



# MARINE MAMMAL COMMISSION

8 December 2014

Ms. Jennifer Bosyk  
Bureau of Ocean Energy Management  
381 Elden Street, HM-3120  
Herndon, Virginia 20170

Dear Ms. Bosyk:

The Marine Mammal Commission (the Commission), in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the Bureau of Ocean Energy Management's (BOEM) 7 November 2014 notice requesting information on the development of a long-term monitoring plan for marine mammals in the Gulf of Mexico (the Gulf; 79 Fed. Reg. 66402). The development of a long-term monitoring plan is a required element of BOEM's petition for rulemaking requesting the National Marine Fisheries Service (NMFS) to authorize takes of marine mammals incidental to geophysical and geological (G&G) surveys in the Gulf under the Marine Mammal Protection Act (MMPA).

In its notice, BOEM specifically requested the following:

- (1) monitoring measures that will improve understanding of the occurrence of marine mammal species in the Gulf, individual responses to acute stressors or impacts of chronic exposures to stressors, how anticipated responses to stressors impact long-term fitness and survival, mitigation and monitoring effectiveness, and the nature, scope, or context of likely marine mammal exposure to potential stressors/impacts ;
- (2) information to better understand the relationships among the G&G activities and existing environment, the affected species, co-occurrence of marine mammals with G&G activities, and the biological or behavioral context of exposure;
- (3) information related to the appropriate scope of the long-term monitoring program, study objectives, the effects of G&G surveys on marine mammals in both the short- and long-term, discrete study questions, and scientific methods;
- (4) information on existing or upcoming marine mammal research efforts that may inform development of the plan, or with which it may be appropriate to coordinate to achieve monitoring goals; and
- (5) information pertaining to any other long-term monitoring plans for marine mammals.

The Commission provided extensive comments on BOEM's notice of intent to prepare a programmatic environmental impact statement on G&G activities in the Gulf of Mexico (see the enclosed 9 July 2013 letter). In that letter, the Commission noted the lack of regular surveys for the 22 marine mammal species/57 marine mammal stocks that reside in or regularly visit the inshore, coastal, and offshore waters of the Gulf. Although the Deepwater Horizon oil spill resulted in extensive surveys of the Gulf to determine injuries resulting from the spill, that information will become outdated quickly without a long-term and consistent investment in collecting the data needed to generate stock assessments and evaluate the impacts of seismic activities on marine

mammals. NMFS guidelines for assessing marine mammal stocks suggest that surveys be conducted at least every eight years to enable detection of a 10 percent decline in abundance (NMFS 2005, Moore and Merrick 2011).

### **Key components of a marine mammal assessment program**

In its letter, the Commission recommended that BOEM work with NMFS and other relevant entities to design a multi-year, Gulf-wide marine mammal assessment program, modeled after BOEM's Atlantic Marine Assessment Program for Protected Species. Such a program would provide information on abundance, distribution, seasonal movements, and trends for marine mammals in the Gulf. The primary objective of that program should be to generate, on an ongoing basis, abundance and distribution data for the most commonly detected marine mammal species in all seasons of the year. The key components of a comprehensive marine mammal assessment program include:

- conducting systematic aerial and vessel-based surveys during all seasons of the year;
- installing fixed passive acoustic recorders around the Gulf to measure ambient sound and to aid in assessments by detecting the presence and location of vocalizing marine mammals;
- conducting tagging and telemetry studies to track movements and habitat use of key species (e.g., sperm whales, Bryde's whales, bottlenose dolphins);
- collecting and integrating associated oceanographic and environmental data; and
- using the best available technology (including new technology, such as high-resolution aerial imaging surveys and/or underwater gliders) to detect marine mammals and to collect oceanographic and environmental data.

Such a program would allow identification of environmentally sensitive areas that may warrant exclusion from G&G surveys during certain seasons or year-round. These areas include key marine mammal foraging, resting, or calving habitats. Determination of why different habitats are important for marine mammals relies on collection and analysis of a broad suite of environmental data such as prey density, bathymetry, water temperature, salinity, ocean circulation patterns, upwelling, pH, weather patterns, ambient sound levels, biotoxin or contaminant concentrations, etc. Data on ambient sound levels, in particular, are important for determining the relative influence of G&G and other sound-producing activities on marine mammal habitat use. Human activities (e.g., shipping, coastal development, fishing, and oil and gas development) may also influence marine mammal distribution and movements.

In designing such a Gulf-wide program it is important to consider up front how data collected can be integrated into other smaller or site-specific studies. Consideration should also be given to facilitating analyses of the data by a broad range of researchers. To that end, data and metadata should be made publicly available in a timely manner through such mechanisms as the National Oceanic and Atmospheric Administration's (NOAA) Cetacean and Sound Mapping program, NOAA and BOEM's Marinecadastre.gov, the Gulf of Mexico Coastal Ocean Observing System, and/or Duke University's Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP).

### **Studies to determine the effects of G&G surveys on marine mammals**

In addition to ongoing assessments of marine mammals, BOEM's monitoring plan should include hypothesis-driven research to better understand the effects of seismic and other G&G surveys on marine mammals. Priority study questions include:

- assessing the overall soundscape for key marine mammal habitats in the Gulf and determining how G&G surveys contribute to that overall soundscape;
- evaluating the individual- and population-level significance of disturbance from a range of different G&G sound types that operate at various source levels and frequencies, including high-resolution geophysical surveys (e.g., those that use sub-bottom profilers and multi-beam echosounders);
- evaluating  $f(0)$  and  $g(0)$  values specific to the protected species observers who are monitoring for marine mammals on various platforms during G&G surveys to provide both a reasonably accurate assessment of the manner in which marine mammals are taken (by Level A or B harassment) and reliable estimates of the numbers of marine mammal taken by those surveys; and
- collecting behavioral response data related specifically to G&G activities to inform NMFS's efforts to revise its acoustic criteria and thresholds.

### **Establishment of a Scientific Advisory Group for the Gulf**

As part of BOEM's long-term monitoring plan for the Gulf, the Commission recommends that BOEM establish a Gulf of Mexico Scientific Advisory Group, comprised of independent scientists, to assist in the identification and prioritization of monitoring needs and hypothesis-driven study questions to better understand the short- and long-term effects of G&G surveys on Gulf marine mammals. Similar scientific advisory groups have been implemented by the U.S. Navy under its Strategic Planning Process for Marine Species Monitoring, in association with numerous NMFS rulemakings (see 78 Fed. Reg. 73010 as an example). BOEM is also in the process of establishing an independent Scientific Review Board under the recently awarded Marine Arctic Ecosystem Study (MARES). Such an advisory group could assist BOEM in identifying the overall monitoring goals and objectives for marine mammals in the Gulf. In particular it could assist in evaluating and prioritizing projects to study the effects of G&G surveys on marine mammals.

### **Expansion of public-private partnerships to aid in data collection**

As noted in the Commission's 2013 letter, the costs associated with collecting the information described above should be shared between regulatory agencies and the industry groups that benefit from extraction of U.S. natural resources. The Commission understands that BOEM has authority under 43 U.S.C. § 1473 to accept and use financial contributions from both public (i.e., governmental) and private sources for environmental assessments and studies and related research in support of BOEM's regulatory and statutory authority and requirements under the Outer Continental Shelf Lands Act (OCSLA). BOEM also has the ability to develop public-private partnerships under the National Oceanographic Partnership Program, as was done with MARES. These and other mechanisms should be used to implement BOEM's long-term monitoring plan.

### **Additional planning resources**

Regarding upcoming events that may help to inform long-term planning efforts, the Commission, along with other public and private partners, will be convening a meeting of Gulf marine mammal scientists and managers on 7-8 April 2015, in New Orleans, Louisiana. The objectives are to:

- provide an overview of marine mammal stocks and human activities;
- review marine mammal research and monitoring programs;
- identify high-priority, overarching marine mammal data needs for the next 5-15 years;
- identify potential funding sources/opportunities for marine mammal research and monitoring; and
- discuss options for collaborations to facilitate long-term research planning, information sharing, and capacity building.

Representatives from BOEM and the Bureau of Safety and Environmental Enforcement are participating as members of the steering committee for this meeting, as are representatives from NMFS, Gulf of Mexico Coastal Ocean Observing System, Texas Sea Grant, University of Southern Mississippi, University of Central Florida, Sarasota Dolphin Research Program, Audubon Nature Institute, and Ocean Conservancy. Invited speakers will include representatives from organizations that are developing programs to monitor marine mammals and other marine organisms in the Gulf, including BOEM. The Commission is confident that the information presented at the meeting, and research priorities arising from it, will be useful to BOEM as it develops a long-term monitoring plan for the Gulf.

Finally, several references to other long-term monitoring plans for marine mammals, which may be relevant for BOEM's planning purposes, include Marine Mammal Commission 2011, NMFS/SEFSC 2008, and United Nations Environment Programme 2008.

I trust these comments will be helpful to BOEM in meeting its responsibilities under OCSLA and the MMPA. Please let me know if you have any questions.

Sincerely,



Rebecca J. Lent, Ph.D.  
Executive Director

Enclosure

cc: Donna Wieting, NMFS Office of Protected Resources

## References

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# MARINE MAMMAL COMMISSION

9 July 2013

Mr. Gary D. Goecke  
Chief, Regional Assessment Section  
Office of the Environment (MS 5410)  
Gulf of Mexico Outer Continental Shelf Region  
Bureau of Ocean Energy Management  
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New Orleans, LA 70123-2394

Dear Mr. Goecke:

The Marine Mammal Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the Bureau of Ocean Energy Management's notice of intent to prepare a programmatic environmental impact statement on geological and geophysical activities in the Gulf of Mexico (78 Fed. Reg. 27427). The programmatic environmental impact statement is being prepared cooperatively with the National Marine Fisheries Service to serve as the requisite environmental analysis for the Service's rulemaking under the Marine Mammal Protection Act governing authorization for incidental taking of marine mammals during geological and geophysical activities in the Gulf of Mexico. The Commission provides the following recommendations and rationale.

## RECOMMENDATIONS

The Marine Mammal Commission recommends that the Bureau of Ocean Energy Management—

- work with the National Marine Fisheries Service, the Department of Defense, and other relevant entities to design a multi-year, Gulf-wide marine assessment program to provide reliable estimates of abundance and distribution for marine mammals and other protected species in the Gulf;
- pursue public-private partnerships between federal agencies, the oil and gas industry, and other entities to fund implementation of both a Gulf-wide marine assessment program and a comprehensive long-term program to monitor the effects of geological and geophysical activities on Gulf marine mammals;
- include in its environmental impact statement alternatives that would (1) increase efforts to maximize the utility of seismic data while minimizing the number and impacts of new seismic studies; and (2) promote the further development, testing, and use of alternative, less harmful technologies to collect the required geophysical information, such as marine vibroseis;
- include in its environmental impact statement alternatives for time-area restrictions to minimize impacts on sperm whales, Bryde's whales, and coastal, bay, sound, and estuarine stocks of bottlenose dolphins; and
- continue to support the development and maintenance of the National Oceanic and Atmospheric Administration's Cetacean & Sound Mapping initiative to facilitate a more

rigorous evaluation of the individual and cumulative impacts of human-induced noise on cetaceans.

## **RATIONALE**

### **Information needs to support science-based decision-making**

The National Environmental Policy Act requires a thorough analysis of a range of alternative proposed federal actions and their potential impacts on the environment. A thorough evaluation of alternatives for geological and geophysical surveys in the Gulf depends on the availability of information on the status of marine mammals and also on information regarding the potential impacts of those surveys. That information is essential to identify and avoid potentially harmful interactions with marine mammals and to minimize impacts on preferred habitats.

Despite decades of oil and gas development in the Gulf, there are no systematic surveys of the 22 marine mammal species/57 marine mammal stocks that reside in or regularly visit the inshore, coastal, and offshore waters of the Gulf of Mexico (Waring et al. 2013). As a result, baseline information on abundance, distribution, stock structure, and trends for most of the Gulf's marine mammal stocks is limited, as is information regarding age structure, reproductive rates, survival rates, and health (nutritional status, immune function, and prior exposure to contaminants, biotoxins, and infections) (Marine Mammal Commission 2011). Without such information, decision-makers have an inadequate basis for determining whether, where, and under what conditions to authorize or conduct activities that could have acute or long-term adverse effects on marine mammals and other marine species.

A long-term and consistent investment in collecting the data needed to generate stock assessments and to evaluate the impacts of seismic activities on marine mammals would ensure that the decisions regarding proposed seismic survey activities are guided by the best available scientific information. Abundance and distribution data in particular should be collected on a sufficiently frequent basis to provide reasonable assurance that the estimated stock size is reliable and that the stock is not declining significantly. The National Marine Fisheries Service's guidelines for assessing marine mammal stocks suggest that surveys be conducted at least every eight years to enable detection of a 10 percent decline in abundance (Moore and Merrick 2011, NMFS 2005). Data on the effects of geological and geophysical surveys (e.g., behavioral responses to airguns and other sound-producing activities) should be collected before, during, and well after activities occur. The cost of collecting such information is not exorbitant, particularly when viewed in the larger context of the expenditures and revenues involved in oil and gas development. However, the ongoing lack of investment in these types of studies undermines the ability to sustainably manage marine resources on the basis of sound science.

In the Atlantic, the Bureau's Environmental Studies Program, in collaboration with the U.S. Fish and Wildlife Service and the U.S. Navy, has committed to providing multi-year funding to the National Marine Fisheries Service for the Atlantic Marine Assessment Program for Protected Species. That program is supporting broad-scale, multi-year collection of abundance and seasonal distribution data for marine mammals and other wildlife in the areas of interest for geological and geophysical surveys. The Commission commends that joint effort, which will improve the quality of

information available for assessments of marine mammal stocks. Clearly, a similar program is long overdue for the Gulf.

The Commission has commented previously that both industry and regulatory agencies have a responsibility to ensure that the research needed to manage resource use is conducted in a timely and comprehensive manner. The Commission believes that the Bureau, other federal agencies, and the oil and gas industry must work together to find the means to facilitate the development and implementation of a Gulf-wide marine mammal stock assessment and comprehensive monitoring program. While the Commission commends contributions already made by the industry on a voluntary basis, such actions could be more effective if institutionalized and required of all companies. The industry, in particular, should provide multi-year financial support for stock assessment surveys and monitoring in areas where seismic surveys are proposed because of the risks to marine mammals stemming from their activities and the associated responsibility of those seeking access to public resources.

To support decision-making for various federally administered activities in the Gulf, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management work with the National Marine Fisheries Service, the Department of Defense, and other relevant entities to design a multi-year, Gulf-wide marine assessment program to provide reliable estimates of abundance and distribution for marine mammals and other protected species in the Gulf. The Marine Mammal Commission further recommends that the Bureau of Ocean Energy Management pursue public-private partnerships between federal agencies, the oil and gas industry, and other entities to fund implementation of both a Gulf-wide marine assessment program and a comprehensive long-term program to monitor the effects of geological and geophysical activities on Gulf marine mammals.

### **Minimizing effects of seismic activities on marine mammals**

The proposed area of interest for geological and geophysical activities includes a wide range of marine mammal habitats. These activities typically involve the use of seismic airguns that emit high energy, low frequency acoustic pulses that travel long distances and may disrupt important marine mammal behaviors that depend on hearing and communication (i.e., feeding, resting, migrating, breeding, calving) and, at close range, can cause physical or physiological injury (Gordon et al. 2004). The sounds generated by airguns also can mask communication calls between conspecifics for some species (Richardson et al. 1995).

In developing its programmatic environmental impact statement, the Bureau should carefully consider the development of alternatives that will reduce significantly the use of seismic airguns in waters of the Outer Continental Shelf, both in the number of surveys conducted each year and in total output of sound. As such, the Commission reiterates previous recommendations that the Bureau of Ocean Energy Management include in its environmental impact statement alternatives that would (1) increase efforts to maximize the utility of seismic data while minimizing the number and impacts of new seismic studies; and (2) promote the further development, testing, and use of alternative, less harmful technologies to collect the required geophysical information, such as marine vibroseis. The rationale for these recommendations was provided in the Commission's comments on the draft programmatic environmental impact statement for geological and geophysical activities



on the Atlantic Outer Continental Shelf, and that rationale applies to the Gulf as well (see the Commission's letter to the Bureau dated 12 July 2012<sup>1</sup>).

In addition, the Commission believes that one of the most effective ways to limit the harmful effect of sound on marine mammals from seismic airguns is to restrict activities to periods when and areas where marine mammals are less likely to be present. This could include avoiding important breeding, calving, resting, or foraging areas for endangered sperm whales, Bryde's whales, coastal bottlenose dolphins, and other vulnerable species. For example—

- Sperm whales concentrate at the mouth of the Mississippi River near the Mississippi and DeSoto Canyon areas, in the area due west of the Florida Keys, and along the steep upper continental slope of the Florida Escarpment between Tampa and Key West (Maze-Foley and Mullin 2006, Baumgartner et al. 2001). The Mississippi Canyon area has been identified as important year-round feeding and breeding habitat for sperm whales (Davis et al. 2000, Davis et al. 2002, Jochens et al. 2008). The Deepwater Horizon oil spill occurred in the Mississippi Canyon area in the midst of this preferred habitat. Movements of sperm whales with home ranges near the spill site indicate that, although whales remained in the area after the oil spill, they avoided the most heavily surface-oiled areas (Mate 2011). The extent to which sperm whales will re-inhabit this area may depend on concentrations of oil and other contaminants they encounter and the availability of prey; limiting other sources of disturbance year-round, at least for some fixed period of time, may facilitate their return.
- The northeastern-shelf edge in the DeSoto Canyon area off Florida is the only known presently occupies habitat for Bryde's whales in the Gulf of Mexico (Maze-Foley and Mullin 2006, Waring et al. 2013). Evidence from whale calls detected in nearly all months of the year suggests Bryde's whales may inhabit this particular area of the northern Gulf year-round (Širović et al. 2013). It is not known to what extent Bryde's whales may be affected by seismic airgun activity, but baleen whales in general are more likely to be affected by seismic activity because of their sensitivity to low frequency sounds (Southall et al. 2007).
- The National Marine Fisheries Service has identified 35 distinct coastal, bay, sound, and estuarine stocks of bottlenose dolphins in the Gulf (Waring et al. 2013). Although research is limited, studies suggest that coastal stocks range more broadly than bay, sound, and estuarine stocks, which tend to exhibit more stable residency patterns. An ongoing unusual mortality event that began before the Deepwater Horizon oil spill appears to be affecting at least some of these stocks in the northern Gulf, with 1,026 bottlenose dolphin strandings documented between February 2010 and June 2013. Of particular concern is the peak in strandings of premature, stillborn, and neonatal dolphins that have occurred in February, March, and April each year since the oil spill—primarily in Louisiana, but also in other northern Gulf states. The Service has convened a working group which is investigating several potential causes, including direct and indirect effects of the Deepwater Horizon oil spill. However, no definitive cause for the mortality event has so far been identified. Regardless of whether the oil spill is determined to be a factor in the strandings, certain bottlenose dolphin stocks may experience significant reductions from this ongoing mortality event. A restriction on seismic

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<sup>1</sup> Past Commission letters are available at [www.mmc.gov/letters/welcome.shtml](http://www.mmc.gov/letters/welcome.shtml).

activities in nearshore waters inhabited by bottlenose dolphins, especially during peak stranding times, could minimize additional, sound-induced stress on these stocks.

To reduce the potential impacts of oil and gas seismic activities on vulnerable marine mammal stocks, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management include in its environmental impact statement alternatives for time-area restrictions to minimize impacts on sperm whales, Bryde's whales, and coastal, bay, sound, and estuarine stocks of bottlenose dolphins.

### **Cumulative impacts**

As part of its environmental analyses, the Bureau must consider the impacts of oil and gas operations in the context of other human activities and natural events (Table 1). Human activities include fishing; commercial shipping; tourism; shore-based and inland industry, agriculture, and residential developments that lead to chemical contaminant and nutrient run-off; and military activities. Also, climate disruption likely will alter the physical, biological, and chemical environment, perhaps dramatically, during the lifetime of any given oil and gas development in this region. Perhaps the most extensive changes will be the result of rising sea level and the most abrupt effects caused by increased frequency and severity of storms in the Gulf. Changes in climatic conditions may also affect the incidence and magnitude of hypoxic zones and harmful algal blooms. Finally, it is important to recognize that according to U.S. Census Bureau projections, 19 million more people will live in the five Gulf states by 2030, and this human population increase is bound to impose increasing stress on the marine environment.

A thorough understanding of the cumulative impacts of human activities and natural events in the Gulf would help inform decisions regarding the permitting of oil and gas seismic activities in this highly industrialized region. The Commission recognizes the difficulty of monitoring and evaluating the individual impacts of specific activities on marine ecosystems, let alone the combined impacts of all of the various activities that occur in the Gulf. This is especially true for marine mammals, for which impacts resulting from the proposed action likely will involve behavioral changes in the affected marine mammals and/or impacts on prey species and habitats. The long-term biological significance of such changes is harder to assess than acute impacts such as injury or death.

Conceptual frameworks to analyze the cumulative impacts of various sound sources and other stressors are the focus of ongoing research and modeling efforts (New et al. *in press*, NOAA 2012, Streever et al. 2012). Such frameworks would support a more quantitative approach to determine if, when, and where marine resources, including marine mammals, are likely to experience cumulative impacts that affect their conservation status or hinder their potential to grow and recover. The National Oceanic and Atmospheric Administration's Cetacean & Sound Mapping initiative, in particular, holds significant promise as a new tool that can be used by the Bureau and others to evaluate the individual and cumulative impacts of human-induced noise on cetaceans (NOAA 2012). The Marine Mammal Commission recommends that the Bureau of Ocean Energy Management continue to support the development and maintenance of the National Oceanic and Atmospheric Administration's Cetacean & Sound Mapping initiative to facilitate a more rigorous evaluation of the individual and cumulative impacts of human-induced noise on cetaceans.

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### Consideration of *Natural Resources Defense Council v. Jewell*

During the comment period for scoping, the District Court for the Eastern District of Louisiana issued a settlement agreement in *Natural Resources Defense Council v. Jewell*. That agreement implemented a 30-month stay of proceedings to ensure final action is taken on the Bureau's application to the Service for a Marine Mammal Protection Act incidental take authorization for oil and gas industry-sponsored seismic surveys for geological and geophysical exploration in the Gulf of Mexico (76 Fed. Reg. 34656). The agreement requires the Bureau to collect additional information from applicants proposing to conduct deep penetration seismic surveys and also requires seismic operators to abide by specified interim mitigation measures, including—

- 1) a seasonal restriction on seismic and other activities in coastal waters of the Gulf to protect stocks of bottlenose dolphins;
- 2) an expansion of the shutdown provisions of the Bureau's Joint Notice to Lessees (NTL) 2012-G02 to include manatees;
- 3) a requirement for seismic operators to maintain a minimum separation distance of either 30 or 40 kilometers between active seismic sources, depending on the area of operation;
- 4) restrictions on seismic operations in certain portions of the Outer Continental Shelf Eastern Planning Area;
- 5) the use of passive acoustic monitoring in certain areas during poor visibility conditions to supplement visual observations; and
- 6) additional reporting requirements.

Among other things, the Bureau must include in its programmatic environmental impact analysis for a Marine Mammal Protection Act incidental take authorization an analysis of 1) the above-mentioned interim mitigation measures; 2) mechanisms to reduce cumulative or chronic exposure of marine mammal populations to noise; 3) requirements or incentives to develop and use emergent alternative technologies for seismic surveys, such as marine vibroseis; and 4) the development of a long-term adaptive monitoring plan that addresses potential cumulative and chronic impacts from seismic surveys on Gulf marine mammal populations. These requirements are consistent with the Commission's recommendations.

We appreciate the opportunity to provide these comments and recommendations. Please contact me if you have any questions.

Sincerely,



Rebecca J. Lent, Ph.D.  
Executive Director

cc: Michael Payne, National Marine Fisheries Service Office of Protected Resources  
Rodney Cluck, Bureau of Ocean Energy Management Environmental Studies Program

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Table 1. Human-caused and natural risk factors in the Gulf and potential consequences to marine mammals.

Activities	Specific risk factor	Potential consequences
Oil and gas development	Oil spills and leaks	Direct exposure: skin irritation/inflammation, necrosis, respiratory effects, organ damage Indirect: shifts in or loss of prey, habitat degradation
	Noise (seismic surveys, construction and decommissioning of platforms, and general operations)	Physical trauma to internal organs, permanent or temporary hearing loss, avoidance of preferred habitat
	Vessel operations	Vessel strikes (injury/mortality), avoidance of preferred habitat
	Production waste (drill fluids and cuttings, produced water, deck drainage, municipal wastes, and debris)	Organ damage and impaired immune system function from heavy metal contamination, habitat degradation (decreased water quality), loss of prey
Commercial and recreational fishing	Fishing with nets and lines	Entanglement in and ingestion of fishing gear
	Fishing for prey species	Reduced availability of prey species, habitat alteration
	Vessel operations	Vessel strikes (injury/mortality), avoidance of preferred habitat
Shipping and vessel traffic	Noise, vessel operations	Vessel strikes (injury/mortality), avoidance of preferred habitat
Military activities	Vessel operations	Vessel strikes (injury/mortality), avoidance of preferred habitat
	Noise (SONAR training and testing, explosives)	Acoustic and non-acoustic physical trauma, avoidance of preferred habitat, mortality in severe cases
Agriculture	Runoff of land-based pollutants (resulting in harmful algal blooms, anoxic or hypoxic “dead” zones)	Direct: injury/mortality Indirect: decreased water quality, shifts in or loss of prey species
Coastal development	Noise from pile driving and other activities associated with marina and bridge/causeway construction	Acoustic trauma (at short range), acoustic disturbance, avoidance of preferred habitat
	Dredging	Loss of sea grass beds, habitat degradation
	Loss of coastal wetlands and other coastal habitats	Loss of prey habitat, habitat degradation
Renewable energy	Pile driving for anchoring wind and wave turbines	Acoustic trauma (at short range), acoustic disturbance, avoidance of preferred habitat
	Turbine operations	Physical trauma, electromagnetic disturbance, avoidance of preferred habitat
Greenhouse gas emissions	Ocean acidification	Shifts in or reduction/loss of prey species
	Warming seas	Habitat degradation, shifts in or reduction/loss of prey
	Increased storm activity and increased severity of storms	Shifts in prey, avoidance of preferred habitat
	Sea level rise, leading to coastal habitat loss	Loss of prey habitat, habitat degradation
Natural events	Seepage of oil	Direct: organ damage Indirect: habitat degradation
	Harmful algal blooms (e.g., red tide)	Injury/mortality, shifts in prey
	Predation	Injury/mortality
	Large-scale ecosystem fluctuations	Shifts in or loss of prey
	Hurricanes	Shifts in prey, avoidance of preferred habitat, displacement of animals, habitat degradation or destruction
	Water temperature anomalies	Shifts in prey, avoidance of affected habitats, cold stress