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THE 1982-83 WARM EPISODE IN THE CALIFORNIA CURRENT

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Abstract. The Warm Episode (El Niño) of 1982-83 has produced elevated steric height (geopotential anomaly) along the coast of California and Baja California. Fifty percent of the stations observed during a survey in February and March had the greatest steric height observed for this season for the entire 33 years of California Cooperative Oceanic Fisheries Investigations (CalCOFI) observations. Where it occurred onshore, along central California in early February, this anomalous height was balanced by a strong countercurrent. Along Baja California in late March the greatest steric height was offshore and hence produced a strong equatorward flow. These conditions may not have been synoptic. An offshore shift in the subsurface thermal anomaly between January and May suggests a reversal of the flow within this time frame.

Introduction

During the winter of 1982-83, high levels of geopotential anomaly (hereafter called steric height) were observed at hydrographic stations off California and Baja California. Steric height, derived from the pressure integral of the specific volume, is the quantity whose lateral gradient is proportional to velocity under the geostrophic assumption. The values given here are for the surface relative to 500 decibars (5MPa) indicated by "0/500 db" and are in the units dynamic cm (10^3 cm^2 sec^{-2}). In one survey during February and March 1983, by the NOAA vessel Townsend Cromwell, conductivity/temperature/depth (CTD) casts were made at stations in the California Cooperative Oceanic Fisheries Investigations (CalCOFI) grid (see e.g. Wyllie, 1966). Of 38 CTD casts which could be compared to the CalCOFI data files, 18 have 0/500 db steric height, which match or exceed long-term records of steric height for each station for this season. The steric height for 11 stations exceed the long-term records for any season. These high levels are commensurate with the large and persistent positive temperature anomaly and the greatly thickened surface mixed layer that has characterized the North American coastal manifestation of the 1982-83 Warm Episode (El Niño) in the Pacific Ocean.

The global-scale climatic fluctuations leading to this Warm Episode were first noted in a Climate Analysis Center bulletin issued 20 September 1982. The large-scale warming in the equatorial zone and along the coast of Peru was fully developed by October 1982 (Rasmusson et al., 1983). Full development of large-scale warming off the North American coast from Mexico to Alaska followed in January 1983 (Auer, 1982, 1983).

Discussion

The physical and biological effects of the El Niño phenomenon upon California waters was central to the presentations at the June 1958 CalCOFI Symposium on "The Changing Pacific Ocean in 1957 and 1958" (Sette and Isaacs, 1960). The 1957-58 El Niño was a strong and well documented event. In the Symposium Proceedings Reid noted that in January 1958 there was, on the average, a 5 dynamic cm steric rise in sea level in the CalCOFI area as a result of both higher temperatures and an increase in thickness of the mixed layer. Stewart (same proceedings) found as much as a 12 cm anomaly in sea level (averaged by months but uncorrected for inverse barometric effects) for the same month at coastal tide stations along California. (There is very nearly a one-to-one correspondence between changes in sea level (cm) and in steric height (dynamic cm).

The large-scale mean distribution of steric height in the North Pacific shows a decrease from mid-ocean toward the California coast, in balance with equatorward flow of the eastern limb of the North Pacific anticyclonic gyre. In winter there is a trough in steric height 40 miles off the California coast and a secondary peak nearshore in balance with the winter coastal countercurrent (Wyllie, 1966). By spring the trough has moved shoreward and the average surface flow is everywhere equatorward along California and Baja California.

In February and March 1983, the high values in steric level along the California coast, north of the middle of the California Bight, exceeded 94 dynamic cm; the highest for these stations in the 33-year CalCOFI record (Figure 1). The high values continued southward in the form of a ridge offshore northern Baja California. The geostrophic flow relative to 500 db for this pattern of steric height is strongly poleward at Pt. Conception and north (20 cm/sec), equatorward south of San Diego (20 cm/sec), and

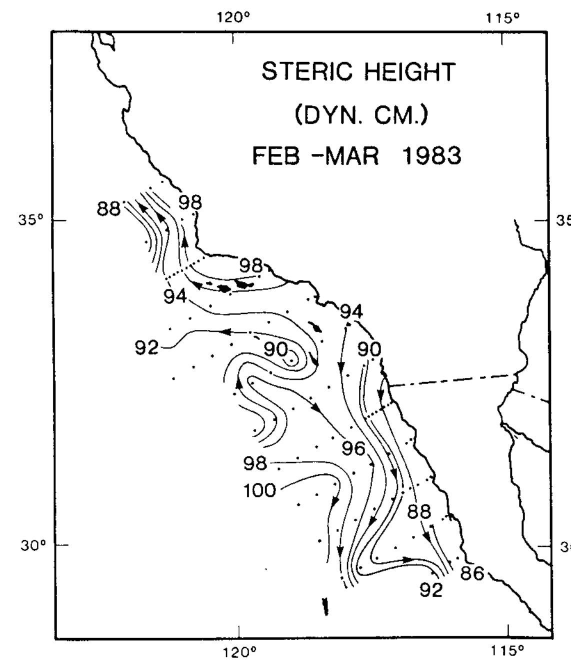

Fig. 1. Steric height 0/500 db in dynamic centimeters for R/V Townsend Cromwell survey 8302-3. The northern four lines were taken in early February, the southern six in late March and the remainder in the intermediate period.

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shoreward along much of the outer station grid, especially at the latitude of the U.S./Mexican border (14 cm/sec).

The anomaly of steric height (Figure 2) is produced by subtracting the seasonal mean from the observed values of Figure 1. Except for two stations off central Baja California, steric height was found to be above seasonal values in this El Niño period. The gain is seen to be in excess of 14 dynamic cm off central California and the pattern of anomaly greater than 10 dynamic cm follows the ridge in steric height offshore Baja California. Also, sea level, as measured at local tide stations, has attained new record levels (D. Brown, personal communication). At the Scripps pier station mean monthly tides were 22 and 16 cm above long-term averages for November and December 1982 (Simpson, 1983).

Time Variation in Steric Height

CTD casts along CalCOFI line 90 have been repeated intermittently during 1983 to monitor conditions associated with the El Niño. Observations were made in late January and early March by the NOAA vessel Townsend Cromwell, in early April by the R/V Wecoma and in early May by the NOAA vessel David Starr Jordan. The steric heights from these surveys (Figure 3) show a continuing excess over the seasonal mean values west of the Channel Islands (outside of 200 km from shore) but within 100 km of the coast, steric height dropped to near the seasonal average after early March. This sequence of observations of steric height implies a reversal of current at that section during March. These changes are commensurate with the displacement of the high values (>3°C) in subsurface temperature anomaly near 75 m from nearshore stations in January to offshore stations in early May (Figure 4). The observations for early March in Figure 4 show a split in the high values with the maximum 200 km offshore and a secondary peak at the nearshore station. In Figures 1 and 2 the four northern lines of stations were taken in the first half of February; the southern six were taken in the latter half of March. It is possible that the ridge in anomalous steric height depicted in Figure 1 may have moved from a coastal position to an offshore position during the 8 weeks spanning the survey. Thus, the distributions given in Figures 1 and 2 probably do not provide a synoptic representation of conditions.

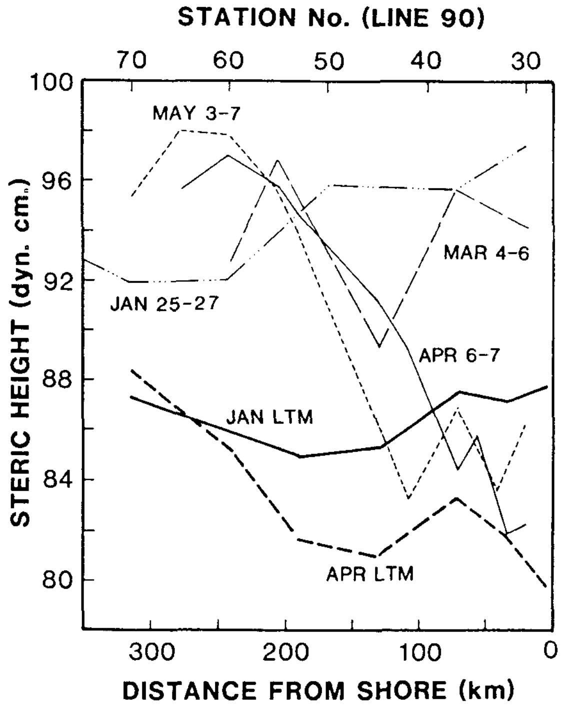

Fig. 3. Steric height along CalCOFI station line 90 for surveys in January, March, April and May 1983 and the long-term mean values for January and April from Lynn et al. (1982).

There is also a circulation reversal along the coast in February and March in the mean seasonal trend where the cessation of the coastal countercurrent is followed by the establishment of equatorward flow. Although sea surface temperatures along the coast from Baja California to Alaska have been about 1 to 2 C higher than normal during the 1982-83 winter and spring, the temperatures decreased 1°C between early February and early March in a narrow band along this coast, possibly indicating a change to southward advection. Additionally, fishermen claim that there was a dramatic reversal from northward flow to southward flow off northern California in April; both flows were strong enough to interfere with trawling operations.

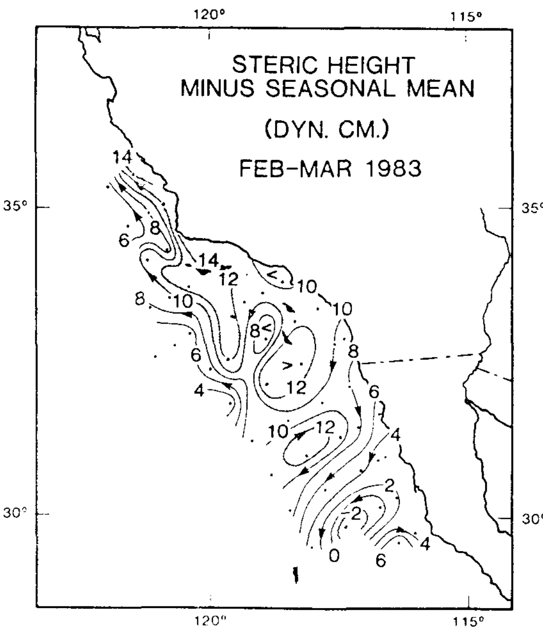

Fig. 2. The difference between the steric height values of Fig. 1 and the seasonal mean values in dynamic centimeters.

The 1957-58 El Niño

The differences in steric height for surveys in 1958 from the long-term monthly mean (Figure 5) show a spatially and temporally coherent pattern (Lynn and Reid, 1975). The January anomaly was more than 4 dynamic cm within a 100 km coastal band from Pt. Conception to the southern tip of Baja California. There is a trough in the pattern 350 km offshore where values fell below the monthly mean. These differences show that the California Current was intensified and broadened during the peak period of the 1957-58 El Niño. The California Current was displaced farther offshore and intensified in a narrow band about its core. The subsequent cruises of April, July and October 1958 show a dimunition, reversal and reestablishment of

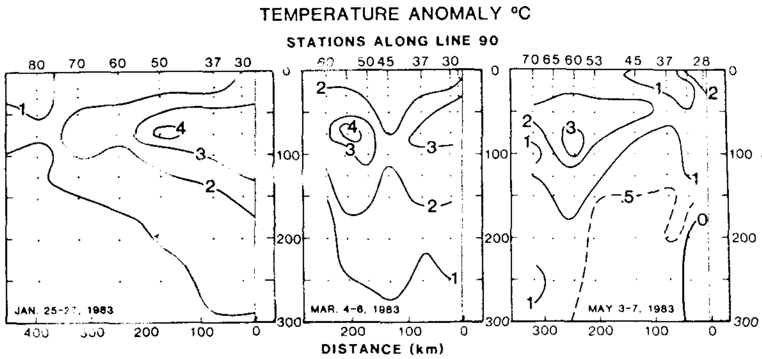

Fig. 4. Vertical sections of temperature anomaly along CalCOFI station line 90 for three periods in 1983 (°C).

the initial anomaly pattern, respectively (Figure 5). Throughout the period there were regions that exceeded a positive anomaly of 8 dynamic cm. Sea surface temperatures were also anomalously high with the greater temperature anomalies generally coincident with the greater steric height anomalies. Negative temperature anomalies were found only in the July survey; these coincident with the negative steric height anomalies. It is yet to be seen whether a similar oscillation of El Niño conditions will also characterize the present event.

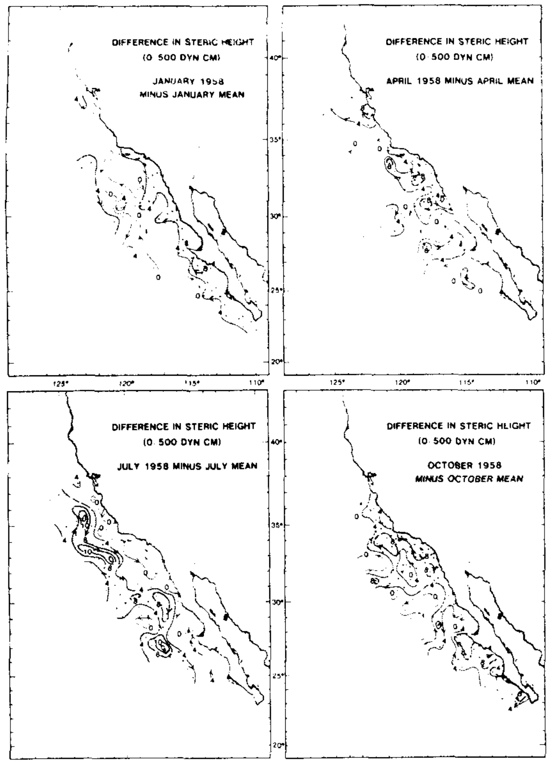

Fig. 5. The difference in steric height (0/500 db) from season mean values for four months in 1958 in dynamic centimeters. Values above 4 dynamic centimeters are shaded.

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