarly, the area in the 200-300 mm and 300-

500 mm depth zones, in Alsek, Yakutat and Bering Valleys and around the Pamplona Spur, are not included in this table.

Table 17a. Summary of square nautical miles within depth zones on shelf and slope in Yakutat Area. Not included is the 0-100 m depth zone for the Fairweather Ground and the 200-300 and 300-500 m depth zones for Alsek Strath, Yakutat Valley and the Pamplona Spur and Bering Valley areas in the so called W Ground.

Geographic Site	Square nautical miles in depth zones					
	0-100	100-200	200-300	300-500	500-700	700-1000
Cross Sound to Alsek Strath	700.03	2285.22	695.47	66.99	63.72	83.91
Alsek Strath to Yakutat Valley	390.64	2440.98	35.93	80.32	111.21	100.77
Yakutat Valley to Bering Valley	997.11	1190.08	77.68	36.73	117.75	159.98
Bering Valley to Cape St. Elias	243.36	375.84	19.18	66.37	95.97	185.63
Total	2331.14	6292.12	828.26	250.41	388.65	530.29

Table 17b. Summary of square kilometers within depth zones on shelf and slope in Yakutat Area. Not included is the 0-100 m depth zone for the Fairweather Ground and the 200-300 and 300-500 m depth zones for Alsek Strath, Yakutat Valley and the Pamplona Spur and Bering Valley areas in the so called W Ground.

Geographic site	Square kilometers in depth zones					
	0-100	100-200	200-300	300-500	500-700	700-1000
Cross Sound to Alsek Strath	2401.10	7838.30	2385.46	229.78	218.56	287.81
Alsek Strath to Yakutat Valley	1339.90	8372.56	123.24	275.50	381.45	345.64
Yakutat Valley to Bering Valley	3420.09	4081.97	266.44	125.98	403.88	548.73
Bering Valley to Cape St. Elias	834.72	1289.13	65.79	227.65	329.18	636.71
Total	7995.81	21581.97	2840.93	858.91	1333.07	1818.89

Table 18 gives the area data for the three valleys, the Fairweather Ground and the Pamplona Spur in the Yakutat Area

Table 18. Valleys and Grounds in the Yakutat Area. The nmi^2 and km^2 of the 0-100 m depth zone of the Fairweather Ground and the area of the 200-300 and 300-500 m depth zones in all three valleys and around Pamplona Spur.

Geographic site	nmi^2			km^2		
	0-100	200-300	300-500	0-100	200-300	300-500
Fairweather Ground	276.77	--	--	949.32	--	--
Alsek Strath	--	281.76	--	--	966.44	--
Yakutat Valley	--	369.59	262.91	--	1267.69	901.78
Pamplona Spur	--	141.42	71.89	--	485.07	246.58
Bering Valley	--	256.95	77.93	--	881.34	267.30

APPENDIX 2

SIGLER'S UNPUBLISHED METHODS FROM 1989

The following is a detailed look at the methods used by Sigler to create the area, in square kilometers, of several distinct geographic sites, along with the shelf and slope above and below each of these geographic sites, used for assessing the abundance of groundfish in the GOA (Tables 1a, 1d). The geographic sites include, from south to north: Dixon Entrance, Iphigenia Bay, Ommaney Trench, Spencer Gully, Alsek Strath, Yakutat Valley, and the W-Grounds.

Eastern Gulf of Alaska (EGOA):

Sigler's calculations for areas on the EGOA slope are from the Haight 1986 Table (Appendix 3) including RACE trawl survey measurements from Brown and Rose. Measurements for EGOA gullies are a combination of Haight's 1986 Table (Appendix 3) and 1987 in-house report (Appendix 1).

Dixon Entrance:

Both Dixon Entrance and Ommaney Trench measurements were mostly taken from Haight. Below are the calculated area sizes for the noted depth stratum, latitudinal range, and data source from which the value came. Calculations are shown on the approach Sigler took to obtain the area sizes for depth increments 201-300 m and 301-400 m.

Depth stratum (m)	Latitudinal range	Calculated area size (km^2)	Data source
301-500	54°30'N - 55°00'N	850.43	Haight (Appendix 1; table 16)
201-400	54°30'N - 55°00'N	1,922.38	Haight (Appendix 3)
401-600	54°30'N - 55°00'N	57.73	Haight (Appendix 3)
301-400[1]		= (301- 500) – (401- 600) = 850.43 – 57.73 = 792.70	Sigler (Appendix 2)
201-300		= (201- 400) – (301- 400) = 1,922.38 – 792.70 = 1,129.68	Sigler (Appendix 2)

Iphigenia Bay:

The entire area of Iphigenia Bay is all within the 201-300 m depth stratum, but the area size of this depth range was not known, so the area size for 201-400 was used. The area size for depth stratum 201-300 m in Iphigenia Bay equals 1,917.61 km^2.

Depth stratum (m)	Latitudinal range	Calculated area size (km^2)	Data source
201-400	55°30'N – 56°00'N	1,591.28	Sigler (Appendix 2)
201-400	55°00'N – 53°30'N	326.33	Sigler (Appendix 2)
201-300		= 1,917.61	Sigler (Appendix 2)

Ommaney Trench:

Depth stratum (m)	Latitudinal range	Calculated area size (km^2)	Data source
301-500	55°30'N – 56°30'N	850.09	Haight (Appendix 1; Table 3)
201-400	55°30'N – 56°30'N	1,130.73	Haight (Appendix 3)
401-600	55°30'N – 56°30'N	122.42	Haight (Appendix 3)
201-300		= (201-400) – (301-400) = 1,130.73 – 609.69 = 521.04	Sigler (Appendix 2)
301-400		= (301-500) – (401- 600) = 850.09 – 240.40 = 609.69	Sigler (Appendix 2)

Spencer Gully:

Both Spencer Gully Southeast (SE) and Spencer Gully Yakutat (Yak) measurements were taken from Haight's 1986 unpublished Table (Appendix 3). Area data is given for depth zones between 200 and 600 m for Spencer Gully SE and between 200 and 800 m for Spencer Gully Yak. Below are the calculated area sizes for the noted depth stratum, longitudinal and latitudinal range, and data source from which the value came. Calculations are shown on the approach Sigler took to obtain the area size for the 201-300 m stratum.

Spencer Gully SE

Depth stratum (m)	Latitudinal range	Calculated area size (km^2)	Data source
201-400	57°30'N – 58°30'N	350.44	Haight (Appendix 3)
401-600	57°30'N – 58°30'N	250.32	Haight (Appendix 3)
201-300*	57°30'N – 58°30'N	= 350.44 / 2 = 175.22	Sigler (Appendix 2)

*Assuming half and half between 201-300 m and 301-400 m, the area size of depth stratum 201-300 m equals 175.22 km^2.

Spencer Gully Yak

Depth stratum (m)	Longitudinal/ latitudinal range	Calculated area size (km^2)	Data source
201-400	137°00'W – 138°30'W	28.06	Haight (Appendix 3)
401-600	137°00'W – 138°30'W	50.18	Haight (Appendix 3)
601-800	137°00'W – 138°30'W	50.18	Haight (Appendix 3)
201-300*	57°30'N – 58°30'N	= 28.06 / 2 = 14.03	Sigler (Appendix 2)

*Assuming half and half between 201-300 and 301-400, the area size of depth stratum 201-300 m equals 14.03 km^2.

Yakutat Slope:

The Yakutat slope measurements between 147 °00'W and 144°00'W longitude were taken directly from Brown and Rose (Appendix 4). Area data is given for depth zones between 200 and 1,000 m in 100 and 200 m increments. Yakutat slope measurements between 144° 00'W and 137°00'W longitude were taken directly from Haight's 1986 unpublished Table (Appendix 3), for depth zones between 200 and 1,000 m in 100 and 200 m increments.

Gullies within the Yakutat Area include Alsek Strath, Yakutat Valley, and W-Grounds. Area measurements are from Haight (Appendix 3) and Haight (Appendix 1). Area data is given for depth zones between 200 and 500 m in 100 and 200 m increments. Below are the calculated area sizes for the noted depth stratum, longitudinal range, and data source from which the value came. Calculations are shown on the approach Sigler took to obtain the area size for the depth increments (301-400 m and 401-500 m) that were not previously calculated by Haight.

Alsek Strath:

The Alsek Strath area measurement is from Haight's 1986 unpublished Table (Appendix 3), including depth zone 200-400 m. For unknown reasons, this area calculation is much different than in Haight (Appendix 1). Since the entire valley < 300 m, this is also the assumed value for the 201-300 m depth interval. Note that this number differs substantially from the value (964.04 km^2) in Haight (Appendix 1; Table 8).

Depth stratum (m)	Longitudinal range	Calculated area size (km^2)	Data source
201-400	138°30'W - 139°30'W	565.20	Haight (Appendix 3)

Yakutat Valley:

Depth stratum (m)	Longitudinal range	Calculated area size ($km^{2)}$	Data source
201-400	139°30'W – 142°00'W	2,035.95	(Appendix 3)
201-300	140°00'W – 142°00'W	1,267.69	Haight (Appendix 1; table 10)
301-500	140°00'W – 142°00'W	901.78	Haight (Appendix 1; table 10)
301-400		= (201-400) – (201-300) = 768.26	Sigler (Appendix 2)
401-500*		= (301-500) – (301-400) = 133.52	Sigler(Appendix 2)

*Assuming that in Haight (Appendix 3), the source of the slope area sizes, that this area is included in the slope.

W-Grounds:

W-Grounds extends from 142°00' – 144°00'. Depths of 301-400 are mostly within 143°00' – 143°30'W. For depth zone 201-400 m, between longitudinal bounds 143°00' – 143°30'W, area = 604.02 km^2. Calculations are shown on the approach Sigler took to obtain the area size for the depth increments 201-300 m and 301-400 m that were not previously calculated by the noted source

Depth stratum (m)	Longitudinal range	Calculated area size (km^2)	Data source
201-400	143°00' – 143°30'	604.02	Haight (Appendix 3)
201-400	142°00' – 144°00'	1,309.68	Haight (Appendix 3)
201-300		= (201-400) – (301-400) = 1,309.68 – 302.01 = 1,007.67	Sigler (Appendix 2)
301-400*		302.01	From Haight (Appendix 3), half of the value for 201-400 within 143°00' - 143°30'W.

* Assume half and half between 201-300 m and 301-400 m for this longitudinal interval, equaling 302.01 km^2.

Central and Western GOA (CGOA and WGOA):

Sigler's area size calculations for the CGOA and WGOA were taken from Brown and Rose's RACE trawl survey estimates (Appendix 4). Values that differ are explained below.

Amatuli Gully:

This value is from the RACE trawl survey estimates, and is referenced as subarea 32 (Deep Gullies) within Kodiak (Martin and Clausen 1995).

Shelikof Trough:

For depth stratum 201-300 m, Brown and Rose (Appendix 4) report two values for the Shelikof Trough, subarea 30 (S. Shelikof Deep) equaling 9,968 km^2 and subarea 31 (N. Shelikof Deep) equaling 3,108 km^2. Sigler estimates that 85 % of subarea 31 (N. Shelikof Deep) equaling 2,642 km^2 and all of subarea 30 (S. Shelikof Deep) is within Chirikof, and 15 % of subarea 31 (N. Shelikof Deep) is within Kodiak.

Geographic area	Trough	Depth stratum (m)	Calculated area size (km^2)
Chirikof	Shelikof Trough	201-300	12,610
Kodiak	Shelikof Trough	201-300	466

Shumagin Gully:

A small portion of Shumagin Gully is at depths of 201-300 m, although all of Shumagin Gully is considered to be within 101-200 m stratum in area measurements from Brown and Rose (Appendix 4). Sigler estimates that about 6 % of Shumagin Gully is between 201and 300 m (max depth = 219 m). Multiplying the Shumagin Gully area measurement from Brown and Rose (11,082 km^2) by six %, Sigler calculated an area measurement for Shumagin Gully at depths 201-300 m equal to 665 km^2.

Depth stratum (m)	Calculated area size (km^2)	Data source
101-200	11,082	Brown and Rose (Appendix 4)
201-300	= 11,082 * 6% = 665	Sigler (Appendix 2)

APPENDIX 3

HAIGHT'S 1986 UNPUBLISHED TABLE

Area, below 200 m, on Continental Slope, Shelf and Gullys in the Eastern Gulf of Alaska (Prepared by Richard Haight, ABL, 1986)

	INPFC Southeastern Area												
	Continental Slope				Slope, Gullys, and Shelf				Area in Gullys and on Shelf				
Latitudes (N)	Depth (m)				Depth (m)				Depth (m)				
	200-400	400-600	600-800	800-1000	200-400	400-600	600-800	800-1000	200-400	400-600	600-800	800-1000	Name of Gully
54°00'-54°30'	37.39	65.90	61.73	59.67	754.00	215.04	61.73	59.67	716.61	149.14	0	0	Dixon Entrance
54°30'-55°00'	127.34	17.52	17.39	15.22	687.80	34.35	17.39	15.22	560.46	16.83	0	0	Dixon Entrance
55°00'-55°30'	112.67	44.79	58.05	69.65	207.81	44.79	58.05	69.65	95.14	0	0	0	Iphigenia Bay
55°30'-56°00'	16.61	49.54	63.58	76.35	584.91	50.82	63.58	76.35	568.30	1.28	0	0	Iphigenia Bay
56°00'-56°30'	81.65	44.55	47.94	59.72	306.94	78.96	47.94	59.72	225.29	34.41	0	0	Ommaney Trench
56°30'-57°00'	100.32	36.16	37.66	46.25	100.32	36.16	37.66	46.25	0	0	0	0	
57°00'-57°30'	52.82	25.78	32.16	36.19	52.82	25.78	32.16	36.19	0	0	0	0	
57°30'-58°00'	27.72	21.25	36.60	36.29	48.24	85.22	36.60	36.29	20.52	63.97	0	0	Spencer Gully
58°00'-58°30'	0	0	0	0	81.65	9.01	0	0	81.65	9.01	0	0	Spencer Gully
Totals	556.52	305.49	355.11	399.34	2906.31	580.13	355.11	399.34	2349.79	274.64	0	0	

Area, below 200 m, on Continental Slope, Shelf and Gullys in the Eastern Gulf of Alaska (Prepared by Richard Haight, ABL, 1986)

INPFC Yakutat Area													
	Continental Slope				Slope, Gullys, and Shelf				Area in Gullys and on Shelf				
Longitudes	Depth (m)				Depth (m)				Depth (m)				
	200-400	400-600	600-800	800-1000	200-400	400-600	600-800	800-1000	200-400	400-600	600-800	800-1000	Name of Gully
137°00'-137°30'	37.39	65.90	61.73	59.67	754.00	215.04	61.73	59.67	716.61	149.14	0	0	Dixon Entrance
137°30'-138°00'	127.34	17.52	17.39	15.22	687.80	34.35	17.39	15.22	560.46	16.83	0	0	Dixon Entrance
138°00'-138°30'	112.67	44.79	58.05	69.65	207.81	44.79	58.05	69.65	95.14	0	0	0	Iphigenia Bay
138°30'-139°00'	16.61	49.54	63.58	76.35	584.91	50.82	63.58	76.35	568.30	1.28	0	0	Iphigenia Bay
139°00'-139°30'	81.65	44.55	47.94	59.72	306.94	78.96	47.94	59.72	225.29	34.41	0	0	Ommaney Trench
139°30'-140°00'	100.32	36.16	37.66	46.25	100.32	36.16	37.66	46.25	0	0	0	0	
140°00'-140°30'	52.82	25.78	32.16	36.19	52.82	25.78	32.16	36.19	0	0	0	0	
140°30'-141°00'	27.72	21.25	36.60	36.29	48.24	85.22	36.60	36.29	20.52	63.97	0	0	Spencer Gully
141°00'-141°30'	0	0	0	0	81.65	9.01	0	0	81.65	9.01	0	0	Spencer Gully
Totals	556.52	305.49	355.11	399.34	2906.31	580.13	355.11	399.34	2349.79	274.64	0	0	

APPENDIX 4
BROWN AND ROSE'S UNPUBLISHED 1985 TABLE

Area (nmi^2) of continental shelf in the Gulf of Alaska by longitude and depth zone (Prepared by Craig Rose, NMFS, 1985)

	Continental Shelf			
Latitude (N)	Depth (m)			
	0-100	100-200	200-300	300-400
54°30'-55°00'	180.00	726.67	636.67	253.33
55°00'-55°30'	390.00	1070.00	310.00	80.00
55°30'-56°00'	606.90	717.24	834.48	158.62
56°00'-56°30'	206.90	637.93	306.90	48.28
56°30'-57°00'	464.29	532.14	128.57	53.57
57°00'-57°30'	328.57	396.43	78.57	53.57
57°30'-58°00'	337.04	403.70	62.96	62.96
58°00'-58°30'	237.04	188.89	70.37	74.07
Longitude (W)				
137°00'-137°30'	39.66	415.52	58.62	60.34
137°30'-138°00'	127.59	570.69	6.90	18.97
138°00'-138°30'	328.80	550.90	23.70	15.25
138°30'-139°00'	162.70	555.90	17.00	13.60
139°00'-139°30'	216.70	473.30	178.30	16.70
139°30'-140°00'	56.70	761.70	100.00	10.00
140°00'-140°30'	106.35	682.54	44.44	14.29
140°30'-141°00'	84.13	557.14	166.67	28.57
141°00'-141°30'	195.24	190.48	165.08	138.10
141°30'-142°00'	195.24	371.43	104.76	31.75
142°00'-142°30'	207.81	237.50	103.13	14.06
142°30'-143°00'	148.44	143.75	87.50	46.88

143°00’-143°30’	67.19	153.13	154.69	39.06
143°30’-144°00’	87.50	204.69	101.56	9.38
144°00’-144°30’	306.25	140.63	4.69	10.94
144°30’-145°00’	250.00	320.00	33.33	31.67
145°00’-145°30’	176.67	558.33	10.00	10.00
145°30’-146°00’	440.00	350.00	28.33	18.33
146°00’-146°30’	775.00	176.67	31.67	25.00
146°30’-147°00’	421.67	525.00	65.00	11.67
147°00’-147°30’	118.64	484.75	240.68	13.56
147°30’-148°00’	122.03	901.69	123.73	16.95
148°00’-148°30’	159.32	594.92	303.39	59.32
148°30’-149°00’	175.86	1056.90	458.62	43.10
149°00’-149°30’	31.03	1318.97	434.82	25.86
149°30’-150°00’	305.26	1031.58	296.49	45.61
150°00’-150°30’	373.21	1269.64	226.79	66.07
150°30’-151°00’	805.36	1055.36	58.93	37.50
151°00’-151°30’	932.73	1014.55	21.82	25.45
151°30’-152°00’	1398.18	920.00	90.91	87.27
Shelikof Strait				
152°00’-152°30’	266.67	264.91	--	--
152°30’-153°00’	112.50	285.71	78.57	--
153°00’-153°30’	130.91	443.64	72.73	--
153°30’-154°00’	220.37	435.19	87.04	--
154°00’-154°30’	122.22	114.81	292.59	--
154°30’-145°00’	120.75	88.68	413.21	--
Albatross Banks				
152°00’-152°30’	992.16	380.39	29.41	43.14
152°30’-153°00’	538.00	388.00	50.00	18.00

153°00’-153°30’	446.94	289.80	38.78	28.57
153°30’-154°00’	631.25	370.83	47.92	83.33
154°00’-154°30’	556.25	295.83	20.83	22.92
154°30’-145°00’	1095.83	195.83	43.75	14.58
Longitude (W)				
155°00’-155°30’	1026.00	232.00	904.00	12.00
155°30’-156°00’	232.00	402.04	736.73	24.49
156°00’-156°30’	370.83	739.58	1081.25	35.42
156°30’-157°00’	842.55	751.06	42.55	31.91
157°00’-157°30’	1370.21	463.83	23.40	12.77
157°30’-158°00’	652.17	684.78	45.65	15.22
158°00’-158°30’	475.51	1228.57	42.86	22.45
158°30’-159°00’	520.41	783.67	191.84	22.45
159°00’-159°30’	861.22	516.33	51.02	14.29
159°30’-160°00’	902.08	412.50	60.42	18.75
160°00’-160°30’	806.25	425.00	66.67	16.67
160°30’-161°00’	523.40	604.26	38.30	12.77
161°00’-161°30’	800.00	368.75	41.67	10.42
161°30’-162°00’	885.11	346.81	38.30	14.89
162°00’-162°30’	804.26	138.30	23.40	10.64
162°30’-163°00’	814.89	74.47	14.89	14.89
163°00’-163°30’	834.78	67.39	17.39	15.22
163°30’-164°00’	726.09	134.78	28.26	19.57
164°00’-164°30’	691.11	164.44	24.44	26.67
164°30’-145°00’	555.56	200.00	62.22	24.44

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