

ASSESSMENT OF SUPERFLUX

RELATIVE TO MARINE SCIENCE AND OCEANOGRAPHY

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It is clearly much too early in the stage of data analysis to attempt a real synthesis of results from Superflux with respect to oceanography and marine science. It is equally impractical to attempt a synthesis of such a diverse and complex program in a short time. That work will require a great deal of effort and will result in at least as much information as has already been presented during this symposium. What is clear is that there are certain threads of scientific commonality which run through all the presentations and indeed were a result of the design of the Superflux experiments.

It has been said that if one has no clear idea of testable hypotheses, no clear idea of how the data will be used to test those hypotheses, and no idea of how the data will look, then one has no business collecting the data to begin with. While Superflux may have been somewhat guilty of this, the experiments produced meaningful and useful data which would not have been gathered otherwise. Most importantly, showing that the data could be collected, and with meaningful results, is in support of the hypothesis that interactive ship, aircraft, and satellite measurements form a mutually exclusive and complementary data set, and further that this data set is required to properly investigate highly dynamic coastal systems.

In some respects Superflux did not produce as complete a data set as would be required to attempt a flux-type calculation, but this was not an expected accomplishment for the first year of a study. We understand much more clearly now the small-scale variances in Bay and plume properties which need to be addressed to properly perform the rather herculean task of quantifying the flux of materials, pollutants, salt, water, carbon, nitrogen, etc., across the transect from Cape Charles to Cape Henry. This information is also essential to understand the dynamics of how coastal waters mix with the waters of the Bay and how the plume affects the environment and resources on the adjacent continental shelf.

The concept of space and time domains is important here. Referring to figure 1 of Campbell et al. (ref. 1), recall that synoptic aircraft measurements sampled a space-time domain unapproachable by ship platforms. Ships cannot cover enough distance in a given time to assess the coherence of conservative (passive) and non-conservative (growth- and time-dependent) properties over regions as large as the Bay and plume. Shipboard measurements can show this coherence where some relatively slowly varying biological entities such as phytoplankton behave as passive contaminants, but only over short times and distances. References 2 and 3 contain several good examples.

This coherence is readily apparent on much larger scales of time and space, such as in the satellite imagery presented in references 4 and 5. These images again demonstrate the existence of a plume, because the data were collected synoptically. However, spatial resolution and time delays inherent in satellite imagery do not lend themselves to aiding real-time experiments by ships, which are required to perform the complicated and lengthy physical, biological, and physiological measurements to determine how organisms are interacting with their environment.

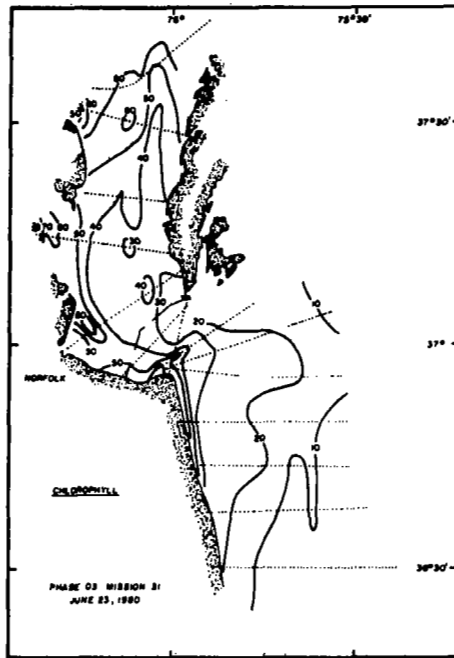
Superflux addressed the middle range of the space and time domain. The excellent shipboard data sets show that the concept of a plume, really the coherence of conservative and nonconservative properties, is not apparent in the data. For some properties, however, this coherence is readily apparent in the aircraft data sets. Figure 1 compares the microwave salinity and the chlorophyll mappings of Kendall (ref. 6) and Hoge (ref. 7), respectively. Further analysis of the data sets (cross-correlations, etc.) will serve to substantiate the existence of such a coherence. The major impact of Superflux was the demonstration, for the first time, of the ability to collect such data sets at subtidal frequencies. This shows that many properties can be treated as passive contaminants within plumes if synopticity is maintained.

The importance of vertical mixing due to tidal energy in the plume area and how it affects the distribution of properties is a topic which has not received much attention in this symposium. Two facts can be pointed out which may be relevant as the data are analyzed further. First, the dates of the Superflux studies were biased toward spring tidal cycles, or periods of relatively high tidal energy dissipation and tidal mixing (fig. 2). Secondly, the bathymetry of the adjacent shelf is such that, for reasonable tidal velocities, the water column should be well mixed during spring tides for a considerable distance offshore. The shelf break occurs approximately at the 50-m isobath (fig. 3). The ratio of water column depth to the cube of the tidal velocity amplitude is within the range which indicates marginal stratification for much of the shelf. Thirdly, 1980 was a year of unusually low runoff, and added buoyancy in the form of fresh water was at a ten-year low for the plume region. It is interesting to match a conceptual diagram of water column density and other properties based upon these facts (fig. 3) with cross-shelf distributions (ref. 2). In particular, attention should be drawn to the band of cooler, clearer water seaward of the plume which was observed in several of the remote sensing images and transects. This may result from tidal mixing of the water column at this point, and is a hypothesis to be tested in the future.

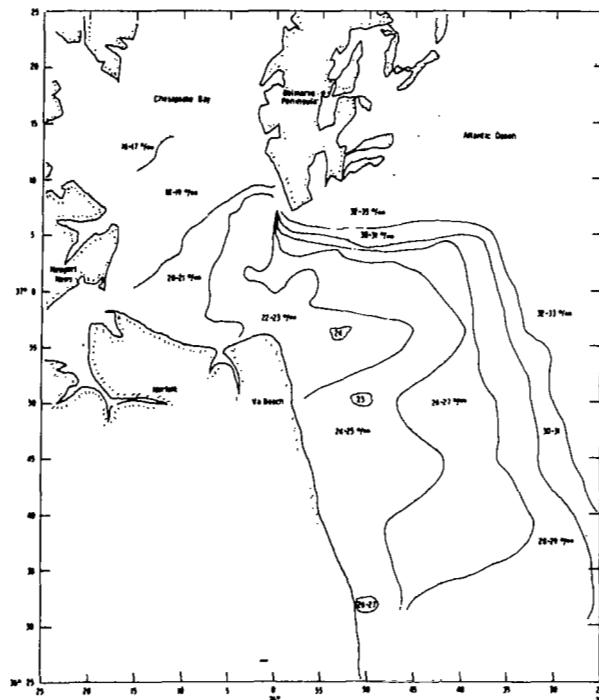
In summary, the Superflux program clearly demonstrated the effectiveness of state-of-the-art technology required to study highly dynamic estuarine plumes, and the necessity of a broadly interdisciplinary, interactive remote sensing and shipboard program required to significantly advance our understanding of transport processes and impacts of estuarine outflows. The scientific accomplishments which have been presented here, and those which will come from additional detailed analysis, support the conceptual and programmatic accomplishments in the areas of experiment design and planning, and have paved the way for future studies in these and similar areas.

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(a) Relative chlorophyll a (from ref. 6).



(b) Salinity (from ref. 7).

Figure 1.- Simultaneous measurements of relative chlorophyll a fluorescence and salinity on June 23, 1980.

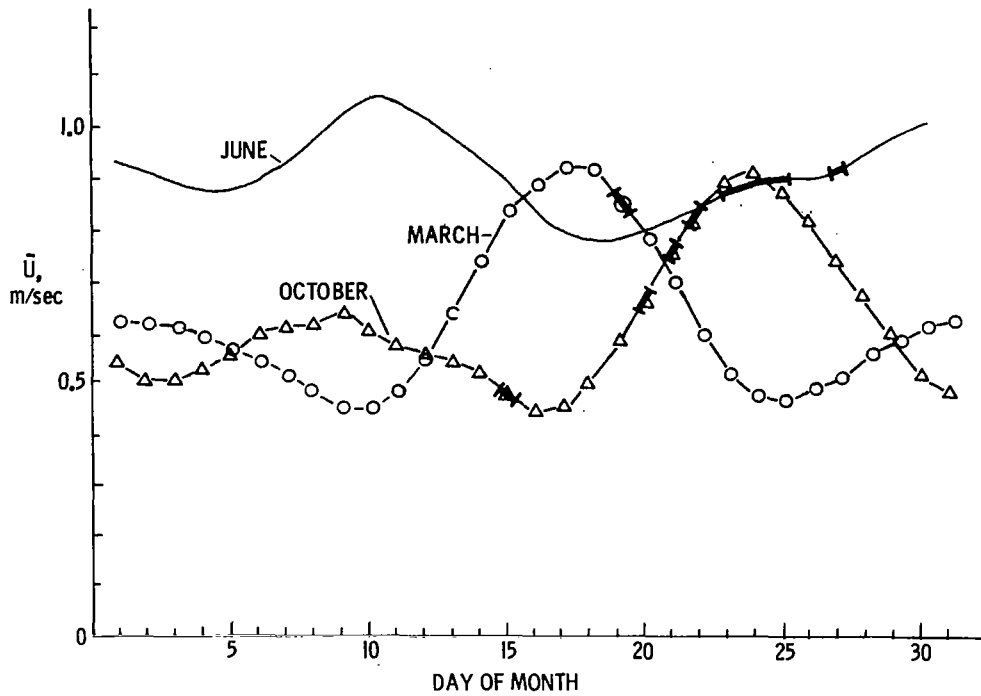


Figure 2.- Daily averages of tidal current maxima at Chesapeake Bay entrance for months of Superflux experiments. Portions of lines inked heavily are dates of specific NASA overflights, illustrating the bias toward periods of strong tidal flow (data from ref. 8).

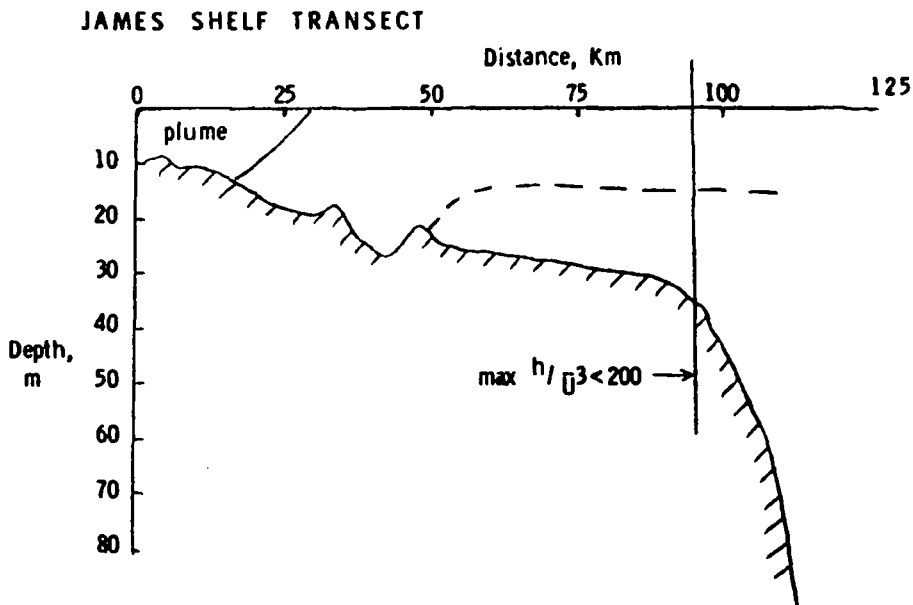


Figure 3.- Profile of depth along the James/shelf transect.