

The Environmental Effects of Offshore Oil Drilling

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The Environmental Effects of Offshore Oil Drilling

WORKING PAPER OVERVIEW

This paper examines the environmental impact of offshore oil drilling on marine life. The research surveyed in this paper strongly supports the conclusion that the environmental effects of offshore oil drilling on marine life are generally not significant and that offshore drilling takes place without causing serious harm to the environment.

The Environmental Effects of Offshore Oil Drilling: **Executive Summary**

OVERVIEW

This Executive Summary covers the five most politically important topics related to the environmental impact of offshore oil drilling: oil input into the sea, oil spills, mercury contamination, hurricanes and seismic surveys. Only the most relevant information is presented, and the reader is strongly urged to read the full Survey of the Literature for a better understanding of the environmental issues surrounding offshore drilling.

DRILLING IS NOT A SIGNIFICANT SOURCE OF OIL INPUT INTO THE SEA

Natural seeps account for the overwhelming majority of oil input into the sea.

“Natural seeps are the highest contributors of petroleum hydrocarbons to the marine environment... Offshore seeps are only known to occur in the northern and southern Gulf of Mexico, where they represent 95 percent of the total oil inputs to the offshore region, and southern California, where they represent 98 percent of oil inputs to the offshore zone.”

(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 33. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

Oil spills from platforms account for a small percentage of total oil input into the sea. “The estimated range of total input of petroleum hydrocarbons from all sources into North American waters is 110,000 tonnes per year to 2,300,000 tonnes per year. The best estimate is 260,000 tonnes per year (see Table 3-2)... The smallest discharge occurs during accidental spills associated with the extraction of petroleum, accounting for 3,000 tonnes per year or roughly 1 percent of the total.”

NOTE: See Appendix for full account of all sources and relative contributions to the sea.
(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 86. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

MAJOR OIL SPILLS ARE VERY RARE AND SPILLS GENERALLY DO NOT POSE A SIGNIFICANT THREAT TO MARINE LIFE

The vast majority of spills from platforms are very small. “According to MMS, 97 percent of OCS spills are one barrel or less in volume and U.S. OCS offshore facilities and pipelines accounted for only 2 percent of the volume of oil released into U.S. waters for the period 1985–2001 (Figure 24.3).”

“...the small spill is representative of the more common “average” spill sizes, while the medium or large spills happen only rarely and represent extreme events...”

(US Commission on Ocean Policy. An Ocean Blueprint for the 21st Century: Final Report of the US Commission on Ocean Policy. Sept. 2004. 361. 11 July 2008

<http://www.oceancommission.gov/documents/full_color_rpt/000_ocean_full_report.pdf>.)

(US Coast Guard. Draft PEIS: Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions. 4-2. 11 July 2008.)

Each year, there is probably greater than a 99.9999% chance that there will be no significant oil spill from any given well. “Even on the basis of historical data without adjustment, it is important to note that large spills are comparatively rare. The annual frequency of spills being greater than 10,000 bbl (1590 m³) and 150,000 bbl (24,000 m³) respectively are approximately 10⁻⁴ (1 in 10,000) and 10⁻⁵ (1 in 100,000). This conclusion is reinforced by data... Taking into account the conservatism in the frequencies calculated above, the spill at the 10⁻⁴ per annum level is likely to be of the order of 1000 m³ or less.”

(Royal Society of Canada. Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia. Natural Resources Canada. Ottawa, 2004. 88. 11 July 2008

<http://www.rsc.ca/files/publications/expert_panels/BC_offshore/fullreportEN.pdf>.)

The environmental risks associated with platform spills are minor. A Coast Guard study looked at the likely impact of small, medium, and large spills on an extensive list of organisms that could be affected by the oil in every region offshore. It found that in the Atlantic, Pacific, and Gulf of Mexico, there was never more than a moderate risk to organisms, and the risk was almost always minimal even for large spills. While there are areas within those regions where the risks would be more significant (such as the Straits of Florida), the report nonetheless gives a good idea of what the environmental impact of an oil spill would typically be. This is important since these are three of the areas where the most offshore drilling would occur if the moratorium were lifted.

NOTE: This report is summarized above because all of this data is disparate in the report except in the form of tables. There is no text that summarizes all of these findings within the report. It is very much stressed that the reader look at the full discussion of this report in the Survey of the Literature to gain a better appreciation for the nuances of this study and its limitations.

(US Coast Guard. Draft PEIS: Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions. 11 July 2008.)

MERCURY INPUT RESULTING FROM DRILLING IS NOT AN ENVIRONMENTAL THREAT

Mercury levels around offshore platforms can be elevated at times but not at significant levels. “Barium (from barite) and mercury have been measured in sediments

around a number of nearshore and offshore platforms in the Gulf of Mexico...At virtually every other platform studied in U.S. waters, mercury concentrations in sediments near the platforms were less than 0.5 ppm, only slightly above background levels (which usually are below 0.15 ppm).”

(Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002. v-vi.)

Mercury levels in marine organisms near platforms are not elevated. “...platforms do not support enhancement of mercury in marine organisms...Biological data indicated that mercury bioaccumulation is not enhanced near platforms. The GOOMEX study data does not support the conclusion that discharges from platforms leads to elevated levels of mercury in fish.”

(Boatman, Mary. “Mercury and the Results from the Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX).” PowerPoint presentation. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003. Slides 30-31)

HURRICANES DO NOT CREATE A SIGNIFICANT THREAT OF DANGEROUS OIL SPILLS

After Hurricane Katrina, spills from oil rigs were minimal and resulted in no significant harm. “The loss of hydrocarbons from wells on the Federal OCS was minimal due to the successful operation of the safety valves that are required to be installed at least 100 feet below the mudline in each wellbore. All OCS facilities in areas threatened by the storms’ approach were shut in prior to the hurricanes so that oil losses were mostly limited to the oil stored on the damaged structures or contained in the individual damaged pipeline segments. There were no accounts of spills from facilities on the Federal OCS that: reached the shoreline; oiled birds or mammals; or involved any discoveries of large volumes of oil to be collected or cleaned up.”

(Minerals Management Service. Estimated Petroleum Spillage From Facilities Associated with Federal Outer Continental Shelf (OCS) Oil and Gas Activities Resulting From Damages Caused by Hurricanes Rita and Katrina in 2005. Department of Interior. 2006. 1. 11 July 2008
<<http://www.mms.gov/incidents/PDFs/HurrKatrinaRitaSpillageRev8thAug2006.pdf>>.)

New regulations have been put in place to make oil platforms more durable during hurricanes and prevent more oil from spilling. “Building on improvements made prior to the 2007 hurricane season, such as new guidance documents focusing on enhanced design standards and a Web site dedicated to hurricane information, MMS incorporated three API bulletins containing the enhanced design standards as well as assessment criteria for both new and existing structures in the Gulf of Mexico into a final rule that becomes effective today, May 15, 2008. The new criteria will increase platform survivability during hurricane conditions and result in fewer damaged platforms.”

(“MMS Prepares for 2008 Hurricane Season.” MMS Press Release. 15 May 2008. Minerals Management Service. 11 July 2008 <http://www.gomr.mms.gov/homepg/whatsnew/newsreal/2008/080515.pdf>)

SEISMIC WAVES DO NOT APPEAR TO CAUSE SIGNIFICANT OR LONG-TERM DAMAGE TO MARINE MAMMAL OR FISH POPULATIONS

There is a major difference between sonar and seismic surveys. “Seismic pulses and mid-frequency sonar signals are quite different. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid-frequency sonars emit non-impulse sounds at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time (though the frequency may change over time). Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals.”

NOTE: This is an important distinction to make because many environmental advocacy groups blur the line between the two types of sound tests and imply that the increasingly disconcerting research on sonar impacts applies to seismic surveys as well.

(Abgrall, Patrick, Valerie Moulton, and W. John Richardson. Updated Review of Scientific Information on Impacts of Seismic Survey Sound on Marine Mammals, 2004-Present. Department of Fisheries and Oceans, Habitat Science Branch. LGL Limited, Environmental Research Associates, 2008. 2. 11 July 2008 <http://www.iagc.org/attachments/contentmanagers/1045/LGL_document_DFO_Updated_Seismic_Mar_Mam_Review_VF_2008_03.pdf>.)

Seismic surveys are unlikely to harm fish population levels. “If we look at the seismic mortality in relation to natural mortality for these life stages, we get the following connections: For species such as cod, herring and capelin, the natural mortality is estimated at 5-15% per day of the total population for eggs and larvae. The daily natural mortality is reduced to 1-3% until the 0 group stage is achieved, i.e. when the fish has reached approx. one-half year in age (Sætre and Ona, 1996). Consequently, the seismic-created mortality for these species and other commercial species in Norwegian waters is so low that it is not considered to have any (significant) negative impact on recruitment to the populations (Dalen et al., 1996).”

(Dalen, John, Egil Dragsund, Arne Naess, and Olav Sand. Effects of Seismic Surveys on Fish, Fish Catches, and Sea Mammals. Cooperation Group-Fishery Industry and Petroleum Industry. DNV Energy, 2007. 13. 11 July 2008 <<http://www.olf.no/?50345.pdf>>.)

Research indicates that whale displacement resulting from seismic surveys is temporary, though the length of displacement can vary. “...there is no evidence to suggest that seismic surveys are displacing marine mammals either permanently or for significant periods of time from areas of the GOM, including those areas that may serve as important habitat (i.e., critical or preferred habitats)...Generally, it is presumed that a spatial displacement of marine mammals from a specific seismic survey’s “zone of responsiveness” would be expected to be short-term in duration.” “These results suggest that whales shifted their distribution into the scan area (i.e. from the north to the south) and away from the northern region where seismic surveys were conducted between 1 August and 8 September. Once the seismic surveys had ceased on 9 September, overall whale and pod numbers in the scan area returned to pre-seismic

levels, suggesting that whales had reoccupied the region from which they had been displaced.”

(Continental Shelf Associates. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Department of Interior. New Orleans: Minerals Management Service, 2004. III-26.)

(Weller, David W., Yulia V. Ivashchenko, Grigory A. Tsidulko, Alexander M. Burdin, and Robert L. Brownell, Jr. Influence of Seismic Surveys on Western Gray Whales Off Sakhalin Island, Russia. International Whaling Commission. 2002. 5. 11 July 2008
<http://www.livingoceans.org/_pvwC21CD930/files/PDF/energy/Gray_whales_and_seismic.pdf>.)

Evidence in support of the idea that seismic surveys cause strandings is very thin.

“There is no conclusive evidence of cetacean strandings as a result of exposure to seismic surveys... In Sept. 2002, there was a stranding of two Cuvier’s beaked whales in the Gulf of California, Mexico, when the Lamont-Doherty Earth Observatory (L-DEO) seismic vessel R/V *Maurice Ewing* was operating a 20-airgun, 8490-in3 airgun array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth 2002; Yoder 2002). Nonetheless, that plus the incidents involving beaked whale strandings near naval exercises involving use of mid-frequency sonar suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales.”

“There are no regular mass strandings or other similar events that may be attributed to impacts associated with seismic activities on the continental shelf of the northern Gulf, though seismic surveys have been occurring there with some regularity for decades.”

(Abgrall, Patrick, Valerie Moulton, and W. John Richardson. Updated Review of Scientific Information on Impacts of Seismic Survey Sound on Marine Mammals, 2004-Present. Department of Fisheries and Oceans, Habitat Science Branch. LGL Limited, Environmental Research Associates, 2008. 2. 11 July 2008
<http://www.iagc.org/attachments/contentmanagers/1045/LGL_document_DFO_Updated_Seismic_Mar_Mam_Review_VF_2008_03.pdf>.)

(Continental Shelf Associates. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Department of Interior. New Orleans: Minerals Management Service, 2004. III-26.)

The Environmental Effects of Offshore Oil Drilling: Survey of the Literature

OVERVIEW

This working paper is divided into four sections: oil input and spills, drilling discharges, hurricanes and seismic surveys, and other concerns. The first section addresses the amount of oil that enters the sea and its respective sources in order to put the entire debate over offshore drilling in context. It also examines the impact of oil spills on the marine environment. The second section deals specifically with the discharges associated with drilling and their respective impacts. The third section looks at the danger hurricanes pose to offshore platforms in terms of their environmental impact as well as the potential hazards associated with seismic surveys. Finally, the last section examines the separate concern of the impact on birds for which little information is available but which is an important part of the discussion about offshore drilling. In the case of many sections, research both critical and supportive of drilling is presented to give the reader a more balanced view of the topic.

SECTION I: OIL INPUT AND SPILLS

DRILLING IS NOT A SIGNIFICANT SOURCE OF OIL INPUT INTO THE SEA

Natural seeps account for the overwhelming majority of oil input into the sea. “Natural seeps are the highest contributors of petroleum hydrocarbons to the marine environment... Offshore seeps are only known to occur in the northern and southern Gulf of Mexico, where they represent 95 percent of the total oil inputs to the offshore region, and southern California, where they represent 98 percent of oil inputs to the offshore zone.”

(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 33. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

Human activities comprise a smaller percentage of oil input, and consumption makes up the vast majority of anthropogenic input. Consumption refers to the use of fossil fuels in daily life and activities. “Of the total load of petroleum hydrocarbons discharged into the sea, natural seeps account for the largest load, nearly 61 percent of the total. Of the anthropogenic load, consumers account for nearly 90 percent of the discharge.”

(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 47. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

Oil spills from platforms account for a small percentage of total oil input into the sea. “The estimated range of total input of petroleum hydrocarbons from all sources into North American waters is 110,000 tonnes per year to 2,300,000 tonnes per year. The best estimate is 260,000 tonnes per year (see Table 3-2)... The smallest discharge occurs during accidental spills associated with the extraction of petroleum, accounting for 3,000 tonnes per year or roughly 1 percent of the total.”

NOTE: See Appendix for full account of all sources and relative contributions to the sea. (National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 86. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

However, the size of a spill is not always indicative of its danger to marine life. “Spill size affects impact; however, the relationship is complex due to the influence of other factors such as location and timing of a spill, and ecological vulnerability (Burger 2003; U.S. NAS 2003b; Wiese and Montevicchi 2003; Birtwell and McAllister 2002; Kenchington 1997). FEP (RSC 2004) noted, for example, that the 1993 *Braer* spill off the U.K., which released almost 600,000 barrels, only resulted in sublethal impacts in gray seals compared to the high mortalities following the smaller *Exxon Valdez* spill. As such, smaller spills can cause significant environmental damage.”

NOTE: This section on oil inputs is meant to provide context in which to evaluate claims about oil spills from offshore drilling activities. As this last point demonstrates, however, the fact that drilling is an insignificant contributor of oil is not enough to make a conclusive statement regarding its environmental impact. The next section discusses the impact of platform spills in order to address this issue directly. See Appendix for table of all numerical values for oil inputs.

(Simon Fraser University. A Review of Offshore Oil and Gas Development in British Columbia. Coastal First Nations. 2004. 26. 11 July 2008
<http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88523>.)

MAJOR OIL SPILLS ARE VERY RARE AND SPILLS GENERALLY DO NOT POSE A SIGNIFICANT THREAT TO MARINE LIFE

SIZES OF SPILLS

The vast majority of spills from platforms are very small. “According to MMS, 97 percent of OCS spills are one barrel or less in volume and U.S. OCS offshore facilities and pipelines accounted for only 2 percent of the volume of oil released into U.S. waters for the period 1985–2001 (Figure 24.3).”

“...the small spill is representative of the more common “average” spill sizes, while the medium or large spills happen only rarely and represent extreme events...”

(US Commission on Ocean Policy. An Ocean Blueprint for the 21st Century: Final Report of the US Commission on Ocean Policy. Sept. 2004. 361. 11 July 2008

<http://www.oceancommission.gov/documents/full_color_rpt/000_ocean_full_report.pdf>.)

(US Coast Guard. Draft PEIS: Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions. 4-2. 11 July 2008.)

Each year, there is probably greater than a 99.9999% chance that there will be no significant oil spill from any given well. “Even on the basis of historical data without adjustment, it is important to note that large spills are comparatively rare. The annual frequency of spills being greater than 10,000 bbl (1590 m³) and 150,000 bbl (24,000 m³) respectively are approximately 10⁻⁴ (1 in 10,000) and 10⁻⁵ (1 in 100,000). This conclusion is reinforced by data... Taking into account the conservatism in the frequencies calculated above, the spill at the 10⁻⁴ per annum level is likely to be of the order of 1000 m³ or less.”

(Royal Society of Canada. Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia. Natural Resources Canada. Ottawa, 2004. 88. 11 July 2008 <http://www.rsc.ca/files/publications/expert_panels/BC_offshore/fullreportEN.pdf>.)

Even this small chance of a significant spill overestimates how likely one really is. “The results will be very conservative, since the spills associated with the frequencies above are undoubtedly overestimates of future expectations... The data include some extreme cases where it is reasonable to deduce that best practice was not used. Adjustments in the estimates have not been made for the better practices that would apply in North American jurisdictions, as against the world as a whole.”

(Royal Society of Canada. Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia. Natural Resources Canada. Ottawa, 2004. 87-88. 11 July 2008 <http://www.rsc.ca/files/publications/expert_panels/BC_offshore/fullreportEN.pdf>.)

There has not been a major oil spill from offshore drilling since 1980 and the chances of a major spill are now extremely small. “The spill rates for U.S. OCS platforms in the last 15 years could not be directly calculated because there were zero platform spills greater than or equal to 1,000 bbl during that period... This shows the U.S. OCS platform rate continues to decline in recent years, with rates for spills greater than or equal to 1,000 bbl and greater than or equal to 10,000 bbl estimated as less than 0.13 spills per Bbbl handled and less than 0.05 spills per Bbbl handled, respectively (Figs. 9 and 10).”

(Anderson, Cheryl M., and Robert P. LaBelle. "Update of Comparative Occurrence Rates for Offshore Oil Spills." Spill Science and Technology Bulletin 6 (2000): 303-21.)

The risks associated with transportation of oil continue to fall. While it is difficult to dispute that extraction activities do not pose a real risk of a major oil spill, transportation activities (e.g., tanker and pipeline) have a greater history of spills. Environmental advocacy groups almost exclusively use examples of tanker

or pipeline spills to highlight the danger of drilling. To allay such concerns the following ought to be taken into consideration: “Fortunately, spill frequency and volumes are declining due to improvements in practices, technology, and regulations despite increases in hydrocarbon production and transportation (RSC 2004; Etkin 2001; JWEL 2001; Anderson and LaBelle 2000). ITOPF (undated(a)) reported that the quantity of oil spilled globally in large (>51 barrels) spills declined from roughly 23 million barrels in the 1970s to just over 8 million barrels in the 1990s. U.S. data also show declining trends (fig. 2.2 and fig 2.3)³.” (Simon Fraser University. A Review of Offshore Oil and Gas Development in British Columbia Coastal First Nations. 2004. 19. 11 July 2008 <http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88523>.)

For every 1 billion barrels of oil transported by tankers in U.S. waters, there are 0.73 significant oil spills. “The spill rates for crude oil spills from tankers in U.S. coastal and offshore waters in the last 15 years drop significantly as compared to the entire record. Spill rates for spills greater than or equal to 1,000 bbl dropped from 1.03 to 0.73 spills per Bbbl handled, and spills greater than or equal to 10,000 bbl dropped from 0.43 to 0.25 spills per Bbbl handled. In these cases, both the “at sea” and “in port” rates decreased (Table 8; Figs. 9 and 10).” (Anderson, Cheryl M., and Robert P. LaBelle. "Update of Comparative Occurrence Rates for Offshore Oil Spills." Spill Science and Technology Bulletin 6 (2000): 303-21.)

ENVIRONMENTAL IMPACT

Acute Effects of Oil Spills

A recent draft Coast Guard Programmatic Environmental Impact Statement (PEIS) provides evidence of the low risk of acute effects from oil spills in the great majority of situations. The PEIS was conducted to determine whether the Coast Guard should change its procedures for cleaning up oil spills. Thus, it was not directed specifically at determining the environmental risks of oil spills, but that was a necessary component of the study. The Coast Guard conducted modeling for six different regions of US waters: Atlantic, Caribbean, Gulf of Mexico, Pacific, Alaska, and Oceania. The spill scenarios were analyzed for six locations within those areas that were meant to give a general idea of the environmental impact of oil spills, though not strictly representative of the regions.

The PEIS found that environmental risks associated with the vast majority of platform spills were minor. The study looked at the impact of spills on eight distinct features of the biological environment including marine mammals, marine and coastal birds, plankton and fish, intertidal habitats, subtidal habitats, sea turtles, areas of special concern, and essential fish habitats. In the case of almost

every biological feature in every geographic region the risk level associated with a small spill was overwhelmingly low, with a few cases of moderate risk depending on spill location and weather conditions. Because small spills are the vast majority of spill cases, it is reasonable to deduce that the overall risk to marine life from spills associated with extraction is relatively low.

The acute effects in the areas most likely to experience increased drilling were relatively low. In three of the six regions the risk level associated with even the largest spill was moderate. It is important to note that the three regions with this comparatively low level of risk are the three most likely to be targets of drilling: the Atlantic, Pacific, and Gulf of Mexico regions. It should be recognized, however, that within each of these regions there are likely to be areas where the risk would be significant and would have to be evaluated differently. For example, in the Atlantic region the Florida Straits are particularly vulnerable to spills, as is the San Francisco Bay area in the Pacific. Therefore, in all probability the environmental risk from accidental spills will continue to be very small because the spills that will occur are almost all insignificant in quantity and will lead to minimal environmental impacts. NOTE: This report is summarized above because all of this data is disparate in the report except in the form of tables. There is no text that summarizes all of these findings within the report.

(US Coast Guard. Draft PEIS: Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions. 11 July 2008.)

Chronic Effects of Oil Spills

NOTE: One of the more significant concerns is the hydrocarbon associated with the routine discharges of produced waters and drilling fluids and the occasional accidental spill of small amounts oil. There are several different issues with regard to the chronic toxic effects of these discharges. However, PAHs are selected for treatment here because they are the most toxic of compounds and the most prominent issue when examining chronic effects. It should also be noted that long-term effects of chronic toxicity are not well studied as noted in the National Research Council 2003 report cited in this working paper.

The most dangerous compounds associated with oil spills and routine discharges are polycyclic aromatic hydrocarbons (PAHs). “PAH includes those compounds that have the most serious environmental effects of the compounds in crude oil. PAH in the environment are derived largely from combustion of oil and coal, but are also produced by the burning of wood, forest fires, and a variety of other combustion sources...Of the hydrocarbon compounds common in petroleum, PAH appear to pose the greatest toxicity to the environment.”

(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 20. 11 July 2008 <http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

Drilling activities do not contribute large amounts of PAHs. Compared to other sources of PAHs, oil spills and other discharges from drilling contribute very little to the marine environment. Thus, the chronic toxicity effects of oil drilling are not substantial. “Extraction activities do not appear to be an important source of PAH. Less than 2 percent of the 5,000 tonnes of PAH entering the marine environment comes from petroleum extraction (Table 2-4). Extraction activities release about 0.07 thousand tonnes of PAH to marine waters in North America, with 74 percent associated with produced water discharges.”

NOTE: See Appendix for table of all numerical values for PAH inputs.

(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 38. 11 July 2008 <http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

SECTION II: DRILLING DISCHARGES

PRODUCED WATER IS NOT A SIGNIFICANT THREAT TO MARINE LIFE IN WELL-MIXED WATERS

GENERAL INFORMATION

Produced water results from drilling and contains petroleum. “...reservoir rocks normally contain both petroleum hydrocarbons (liquid and gas) and water...This water is frequently referred to as “connate water” or “formation water” and becomes produced water when the reservoir is produced and these fluids are brought to the surface. Produced water is any water that is present in a reservoir with the hydrocarbon resource and is produced to the surface with the crude oil or natural gas.”

(Veil, John A., et. al. A White Paper Describing Produced Water From Production of Crude Oil, Natural Gas, and Coal Bed Methane. Argonne National Laboratory, Department of Energy. 2004. 1. 11 July 2008 <<http://www.ead.anl.gov/pub/doc/ProducedWatersWP0401.pdf>>.)

Produced water is the largest contributor of petroleum to the sea from oil extraction activities. “Over 90 percent of the inputs from extraction activities are from produced water discharges (Fig. 2-5), which release low but continuous amounts of dissolved components and dispersed crude oil (Utvik, 1999).”

(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 38. 11 July 2008 <http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

Produced water dilutes rapidly. “Saline produced waters dilute rapidly upon discharge to well-mixed marine waters. Dispersion modeling studies of the fate of produced water differ in specific details but all predict a rapid initial dilution of discharges by 30- to 100-fold within the first few tens of meters of the outfall, followed by a slower rate of dilution at greater distances (Smith, 1993; Terrens and Tait, 1993; Strømgren et al., 1995; Brandsma and Smith, 1996).”

(Neff, Jerry M. Bioaccumulation in Marine Organisms: Effects of Contaminants From Oil Well Produced Water. Elsevier, Ltd., 2002. 19.)

DANGEROUS COMPOUNDS

BTEX compounds are of great concern and are toxic. “The monoaromatic hydrocarbons of greatest concern in the environment are benzene, toluene, ethylbenzene, and *m*-, *p*-, and *o*-xylenes (BTEX) (Figure 9).”

“BTEX is the collective name for benzene, toluene, ethyl benzene, and xylenes, the volatile aromatic compounds often found in discharges, and petroleum oils and products (Wang and Fingas, 1996)...BTEX compounds are acutely toxic to aquatic organisms if contact is maintained...BTEX are generally neurotoxic to target organisms. Benzene, in particular, has also been found to be carcinogenic to mammals and humans.”

(Neff, Jerry M. Bioaccumulation in Marine Organisms: Effects of Contaminants From Oil Well Produced Water. Elsevier, Ltd., 2002. 225.)

(National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 127. 11 July 2008 <http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

BTEX compounds in produced water disperse quickly. “... [BTEX] compounds dilute very rapidly in the receiving water environment following discharge of produced water to the ocean. The water quality criteria for individual monocyclic aromatic hydrocarbons, intended to protect marine organisms and their consumers, including man, are virtually never exceeded in marine waters near produced water discharges...”

(Neff, Jerry M. Bioaccumulation in Marine Organisms: Effects of Contaminants From Oil Well Produced Water. Elsevier, Ltd., 2002. 239.)

PAHs in produced water normally exist at safe levels. “Slightly elevated (compared to background) concentrations of PAHs were detected in samples collected up to 10 km from the platforms. Dilution modeling showed that most of the produced water plume was restricted to the upper 15 to 20 m of the water column. Dilution was very rapid. Potentially toxic concentrations and contact times of hydrocarbons were not predicted even in the near-field.”

“The low molecular weight PAHs characteristic of produced water are less toxic and are released more rapidly from tissues than the higher molecular weight PAHs. Therefore, they rarely represent a significant hazard to marine organisms at the concentrations at which they occur in the receiving waters of an offshore production platform.”

(Neff, Jerry M. Bioaccumulation in Marine Organisms: Effects of Contaminants From Oil Well Produced Water. Elsevier, Ltd., 2002. 24,318.)

However, it is important to remember that long-term effects are not known.

“Besides, and this is critically important, the long-term biological effects of low concentrations of produced waters have not been studied yet. Research in this direction may radically change the presently dominating concept about the insignificance of ecological disturbances in the marine environment caused by produced waters.”

NOTE: The author of this passage, while well-respected in his field, can be considered an alarmist in many of his conclusions. This passage is added to point out the potential environmental impact of produced water in the long-term, but the research reviewed and the experts interviewed for this working paper do not seem to support the idea that such long-term consequences would be the catastrophe this passage implies.

(Wills, Jonathan. Muddied Waters: a Survey of Offshore Oilfield Drilling Wastes and Disposal Techniques to Reduce the Ecological Impact of Sea Dumping. Sakhalin Environment Watch. 2000. 71. 11 July 2008 <<http://www.alaskaforum.org/other/muddiedwaters.pdf>>.)

DRILLING MUDS ARE NOT A SIGNIFICANT THREAT TO MARINE ORGANISMS

GENERAL INFORMATION

Drilling muds are a necessary part of extraction. “Drilling muds of the types permitted for offshore discharge are mixtures of natural clays, weighting agents, and other ingredients in seawater or freshwater. They are essential to successful drilling of a well because they provide lubrication and help carry drill cuttings to the surface and control well pressure.”

“Currently, the industry discharges both WBM [water-based mud] or SBM [synthetic-based mud] drill cuttings over the side, as well as re-injecting OBM [oil-based mud] drill cuttings into a permitted disposal well.”

(Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002. iv-v.)

(Jacques Whitford Environment Limited. British Columbia Offshore Oil and Gas Technology Report. British Columbia Ministry of Energy and Mines. 2001. 100. 11 July 2008 <<http://www.offshoreoilandgas.gov.bc.ca/reports/jwl-report/>>.)

Oil-based muds are strictly limited in US waters. See Table 1 of Appendix E from the below source for full description of discharge criteria and limitations. These make clear that OBMs are not a significant issue when discussing drilling discharges in US waters.

(Final NPDES General Permit for New and Existing Sources and New Dischargers in the Offshore Subcategory of the Oil and Gas Extraction Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000). Environmental Protection Agency. 2004. <<http://www.epa.gov/region6/water/npdes/genpermit/gmg290000finalpermit2004.pdf>>.)

SYNTHETIC-BASED MUDS

Some research has disputed the safety of discharging SBMs into the sea.

“SBM tests in the UK suggested these fluids, with the possible exception of one, were no better than OBM and seabed studies confirmed this...”

“The same point was made by OSPAR’s Working Group on Sea-Based Activities (SEBA), meeting in Amsterdam on 14 – 18 February 2000⁸², which noted “the report

(SEBA 96/5/1) that recently developed synthetic drilling fluids are likely to persist when discharged into the marine environment at high concentration on drill cuttings where anaerobic conditions develop.”

(Wills, Jonathan. Muddied Waters: a Survey of Offshore Oilfield Drilling Wastes and Disposal Techniques to Reduce the Ecological Impact of Sea Dumping. Sakhalin Environment Watch. 2000. 51-52. 11 July 2008 <<http://www.alaskaforum.org/other/muddiedwaters.pdf>>.)

SBM discharges are tightly regulated. “EPA used a two part approach to control SBF-cuttings discharges: (1) product substitution through use of stock limitations (e.g., sediment toxicity, biodegradation, polynuclear aromatic hydrocarbons content, metals content) and discharge limitations (e.g., diesel oil prohibition, formation oil prohibition, sediment toxicity, aqueous toxicity); and (2) control of the quantity of SBF discharged with SBF-cuttings. EPA finds that the second part is particularly important because limiting the amount of SBF content in discharged cuttings controls: (1) the amount of SBF discharged to the ocean; (2) the biodegradation rate of discharged SBF; and (3) the potential for SBF-cuttings to develop cuttings piles and mats which are detrimental to the benthic environment.”

(Johnston, Carey A. U.S. EPA Regulation of the Offshore Oil and Gas Extraction Industry. Presented to SEMARNA/PEMEX Seminar, Veracruz, Mexico. Office of Water, Environmental Protection Agency. 2003. p. 6-7)

SBMs pose no risk to water column organisms. “Because of the rapid descent of the cuttings, very little SBF base chemical dissolves or is dispersed in the water column... Thus, there is no risk of a toxic response in water column organisms from exposure to SBF cuttings settling through the water column.”

(Neff, Jerry M., S McKelvie, and Robert C. Ayers, Jr. Environmental Impacts of Synthetic Based Drilling Fluids. Minerals Management Service, Department of Interior. New Orleans, 2000. 64. 11 July 2008 <<http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3175.pdf>>.)

Benthic communities are not threatened by controlled SBM discharges in the long-term. “Synthetic-based drill cuttings are biodegradable...Monitoring studies have shown that synthetic-based cuttings have little or no affect on benthic communities outside a radius of 250 m...”

“It is probable that within three to five years of cessation of SBF cuttings discharges, concentrations of SBFs in sediments will have fallen to low enough levels and oxygen concentrations will have increased enough throughout the previously affected area that complete recovery will be possible...”

(Jacques Whitford Environment Limited. British Columbia Offshore Oil and Gas Technology Report. British Columbia Ministry of Energy and Mines. 2001. 101. 11 July 2008 <<http://www.offshoreoilandgas.gov.bc.ca/reports/jwl-report/>>.)

(Neff, Jerry M., S McKelvie, and Robert C. Ayers, Jr. Environmental Impacts of Synthetic Based Drilling Fluids. Minerals Management Service, Department of Interior. New Orleans, 2000. 67. 11 July 2008 <<http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3175.pdf>>.)

WATER-BASED MUDS

Some scientists dispute the safety of WBMs. “Patin says water-based drilling muds, while preferred over OBMs or SBMs for obvious environmental reasons, can still damage marine life. Leaving aside the question of toxicity, WBMs deposited on seabed sediments may smother benthic animals and, if in the form of very fine particles suspended in the water, can interfere with respiration in small marine animals and pelagic fish.”

(Wills, Jonathan. Muddied Waters: a Survey of Offshore Oilfield Drilling Wastes and Disposal Techniques to Reduce the Ecological Impact of Sea Dumping. Sakhalin Environment Watch. 2000. 47. 11 July 2008 <<http://www.alaskaforum.org/other/muddiedwaters.pdf>>.)

The impact of WBM discharges on the water column is minimal and of short duration. “Given the wide dispersal of dissolved and solid components of WBM and cuttings discharges to the ocean, and the low toxicity of WBM that do not contain high concentrations of petroleum products, one would expect that impacts of these discharges on the water column and benthic environment would be minimal and of short duration.”

(Neff, Jerry M. Composition, Environmental Fates, and Biological Effects of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment: a Synthesis and Annotated Bibliography. Petroleum Environmental Research Forum & American Petroleum Institute. Battelle, 2005. 47.)

The impact of WBM discharges on benthic communities is minimal and of short duration. “The studies discussed above as well as several others show that significant effects of drilling waste discharges on benthic ecosystems occur only when large amounts of solids accumulate on the bottom near the discharge site

(shallow-water or shunted discharges to low-energy benthic environments) or the solids accumulations on the bottom (cuttings pile) contain a high concentration of biodegradable organic matter...Recovery begins as soon as discharge of drilling wastes is completed and often is well advanced within a year. However, it may be delayed until concentrations of biodegradable organic matter decrease through microbial biodegradation to the point where surface layers of sediment become oxygenated (Hartely et al., 2003).”

(Neff, Jerry M. Composition, Environmental Fates, and Biological Effects of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment: a Synthesis and Annotated Bibliography. Petroleum Environmental Research Forum & American Petroleum Institute. Battelle, 2005. 55-56.)

NOTE: As a general note, there are myriad regulations that pertain to drilling discharges and ensure that they exist at safe levels in the marine environment. For a detailed look at these rules, see: Johnston, Carey A. U.S. EPA Regulation of the Offshore Oil and Gas Extraction Industry. Presented to SEMARNA/PEMEX Seminar, Veracruz, Mexico. Office of Water, Environmental Protection Agency. 2003.

MERCURY INPUT RESULTING FROM DRILLING IS NOT AN ENVIRONMENTAL THREAT

GENERAL INFORMATION

Mercury is released into the sea via barite in drilling muds. “The weighting agent is added to increase the density of the mud to counteract high pressures in the geologic formations and thus prevent a blowout. Barite (barium sulfate: BaSO₄), a dense natural mineral, is used most frequently as a weighting agent in drilling muds. It is the primary source of mercury in drilling muds because mercury is found in naturally occurring trace minerals in barite deposits.”

(Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002. iv-v.)

Mercury is only of significant concern if it is methylated. “If sediment bacteria cannot accumulate and transform this mercury into methylmercury (i.e., methylate it), the mercury from barite and drilling cuttings is unlikely to accumulate in the tissues of other marine organisms near the platform.”

“To get into the fish we eat, mercury must first be converted to the organic methylmercury form.”

(Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002. v.)

(Boatman, Mary. "Mercury and the Results from the Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX)." Paper presented to conference. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003. p. 1)

Environmental advocacy groups allege that drilling activities release dangerous levels of mercury and other metals. "Oil and gas operations dump more than 1 billion pounds of mercury-contaminated drilling fluids into the Gulf each year. Mercury levels in the sand around some Gulf rigs are three times higher than levels found at EPA Superfund sites where fishing is prohibited. Mercury levels in marine creatures living around these rigs are at least 25 times higher than in fish found elsewhere in the Gulf...A single production platform, which can drill 50-100 wells, discharges over 90,000 metric tons of drilling fluid and metal cuttings into the ocean. A single exploratory well dumps approximately 25,000 pounds of toxic metals into the ocean."

NOTE: The source of these figures is not given by any advocacy group researched for this working paper. It is possible that they come from an investigative series done by the *Mobile Register* about mercury levels in the Gulf of Mexico in 2002.

("Offshore Drilling." Sierra Club, Florida Chapter. 11 July 2008
<<http://florida.sierraclub.org/offshore.asp>>.)

BIOAVAILABILITY

The mercury contained in barite is not easily dissolved. "The mercury present in drilling muds is contained in insoluble barite. It is present in the barite as minute particles of sulfide minerals that also are highly insoluble. Thus, the mercury associated with drilling mud barite and cuttings cannot dissolve in the seawater."

(Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002. v.)

The mercury contained in barite is not easily absorbed by marine organisms. "Synthesis of published research indicates that mercury in [the] discharged drilling fluid barite [is] not easily transferred either to the water column or to exposed marine organisms. Leaching of Hg into seawater [is] insignificant even from barite with high Hg levels."

(Trefry, John. and Smith, J.P. "Forms of Mercury in Drilling Fluid Barite and Their Fate in the Marine Environment-A Review and Synthesis." PowerPoint presentation. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003. Slide 15)

LEVELS OF MERCURY

Drilling contributes very small amounts of mercury to the sea. The above figure of 1 billion pounds quoted by environmental advocacy groups takes into account both the weight of mercury contributed by offshore drilling and the weight of the contaminated fluids themselves. But as research demonstrates, the actual amount of mercury that is contributed by drilling is far smaller: “About 338 pounds of mercury was discharged to the Gulf of Mexico in 2001 in drilling mud and cuttings used or generated during drilling of 900 wells in offshore waters (discharges were not permitted from rigs drilling in state waters)...Thus, the total estimated amount of mercury discharged to the Gulf of Mexico from offshore oil and gas activities each year is about 0.7% of the amount entering the Gulf from the Mississippi River.”

(Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002. v.)

Mercury levels around offshore platforms can be elevated at times but not at significant levels. “Barium (from barite) and mercury have been measured in sediments around a number of nearshore and offshore platforms in the Gulf of Mexico...At virtually every other platform studied in U.S. waters, mercury concentrations in sediments near the platforms were less than 0.5 ppm, only slightly above background levels (which usually are below 0.15 ppm).”

(Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002. v-vi.)

Mercury levels in marine organisms near platforms are not elevated.

“...platforms do not support enhancement of mercury in marine organisms...Biological data indicated that mercury bioaccumulation is not enhanced near platforms. The GOOMEX study data does not support the conclusion that discharges from platforms leads to elevated levels of mercury in fish.”

(Boatman, Mary. “Mercury and the Results from the Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX).” PowerPoint presentation. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003. Slides 30-31)

Methylmercury levels are not elevated around oil rigs. “Overall, the statistical results from this study of six offshore drilling sites, coupled with data from sites EI346 and EW963 that show lower levels of MeHg in some [nearfield] sediments than [farfield] sediments, suggest that elevated levels of MeHg in sediments around drilling platforms are not a wide-spread phenomenon.”

(Trefry, John, et. al. “Concentrations of Total Mercury and Methylmercury in Sediment Adjacent to Offshore Drilling Sites in the Gulf of Mexico.” Final Report to the Synthetic Based Muds (SBM) Research Group. p. 43. ONLINE. November 2002. Available: https://www.mms.gov/homepg/regulate/enviro/ongoing_studies/gm/MeHgFinal10_25.pdf)

SECTION III: HURRICANES AND SEISMIC SURVEYS

HURRICANES DO NOT CREATE A SIGNIFICANT THREAT OF DANGEROUS OIL SPILLS

KATRINA AND OIL SPILLS

After Hurricane Katrina, spills from oil rigs were minimal and resulted in no significant harm. “The loss of hydrocarbons from wells on the Federal OCS was minimal due to the successful operation of the safety valves that are required to be installed at least 100 feet below the mudline in each wellbore. All OCS facilities in areas threatened by the storms’ approach were shut in prior to the hurricanes so that oil losses were mostly limited to the oil stored on the damaged structures or contained in the individual damaged pipeline segments. There were no accounts of spills from facilities on the Federal OCS that: reached the shoreline; oiled birds or mammals; or involved any discoveries of large volumes of oil to be collected or cleaned up.”

(Minerals Management Service. Estimated Petroleum Spillage From Facilities Associated with Federal Outer Continental Shelf (OCS) Oil and Gas Activities Resulting From Damages Caused by Hurricanes Rita and Katrina in 2005. Department of Interior. 2006. 1. 11 July 2008 <<http://www.mms.gov/incidents/PDFs/HurrKatrinaRitaSpillageRev8thAug2006.pdf>>.)

Any spills resulting from Katrina were small in volume. “As of August 8, 2006, MMS has identified 124 spills...on the Federal OCS as a result of damages from Hurricanes Katrina and Rita in 2005. Using the USCG size classifications for offshore spills, 110 of the spills or 89% were MINOR in size (less than 238 bbl), and 14 or 11% were MEDIUM in size (238 to 2,380 bbl). There were no MAJOR spills (2,381 bbl or greater).”

(Minerals Management Service. Estimated Petroleum Spillage From Facilities Associated with Federal Outer Continental Shelf (OCS) Oil and Gas Activities Resulting From Damages Caused by Hurricanes Rita and Katrina in 2005. Department of Interior. 2006. 1. 11 July 2008 <<http://www.mms.gov/incidents/PDFs/HurrKatrinaRitaSpillageRev8thAug2006.pdf>>.)

NEW REGULATIONS

New regulations have been put in place to make oil platforms more durable during hurricanes and prevent more oil from spilling. “Building on improvements made prior to the 2007 hurricane season, such as new guidance documents focusing on enhanced design standards and a Web site dedicated to hurricane information, MMS incorporated three API bulletins containing the enhanced design standards as well as assessment criteria for both new and existing structures in the Gulf of Mexico into a final rule that becomes effective

today, May 15, 2008. The new criteria will increase platform survivability during hurricane conditions and result in fewer damaged platforms.”

(“MMS Prepares for 2008 Hurricane Season.” MMS Press Release. 15 May 2008. Minerals Management Service. 11 July 2008

<http://www.gomr.mms.gov/homepg/whatsnew/newsreal/2008/080515.pdf>)

The new regulations build sturdier and more reliable platforms and strengthen tie-downs to keep equipment on platforms. In strengthening tie-downs, equipment containing petroleum (such as tanks containing drilling muds) will be less likely to fall into the sea and contaminate the area. “Ensure that you design the decks of all new L-1 and L-2 platforms and related structures to a height equal to or greater than the HWE. *Apply the local random wave crest factor (15%) to the wave crest elevation only. Do not apply the factor for the local random wave crest to tide, surge, or loads.* Do not omit the 5-foot air gap in the design of new structures... When designing equipment tie-downs that are expected to operate anywhere in the GOM, use the conditions set forth in API Bulletin 2INT-MET for the Central Region. If a tie-down is expected to be used solely in one location, you may use site-specific metocean conditions. Refer to Section 4.2 of API Bulletin 2INT-DG when factoring motions associated with tie-downs and platforms.”

(Herbst, Lars T. Minerals Management Service. Department of Interior. Notice to Lessees and Operators of Federal Oil and Gas Leases and Pipeline Right-of-Way Holders in the Outer Continental Shelf (OCS), Gulf of Mexico OCS Region: Design of New OCS Platforms and Related Structures for Hurricane Conditions. 1 Oct. 2007. 4. 11 July 2008

<<http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2007NTLs/07-g26.pdf>>.)

SEISMIC WAVES DO NOT APPEAR TO CAUSE SIGNIFICANT OR LONG-TERM DAMAGE TO MARINE MAMMAL OR FISH POPULATIONS

GENERAL INFORMATION

Seismic surveys are necessary for oil exploration. “Seismic surveys are routinely conducted in offshore [exploration and production] operations to define subsurface geological structure. The use of seismic data is essential for defining drilling locations. Currently, using the seismic survey method described below is the only feasible technology available to accurately prospect for offshore hydrocarbon reserves. The aim is to prevent drilling “dry holes” (where there is no oil or gas present) and avoid inefficient recovery from producing fields – both of which may carry significant environmental costs.”

(International Association of Geophysical Contractors and International Association of Oil and Gas Producers. Seismic Surveys and Marine Mammals: Joint OGP/IAGC Position Paper. 2004. 3.)

There is a major difference between sonar and seismic surveys. “Seismic pulses and mid-frequency sonar signals are quite different. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid-frequency sonars emit non-impulse sounds at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time (though the frequency may change over time). Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals.”

NOTE: This is an important distinction to make because many environmental advocacy groups blur the line between the two types of sound tests and imply that the increasingly disconcerting research on sonar impacts applies to seismic surveys as well.

(Abgrall, Patrick, Valerie Moulton, and W. John Richardson. Updated Review of Scientific Information on Impacts of Seismic Survey Sound on Marine Mammals, 2004-Present. Department of Fisheries and Oceans, Habitat Science Branch. LGL Limited, Environmental Research Associates, 2008. 2. 11 July 2008
<http://www.iagc.org/attachments/contentmanagers/1045/LGL_document_DFO_Updated_Seismic_Mar_Mam_Review_VF_2008_03.pdf>.)

FISH

Some studies have shown significant displacement of fish resulting from seismic waves. “Seismic shooting severely affected fish distribution, local abundance, and catch rates in the entire investigation area of 40 ´ 40 nautical miles. Trawl catches of cod and haddock and longline catches of haddock declined on average by about 50% (by mass) after shooting started... Reductions in catch rates were observed 18 nautical miles from the seismic shooting area (3 ´ 10 nautical miles), but the most pronounced reduction occurred within the shooting area, where trawl catches of both species and longline catches of haddock were reduced by about 70% and the longline catches of cod by 45%...” (Engas, Arill, Svein Lokkenborg, Engil Ona, and Aud Vold Soldal. "Effects of Seismic Shooting on Local Abundance." Canadian Journal of Fisheries and Aquatic Sciences (1996): 2238.)

There is evidence that prolonged exposure to seismic pulses damages fish hearing.

“...the ears of fish exposed to an operating air-gun that was moved toward and away from the animals sustained extensive damage to their sensory epithelia that was apparent as ablated hair cells. The damage was regionally severe and there was no evidence of repair or replacement of damaged sensory cells up to 58 days after exposure.”

NOTE: The results of this study have been criticized as dubious due to the fact that the fish were caged and forcefully exposed to the air gun arrays. Under real-world conditions in which the fish would be able to escape as the array neared them it is unlikely that fish would stay in place and endure the hearing damage

associated with proximity to the array. As indicated below, research has shown that studied fish flee when seismic survey vessels approach.

(McCauley, Robert D., Jane Fewtrell, and Arthur N. Popper. "High Intensity Anthropogenic Sound Damages Fish Ears." Journal of the Acoustic Society 113 (2003): 638.)

The Minerals Management Service (MMS) found the impact of seismic surveys on fish was negligible. "Neither seismic surveys nor other [geological and geophysical] activities are expected to cause long-term or permanent displacement of any listed species (i.e., smalltooth sawfish and Gulf sturgeon) from critical habitat or other preferred habitat, nor to result in destruction or adverse modification of critical habitat or EFH. Therefore, potential impacts to fish resources will be negligible most of the time, with occasional impacts being potentially adverse but not significant (e.g., when fish in very close proximity to an airgun array cannot avoid exposure to seismic survey noise)."

NOTE: This study was limited to investigating Gulf of Mexico fish and may not be applicable to all fish populations. However, it at least gives a good indication of what the effect of seismic surveys might be at least where seismic surveys are relatively common. Furthermore: "Fishes of the GOM are generally representative of the species for which quantitative hearing data are available."

(Continental Shelf Associates. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Department of Interior. New Orleans: Minerals Management Service, 2004. III-44, III-46.)

Seismic surveys are unlikely to permanently damage fish hearing. "The seismic sound waves may cause short-term (temporary) hearing damage to fish. These effects vary by species, with distance from airgun arrays, and in relationship to sound wave characteristics, among other factors. Given that fish avoid seismic noise, fish will not likely be exposed to levels of sound from an airgun array high enough to cause hearing damage. (LGL Ltd., Orphan Basin SEA Report, 2003)."

NOTE: Evidence is less certain regarding multiple exposures to seismic surveys as it relates to temporary hearing loss, as there is simply not enough known to make a definitive statement one way or the other.

(Peterson, David L. Background Briefing Paper for a Workshop on Seismic Survey Operations: Impacts on Fish, Fisheries, Fishers and Aquaculture. British Columbia Seafood Alliance. 2004. 6. 11 July 2008
<<http://www.em.gov.bc.ca/DL/offshore/Reports/BCSeafoodAlliance/SeismicAndFisheriesBriefingDoc.pdf>>.)

Seismic surveys are unlikely to harm fish population levels. "If we look at the seismic mortality in relation to natural mortality for these life stages, we get the following connections: For species such as cod, herring and capelin, the natural mortality is estimated at 5-15% per day of the total population for eggs and larvae. The daily natural mortality is reduced to 1-3% until the 0 group stage is achieved, i.e. when the fish has reached approx. one-half year in age (Sætre and Ona, 1996). Consequently, the seismic-created mortality for these species and

other commercial species in Norwegian waters is so low that it is not considered to have any (significant) negative impact on recruitment to the populations (Dalen et al., 1996).”

(Dalen, John, Egil Dragsund, Arne Naess, and Olav Sand. Effects of Seismic Surveys on Fish, Fish Catches, and Sea Mammals. Cooperation Group-Fishery Industry and Petroleum Industry. DNV Energy, 2007. 13. 11 July 2008 <<http://www.olf.no/?50345.pdf>>.)

However, it should be noted that most literature points to a decrease in local fish abundance during seismic testing, which can have an economic impact.

“For a long time, fishers have expressed concern that certain types of geophysical surveys conducted in fishery areas led to smaller catches. Scientific studies have been conducted to examine and quantify such effects from firing air guns (Dalen and Raknes, 1985; Malme et al., 1986a; Pearson et al., 1987; Skalski et al., 1992; Løkkeborg and Soldal, 1993; Engås et al., 1996; i Jakupsstovu et al., 2001). All of these studies demonstrated catch reductions during the course of the air gun shooting, compared with catches before the shooting began.”

(Dalen, John, Egil Dragsund, Arne Naess, and Olav Sand. Effects of Seismic Surveys on Fish, Fish Catches, and Sea Mammals. Cooperation Group-Fishery Industry and Petroleum Industry. DNV Energy, 2007. 15. 11 July 2008 <<http://www.olf.no/?50345.pdf>>.)

MARINE MAMMALS

There are indications that seismic surveys might displace marine mammals.

“Results showed the main effect of condition was significant, with both the number of whales and the number of pods during pre- and post-seismic conditions significantly differing from the seismic condition...Disruption of feeding in preferred areas is a biologically significant event that could have major negative effects on individual whales, their reproductive success, and thus the population as a whole.”

(Weller, David W., Yulia V. Ivashchenko, Grigory A. Tsidulko, Alexander M. Burdin, and Robert L. Brownell, Jr. Influence of Seismic Surveys on Western Gray Whales Off Sakhalin Island, Russia. International Whaling Commission. 2002. 1. 11 July 2008 <http://www.livingoceans.org/_pvwC21CD930/files/PDF/energy/Gray_whales_and_seismic.pdf>.)

Some scientists believe seismic surveys can damage the hearing of marine mammals and mask important sounds. “[Seismic surveys] represent the most severe acoustic insult to the marine environment I can imagine short of naval warfare...In cases where there is seismic exploration activity, the noise is so loud that it drowns out whale songs and contact calls...”

“Certainly, within a zone of many kilometres around a seismic source, significant behavioral impacts will occur. These include masking of biologically significant sounds such as those used for communication and finding food, or avoiding predators, or getting out of the way of a ship barreling along at 20 knots. The fin

whale carcass that ended up on the bow of a cruise ship in Vancouver harbour a few years ago tells us these kinds of tragedies do occur.”

(Clark, Christopher W. “Dr. Chris Clarke's Testimony At Cape Breton Hearings on Seismic Testing.” 2001. 2, 4. 11 July 2008

<http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88118>.)

(Spong, Paul. "Dr. Paul Spong's Submission to the Priddle Hearings on the BC Moratorium." 11 May 2004. 3. 11 July 2008

<http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88120>.)

There are coincidences hinting at strandings resulting from seismic surveys.

“Two incidents hint at the possibility of similar links between air guns and beaked whale strandings. In 2002 two beaked whales were found stranded in the Gulf of California close to an area in which a scientific survey, using a powerful air gun array, was being conducted by the RV *Maurice Ewing* (Malakoff, 2002). The same vessel had been potentially linked to a beaked whale stranding event in the Galapagos in 2000 (Gentry, 2002). It should be stressed that a causal link was not established in either case, but concern was sufficient for U.S. courts to agree to a restraining order until a more complete investigation could be completed. This is perhaps the strongest indication that air guns could lead directly to stranding and cetacean mortality.”

(Gordon, Jonathan, Douglas Gillespie, John Potter, Alexandros Frantzis, Mark P. Simmonds, Rene Swift, and David Thompson. "A Review of the Effects of Seismic Surveys on Marine Mammals." Marine Technology Society Journal 37 (2004): 18.)

Research indicates that whale displacement resulting from seismic surveys is temporary, though the length of displacement can vary.

“...there is no evidence to suggest that seismic surveys are displacing marine mammals either permanently or for significant periods of time from areas of the GOM, including those areas that may serve as important habitat (i.e., critical or preferred habitats)...Generally, it is presumed that a spatial displacement of marine mammals from a specific seismic survey's “zone of responsiveness” would be expected to be short-term in duration.”

“These results suggest that whales shifted their distribution into the scan area (i.e. from the north to the south) and away from the northern region where seismic surveys were conducted between 1 August and 8 September. Once the seismic surveys had ceased on 9 September, overall whale and pod numbers in the scan area returned to pre-seismic levels, suggesting that whales had reoccupied the region from which they had been displaced.”

(Continental Shelf Associates. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Department of Interior. New Orleans: Minerals Management Service, 2004. III-26.)

(Weller, David W., Yulia V. Ivashchenko, Grigory A. Tsidulko, Alexander M. Burdin, and Robert L. Brownell, Jr. Influence of Seismic Surveys on Western Gray Whales Off Sakhalin Island, Russia. International Whaling Commission. 2002. 5. 11 July 2008

<http://www.livingoceans.org/_pvwC21CD930/files/PDF/energy/Gray_whales_and_seismic.pdf>.)

Evidence indicates that seismic surveys are highly unlikely to permanently harm marine mammal hearing. "...there has been no specific documentation that TTS [temporary threshold shift] let alone PTS [permanent threshold shift] occurs when marine mammals are exposed to sequences of airgun pulses under realistic field conditions...DFO (2004a) concluded that the significance of TTS effects from seismic surveys on marine mammals exposed to is likely to be unimportant. Most cetaceans show some degree of avoidance of seismic vessels operating an airgun array. It is unlikely that these cetaceans would be exposed to airgun pulses at a sufficiently high level for a sufficiently long period to cause more than mild TTS...Commonly applied monitoring and mitigation measures, including visual monitoring, ramp-ups, and power-downs/shutdowns of the airguns when mammals are seen within the "safety radii", are expected to minimize the already-low probability of exposure of cetaceans to sounds strong enough to potentially induce PTS."

(Abgrall, Patrick, Valerie Moulton, and W. John Richardson. Updated Review of Scientific Information on Impacts of Seismic Survey Sound on Marine Mammals, 2004-Present. Department of Fisheries and Oceans, Habitat Science Branch. LGL Limited, Environmental Research Associates, 2008. 2, 6, 8. 11 July 2008
<http://www.iagc.org/attachments/contentmanagers/1045/LGL_document_DFO_Updated_Seismic_Mar_Mam_Review_VF_2008_03.pdf>.)

Evidence in support of the idea that seismic surveys cause strandings is very thin. "There is no conclusive evidence of cetacean strandings as a result of exposure to seismic surveys...In Sept. 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the Lamont-Doherty Earth Observatory (L-DEO) seismic vessel R/V *Maurice Ewing* was operating a 20-airgun, 8490-in3 airgun array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth 2002; Yoder 2002). Nonetheless, that plus the incidents involving beaked whale strandings near naval exercises involving use of mid-frequency sonar suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales."

"There are no regular mass strandings or other similar events that may be attributed to impacts associated with seismic activities on the continental shelf of the northern Gulf, though seismic surveys have been occurring there with some regularity for decades."

(Abgrall, Patrick, Valerie Moulton, and W. John Richardson. Updated Review of Scientific Information on Impacts of Seismic Survey Sound on Marine Mammals, 2004-Present. Department of Fisheries and Oceans, Habitat Science Branch. LGL Limited, Environmental Research Associates, 2008. 2. 11 July 2008

<http://www.iagc.org/attachments/contentmanagers/1045/LGL_document_DFO_Updated_Seismic_Mar_Mam_Review_VF_2008_03.pdf>.)

(Continental Shelf Associates. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Department of Interior. New Orleans: Minerals Management Service, 2004. III-26.)

A comprehensive environmental assessment by MMS found no significant impact results from seismic surveys on marine organisms in areas of high

seismic survey activity. “Based on established significance criteria, the results of the impact analyses are that [geological and geophysical] activities are not expected to result in significant adverse impacts to any of the potentially affected resources. Potentially adverse but not significant impacts were identified for marine mammals (except the manatee) and commercial and recreational fishing; negligible to potentially adverse but not significant impacts were identified for sea turtles, fish, and benthic communities...”
(Continental Shelf Associates. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Department of Interior. New Orleans: Minerals Management Service, 2004. i.)

Attention should be paid toward seals as new evidence suggests it is possible they may be particularly susceptible to hearing damage under current regulations. However, it is also important to note that seals only inhabit about half of U.S. OCS waters (roughly New England, the Pacific Coast, and Alaska). “We assumed that the known pinniped-to-cetacean difference in TTS-onset upon exposure to nonpulse sounds would also apply (in a relative sense) to pulses. Specifically, with nonpulse sounds, harbor seals experience TTS-onset at *ca.* 12 dB lower RLs than do belugas (i.e., 183 vs 195 dB re: 1 μ Pa²-s; Kastak et al., 1999, 2005; Southall et al., 2001; Schusterman et al., 2003 vs Finneran et al., 2000, 2005a; Schlundt et al., 2000; Nachtigall et al., 2003, 2004). Assuming that this difference for nonpulse sounds exists for pulses as well, TTS-onset in pinnipeds exposed to single underwater pulses is estimated to occur at a peak pressure of 212 dB re: 1 μ Pa (peak) and/or an SEL exposure of 171 dB re: 1 μ Pa²-s. Each of these metrics is 12 dB less than the comparable value for mid-frequency cetaceans (see Finneran et al., 2002b, and above).”

(Southall, Brandon L., Ann E. Bowles, William T. Ellison, James J. Finneran, Roger L. Gentry, Charles R. Greene Jr., David Kastak, Darlene R. Ketten, James H. Miller, Paul E. Nachtigall, W. J. Richardson, Jeanette A. Thomas, and Peter L. Tyack. "Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations." Acquatic Mammals 33 (2007): 411-521)

SECTION IV: OTHER CONCERNS

EXTRACTION ACTIVITIES DO NOT POSE A SUBSTANTIAL RISK TO MIGRATORY BIRDS, THOUGH THEIR DANGER TO SEABIRDS IS UNKNOWN

GENERAL INFORMATION

Oil is particularly deadly for birds. “An obvious negative influence around oil platforms is the intermittent presence of oil on the water. The hydrophobic nature of oil causes plumage to lose water-proofing, insulation and buoyancy, resulting in death due to hypothermia, exhaustion and

starvation. Oil is ingested and inhaled while preening feathers (Birkhead *et al.*, 1973; Stout, 1993) or by ingesting contaminated prey (e.g. fish around oil platforms, Davies and Bell, 1984), reducing survival and lifetime reproductive success (Leighton, 1990; Khan and Ryan, 1991; Frink and Miller, 1995; Hartung, 1995). The resultant increases in mortality and decreases in recruitment rates create potential effects on population trends.” (Wiese, Francis K., W A. Montevicchi, G K. Davoren, F Huettmann, A W. Diamond, and J Linke. "Seabirds At Risk Around Offshore Oil Platforms in the North-West Atlantic." Marine Pollution Bulletin 42 (2001): 1286.)

Birds are attracted to the lights and flares on a platform which may cause death. “Whether by instinct or learned capacity to associate light and smell with food, seabirds have been known to circle platforms and the flare for days eventually dying of starvation (Bourne, 1979). Storm-petrels often fly directly into lights (Terres, 1956; Weir, 1976; Crawford, 1981; Verheijen, 1981; Reed *et al.*, 1985) and flares (Bourne, 1979; Sage, 1979; Avery *et al.*, 1980; Wood, 1999), resulting in death or injury by impact or burning (Hope-Jones, 1980; De Groot, 1996).”

(Wiese, Francis K., W A. Montevicchi, G K. Davoren, F Huettmann, A W. Diamond, and J Linke. "Seabirds At Risk Around Offshore Oil Platforms in the North-West Atlantic." Marine Pollution Bulletin 42 (2001): 1286.)

Migratory birds are particularly vulnerable to nocturnal circulation. “The impact of circulations on trans-Gulf migrants is difficult to evaluate. Any delay in migration induced by a circulation clearly must have some impact on the migrants involved, because they expend energy during the delay that might otherwise be needed to complete the crossing successfully, particularly if adverse weather conditions are encountered later on...Because of the anecdotal nature of our circulation observations, we are reluctant even to speculate about the average duration of participation in circulations or the typical energetic consequences of participating in these events.”

(Russell, Robert W. Interactions Between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico. Department of Interior. Minerals Management Service, 2005. 267.)

MIGRATORY BIRDS

Drilling platforms kill relatively few migratory birds. “...an average Gulf platform may cause 50 deaths by collision per year, suggesting that the platform archipelago may cause roughly 200,000 deaths per year. This number may be biased low because some birds that collide with platforms undoubtedly fall into the sea and avoid detection. Nevertheless, the numbers still pale compared to human-related sources of bird mortality on land. At least 100 million — and perhaps as many as a billion — birds die each year from striking plate glass windows...Overall, bird mortality currently caused

by offshore platforms is negligible within the larger scheme of anthropogenic impacts on migratory birds.”

(Russell, Robert W. Interactions Between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico. Department of Interior. Minerals Management Service, 2005. 304.)

It should be noted that more platforms are expected to increase the number of migratory bird deaths. “An important caveat to this conclusion is that future development of the eastern Gulf of Mexico may result in a disproportionately large increase in collision mortality in neotropical migrants...In addition, future platforms in the eastern Gulf are likely to be geographically isolated due to the economics of deepwater production, and geographical isolation seems to be a factor associated with the development of nocturnal circulations (Chapter 16), which put birds at higher risk of collision.”

(Russell, Robert W. Interactions Between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico. Department of Interior. Minerals Management Service, 2005. 304.)

SEABIRDS

A risk assessment by the Coast Guard found that modeled oil spills are only of moderate concern for marine birds. As described previously in this document, the Coast Guard did a risk assessment for the impact of certain oil spills on marine resources in each of six offshore geographic regions in the US. While the risks for birds were consistently higher than for most organisms, in five regions the risk was never higher than moderate for even large oil spills. In the sixth region—Alaska—the risk was high only when a large spill occurred. Thus, this assessment indicates that for the overwhelming number of spills the risks to birds are no more than moderate. (US Coast Guard. Draft PEIS: Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions. 4-2. 11 July 2008.)

However, no comprehensive study has been done on the impact of oil extraction activities on seabirds. It is important to understand the distinction between seabirds and migratory birds. While seabirds are also migratory, they are confined to the sea environment, migrating between breeding and feeding grounds. Migratory birds of the type described here and commonly in the literature are not bound to the sea and migrate over greater distances, usually interacting with the marine environment during migration.

A comprehensive MMS report on migratory birds and the risk posed to them by oil extraction activities goes a long way toward answering most of the concerns about offshore drilling. This report is quoted above. No such study has been produced on seabirds, however. Thus, while it is possible to dispel

concerns about flaring, oiling, or other impacts of offshore drilling as they relate to migratory birds, there is simply not enough research to come to any definitive conclusions about the impact of offshore drilling activities on seabirds.

Works Cited

- Abgrall, Patrick, Valerie Moulton, and W J. Richardson. Updated Review of Scientific Information on Impacts of Seismic Survey Sound on Marine Mammals, 2004-Present. Department of Fisheries and Oceans, Habitat Science Branch. LGL Limited, Environmental Research Associates, 2008. 11 July 2008
<http://www.iagc.org/attachments/contentmanagers/1045/LGL_document_DFO_Updated_Seismic_Mar_Mam_Review_VF_2008_03.pdf>.
- Anderson, Cheryl M., and Robert P. LaBelle. "Update of Comparative Occurrence Rates for Offshore Oil Spills." Spill Science and Technology Bulletin 6 (2000): 303-21.
- Boatman, Mary. "Mercury and the Results from the Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX)." Paper presented to conference. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003.
- Boatman, Mary. "Mercury and the Results from the Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX)." PowerPoint presentation. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003.
- Clark, Christopher W. "Dr. Chris Clarke's Testimony At Cape Breton Hearings on Seismic Testing." 2001. 11 July 2008
<http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88118>.
- Continental Shelf Associates. Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf. Department of Interior. New Orleans: Minerals Management Service, 2004.
- Dalen, John, Egil Dragsund, Arne Naess, and Olav Sand. Effects of Seismic Surveys on Fish, Fish Catches, and Sea Mammals. Cooperation Group-Fishery Industry and Petroleum Industry. DNV Energy, 2007. 11 July 2008
<<http://www.olf.no/?50345.pdf>>.

Engas, Arill, Svein Lokkenborg, Engil Ona, and Aud Vold Soldal. "Effects of Seismic Shooting on Local Abundance." Canadian Journal of Fisheries and Aquatic Sciences (1996): 2238-2249.

Final NPDES General Permit for New and Existing Sources and New Dischargers in the Offshore Subcategory of the Oil and Gas Extraction Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000). Environmental Protection Agency. 2004.
<<http://www.epa.gov/region6/water/npdes/genpermit/gmg290000finalpermit2004.pdf>>.

Gordon, Jonathan, Douglas Gillespie, John Potter, Alexandros Frantzis, Mark P. Simmonds, Rene Swift, and David Thompson. "A Review of the Effects of Seismic Surveys on Marine Mammals." Marine Technology Society Journal 37 (2004): 18-34.

Herbst, Lars T. Minerals Management Service. Department of Interior. Notice to Lessees and Operators of Federal Oil and Gas Leases and Pipeline Right-of-Way Holders in the Outer Continental Shelf (OCS), Gulf of Mexico OCS Region: Design of New OCS Platforms and Related Structures for Hurricane Conditions. 1 Oct. 2007. 11 July 2008
<<http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2007NTLs/07-g26.pdf>>.

International Association of Geophysical Contractors and International Association of Oil and Gas Producers. Seismic Surveys and Marine Mammals: Joint OGP/IAGC Position Paper. 2004.

Jacques Whitford Environment Limited. British Columbia Offshore Oil and Gas Technology Report. British Columbia Ministry of Energy and Mines. 2001. 11 July 2008 <<http://www.offshoreoilandgas.gov.bc.ca/reports/jwl-report/>>.

Johnston, Carey A. U.S. EPA Regulation of the Offshore Oil and Gas Extraction Industry. Presented to SEMARNA/PEMEX Seminar, Veracruz, Mexico. Office of Water, Environmental Protection Agency. 2003.

McCauley, Robert D., Jane Fewtrell, and Arthur N. Popper. "High Intensity Anthropogenic Sound Damages Fish Ears." Journal of the Acoustic Society 113 (2003): 638-642.

Minerals Management Service. Estimated Petroleum Spillage From Facilities Associated with Federal Outer Continental Shelf (OCS) Oil and Gas Activities Resulting From Damages Caused by Hurricanes Rita and Katrina in 2005. Department of Interior. 2006. 11 July 2008

- <<http://www.mms.gov/incidents/PDFs/HurrKatrinaRitaSpillageRev8thAug2006.pdf>>.
- “MMS Prepares for 2008 Hurricane Season.” MMS Press Release. 15 May 2008.
Minerals Management Service. 11 July 2008
<http://www.gomr.mms.gov/homepg/whatsnew/newsreal/2008/080515.pdf>
- National Academy of Sciences. Oil in the Sea: Inputs, Fates, and Effects. National Research Council. Washington, DC: National Academies P, 2003. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.
- Neff, Jerry M. Bioaccumulation in Marine Organisms: Effects of Contaminants From Oil Well Produced Water. Elsevier, Ltd., 2002.
- Neff, Jerry M. Composition, Environmental Fates, and Biological Effects of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment: a Synthesis and Annotated Bibliography. Petroleum Environmental Research Forum & American Petroleum Institute. Battelle, 2005.
- Neff, Jerry M. Evaluation of the Environmental Effects of Offshore Oil Activities and Associated Coastal Facilities on the Marine Environment of the Campeche Sound PEMEX Marine Phase 2, Period 2. Instituto Mexicano Del Petroleo. Battelle, 2005.
- Neff, Jerry M. Fates and Effects of Mercury From Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute & Ad Hoc Upstream Industry Mercury Working Group. 2002.
- Neff, Jerry M., S McKelvie, and Robert C. Ayers, Jr. Environmental Impacts of Synthetic Based Drilling Fluids. Minerals Management Service, Department of Interior. New Orleans, 2000. 11 July 2008
<<http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3175.pdf>>.
- "Offshore Drilling." Sierra Club, Florida Chapter. 11 July 2008
<<http://florida.sierraclub.org/offshore.asp>>.
- Peterson, David L. Background Briefing Paper for a Workshop on Seismic Survey Operations: Impacts on Fish, Fisheries, Fishers and Aquaculture. British Columbia Seafood Alliance. 2004. 11 July 2008
<<http://www.em.gov.bc.ca/DL/offshore/Reports/BCSeafoodAlliance/SeismicAndFisheriesBriefingDoc.pdf>>.
- Royal Society of Canada. Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia. Natural Resources Canada. Ottawa, 2004. 11 July 2008

<http://www.rsc.ca//files/publications/expert_panels/BC_offshore/fullreportEN.pdf>.

Russell, Robert W. Interactions Between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico. Department of Interior. Minerals Management Service, 2005.

Simon Fraser University. A Review of Offshore Oil and Gas Development in British Columbia. Coastal First Nations. 2004. 11 July 2008
<http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88523>.

Southall, Brandon L., Ann E. Bowles, William T. Ellison, James J. Finneran, Roger L. Gentry, Charles R. Greene Jr., David Kastak, Darlene R. Ketten, James H. Miller, Paul E. Nachtigall, W J. Richardson, Jeanette A. Thomas, and Peter L. Tyack. "Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations." Acquatic Mammals 33 (2007): 411-521.

Spong, Paul. "Dr. Paul Spong's Submission to the Priddle Hearings on the BC Moratorium." 11 May 2004. 11 July 2008
<http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88120>.

Trefry, John, Robert P. Trocine, Michelle L. McElvaine, and Robert D. Rember. "Concentrations of Total Mercury and Methylmercury in Sediment Adjacent to Offshore Drilling Sites in the Gulf of Mexico." Final Report to the Synthetic Based Muds (SBM) Research Group. ONLINE. November 2002. Available: https://www.mms.gov/homepg/regulate/enviro/ongoing_studies/gm/MeHgFinal10_25.pdf

Trefry, John. and Smith, J.P. "Forms of Mercury in Drilling Fluid Barite and Their Fate in the Marine Environment-A Review and Synthesis." PowerPoint presentation. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003.

US Coast Guard. Draft PEIS: Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions. 11 July 2008.

US Commission on Ocean Policy. An Ocean Blueprint for the 21st Century: Final Report of the US Commission on Ocean Policy. Sept. 2004. 11 July 2008
<http://www.oceancommission.gov/documents/full_color_rpt/000_ocean_full_report.pdf>.

Veil, John A. A White Paper Describing Produced Water From Production of Crude Oil, Natural Gas, and Coal Bed Methane. Argonne National Laboratory, Department

- of Energy. 2004. 11 July 2008
<<http://www.ead.anl.gov/pub/doc/ProducedWatersWP0401.pdf>>.
- Weller, David W., Yulia V. Ivashchenko, Grigory A. Tsidulko, Alexander M. Burdin, and Robert L. Brownell, Jr. Influence of Seismic Surveys on Western Gray Whales Off Sakhalin Island, Russia. International Whaling Commission. 2002. 11 July 2008
<http://www.livingoceans.org/_pvwC21CD930/files/PDF/energy/Gray_whales_and_seismic.pdf>.
- Wiese, Francis K., W A. Montevecchi, G K. Davoren, F Huettmann, A W. Diamond, and J Linke. "Seabirds At Risk Around Offshore Oil Platforms in the North-West Atlantic." Marine Pollution Bulletin 42 (2001): 1285-1290.
- Wills, Jonathan. Muddied Waters: a Survey of Offshore Oilfield Drilling Wastes and Disposal Techniques to Reduce the Ecological Impact of Sea Dumping. Sakhalin Environment Watch. 2000. 11 July 2008
<<http://www.alaskaforum.org/other/muddiedwaters.pdf>>.

Works Consulted

- Bertram, Douglas F. "Seabird Habitats and Trophic Interactions: Science Gaps and Ecosystem Consequences of Offshore Oil and Gas Activities." PowerPoint presentation. Report to the Royal Society of Canada Workshop on Oil and Gas. 28 Oct. 2003.
- Birtwell, I K., and C D. McAllister. Hydrocarbons and Their Effects on Aquatic Organisms in Relation to Offshore Oil and Gas Exploration and Oil Well Blowout Scenarios in British Columbia, 1985. Canadian Technical Report of Fisheries and Aquatic Sciences 2391. Fisheries and Oceans Canada Science Branch. 2002.
- Burger, Alan E. Summary of Presentation to the Royal Society Expert Panel on Oil and Gas Activities Offshore British Columbia. 2003. 11 July 2008
<http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88116>.
- Canadian Association of Petroleum Producers. Offshore Drilling Waste Management Review. 2001. 11 July 2008
<<http://www.capp.ca/raw.asp?x=1&dt=PDF&dn=25022>>.
- Chandler, John E. and Ronnie J. Primeaux. "Field Measurements of Barite Discharges in the Gulf of Mexico." Paper presented to conference. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003.
- Chandler, John E. and Ronnie J. Primeaux. "Field Measurements of Barite Discharges in the Gulf of Mexico." PowerPoint Presentation. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX. March 2003.
- Continental Shelf Associates. Deepwater Gulf of Mexico Environmental and Socioeconomic Data Search and Literature Synthesis: Volume I. Department of Interior. New Orleans: Minerals Management Service, 2000.

- Cummings, Jim, and Natalie Brandon. Sonic Impact: a Precautionary Assessment of Noise Pollution From Ocean Seismic Surveys. Greenpeace. 2004. 11 July 2008 <http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88130>.
- Engel, Marcia H., Milton C. Marcondes, Cristiane C. Martins, Fabia O. Luna, Regis P. Lima, and Alexandre Campos. "Are Seismic Surveys Responsible for Cetacean Strandings? An Unusual Mortality of Adult Humpback Whales in Abrolhos Bank, Northeastern Coast of Brazil." 11 July 2008 <http://www.marineconnection.org/docs/humpback_stranding.pdf>.
- GESAMP. Estimates of Oil Entering the Marine Environment From Sea-Based Activities. London: International Maritime Organization, 2007. 11 July 2008 <<http://gesamp.net/open.php?table=documentextern&recordID=88&file=/documentextern/rs75e.pdf>>.
- Hurley, Geoffrey, and Joanne Ellis. Environmental Effects of Exploratory Drilling Offshore Canada: Environmental Effects Monitoring Data and Literature Review-Final Report. Canadian Environmental Assessment Agency. 2004. 11 July 2008 <http://pr-ac.ca/files/drilling_offshore_DOC_Oct_26_2004.pdf>.
- Jasny, Michael, Joel Reynolds, Cara Horowitz, and Andrew Wetzler. Sounding the Depths II: the Rising Toll of Sonar, Shipping and Industrial Ocean Noise on Marine Life. National Resources Defense Council, 2005. 11 July 2008 <<http://www.nrdc.org/wildlife/marine/sound/sound.pdf>>.
- Kenchington, Trevor J. Impacts of Seismic Surveys on Fish Behaviour and Fisheries Catch Rates on Georges Bank. Georges Bank Review Panel. 1999. 11 July 2008 <http://ofc.domain7.com/?action=d7_article_viewer_get_first_file&Join_ID=88135>.
- McCauley, Robert. "Dr. McCauley's Submission to the Royal Society Review of the BC Moratorium." 14 Nov. 2003. <http://www.oilfreecoast.org/?action=d7_article_viewer_get_first_file&Join_ID=88122>.
- Meier, Sonnich, Tom E. Andersen, Linda Hasselberg, Olav S. Kjesbu, Jarle Klungsoyr, and Asbjorn Svardal. Hormonal Effects of C4-C7 Alkylphenols on Cod. 2001. 11 July 2008 <http://www.imr.no/_data/page/3859/Hormonal_effects_of_C4-C7_alkylphenols_on_cod.pdf>.
- "MMS Rule Enhances Hurricane Safety of Offshore Platforms." MMS Press Release. 15 April 2008. Minerals Management Service. 11 July 2008 <<http://www.gomr.mms.gov/homepg/whatsnew/newsreal/2008/080415.pdf>>

- Popper, Arthur N. "Effects of Anthropogenic Sound on Fish & The Response of Clupeid Fish to Ultrasound." PowerPoint Presentation. University of Maryland. <http://www.imr.no/fishbehave/presentations/3-Wednesday/3We_0955_Popper_combined.pdf>.
- Popper, Arthur N. "Effects of Seismic Airguns on Fish." PowerPoint Presentation. University of Maryland. <http://www.umweltbundesamt.de/antarktis/archiv/4-2_Popper_fin-fish.pdf>.
- Seaflow. Seismic Surveys: Another Assault on Our Oceans. 2006.
- Simmonds, Mark, Sarah Dolman, and Lindy Weilgart, eds. Oceans of Noise 2004: a WDCS Science Report. Whale and Dolphin Conservation Society. 2004. 11 July 2008 <http://www.wdcs.org/submissions_bin/OceansofNoise.pdf>.
- Stone, Carolyn J. Effects of Seismic Activity on Marine Mammals in UK Waters, 1998-2000. Joint Nature Conservation Committee. 2003. 11 July 2008 <<http://www.jncc.gov.uk/pdf/jncc323.pdf>>.
- Thompson, Denis H., Jack W. Lawson, and Anne Muecke. Proceedings of a Workshop to Develop Methodologies for Conducting Research on the Effects of Seismic Exploration on the Canadian East Coast Fishery, 7 Sept. 2000, LGL, Ltd. 11 July 2008 <<http://dsp-psd.pwgsc.gc.ca/Collection/NE22-4-139-1999E.pdf>>.
- Veil, John A. "Comparison of Two International Approaches to Controlling Risk from Produced Water Discharges." PowerPoint Presentation. NEL Produced Water Workshop, Aberdeen, Scotland. Argonne National Laboratory. April 23-24, 2008.

Experts Consulted

More than a dozen of the world's top experts in their respective fields were consulted in the development of this working paper. Several agreed to review it upon completion to ensure its accuracy and thoroughness. We are deeply indebted to them all for their generous gift of their valuable time and knowledge in helping us understand the issues involved and the relevant research.

APPENDIX

TABLE 2-2 Average, Annual Releases (1990-1999) of Petroleum by Source (in thousands of tonnes)

	North America ^a		Min.	Max.	Worldwide		
	Best Est.	Regions ^b			Best Est.	Min.	Max.
Natural Seeps	160	160	80	240	600	200	2000
Extraction of Petroleum	3.0	3.0	2.3	4.3	38	20	62
Platforms	0.16	0.15	0.15	0.18	0.86	0.29	1.4
Atmospheric deposition	0.12	0.12	0.07	0.45	1.3	0.38	2.6
Produced waters	2.7	2.7	2.1	3.7	36	19	58
Transportation of Petroleum	9.1	7.4	7.4	11	150	120	260
Pipeline spills	1.9	1.7	1.7	2.1	12	6.1	37
Tank vessel spills	5.3	4.0	4.0	6.4	100	93	130
Operational discharges (cargo washings)	na ^c	na	na	na	36	18	72
Coastal facility spills	1.9	1.7	1.7	2.2	4.9	2.4	15
Atmospheric deposition	0.01	0.01	trace ^d	0.02	0.4	0.2	1
Consumption of Petroleum	84	83	19	2000	480	130	6000
Land-based (river and runoff)	54	54	2.6	1900	140	6.8	5000
Recreational marine vessel	5.6	5.6	2.2	9	nd ^e	nd	nd
Spills (non-tank vessels)	1.2	0.91	1.1	1.4	7.1	6.5	8.8
Operational discharges (vessels ≥100 GT)	0.10	0.10	0.03	0.30	270	90	810
Operational discharges (vessels <100 GT)	0.12	0.12	0.03	0.30	nd ^f	nd	nd
Atmospheric deposition	21	21	9.1	81	52	23	200
Jettisoned aircraft fuel	1.5	1.5	1.0	4.4	7.5	5.0	22
Total	260	250	110	2300	1300	470	8300

^aNumbers are reported to no more than two significant figures.

^b“Regions” refers to 17 zones or regions of North American waters for which estimates were prepared. These are discussed later in this chapter.

^cCargo washing is not allowed in U.S. waters, but is not restricted in international waters. Thus, it was assumed that this practice does not occur frequently in U.S. waters (see [Chapter 3](#) and [Appendix E](#)).

^dEstimated loads of less than 10 tonnes per year reported as “trace.”

^eWorldwide populations of recreational vessels were not available (see [Chapter 3](#) and [Appendix F](#)).

^fInsufficient data were available to develop estimates for this class of vessels (see [Chapter 3](#) and [Appendix E](#)).

(National Academy of Sciences. [Oil in the Sea: Inputs, Fates, and Effects](#). National Research Council. Washington, DC: National Academies P, 2003. 28. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

TABLE 2-4 Estimated PAH Contribution to North American Waters and Assumptions of Oil Type Composition by Source

Source	Description of Composition by Oil Type	Estimated PAH Contribution (thousands of tonnes per year)
Natural Seeps	Crude oil	2.5
Petroleum Extraction		
Platforms	Crude oil, heavy distillates, light distillates, and gasoline	0.0016
Produced waters	Crude oil	0.052
Atmospheric deposition	See Chapter 3 and Appendix D	0.016
Subtotal		0.070
Petroleum Transportation		
Vessel spills	Crude oil, heavy distillates, light distillates, and gasoline	0.12
Pipelines	Crude oil, heavy distillates, light distillates, and gasoline	0.030
Coastal facilities	Crude oil, heavy distillates, light distillates, gasoline	0.0040
Atmospheric deposition	See Chapter 3 and Appendix E	0.016
Subtotal		0.17
Petroleum Consumption		

Land-based	See Chapter 3 and Appendix I	0.54
Aircraft dumping	Jet fuel	0.031
Recreational vessels	Lube oil	0.0015 ^a
< 100 GT vessels	Light distillates	0.0040
> 100 GT vessels	Heavy distillates and light distillates	0.0084
Atmospheric deposition	See Chapter 3 and Appendix H	1.60
Subtotal		2.2
Total		4.9

^aPyrogenic PAH produced during incomplete combustion is not included in this value, which must therefore be considered as a minimum estimate.

(National Academy of Sciences. [Oil in the Sea: Inputs, Fates, and Effects](#). National Research Council. Washington, DC: National Academies P, 2003. 32. 11 July 2008
<http://books.nap.edu/openbook.php?record_id=10388&page=R1>.)

Table 1. Worldwide gaseous emissions and mean emission rate per unit mass of production associated with oil and gas production and processing. From OGP (2004).

Gas	Emission 2003 (10 ³ tons)	Emission/Production (tons/10 ³ tons)
Carbon Dioxide (CO ₂)	304,900	126.5
Methane (CH ₄)	3016	1.25
Other Volatile Organic Compounds (VOCs)	1778	0.76
Sulfur Dioxide (SO ₂)	436	0.19
Nitrogen Oxides (NO _x)	768	0.33

(Neff, Jerry M. [Evaluation of the Environmental Effects of Offshore Oil Activities and Associated Coastal Facilities on the Marine Environment of the Campeche Sound PEMEX Marine Phase 2, Period 2](#). Instituto Mexicano Del Petroleo. Battelle, 2005. 75.)

Table 2. Worldwide gas emissions in 2003 by oil and gas production and processing operations. Masses are 10³ tons. From OGP (2004).

Operation	CO ₂	CH ₄	Other VOC	SO ₂	NO _x
Drilling	2400	0.90	1.99	4.87	47.1
Process & Treatment	73,080	354	295	36.3	214
Flared	90,800	767	168	210	44.9
Vented	3130	807	428	10.6	0.0

Terminal	740	6.53	19.4	3.85	1.91
Other	40	59.4	135	0.17	0.30
Unspecified Production	112,790	763	727	168	454
Total	283,980	2759	1774	434	762

(Neff, Jerry M. Evaluation of the Environmental Effects of Offshore Oil Activities and Associated Coastal Facilities on the Marine Environment of the Campeche Sound PEMEX Marine Phase 2, Period 2. Instituto Mexicano Del Petroleo. Battelle, 2005. 76.)