A DESCRIPTIVE STUDY OF THE PHYSICAL OCEANOGRAPHY OF KANEOHE BAY, OAHU, HAWAII

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ABSTRACT

The results of a thirteen-month hydrographic survey of Kaneohe Bay are presented in this primarily descriptive study. The subjects covered in the study are the hypsographic conditions, tides, circulation patterns, volume transports, sewage distribution, heat budget, preceipitation, runoff and the distribution of water properties in the Bay. The interrelations between these subjects are also examined.

A primary conclusion of the study is that the bathymetry of the Bay has a controlling effect on the circulation. This is due to the large reef areas that restrict the flow, especially from the southeast basin. The flow, in turn, governs the volume of water transported into and out of the Bay, the areas of heat gains and losses, the amount of stratification, and the sewage distribution in the Bay.

The amplitude and phase of the tides in the Bay were determined. The wind was found to exert an influence on the differences between the Honolulu and Kaneohe Bay tides. Stronger trade winds increase the amount of time a tide in the Bay preceeds the Honolulu tide and also increase the tidal height in the Bay relative to Honolulu.

The tidal records for the Bay show an unexpectedly high number of free oscillations. The theoretical free oscillations for the Bay were therefore calculated and the results are compared with the observed oscillations. The observations indicate a predominance of single and binodal free oscillations; however, the influence of these

oscillations on the current velocities in the Bay is small.

The circulation patterns present in the Bay during an incoming and an outgoing tide were determined. Both patterns show considerable variation in current velocity and direction depending upon the location in the Bay. The overall current patterns, however, are very consistent. The northwest half of the Bay has a more active circulation than the southeast half, because there are fewer flow restrictions in the northwest half of the Bay. Circulation patterns below 4 m in the deeper inshore portions of the Bay are very consistent, and frequently circulate in opposite directions to the surface circulation. The current patterns during the changing tides reverse at some locations, as in the southeast channel. The amount of this flow reversal is dependent upon the tidal cycle and the wind.

A considerable amount of water is exchanged across the entrance reefs and in the two channels during each tidal change. The net flow through the inshore portion of the Bay, however, is limited since a majority of the water exchanged is the surface water that is close to the Bay entrance. The result is the flushing rate in the inshore portion of the Bay is low. The Bay accumulates water from precipitation, runoff, and the addition of sewage. This accumulated volume leaves the basin with the tidal exchange transports, appearing as a daily net volume outflow from the Bay. Since the precipitation and evaporation are approximately equal, this net outflow from the Bay is essentially a result of the addition of runoff and sewage to the Bay.

The circulation throughout the Bay determines the distribution of temperature, salinity, oxygen, and phosphate. The distribution of these properties was determined each month. The results, presented in maps for the surface, 5 m and 10 m indicate the Bay is more stratified in the summer than during the winter. An analysis of diurnal measurements shows the range of daily water property variations due to the combined effects of heating, circulation, and tides, is approximately 1/5th of the seasonal variations.

The yearly mean water temperature in the Bay was higher than the open ocean, implying that heat must have been advected from the Bay during the year. A computation using the temperature and volume of the mean monthly net and exchange transports showed such a heat loss. The Bay must, therefore, have an annual heat gain at the surface. Such an annual heat gain was demonstrated by computing the heat exchanged at the surface of the Bay. The results of an alternate method for computation of the heat exchanged at the surface of the Bay shows a slight loss of heat throughout the year. Heat losses from the surface of the Bay are prevalent on the reefs while heat gains are generally found in the deep inshore areas and areas adjacent to the stream mouths.

Runoff contributes to the stratification in the Bay and also influences the seasonal distribution of phosphate on the surface of the southeast basin. The mixing during winter storms prevents stratification in the basin. As a result, the phosphate, temperature,

and salinity values in the southeast basin during the winter are more uniform with depth. In the summer the stratification in the basin causes the sewage and runoff to remain on the surface, resulting in greater phosphate, temperature and salinity variation in both the surface and deep water of the basin.

A time series analysis, used to correlate the preceipitation measured at Mokuoloe Island with the stream runoff into the Bay, revealed a very gradual increase in stream runoff into the southeast basin over the past thirty-one years. This increase is attributed to an increase in urban construction in the drainage area of the streams emptying into the basin.