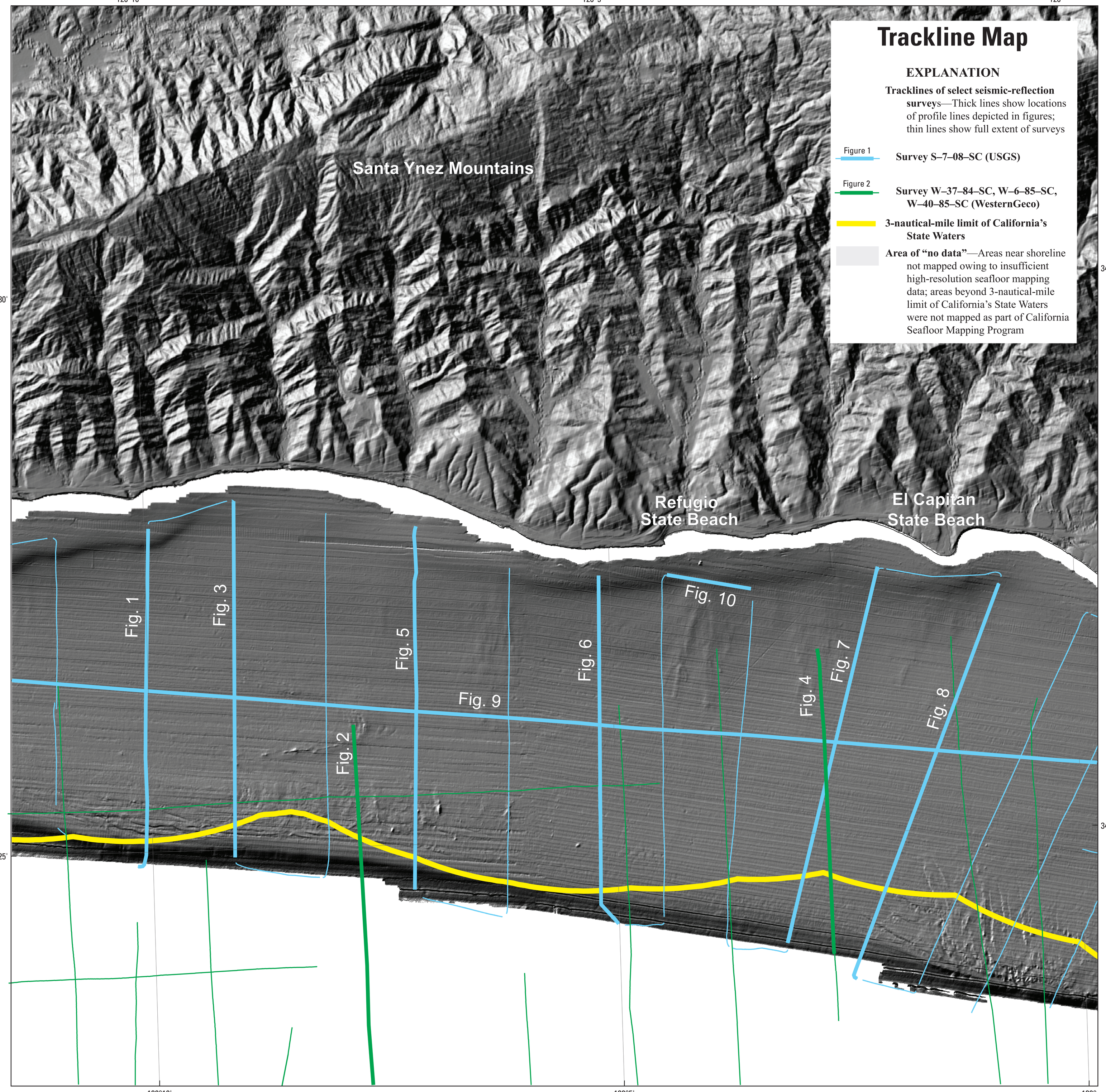


Onshore elevation data from NOAA Coastal Services Center (data collected by EarthData International in 2002-2003) and from U.S. Army Corps of Engineers (data collected by Fugro Pelagos in 2009). Offshore shaded-relief bathymetry from map on sheet 2, this report. California's State Waters limit from NOAA Office of Coast Survey
Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

SCALE 1:50 000

ONE MILE = 0.869 NAUTICAL MILES

GIS database and digital cartography by Eleyne L. Phillips and Florence L. Wong
Edited by Sarah E. Nagorsen
Manuscript approved for publication February 4, 2015

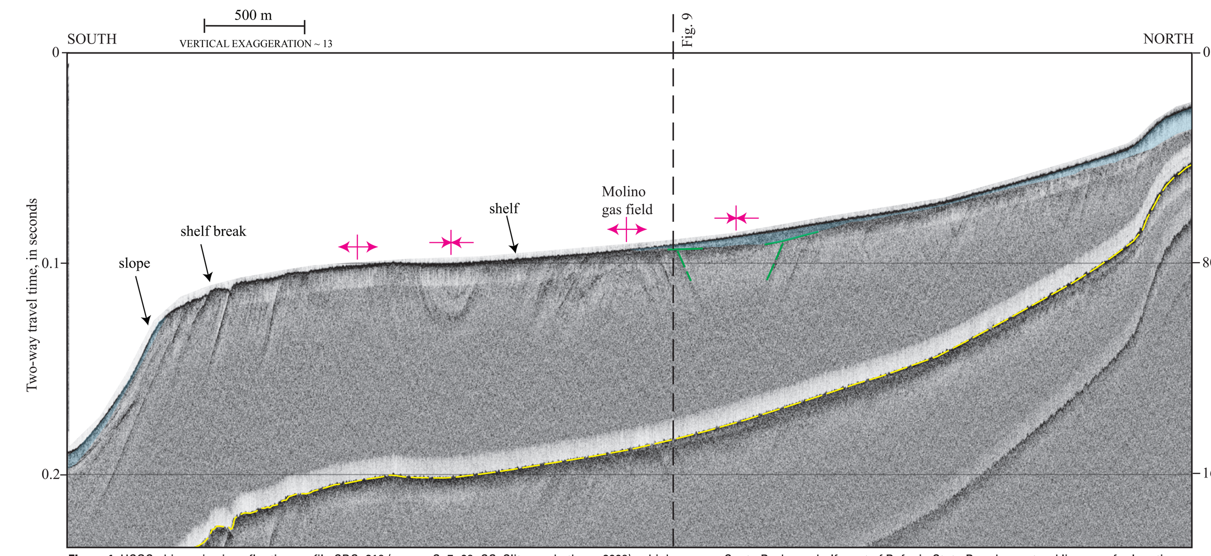


Figure 1. USGS chirp seismic-reflection profile SBC–219 (survey S–7–08–SC; Sliter and others, 2008), which crosses Santa Barbara shelf west of Refugio State Beach; see trackline map for location. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 8 m in nearshore on this transect but, in general, are thinner or altogether absent farther offshore. Dashed green lines highlight part of angular unconformity that separates upper unit from underlying tilted, Miocene and younger strata; at shelf break, these older strata dip about 15° offshore (note vertical exaggeration), which could facilitate (through bedding-plane slip) submarine landslides such as Goleta landslide complex (Fisher and others, 2005; Greene and others, 2006), mapped to east in adjacent Offshore of Coal Oil Point map area. Also shown is Molino gas field (see fig. 1–2 [in pamphlet] for location). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

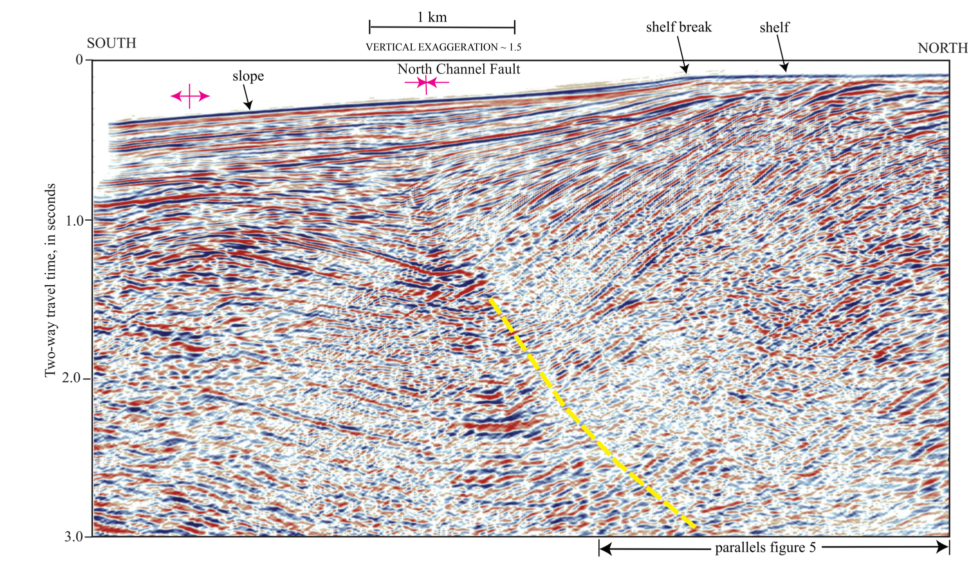


Figure 2. Industry 2-D, migrated multichannel air-gun seismic-reflection profile WC85–252 (collected in 1985 on survey W–40–85–SC), which traverses part of Santa Barbara shelf southwest of Refugio State Beach; see trackline map for location. Note that profile has similar horizontal scale to USGS high-resolution seismic-reflection profiles shown in figures 1, 3, 5, 6, 7, 8, 9, and 10, but it has much less vertical exaggeration (1.5:1). Note also that profile has not been depth converted and so no depth scale is shown, but it probably extends to depths of about 4 km. Dashed yellow line shows inferred trace of North Channel Fault, a "blind" structure that does not rupture surface. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, syncline). Profile parallels southern part of figure 5 (located about 1 km to east; see trackline map). Profile shows predominant south dip of Tertiary strata beneath shelf and upper slope north of North Channel Fault (also seen on high-resolution profiles in figures 1, 3, 5, 6, 7, and 8), as well as syncline and anticline axes beneath slope south of fault.

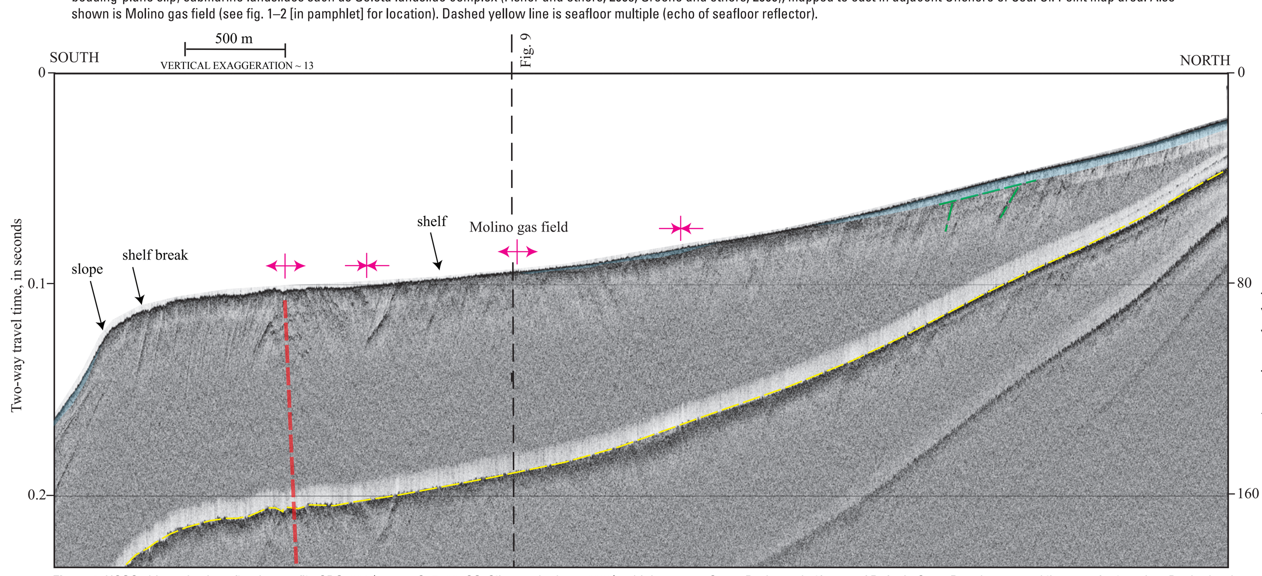


Figure 3. USGS chirp seismic-reflection profile SBC–221 (survey S–7–08–SC; Sliter and others, 2008), which crosses Santa Barbara shelf west of Refugio State Beach; see trackline map for location. Dashed red line shows inferred fault in core of anticline. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of only about 3 m on this transect but, in general, are thinner or altogether absent. Dashed green lines highlight part of angular unconformity that separates upper unit from underlying tilted, Miocene and younger bedrock; at shelf break, these older strata dip about 19° offshore (note vertical exaggeration), which could facilitate (through bedding-plane slip) submarine landslides such as Goleta landslide complex (Fisher and others, 2005; Greene and others, 2006), mapped to east in adjacent Offshore of Coal Oil Point map area. Also shown is Molino gas field (see fig. 1–2 [in pamphlet] for location). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

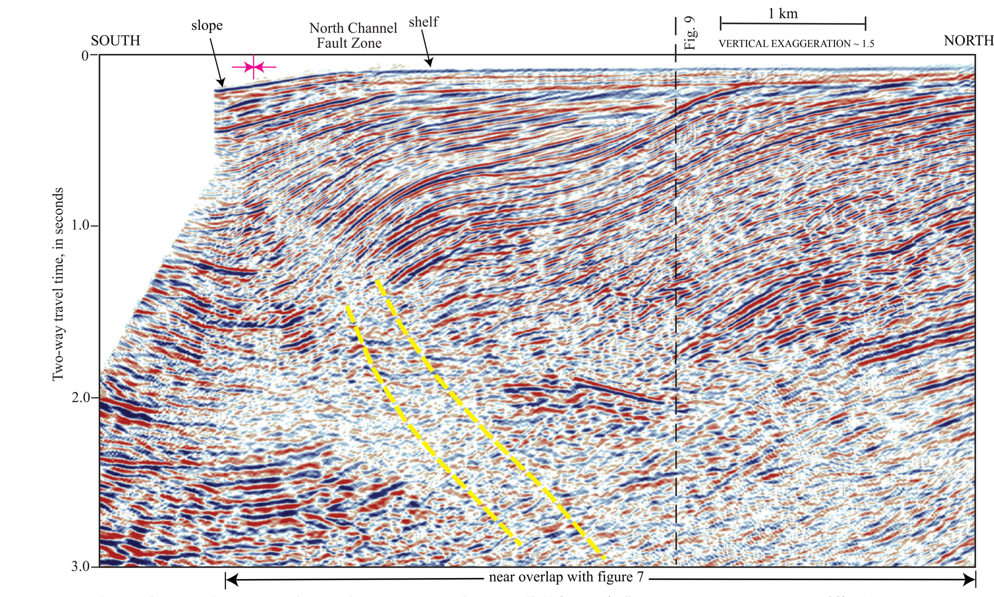


Figure 4. Industry 2-D, migrated multichannel air-gun seismic-reflection profile WC85–244 (collected in 1985 on survey W–40–85–SC), which extends south across Santa Barbara shelf southeast of Refugio State Beach; see trackline map for location. Note that profile has similar horizontal scale to USGS high-resolution seismic-reflection profiles shown in figures 1, 3, 5, 6, 7, 8, 9, and 10, but it has much less vertical exaggeration (1.5:1). Note also that profile has not been depth converted and so no depth scale is shown, but it probably extends to depths of about 4 km. Dashed yellow lines show inferred faults in North Channel Fault Zone, a "blind" structure that does not rupture to the surface. Magenta symbol shows syncline axis. Note near overlap with figure 7 (see trackline map). Profile shows predominant south dip of Tertiary strata beneath shelf and upper slope north of North Channel Fault (also seen on high-resolution profiles in figures 1, 3, 5, 6, 7, and 8), as well as axis of prominent syncline beneath slope south of fault.

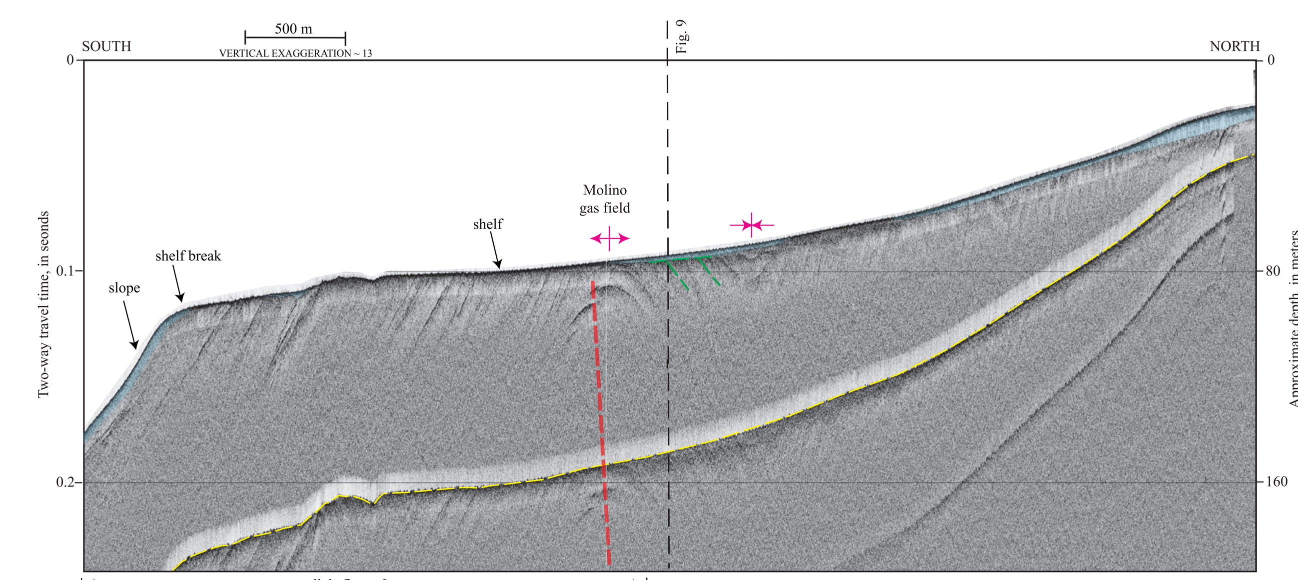


Figure 5. USGS chirp seismic-reflection profile SBC–225 (survey S–7–08–SC; Sliter and others, 2008), which crosses Santa Barbara shelf west of Refugio State Beach; see trackline map for location. Dashed red line shows inferred fault in core of anticline. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 6 m near the coast on this transect but, in general, are thinner or altogether absent farther offshore. Dashed green lines highlight part of angular unconformity that separates upper unit from underlying tilted, Miocene and younger bedrock; at shelf break, these older strata dip about 7° offshore (note vertical exaggeration), which could facilitate (through bedding-plane slip) submarine landslides such as Goleta landslide complex (Fisher and others, 2005; Greene and others, 2006), mapped to east in adjacent Offshore of Coal Oil Point map area. Also shown is Molino gas field (see fig. 1–2 [in pamphlet] for location). Profile parallels northern part of figure 2 (located about 1 km west; see trackline map), which has much lower resolution but much greater depth penetration. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

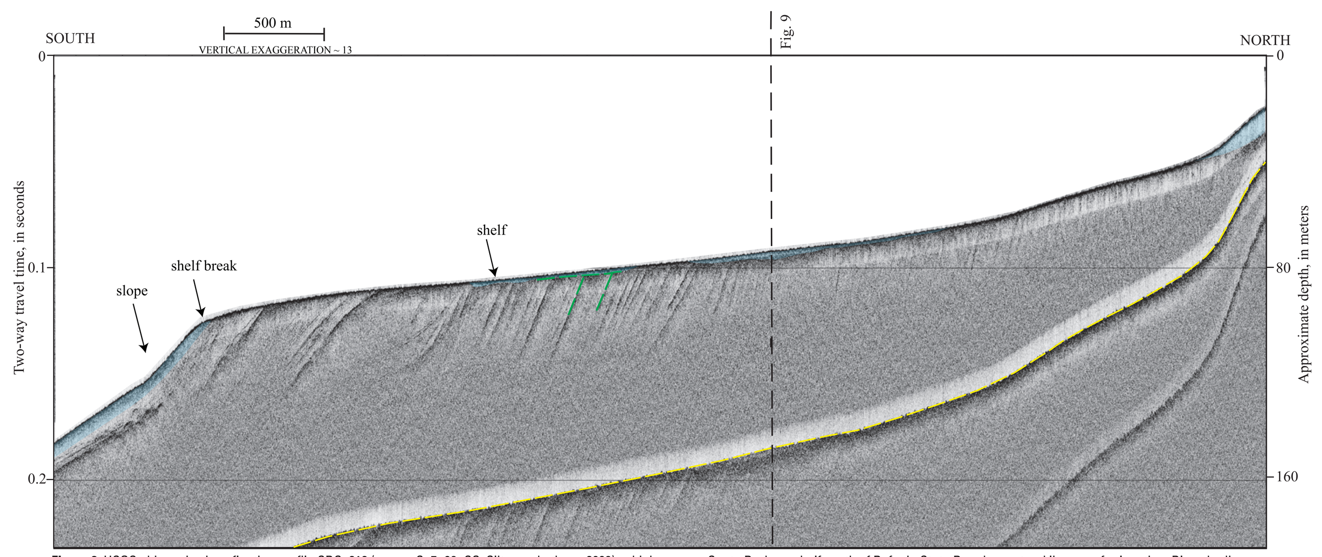


Figure 6. USGS chirp seismic-reflection profile SBC–212 (survey S–7–08–SC; Sliter and others, 2008), which crosses Santa Barbara shelf south of Refugio State Beach; see trackline map for location. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 9 m on this transect but, in general, are thinner or altogether absent farther offshore. Dashed green lines highlight part of angular unconformity that separates upper unit from underlying tilted, Miocene and younger bedrock. Bedrock dips offshore across entire profile; at shelf break, these older strata dip about 6° offshore (note vertical exaggeration), which could facilitate (through bedding-plane slip) submarine landslides such as Goleta landslide complex (Fisher and others, 2005; Greene and others, 2006), mapped to east in adjacent Offshore of Coal Oil Point map area. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

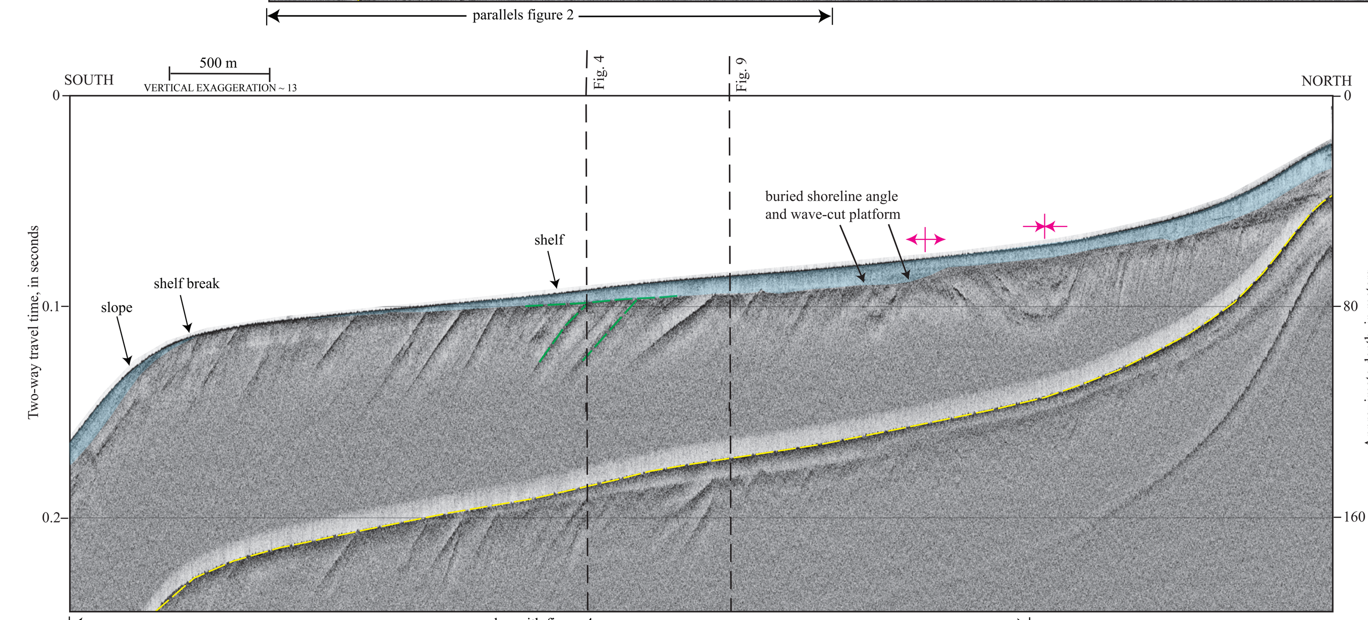


Figure 7. USGS chirp seismic-reflection profile SBC–206 (survey S–7–08–SC; Sliter and others, 2008), which crosses Santa Barbara shelf south of El Capitan State Beach; see trackline map for location. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 8 m on this transect. Dashed green lines highlight part of angular unconformity that separates upper unit from underlying tilted, Miocene and younger bedrock; at shelf break, these older strata dip about 7° offshore (note vertical exaggeration), which could facilitate (through bedding-plane slip) submarine landslides such as Goleta landslide complex (Fisher and others, 2005; Greene and others, 2006), mapped to east in adjacent Offshore of Coal Oil Point map area. Note near overlap with figure 4 (see trackline map), which has much lower resolution but much greater depth penetration. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

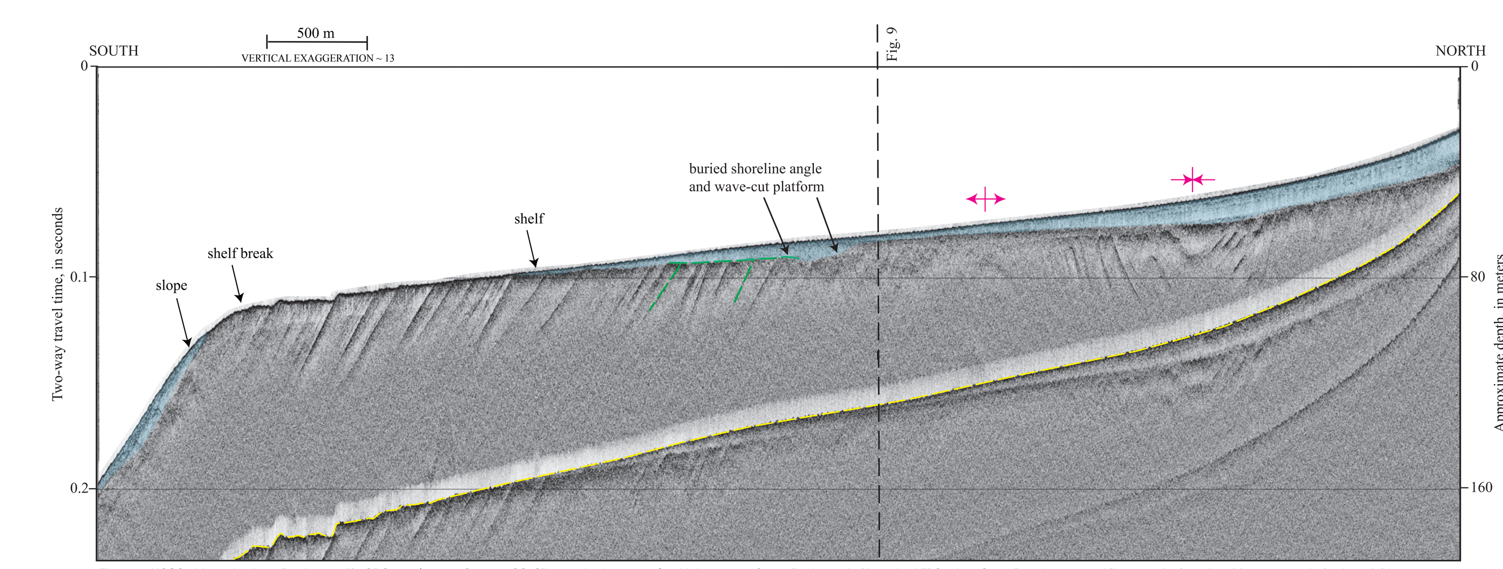


Figure 8. USGS chirp seismic-reflection profile SBC–204 (survey S–7–08–SC; Sliter and others, 2008), which crosses Santa Barbara shelf south of El Capitan State Beach; see trackline map for location. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 12 m near coast but, in general, are thinner or altogether absent farther offshore. Dashed green lines highlight part of angular unconformity that separates upper unit from underlying tilted, Miocene and younger bedrock; at shelf break, these older strata dip about 9° offshore (note vertical exaggeration), which could facilitate (through bedding-plane slip) submarine landslides such as Goleta landslide complex (Fisher and others, 2005; Greene and others, 2006), mapped to east in adjacent Offshore of Coal Oil Point map area. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

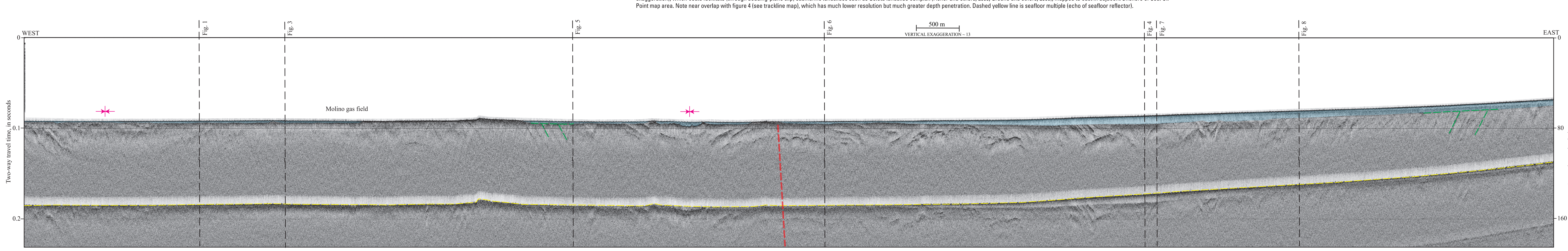


Figure 9. USGS chirp seismic-reflection profile SBC–213T (survey S–7–08–SC; Sliter and others, 2008), which crosses outer Santa Barbara shelf offshore of Refugio State Beach, subparallel to shoreline; see trackline map for location. Dashed red line shows fault. Magenta symbols show syncline axes. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 7 m but are thin to absent over much of western part of profile. Dashed green lines highlight part of angular unconformity that separates upper unit from underlying tilted, Miocene and younger bedrock. Profile crosses axis of same syncline twice (see sheet 10) and crosses the predominant structural trend at a highly oblique angle, resulting in irregular, hummocky character of bedrock reflections (in contrast to figures 1, 3, 5, 6, 7, and 8, which are roughly perpendicular to structural trend). Also shown is Molino gas field (see fig. 1–2 [in pamphlet] for location). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

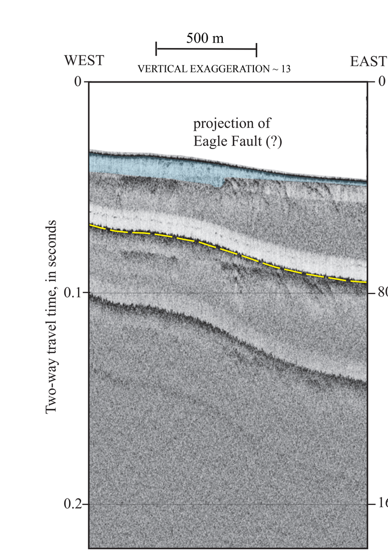
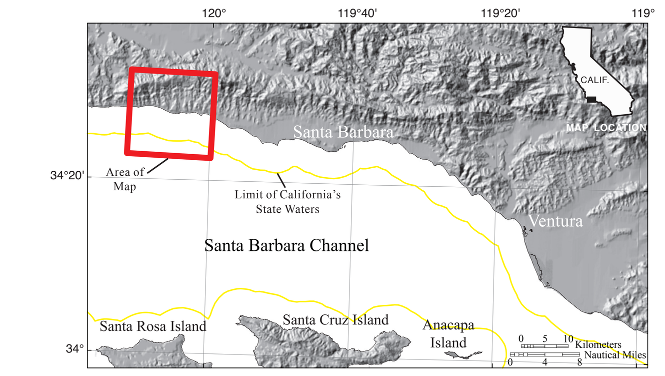


Figure 10. USGS chirp seismic-reflection profile SBC–209 (survey S–7–08–SC; Sliter and others, 2008), which crosses nearshore area south of Refugio State Beach, roughly parallel to shoreline; see trackline map for location. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 7 m on this profile but thin abruptly over buried, near-vertical scarp that aligns with possible westward projection of Eagle Fault, mapped onland by Dibblee (1981a) and Minor and others (2009). Underlying strata are probably rocks of the lower Miocene Rincon Shale and (or) the Miocene Monterey Formation. Dashed yellow line is seafloor multiple (echo of seafloor reflector).



DISCUSSION

This map sheet shows seismic-reflection profiles from two different surveys of the Offshore of Refugio Beach map area, providing imagery of the subsurface geology. The area extends from the nearshore across the continental shelf and onto the upper slope, with maximum water depths of about 100 m in California's State Waters. The seismic-reflection data reveal that the shelf is largely underlain by upper Pleistocene and Holocene marine sediments (blue shading in profiles; Sommerfield and others, 2009; Draut and others, 2009) deposited in the past about 21,000 years, following the last major glaciation and sea-level lowstand (see, for example, Fleming and others, 1998). This postglacial stratigraphic unit has a maximum thickness of about 12 m (fig. 8) offshore of El Capitan State Beach in the eastern part of the map area, but it is typically less than 5 m thick and pinches out locally over bedrock highs. Nearshore and shelf sediment is mainly derived from eastward littoral drift, bluff erosion, and local coastal watersheds (Warrick and Farnsworth, 2009; see also, fig. 1–2 in pamphlet). Underlying bedrock is predominantly fine-grained Miocene marine strata, on the basis of the extension of adjacent onshore geologic mapping by Dibblee (1981a,b). This Neogene bedrock, which lies above the north-dipping North Channel Fault, is deformed into west- to northwest-trending folds that dip predominantly to the south, toward the Santa Barbara Basin (Kamerling and others, 2001). The offshore dips of beds are especially notable at the shelf break, where they could facilitate (by bedding-plane slip) submarine landslides, such as the Goleta landslide complex and Gaviota landslide (Fisher and others, 2005; Greene and others, 2006), both mapped to the east in the adjacent Offshore of Coal Oil Point map area. Previously Ashley and others (1977) also used seismic-reflection profiles to generate structural and stratigraphic interpretations in this map area.

Most high-resolution seismic-reflection profiles displayed on this map sheet (figs. 1, 3, 5, 6, 7, 8, 9, 10) were collected in 2008 on U.S. Geological Survey (USGS) cruise S–7–08–SC (Sliter and others, 2008). Single-channel seismic-reflection data were acquired using the EdgeTech 512 chirp, a subbottom-profiling system that consists of a source transducer and an array of receiving hydrophones housed in a 500-lb fish, towed at a depth of several meters below the sea surface. The swept-frequency chirp source signal was 500 to 4,500 Hz and 50 ms in length. The data were digitally recorded in standard SEG-Y 32-bit floating-point format, using Triton Subbottom Logger (SBL) software that merges seismic-reflection data with differential GPS-navigation data. After the survey, a short-window (20 ms) automatic gain control algorithm was applied to the data. The vertical scale on the high-resolution seismic-reflection profiles (figs. 1, 3, 5, 6, 7, 8, 9, 10) is shown as two-way travel time in seconds, as well as in meters on the basis of an inferred velocity of 1,600 m/sec for near-surface sediments.

Figures 2 and 4 show deep-penetration, migrated, multichannel seismic-reflection profiles collected in 1985 by WesternGeco on cruise W–40–85–SC. These profiles and other similar data were collected in many areas offshore of California in the 1970s and 1980s when the area was considered a frontier for oil and gas exploration. Much of these data have been publicly released and are now archived at the USGS National Archive of Marine Seismic Surveys (U.S. Geological Survey, 2009). These data were acquired with a large-volume air-gun source that has a frequency range of 3 to 40 Hz and recorded with a multichannel hydrophone streamer about 2 km long; shot spacing was about 30 m. These data can resolve geologic features that are 20 to 30 m thick, down to subbottom depths of about 4 km.

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Coastal Conservancy
CALIFORNIA OCEAN PROTECTION COUNCIL
NOAA

Seismic-Reflection Profiles, Offshore of Refugio Beach Map Area, California

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