MEASUREMENTS OF COASTAL CURRENTS

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We have developed a series of numerical models to help in understanding the distribution and fates of effluent constituents discharged into the coastal waters off southern California. The models are now helping us evaluate the ability of hypothetical processes to explain observed distributions and fates of wastewater constituents (or to indicate if some other processes are required). We eventually hope to be able to use these models as predictive tools.

In the Project's 3 yr report, we described a large scale model of the Southern California Bight. This model could, in principle, be used to estimate the distributions of certain types of materials introduced into the coastal waters, or to estimate the potential reduction in the dispersion of the wastefield (following the initial dilution process)* that might result from a recirculation of previously discharged wastewater into the outfall area. A second model, described here, investigates the relative importance of some of the mechanisms that may govern the fate of trace metals in outfall areas. The development of both of these models emphasized to us the inadequacy of the information available on the characteristics and properties of currents near the coast.

From either a conceptual or a computational viewpoint, the fluctuating currents in coastal waters can be represented by a collection of component currents, each having a characteristic period of fluctuation and some distribution of speeds. Although all of these component currents should, in principle, be predictable, the observed currents are, in reality, only predictable to a limited degree due to the lack of input information or computational restrictions; hence at the present time, these characteristics must be obtained by observation.

*The initial dilution is not as likely to be affected by recirculation since the wastefield is vertically displaced from the dilution water, which is entrained into the rising plume, and vertical transfer rates in the ocean are usually quite slow.

The manner in which these component currents are incorporated into an estimate of dispersion processes depends on their speed and periodicity, and on the space and time scales relevant to the problem. For example, significant changes in the sediments occur over distances of a few hundred meters; hence component currents that have speeds and periodicities capable of producing comparable displacements should be explicitly incorporated into a model estimating sedimentation in the outfall area. In contrast, to estimate the distribution of effluent (or related effects on the environment) over the entire coastal area and offshore islands, we must consider changes over much greater distances. Thus component currents that produce displacements of a few kilometers probably would not be explicitly incorporated in the estimate (but might be implicitly incorporated into the diffusive portion of the simulation).

Since a wide range of length and time scales are involved in estimating the fates of various constituents of wastewaters, it is necessary to examine a wide range of periodicities in the component currents. In addition, to make estimates of the properties of these component currents, it is necessary to make current measurements over a period of time greater than the longest period of the component currents that are relevant to the problem, and with a sampling interval shorter than the shortest component current period. In general, these conditions were not met in the measurements previously available to us. Since that time, a set of measurements that come much closer to fulfilling these criteria have been taken by Los Angeles County Sanitation Districts personnel and made available to us. The measurements were taken intermittently between March and May 1973 and continuously between August and October 1973 at a station in 60 m of water off the Whites Point outfall. Two Savonious rotor current meters were suspended on taut line moorings at depths of 16 and 46 m. Speed and direction measurements were taken from these meters at 1/2 hour intervals, transferred to punch cards, and analyzed by digital computer.

Since these measurements were only made for a few months of one year, there was some question about how representative they might be of the "typical" currents occurring during the two seasons. When we compared the speed distributions and the relative transport in various directions from the 1973 data with data collected during 1960 to 1964 (and described in Technical Memorandum 210), we found that with the exception of the autumn currents at the 16 m depth the currents were quite similar during the two periods, and that the principal differences were probably due to improvements in measurement methods.

The average speed at both 16 and 46 m was less in the spring than in the autumn period, a variation that is also commonly observed in the Southern California Countercurrent (the principal current offshore). At the 46 m depth, the average speeds in spring and autumn were 8 cm/see and 10 cm/see, respectively, while the 16 m speeds were 13 cm/see and 15 cm/see, respectively about 50 percent faster.

It had been previously recognized that component currents with tidal like periods could produce displacements on the order of a few kilometers during one tidal period and hence could be important in distributing material in the outfall area. We examined the measured currents for component currents with tidal like periods by constructing a 3 day running average velocity for the longshore and offshore directions; we then subtracted this average velocity from the observed values to obtain the short period fluctuations. A typical result is shown in Figure 1, which illustrates the presence of fluctuations with semidiurnal (12 hr) and diurnal (24 hr) periodicities. It was interesting to discover that the diurnal variation dominated the longshore short period flows at the 46 m depth, even though the principal component of the mixed tides in this area has a semidiurnal period. As might be expected from this observation, the short period currents did not exhibit a strong correlation with the tides. This is not entirely unexpected on theoretical grounds, but it was somewhat surprising in view of the fact that short period currents showed a good correlation with the tides in earlier observations (February 1972) at the Point Loma outfall (Figure 2).

Tidal like periodicities may be produced not only by tides, but also by other mechanisms, such as internal waves.

Over a short period of time, the currents produced by these two mechanisms may be superficially identical, but over longer periods, the difference can become more apparent. Currents associated with internal waves may appear as short packets of tidal period waves but without a distinct relationship among the timing of the packets, while the tidal currents will always be related to one another. Since the amount of "randomness" or conversely the predictability of currents is important in developing statistical representations of dispersion processes, it is desirable to identify, if possible, the extent of the "randomness" in the tidal like period component currents.

We analyzed the 1973 currents data for the presence of fluctuations with tidal harmonic periodicities and obtained the amplitudes contained in Table 1. We then compared the variations produced from these harmonics with the observed fluctuations and found that although the general trend of the fluctuations could be reproduced, there were considerable differences in the detailed structure. Additional analysis will be undertaken to determine the actual contribution of tidal currents to the observed fluctuations.

During autumn, typical amplitudes of the short period fluctuations at the 46 m and 16 m depths were on the order of 9 cm/see and 15 cm/see, respectively. Hence displacements during one tidal period would be on the order of +1.2 to +4 km, demonstrating the importance of these currents in predicting the distribution of wastewater constituents in the outfall area.

Since tidal period fluctuations produce displacements that would remain within the general outfall area, flushing of this area will be strongly influenced by longer period currents. These currents (i.e., the 3 day running average velocities) at the 46 m depth are shown in Figure 3 for the autumn period. The length of the data record is too short to permit characterization of the speed and periodicities present in this record, but it is interesting to note that the average speed of 7 cm/see is comparable with speeds of 10 cm/see and 7 cm/see observed in the Point Loma outfall area over shorter periods of time and is somewhat greater

than the average speed used in the large scale model.

These measurements should provide a significant improvement in our ability to estimate the dispersion of wastewater constituents in the Whites Point area. We also plan to collect additional data with four current meters that we have recently acquired. This data will provide additional insight into the properties of the long period currents (including their spatial extent), the characteristics of currents in Santa Monica Canyon, and the variations and patterns of flows in the coastal waters (particularly in the outfall areas); the data will also be examined to determine the extent to which flow variations can be related to winds, offshore (geostrophic) flows, internal waves, etc. This additional data is expected to provide additional refinements in predicting the dispersion in the outfall areas; it should also assist in estimating the flushing rates of these areas and the dispersion of effluent in the coastal waters and help in interpreting data collected during other field studies conducted by the Project.

Additional detail on the 1973 current measurements will be published by the Project in the form of a technical memorandum.

FIGURES

Figure 1.

Short period currents at a depth of 46 m and tidal heights at the Whites Point outfall area

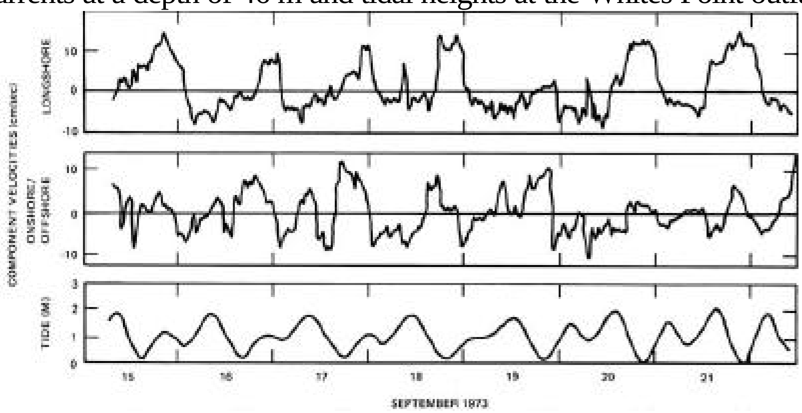


Figure 2.

Short period longshore flow at a depth of 22 m and tidal elevation in the Point Loma outfall area

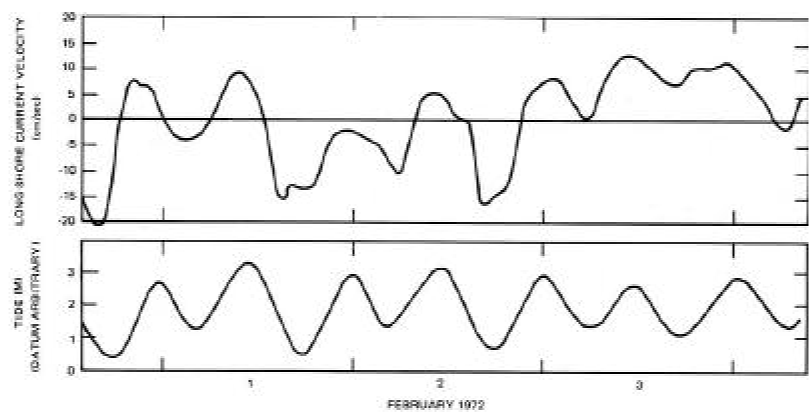
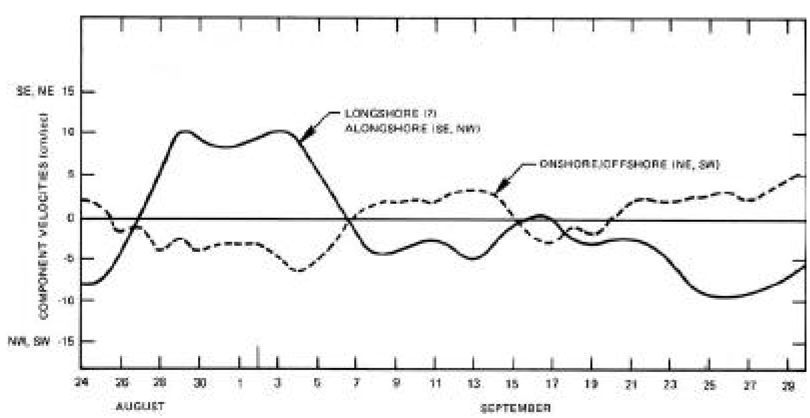


Figure 3.

Long period ~ > 3 days) currents observed at a depth of 46 m in the Whites Point outfall area {1973)



TABLES

Table 1.
Fitted tidal harmonics at 46 m in the Whites Point outfall area.

Tidal Harmonic	Period (hr)	Fitted Amplitude (cm/sec)
Principal lunar (M_2)	12.42	1.5
Principal solar (S_2) and	11.99	0.8
Lunisolar semidiurnal (K_2)		
Larger lunar eliptic	12.66	1
Principal solar diurnal (P_1) and Lunisolar diurnal (K_1)	23.96	2.2
Principal lunar diurnal (O_1)	25.82	2.6
Larger lunar elliptic (O_1)	26.87	1.4
Inertial period	26.67	