Effects of Cape-Related Shoals on the Variability of Long Gravity Waves (OS23A-1989)


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Inner-shell and shoreline morphology exert control on the variability of long gravity waves (LGWs, also called infragravity waves typically from 20 to 500 s, or 2 to 50 mHz) [1, 2]. In turn, nearshore morphodynamics can be decisively influenced by infragravity motions [3], which are not well understood over cape-related shoals. In order to study the effects of shoals on LGW variability, water level and velocity data were collected during Fall 2013, Spring 2014 and Fall 2014 at outer and inner swales of Shoal E offshore Cape Canaveral, Florida [4]. Landward- (F⁺) and seaward-oriented (F⁻) cross-shoal infragravity energy fluxes were calculated from the auto- and coincident spectra of pressure and cross-shoal velocities. Bulk infragravity reflection coefficients (R⁺) were then quantified as the ratio of seaward- to landward-oriented bulk LGW energy fluxes [5, 6]. In general, R⁺ values were proportional to the Ursell parameter and ranged from 0.3 to 3. Spatial variations in LGW fluxes suggest meanders were located in the shoaling zone during Fall 2013 [6]. Larger R⁺ values at the outer swale (95% of confidence) and flux differences between inner and outer swales suggest Shoal E acted as a source (sink) in the F⁻ (F⁺). Differences between swales could be attributed to dissipation, trapping (as edge waves), focusing over the shoal, and partial reflection [8, 10]. However, by assuming cross-shoal motions we did not resolve along-shoal propagating motions (edge waves) that might be present at the shoal [9]. Our results provide preliminary evidence regarding the effects of cape-related bathymetry on the variability of LGWs. LGW dissipation and reflection by cape-related shoals may provide a positive feedback for the long-term maintenance of cuspate forelands by preventing the totality of the wave energy from reaching the shoreline [10, 11].

Fig. 1. Location of acoustic Doppler current profilers (ADCPs) at the shoals of Cape Canaveral. Black rectangles in A and B highlight the location of Florida in North America and Cape Canaveral in Florida Peninsula, respectively. The map in C shows the bathymetry off Cape Canaveral with an inset highlighting Shoal E. Magenta filled circles represent the approximate ADCP locations at the outer and inner swales of Shoal E (water depths ~3 m). The brown line corresponds to an approximate bottom profile across Southeast shoal (D).

Fig. 2. (A – F) Colormaps of spectral densities show unsteadiness in variance at the long gravity (infragravity) band below 50 mHz. Each spectrum was calculated from detrended, Hanning-windowed, and attenuation-corrected pressure values measured during 3-hour intervals [3]. Red, green, and blue lines correspond to significant wave heights for the short band, HSGW, and the long gravity (infragravity) band (Hlgw). Examples of LGW variability include Shoal E (A – F) and Cape Canaveral (G – I). Experiments were conducted at inner and outer swales of Shoal E during Fall 2013 and Spring 2014 (C and D), and Fall 2014 (E and F). Top panels correspond to inner swale, bottom panels to outer swale.

Fig. 3. (A) Reflection coefficients, R⁺ [6] versus Ursell parameters, U⁺ [5] sorted by peak periods, T⁺. In this shoaling zone where waves were higher and longer, R⁺ larger than 1 corresponded to peak directions between 180° and 360° (B). Long gravity significant wave heights, Hlgw were proportional to U⁺ and ranged from 2 to 20 cm.

Fig. 4. (A – F) The comparison of seaward- (F⁺) and landward-oriented (F⁻) cross-shoal LGW energy fluxes between inner (orange and turquoise lines) and outer (red and blue lines) swales suggest loss (gain) of seaward (landward) oriented flux. Instruments registered a variable shoaling zone width. Panels A, C, and E correspond to F⁺, whilst B, D, and F show F⁻. During Fall 2013 (A and B) both fluxes decreased offshore and suggested Shoal E was in the shoaling zone. During Spring 2014 both fluxes had similar values at the two swales, which suggests the transition from deep to shoaling zones [6]. During Fall 2014, both fluxes decreased onshore possibly due to dissipation and trapping. (G and H) Fluxes for the sub-band between 8 and 50 mHz (red and blue) increased with Hlgw(max) and J Ratio of outer to inner fluxes versus Hlgw support suggested regimes: increasing (Fall 2013), constant (Spring 2014), and decreasing (Fall 2014).

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