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# Analysis of the Transport of Instrumented Surrogate Munitions Deployed in the Swash Zone of a Large-Scale Wave Flume

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The presence of munitions, also known as unexploded ordnance (UXO), on the seafloor, due to past military activity, is a worldwide concern. In the US, more than 400 sites potentially containing munitions have been identified by the Army Corps of Engineers (SERDP, 2010). Thus, those sites are potentially at risk, since munitions may be transported through active migration and/or exhumation, depending on the munition characteristics, the forcing and the bed morphology/sediment conditions. Knowledge of the physics responsible of the mobility of munitions in the nearshore environment is needed for safety reasons. More attention has been posed on studies of munition transport in deeper water, while observations in the proximity of the beach are scarce.
The present study is focused on observations of surrogate munitions in the swash zone. The swash zone is the region of the beach alternately covered by wave runup where hydrodynamic processes may be intense. Four instrumented surrogates (BLU-61 Cluster Bomb, 81 mm Mortar, M151-70 Hydra Rocket and M107 155 mm High Explosive Howitzer) were designed and deployed during a large-scale laboratory. Errors between real munitions and surrogate parameters (mass, center of gravity and axial moment of inertia) are all within an absolute error of 20%. Internal munitions sensors consist of inertial motion units (for acceleration and angular velocity in and around the three directions and orientation), pressure transducers (for water depth above surrogate), shock recorders (for high frequency acceleration to detect wave impact on the surrogate), and an in-house designed array of optical sensors (for burial/exposure and rolling).
During the study, simultaneous measurements of the hydrodynamic conditions, bed morphology changes and munitions mobility have been collected under different forcing conditions. In situ sensors that measure hydrodynamics, bed morphology and sediment concentrations, were deployed in the swash zone, aligned with the surrogate deployment. Munition mobility was detected through GPS measurements of surrogate positions, imagery from cameras overlooking the study sites and munition sensors.
Relationships between burial/migration and incoming forcing conditions, munitions characteristics (such as specific gravity, length/diameter) and runup will be shown. Forces acting on the surrogate munitions during a swash event have been estimated through the hydrodynamic measurements and munition sensors responses for different munitions and different conditions. A comparison of different cases of munitions force balance evaluation will be discussed.