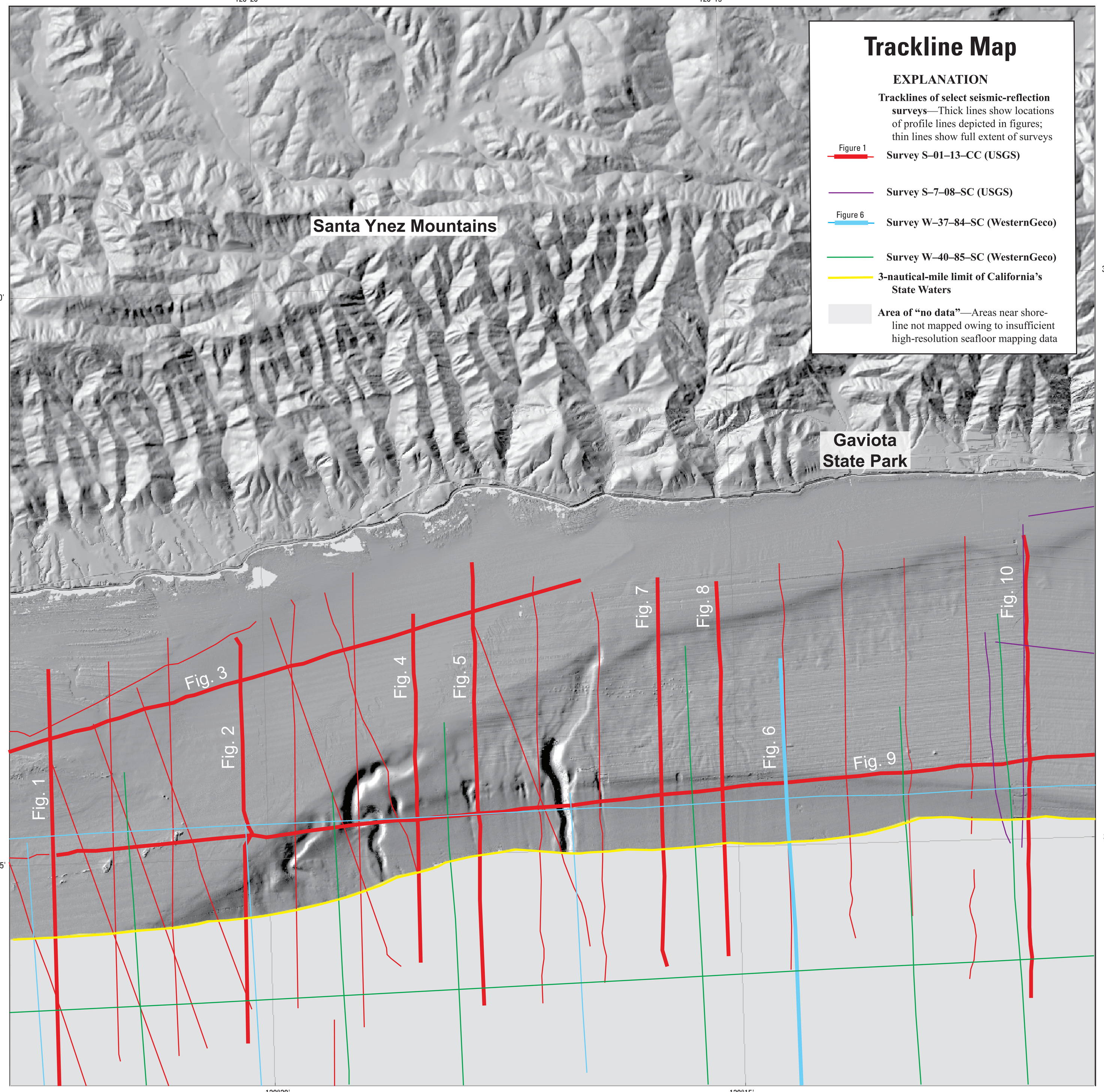
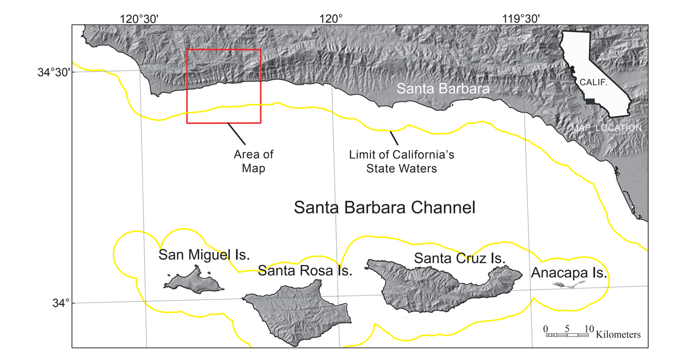
Open-File Report 2018–1023
Sheet 7 of 9
Pamphlet accompanies map





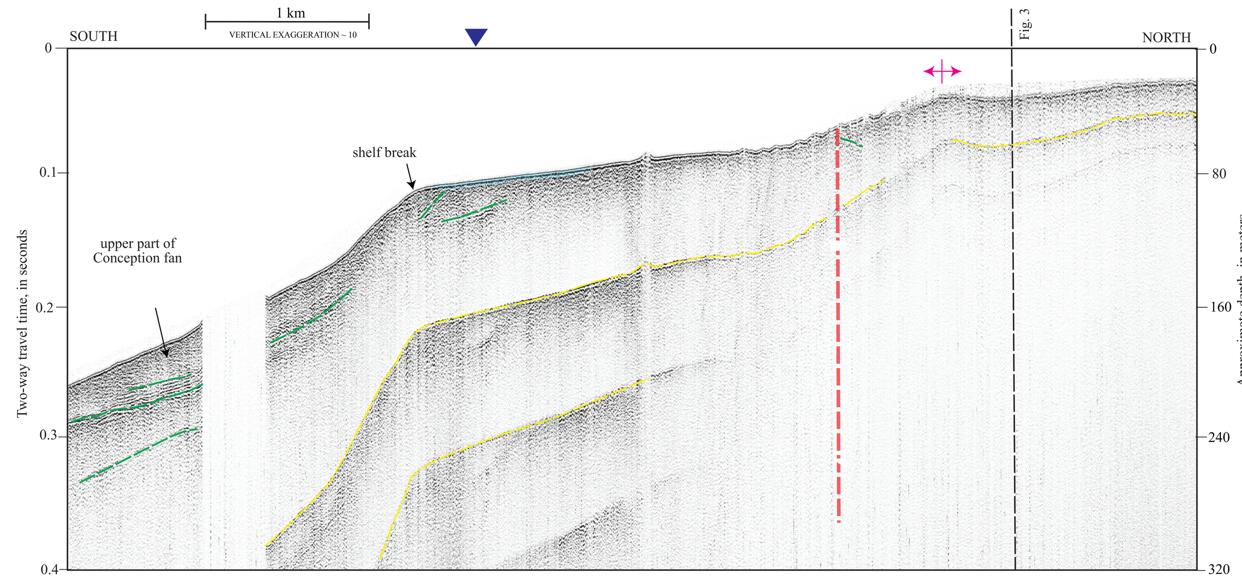


Figure 1. USGS high-resolution minisparker seismic-reflection profile GS–59 (collected in 2014 on cruise S–01–13–CC), which crosses shelf and upper slope west of Gaviota State Park; see trackline map for location. Profile predominantly shows reflection-free bedrock that extends to seafloor (note trackline map). Dashed red line shows inferred fault. Magenta symbol shows anticline axis (structural interpretation is largely based on seafloor outcrops; see sheet 1). Blue shading shows very thin layer on outer shelf (north [to right] of shelf break) of inferred uppermost Pleistocene and Holocene nearshore and shelf deposits. Dashed green lines highlight variably continuous reflections that reveal structure and stratigraphic architecture (not distinctive stratigraphic markers). Dashed yellow lines are seafloor multiples (echoes of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

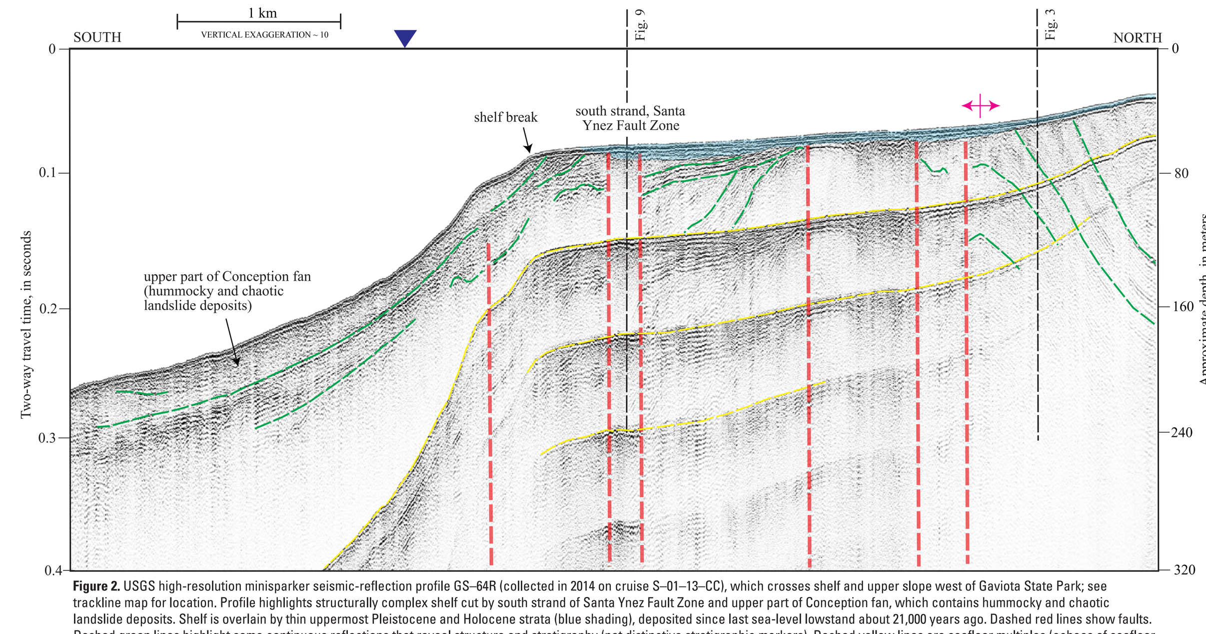


Figure 2. USGS high-resolution minisparker seismic-reflection profile GS–64R (collected in 2014 on cruise S–01–13–CC), which crosses shelf and upper slope west of Gaviota State Park; see trackline map for location. Profile highlights structurally complex shelf cut by south strand of Santa Ynez Fault Zone and upper part of Conception fan, which contains hummocky and chaotic landslide deposits. Shelf is overlain by thin uppermost Pleistocene and Holocene strata (blue shading), deposited since last sea-level lowstand about 21,000 years ago. Dashed red lines show faults. Dashed green lines highlight some continuous reflections that reveal structure and stratigraphy (not distinctive stratigraphic markers). Dashed yellow lines are seafloor multiples (echoes of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

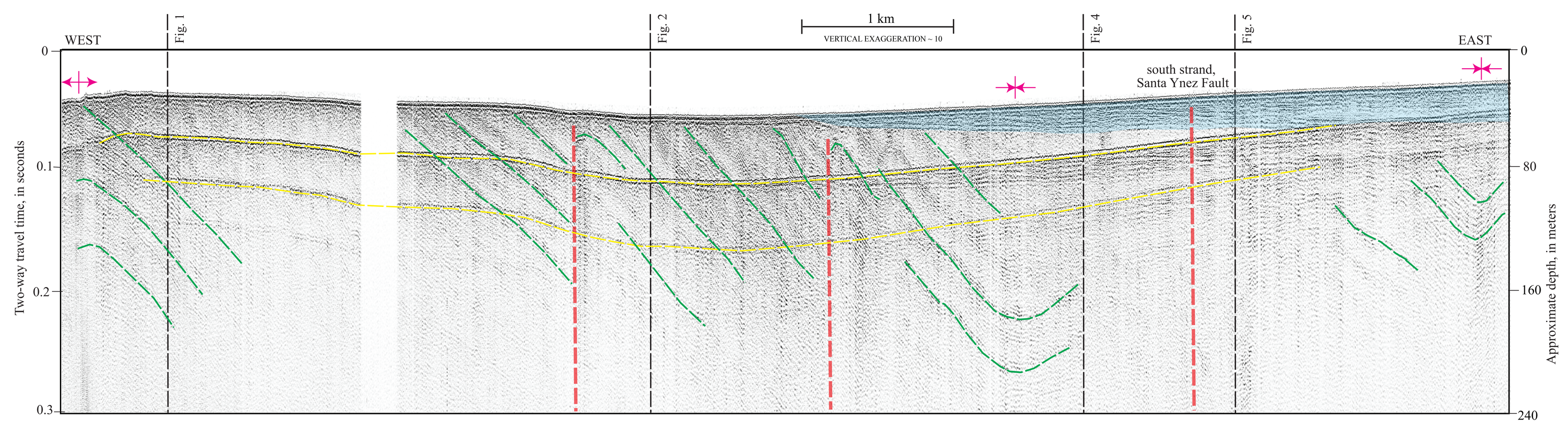


Figure 3 (left). USGS high-resolution minisparker seismic-reflection profile GS–128 (collected in 2014 on cruise S–01–13–CC), which crosses inner shelf west of Gaviota State Park; see trackline map for location. Profile highlights folded and faulted Neogene strata beneath shelf. Dashed red lines show faults. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors image deformed Neogene strata. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow lines are seafloor multiples (echoes of seafloor reflector).

Figure 5 (below). USGS high-resolution minisparker seismic-reflection profile GS–70 (collected in 2009 on cruise S–01–13–CC), which crosses shelf and upper slope southwest of Gaviota State Park; see trackline map for location. Profile highlights Gaviota sediment bar, which has internal clinoforms and debris lobes, and upper part of Conception fan, which consists of mixed landslide and stratified slope deposits. Dashed red line shows inferred fault. Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors locally image deformed Neogene strata. Dashed green lines highlight some continuous reflections that reveal depositional patterns and structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

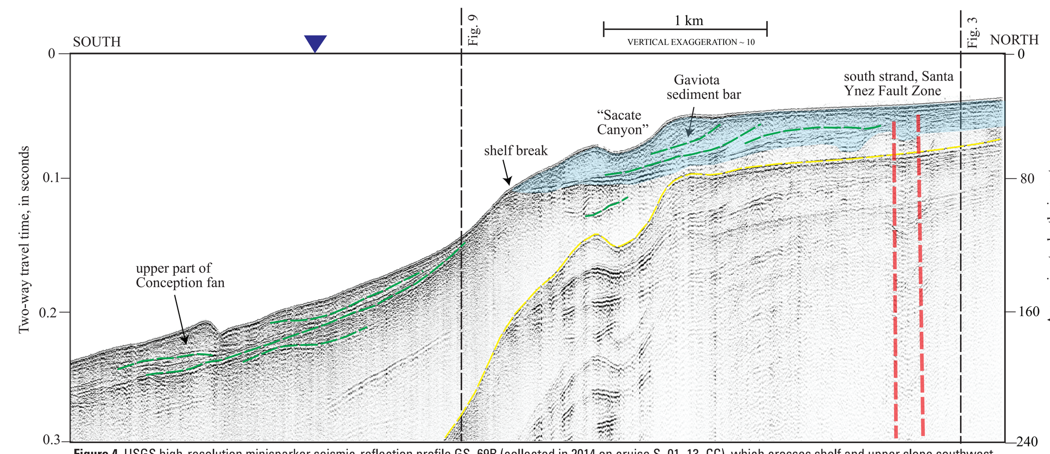
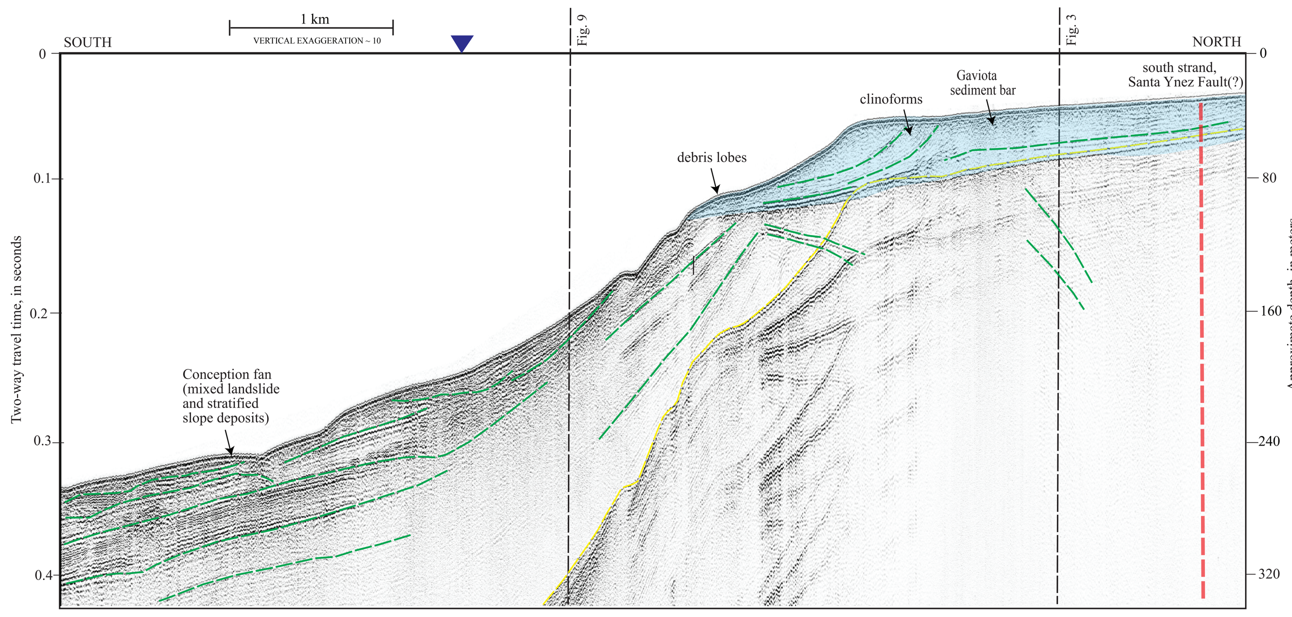


Figure 4. USGS high-resolution minisparker seismic-reflection profile GS–69R (collected in 2014 on cruise S–01–13–CC), which crosses shelf and upper slope southwest of Gaviota State Park; see trackline map for location. Profile highlights south strand of Santa Ynez Fault Zone, Gaviota sediment bar, "Sacate Canyon," and upper part of Conception fan. Dashed red lines show faults. Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors locally image deformed Neogene strata. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).



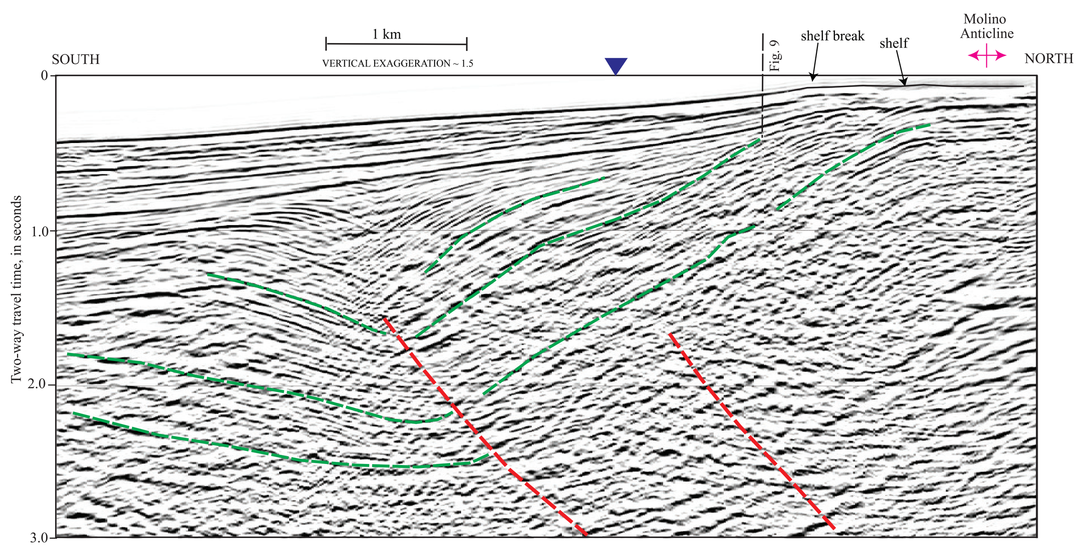


Figure 6. Migrated, deep-penetration industry, 2-D, multichannel air-gun seismic-reflection profile WC–84–262 (collected in 1984 on WesternGeco survey W–37–84–SC; from USGS National Archive of Marine Seismic Surveys [Triezenberg and others, 2016]), which crosses shelf and slope south of Gaviota State Park and extends into Santa Barbara Basin; see trackline map for location. Note that vertical scale and exaggeration are significantly different than that of high-resolution seismic-reflection profiles shown in figures 1, 2, 3, 4, 5, 7, 8, 9, and 10. Profile highlights blind Pitas Point–North Channel Fault system (dashed red lines) and south limb of Molino Anticline (magenta symbol) beneath shelf. Dashed green lines highlight some continuous reflections that reveal depositional patterns and structure (not distinctive stratigraphic markers). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

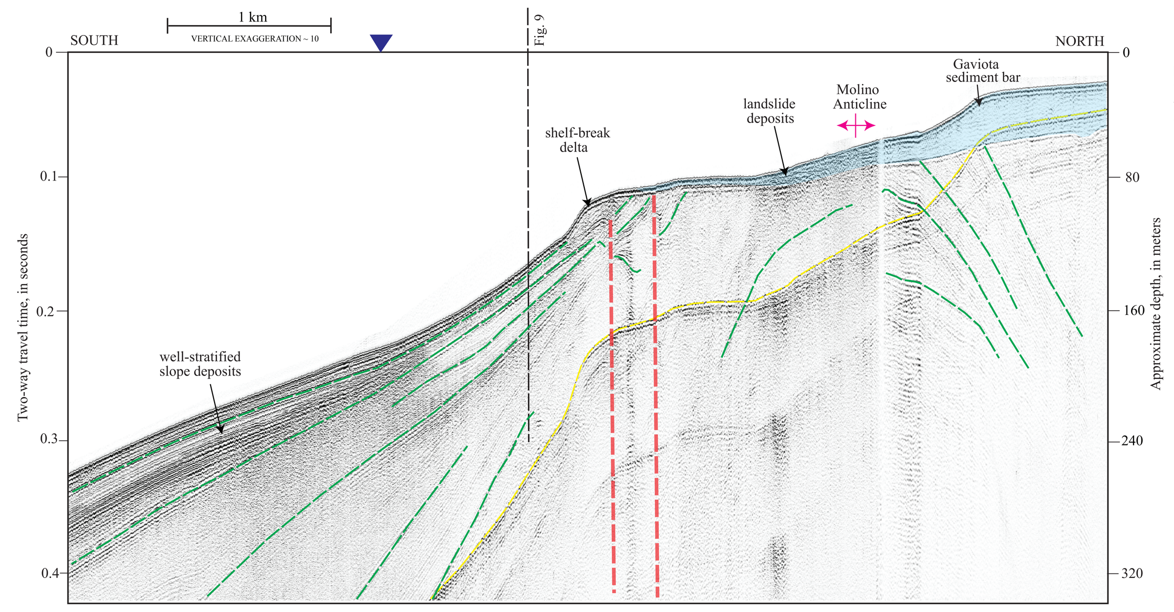
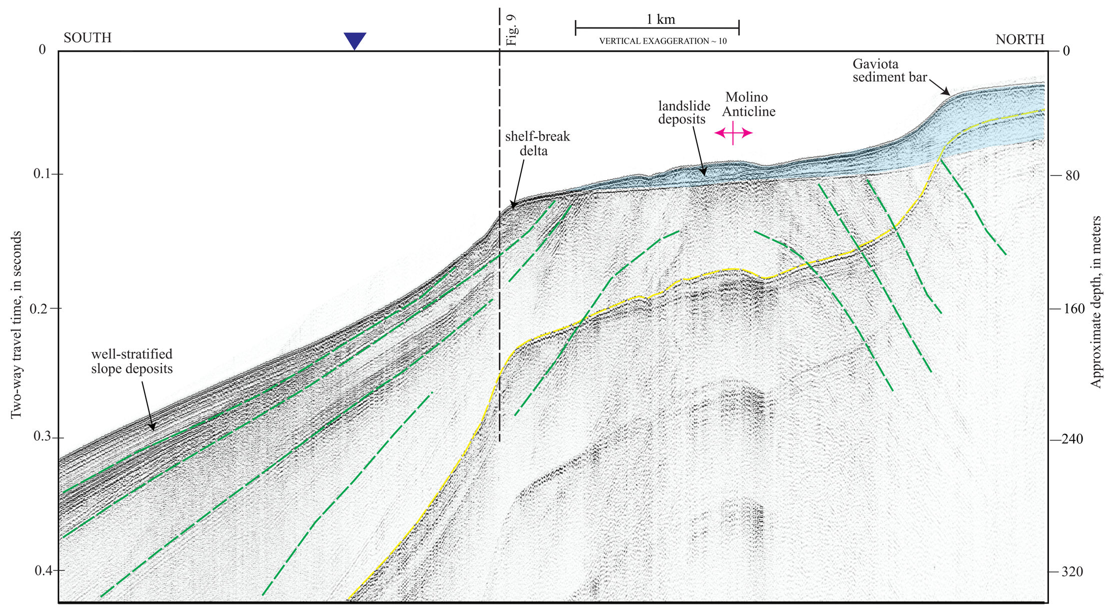


Figure 7. USGS high-resolution minisparker seismic-reflection profile GS–73 (collected in 2014 on cruise S–01–13–CC), which crosses shelf and upper slope southwest of Gaviota State Park; see trackline map for location. Profile highlights Gaviota sediment bar and flanking landslide deposits. Dashed red lines show inferred faults. Magenta symbol shows anticline axis. Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors locally image deformed Neogene strata. Dashed green lines highlight some continuous reflections that reveal depositional patterns and structure (not distinctive stratigraphic markers). Presence of interstitial gas along axis of Molino Anticline masks reflections. Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

Figure 8. USGS high-resolution minisparker seismic-reflection profile GS–74 (collected in 2014 on cruise S–01–13–CC), which crosses shelf and upper slope southwest of Gaviota State Park; see trackline map for location. Profile highlights Gaviota sediment bar and flanking landslide deposits. Magenta symbol shows anticline axis. Blue shading shows inferred uppermost Pleistocene and Holocene strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors locally image deformed Neogene strata. Dashed green lines highlight some continuous reflections that reveal depositional patterns and structure (not distinctive stratigraphic markers). Presence of interstitial gas along axis of Molino Anticline masks reflections. Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).



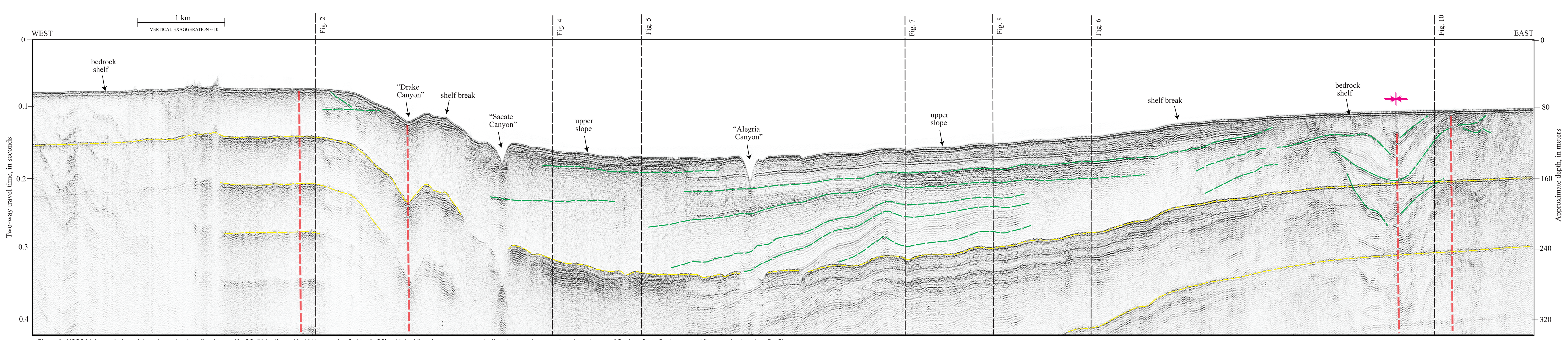


Figure 9. USGS high-resolution minisparker seismic-reflection profile GS–76 (collected in 2014 on cruise S–01–13–CC), which obliquely crosses outer shelf and upper slope south and southwest of Gaviota State Park; see trackline map for location. Profile highlights upper slope deposits and incised heads of submarine canyons. Dashed red lines show faults. Magenta symbol shows syncline axis. Dashed green lines highlight some continuous reflections that reveal depositional patterns and structure (not distinctive stratigraphic markers). Dashed yellow lines are seafloor multiples (echoes of seafloor reflector).

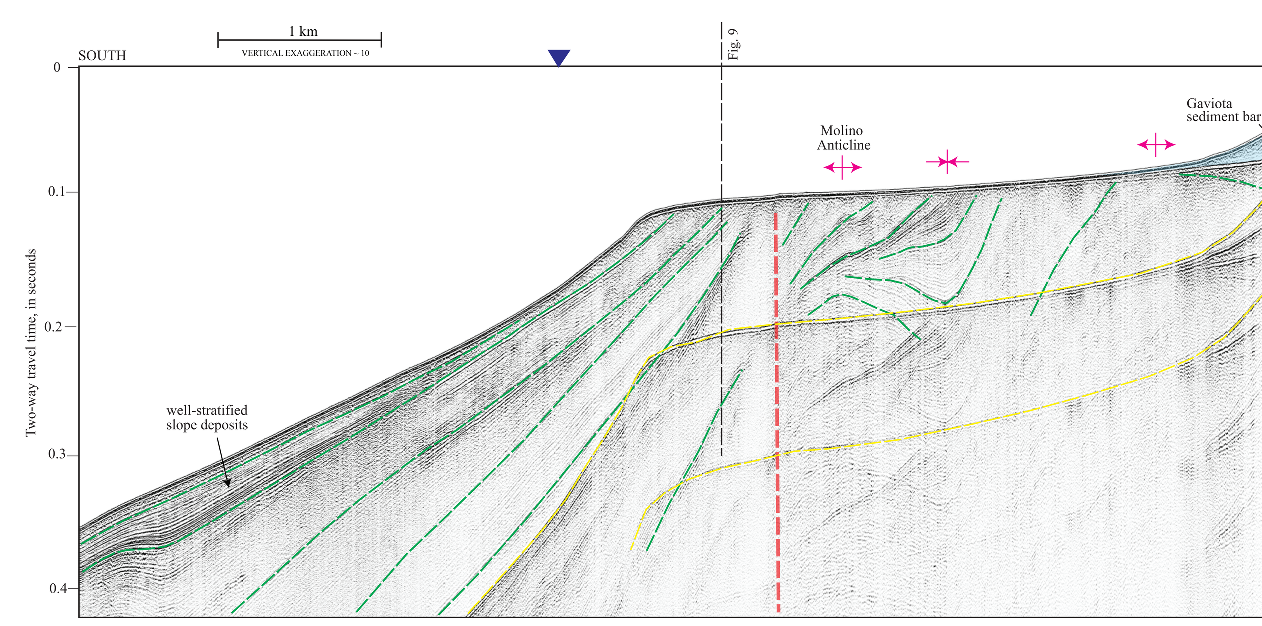


Figure 10. USGS high-resolution minisparker seismic-reflection profile GS–53 (collected in 2014 on cruise S–01–13–CC), which crosses shelf and upper slope southeast of Gaviota State Park; see trackline map for location. Profile highlights bedrock shelf and well stratified slope deposits. Dashed red line shows fault. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, deposited since last sea-level lowstand about 21,000 years ago. Dashed green lines highlight some continuous reflections that reveal depositional patterns and structure (not distinctive stratigraphic markers). Dashed yellow lines are seafloor multiples (echoes of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on trackline map).

DISCUSSION

This map sheet shows seismic-reflection profiles from two different surveys of the Offshore of Gaviota map area, providing imagery of the subsurface geology in the western Santa Barbara Channel. The width of the continental shelf in the map area ranges from about 4.5 to 6 km; the shelf slopes are highly variable in the map area because of the presence of the large Gaviota sediment bar (see figs. 4, 5, 7, 8, 10; see also, sheet 9), which extends obliquely southwestward across the shelf for about 11 km. In the east half of the map area, the shelf break is at a depth of about 87 to 91 m and trends about 276°. Farther west, the shelf break is notably embayed, bends to a trend of about 236°, and is as shallow as 52 to 73 m in an area of significant slope failure.

The high-resolution seismic-reflection profiles displayed on this sheet (figs. 1, 2, 3, 4, 5, 7, 8, 9, 10) were collected in 2014 on U.S. Geological Survey (USGS) cruise S–01–13–CC, using the SIG 2Mille minisparker system. This system used a 500-J high-voltage electrical discharge fired 1 to 2 times per second, which, at normal survey speeds of 4 to 4.5 nautical miles per hour, gives a data trace every 1 to 2 m of lateral distance covered. 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, along with a 160- to 1,200-Hz bandpass filter and a heave correction that uses an automatic seafloor-detection window (averaged over 30 m of lateral distance covered). These data can resolve geologic features a few meters thick (and, hence, are considered "high-resolution"), down to subbottom depths of as much as 400 m.

Figure 6 shows a migrated, deep-penetration, multichannel seismic-reflection profile collected in 1984 by WesternGeco on cruise W–37–84–SC. This profile and other similar data were collected in many areas offshore of California in the 1970s and 1980s when these areas were considered a frontier for oil and gas exploration. Much of these data have been publicly released and are now archived at the U.S. Geological Survey National Archive of Marine Seismic Surveys (Triezenberg and others, 2016). These data were acquired using 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 as much as 4 km.

The shelf is underlain by Neogene sedimentary rocks and uppermost Pleistocene to Holocene sediments (see sheet 9). Neogene units include the Miocene Monterey Formation and the upper Miocene and lower Pliocene Sisquoc Formation. On high-resolution seismic-reflection profiles, these strata commonly yield parallel to subparallel, continuous, variable-amplitude, high-frequency reflections (terminology from Mitchum and others, 1977); however, these strata commonly are folded, in many places too steeply folded to be imaged on seismic-reflection profiles. Local zones that lack reflections probably also are the result of the presence of interstitial gas within the sediments. This effect has been referred to as "gas blanking," "acoustic turbidity," or "acoustic masking" (Hovland and Judd, 1988; Fader, 1997). The gas scatters or attenuates the acoustic energy, preventing penetration. Not surprisingly, this effect is especially prevalent near the Molino Anticline (see figs. 7, 8, 10) and near the crests of other small anticlines.

Eustasy was an important control on latest Pleistocene to Holocene shelf deposition in the Offshore of Gaviota map area. Surficial and shallow sediments were deposited on the shelf in the last about 21,000 years during the sea-level rise that followed the last major lowstand and the Last Glacial Maximum (LGM) (Stanford and others, 2011). Global sea level was about 120 to 130 m lower during the LGM, at which time the shelf on the north flank of the Santa Barbara Channel was emergent. The post-LGM sea-level rise was rapid (about 9 to 11 m per thousand years) until about 7,000 years ago, when it slowed considerably to about 1 m per thousand years (Stanford and others, 2011). The sediments deposited on the shelf during the post-LGM sea-level rise (above a transgressive surface of erosion) are shaded blue in many of the high-resolution seismic-reflection profiles (figs. 1, 2, 3, 4, 5, 7, 8, 10), and their thicknesses are shown on sheet 8.

On most profiles, the base of the post-LGM depositional unit is a flat to concave angular unconformity characterized by an obvious change in reflectivity. The post-LGM sediment unit has its maximum thickness (36 m) in the Gaviota sediment bar (figs. 4, 5, 7, 8, 10), which is as wide as 2 km and extends southwestward for about 9 km from the mouth of Cañada de la Gaviota to the shelf break. The bar, which faces southeast, has a relatively flat (about 1.4°) top that extends to water depths of 60 m. The steep (as much as 5°) bar front, formed by advancing clinoforms (figs. 4, 5), is bounded seaward by an apron of coalescing slump deposits and mass-flow lobes (see figs. 7, 8; see also, sheets 1, 2, 9). Post-LGM sediment thins markedly, and is locally absent, both southeast and northwest of the Gaviota sediment bar.

All but the westernmost one-sixth (about 2 km wide) of the map area includes the shelf break and upper slope. For the eastern two-fifths (about 7 km wide) of the map area, the shelf break is relatively sharp, and it locally contains a relatively thin (as much as 12 m) mound of sediment that is interpreted as a lowstand shelf-break delta (figs. 7, 8). Seismic-reflection profiles that cross the smooth upper slope south of the shelf break reveal continuous, subparallel, offshore-dipping reflections (figs. 7, 8, 10), inferred to represent LGM-lowstand and older Quaternary deposits. Although the upper slope in this area is locally as steep as 6°, the seismic-reflection data lack the chaotic to massive reflections that are interpreted as buried landslide deposits in the Goleta landslide complex to the east (Fisher and others, 2005; Greene and others, 2006; Lee and others, 2009) and the Conception fan to the west.

Farther west, the shelf break and the distal portion of the Gaviota sediment bar are incised by three large (150- to 300-m-wide) channels (see sheets 1, 2, 9) that have been referred to as "the Gaviota Canyons" (Fischer and Cherven, 1998) or as "Drake Canyon," "Sacate Canyon," and "Alegria Canyon" (Eichhubl and others, 2002). The upper slope below this part of the shelf break consists of a hummocky, incised debris apron, referred to as the Conception fan (Fischer and Cherven, 1998; Eichhubl and others, 2002). Seismic-reflection profiles that cross the hummocky upper slope reveal massive, reflection-free zones and chaotic reflections (figs. 1, 2, 4, 5) that are interpreted as submarine-landslide deposits, in marked contrast to the smooth slope and continuous reflections that characterize the upper slope to the east (see figs. 7, 8, 10).

High-resolution seismic-reflection profiles in the Offshore of Gaviota map area primarily show Neogene strata that, on a larger scale, are folded within a large homocline that extends from the south flank of the Santa Ynez Mountains (see fig. 1–2 in pamphlet) into the offshore. The homocline formed above the blind Pitas Point–North Channel Fault system (fig. 1–3 in pamphlet), as indicated on nearby regional cross sections (Tennyson and Kropp, 1998; Redin and others, 2005) and on industry seismic-reflection profiles (see fig. 6; see also, Sorlien and Nicholson, 2015). The tip of the fault system is inferred to be buried to a depth of about 2 km below sea level (about 1.5 sec two-way travel time [TWT]) about 10 km offshore, beneath the slope on the north flank of the Santa Barbara Basin.

The southwest-striking south strand of the Santa Ynez Fault (see figs. 3, 4, 5; see also, sheet 9) obliquely cuts the shelf in the western part of the map area. As mapped onshore by Dibblee (1950, 1988a,b), this fault is unique among Santa Barbara fold-belt structures in that it obliquely crosses the Santa Ynez Mountains and the dominant east-west-trending structural grain. In the offshore, the fault was difficult to map, despite our dense coverage of seismic-reflection data (see trackline map), because (1) the pre-LGM section on the shelf includes massive, reflection-free zones that probably are caused by interstitial gas or steeply dipping strata, and (2) the adjacent slope is mainly underlain by the massive to chaotic seismic facies of the Conception fan (figs. 1, 2, 4, 5).

The hanging wall of the Pitas Point–North Channel Fault system (see fig. 1–3 in pamphlet) is inferred to include several blind splays that are structurally above the main fault, on the basis of the irregular pattern of shallow folds in the map area. Closely spaced seismic-reflection profiles reveal many shallow folds that have variable geometries, lengths, amplitudes, degrees of continuity, and wavelengths (see sheet 9). The most continuous folds are the 17-km-long Molino Anticline (host of the Molino gas field) and the 22-km-long Government Point Syncline, both of which are truncated to the west and east, respectively, by the south strand of the Santa Ynez Fault (see sheets 8, 9).

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Seismic-Reflection Profiles, Offshore of Gaviota Map Area, California

By
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2018

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