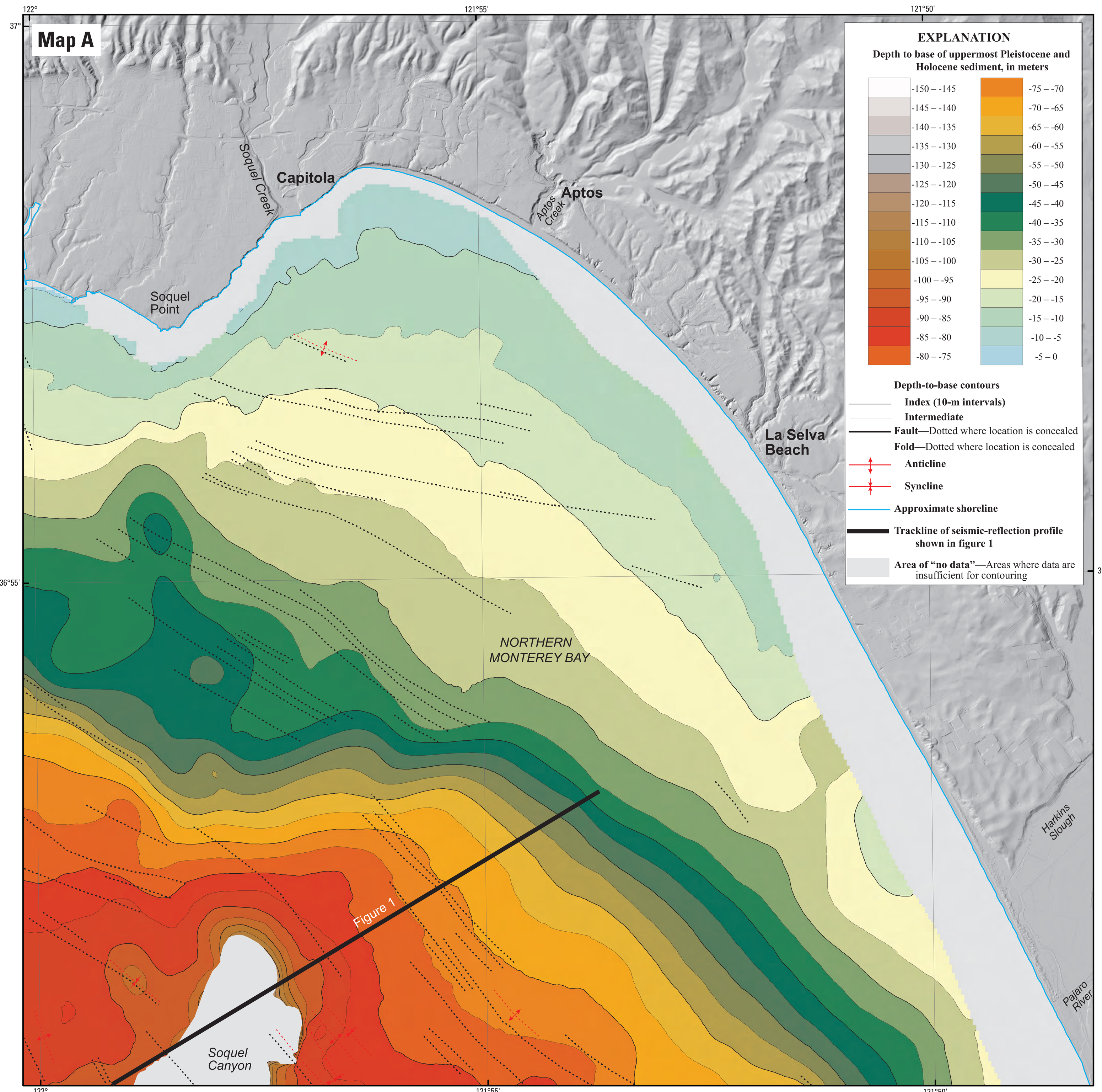

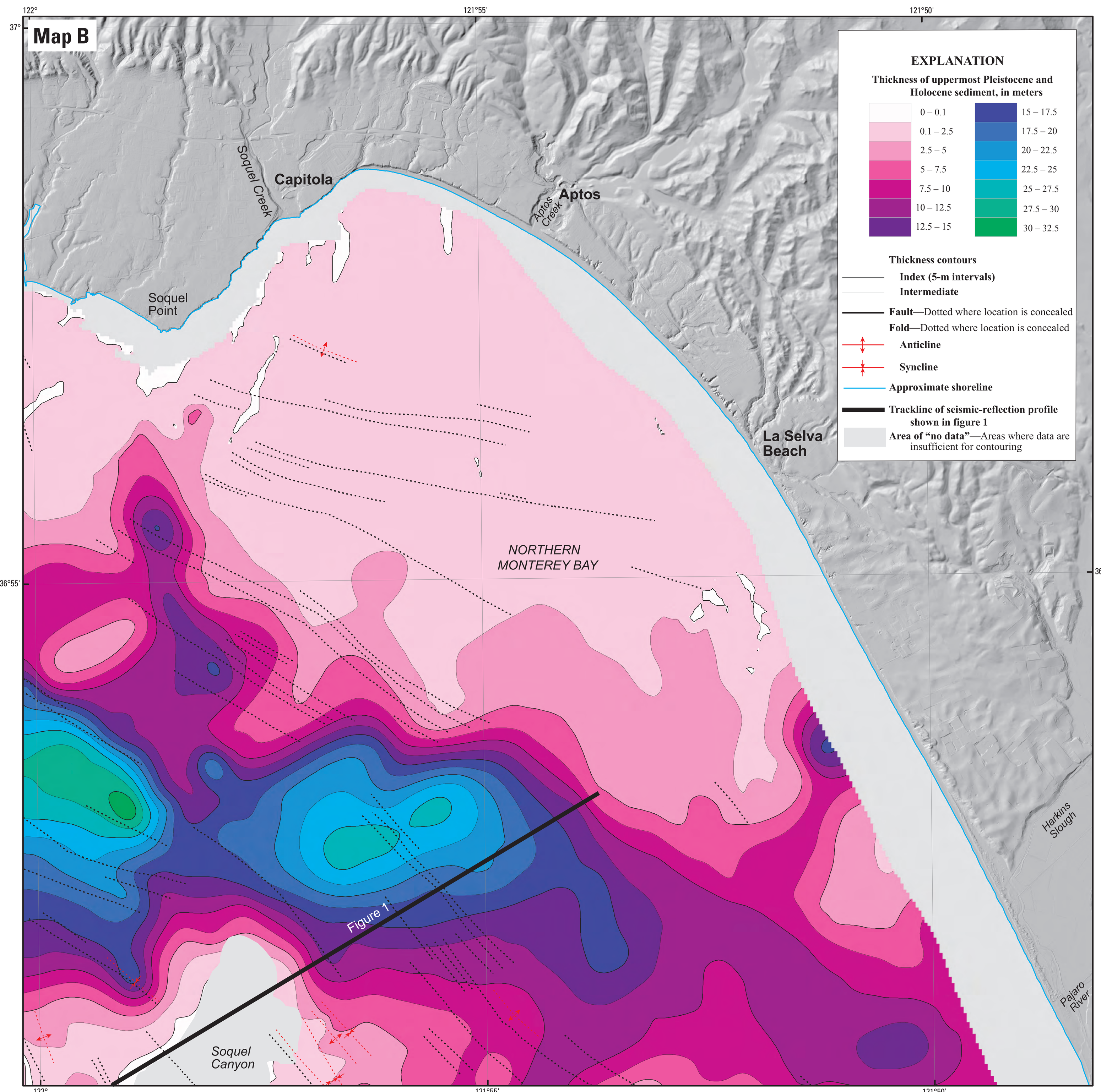

DISCUSSION

This sheet includes maps that show the interpreted thickness and the depth to base of uppermost Pleistocene and Holocene deposits in California's State Waters for the Offshore of Aptos map area (Maps A, B), as well as for a larger area that extends about 91 km along the coast from the Pigeon Point area to southern Monterey Bay (Maps C, D), to establish a regional context. High-resolution seismic-reflection profiles (fig. 1; see also, sheet 8) show a lower unit of deformed Neogene bedrock; a middle unit consisting of mixed eolian and fluvial deposits, present locally in the southeast part of the map area; and an upper unit of inferred upper Quaternary marine sediments. The contact between the two units and overlying upper Quaternary marine sediments is an angular unconformity.

The inferred upper Quaternary sequence of marine sediments includes two subunits (fig. 1; also see figs. 1, 4, 6 on sheet 8). The lower unit (pink shading in profiles) has local occurrence and notably includes low-amplitude, low-angle (1° to 3°), offshore-dipping clinoforms (Catuneanu, 2006) that are as thick as 13 m. The widespread upper unit (blue shading in profiles) typically is characterized by moderate-amplitude, continuous to moderately continuous, diffuse, subparallel reflections, and it has a maximum thickness of about 32 m in paleochannel fills. Our preferred hypothesis is that the clinoforms in the lower (pink shading) of the two upper Quaternary units represent a progradational delta and shoreface complex that formed between about 30,000 and 21,000 years ago, during the sea-level regression before the Last Glacial Maximum (LGM) (Waelbroeck and others, 2002). The upper unit (blue shading) represents shelf sediments that were deposited during the post-LGM sea-level rise of the last about 21,000 years (Stanford and others, 2011). In this interpretation, the contact between the upper and lower units is a transgressive surface of erosion that formed as the shoreline migrated landward. Because these two upper Quaternary units each consist of unconsolidated sediments and together overlie the prominent angular unconformity with bedrock and (or) inferred Pleistocene eolian-fluvial deposits, we have combined their thicknesses on Maps B and D.

To make these maps, water bottom and depth to base of the uppermost Pleistocene and Holocene horizons were mapped from seismic-reflection profiles (fig. 1; see also, sheet 8). The difference between the two horizons was exported for every shot point as XY coordinates (UTM zone 10) and two-way travel time (TWT). The thickness of the uppermost Pleistocene and Holocene unit (Maps B, D) was determined by applying a sound velocity of 1,600 m/sec to the TWT. The thickness points were interpolated to a preliminary continuous surface, overlaid with zero-thickness bedrock outcrops (see sheet 10), and contoured, following the methodology outlined in Wong and others (2012).

The thickness of the uppermost Pleistocene and Holocene sediments in the Offshore of Aptos map area ranges from 0 to 32 m (Map B), and the depth to the unconformity at the base of this unit ranges from less than 10 to more than 100 m at the head of Soquel Canyon (Map A). Mean sediment thickness for the map area is 7.4 m and total sediment volume is $1{,}242 \times 10^6$ m^3 (table 7–1 in pamphlet).

Map B shows that much of the inner shelf (water depths of about 10 to 30 m) in the Offshore of Aptos map area consists of exposed bedrock or bedrock overlain by only a thin (<2.5 m) cover of sediment. This sediment-poor shelf is cut by two sediment-filled paleochannels that extend seaward from the mouths of Soquel Creek and the Pajaro River. The paleochannels connect with a west-trending midshelf (water depths of about 35 to 60 m) depocenter comprising two oblate sub-depocenters (maximum sediment thicknesses of 29 and 32 m) linked by a "neck" of sediment with a thickness of about 16 m (Maps B, D). The depocenter is centered above and south of an offshore increase in the slope (from about 0.2° to more than 1.3°) of the underlying angular unconformity. The sediment cover progressively thins to the south in deeper water.

The locally occurring lower clinoform-bearing unit (pink shading) forms the lower part of the upper Quaternary sediment cover in the midshelf depocenter and, by itself, is as thick as 15 m (figs. 1, 4, 6 on sheet 8; fig. 1 on sheet 9). During the LGM, this regressive delta-shoreface complex became emergent and was locally incised by Soquel Creek. During the following sea-level rise, this delta-shoreface complex was partly to wholly eroded as the shoreline migrated landward; preservation of this unit occurred primarily in accommodation space above the local change in the slope of the bedrock unconformity, yielding the more gentle, smooth offshore-dipping (about 0.1° to 0.4°) surface of the modern continental shelf. The upper unit (blue shading) occurs across the entire offshore map area (excluding bedrock outcrops), filling paleochannels and draping the transgressive surface of erosion.

Six different informal "domains" of thickness of uppermost Pleistocene to Holocene sediment (see table 7–1 in pamphlet) are recognized on the regional sediment-thickness map (Map D), each with its own diverse set of geologic and (or) oceanographic controls. Note that data from within the Monterey Canyon system (including Soquel Canyon), in the southern part of the Pigeon Point to southern Monterey Bay region, were excluded from this analysis because available seismic-reflection data are insufficient to map sediment distribution in this extremely variable environment.

(1) The southern Monterey Bay domain is bounded by the Monterey Bay shoreline on the south and east, the Monterey Canyon on the north, and the limit of California's State Waters on the west. Sediment derived from the Salinas River forms a large, shore-parallel, subaqueous delta (thickness of as much as 32 m) that progrades across a thinly sediment-mantled bedrock shelf. Small changes in sediment thickness on the shelf are controlled by irregular bedrock relief that is at least partly attributable to the Monterey Bay Fault Zone (Greene, 1990).

(2) The northern Monterey Bay domain is bounded on the south by Monterey Canyon, on the north and east by the Monterey Bay shoreline, and on the west by the limit of California's State Waters. The head of Monterey Canyon extends nearly to the shoreline, and the canyon forms a sediment trap that effectively separates the littoral- and shelf-sediment transport systems of the two (northern and southern) Monterey Bay domains. The northern Monterey Bay domain is characterized by (a) a sediment-poor inner shelf cut by paleochannels of the San Lorenzo River, the Pajaro River, and Soquel Creek; (b) a midshelf depocenter that has sediment as thick as 32 m, much of which was deposited in a pre-LGM prograding delta and (or) shoreface complex and was preserved above a decrease in slope on the underlying unconformity; and (c) a midshelf to outer shelf zone in which sediment generally becomes progressively thinner in the offshore direction.

(3) The Davenport shelf domain extends from the northern limit of Monterey Bay northward to the southern margin of the Waddell Creek depocenter (to the north in the Waddell Creek delta domain). The Davenport shelf domain, as well as the three domains farther north, occupy a section of open, wave-dominated coast that is exposed to wave energy higher than that of the Monterey Bay domains to the south. The Davenport shelf domain includes the Davenport depocenter, a prominent midshelf, shore-parallel depocenter present between Davenport and Santa Cruz that mostly consists of a lower, pre-LGM, clinoform-bearing unit of inferred prograding-shoreface origin. Sediment in this depocenter also is preserved in accommodation space linked to an offshore decrease in the slope of the underlying unconformity. Sediment thickness within the Davenport shelf domain decreases to both the northwest and southeast of this depocenter, owing to the presence of elevated bedrock and (or) the related absence of the lower clinoform-bearing unit.

(4) The Waddell Creek delta domain lies offshore of the mouth of the Waddell Creek coastal watershed, and it is connected to it by a submerged channel. The domain is both distinguished and delineated by the significant Waddell Creek depocenter (maximum sediment thickness of 19 m), which forms a moundlike delta that consists entirely of inferred post-LGM deposits whose primary source is Waddell Creek. Sediment thins both north and south of this moundlike delta; its preservation is attributed to its semiprotected (from erosive wave energy) location on the south flank of Point Año Nuevo.

(5) The Año Nuevo shelf domain lies offshore of Point Año Nuevo, from just north of Franklin Point on the north to just north of the mouth of Waddell Creek on the south. Bedrock exposures, which locally reach water depths of 45 m, cover a substantial part of this wave-exposed domain; in deeper waters farther offshore, sediment cover is relatively thin. Sediment thickness in this domain appears to be limited both by the lack of sediment supply (because of its distance from large coastal watersheds) and by the presence of uplifted bedrock, which is linked to a local zone of transpression in the San Gregorio Fault Zone (Weber, 1990). The uplift has raised this domain and exposed it to the high wave energy that is characteristic of this area (Storlazzi and Wingfield, 2005).

(6) The Pigeon Point shelf domain lies on the west flank of the Pigeon Point high (McCulloch, 1987). Sediment in the Pigeon Point shelf domain is thickest in a shore-parallel band that overlies a slope break in the underlying bedrock surface. Much of the sediment probably was derived from Pescadero Creek, a large coastal watershed that enters the Pacific Ocean about 3 km north of the Pigeon Point to southern Monterey Bay regional map area (Maps C, D). The Pigeon Point shelf domain is transitional to the Pacifica-Pescadero shelf domain just north of it (see Watt and others, 2014).

Map E shows the regional pattern of major faults and of earthquakes occurring between 1967 and April 2014 that have inferred or measured magnitudes of 2.0 and greater. Fault locations, which have been simplified, are compiled from interpretation of regional seismic-reflection data, our mapping within California's State Waters (see sheet 10), Wagner and others (2002), and the U.S. Geological Survey's Quaternary fault and fold database (U.S. Geological Survey and California Geological Survey, 2010). Earthquake epicenters are from the Northern California Earthquake Data Center (2014), which is maintained by the U.S. Geological Survey and the University of California, Berkeley, Seismological Laboratory. The epicenter of the Loma Prieta earthquake (M6.9, 10/17/1989) on the San Andreas Fault Zone is located just 3.8 km north of the map area in the Santa Cruz Mountains (Spudich, 1996). The largest recorded earthquake in the Offshore of Aptos map area (M4.6, 10/18/1989) occurred just one day after the Loma Prieta earthquake about 5 km northeast of Aptos in the Santa Cruz Mountains.

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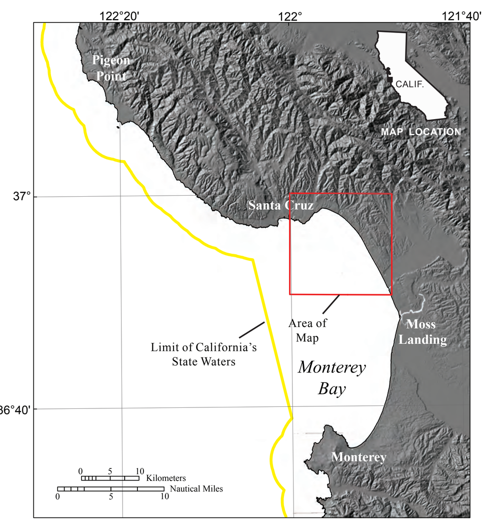


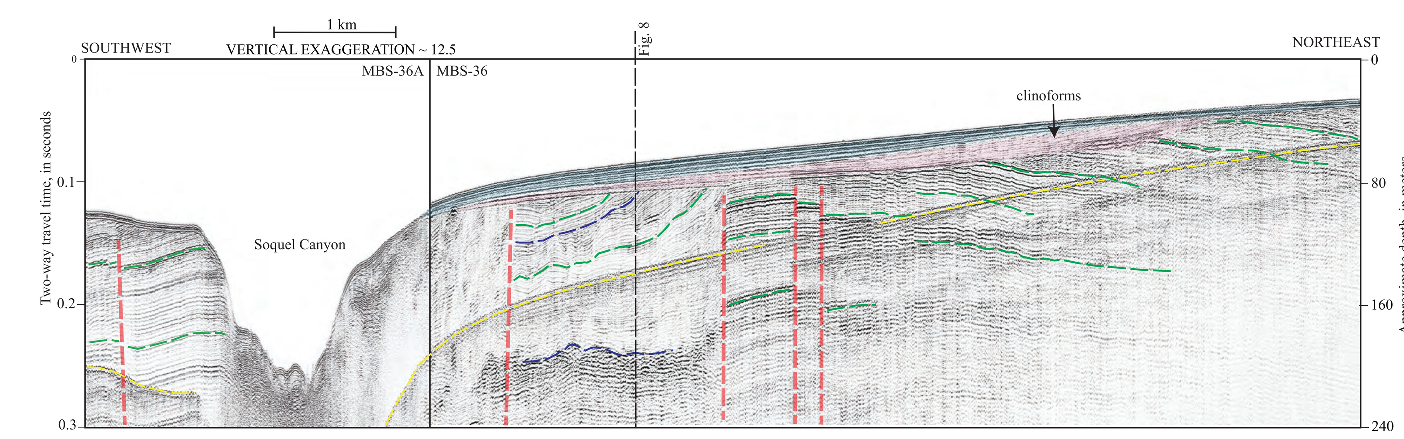
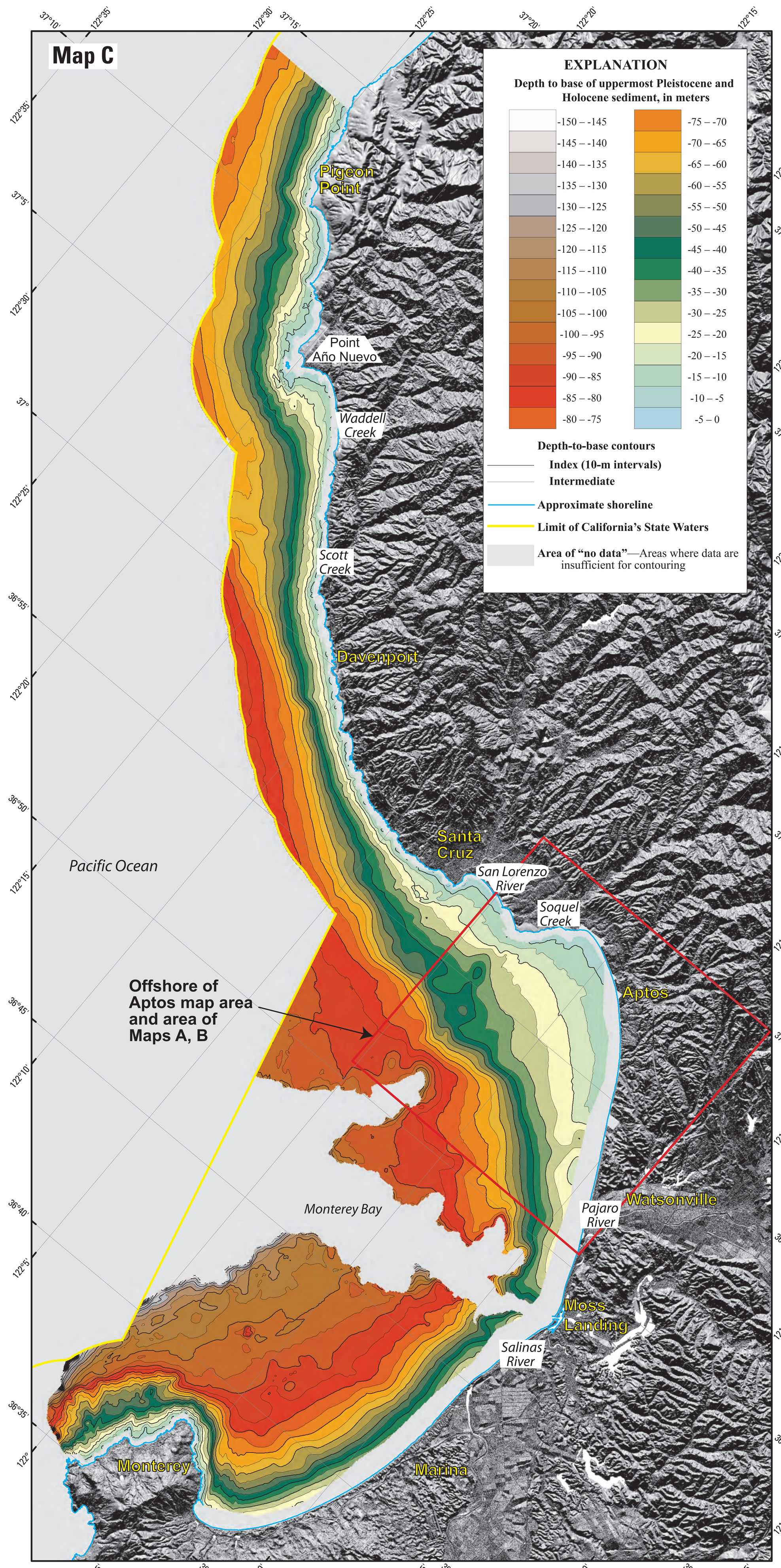
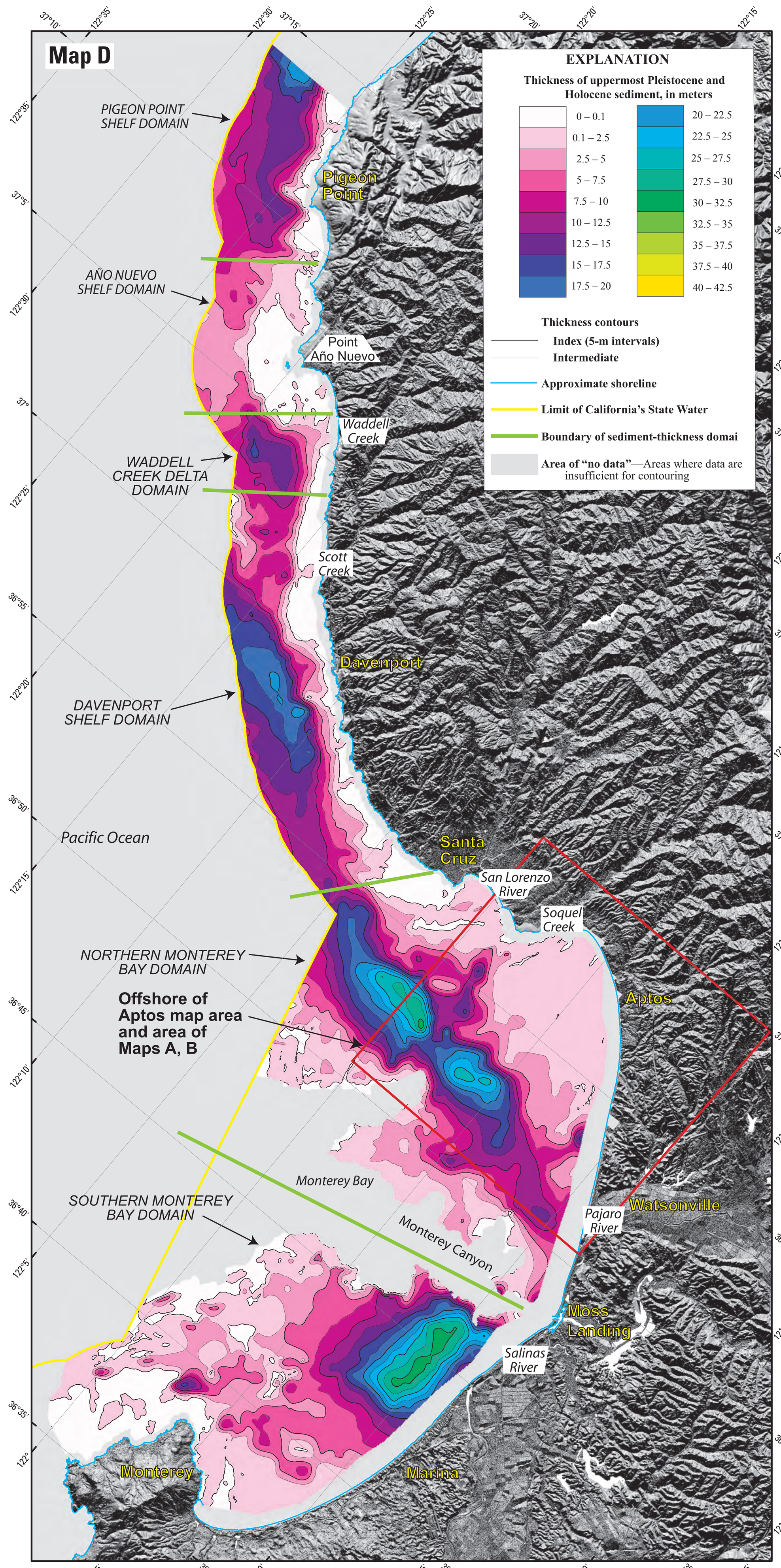
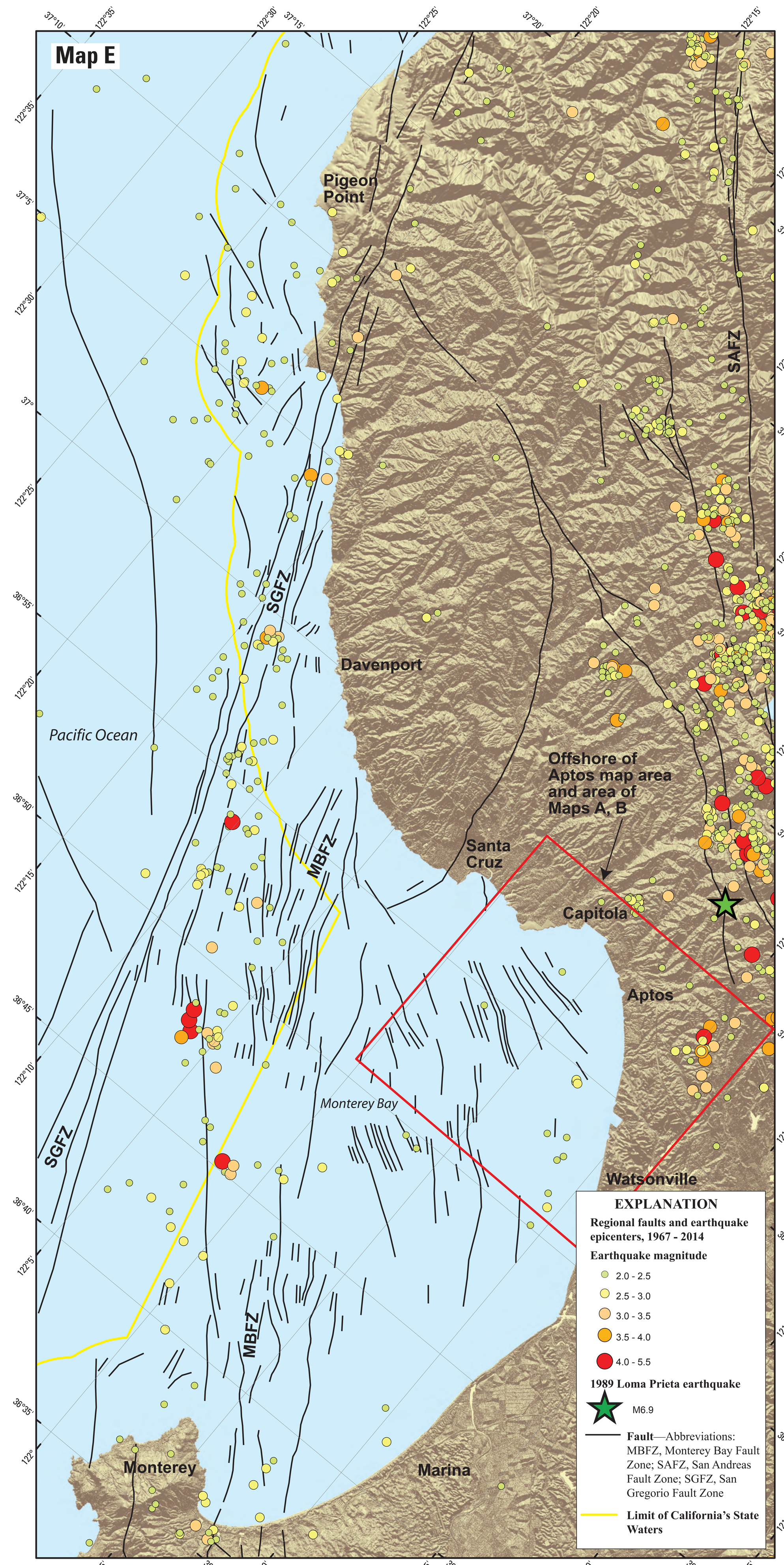


Figure 1. USGS high-resolution minisparker seismic-reflection profiles MBS-36A (left) and MBS-36 (right) (collected in 2009 on cruise S–N1–09–MB), which crosses shelf southwest of Aptos (see Maps A, B for location). Profile highlights head of Soquel Canyon and faulted strata beneath continental shelf in northern Monterey Bay. Dashed red lines show faults. Blue and pink shading shows inferred uppermost Pleistocene and Holocene strata, deposited since about 30,000 years ago during final stages of sea-level fall and subsequent sea-level rise. Underlying reflectors image deformed Neogene strata. Dashed purple lines shows unconformities in Neogene section. Dashed green lines highlight some continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector).







Onshore elevation data from U.S. Geological Survey's National Elevation Dataset (available at http://ned.usgs.gov/). California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

SCALE 1:200 000

ONE MILE = 0.869 NAUTICAL MILES

Depth and thickness mapped by Samuel Y. Johnson and Stephen R. Hartwell, 2011–2012

GIS database and digital cartography by Stephen R. Hartwell

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Local (Offshore of Aptos Map Area) and Regional (Offshore from Pigeon Point to Southern Monterey Bay) Shallow-Subsurface Geology and Structure, California

By

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2016

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