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TIDAL JET FRONTOGENESIS

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SUMMARY Tidal jets and their associated frontal structures in shallow coastal systems are of interest in their own right, but also as they provide a critical test case for numerical tidal circulation models. Tidal jets are formed on the ocean side of an estuary entrance whenever the estuary has a large surface area and the tidal range is sufficient to induce large velocities at the entrance. In such cases the ebb tide induces a flow of water out of the entrance leading to a separated buoyant jet, imparting momentum and buoyancy to the surrounding coastal waters. By contrast, on the rising tide the streamlines show a general convergence towards the mouth with the ocean water flowing back into the estuary entrance in a near radial fashion.

Detailed measurements of the flow adjacent to The Cut in Koombana Bay, Western Australia, have just been completed. Data was taken both in winter (large buoyancy flux) and in summer (small buoyancy flux). The variables measured included the direct meteorological forcing, the tidal elevation on both sides of the entrance, in situ currents, detailed fine scale temperature, conductivity and pH fields during two ten-day field exercises, drogue tracking of the flow path lines in the outflowing jet and the convergent inflow and some microstructure casts in the frontal regions.

The data was analysed at three levels. First, the mean flow field was extracted and its dependence on the entrance flow internal Froude number has been determined. For Froude numbers less than about 2, the tidal jet was observed to lift off the ocean floor and spread both in the forward and lateral direction. For Froude numbers greater than about 2 lift-off was retarded and the jet became progressively more elongated in the direction of the jet axis, with bottom friction becoming increasingly more important. However, separation at the entrance was at no time completely suppressed and the vertical vorticity generated throughout the estuary entrance contained the well defined jet to a distance of nearly 1500 m. By contrast the flood tidal flow was governed by a simple balance of bottom friction and the pressure gradient set up by the water surface slope leading to streamlines which were perpendicular to the depth contours.

The second level of analysis involved the determination of global mixing characteristics associated with the outflowing jet. Tracking the water mass periodically introduced at the estuary entrance on the start of each ebb tide, as it moved across the coastal water in Koombana Bay, made it possible to obtain a measure of the bulk dilution. The dilution rates were shown to be a strong function of the entrance Froude number and the depth of the mixed layer penetration. Data will also be presented showing the dependence of the propagation speed on this dilution rate.

The third level of analysis involved a detailed examination of the frontal structure associated with the tidal jets. Estimates of the turbulent kinetic energy dissipation throughout the front were obtained both from the fine scale profiles via the displacement scale method and from the temperature microstructure measurements using the spectral fitting technique. The values in the receiving water were typically 10^{-8} m^2s^{-3} rising to 10^{-6} m^2s^{-3} in the overflowing jet. In the cases where the receiving water was strongly stratified from a previous overflow, strong internal wave activity was observed in front of the propagating front.

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