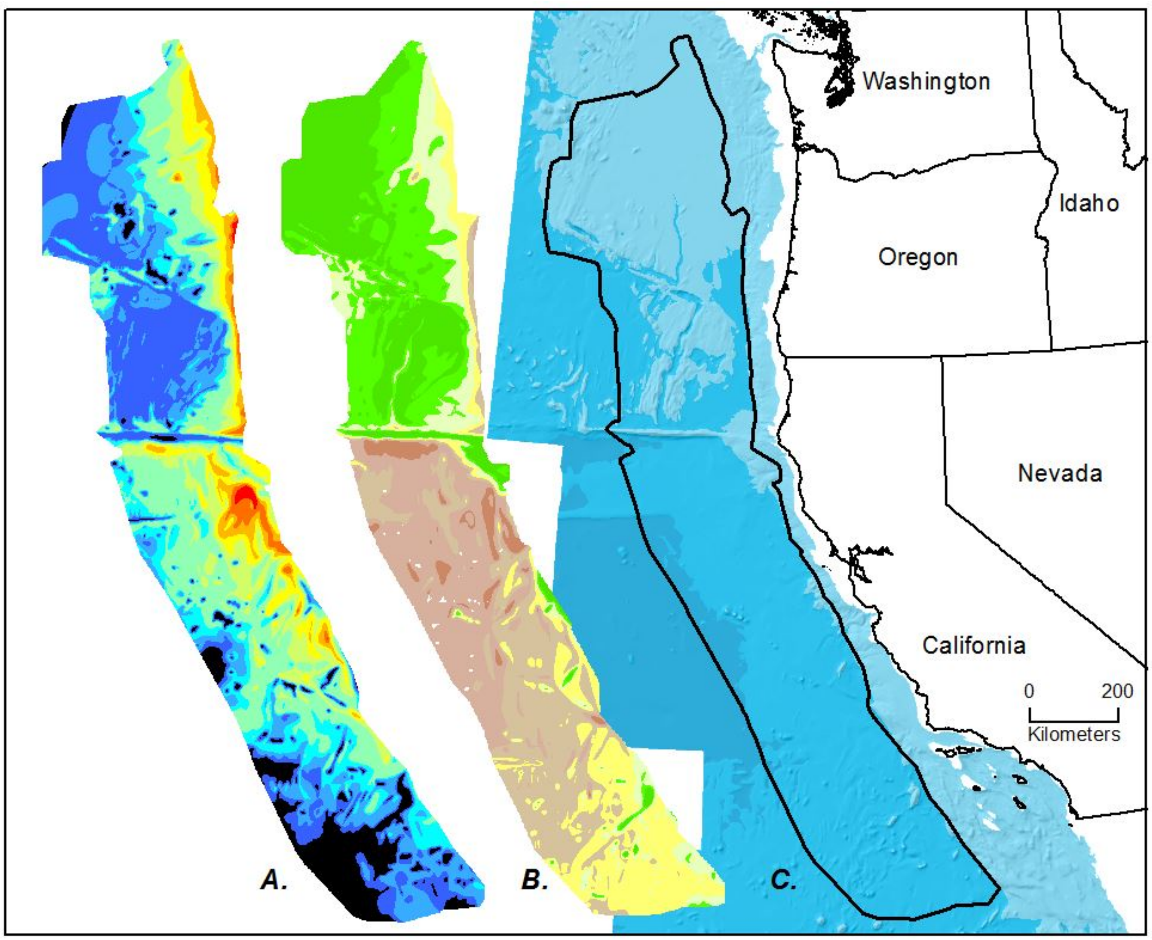
Depth-to-Basement, Sediment-Thickness, and Bathymetry Data for the Deep-Sea Basins Offshore of Washington, Oregon, and California

By Florence L. Wong and Muriel S. Grim



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Cover: Maps of *A*, sediment thickness; *B*, depth to basement; and *C*, bathymetry of the deep-sea basins offshore of Washington, Oregon, and California. Outline over bathymetry is the area of the sediment-thickness and depth-to-basement data.

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	247.1	acre
square meter (m^2)	10.76	square foot (ft^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	1.308	cubic yard (yd^3)
cubic kilometer (km^3)	0.2399	cubic mile (mi^3)

Horizontal coordinate information is referenced to the “World Geodetic System 1984 (WGS84).”

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Abstract

Contours and derivative raster files of depth-to-basement, sediment-thickness, and bathymetry data for the area offshore of Washington, Oregon, and California are provided here as GIS-ready shapefiles and GeoTIFF files. The data were used to generate paper maps in 1992 and 1993 from 1984 surveys of the U.S. Exclusive Economic Zone by the U.S. Geological Survey for depth to basement and sediment thickness, and from older data for the bathymetry.

Introduction

In 1984, the U.S. Geological Survey did a series of reconnaissance surveys of the U.S. Exclusive Economic Zone (EEZ) offshore of Washington, Oregon, and California (EEZ-SCAN 84 Scientific Staff, 1985), called here the West Coast EEZ. The surveys F-1-84-SC, F-2-84-NC, F-3-84-NC, and F-4-84-WO (U.S. Geological Survey, 1984) covered the area seaward of 200 meters water depth to the 200-nautical-mile boundary of the EEZ using the Geological Long-Range Inclined Asdic (GLORIA) side-scan sonar, a 160-in.^{3} airgun seismic-reflection profiler, a 3.5-kHz high-resolution seismic-reflection profiler, a 10-kHz echo sounder, and a proton-precession magnetometer (fig. 1). The nominal trackline spacing throughout the survey was 30 km. The processed and mosaicked GLORIA sidescan sonar data and seismic-reflection data are available in a hardcopy atlas (EEZ-SCAN 84 Scientific Staff, 1986); the GLORIA sidescan sonar data are available online (Paskevich and others, 2011).

Contour maps of sediment thickness (Gardner and others, 1992a, 1993a, 1993b) and depth to basement (Gardner and others, 1992b, 1993c, 1993d) in the basins of the West Coast EEZ were interpreted from both the sonar-image data and the seismic-reflection data obtained during these surveys. Maps of bathymetry of the EEZ and adjacent areas were compiled from data available in the late 1980s, but do not include bathymetric data from the 1984 GLORIA surveys (Chase and others, 1992a, 1992b; Grim and others, 1992).

This report provides the (1) shapefiles of sediment thickness, depth to basement, and bathymetry contours used in the hardcopy maps; (2) raster surfaces (that is, grids) in GeoTIFF format interpolated from those contours; and (3) layer files for rendering the data in Esri's Arcmap application (Esri Arcmap 10.1). The data are available for download as zipped files from the Data Catalog page of this report.

The data presented in this report are provided as digital records of previous research. These data are best used only for small-scale maps because horizontal displacements of seafloor features (seamounts, seafloor ridges) of as much as 10 km are detectable compared to more recent bathymetric compilations (for example, Amante and Eakins, 2009).

Methods

Methods of data interpretation and compilation are detailed here. The descriptions are taken primarily from the text of the original published maps and are supplemented with more recent information where warranted.

Sediment-Thickness and Depth-to-Basement Data Interpretation

Basement Outcrops

GLORIA imagery was used to locate areas of basement outcrop throughout the study area (fig. 2). Where possible, sediment thickness on and immediately adjacent to basement outcrops was measured from seismic-reflection profiles. Where there was no bathymetric or seismic control, a seamount peak was assumed to have no sediment cover. Seamount peaks were digitized separately as part of the depth-to-basement data and are available only between 35°N. and 35°30'N. latitudes. As a separate creation, they do not have the same footprints as zero-thickness contours in the sediment-thickness data.

Data Reduction

Acoustic basement (or the base of unconsolidated sediment) in the basins was observed on all of the seismic-reflection records (fig. 3). One-way travel time was measured from the seafloor to acoustic basement. Because the trackline spacing of about 30 km is relatively large compared to the data density along track, the sediment thickness was measured every 0.5 hour, or at an interval of approximately 7.5 km. Water depth was measured with a 10-kHz profiler. Depth to basement was calculated by using the sea surface as the zero datum and adding the corrected water depth (Carter, 1980) to the sediment thickness. Acoustic travel times were converted to depths by calculating a regression equation from the interval velocity versus depth data of Connard and others (1984). Their database consists of a compilation of all available Deep Sea Drilling Project data plus wide-angle refraction data, which were collected in Cascadia Basin west of Oregon, and it represents the best dataset available for the West Coast EEZ. The regression equation was integrated to determine sediment thickness as a function of one-way traveltime. The resulting equation is

$$z = 1{,}400t + 0.5t \wedge 2,$$

where z is sediment thickness in meters, and t is one-way traveltime in seconds. Sediment thicknesses calculated using this equation were compared to values calculated from the general equation by Carlson and others (1986). Values for sediment thickness calculated by the two equations differed by no more than 10 percent throughout the range of travel times.

Data Digitalization

Seafloor-depth and acoustic-basement horizons at 0.5-hour intervals were manually digitized from seismic-reflection paper records. A plot of the point values was overlaid with a mylar sheet on which contours were sketched. The mylar overlay was digitized with a Tektronix drum scanner, the output of which was formatted for plotting in Mapgen (Evenden and Botbol, 1985; Grim, 1992).

Bathymetric Data Compilation

Data Source 1 (lat 32–41°N.)

Bathymetric contours between 32°N. and 41°N. latitudes (offshore of the U.S.-Mexico border to north of Cape Mendocino) were digitized from a map by Chase and others (1981) and from the unpublished large-scale versions of that map (T.E. Chase, written commun., 1981). Chase obtained the data for the area seaward of the continental slope (-2,000-m depth) primarily from the U.S. Coast and Geodetic Survey (C&GS) 1955 Pacific Exploratory Survey, a systematic and detailed (~8-nmi-trackline spacing) survey between Mexico and Canada. The USGS provided data from cruises S3-78-NC, L2-77-NC, L10-76-NC, K-73-NC, and Bartlett 72 (U.S. Geological Survey, 1978). Data were also obtained from Scripps Institution of Oceanography cruises Blue Flash, Kayak B, Scan I, and Seven Tow (Chase and Menard, 1971; Chase and others, 1975). The 200-m contour was derived from National Ocean Service (NOS) charts 1206N-16 (1975a) and 1306N-20 (1975b), and from C&GS charts 1206N-15 (1967a) and 1306N-19 (1967b). Seafloor depths were corrected for sound velocity in seawater using Matthew's (1939) tables.

Data Source 2 (lat 40–49°N.)

Bathymetric contours for 40°N. to 49°N. latitudes were compiled from five sources: (1) a published map (Chase and others, 1981), (2) National Oceanic and Atmospheric Administration (NOAA) digital bathymetric data from the Juan De Fuca Ridge, (3) NOAA digital bathymetric data from the continental slope off the coast of Oregon, (4) unpublished maps of the Gorda Ridge (M.L. Holmes, unpub. data, 1989), and (5) the seafloor west of long 130°W. (T.E. Chase, unpub. data, 1990).

For Area 1 (fig. 4) data used in the region seaward of the continental slope (~2,000-m depth) were obtained primarily by the C&GS during the 1955 Pacific Exploratory Survey, a systematic and detailed (~8-nmi-trackline spacing) survey between Mexico and Canada. Data also were obtained from Scripps Institution of Oceanography (SIO) cruises Kayak E, Scan I, and Seven Tow (Chase and Menard, 1971; Wilde and others, 1977, 1978, 1979). The 200-m contour was derived from C&GS charts 1308N-12, 1308N-17, and 1308N-22 (Coast and Geodetic Survey, 1968a, 1968b, 1969).

The data contoured in Area 2 (fig. 4) were collected by NOAA from 1980 to 1990 in support of ongoing plate-boundary dynamics studies. The research program, originally part of the NOS, later became the VENTS research program, based at NOAA's Pacific Marine Environmental Laboratory in Newport, Oregon. All data were collected using SeaBeam multibeam sonar systems.

Area 3 (fig. 4) contours are based on high-resolution bathymetric data collected by the NOS during the early 1980s in about 45 percent of the conterminous West Coast EEZ using multibeam, swath-sounding techniques. When the data for the paper maps were compiled, only the data from Area 3 were available for inclusion.

The primary source of the data contoured in Area 4 (fig. 4) was the C&GS 1955 Pacific Exploratory Survey. Data from the USGS, the University of Washington, and SIO also was used in the interpretation of Area 4 data. Bathymetric surveys have revealed a high degree of roughness of the seafloor in the West Coast EEZ. In an attempt to depict this roughness, the contours in Area 4 were drawn (in 1992) with a rippled appearance.

The data contoured in Area 5 (fig. 4) were obtained in 1983 by the Hawaii Institute of Geophysics by using the SeaMARC II swath-mapping system (Blackinton and Hussong, 1983). The survey, concentrated in the axial and near-axial zone of the Gorda Ridge and in the eastern part of the Blanco Fracture Zone, was part of a USGS-Minerals Management Service cooperative study on mineral resources in the U.S. EEZ. These data were partially published by Clague and Holmes (1986). Area 5 also was surveyed as part of the VENTS program, and contours of those data were used to verify the contours from the SeaMARC II data.

At adjoining boundaries, the various datasets were in good agreement. Automated and interactive computer techniques were used to link contours between datasets where no adjustment was required for smooth joining of the contours. When an adjustment was needed, contours in the gaps between datasets were manually drawn, digitized, and interactively linked to the contours from adjacent datasets.

NOS survey positioning was determined using the North American Datum of 1983 (NAD 83) spheroid, whereas the map data in this report were compiled using the North American Datum of 1927 (NAD 27) spheroid. The difference between the two datums is approximately100 m on the Earth's surface in the mapped area; at 1:1,000,000 scale, this difference is imperceptible.

Grid Calculation

The grids for sediment thickness, depth to basement, and bathymetry were similarly processed. A 1,000-m grid was constructed from contour-line shapefiles (in UTM Zone 10 coordinates) and supplemented by point shapefiles of zero value using the ArcGIS TopoToRaster tool. TopoToRaster has the following input (table 1):

CONTOUR <*line_input_variable*> INCREM
POINT <*point_input_variable*> GRID_CODE
ENFORCE OFF
DATATYPE CONTOUR
ITERATIONS 40
ROUGHNESS_PENALTY 0.00
DISCRETE_ERROR_FACTOR 1.00
VERTICAL_STANDARD_ERROR 0.00
TOLERANCES 2.50 100.00

Table 1. Inputs and products of grid calculation for sediment thickness, depth to basement, and bathymetry for the deep-sea basins offshore of Washington, Oregon, and California.

Theme	Line input	Point input	Grid
Sediment thickness	cowthk.shp	Zero thickness or outcrop	cowthkg.tif
Depth to basement	cowbsm.shp	Seamount peak or outcrop	cowbsmg.tif
Bathymetry	cowbat.shp		cowbatg.tif

The grid of sediment thickness was calculated from (1) digital contours at 100-m intervals from 0 to 2,300 m from construction of 1992–93 sediment-thickness maps (cowthk.shp, also in this dataset), and (2) points with zero value enclosed by outlines of "outcrop" (fig. 2). TopoToRaster interpolation produced patches of negative thicknesses, which were recalculated to 0. The final grid was clipped to the extent of source contours (fig. 5). The sediment-thickness grid has a maximum value of 2,342 m.

The depth-to-basement grid was calculated from (1) digital contours at 100-m intervals from 800 to 5,400-m depth (from construction of 1992–93 depth-to-basement maps (cowbsm.shp, also in this dataset), and (2) points enclosed by outlines of "seamount peak" that were treated as "no data." The resulting grid was masked by seamount-peak polygons and clipped to the extent of the input contours (fig. 6). The greatest depth to basement is 5,583 m.

Bathymetric contour data (100-m interval from 200 to 5,300 m) from the shapefile, cowbat.shp included in this report were developed from data developed before the 1984 GLORIA surveys (EEZ-SCAN 84 Scientific Staff, 1985). The contours and a coastline (for zero depth) from NOAA (National

Ocean and Atmospheric Administration, 2011; Wessel and Smith, 1996) were used to generate a continuous raster. All contours were projected to the UTM Zone 10, WGS84 coordinate system for this calculation. The resultant grid was clipped to the extent of the bathymetric contours, which has a different footprint than the other two datasets (fig. 7). The range in depth for the bathymetry grid is from 200 to 5,313 m.

Horizontal and Vertical Accuracy

Bathymetric contours were compared to ETOPO1 (Amante and Eakins, 2009), a current compilation of global relief. By visual inspection, ridges, seamounts, and other seafloor features are offset by as much as 10 km. The interpolated bathymetry grid generated for this report was compared to ETOPO1 gridded data (Amante and Eakins, 2009). A depth-difference calculation determined that the 1992 bathymetry data underestimate heights and elevations by a mean of 4 m, with a standard deviation of 130 m. The vertical underestimate can be partly attributable to horizontally displaced features.

Data Catalog

The data described in this report are available for download from http://pubs.usgs.gov/of/2015/1118/data_catalog.html.

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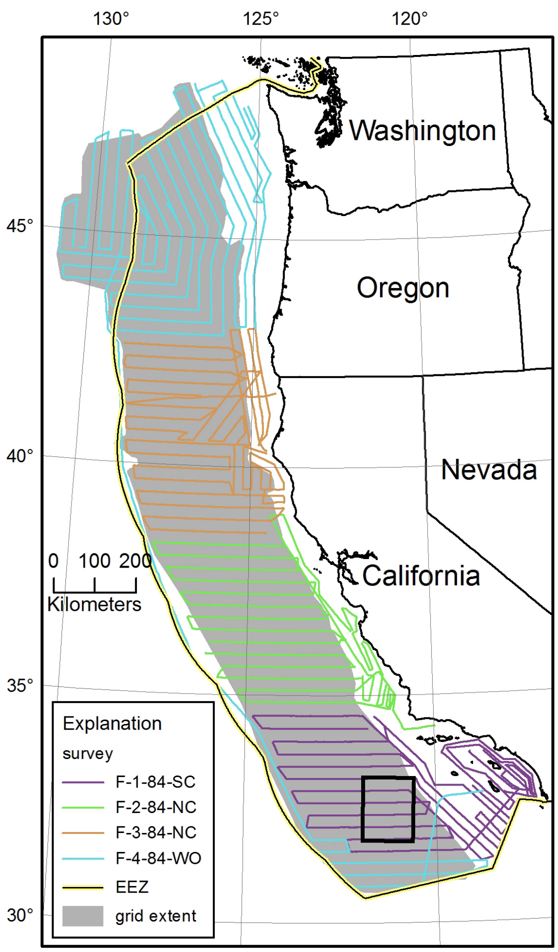

Figure 1. Map showing location of 1984 U.S. Geological Survey reconnaissance survey tracklines, offshore of Washington, Oregon, and California. Gray polygon is the extent of sediment-thickness and depth-to-basement grids described in this report. Black rectangle encloses area of map in figure 2.

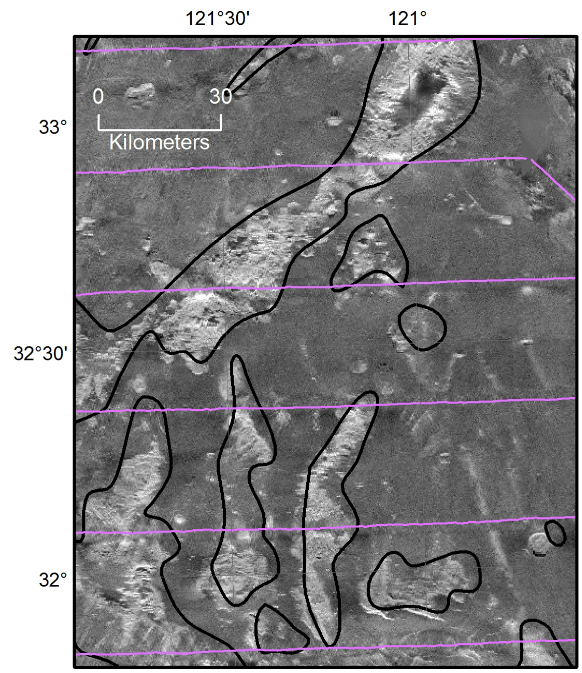

Figure 2. Map showing polygons of outcrop exposures (thickness = 0), in an area west of southern California (fig. 1), selected from bright areas (high reflectance) of GLORIA sidescan image (EEZ-Scan 84 Scientific Staff, 1986). Violet lines indicate GLORIA survey tracklines with approximately 30-km separation.

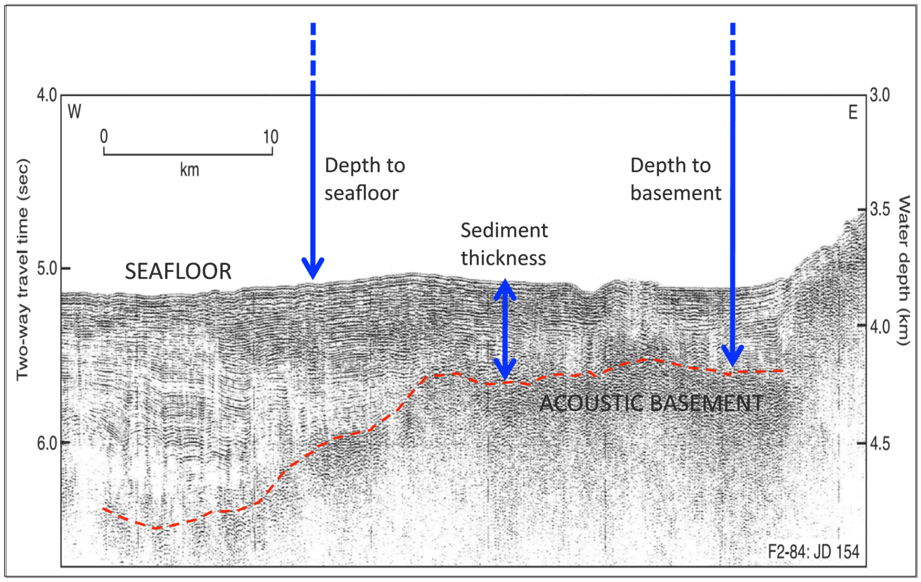

Figure 3. Diagram of sediment thickness and acoustic basement as imaged in a seismic-reflection record. Vertical axis represents two-way travel time in seconds at 4 s and deeper. After Fildani and Normark (2004).

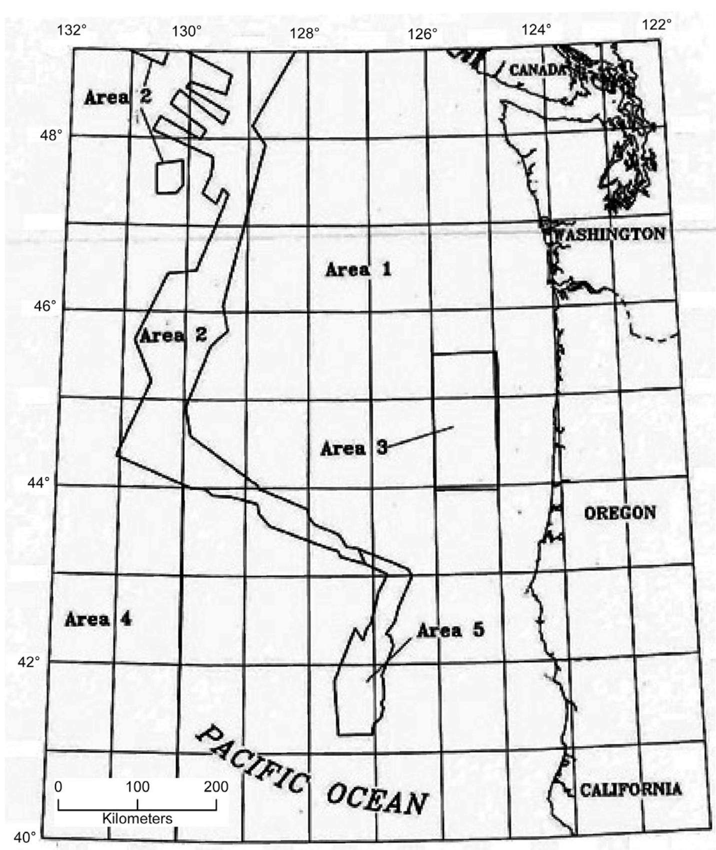

Figure 4. Map showing locations of bathymetric data sources for northern part of map area (Grim and others, 1992). Area 1, data published by Chase and others (1981); Area 2, National Oceanic and Atmospheric Administration Sea Beam data from Juan de Fuca Ridge area; Area 3, NOAA multibeam data from the continental slope off Oregon; Area 4, unpublished map compiled by T.E. Chase (1990); Area 5, unpublished map compiled by M.L. Holmes (1989).

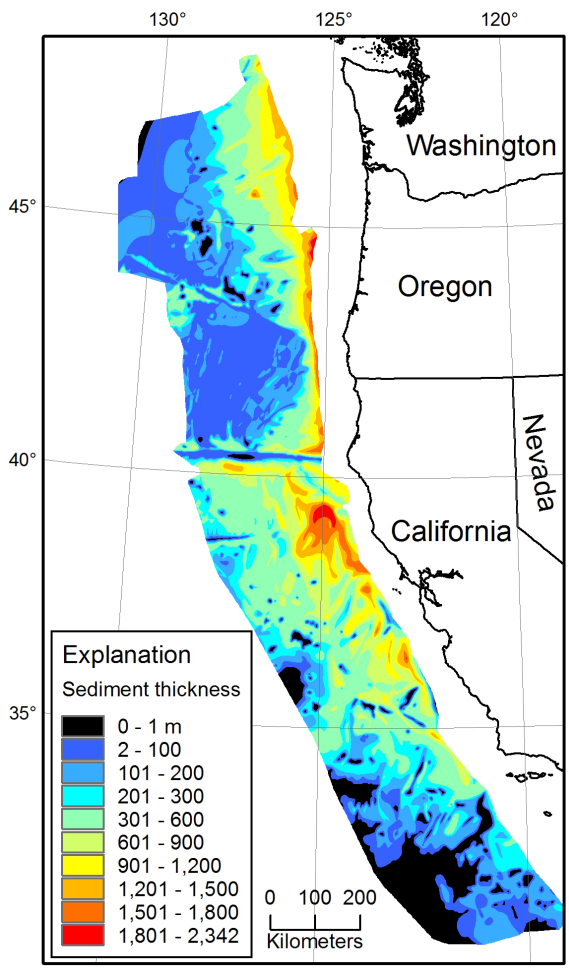

Figure 5. Map showing grid of sediment thickness interpolated from contours, offshore of Washington, Oregon, and California.

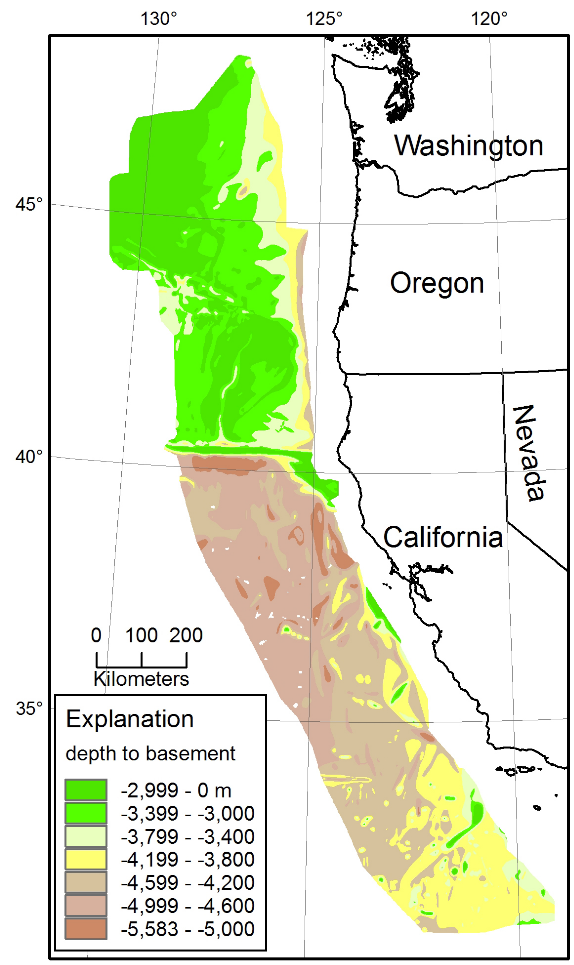

Figure 6. Map showing grid of depth to acoustic basement interpolated from contours, offshore of Washington, Oregon and California.

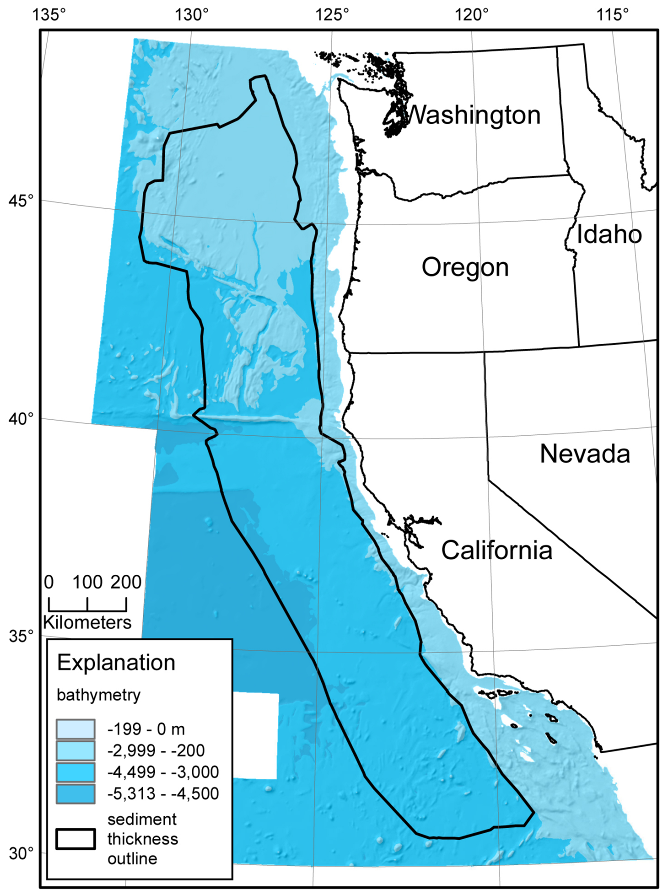

Figure 7. Map showing grid of bathymetry interpolated from depth contours rendered with shaded relief, offshore of Washington, Oregon, and California. Black polygon encloses area of grids of sediment thickness and depth to basement.