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NEAR-SHORE CIRCULATION IN THE CALIFORNIA CURRENT

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A great many of you are very familiar with the major current along the California Coast. What we wish to do today is to review the currents closer to the coast, since they are equally pertinent to the problem of pollution along the coast.

Figure 1 is a 16-year mean chart of the surface currents (relative to geostrophic flow) along the California coast in winter (January). The normal offshore flow all during the year is towards the southeast. In the wintertime the Davidson Current nearshore moves northward opposite to the current farther offshore. This northward flow in winter is attributed to the seasonal change in the wind patterns across California, Oregon and Washington. The winter winds are primarily from the south in the coastal area northward from San Francisco.

Question: Can you tell us what the speeds are that correspond to the California Current?

Schwartzlose: The average speed of the general California Current is about ¼ to ½ knot (12.5–25 cm/sec). Direct measurements, using drogues, which we have made off Monterey, southern California and northern Baja California, indicate that speeds up to a knot (50 cm/sec) can obtain for short periods of time. Primarily they are in the range of .4–.6 knot (20–30 cm/sec). It appears that the general current is not straight, but includes loops and eddies with a general southeast drift at about ¼ knot (12.5 cm/sec).

Figure 2 is the mean January geostrophic flow at 200 meters. The northward current or undercurrent is slightly wider than at the surface. This undercurrent persists throughout the year flowing northward at these depths along the coast. There have been some direct measurements of this current by Wooster and Jones using current meters in the area off Cape Colnett in northern Baja California, and various measurements with drogues have been made by Schwartzlose, Reid, Jennings, and Brown.

Figure 3 is the January 1964 flow charts. The difference from the mean charts (Figs. 1 and 2) is not very great, though more detail can be seen in Fig. 3. The Davidson Current and the eddy system in southern California are well developed. At 200 meters we see the undercurrent moving northward along the coast.

Question: What is the speed of undercurrents?

Schwartzlose: Very low, .1–.2 knot (5–10 cm/sec) according to the drogue measurements, but at least one series of direct current measurements by Wooster and Jones has shown speeds as high as half at knot (25 cm/sec) in a narrow layer.

Figure 4 shows drift-bottle results for December 1969. The Davidson Current was very well developed. There was water moving out of southern California northward along the coast. One drift bottle went to Alaska. The minimum speed of some of the December 1969 drift bottles that moved northward in the Davidson Current was about .3 knot (15 cm/sec).

We have records from other drift bottles in other years during the winter that indicated minimum speeds in the Davidson Current of .6 knot (30 cm/sec) for long periods of time, up to 2 to 3 months. This Davidson Current is usually a very strong current compared to the offshore California Current and it extends to the Gulf of Alaska. In January 1958 a large number of drift bottles from central California were recovered off northern Oregon, Washington and British Columbia; this was due to a very strong development of the Davidson Current.

The Davidson Current is usually between 40 and 50 miles wide, and in the northern area the overlying wind is from the south. In December of 1969 one of the returned bottles had been released 80 miles from shore; it is rare to see any returns from that distance. Our other drift-bottle charts show that the Davidson Current is the narrowest at its southern end off Point Conception, and it slowly widens northward. Pearcy's Figure 2 that we saw the other day showing the plume of the Columbia River going northward in the wintertime is a very good indication of the same type of information that the drift bottles show, and at that location the plume appeared, as you recall, to be something like 50–60 miles wide.

Another interesting feature seen from the drift-bottle returns is that usually we receive few returns from Baja California because of the small, scattered population. The returns are from farther south in winter than in summer.

Figure 5 is presented to show that the interpretation of the drift-bottle data is at times not clear. Note that from the January 19 release of bottles just north of Point Conception one bottle went northward and one bottle landed well south, near San Diego. There is, of course, some diffusion or spreading of the bottles as they drift. If the release location is near the boundary of the southward-flowing portion of the California Current, a few of the bottles may spread into that current.

In the spring of the year, primarily in April, sometimes in May, the winds off northern California turn southward again and the northward flow of the California Current ceases (Figure 6). The storm centers are farther north than in winter. The current all along the coast is usually moving southward, including the area through the Channel Islands. In April the water flows right through the southern California borderland, and the normal gyre that exists the remainder of the year in the southern California borderland is not found.

Figure 7 presents the 15-year mean geostrophic flow for July. The Davidson Current, of course, is not present, but we do find the gyre off southern California. This is the period of time when the California Current is the strongest due to the northwest winds.

In figure 8, the mean July geostrophic flow at 200 m shows the undercurrent along the coast flowing very slowly northward from southern Baja California through northern California. The width of this northward undercurrent appears to be 40 to 50 miles.

Figure 9 shows the percent of drift-bottle recoveries from releases at various distances offshore. As can be seen, the recovery from 15 miles inward is very good off southern California, whereas it is poor off Baja California, possibly because there are not so many people on the beaches. Many of the recoveries from 70 to 90 miles off southern California are from the currents that form the gyre within the southern California bight.

The drift bottles that are dropped within 3–5 miles of the beach usually go ashore very quickly, not far from the point where they have been released. There are problems in interpretation of the returns, since there is no way of knowing how long the bottles may have lain on the beach before recovery or how many beaches they have been on.

Some direct drogue measurements were made earlier in the CalCOFI Program from the Catalina Channel to west of the north end of San Clemente Island. These data suggest the presence of a number of small gyres (Figure 10).

We have a little more data from a current meter that was placed about 6 miles west of Scripps for 15 days. It was about 25 feet below the surface. The data showed a current moving northward about half of the time, then shifting rapidly within a few hours and moving southward. These nearshore currents were primarily between $\frac{1}{4}$ knot (12.5 cm/sec) and $\frac{1}{2}$ knot (25 cm/sec). They were persistent for more than a week in one direction and then reversed themselves.

There have been a number of studies of currents around sewer outfalls, but usually these are only for several days, not for long periods of time.

Question: How much water leaves the southern California bight? Is there internal circulation?

Schwartzlose: I do not know. There is internal circulation within the bight, but there is mixing with new water coming in from the main stream of the California Current.

Sargent: Some act like ball bearings between the others. I think this problem is susceptible of a rough solution with a computer, but no one has been interested enough to get down and do it. The question was asked about the rate of escape, but no one has ever done it.

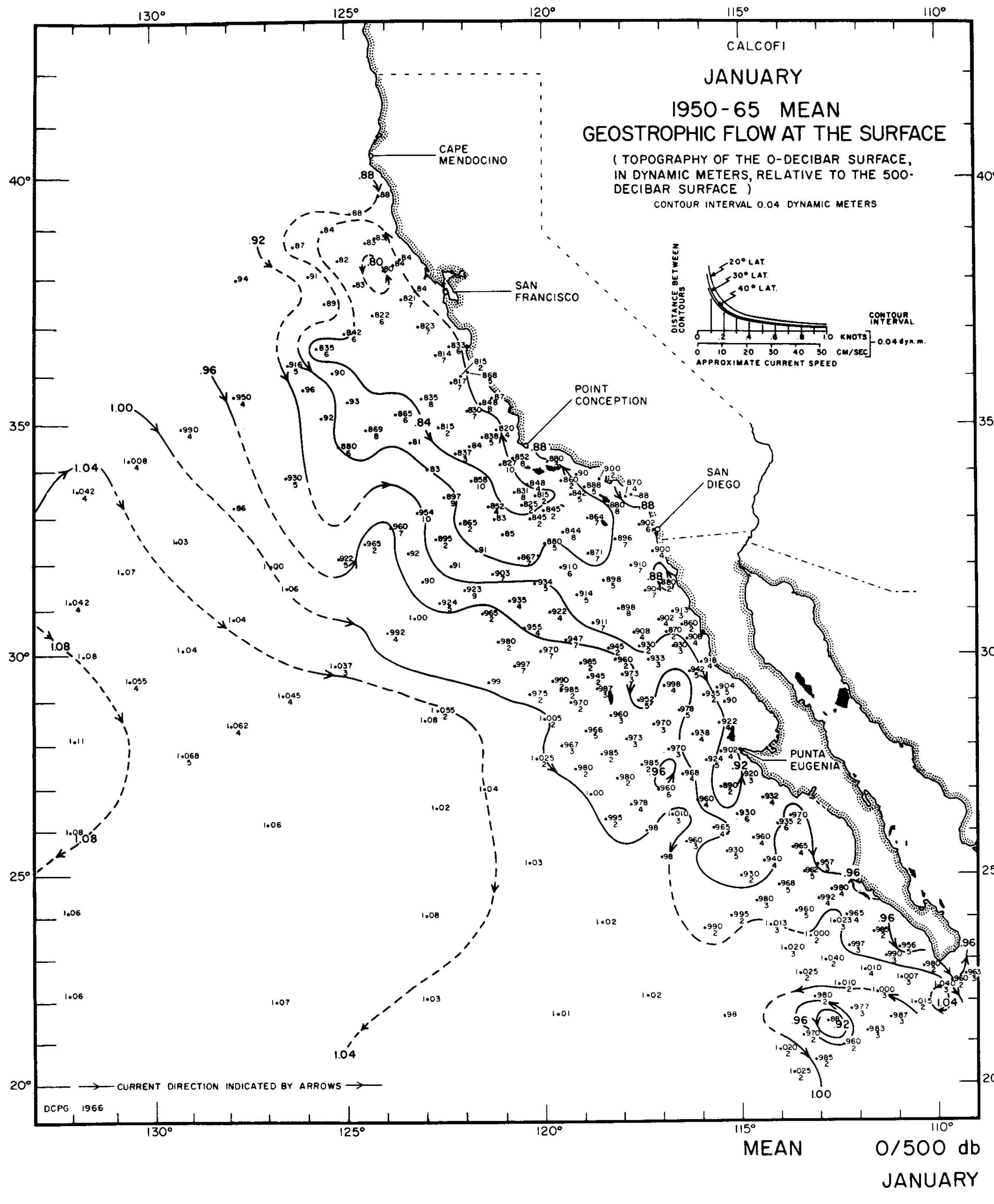

FIGURE 1. Mean January geostrophic flow (1950–1965) (sea surface relative to the 500-decibar surface, in dynamic meters).

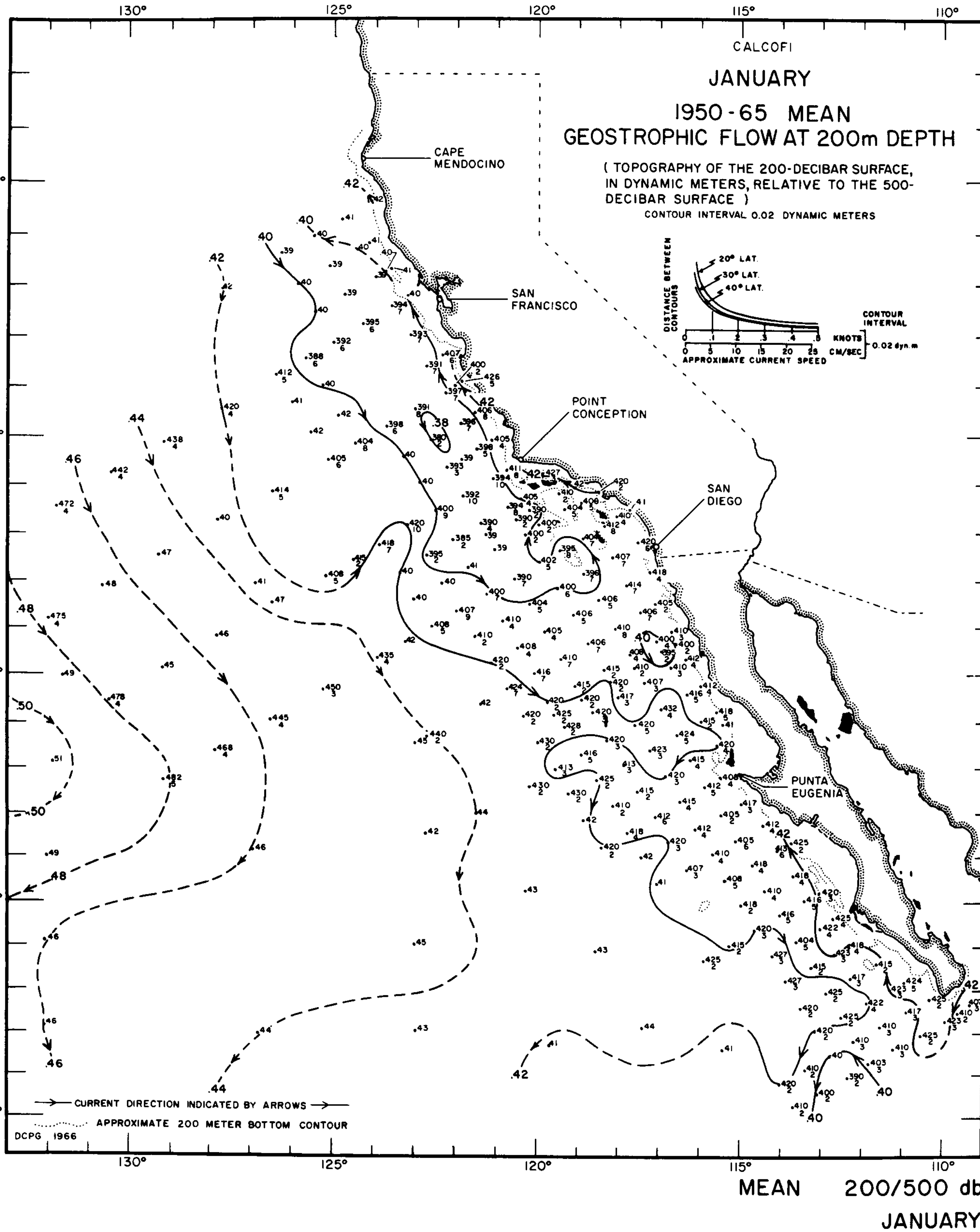

FIGURE 2. Mean January geostrophic flow (1950–1965) (200-decibar surface relative to the 500-decibar surface, in dynamic meters).

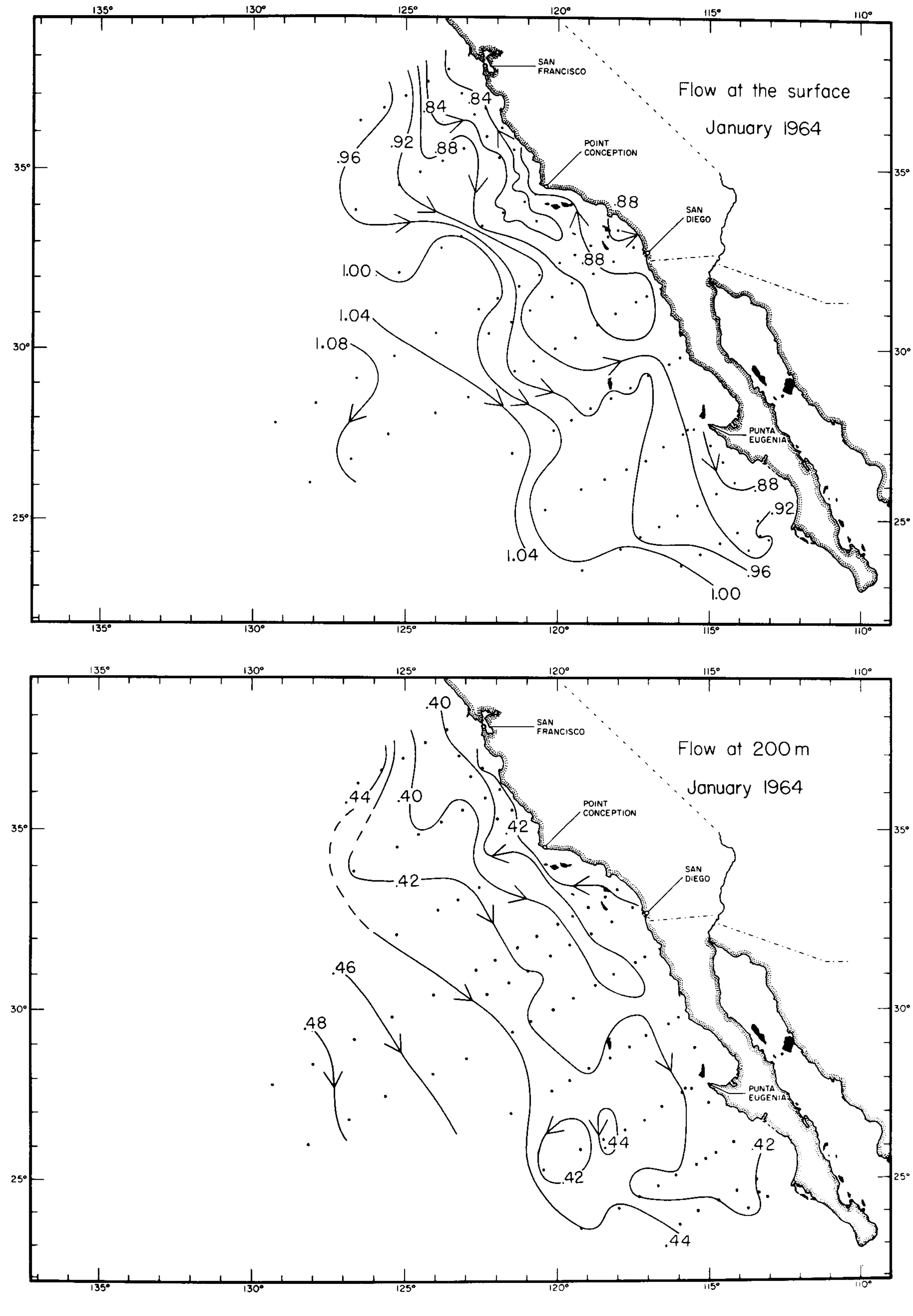

FIGURE 3. Geostrophic flow in January 1964 at the surface and at 200m depth (topography of the 0- and 200-decibar surfaces relative to the 500-decibar surface, in dynamic meters).

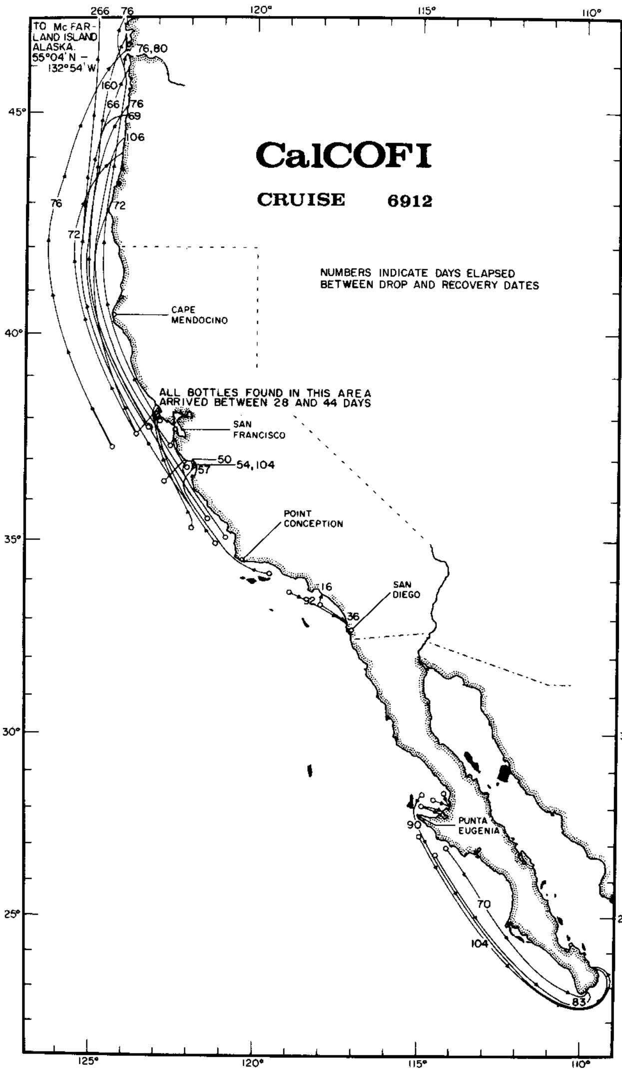

FIGURE 4. Drift-bottle returns for December 1969.

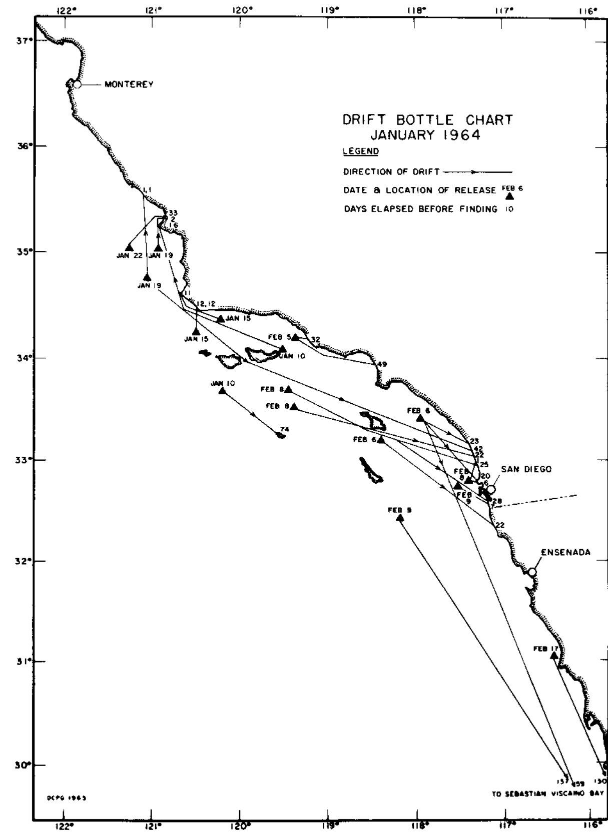

FIGURE 5. Drift-bottle returns for January 1964.

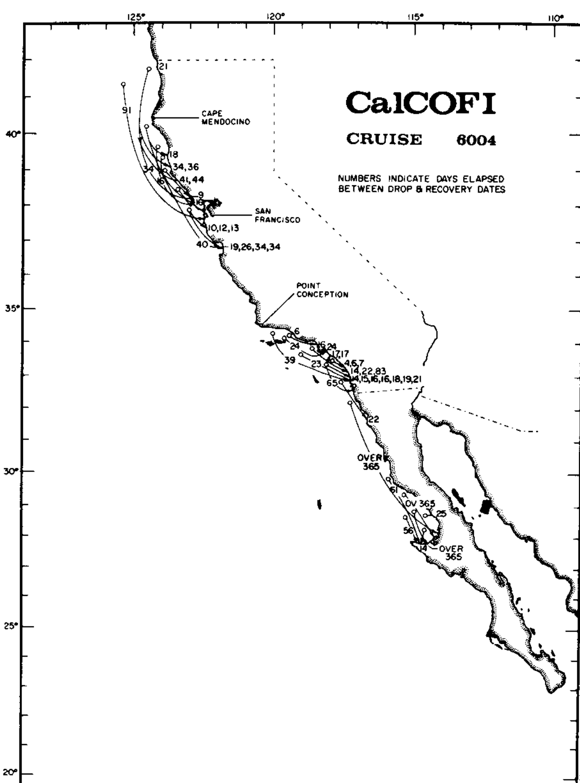

FIGURE 6. Drift-bottle returns for April 1960.

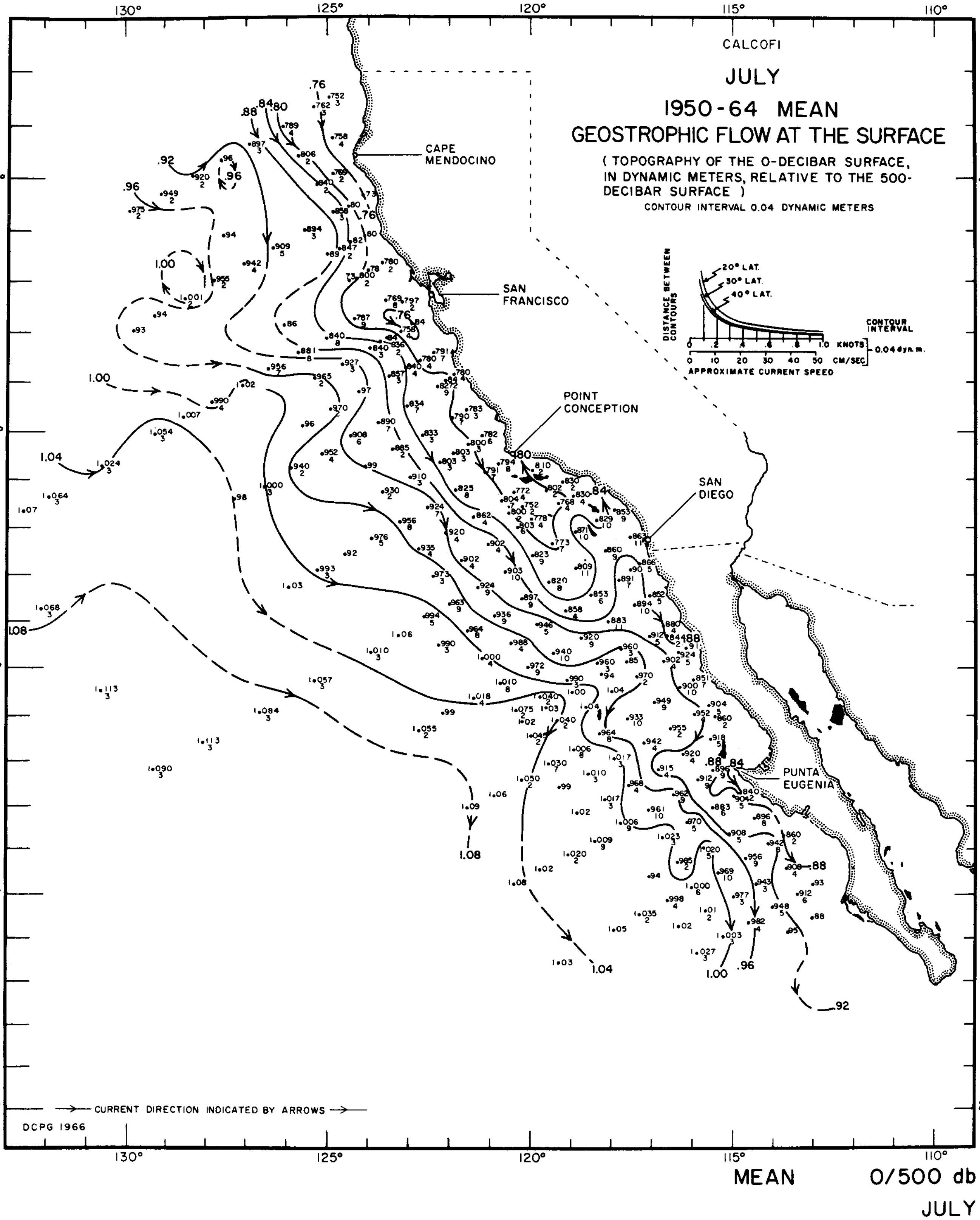

FIGURE 7. Mean July geostrophic flow (1950–1964) (sea surface relative to the 500-decibar surface, in dynamic meters).

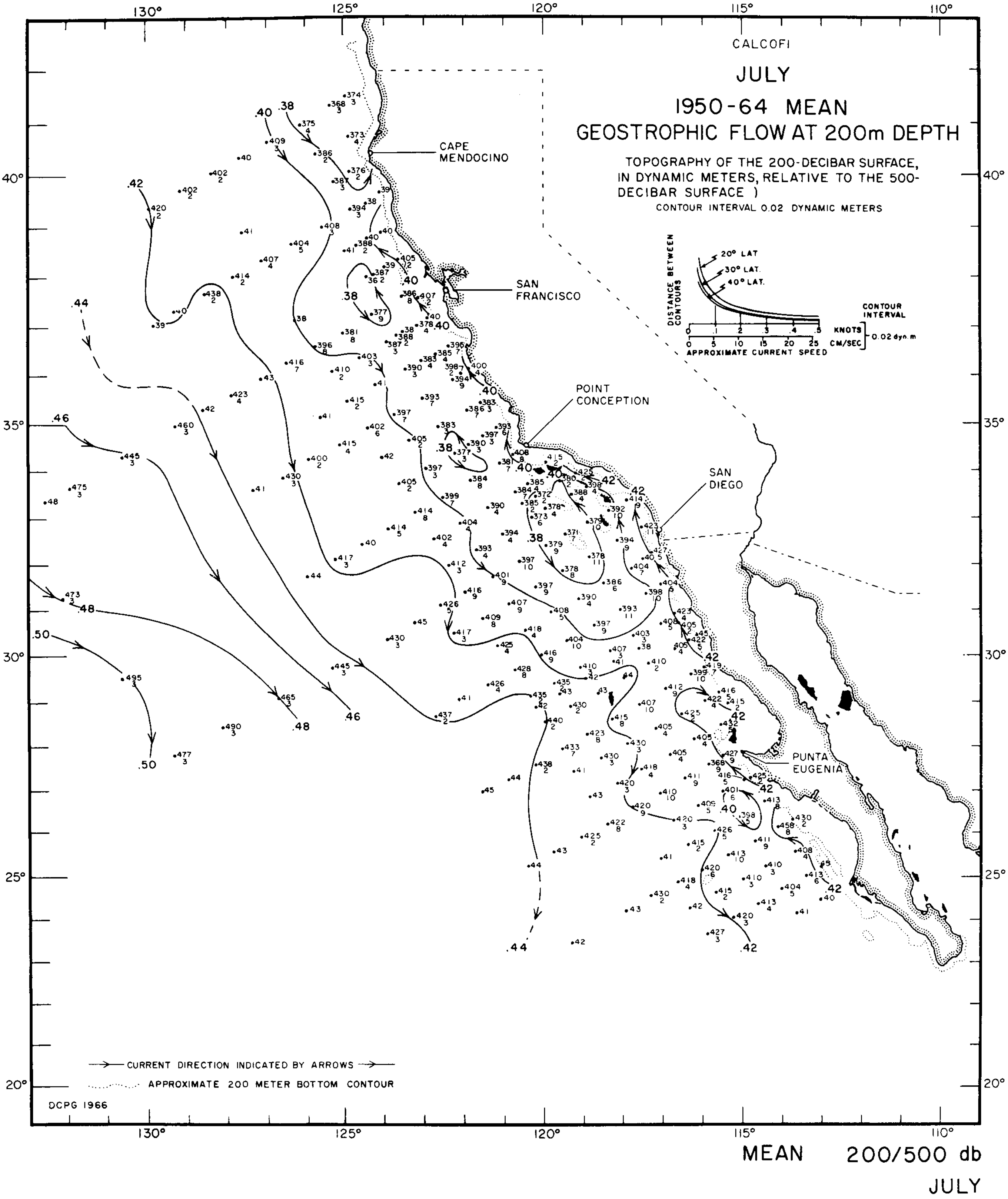

FIGURE 8. Mean geostrophic flow (1950–1964) (200-decibar surface relative to the 500-decibar surface, in dynamic meters).

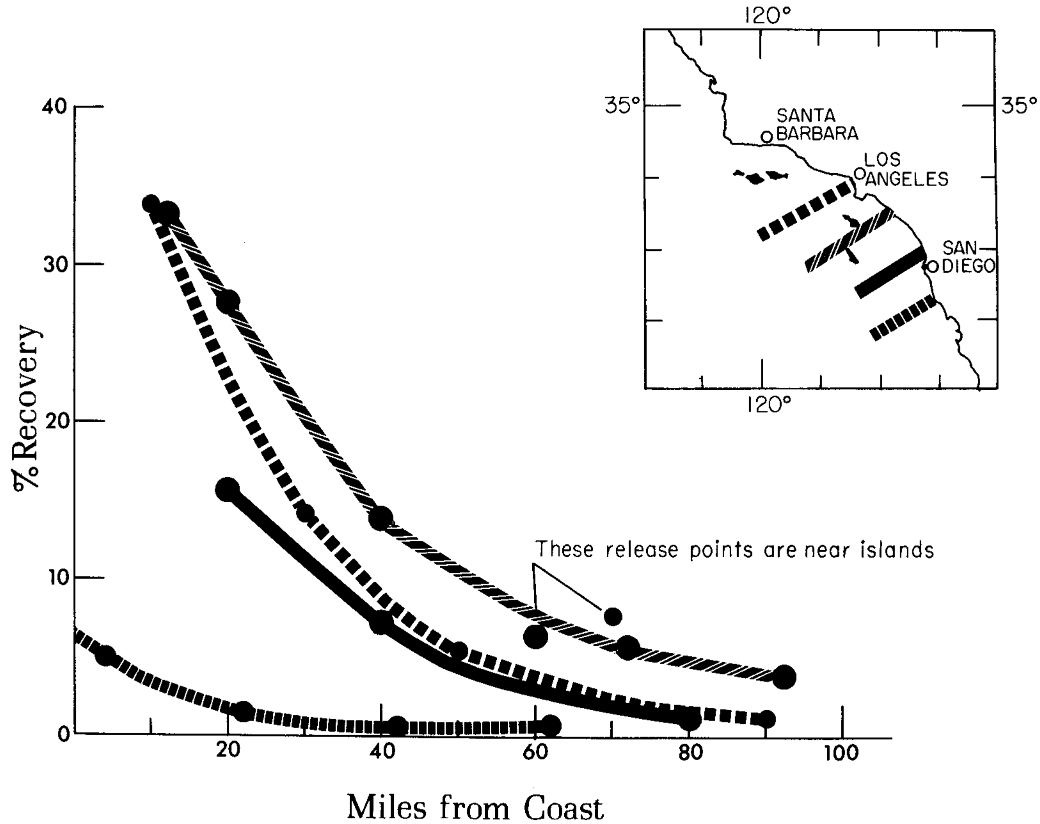

FIGURE 9. Drift-bottle recoveries from releases at various distances offshore.

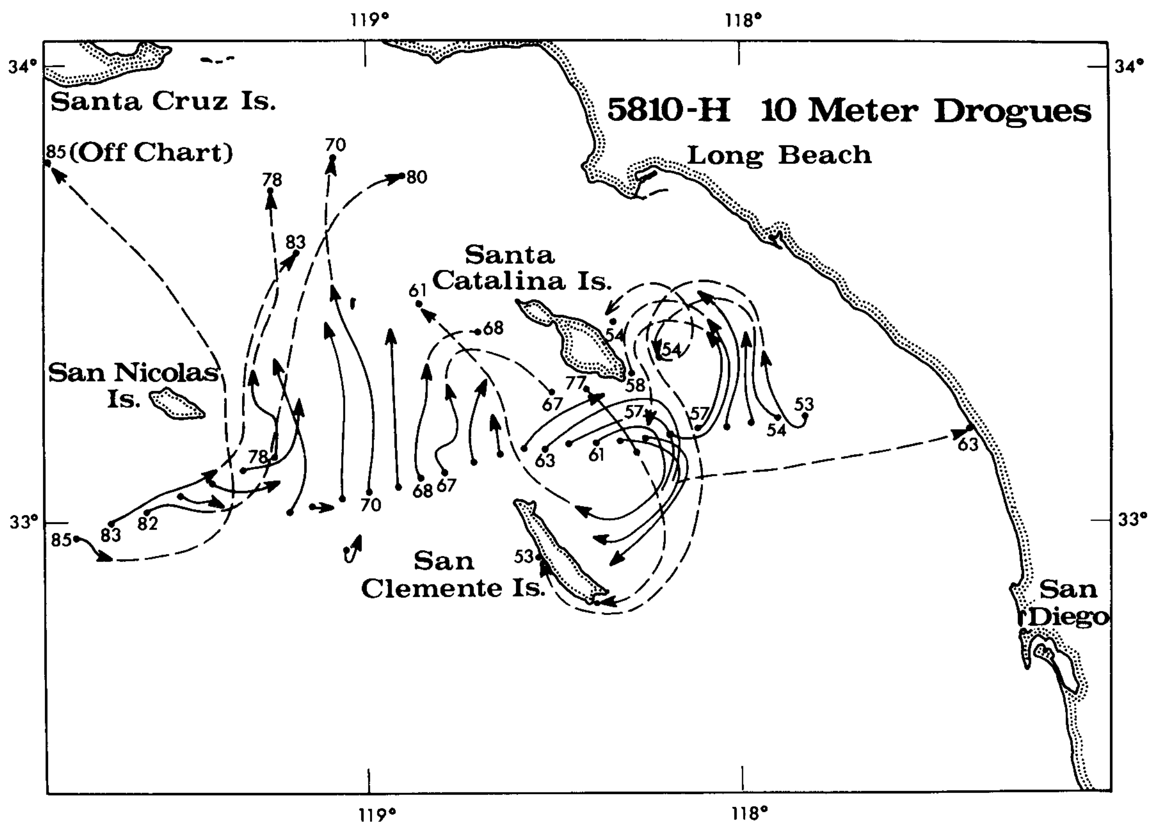

FIGURE 10. Drogue measurements off southern California in October 1958.