

7.5 Dye Tracer Experiments in Jamaica Bay

Robert Houghton, Arnold Gordon and Bruce Huber

7.5.1 INTRODUCTION

The residence or flushing time of Jamaica Bay has increased due to dredging. The commonly quoted value (see, for example, West-Valle et al., 1992) is that the resident time increased from 10 days to 35 days as dredging increased the mean depth of Jamaica Bay from 3 feet to 16 feet. All literature references of this fact go back to the National Academy of Science and National Academy of Engineers Report of the Jamaica Bay Environmental Study Group, vol. II (1971). Here the 35 day residence time is simply stated with no supporting reference or indication how the number was derived.

To confirm or revise this residence time the dispersion of a purposeful tracer was studied. To make the experiment tractable Grassy Bay was chosen as the study site.

Two injections of fluorescein dye into Grassy Bay were conducted in the summer of 2000. On June 7 19 kg of dye was injected at 5.5 m depth and on September 11 54 kg of dye was injected at 10 m depth. There were surveys of the dye distribution for the subsequent 2 days in June and 4 days in September. The dye surveys were carried out in conjunction with CTD surveys throughout Jamaica Bay as described in the section on temperature, salinity and currents in Jamaica Bay.

7.5.2 METHODS

The fluorescent dye, fluorescein, was injected by pumping an approximately 30 % solution mixed with isopropanol to achieve in situ density through a garden hose to the required depth; either the bottom or 5 m below the surface. The dye is then detected in situ using a Chelsea Ltd. Aquatracka III fluorometer attached to a Sea-Bird Electronics SBE19 CTD. The fluorometer could detect the dye down to concentrations of 1 part per 10^{11} by weight. Through a series of rapidly-taken, closely-spaced stations we were able to map the dye distribution throughout Grassy Bay and the adjacent channels.

7.5.3 RESULTS

The flushing rate is given as an e-folding time of an exponential decay. For tidal exchange it is given by

$$T_f = 1/(1-b) VT/P$$

Where V is the volume, P the tidal displacement, T the tidal period, and b the fraction of the water from the ebb flow that returns into the bay on the subsequent flood.

For Grassy Bay $V = 28 \times 10^6 \text{ m}^3$ and $P = 5.6 \times 10^6 \text{ m}^3$, for a 1.5 m tidal range, so $T_f \sim 3.5$ days for $b=0$. From the dye measurements we estimate that $b=1/2$ which yields $T_f = 7$ days. This is a lower bound assuming barotropic flow in a homogeneous basin. In fact Grassy Bay is weakly stratified with a pycnocline at approximately 5 m, a mean depth of 9.5 m, maximum depth 12.5 m and sill depths of 6 m into the North Channel and 8 m into Winhole Channel.

From the decay of the dye inventory in Grassy Bay we get e-folding times of 2 to 4 days. This could be an under estimate since adsorption of the dye on particles in the water column will reduce its fluorescence. However, subsequent lab tests show that adsorption on inorganic particles is approximately 10%. A test using Jamaica Bay water taken during a plankton bloom

showed little additional adsorption although it is difficult to recreate the Bay in situ conditions in the lab. It is unlikely that adsorption could decrease the observed time constant by more than 50%.

The dye experiments do show that dye injected at depth (10 m) has a greater residence time than the dye injected at mid-depth. Lateral diffusivity is approximately $10 \text{ m}^2/\text{s}$ and vertical diffusivity is approximately $3 \times 10^{-5} \text{ m}^2/\text{s}$ in the interior where the stratification has a Brunt-Väisälä period of 1-4 minutes.

There is evidence of shear during the ebb flow in Winhole channel near Grassy Bay. The outflow from Grassy Bay is predominantly in the upper half of the water column. The lower half is water with characteristics of the western Jamaica Bay. The vertical mixing of this water prior to the next flood effects water exchange with Grassy Bay and reduces the flushing time.

From the dye experiments we estimate a Grassy Bay bulk flushing time of approximately one week.

7.5.4 REFERENCES

National Academy of Science and National Academy of Engineers, 1971. Jamaica Bay and Kennedy Airport. Report of the Jamaica Bay Environmental Study Group, vol. II . Port Authority of New York and New Jersey. 149pp.

West-Valle, A.s, Decker, C.J., and Swanson, R. L., 1992. Use Impairments of Jamaica Bay. Special Report #99, Reference # 92-4, Marine Sciences Research Center, the University at Stony Brook, 187pp.

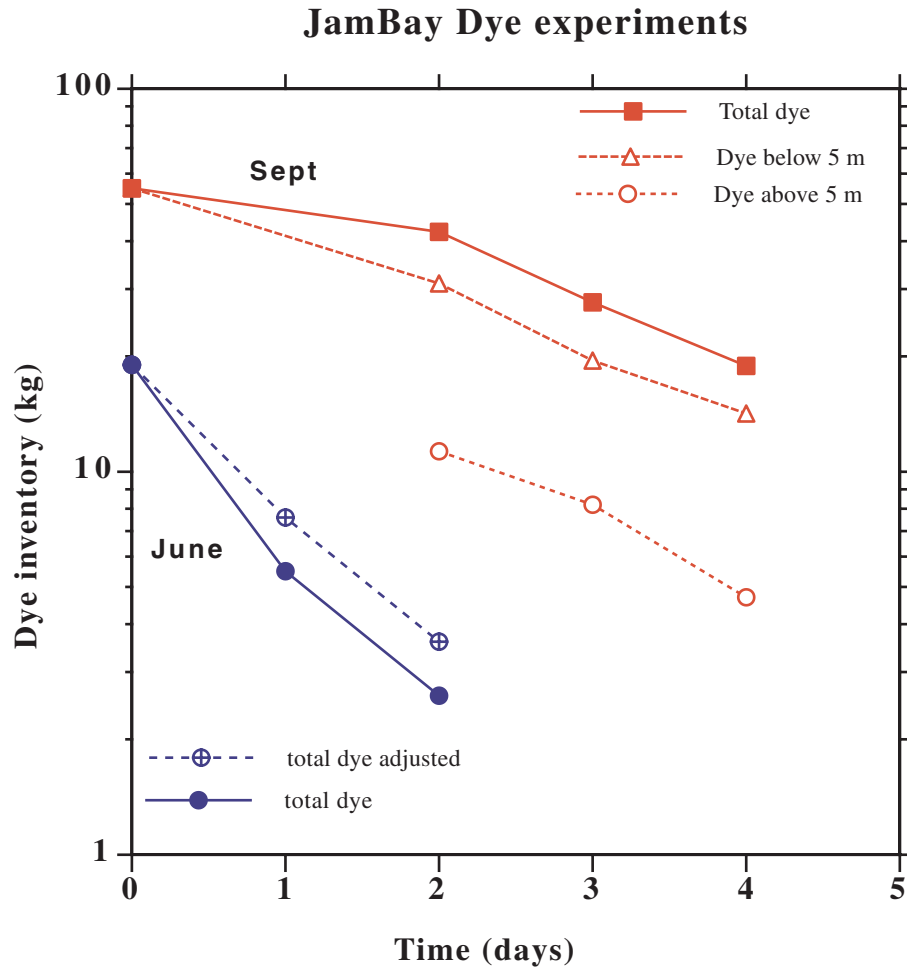


Figure 7.5-1. A log-linear plot of dye inventory for the 2 experiments. Exponential decay will be a straight line. The decay time in June, injection at mid depth, is approximately 2 days while for September, injection at bottom, is approximately 4 days. These are lower bounds since adsorption onto particles could reduce the dye fluorescence.