Title	Offshore Analysis of Seafloor Instability and Sediments (OASIS Partnership) With Applications to Offshore Safety and Marine Archaeology
Administered by	GOM OCS Region
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Conducting Organization(s)	TBD
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Final Report Due	TBD
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PICOC Summary	
Problem	Gravity flows (GF) (or currents) in the Mississippi River Delta Front (MRDF) are known to displace large volumes of sediment mixed with seawater. These high-energy events have damaged infrastructure, causing multiple oil spills including the second largest oil spill in U.S. history. GF additionally have displaced shipwrecks hundreds of meters over short time periods, potentially impacting these wrecks and further endangering nearby oil and gas infrastructure. There is currently a limited understanding of the triggering mechanisms for GF, the dynamic processes at work once they are underway, as well as their frequency, power, and scale.
Intervention	Use new and existing data sets to characterize sediments and physical oceanographic processes at selected locations in the MRDF, including known shipwreck locations; conduct baseline archaeological analysis at these sites; and test if *in situ* acoustic sensors could monitor potential future shipwreck displacement due to GF activity.
Comparison	Evaluate the spatial extent, frequency, and magnitude of previous GF events at these selected locations, relative to regional and site-specific analyses from previous studies within the MRDF.
Outcome	Identification of high, intermediate, and low-risk areas for future occurrence of GF. Identification of key locations to deploy monitoring equipment able to detect intermediate to large high-energy sediment transport events. Obtain a better understanding of

	factors and processes that initiate these events in the MRDF and test new and/or existing technologies to detect and monitor GF events.
Context	Central GOM; MRDF offshore Louisiana

BOEM Information Need(s): This study proposes a multi-disciplinary investigation of selected known and potential shipwreck sites within the Mississippi River Delta Front (MRDF) as markers to identify previous and predict future impacts from Gravity Flows (GF; also called density flows or gravity currents), and to examine the localized environmental factors influencing the magnitude and frequency of these events. A better understanding of GF occurrences and their impacts is needed to inform BOEM's National Historic Preservation Act (NHPA) and National Environmental Policy Act (NEPA) analyses of the affected environment and potentially significant historic properties on the OCS; to develop appropriate mitigation strategies for industry avoidance of shipwrecks and benthic habitats in the MRDF; and to inform leasing and permitting decisions regarding exploration and development activities in the MRDF. Specifically, the information needed includes: a) the type, size, distribution, and depth of sediments; b) the probability of GF event occurrence in the study area in the short-term (i.e., sub-decadal) and identification of low- to high-risk areas; c) documentation and monitoring of known shipwreck locations and conditions; d) the impacts of gravity flows on benthic communities; and e) an evaluation of the applicability of new or existing technologies to detect high-energy sediment transport events in the study areas remotely, more accurately, and in near-real time.

Background: Gravity Flows are driven by gravitational forces, involve a combination of water and sediments or rocks, and require a sloping bottom to develop momentum. Scientists classify GFs into several sub-types depending on their density, among other properties, e.g., debris flows, hyperpycnal flows, grain flows, fluidal flows, and turbidity flows, among others. The OASIS study will consider any high-energy sediment transport as GFs in general.

The MRDF is a highly dynamic environment where oceanic, atmospheric, and fluvial drivers interact. These interactions include sediment deposition, seafloor instability, annual storms and hurricanes, and occasional high-energy sediment transport processes. In 2004, the Taylor Energy platform in MC20 was toppled by gravity flows a few days after the passage of Hurricane Ivan. This led to the longest and second largest oil spill in U.S. history. Annually, GFs are the cause of about 5 percent of all broken/damaged pipelines in the Gulf of Mexico. In addition to being actively leased for oil and gas development, the MRDF also contains dozens of known shipwrecks of potential historical significance and benthic habitats. Industry surveys and recent BOEM collaborative research yielded evidence that shipwrecks are being displaced as much as hundreds of meters by GF events of unknown frequency and scale (Chaytor et al. 2019). As part of its responsibilities under the NHPA, BOEM requires avoidance of historic shipwrecks during permitted activities; however, there is often a delay of years or decades between when industry surveys locate these sites and when permitted activities take place. During this interval, sediment transport processes have displaced shipwrecks in the MRDF beyond the boundaries of the initial avoidance requirement, placing both the archaeological sites and industry infrastructure at risk.

Since the late 1970s, BOEM and industry have sponsored numerous studies that examined sediment transport in the MRDF and identified areas of instabilities and GF activity that pose a considerable risk to oil- and gas-related infrastructure (Coleman et al. 1980, Nodine et al. 2007, Bentley et al. 2018). Using coupled ocean-wave-sediment models, Arango et al. (2016) identified a time lag of a few days between maximum atmospheric forcing and maximum offshore sediment transport, consistent with observed time lag between the passage of Hurricane Ivan in 2004 and the toppling of the Taylor Energy platform (MC20) by GFs. Many of these studies have identified impacts to oil and gas infrastructure following hurricanes or major storm events; however, more recent studies suggest that GFs may be occurring during annual or shorter timescales (Obelcz et al. 2017, Galloway 2017).

Industry surveys of lease blocks within the MRDF to date have resulted in avoidance mitigations applied to 11 suspected shipwrecks and another 10 sonar targets indicative of potential shipwrecks. Repeat surveys have identified significant seafloor displacement of at least three of these shipwrecks, including a known World War II casualty (S.S. *Virginia*) and another suspected World War II wreck (S.S. *Rawleigh Warner*). Only *Virginia*'s current location is accurately known, and GFs have moved it more than 500 m since it was discovered in 2003, well outside of its original avoidance area. The movement of shipwrecks during GF could pose a hazard to nearby pipelines or other oil and gas infrastructure and introduce adverse impacts to the shipwrecks that invalidate previous NEPA and NHPA analyses, potentially triggering renewed agency consultations. Furthermore, because these shipwrecks provide temporally well-constrained markers of short- and long-term GF dynamics, they are invaluable seafloor features for evaluating the geologic conditions actively driving GFs.

BOEM is currently leading an interagency working group (OASIS) of Federal agencies with scientific research and/or resource management interests related to GFs in the MRDF. The OASIS group currently includes BOEM, BSEE, USGS, NOAA, Naval Research Laboratory, Naval Oceanographic Office, and National Geospatial-Intelligence Agency. BOEM anticipates that there will be multiple partnership opportunities to collaboratively achieve the objectives of this study.

Objectives: In addition to other objectives from OASIS partners, BOEM's are:

- Identify areas of past high-energy sediment transport, i.e., GFs;
- Identify areas of low to high risk for the near-future occurrence of GFs;
- Quantify the volume, frequency, energy, and speed of past events;
- Identify hazard potential/risk for shipwrecks, offshore infrastructure (including pipelines) based on their location, type, and occurrence and probability;
- Provide quantitative and qualitative characterizations of benthic communities affected by these events, e.g., before-and-after descriptions; and
- Track the long-term movement of known shipwrecks and evaluate their physical condition while characterizing chemical and biological states over time.

Methods: Analyze existing and to-be collected observational data including a) sediment type, size, depth; b) time-series bathymetry; and c) acoustic recordings, as well as modeling results aimed to enhance our understanding of triggering mechanisms and GF evolution processes. Use machine-learning tools to identify historical events and patterns among other applications. In addition, select known and potential shipwreck sites for additional investigation from current data; collect new geotechnical and geophysical data at selected study locations, including sediment cores, ultra-high resolution multibeam bathymetry (<2 m resolution), side-scan sonar, and CHIRP seismic profiles; conduct ROV investigations of confirmed wrecks and their surrounding seabed to inform archaeological analysis and seabed characterization.

Specific Research Question(s): 1) What are the site-specific geological and environmental conditions at areas on the MRDF known to have been impacted by GF? 2) What are the areas with high, moderate, and low probability of GF occurrence? 3) What is the frequency, power, location, and scale of past GF events? 4) How do GF events impact known archaeological sites, and is there a risk of associated impacts to infrastructure? 5) In what ways might archaeological sites be used to effectively track and study future GF events, and what locations should be monitored with which types of sensors? 6) How are benthic communities impacted by GF events?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: N/A

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