Currents in La Jolla and Scripps Submarine Canyons

Abstract. *Velocities up to 34 centimeters per second have been recorded near the floors of submarine canyons off La Jolla, California. Currents move alternately down- and upcanyon with variable periods. All 3- to 6-day measurements show net current transport downcanyon. Many of the downcanyon currents of higher velocity correlate with ebbing tides, as measured at the nearby pier. Other factors producing the currents probably include internal waves. Velocities are sufficient to transport large quantities of fine sand.*

Floor currents were first measured in submarine canyons off La Jolla in 1938 (*1*), and these currents moved both up- and downcanyon. These alternating currents were later observed during many scuba dives and during descents in diving vehicles (*2*). Systematic measurement of the currents was begun in April 1968, with the Isaacs-Schick (*3*) continuous recording current-meter system, which is dropped to the ocean bottom. The current meter is positioned 3.6 m above the bottom. It returns to the surface after the timed release of an attached weight. Current meters record both speed and direction. Continuous records of up to 6 days have been obtained. In addition, using as many as six current meters, we have taken simultaneous records on the continental shelf on both sides of the canyons and on a ridge between La Jolla and Scripps canyons. We have also superimposed three current meters at 3.6 m, 19 m, and 34 m above the bottom of La Jolla Canyon.

Frequent oscillations in direction are apparent in recordings of two stations on the floor of the same canyon, but while there is far more movement downcanyon than upcanyon, there are no readily discernible tidal relationships (Fig. 1A). Correlation between these two stations is high, although simultaneous flows in opposite directions occur, which suggests cellular phenomena. Changes in flow from upcanyon

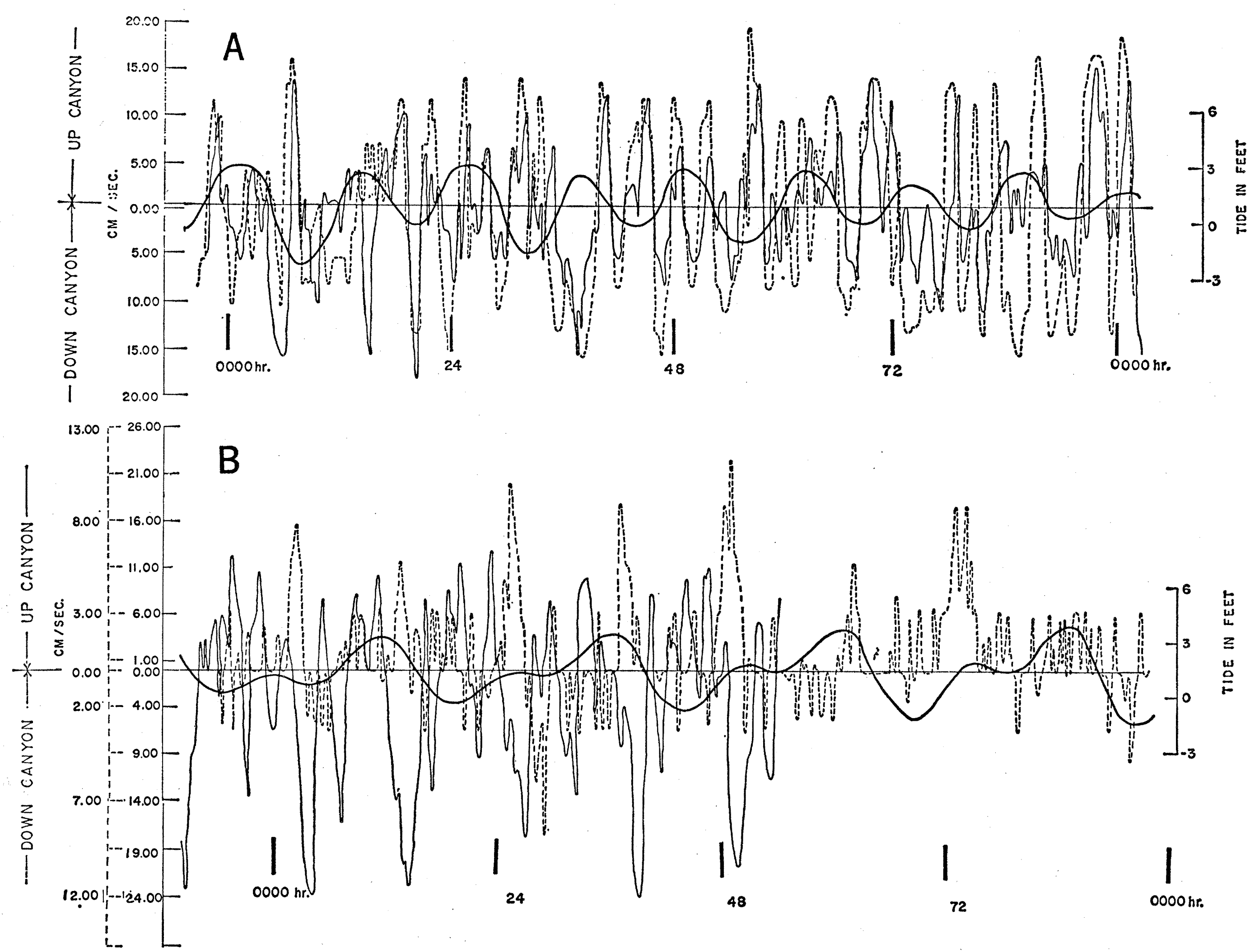

Fig. 1. (A) Axial current components for two records in La Jolla Canyon over a 4-day period with relation to tidal curve at Scripps Oceanographic Institution pier. Winds westerly, 0 to 3 knots, swell 260° to 280°, 7 to 9 seconds, and 0.3 to 0.5 m high. (Light solid line) Station 5, canyon floor depth 167 m; (broken line) station 3, canyon floor depth 206 m; (heavy solid line) tide curve. Measurements from 18 to 22 July 1968. (B) Axial current components in La Jolla Canyon compared to north-south components of currents on a ridge between Scripps and La Jolla canyons and relation to tidal curve at Scripps Oceanographic Institution pier. Winds westerly, 2 to 5 knots, swell 270° to 280°, 6 to 8 seconds, and 0.3 to 0.7 m high. (Light solid line) Station 3, canyon floor depth 206 m; (broken line) station 4, intercanyon ridge depth 134 m; (heavy solid line) tide curve. Measurements from 10 to 14 August 1968.

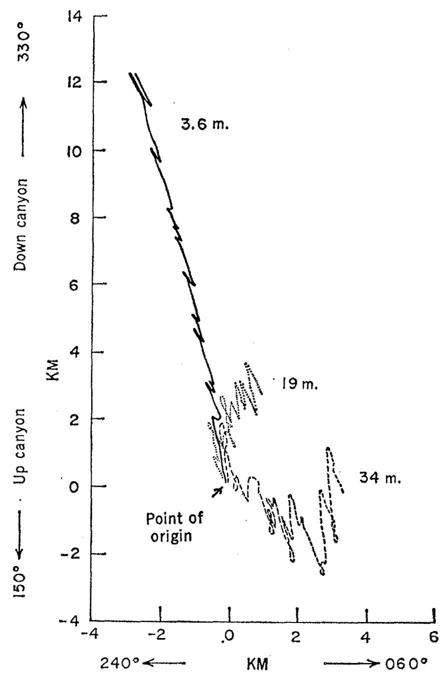

Fig. 2. Trajectories of the movement of particles of water at three depths above the floor of La Jolla Canyon where the axis is 206 m deep.

to downcanyon are generally slow, but are much more rapid than are changes from downcanyon to upcanyon.

Virtually all higher speed currents occur during ebb tides in the Scripps and La Jolla canyon records (Fig. 1B). Many of the peaks clearly have a tidal cycle, although others are associated with changes of direction of short duration that are not related to the tide. The currents on the ridge have peaks in a southerly direction during most of the ebb tides, indicating that these do have a tidal relation.

Plots of the total movement or trajectory of currents near the floor of a canyon show a large residual in the downcanyon direction. Superimposed records of three current meters (Fig. 2) indicate a large net movement downcanyon near the floor. Slight net movement downcanyon occurred 19 m above the bottom, and at 34 m the movement was at first toward shore and then it reversed, so that a water particle would have had no net axial transport. As distance above the canyon bottom increases, net transport becomes more related to ordinary tide-influenced oceanic patterns (*4*).

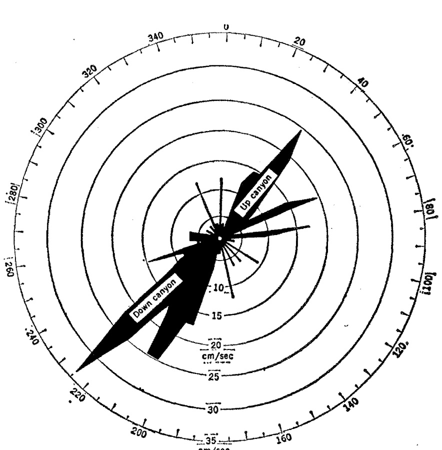

Fig. 3. Vectoral components of current at a depth of 107 m near the floor of Scripps Canyon from 13 to 18 December 1968.

Currents may also be examined by constructing a vector rose of velocities. One such record includes the highest velocity we have observed to date, which was downcanyon (Fig. 3). Some unusual directions are related to periods of changing direction, and others may be small transverse oscillations conceivably related to the passing of large fish, but the greater part of the currents are up- and downcanyon. This would be expected because of the narrowness of the canyon.

During 34 percent of the time we recorded, flow was downcanyon; 42 percent of the time, flow was upcanyon; and during the remaining 24 percent of the time it was changing direction. Currents capable of eroding sand (over 18 cm/sec) make up 4.8 percent of all recorded flow time, or 14.4 percent of downcanyon flow time. Erosive currents upcanyon occur, but they are negligible in number and duration. Net transport is always downcanyon since average downcanyon flow is 8.25 cm/sec, whereas average upcanyon flow is 1.85 cm/sec. Downcanyon flows last 47 minutes on the average, and upcanyon flows last for an average of 74 minutes.

Although many changes in direction appear to show no periodicity, we have found several cases in which reversals occurred at periods of about 4 hours. A similar period has been found in studies of internal waves at the U.S. Navy platform off Mission Beach, California (*5*).

We have compared current velocities during periods of spring tides to those during neap tides and have failed to find any relationship. Similarly, we could find little difference between currents related to periods of rapidly falling or rapidly rising tide as compared to periods of slow tidal changes or to extreme spring tides (Fig. 1).

As yet we have not had the opportunity to obtain a record during unusually large waves. There are some indications that considerably higher velocities may exist during storms, and we hope to test this. However, we have clear evidence that the normal current velocities are capable of moving considerable quantities of sand down the axis of a canyon (*6*). These currents are entirely different from powerful turbidity currents.

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References and Notes

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Fluoride in Seawater: Measurement with Lanthanum Fluoride Electrode

Abstract. *Fluoride ion concentrations are quickly and easily determined in seawater by means of a fluoride-selective electrode. Samples require little pretreatment; a determination takes 15 minutes; error limits are 5 percent; equipment required is rugged, inexpensive, and motion-insensitive; and minimum demands are made on the operator.*

Specific-ion electrodes offer an attractive approach to the analysis of minor constituents in complex solutions. The determination of fluoride in seawater is a representative problem of particular interest because fluoride may not be a conservative constituent (*1*). Using an Orion model 94-09 LaF_3 electrode with an Orion model 90-01 reference electrode, I have measured fluoride concentrations directly in synthetic and natural seawaters. The method permits simple compensation for variation in salinity and is designed for easy adaptation to measurements *in situ.*