

CALIFORNIA UNDERCURRENT IN THE SOUTHERN CALIFORNIA BIGHT

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ABSTRACT

In September 1974 hydrographic measurements were made to study the California undercurrent in the Southern California Bight. Three sections, extending 10 to 15 miles offshore from Del Mar, Oceanside, and Dana Point, were occupied with closely spaced STD stations. The observed distributions of properties suggested that an undercurrent (100–400 m) with a width of only a few miles was present at 5 to 10 miles from the shore.

INTRODUCTION

The California undercurrent, sometimes called the California countercurrent, is a narrow northward flow that is present below about 200 m and that extends along the coast from Baja California to Cape Mendocino (40°N) or farther north (Reid, Roden and Wyllie, 1958). Water transported by this current is of equatorial origin and characterized by high temperature, high salinity, low oxygen, and high nutrients as compared to California Current water farther offshore. On the temperature-salinity diagram undercurrent water is indicated by a high-salinity bulge centered near 150 cl/t of thermosteric anomaly (Wooster and Jones, 1970). Therefore, the distribution of the California undercurrent can be studied by mapping salinity on the 150 cl/t isanosteric surface. The 150 cl/t surface is 250–300 m deep and probably close to the core depth of the undercurrent. The area of the undercurrent indicated by high salinity (above 34.3‰) on this surface varies considerably from cruise to cruise (Wooster and Jones, 1970). Nevertheless, south of about 29°N (slightly north of Punta Eugenia) it has generally a large offshore extent (>200 miles) and is characterized by a distinct vertical maximum of salinity centered at about the depth of this isanosteric surface. North of 29°N the area of high salinity is limited to a very narrow strip next to the coast, and the vertical distribution of salinity does not exhibit a well defined maximum. (A similar distribution can be seen on the maps of the monthly mean salinity at 150 m prepared by Wyllie and Lynn, 1971.) Subsurface drogoue measurements made by Reid (1963) off northern Baja California also indicate that the northward flow is narrow and found only within about 50 km of the coast. Because of the narrowness of the feature, it can easily escape from the network of the routine CalCOFI observations.

Recently, Wooster and Jones (1970) studied the undercurrent off Punta Colnett (31°N) with an array of closely spaced stations. Their measurements indicate that the northward undercurrent is only 20 km wide and bound to the continental slope.

STUDY AREA AND METHODS

In September 1974 the northward extension of this flow into the Southern California Bight, where the bottom topography is more complex, was investigated from the E. B. SCRIPPS during her first Southern California Bight study cruise (SCBS-1). Three sections, 20 miles apart, were occupied off Del Mar, Oceanside, and Dana Point (Figure 1). The station intervals were about 1 mile over the steep bottom slope from 100 m to 600 m and 3 to 4 miles in deep water farther offshore. On each station an STD was lowered nearly to the bottom. On seven stations oxygen samples were collected from Nansen bottles attached to the STD cable. No effort was made to directly observe the current velocity.

RESULTS

Property curves are plotted for two stations (Figure 2). Station 9 represents the distribution outside the undercurrent, and Station 7 represents the distribution in the undercurrent. There are clear differences in the distribution between the California Current and the undercurrent. At temperatures between 7°C and 10°C (depth 100–400 m), salinity at Station 7 is much higher and exhibits a well defined maximum centered near 150 cl/t of thermosteric anomaly. In the same temperature range, oxygen at Station 7 is about 1 ml/l lower than at Station 9.

The distributions of temperature and salinity are illustrated for the southernmost section off Del Mar (Figure 3). The shallow salinity minimum in the thermocline is derived from the California Current and is present everywhere on the section. The salinity maximum at about 300 m is associated with the northward undercurrent. The maximum is evident at Stations 10, 11, and 12, but Station 9 (shown in Figure 2) does not show any evidence of the undercurrent. The width of this high salinity water appears to be only 3 to 4 miles. On the temperature section, the isotherms for 8° and 9°C slope down toward the shore and suggest a northward geostrophic flow with its maximum speed at a depth of about 150 m, where isotherms are nearly level.

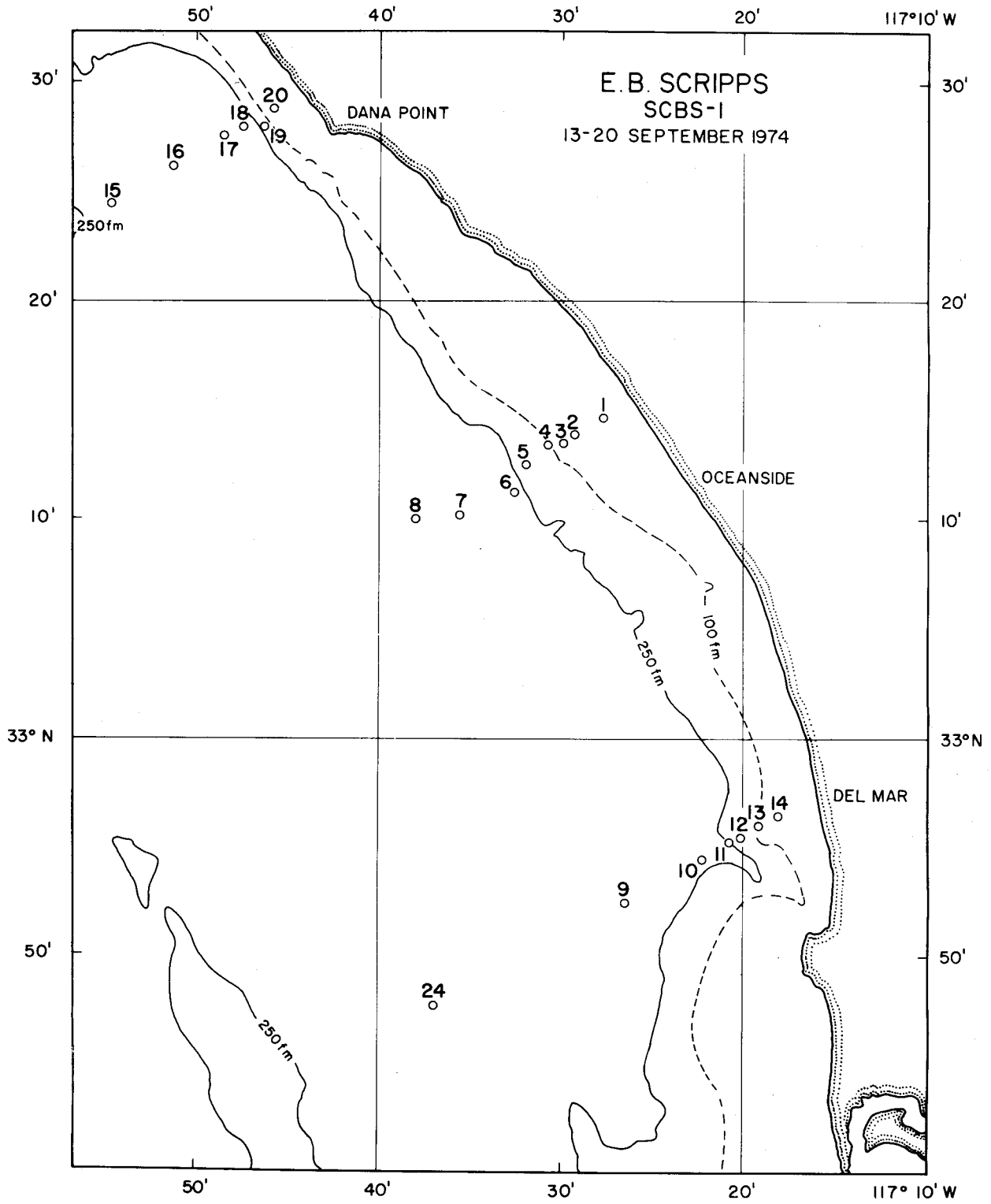


FIGURE 1. Station positions.

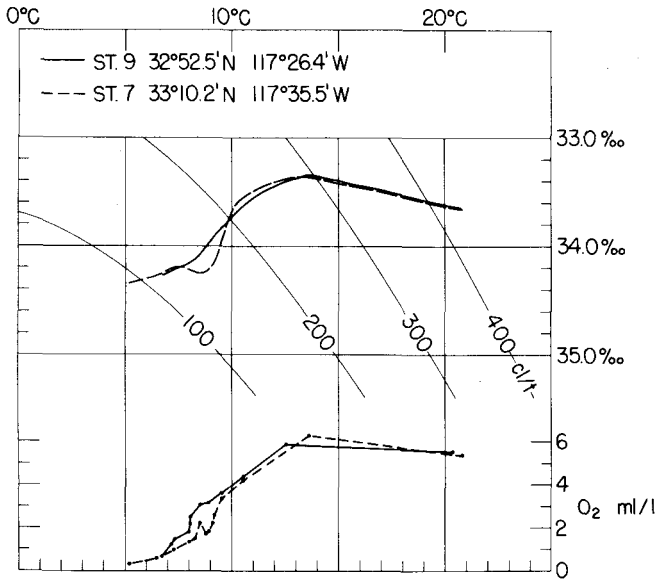


FIGURE 2. Temperature-salinity (top) and temperature-oxygen (bottom) curves (For station positions, see Figure 1).

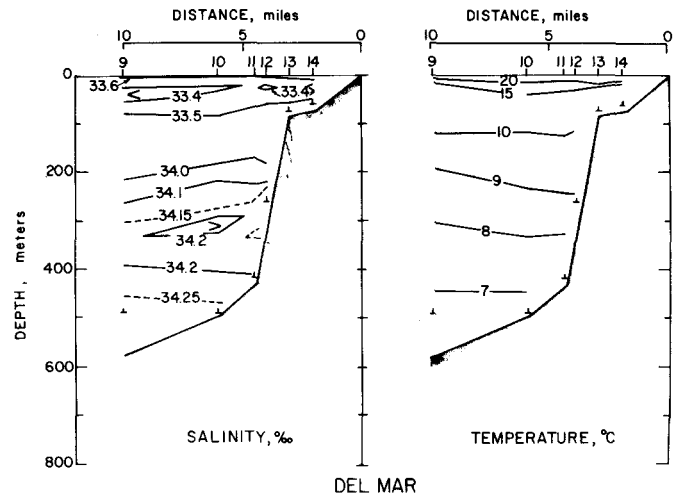


FIGURE 3. Vertical sections of temperature and salinity off Del Mar.

On the Oceanside section (Figure 4) 20 miles farther north, the salinity maximum is again apparent at Stations 7 and 8. The slope of the isotherms for 8° and 9°C between these stations is consistent with a northward geostrophic flow. The offshore portion of the undercurrent may have escaped from this section. Farther inshore, there is no evidence of the undercurrent except that isolated warm high salinity water is found at the bottom 30 m of Station 5 (not revealed by the isopleths in Figure 4).

On the northernmost section off Dana Point (Figure 5) there is no indication of high salinity water of equatorial origin. All stations show temperature-salinity and temperature-oxygen

curves characteristic of the California Current.

In summary, the distributions of properties observed in September 1974 suggest that a northward undercurrent only a few miles wide was present at 100–400 m in the southern half of the study area. It was located at distances 5 to 10 miles from the coast. However, in view of the fact that Station 23, made 50 miles off Del Mar, and Station 24 (Figure 1) indicated the presence of high salinity water of equatorial origin, the main flow or a branch of the undercurrent may have occurred farther offshore. Clearly, more field work is needed to obtain a clear picture of the California undercurrent in the Southern California Bight.

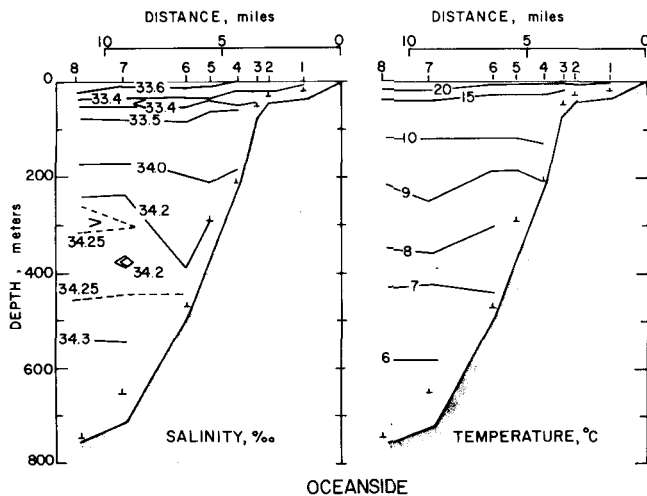


FIGURE 4. Vertical sections of temperature and salinity off Oceanside.

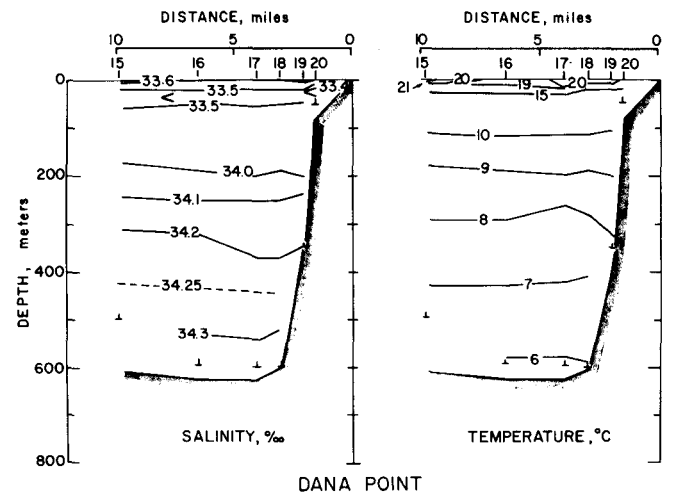


FIGURE 5. Vertical sections of temperature and salinity off Dana Point.

ACKNOWLEDGMENTS

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