U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with
Scripps Institution of Oceangraphy

Scientific Investigations Map 3324
Sheet 3 of 3

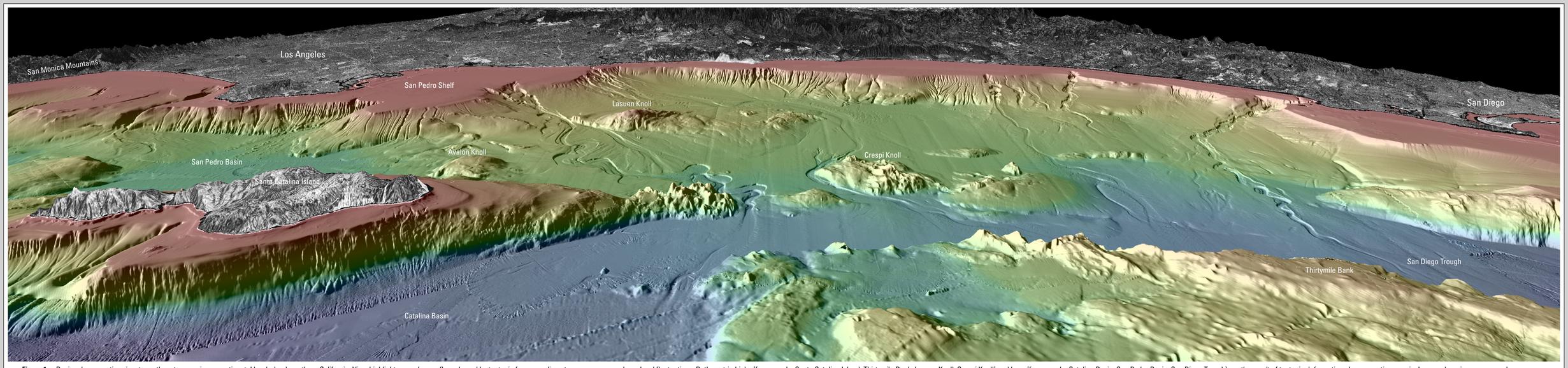



**Figure 1**. Regional perspective view to northeast across inner continental borderland, southern California. View highlights complex seafloor shaped by tectonic forces, sedimentary processes, and sea-level fluctuations. Bathymetric highs (for example, Santa Catalina Island, Thirtymile Bank, Lasuen Knoll, Crespi Knoll) and lows (for example, Catalina Basin, San Pedro Basin, San Diego Trough) are the result of tectonic deformation along an active margin. Large submarine canyon-and-channel systems as well as smaller gullies were cut into mainland shelf and slope, forming meandering paths around bathymetric highs and transporting sediment from mainland shelf to deep basins. Lower sea levels during glacial periods allowed rivers to connect with some offshore canyons, and wave action during lower sea levels smoothed mainland shelf (for example, San Pedro shelf). Vertical exaggeration of perspective view, 4x; distance across bottom of view, about 115 km; distance from Santa Monica Mountains to San Diego, about 200 km.

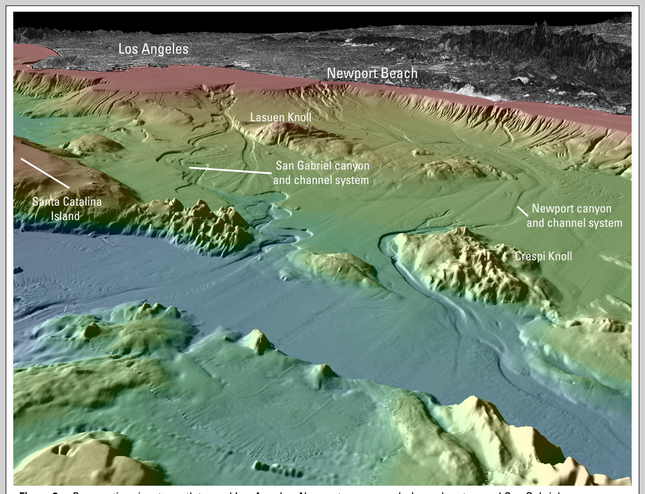



**Figure 2**. Perspective view to north toward Los Angeles. Newport canyon-and-channel system and San Gabriel canyon-and-channel system meander down mainland slope and around bathymetric highs of Lasuen and Crespi Knolls and Santa Catalina Island. San Gabriel canyon-and-channel system, which can be traced for about 80 km, empties into bathymetric low southeast of Emery Knoll in Catalina Basin (see map view). Newport canyon-and-channel system can be traced for about 100 km, from its head directly offshore of Newport Beach, then around Crespi Knoll and into San Diego Trough (see map view). Vertical exaggeration of perspective view, 4x; distance across bottom of view, about 22 km.

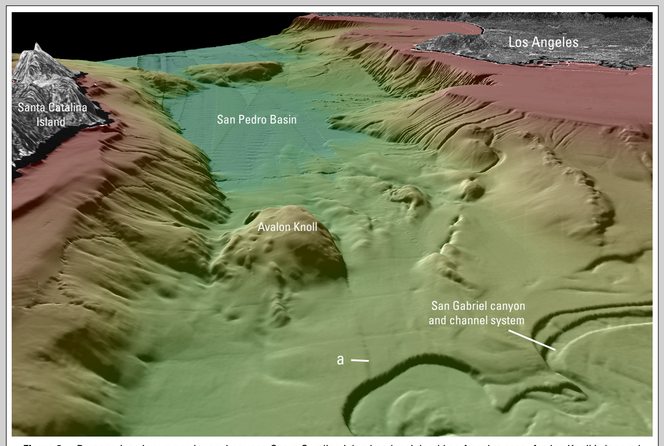



**Figure 3**. Perspective view to northwest between Santa Catalina Island and mainland Los Angeles area. Avalon Knoll is located at southeast end of San Pedro Basin. In this view, San Diego Trough Fault (see also, fig. 5) can be traced by vertical offset of seafloor (a) from San Gabriel canyon-and-channel system to northeast edge of Avalon Knoll; vertical offset at scarp (a), 7 m. Vertical exaggeration of perspective view, 4x; distance across bottom of view, about 15 km.

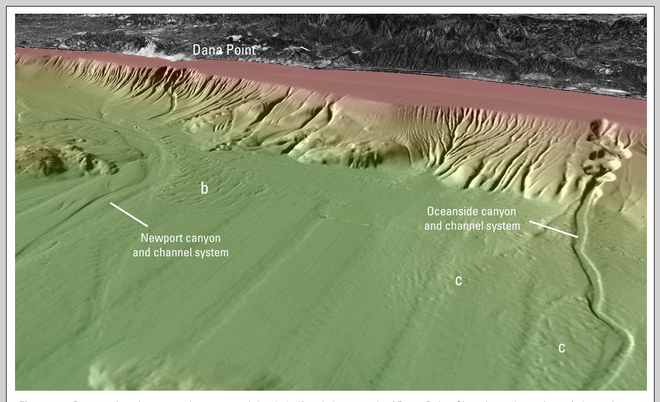
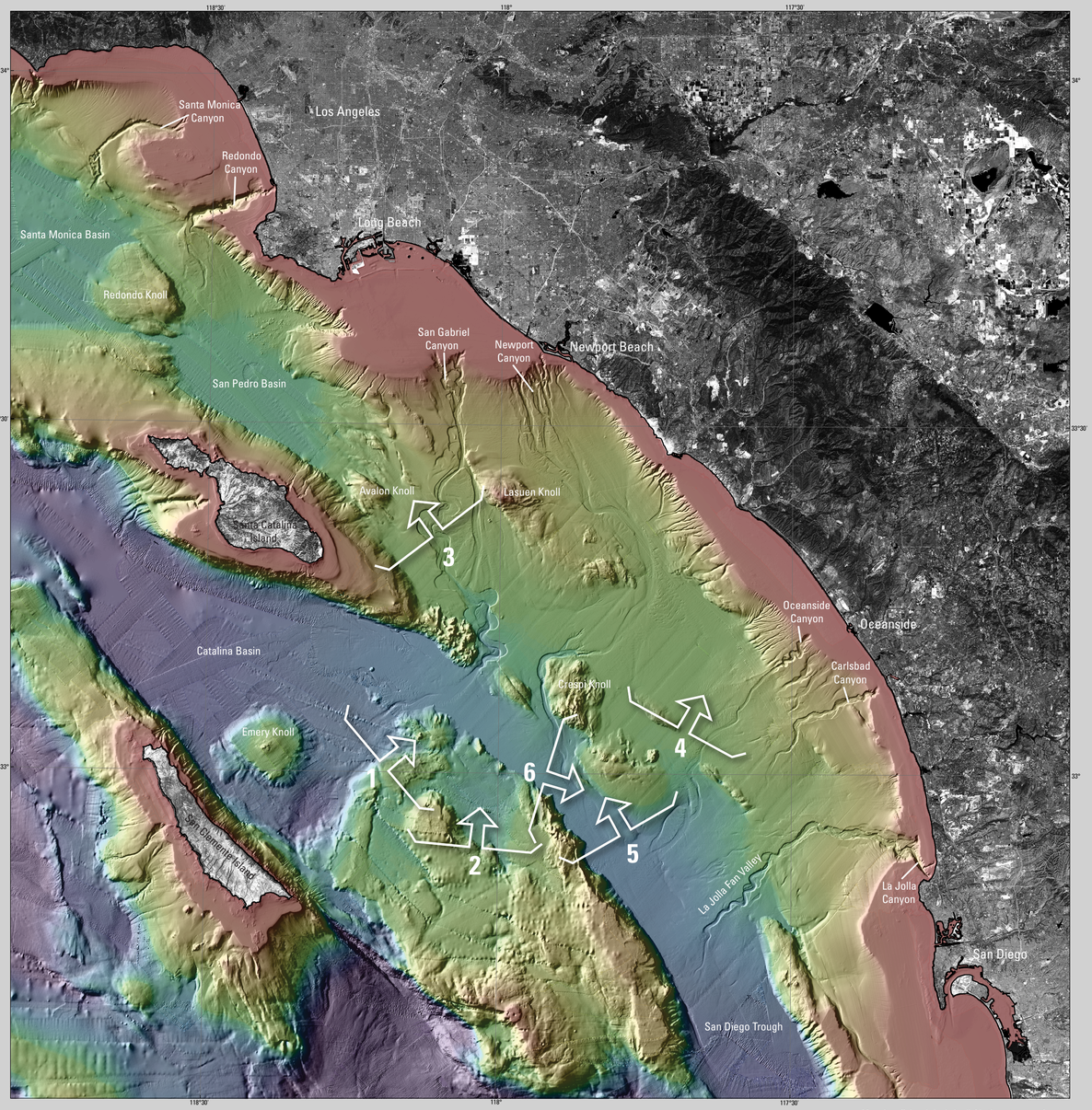



**Figure 4**. Perspective view to northwest at mainland shelf and slope south of Dana Point. Slope is cut by variety of channels, gullies, and canyons. Oceanside canyon-and-channel system is to south (right), and lower reaches of Newport canyon-and-channel system is to north (left). Channels, gullies, and canyons serve as conduits that carry sediment off of shelf and into offshore basins. These canyon-and-channel systems are largely inactive during sea-level highstands, but they become active during lowstands when shoreline is at shelf edge (Covault and others, 2007). Likely overbank deposits are visible near both canyon-and-channel systems: relatively large deposit (b) is visible where Newport channel meanders around bathymetric high southeast of Lasuen Knoll (to left, outside of figure view); smaller deposits (c) are visible near Oceanside canyon-and-channel system. Vertical exaggeration of perspective view, 4x; distance across bottom of view, about 18 km.




Onshore imagery modified from LANDSAT-8 satellite data (available from U.S. Geological Survey, Earth Explorer, at http://earthexplorer.usgs.gov/).
Offshore shaded-relief bathymetry from map on sheet 1, this report.
Universal Transverse Mercator projection, Zone 11N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2015

10 5 0 10 MILES
10 5 0 10 KILOMETERS
ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Map view. Colored shaded-relief bathymetry map of offshore of southern California. Colors show depth: reds indicate shallower areas; purples, deeper areas. Illumination azimuth is 300°, from 45° above horizon. Numbered arrows show viewing directions of perspective views shown on this sheet; numbers correspond to figure numbers of views.

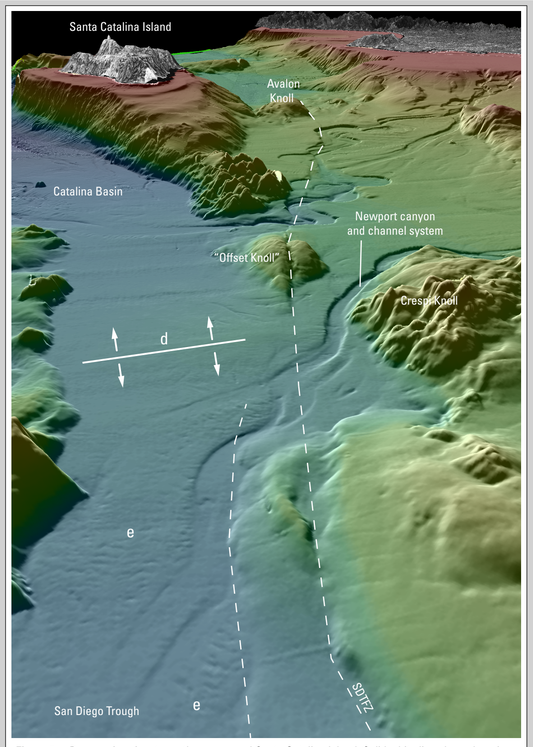



**Figure 5**. Perspective view to northwest toward Santa Catalina Island. Solid white line shows location of bathymetric divide (d) between San Diego Trough and Catalina Basin (arrows show downslope direction). Dashed white lines show trace of San Diego Trough Fault Zone (SDTFZ; trace modified from Ryan and others, 2012), which can be followed next to and across series of seafloor ridges, including Crespi Knoll, "Offset Knoll" (Ryan and others, 2012), and Avalon Knoll. Source of sediment waves and overbank deposits (e), visible in San Diego Trough, is likely sediment passing through Newport canyon-and-channel system. Vertical exaggeration of perspective view, 4x; distance across bottom of view, about 9 km.

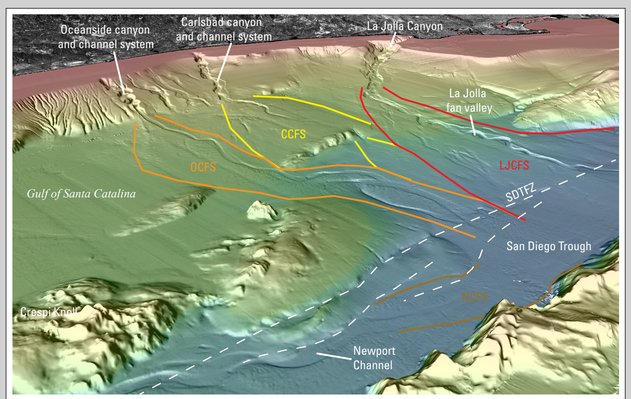



**Figure 6**. Perspective view to southwest over San Diego Trough and Gulf of Santa Catalina. Dashed white lines show trace of San Diego Trough Fault Zone (SDTFZ; trace modified from Ryan and others, 2012), which can be followed from northwest (lower left) to southeast (right) by small offsets of seafloor, as well as of larger ridges. Main canyons and channels of Oceanside, Carlsbad, and La Jolla canyon-and-channel systems are clearly visible in this view. Oceanside canyon-and-channel system was active between 45 and 13 ka; Carlsbad canyon-and-channel system was active between about 50 and 10 ka; and La Jolla canyon-and-channel system was active during two time periods, between about 50 and 40 ka and between 13 ka and present (Covault and others, 2007). All main deep-sea fan systems shown merge in San Diego Trough: yellow lines outline Carlsbad Canyon fan system (CCFS); red lines, La Jolla Canyon fan system (LJCFS); orange lines, Oceanside Canyon fan system (OCFS); brown lines, Newport Canyon fan system (NCFS). Vertical exaggeration of perspective view, 4x; distance across bottom of view, about 20 km.

# Perspective Views of Bathymetry

## Colored Shaded Relief Bathymetry, Acoustic Backscatter, and Selected Perspective Views of the Inner Continental Borderland, Southern California

By

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Ryan, H.F., Conrad, J.E., Paull, C.K., and McGann, M., 2012, Slip rate on the San Diego Trough Fault zone, inner California Borderland, and the 1986 Oceanside earthquake swarm revisited: Bulletin of the Seismological Society of America, v. 102, no. 6, p. 2300–2312.