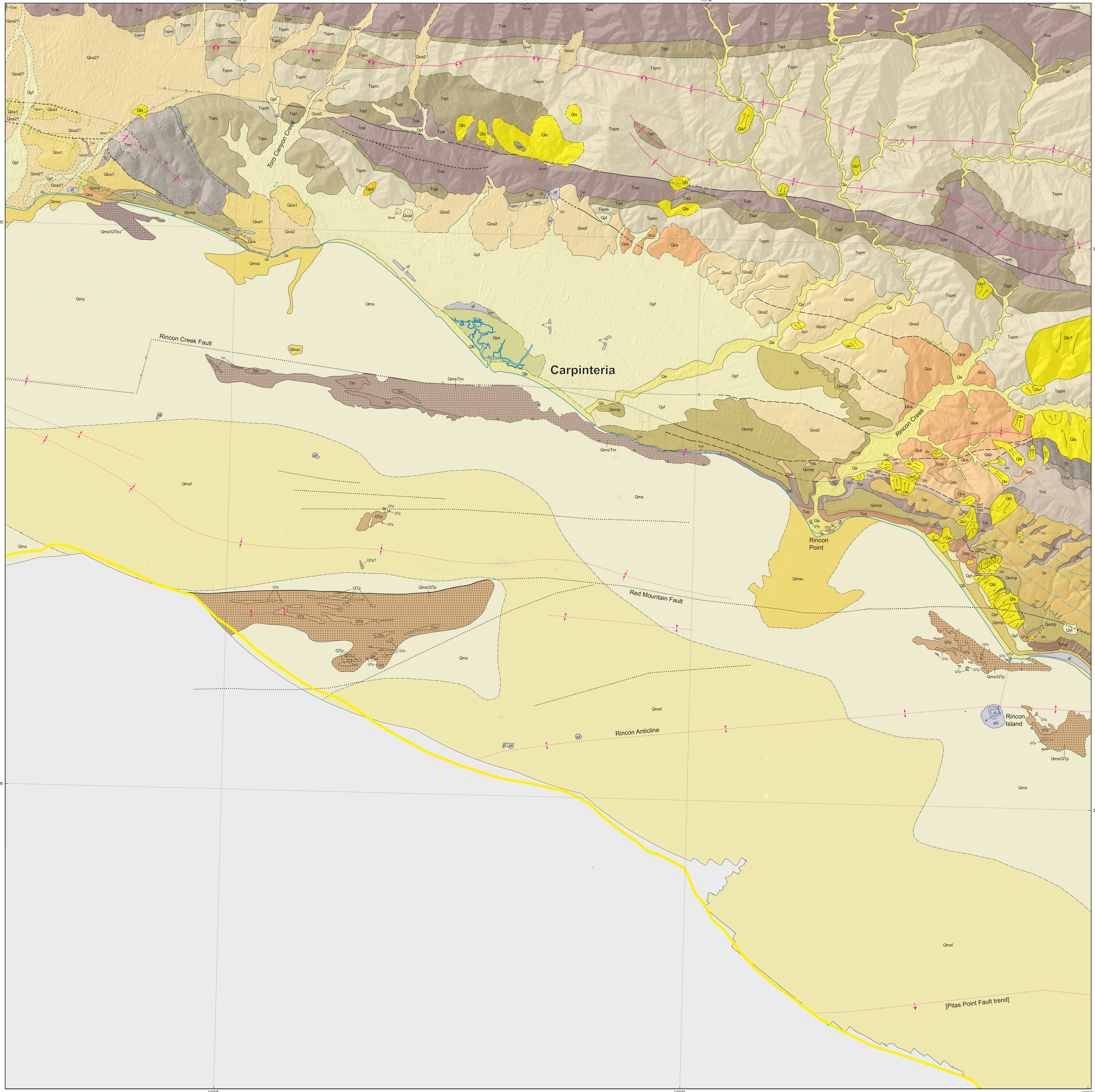
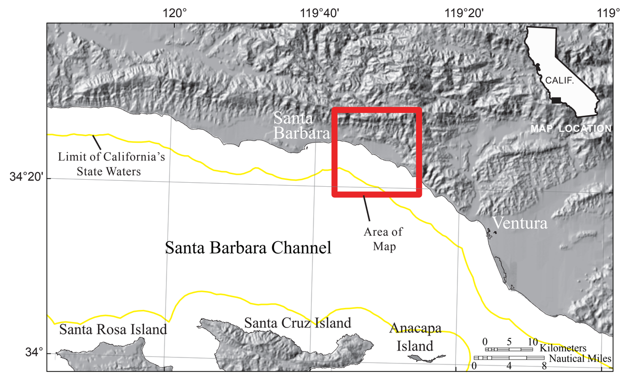
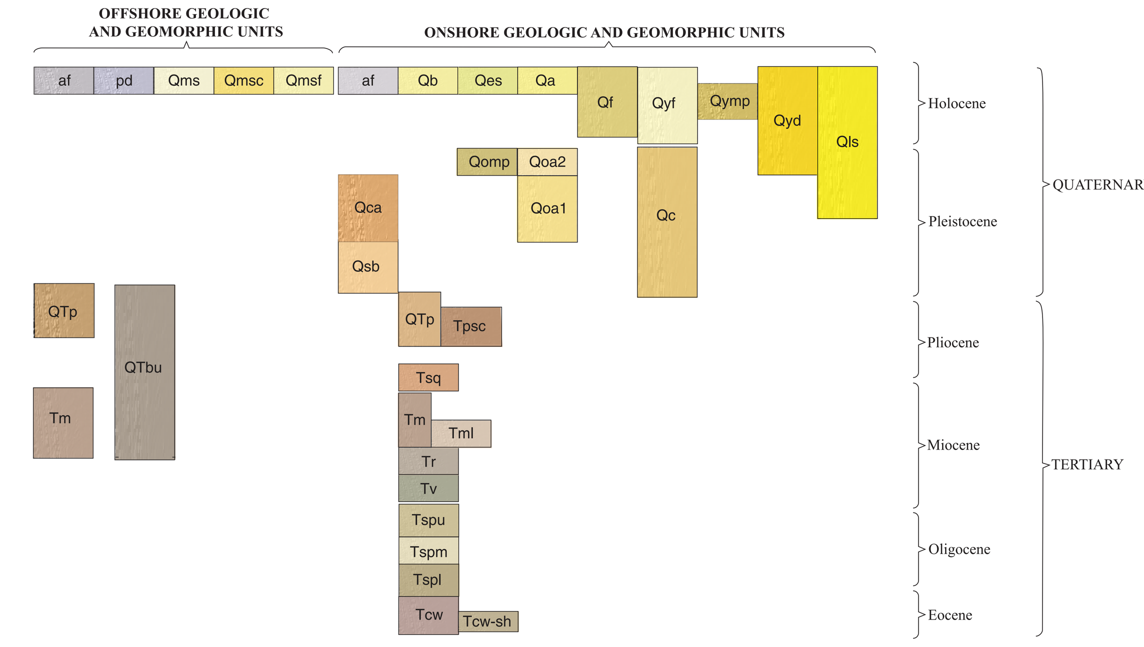




CORRELATION OF MAP UNITS

[See Description of Map Units (chapter 8, in pamphlet) for precise unit ages]



LIST OF MAP UNITS

[See Description of Map Units (chapter 8, in pamphlet) for complete map-unit descriptions]

OFFSHORE GEOLOGIC AND GEOMORPHIC UNITS

[Note that composite units (gray- and white-stippled areas) are designated on map by composite label indicating both overlying sediment cover and lower (older) unit, separated by slash (for example, Qms/Tm indicates that thin sheet of Qms overlies Tm)]

af **Artificial fill (late Holocene)**—Rock, sand, and mud; placed and (or) dredged. Also includes construction debris and seafloor significantly modified by human activity

pd **Oil-platform debris (late Holocene)**—Mixed accumulations of construction material, sediment, and shells shed from anthropogenic structures

Qms **Marine nearshore and shelf deposits (late Holocene)**—Mostly sand; ripple marks common

Qmsc **Coarse-grained marine nearshore and shelf deposits (late Holocene)**—Coarse sand, gravel, cobbles, and boulders

Qmsf **Fine-grained marine shelf deposits (late Holocene)**—Mostly mud to muddy sand

QTp **Pico Formation (Pleistocene and Pliocene)**—Claystone, siltstone, sandstone, and conglomerate

QTbu **Bedrock, undivided (Pleistocene, Pliocene, and Miocene)**—Strata of the Pico, Sisquoc, and Monterey Formations. Mapped only as part of composite unit Qms/QTbu, where thin sheets of Qms overlie unit

Tm **Monterey Formation (Miocene)**—Predominantly well-bedded siliceous and calcareous mudstone and shale

ONSHORE GEOLOGIC AND GEOMORPHIC UNITS

[Units are compiled from Dibblee (1986), Tan and others (2003a,b), Tan and Clahan (2004), and Minor and others (2009); unit ages, which are derived from these sources, reflect local stratigraphic relations]

af **Artificial fill (late Holocene)**—Engineered and (or) nonengineered

Qb **Beach deposits (late Holocene)**—Unconsolidated, loose, fine- to coarse-grained sand; well sorted

Qes **Coastal-estuarine deposits (late Holocene)**—Locally organic-rich clay, silt, and subordinate amounts of sand

Qa **Channel alluvium (late Holocene)**—Unconsolidated sediments, primarily pebble to boulder gravel

Qf **Alluvial fan deposits (late Holocene)**—Moderately to poorly sorted and bedded gravel, sand, silt, and clay

Qyf **Alluvial fan deposits (Holocene)**—Moderately to poorly sorted and moderately to poorly bedded sandy clay, with some silt and gravel

Qymp **Paralic deposits of Sea Cliff marine terrace (Holocene)—**Semiconsolidated, marine, fossiliferous gravel, sand, and silt

Qyd **Debris-flow deposits (Holocene and late Pleistocene)**—Massive, weakly consolidated rock-debris breccia

Qls **Landslide deposits (Holocene and late and middle Pleistocene)**—Ranges from poorly sorted and disrupted mixtures of rock fragments and soil to relatively intact bedrock slump blocks

Qomp **Paralic deposits of Punta Gorda marine terrace (late Pleistocene)—**Weakly to moderately consolidated, marine, fossiliferous gravel, sand, and silt

Qoa2 **Alluvial deposits (late Pleistocene)**—Weakly consolidated, stratified silt, sand, and gravel

Qoa1 **Older alluvial deposits (late and middle Pleistocene)**—Moderately consolidated, crudely stratified silt, sand, and gravel

Qc **Colluvium (Pleistocene)**—Silt, sand, clay, and gravel

Qca **Casitas Formation (late and middle Pleistocene)**—Nonmarine siltstone and silt, sandstone and sand, and conglomerate and gravel; deposited mainly as alluvium

Qsb **Santa Barbara Formation (middle and early Pleistocene)**—Mostly marine sandstone, with intervals of shale and siltstone

QTp **Pico Formation, undivided (Pleistocene and Pliocene)**—Claystone, siltstone, and sandstone; locally pebbly

Tpsc **Lower sandstone and conglomerate unit (Pliocene)**

Tsq **Sisquoc Formation (early Pliocene and late Miocene)**—Marine diatomaceous mudstone and shale, conglomerate, and subordinate amounts of dolomite

Tm **Monterey Formation, undivided (Miocene)**—Marine, predominantly well-bedded, siliceous and calcareous mudstone and shale, with subordinate amounts of porcelanite and dolomite

Tml **Lower, calcareous unit (middle and early Miocene)—**Calcareous, siliceous, and phosphatic mudstone and shale, with subordinate amounts of dolomite, porcelanite, breccia, glauconitic sandstone, and tuff

Tr **Rincon Shale (early Miocene)**—Marine mudstone, with subordinate amounts of dolomite, siliceous shale, sandstone, and tuff

Tv **Vaqueros Formation (early Miocene)**—Shallow-marine, massive and bioturbated, resistant sandstone

Sespe Formation (early Miocene to late Eocene)

Tspu **Upper unit (early Miocene and late Oligocene)—**Interbedded sandstone and mudstone

Tspm **Middle unit (Oligocene)**—Interbedded conglomerate, sandstone, and mudstone

Tspl **Lower unit (early Oligocene and late Eocene)**—Interbedded conglomerate, conglomeratic sandstone, sandstone, mudstone, and minor amounts of shale

Tcw **Coldwater Sandstone (late? and middle Eocene)**—Thin- to thick-bedded sandstone, with subordinate amounts of siltstone, shale, and mudstone

Tcw-sh **Shale unit (late? and middle Eocene)**—Siltstone, with occasional interbeds of sandstone

EXPLANATION OF MAP SYMBOLS

Contact—Solid where location is certain, long-dashed where location is approximate, short-dashed where location is inferred, queried where uncertain

Landslide complex—Arrow(s) show direction of downslope movement; pattern shows area of slip surface and direction of slip

Fault—Solid where location is certain, long-dashed where location is approximate, short-dashed where location is inferred, dotted where location is concealed, queried where uncertain

Folds—Solid where location is certain, short-dashed where location is inferred, dotted where location is concealed

Antiform

Synform

Monoform

Overturned syncline

Anticlinal upwarp axis in Quaternary deposits

Former shoreline or marine limit

Approximate modern shoreline—Defined as Mean High Water (MHW) (+1.33 m), North American Vertical Datum of 1988 (NAVD 1988)

3-nautical-mile limit of California's State Waters

Area of "no data"—Areas beyond 3-nautical-mile limit of California's State Waters were not mapped as part of California Seafloor Mapping Program

DISCUSSION

Marine geology and geomorphology was mapped in the Offshore of Carpinteria map area from approximate Mean High Water (MHW) to the 3-nautical-mile limit of California's State Waters. MHW is defined at an elevation of 1.33 m above the North American Vertical Datum of 1988 (NAVD 88) (Weber and others, 2005). Offshore geologic units were delineated on the basis of integrated analyses of adjacent onshore geology with multibeam bathymetry and backscatter imagery (sheets 1, 2, 3), seafloor-sediment and rock samples (Reid and others, 2006), digital camera and video imagery (sheet 6), and high-resolution seismic-reflection profiles (sheet 8).

The onshore geology was compiled from Dibblee (1986), Tan and others (2003a,b), Tan and Clahan (2004), and Minor and others (2009). Unit ages, which are from these sources, reflect local stratigraphic relations.

The offshore part of the map area largely consists of a relatively shallow (less than about 45 m deep), gently offshore-dipping (less than 1°) shelf underlain by sediments derived primarily from relatively small coastal watersheds that drain the Santa Ynez Mountains. Shelf deposits are primarily sand (unit Qms) at depths less than about 25 m and, at depths greater than about 25 m, are the more fine-grained sediments (very fine sand, silt, and clay) of unit Qmsf. The boundary between units Qms and Qmsf is based on observations and extrapolation from sediment sampling (see, for example, Reid and others, 2006) and camera ground-truth surveying (see sheet 6). It is important to note that the boundary between units Qms and Qmsf should be considered transitional and approximate and is expected to shift as a result of seasonal- to annual- to decadal-scale cycles in wave climate, sediment supply, and sediment transport.

Coarser grained deposits (coarse sand to boulders) of unit Qmsc, which are recognized on the basis of their moderate seafloor relief and high backscatter (sheet 3), as well as camera observations (sheet 6) and sampling (Reid and others, 2006; Barnard and others, 2009), are found locally in water depths less than about 15 m, except offshore of Rincon Point where they extend to depths of about 21 m. The largest Qmsc deposits are present at the mouths of Rincon Creek and Toro Canyon Creek. The convex seafloor relief of these coarse-grained deposits suggests that they are wave-winnowed lags that armor the seafloor and are relatively resistant to erosion. The sediments may, in part, be relict, having been deposited in shallower marine (or even alluvial?) environments at lower sea levels in the latest Pleistocene and Holocene; this seems especially likely for the arcuate lobe of unit Qmsc that extends 1,700 m offshore from Rincon Point. The Qmsc deposits offshore of Toro Canyon Creek are found adjacent to onshore alluvial and alluvial fan deposits (Minor and others, 2009) and, thus, may have formed as distal-alluvial or fan-delta facies of that system.

Offshore bedrock exposures are assigned to the Miocene Monterey Formation (unit Tm) and the Pliocene and Pleistocene Pico Formation (unit QTp), primarily on the basis of extrapolation from the onshore mapping of Tan and others (2003a,b), Tan and Clahan (2004), and Minor and others (2009), as well as the cross sections of Redin and others (1998, 2004) that are constrained by industry seismic-reflection data and petroleum well logs. Where uncertainty exists, bedrock is mapped as an undivided unit (QTbu). These rocks are exposed in structural highs that include the Rincon Anticline and uplifts bounded by the Rincon Creek Fault and by the north and south strands of the Red Mountain Fault.

Bedrock is, in some places, overlain by a thin (less than 1 m?) veneer of sediment, recognized on the basis of high backscatter, flat relief, continuity with moderate- to high-relief bedrock outcrops, and (in some cases) high-resolution seismic-reflection data; these areas, which are mapped as composite units Qms/Tm, Qms/QTbu, or Qms/QTp, are interpreted as ephemeral sediment layers that may or may not be continuously present, whose presence or absence is a function of the recency and intensity of storm events, seasonal and (or) annual patterns of sediment movement, or longer term climate cycles.

Two offshore anthropogenic units also are present in the map area, each related to offshore hydrocarbon production. The first (unit af) consists of coarse artificial fill associated with construction of the Rincon Island petroleum-production facility near the east edge of the map area. The second (unit pd) consists of coarse artificial fill mixed with sediment and shell debris, mapped in outcrops surrounding Rincon Island and at the locations of former oil platforms "Heidi," "Hope," "Hazel," and "Hilda" from the Summerland and Carpinteria oil fields (Barnum, 1998). The Monterey Formation is the primary petroleum-source rock in the Santa Barbara Channel, and the Pico Formation is one of the primary petroleum reservoirs.

The Offshore of Carpinteria map area is in the Ventura Basin, in the southern part of the Western Transverse Ranges geologic province, which is north of the California Continental Borderland (Fisher and others, 2009). This province has undergone significant north-south compression since the Miocene, and recent GPS data suggest north-south shortening of about 6 to 10 mm/yr (Larson and Webb, 1992; Donnellan and others, 1993). The active, east-west-striking, north-dipping Pitas Point Fault (a broad zone that includes south-dipping reverse-fault splays), Red Mountain Fault, and Rincon Creek Fault are some of the structures on which this shortening occurs (see, for example, Jackson and Yeats, 1982; Sorlien and others, 2000). This fault system, in aggregate, extends for about 100 km through the Ventura and Santa Barbara Basins and represents an important potential earthquake hazard (see, for example, Fisher and others, 2009).

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Onshore elevation data collected 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 base map from sheet 2 of this report. California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 11N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2013

SCALE 1:24 000

BATHYMETRIC CONTOUR INTERVAL 10 METERS

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Offshore geology mapped by Samuel Y. Johnson and Andrew C. Ritchie, 2010-2011. Onshore geology compiled by Gordon G. Seitz and Carlos I. Guiterrez from Dibblee (1986), Tan and others (2003a,b), Tan and Clahan (2004), and Minor and others (2010). Bathymetric contour intervals by Andrew C. Ritchie

GIS database and digital cartography by Andrew C. Ritchie and Eleyne L. Phillips

Edited by Taryn A. Lindquist

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Offshore and Onshore Geology and Geomorphology, Offshore of Carpinteria Map Area, California

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2013

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