TIME-VARYING WAVE EFFECTS ON FLOWS AND DYNAMICS AT AN UNSTRATIFIED INLET

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INTRODUCTION
Surface gravity waves alter discharge and circulation near and within coastal inlets, affecting the exchange and transport of water masses, nutrients, sediments, and pollutants between inland waters and the ocean. Field observations and numerical simulations suggest that, during storms, wave forcing (radiation-stress gradients) owing to wave dissipation across the ebb shoal can enhance fluxes into the inlet (Bertin et al. 2009; Wargula et al. 2014). As a result, water levels may increase inside the bay (Olabarrieta et al. 2011; Dodet et al. 2013), creating an offshore-directed pressure gradient that may balance onshore fluxes during energetic waves, and may enhance offshore fluxes after the waves decrease. Spatial and tidal variability in water depths on the ebb shoal lead to complex wave breaking patterns that drive spatially and tidally asymmetric flows. Here, field observations and numerical simulations are used to evaluate the effects of waves on discharge and circulation, and the relative importance of wave radiation-stress and pressure gradients at an unstratified inlet during and following energetic waves.

SITE LOCATION
New River Inlet, NC (Fig. 1) is 1 km wide at the mouth, with a 1- to 2-m deep, 800-m-radius, semi-circular ebb shoal. On the southwestern side of the inlet, a "deep channel" (5 m depth inside the mouth) extends across the ebb shoal. New River extends about 25 km upstream from the inlet, and the backbay has an area of about 68 km^2. About 3 km upstream from the mouth, the inlet intersects the Intracoastal Waterway, which connects to other inlets.

OBSERVATIONS
Water depths, waves, and currents were observed nearly continuously during May 2012. Cross-shore tidal currents in the deep channel on the ebb shoal ranged from -1.4 to 0.5 m/s (positive is flood), and offshore significant wave heights ranged from 0.5 to 2.5 m. Boat-mounted current profile transects across the inlet mouth during two tidal cycles are used to validate discharge estimates using point measurements from *in situ* sensors. Discharge estimates offshore of the inlet mouth (Fig. 1, white dashed curve) ranged from -1100 to 1000 m/s^3. Momentum balances were estimated in the deep channel across the ebb shoal using sensors O, M, and I (Fig. 1).

NUMERICAL MODEL
NearCoM-TVD, a quasi-3D model that couples the spectral wave model SWAN with the nearshore circulation model SHORECIRC, reproduces water levels, waves, and currents observed at New River Inlet reasonably well (Chen et al. 2015). Momentum balance terms also are resolved reasonably well. To examine the effects of waves on the flows, discharge, and dynamics, simulations were conducted with offshore boundary conditions consisting of i) no waves, ii) observed ("moderate") waves that ranged from 0 to 2.5 m over 30 days, and iii) 4-m high ("energetic") waves (the maximum observed offshore significant wave height at New River between 2012 and 2014).

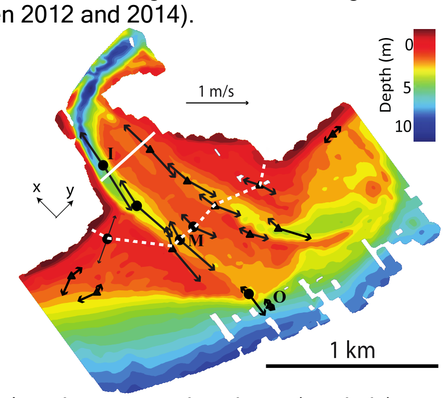

Figure 1 - Instrument locations (symbols) and phase-averaged flood and ebb velocities (arrows) superposed on bathymetry (color contours) of New River Inlet. The solid white line indicates the boat-mounted transect. The dashed white curve and the intersected instrument locations indicate the semi-circular region used for estimates of discharge on the shoal. Cross- and alongshore directions are indicated with the black arrows labeled x and y.

DISCUSSION
Observed and modeled momentum balances in the deep channel on the ebb shoal suggest that wave forcing is small relative to the pressure gradient, except on flood during storms. Comparisons of simulations using observed moderate (1 to 2.5 m) waves on the offshore boundary with simulations without waves suggest that although waves are small on the ebb shoal during ebb, radiation stresses reduce the pressure gradient (less forcing out of the inlet) and volume transport out of the inlet is decreased 2%, suggesting the importance of nonlocal wave-driven processes. On flood, the net forcing (pressure-gradient plus wave forcing) into the inlet also is decreased (less forcing into the inlet) and volume transport into the inlet is increased 5 to 13%, suggesting horizontal variability in the flow response on the ebb shoal. Tidal asymmetry in wave-induced discharge may be owing to the timing of the storms (and the wave-induced setup), as well as to flood-ebb differences in the response of water levels and flows to the waves. The effects of storm timing and of energetic (4-m high) waves on the discharge and circulation outside the inlet mouth will be discussed.

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