Integrating Oyster Castles into Living Shorelines to promote coastal bays resilience to Sea Level Rise

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Abstract

Living shorelines are native marsh plantings that control coastal erosion and provide coastal resilience to sea level rise (SLR) by migrating upland during SLR. Living shorelines require ripraps to dissipate wave energy which prevent marsh boundary erosion and facilitate sedimentation. Currently, ripraps are built with rocks which cannot adapt to SLR to continue attenuating wave energy. Alternatively, oyster castles are modular cinder blocks for building breakwaters and coastal structures that initiate the development of oyster reefs which can grow equivalently with SLR. Thus, oyster castle breakwaters can adapt to SLR while retaining their breakwater function. This research used Delft3D and SWAN to model the effects of climate changes, especially SLR, on coastal morphology with 3 domain configurations: 1) only marsh, 2) traditional living shoreline with riprap and 3) living shoreline with oyster castle. We built a model comparing marsh deposition between these coastal structures over time, and determined the most important parameters affecting living shoreline evolution. All domains were 2 km wide by 1 km in length to mimic coastal bay conditions. Model runs were set up for a temporal scale of 150 days. This duration was increased by a morphological factor of 150 to project our results to 30 and 60 years. The parameters tested included vegetation density, nearshore slope, SLR, and suspended sediment concentration (SSC). Oyster castles facilitated greater marsh deposition than riprap at +8.9 mm under current sea level, +3.5 mm with SLR of 0.4 m, and +3.3 mm with SLR of 0.8 m. Increased nearshore slope and higher SSC both increased sediment deposition in the marsh. Increased sea level and higher marsh density decreased maximum bed shear stress. Therefore, coastal restoration efforts should strive to integrate oyster castle into living shorelines, and increase marsh density to enhance sediment deposition and coastal resilience. Our modelling efforts focus on quantifying the impacts of coastal processes on created marsh dynamics.

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Abstract Text:

Living shorelines are native marsh plantings that control coastal erosion and provide coastal resilience to sea level rise (SLR) by migrating upland during SLR. Living shorelines require ripraps to dissipate wave energy which prevent marsh boundary erosion and facilitate sedimentation. Currently, ripraps are built with rocks which cannot adapt to SLR to continue attenuating wave energy. Alternatively, oyster castles are modular cinder blocks for building breakwaters and coastal structures that initiate the development of oyster reefs which can grow equivalently with SLR. Thus, oyster castle breakwaters can adapt to SLR while retaining their breakwater function. This research used Delft3D and SWAN to model the effects of climate changes, especially SLR, on coastal morphology with 3 domain configurations: 1) only marsh, 2) traditional living shoreline with riprap and 3) living shoreline with oyster castle. We built a model comparing marsh deposition between these coastal structures over time, and determined the most important parameters affecting living shoreline evolution. All domains were 2 km wide by 1 km in length to mimic coastal bay conditions. Model runs were set up for a temporal scale of 150 days. This duration was increased by a morphological factor of 150 to project our results to 30 and 60 years. The parameters tested included vegetation density, nearshore slope, SLR, and suspended sediment concentration (SSC). Oyster castles facilitated greater marsh deposition than riprap at +8.9 mm under current sea level, +3.5 mm with SLR of 0.4 m, and +3.3 mm with SLR of 0.8 m. Increased nearshore slope and higher SSC both increased sediment deposition in the marsh. Increased sea level and higher marsh density decreased maximum bed shear stress. Therefore, coastal restoration efforts should strive to integrate oyster castle into living shorelines, and increase marsh density to enhance sediment deposition and coastal resilience. Our modelling efforts focus on quantifying the impacts of coastal processes on created marsh dynamics.

Plain-Language Summary:

This research used Delft3D and SWAN to model the effects of climate changes, especially SLR, on coastal morphology with 3 domain configurations: 1) only marsh, 2) traditional living shoreline with riprap and 3) living shoreline with oyster castle. We built a model comparing marsh deposition between these coastal structures over time, and determined the most important parameters affecting living shoreline evolution. Model runs were set up for a temporal scale of 150 days. This duration was increased by a morphological factor of 150 to project our results to 30 and 60 years. The parameters tested included vegetation density, nearshore slope, SLR, and suspended sediment concentration (SSC). Oyster castles facilitated greater marsh deposition than riprap at +8.9 mm under current sea level, +3.5 mm with SLR of 0.4 m, and +3.3 mm with SLR of 0.8 m. Increased nearshore slope and higher SSC both increased sediment deposition in the marsh.

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