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Comparison of shelf currents off central California prior to and during the 1997–1998 El Nino

H.F. Ryan*, M.A. Noble

US Geological Survey, 345 Middlefield Road, MS 999 Menlo Park, CA 94025, USA

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Abstract

Moored current, temperature, salinity, and pressure data were collected at three sites that transect the narrow continental shelf offshore of Davenport, CA, starting in August 1996 and continuing to the spring of 1998. This data set allowed a comparison of oceanographic conditions prior to (8/96–3/97) and during (8/97–3/98) the last major El Niño. During this El Niño, mean temperatures over the 8-month time period were about 3 °C warmer than during the prior year at all of the sites. Correlations between near-surface and near-bottom temperatures, and between near-surface temperature and wind stress decreased during the El Niño compared to conditions the year before. The mean alongshore currents were more strongly poleward during El Niño at sites over the mid-shelf and near the shelf break. There was a general tendency for the energy in alongshore currents to move toward lower frequencies during the El Niño, particularly at the sites farther offshore. The processes that forced the shelf flows changed in relative importance throughout the study. The local alongshore wind stress was less important in driving shelf currents during the El Niño when much of the wind-induced upwelling was confined to less than 5 km of the coast. The observed strong poleward shelf currents on the mid- to outer-shelf were not clearly tied to local forcing, but were remotely driven, most likely by slope currents. The response of the Davenport shelf to an El Niño event may differ from other areas since the shelf is narrow, the wind forcing is weaker than areas to the north and south, and the shelf may be at times isolated by fronts that form at strong upwelling centers. In the winter, strong storm-related winds are important in driving currents at periods not only in the synoptic wind band, but also for periods on the order of 20 d and longer.
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1. Introduction

Alongshore shelf currents along many continental shelves are typically driven by fluctuations in the alongshore wind stress (e.g. Brink et al., 1987; Chapman, 1987; Winant et al., 1987; Noble et al.,

*Corresponding author. Fax: 650 329 5299.
E-mail address: hryan@usgs.gov (H.F. Ryan).

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1987; Largier et al., 1993). This is particularly evident along the strongly wind-driven northern California coast where, during the spring and summer, the alongshore wind stress is well correlated with the alongshore currents at all shelf depths (Winant et al., 1987). Wind-driven currents are typically strongest over the mid- and outer-shelf and not observed over the adjacent slope (Brink et al., 1987), although off of San Francisco, weak wind-driven flows can be observed in the upper 100 m of water over the slope (Noble and Ramp, 2000). During times of upwelling in the late spring and summer, wind-forced equatorward flow is strongest.

In the absence of strong equatorward wind stress, poleward flow tends to dominate the shelf (the Inshore Countercurrent), particularly during the fall and winter (e.g., Lynn and Simpson, 1987; Chelton et al., 1988). Slope flows in the region are primary poleward and typically have longer periods compared to shelf flows (Brink et al., 1987; Noble and Ramp, 2000). The California Undercurrent, which typically flows poleward at depths of 200–300 m along the slope, is not an undercurrent but is rather at the surface in the Farallones region (Noble and Ramp, 2000).

Shelf and slope currents are generally independent (e.g. Winant et al, 1987; Chelton et al., 1988) with the majority of wind driven flow inshore. Brink et al. (2000) show that few drifters approach within 100 km of the coast in central California between Point Reyes and Point Conception. They suggest that poleward flow from the southern California Bight along the coast may prevent the drifters from impinging on the coast. However, some localized interactions occur between shelf and slope waters. The poleward undercurrent has been found to extend up over the slope and on to the shelf (e.g. Strub et al., 1987). In addition, low-frequency mesoscale eddies can impinge on the coast, particularly near upwelling centers such as Point Reyes and Point Arena (Largier et al., 1993).

We collected moored current meter and temperature data at three sites along the narrow continental shelf (13-km wide) offshore of Davenport, CA, from August 1996 through March 1998 (Fig. 1). Davenport is located 17 km south of Point Año Nuevo and just north of the western end of Monterey Bay. In the area around Monterey Bay, a semi-permanent anticyclonic gyre exists (Paduan and Rosenfeld, 1996). Outer Monterey Bay tends to be dominated by equatorward flow (meander of the California Current), with a narrow band of poleward flow inshore. North of Monterey Bay, an upwelling center at Point Año Nuevo, typically shows bifurcated flow in both the offshore and equatorward direction (Rosenfeld et al., 1994).

The suite of data we collected spanned a time period that encompassed a variety of oceanographic and meteorological conditions. These included a weak La Niña during which a 100-year storm event occurred (winter of 1996–1997), an unusually strong upwelling season (early spring of 1997), and an extreme El Niño event with attendant cyclogenesis (fall and winter of 1997–98). This data set allowed both a comparison

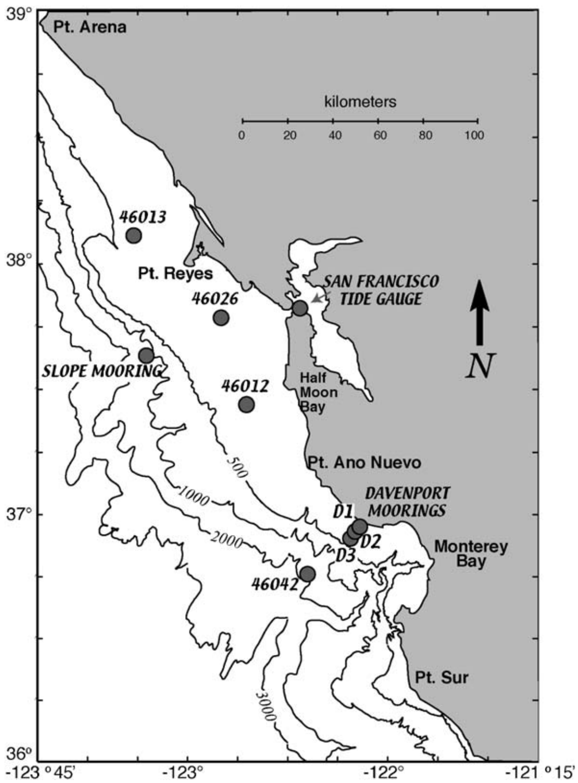

Fig. 1. Location map of tide gauge station, NOAA wind buoys (46012, 46013,46026 and 46042), Davenport moorings (D1 at 26 m, D2 at 64 m, and D3 at 114m water depth), and slope mooring at 1200 m water depth used in this study.