UNESCO SCIENTIFIC COLLOQUIUM ON FACTORS IMPACTING THE UNDERWATER CULTURAL HERITAGE
10th Anniversary of the Convention on the Protection of the Underwater Cultural Heritage

Royal Library of Belgium, Brussels, Belgium.
13th & 14th December, 2011.

The consideration of archaeological sites in oil and gas drilling operations

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Abstract: In the United States, Gulf of Mexico, oil and gas industry operators are required by the Bureau of Ocean Energy Management to provide archaeological assessments of potential resources in their project area as a condition of the permit application process. Permit approval may depend on the investigation, mitigation, or avoidance of a submerged archaeological resource. All reasonable types of submerged cultural resources must be addressed in the assessment, and in shallow waters includes both historic shipwrecks and late Pleistocene/early Holocene occupation areas. All areas available for lease by oil and gas operators require an archaeological assessment, including the ever-increasing depths of deepwater exploration. The area of impact, as defined in the permit approval process, includes any ground disturbing activity. During construction activities this may include a drilling site for well installation, pipeline trench, or anchor spread. Ancillary impacts may include drilling splay, or temporary ground installations such as mud mats or acoustic positioning beacons. This presentation will introduce common methods used in assessing the potential presence of submerged archaeological resources, as well as oil and gas industry activities that have the potential to impact or damage submerged cultural resources.

Introduction

The northwestern Gulf of Mexico has experienced over 500 years established nautical history, and the continental shelf, which was exposed as dry land during the last glacial maximum, was available for habitation by indigenous populations until nearly 6,000 years ago. Over the last 70 years, the northwestern Gulf has also been home to one of the most heavily developed oil and gas fields in the world. The United States federal government requires that oil and gas operators complete an archaeological survey and assessment of their project area prior to permit approval for ground disturbing activities on the outer continental shelf (for more on this topic see the preceding paper by Brian Jordan, BOEM, USA). The purpose of these surveys is to identify any and all potential archaeological resources that may be present in the survey area in order to avoid damaging or destroying these resources. The effective protection of archaeological resources depends upon an understanding of both the impact of the proposed activity and the area of potential effect.

The Gulf of Mexico region was home to the world's first offshore well and continues to be one of the densest and most productive continually-used oil and gas fields in the world. The MMS/BOEM has been at the forefront in terms of regulating submerged archaeological resources in this region making this area an excellent case study. Although the focus here is on the Gulf of Mexico region, the technological and archaeological issues are relevant world-wide.

<u>Oil and Gas Industry in the Gulf of Mexico</u>

Oil and gas operators first began drilling in the world's oceans in the 1890s, but the actual drilling platforms were connected to land, built on piers extending from the shore. In 1937, the world's first freestanding drilling structure was built in the Gulf of Mexico (GOM), located one and a half miles from shore in approximately 14 feet (4.3 meters) of water (National Commission 2011). In 1947, the first successful well was drilled out of sight of land. It was located approximately 10.5 miles (17 kilometers) offshore of Louisiana, in 20 feet (6 meters) of water in the Gulf of Mexico (National Commission 2011). Since then, over 5,500 platforms, and over 30,000 miles (48,280 kilometers) of pipelines have been installed in federal waters of the Gulf of Mexico alone (Cranswick 2000). Today, offshore development can be operationally distinguished by water depth, which ranges from shallow water (less than 656 feet/200 meters BSL), to deepwater (656 to 4,999 feet/200 to ~1,500 meters BSL), and ultra-deepwater (greater than 5,000 feet/1,500 meters BSL). Activity in the Gulf of Mexico prior to 2010 was high, with an average of 30 drilling rigs active every year from 2006 to 2008, each of which typically drilled multiple wells each year. In 1986 the first verified deepwater oil field was discovered (Nixon et al. 2009:10), and marked the beginning of an industry-wide shift away from shallow water reserves to more profitable deepwater fields. Although the vast majority of infrastructure in the Gulf of Mexico is located in shallow water, as of 2008, approximately 26% of all new Gulf of Mexico oil and gas industry leases were in shallow water, while 74% were in deep- and ultra-deepwater (Nixon et al. 2009:24).

In the United States, offshore oil and gas industry activities are regulated by the Bureau of Ocean Energy Management (BOEM). The need to protect submerged archaeological resources in the Gulf of Mexico from oil and gas development was first recognized by the Bureau of Land Management and later the Minerals Management Service (now BOEM). Archaeological lease stipulations were first issued to oil and gas operators in 1973 to protect submerged cultural resources from industry related damage. The following year geophysical survey guidelines and report specifications were issued. From the beginning, guidelines addressed both historic shipwrecks and submerged prehistoric sites on the continental shelf, requiring archaeological assessments in order for an operator to obtain approval to drill a well, or install a pipeline.

The current survey requirements in shallow water in the GOM require acquisition of sidescan sonar, magnetometer, subbottom profiler, and bathymetry data utilizing either a maximum of 50 or 300 meter line spacing. Deep water surveys require only sonar at 300 meter intervals using an acoustically tracked deep-tow array or Autonomous Underwater Vehicle (AUV). The limitations of the 50 and 300 meter survey line spacing intervals, particularly in regards to shallow water magnetics, are known and have been discussed by a number of MMS/BOEM funded studies (Garrison et al. 1989; Pearson et al. 2003; Enright et al. 2006). Alternative investigation techniques such as archaeologically directed diver or remotely operated vehicle (ROV) investigations may also be considered, but are generally atypical at this point in time. When potentially significant sonar targets, magnetic anomalies, or subbottom feature are identified, an avoidance zone is assigned to the resource and the operator is required to ensure that no ground disturbing activities take place within this exclusion zone. Failure to comply with this avoidance can result in operator-financed mitigation, and even civil penalties. Mitigation can include any number of measures, such as detailed diver or ROV site documentation and assessment of historical significance.

Offshore Drilling

Oil and gas wells are drilled offshore using depth-specific techniques and equipment that have variable levels of impact on the seabed below. Worldwide, seafloor mounted jackup rigs are the most common type of drilling rig utilized offshore, representing 42% of the world's offshore rig fleet (statistics derived from rigzone.com, as of November 2011). In the Gulf of Mexico, semi-submersible rigs are the next most common type of rig used, and account for the majority of deepwater and ultradeepwater drilling. Although the permitted area of impact associated with drilling activities on the continental shelf is typically fairly restricted, the overall disturbance associated with drilling can extend beyond the footprint of the rig.

In shallow water, drilling operations are typically conducted using seafloor mounted drill rigs, called jack-up rigs. These rigs are generally towed on site by support vessels. Upon arriving at the drilling location, the legs of the rig are lowered to the seafloor through the platform. Jack-ups typically have three (3) legs that support the rig, but the mat-supported rig also has a large A-shaped base that distributes the weight across the legs. In shallow water, both submerged prehistoric sites and historic shipwrecks may be impacted by drilling activities.

Due to the geomorphology of the Gulf of Mexico and the location of the maximum low sea-level stand, submerged prehistoric resources are not present beyond the shallow water areas of the continental shelf, therefore only historic shipwrecks are present in deepwater and ultra-deepwater lease areas. Wells in these water depths are typically drilled using either dynamically positioned semi-submersible drilling rigs, or moored semi-submersible drilling rigs. The difference between the two is that the moored drilling rigs are secured to the seafloor by anchors with mooring lines. A typical anchor spread utilizes eight anchors, except during hurricane season (June – November) when twelve anchors are required in the GOM. The typical anchor radius is 2.5 times the water depth, therefore in 5,000 feet (1,524 meters) of water, the anchors can extend 12,500 feet beyond the well site (3,811 meters). Dynamically positioned rigs, also known as DP rigs, use advanced thrusters to maintain their position in the water during drilling operations. Bottom impacts for DP rigs are therefore limited to the actual drilling site, transponder beacons set around the site for positioning, and associated drilling splay. The use of moored or anchored rigs causes greater bottom impacts due to the placement of anchors and associated structures, as well as the sweep of anchor chains or mooring lines.

In addition to the bottom disturbance caused by the rig, the act of drilling creates an impact beyond the well shaft; drill cuttings, drilling mud or fluid, and produced water may splay outwards from the well site during drilling operations (Boesch et al. 1987:22). Drill cuttings are fragments of earth produced during drilling and removed from the well hole via drilling fluid or "mud". Three (3) different types of drilling muds or fluids exist: water-based, petroleum-based, and synthetic-based. Drilling mud is defined as a "freshwater or seawater slurry of clay (or natural organic polymer), barium sulfate, lignosulfonate, lignite, and sodium hydroxide, plus several minor additives" (Boesch et al. 1987:23). Drill cuttings consist of crushed rock and sediment produced by the grinding action of the drill bit as it penetrates through the well shaft towards the target depth (Boesch et al. 1987:23). Drilling fluid or mud must be continually circulated through the well shaft in order to lubricate the drill bit, prevent the drill bit from overheating, and remove drilling solids from the well shaft (Neff et al. 1987:150). Operators will often try to recirculate drilling fluids on the rig deck in order to separate out the drill cuttings so that they can reuse the drilling fluid (Neff et al. 1987:150). The separated drill cuttings are disposed of over the side of the rig, and left to settle on the bottom, creating a secondary disposal pile in addition to the drilling splay at the well site (Neff et al. 1987:150).

Only water-based drilling fluid may be discharged in US coastal and offshore waters. According to Boesch et al. (1987:23), drilling of an exploratory (non-producing) well can generate "5,000 to 30,000 barrels of drilling fluid (containing 200 – 2,000 metric tons of solids)" and "from 1,000 to 2,000 metric tons of drill cuttings." Development wells, added to the site of a successful exploratory well, are often shallower, and have a smaller diameter than the exploratory well, thus producing less drilling fluid and cuttings. In water depths greater than 120 feet (37 meters), drill cuttings have been observed to extend outward from the well site to a radius of 82 feet (25 meters) in diameter (Neff et al. 2000:15). According to Neff et al. (2000:15), drill solids disposal piles located near platforms can be up to 26 meters high, however most are less than 10 meters in height.

It is possible that drilling splay or cuttings piles could accumulate at or over a previously unobserved archaeological resource in deepwater. Observations have shown that in shallower waters, however, drill cuttings typically do not collect on the seabed but instead dissipate due to the high energy effects of currents and waves (Zingula 1977:548; Neff et al. 2000:15). While numerous studies have been conducted analyzing the impact of cuttings on biologic communities (NRC 1983; Boesch and Rabalais 1987; Neff et al. 2000; and UKOOA 2005), no known studies have been conducted that examine their impact on shipwreck sites. Based on research conducted in the wake of the Exxon Valdez oil spill, contamination of radiocarbon samples was examined at ten (10) different oil-impacted sites. No adverse impacts to radiocarbon dating were identified (Reger et al. 1992). Without further study though, it is unknown to what degree, if any, petroleum-based drilling fluid or additives in water-based or synthetic-based fluids could contaminate a site and adversely impact sample testing or data recovery. Certainly burial under drilling splay would obscure an archaeological site and make documentation more difficult or time-consuming.

Although drilling is the primary goal of oil and gas operators, a well site is part of a much larger system and cannot be considered in isolation. This is an important point to recognize when drilling a well location in proximity to a potential archaeological resource. Although the avoidance zone assigned to the resource may be adequate to ensure that drilling activities do not impact the site, the site may be subjected to greater development if the exploratory well is successful. The proximity of the resource to the construction area can complicate construction plans, or result in inadvertent damage to the site. This issue can be alleviated by ensuring that future activities are taken into account when a well site is initially permitted.

Platform Installation

Installation of a permitted structure such as a platform or caisson often takes place at the site of a successfully drilled well location. During drilling and subsequent platform operation phases, activities at a well site may include drilling additional wells with a different rig footprint, the use of seafloor mounted lift boats for maintenance or repair work, and anchoring associated with dive boats or other support vessels. Materials are frequently discarded from the rig or platform or from other service support vessels, usually through accidental loss. In addition to ancillary activities associated with resource extraction, platforms and well caissons often become popular sites for fishermen and recreational divers who can also produce impacts to archaeological sites. Despite the wide range of potential impacts associated with drilling a well, the area of impact is generally relatively localized, focused on the immediate vicinity of the well site.

Pipeline Installation

If a well is successful, then product will need to be transported off-site for refinement and distribution. The installation and use of subsea pipelines is the most common method for moving oil and gas from wells to production facilities. Pipelines in the GOM are required to be buried to a depth of at least 0.9 meter (3 feet) below the seafloor in water depths under 61 meters (200 feet). Within shipping fairways, pipelines are required to be buried 3 meters (10 feet) below the seafloor and within anchorage areas, 4.9 meters (16 feet) to avoid incidental damage from anchoring (30 CFR 250.1003(a)(1)). The two (2) most common methods for pipeline installation are through the use of anchored lay-barges or dynamically positioned reel-ships. Although dynamically positioned pipeline installation can occur in water depths as shallow as 33 meters (100 feet), it is generally not used in less than 61 meters (200 feet) of water (Cranswick 2001). This installation method does not require anchoring, limiting the seabed disturbance to the actual footprint of the pipeline.

Anchored lay-barges are the most common pipeline installation method in shallow water. Operational procedures for anchored lay-barges restrict their use to areas less than 300 meters deep (1,000 feet) (Cranswick 2001), although the amount of anchor cable available on an individual vessel may restrict the operating depth to shallower water. Pipeline burial is accomplished during installation through the use of a jet-sled or plow. The lay-barge deploys the pipe from the surface via a device called a stinger and the jet-sled or plow digs a trench into the seabed in which the pipeline is laid. Jetting can cause substantial impacts to a shipwreck, but it should be noted that it is also in the installer's best interests to avoid impacting any wrecks, since the wreck could damage the highly specialized and expensive equipment or cause considerable construction delays.

In addition to the impacts caused by jetting and laying the pipeline, anchors and anchor chain used by the lay-barge during installation also can cause substantial bottom disturbing activities. A standard pipeline lay-barge extends anchors equal to a distance of five (5) times the water depth. An anchored barge typically requires between eight (8) and 12 anchors, each weighing between 30,000 to 50,000 tons (Cranswick 2001). The anchors are lifted onto anchor handling support tugs which are used to deploy the anchors along the route. Winches aboard the lay-barge are used to move the barge along the route by tightening up on the foreword anchors. Generally, after anchors are set, they would need to be repositioned every 610 meters (2,000 feet) along the pipeline route (Cranswick 2001). Ground disturbance is not limited to the actual anchor touch-down points. During barge movements slack is placed on the stern lines prior to pulling the vessel forward along the bow anchor lines, which may allow portions of the chain to rest or drag on the bottom. The large diameter wire rope used to handle these massive anchors can cause substantial damage to a shipwreck site.

Pipeline installation may be the most significant threat to shipwreck sites associated with oil and gas development. The anchors and anchor chains can cause severe damage to shipwrecks in shallow water depths, and deepwater pipelines have been laid through or in close proximity to shipwrecks (Jones 2004; Ford et al. 2008). These incidents have in turn resulted in changes to regulations to ensure that additional sites are not damaged in the same manner. If operators adhere to current regulations the risk to submerged resources caused by pipeline installation can be minimized; although it should be noted that current regulations in the GOM may be insufficient for identifying all shipwrecks, particularly buried wooden wrecks in shallow water.

Ancillary Activities

Ancillary activities such as those conducted by lift boats and anchored vessels offering support (such as dive ships) are not explicitly regulated by the BOEM. These vessels can produce fairly significant bottom disturbances but due to the frequency with which they operate and the number of vessels involved, it would be difficult to regulate these bottom disturbing activities on a case by case basis. Bottom disturbing activities associated with lease development or pipeline installation are regulated under the permitted activity, so it is the operator's responsibility to ensure that contractors do not impact targets or anomalies that have been stipulated for avoidance. Off-lease bottom disturbing activities are typically exempt from survey requirements. These activities are usually risk aversion activities that cannot be explicitly regulated, and include actions such as anchoring a vessel or setting a platform on the seafloor during severe weather conditions to mitigate risk to the vessel and crew.

Conclusion

Throughout most of the Gulf of Mexico, BOEM regulations governing oil and gas activities are the only protection for submerged archaeological sites. The BOEM, however does not have the authority to regulate other activities that may impact submerged sites, such as offshore fishing or recreational diving. Due to this lack of regulation, the surveys required by the BOEM are the primary method in which sites are discovered in this region and the only impetus for subsequent archaeological study of these resources.

It is not possible to predict every scenario or protect against all potential threats to a site. During installation, proper regulation and monitoring can ensure that submerged cultural heritage sites are avoided by vessels, anchors, and the actions of offshore personnel. Post-installation industry presents few threats to submerged archaeological resources. The most practical way to protect sites against impacts related to future infrastructure is to ensure that the location is selected in consideration of the current avoidance zone and potential placement of subsequent installations.

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