Offshore Oil
Anthropogenic Activity Background Document

I. Activity Overview

Offshore oil development is a multi-phase process that includes exploration, construction, extraction, transmission, and decommissioning over the lifetime of a project. Oil exploration begins with conducting surveys and completing exploratory drilling to locate oil reserves trapped in subsea sediments on the continental shelf. Once surveys are completed and oil is located, specialized drilling vessels and equipment are used to drill through sediments below the seafloor to release and extract the target crude oil and associated liquid hydrocarbons from undersea reservoirs. A platform and associated production infrastructure, collectively called a "rig," is then installed on the surface of the ocean by barges to replace the drilling infrastructure. The platform houses the crew, machinery, and facilities used to pump the crude oil to the surface through pipes for separation, cleaning, and storage. Once separated from other materials, crude oil is pumped onshore to refinery or distribution facilities through pipelines buried on the seafloor. After wells stop producing oil, the rigs and pipelines are decommissioned and removed piece by piece for onshore disposal. Some decommissioned rigs can be used as artificial reef habitat under "rigs to reefs" programs administered by coastal states. The U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) utilizes a five-year planning framework to identify potential drilling sites. BOEM then implements a multi-stage parcel leasing and environmental review process that regulates oil exploration and production activities in designated areas on the continental shelf.

The development and extraction of offshore oil is complex. This document is organized around activity subsections to facilitate an exploration of the habitat impacts associated with each phase of this process, and identify the risks and unintended consequences of oil development. The four subsections include: 1) surveying and exploration, 2) drilling, construction and extraction, 3) decommissioning; and 4) oil spills.

1. <u>Surveying and Exploration</u>

Producers use seismic and acoustic surveying equipment such as air guns towed behind vessels to locate oil reserves by refracting sound waves off of the seafloor. Remote sensing technologies that use underwater imaging can also help producers locate subsurface fractures in rock that may contain oil reserves. These survey techniques may require placing sensors on the seafloor to provide additional geological information on sediment composition and density before drilling begins. These activities have the potential to impact marine species and habitats with underwater sound and direct contact with the seafloor.

2. <u>Drilling, Construction and Extraction</u>

a) Exploratory and Production Drilling

Once surveys are completed, specialized drilling equipment is used to drill exploratory wells and sediment cores to determine the specific composition of the hydrocarbons under the seafloor. Special drill ships, semi-submersible vessels, or "jackup rigs," can all be used to drill wells over

10,000 feet deep. Jackup rigs are the most commonly used drilling vessels and must be towed by barges or tugboats to a drill site. These rigs use extendable legs that rest on the seafloor to prop the rig up above the surface of the ocean. To begin drilling, vessels lower slender sections of steel pipe with an attached drill bit, called a "drill string," through their hulls until the drill bit contacts the seafloor. A drilling collar allows the rig to drill at all angles from the vessel through a process known as directional drilling; this technology allows a single drill rig to tap several lateral reserves, and can avoid the need to drill through sensitive habitats.

Steel pipe casings are placed around the drill string to protect it from damage and leaks during operation. As the drill bit rotates and bores into sediments, lubricating and cooling fluids known as "drilling muds" circulate through the casings to keep the drill bit functioning properly in the borehole. Drilling muds can be water-based, oil-based, or entirely synthetic and may incorporate chemicals such as hydrocarbons. As the drilling depth increases, metal casings are placed just below the seafloor and filled with concrete to help stabilize the borehole. These casings also keep unwanted natural gas, hydrocarbons, and hot, saline, metal-filled seawater mixtures called "produced waters" trapped in subsea sediments from flowing through the casings back to the surface. The drilling muds, crushed rock cuttings created during drilling, and produced waters are pumped to the surface for cleaning and then re-circulated back to the drill bit in a continuous cycle. Eventually, these drilling fluids and cuttings must be cleaned and discarded. The U.S. Environmental Protection Agency (EPA) regulates the discharge of these materials from casings in a process known as "shunting." Under Clean Water Act regulations, the EPA typically requires producers to clean and dispose of the slurry of fluids and cuttings onshore, or to pump them back into subsea sediments to avoid dispersion in the water column and prevent the release of toxins that may occur if discarded at the surface platform. Occasionally, drilling gear may contact natural fractures or create new ones in rock formations. These events, called "frac-outs," can potentially release drilling muds, produced waters, and hydrocarbons from subsea reservoirs, which can reduce water quality and introduce toxins into surrounding waters.

After drilling is completed, another casing pipe incorporating several pressure release valves is lowered down into the well to allow the oil to flow to the surface platform. The drill string is then retrieved by the jackup rig and disassembled for future use. A large metal "blowout preventer" is installed on the casing just below the surface platform to control natural pressure releases that may occur during normal operations. In the event of large, uncontrollable pressure releases called "blowouts," rams on the blowout preventer can sever the pipe casing shut to prevent large-scale oil releases and explosions.

b) Platform and Pipeline Installation

After the drill rig retrieves the drill string, the rig is towed away by barges and replaced with a production platform. While there are many designs for semi-submersible and floating platforms, most platforms are attached to the seafloor by steel-coated piles and anchored cable systems. Production platforms can be quite large to provide space for maintenance machinery, oil-processing equipment, living quarters for a small permanent crew, and other resources. They are built onshore as modules and barged to the site; this modular structure also allows for easy disassembly at the end of the project’s lifespan.

Pipelines must be installed to connect the platform to onshore infrastructure, including refineries and distribution networks. The pipes can measure up to five feet in diameter and must be buried at least three feet below the seafloor or covered with three feet of rock when sited in water less than 200 feet deep. Where pipelines approach nearshore navigation corridors, they must be buried at least ten feet deep according to U.S. Army Corps of Engineers (Corps) permitting regulations. Installing pipes from the project site to shore can potentially have a very large footprint on the seafloor, and cause significant benthic impacts depending on the installation methods used.

Trench excavation methods for burying pipelines include mechanical plowing, pressurized hydraulic jetting, and dredging techniques. Where hard-bottom substrates obstruct pipeline pathways, explosives may be used to clear a path, which can cause significant damage to benthic habitats. Once laid on the seafloor, pipes are flushed with pressurized liquids that may contain biocides and other chemicals to test for leaks and durability in a process known as hydrostatic pressure testing. The construction vessels and excavation equipment required to lay pipelines can necessitate construction corridors up to a half-mile wide. During the consultation process, National Oceanic and Atmospheric Administration (NOAA) Fisheries Habitat Conservation Division staff provide input on pipeline siting, excavation, and installation methods to avoid impacts to sensitive benthic habitats resulting from these activities.

c) Operations

Once pipelines are in place, production begins when a series of small explosive charges are set off at the base of the well to allow oil to flow to the surface platform. The platform separates target crude oil from other compounds like natural gas and seawater, and then transfers oil into pipelines to be transported to shore for distribution. To support ongoing oil production, supply vessels routinely ferry crew and supplies back and forth from shore. Over the decades-long lifespan of a rig, chemicals and debris from operation, maintenance, and repair activities can be released into surrounding waters. This can impact water quality and result in the accumulation of toxins such as hydrocarbons in substrates.

3. <u>Decommissioning</u>

BOEM requires that within five years of ceasing production, rigs and all associated infrastructure be removed and the site be restored to pre-project conditions. This breakdown and cleanup process uses large construction barges and cranes to plug the well with cement and collect piles and rig components for onshore disposal under EPA rules. Abrasive cutting tools and explosives can be used to remove piles, pipes and the structure of the well at least fifteen feet below the seafloor. The tanks, platform processing equipment, and pipelines must all be flushed to remove oil and chemical residue, and all rig structure must be cleaned of any growth. After decommissioning is complete, pipelines may be left in place as long as they will not interfere with navigation or fishing operations in the future.

Decommissioned rigs may be disassembled, salvaged, and disposed of onshore. Rigs may be sunk in place, or a portion of the rig structure may be severed to leave 85 feet of clearance for vessels. Explosives may be used to sever rig legs from the seafloor when abrasive or other mechanical means are not feasible. Once all project-related structure is removed, producers employ bottom trawls to remove any debris lost overboard during operations. Surveys and diver or Remotely Operated Vehicle (ROV) verification are required to ensure proper cleaning and removal of any hazards to navigation. Through "rigs to reefs" partnership programs, some of the rig structures such as rig legs and piles may be used to create artificial habitat for fish and other species. Most rigs decommissioned for this purpose are moved to designated artificial reefing sites in state waters, though rig operators and owners may also work with state and other partners to leave rigs at the project site.

4. Oil Spills

Oil spills have the potential to severely impact all habitat types and species across ecosystems. Oil can be accidentally leaked or spilled during any stage of exploration, construction, production, shipping, or decommissioning activities. Spills can range in volume from small operational discharges of produced waters to major disasters such as the *Deepwater Horizon* blowout that spilled millions of barrels of crude oil into the Gulf of Mexico. Crude oil and its associated hydrocarbons can move great distances after a spill, reduce water and habitat quality across all depths and distances from shore, and may be toxic to all living organisms that come in contact with it. While unlikely, large spills have the potential to cause the most widespread and lasting impacts on habitat from oil development activities (see Oil Spill Appendix).

Activity in the Mid-Atlantic Region

Under BOEM's five-year planning and leasing framework, no offshore oil exploration or development is planned in the Mid-Atlantic region through 2017. However, with its large population centers, existing infrastructure for shipping, processing, and refining crude oil, and political movement to expand domestic production, oil development is likely in the region's future. The Mid-Atlantic Regional Planning Board coordinates energy-leasing activities in the region along with the U.S. Department of Interior and states, and may recommend sites for leasing during the 2017-2022 planning cycle.

II. Habitat Impacts of Oil Development by Habitat Type

While the activity is generally known as "offshore" oil development, it can occur in both nearshore and offshore waters and impact all habitat types. Impacts from drilling, pipeline-associated activities, and decommissioning are generally localized and primarily impact benthic substrates. However, given the scope of activities and phases involved, the ability to extract and pipe oil far from shore, and the long duration of operations, offshore oil development may result in a very large footprint of impact. The total footprint of impact is related to the different temporal and spatial natures of each phase of offshore oil development and extraction. For example, surveying may occur for a short time over a large area, while drilling and extraction may extend over a long period of time over a small area. While rare, oil spills have the greatest potential to cause significant impacts across all habitat types and impacts may persist over long timeframes (see Oil Spill Appendix). The following analysis considers all potential habitat impacts of offshore oil development and does not assess the likelihood of oil development in state and federal waters.

Distribution (Nearshore (Including Estuarine)/Offshore)

a) Nearshore
All habitat types in nearshore waters have the potential to be impacted by oil development. Construction and drilling activities such as driving piles with vibrating or percussive hammers, anchoring platforms, and extending the legs of jackup rigs all have the potential to crush, bury, or disturb benthic habitats in nearshore waters. Construction barges and drilling vessels may sweep anchors and cables along the seafloor across wide areas and cause similar impacts, though to a lesser extent. Excavating and burying pipelines can remove and convert nearshore habitats. Even when platforms are sited far offshore, pipelines must still be routed through nearshore areas. Explosives may be used to permanently remove hard substrates in the path of pipelines, and can cause significant damage to benthic habitats. In nearshore, shallow waters, pipeline-associated activities can exacerbate shoreline erosion, cause steep cliffs of sediment called escarpments to form, and increase sedimentation, altering nearshore communities (see Indirect Impacts). Shunting produced waters, drilling muds, and cuttings on the seafloor can also result in the accumulation and alteration of benthic substrates. All of these activities may increase sedimentation and turbidity, and may resuspend contaminated sediments and toxins that can reduce water quality and impact species that rely on nearshore habitats.

Rig decommissioning activities can cause impacts by disturbing the habitats near rigs, platforms, and pipelines. Moving and sinking rigs to serve as artificial habitat can alter benthic habitat and impact species behavior (see Indirect Impacts). In the event of a spill, waves, wind, currents, and tidal action tend to transport and accumulate spilled oil nearshore. These forces drive oil into interstitial spaces between sediment on beaches and tidal areas, which can cause significant water quality impacts and expose coastal vegetation and the many life stages of species that rely on these areas for habitat to toxins. Over the long term, oil accumulation may decrease coastal vegetation and habitability of sediments in shallow, nearshore waters (see Oil Spill Appendix).

Estuarine
Trenching for pipelines in estuarine habitat can cause marshes to drain more rapidly during low tides or periods of low precipitation, and interrupt freshwater and littoral sediment inflow. Altering these processes can allow increased saltwater intrusion in low salinity areas at high tides, killing saltwater-intolerant plants and submerged aquatic vegetation (SAV). These activities may also cause soil erosion, sedimentation, and increased turbidity. Resuspended contaminated sediments cannot disperse in estuaries due to their tidal influence and low water volumes. The presence of pipelines in estuaries may disrupt current flow, lead to adjacent scour and erosion, and cause escarpments to form on coastal dunes or marshes. These alterations

can lead to mortality and reduced productivity of coastal vegetation and fragmentation of coastal wetlands.

If oil exploration activities occur nearshore, shunting produced waters and drilling muds near estuaries has the potential to reduce water quality through the introduction of toxins and disruption of salinity gradients, which can reduce habitat suitability for eggs, larvae, and juvenile fish and shellfish. Given the enclosed nature of estuaries, spilled oil can accumulate and persist over long timeframes, which can cause SAV die-offs and long term exposure of resident organisms to toxins. During cleanup activities, trampling and cutting salt marshes can have long-lasting impacts on estuarine habitat productivity.

b) Offshore
Oil development projects sited far from shore can result in the same impacts associated with drilling, platform construction, laying pipelines, and decommissioning as described above. The further from shore a project is sited, the more pipeline must be laid in offshore benthic habitats. Wind and currents can transport spilled oil far offshore after a spill, potentially reducing offshore water quality and impacting marine communities over a large area of the ocean (see Indirect Impacts).

<u>Depth (Pelagic/Demersal/Benthic)</u>

a) Pelagic
Under some circumstances, drilling muds and produced waters can be shunted at the surface near the production platform rather than in sediments below the seafloor. This can reduce pelagic water quality by releasing toxins and increasing the dispersion area of contaminated materials throughout the water column. Chemicals (e.g. biocides) that leach from piles and other in-water structures may also reduce pelagic water quality and introduce toxins. Conducting seismic and acoustic surveys, drilling, driving piles, using explosives, and decommissioning activities emit sound waves that can travel long distances in pelagic waters and cause direct mortality or behavioral changes in marine species (see Indirect Impacts).

b) Demersal
Drilling, construction, and decommissioning activities near the seafloor can disturb and resuspend sediments, causing increased turbidity and sedimentation in demersal waters. Shunted fluids, cuttings, and suspended contaminated sediments near the seafloor may reduce water quality by releasing metals, pesticides, chemicals, and other toxins such as hydrocarbons into surrounding waters, altering habitat suitability and potentially causing lethal and sublethal impacts on demersal and benthic organisms (see Indirect Impacts).

c) Benthic
Drilling, construction, pipeline installation, and decommissioning activities physically contact the seafloor and can directly destroy benthic habitats. Drilling, driving piles, and excavating trenches for pipelines can crush, remove, bury, or convert benthic habitats and suspend sediments. The suspension of sediments can increase turbidity, which causes sedimentation,

alters existing substrates, and can expose new substrates with different chemical and physical properties. Suspended contaminated sediments eventually accumulate on the seafloor, reducing benthic habitat quality and potentially impacting organisms that live or feed there (see Indirect Impacts). The legs of rigs and piles may also disrupt currents and cause scour, which removes and exposes benthic sediments, alters habitat complexity, and can change species behavior (see Indirect Impacts). Excavating sediments to lay and bury pipelines can reduce benthic habitat suitability and complexity by altering seafloor contours and smoothing depressions and mounds; these activities can have a large footprint of benthic impact. When buried improperly, in nearshore substrates, or adjacent to undersea cliffs, pipelines have the potential to cause scour and may lead to formation of escarpments, leading to erosion and long-term sedimentation.

During decommissioning, barge anchors, explosives, and mechanical cutting tools can also directly destroy, remove, alter or suspend unconsolidated benthic sediments. Trawling the project area after decommissioning may damage or alter benthic substrates, and impact benthic species survival and behavior (see Indirect Impacts). In the event of a spill, oil and its associated hydrocarbons stick to sediments suspended in the water column, causing them to sink and eventually settle to the seafloor through the process known as adsorption. As a result, oil accumulates in benthic sediments, introducing toxins and reducing the suitability of substrate for growth of aquatic vegetation and causing lethal and sublethal impacts to organisms feeding or living on the seafloor (see Indirect Impacts).

<u>Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)</u>

a) Submerged Aquatic Vegetation
Depending on project siting, construction and pipeline-associated activities can disturb the seafloor, erode and suspend sediments and contaminants, and cause scour, which increases turbidity and sedimentation. The resulting turbidity can bury or smother SAV, cause siltation, and reduce sunlight penetration, which decreases survival and productivity of SAV habitats and can exacerbate shoreline erosion. Suspended contaminated sediments may resettle on benthic substrates where SAV grows, reducing habitat quality and potential growth in the future. SAV is particularly at risk to impacts from exposure to toxins in oil. In the event of a spill, oil tends to accumulate in shallow, nearshore waters where SAV grows, and can cause die-offs or permanently impair growth if the spill occurs during spring growing seasons (see Oil Spill Appendix).

b) Structured
It is unlikely that drilling and rig construction activities will occur in areas with structured habitats such as shell beds, gravel, or other hard-bottom substrates. If projects are sited in or near these areas in the future, benthic impacts can be expected as described above. Structured habitats, however, may be subject to significant impacts from the use of explosives to remove hard bottom barriers in the path of pipelines and from barge anchors sliding on the seafloor. These activities can permanently remove and alter structured habitat and reduce sources of habitat complexity such as boulder or cobble mounds.

c) Soft
Construction and decommissioning activities are likely to occur on soft-bottom substrates like mud, clay, and silt, which are susceptible to disturbance and resuspension. These processes can remove, convert, bury, or expose substrates and increase turbidity, causing sedimentation and siltation. Turbidity can pose additional problems during an oil spill. Oil adsorption is particularly likely on suspended clay due to its physical and chemical properties, which can expose benthic organisms contacting or feeding in these soft substrates to toxins and cause contamination over decades (see Indirect Impacts).

III. Potential Impacts of Offshore Oil to MAFMC Managed Stocks

Considering all potential configurations and siting options for hypothetical offshore oil developments in the Mid-Atlantic, each habitat used by Mid-Atlantic Fishery Management Council (MAFMC) species could be impacted to some extent. Given the necessity of laying pipelines to connect rigs with onshore infrastructure, nearshore habitats will be impacted regardless of where rigs are sited. Impacts from construction, extraction, and decommissioning activities are most likely benthic or demersal in nature. SAV and estuarine habitats are particularly vulnerable to these impacts, and may incur significant impacts if pipelines are laid in these areas. Oil spills have the potential to severely impact all habitats across timescales of decades.

The following table lists the habitat types designated as Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for the different life stages of MAFMC managed species (see *Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods*). Cells highlighted in orange indicate an overlay between the habitat used and the potential for the habitat type to be adversely impacted by offshore oil activities; cells highlighted in yellow indicate a lower potential for adverse impacts.

If oil exploration and development projects are permitted in the Mid-Atlantic region, federally managed species that depend on nearshore, benthic habitats during at least one life stage have the most potential to be impacted. Should pipelines be routed through sensitive estuarine habitats, additional species may be impacted due to their importance to early life stages of many stocks. Golden tilefish eggs and larvae and shortfin squid (*Illex*) eggs and pre-recruits are the only MAFMC managed species not likely to be impacted directly by offshore oil development activities and regular operations due to their reliance on offshore, pelagic habitats. However, in the event of an oil spill, every life stage of each MAFMC species has the potential to be significantly impacted through direct mortality, reductions in water quality, and disruption of food chains and ecological functions by exposure to toxins (see Oil Spill Appendix).

Visual Overlay of Potential Impacts from Offshore Oil and MAFMC Species' EFH/HAPC

Legend

Orange = potential for adverse impacts

Yellow = low potential for adverse impacts

Green = no potential for adverse impacts

MAFMC Species	Distribution			Water Column			Benthic Substrate/Structure		
	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

IV. Indirect Impacts

In addition to the habitat impacts described above, exploration, drilling, construction, extraction, and transport activities associated with oil development may cause indirect and non-habitat impacts to the marine environment. While some impacts such as reduced water quality are likely temporary and occur mostly near rigs, impacts from oil spills can be widespread and last for decades. Oil development can cause significant impacts to species, such as complex changes to species behavior and responses to altered environments.

a) Underwater Sound

Air guns used in acoustic surveys, drilling wells, driving piles, and utilizing explosives to remove hard substrates can emit harmful sound waves and result in sudden changes in pressure. These sound and pressure changes can cause direct mortality, damage hearing and communication organs, and alter behaviors such as swimming, migration, and foraging in marine mammals and fish. Sound impacts are exacerbated among species that have swim bladders and those that are attracted to rigs. Sound waves can also travel great distances in water, and may reduce the communication and navigation effectiveness of marine mammals far from the source of the sound. Timing windows that restrict survey and construction activities may be implemented to mitigate these impacts.

b) Water Quality

Water quality can be impacted by discharging drilling muds and produced waters, releasing debris, waste, fuel and lubricants from production platforms and associated vessels, and leaching chemicals from in-water structures. Contaminants can disperse over wide areas up to 1,000 meters away from discharge sites and eventually accumulate in substrates and the tissue of marine species. This can cause direct mortality as well as physiological and behavioral changes in fish and invertebrates.

c) Species Behavior and Fitness

Oil development activities can impact species productivity and fitness through sedimentation, turbidity, and siltation. These mechanisms may suffocate and bury eggs with fine sediments, reduce growth and survival of fish and shellfish, disrupt migration and spawning effectiveness, impact physiological processes, and alter species behavior through attraction or avoidance. Activities associated with trenching and burying pipelines may reduce habitat complexity through smoothing, removing depressions and irregularities, and filling areas with sediment. These activities can also displace burrowing organisms, alter benthic species migrations, and disrupt community dynamics by changing available substrates.

d) Decommissioning and Artificial Habitat

The presence of underwater rig structures can have positive and negative impacts on marine species. Rigs and their associated infrastructure can introduce new structured habitat and create artificial reefs. While this may contribute to productivity, it can alter avoidance or attraction behaviors, provide ambush sites for predators and refuge structure for prey, and disrupt community dynamics by changing species dominance in an area. In addition, this infrastructure may impede and disrupt migratory pathways and alter behaviors such as feeding in marine mammals, fish, and invertebrates.

Each decommissioning option can destroy existing artificial habitat throughout the water column through destruction, removal, and alteration. Cleaning and trawling activities directly remove debris near project sites that may have become de facto artificial habitat during the lifespan of the rig. Decommissioning can also create new artificial habitat in rigs to reefs program areas that may be beneficial to some species over long timeframes; research is needed to understand if these projects increase local fish production or simply aggregate existing fish from nearby areas.

e) Spills

While unlikely, oil spills have the most potential of any aspect of offshore oil development to significantly impact MAFMC habitats and species. Oil may be spilled during any stage of the drilling and extraction process, such as during “frac-outs,” blowouts or spills during shipping and may have significant, long-term impacts. Oil is highly toxic, carcinogenic, and mutagenic and is likely to cause lethal and sublethal impacts such as reduced fitness and physiological and behavioral changes in all species that come in contact with it such as seabirds, marine mammals, fish, invertebrates, and others (see Oil Spill Appendix).

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VI. Oil Spill Appendix

This appendix is intended to build on and capture additional insights from our research to help the MAFMC understand the specific mechanisms and threats to habitats and species that may result from oil spills. It supplements the basic habitat impacts description in the "Oil Spills" section of the document, explains sources of impacts, and puts boundaries on the wide range and severity of potential mechanisms and impacts a spill can have on the marine environment.

Sources

Oil leaks and spills can occur at any stage of the offshore oil development process. Spilled oil can enter marine waters after shipping accidents and collisions, pipeline leaks or ruptures, severe storm events, and blowouts at wells. While large blowouts and catastrophic shipping accidents have the potential to spill large volumes of oil, these events are rare. Over 90% of spilled oil by volume enters marine waters from small, daily operational discharges of produced waters, drilling muds, leaks in pipelines or tankers, and natural pressure releases at wells.

Spill Mechanics

Crude and refined oil is composed of many kinds of hydrocarbons with different chemical and physical properties that can be toxic to marine organisms, depending upon the pathway, severity, and duration of exposure. After a spill or leak, oil floats along the surface of the ocean and can be transported great distances by the forces of wind, waves, currents, and tides. Sunlight can multiply the toxicity of some light hydrocarbon compounds and increase their uptake into living organisms near the ocean's surface, such as plankton. This enhanced toxicity can disrupt ecosystem dynamics by directly impacting plankton at the base of the food chain.

Some oil compounds become more soluble in seawater over time through the degrading forces of waves and wind, and can become suspended and partially dissolve throughout the water column. As these water-oil globules dissolve, a portion of hydrocarbons are broken down by microbes, while the rest introduce toxins and reduce water quality that can impact the entire pelagic community. Wave and wind action over time also increase adsorption of oil onto suspended sediments in the surrounding water, causing it to sink and eventually settle on benthic substrates, contaminating them over decades. The more suspended sediments are present in the water column after a spill, the more oil can be transported to the seafloor and held on benthic sediments. Heavier hydrocarbon components of oil tend to sink more quickly and are lipophilic: they are readily incorporated into the fatty tissues of organisms feeding on and contacting the seafloor.

Water Quality Impacts

Oil and its associated hydrocarbons build up in benthic sediments and can reduce the suitability of habitat for organisms living or feeding near the seafloor, including living habitat (e.g. SAV). Contaminated sediments may also cause direct mortality and sublethal impacts such as reduced fitness in fish and invertebrates that come in contact with them, especially at early life stages.

Species Impacts

Exposure to hydrocarbons can have significant impacts on species ranging from direct mortality to disruption of physiology, metabolism, and feeding and reproduction behaviors. Oil components can be mutagenic, carcinogenic, or both to many species even at low levels of exposure. The wide range of likely sublethal impacts to species from exposure to toxins in hydrocarbons can include, but are not limited to: deformities in eggs and larvae, abnormalities such as altered organ development, diseases of the liver and spleen, altered skin pigmentation, impaired feeding, growth, reproductive efficiency, and recruitment, altered blood and hormone chemistry, increased susceptibility to diseases and infections, and altered behaviors such as lowered return rates of migratory species to spawning grounds and avoidance of areas. In addition, the lipophilic properties of hydrocarbon compounds can cause sublethal impacts such as altered fitness, physiology, and behavior in species and their predators.

Oil can impact all species that come in contact with it, especially seabirds, marine mammals, and fish because it sticks to feathers, skin, and scales easily, is very difficult to remove, and disrupts basic life functions such as respiration and feeding. Early life stages of species that are frequently found in estuaries and sheltered inshore waters are at especially high risk of incurring impacts from exposure to toxins in oil because it cannot disperse easily in enclosed areas. Generally, eggs and larvae are more susceptible to impacts from exposure to oil toxins than juveniles and adults. Eggs, larvae, and other plankton are generally vulnerable to oil impacts because they are often found in high concentrations, cannot actively relocate to avoid oiled areas, and oil absorbs quickly into their small bodies. Impacts to these life stages and plankton can disrupt the prey base of an ecosystem and flow up the food chain to alter pelagic communities and ecosystem dynamics beyond the area directly affected by oiling.

Cleanup Impacts

Impacts to habitats and species can be exacerbated by oil removal and cleanup activities. Oil can be removed from marine waters through burning or skimming activities on the ocean's surface, dispersal with chemicals, scrubbing sediments using sorbents, direct removal by trenching, and natural degradation by microbes. Each of these options can have significant impacts on species and habitats. While the specific impacts of burning oil from the surface are unclear, chemical dispersants are known to reduce water quality and introduce toxins into living habitats such as SAV. They can cause similar impacts to species as oil itself, such as direct mortality, reduced fitness, survival, egg fertilization, and other sublethal impacts over long timeframes. Spill cleanup activities can suspend contaminated sediments and exacerbate the adsorption of oil and chemical dispersants, transporting more oil to benthic substrates where it is harder to remove. Spill cleanup activity in coastal areas can lead to trampling and cutting of salt marshes and nearshore vegetation, which can severely damage these habitats and lead to die-offs, sedimentation, and reduced productivity. Lastly, vessels involved in cleanup activities can discharge, spill, leak, or spread bilge water, collected hydrocarbons, and dispersants that increase organisms' exposure to toxins and reduce water quality on a small scale.