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Minerals Management Service Overview of Seismic Survey Mitigation and Monitoring on the U.S. Outer Continental Shelf

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Abstract

The Minerals Management Service administers about 7,500 active leases on 40 million acres of the Outer Continental Shelf (OCS). Under statutory authority of the OCS Lands Act, we regulate oil and gas exploration and development related seismic survey activity on the U.S. OCS and have been actively involved in research and environmental analysis of those activities for over 20 years. The MMS protected species program involves complying with the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA); analyzing impacts; designing mitigation, monitoring guidelines; providing information necessary for promulgating regulations; and identifying, funding, and participating in research necessary for the protection and enhancement of protected species and their habitat. MMS implements mitigation and monitoring measures to avoid or reduce the potential impacts of noise through a variety of mechanisms which include our regulations (30 CFR Part 250 - Oil and Gas and Sulphur Operations in the OCS) that implement provisions of the OCS Lands Act (U.S. Code Title 43, Chapter 29 Subchapter III), lease stipulations, and notices to lessees (to clarify requirements addressed in our regulations). MMS has focused two programmatic environmental analyses (under the National Environmental Policy Act-NEPA) on seismic surveys, one for the Gulf of Mexico and the other for the Alaskan Beaufort and Chukchi Seas. The MMS approach to mitigation and monitoring is based on the best scientific information available rather than requiring scientific certainty. We assess the available data and apply our technical expertise to make judgments based on scientific data in a manner consistent with the conservation purposes of laws such as the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA).

REGULATORY BACKGROUND

The MMS has a mandate to ensure that the seismic-survey data and information collected by industry and government are obtained in a technically safe and environmentally sound manner. The MMS regulations (30 CFR 251) state that geological and geophysical activities cannot:

- interfere with or endanger operations under any lease or right-of-way easement, right-of-use, scientific notice, or permit issued or maintained pursuant to the OCSLA;
- cause harm or damage to aquatic life, property, or to the marine, coastal, or human environments;
- cause pollution;
- create hazardous or unsafe conditions;
- unreasonably interfere with or harm other uses of the area;
- disturb archaeological resources; or
- cause hazardous or unsafe conditions.

Pursuant to 30 CFR 251.4, an operator or lessee must obtain from MMS a geological and geophysical (G&G) permit to conduct geological or geophysical exploration for oil, gas, and sulphur resources. MMS requires separate permits for geological or geophysical explorations for mineral resources. The G&G activities which are ancillary and conducted pursuant to a lease issued or maintained under the OCSLA do not require a permit. High energy 2-D and 3-D seismic surveys usually occur over unleased

OCS lands by potential lessees to collect information in preparation for bidding in a lease sale. The 2-D/3-D surveys also may be proposed over areas of: leased blocks by the lessee or operator to gather information to identify the best sites on their leases to consider for exploration/delineation drilling; or on- and off-lease to provide seismic-survey information between their leases and other wells, so the geologic information from wells can be "extrapolated" to their leases with the seismic-survey information. Both types of seismic surveys are considered geophysical exploration activities and require a geophysical exploration permit from the MMS.

High-resolution seismic surveys (referred to as postlease, on-lease, or site-clearance surveys) are ancillary activities authorized by the lease and are conducted under regulations (30 CFR 250). These surveys are done by the lessee or operator on a lease or unit (several leases managed as a group to produce common reservoirs) to collect required site-specific information (on potential geohazards or sensitive seafloor resources) in support of the preparation of an exploration plan or a development and production plan. Although MMS requires notification of these activities and the mitigation measures imposed by lease stipulations are specified in notices to lessees and operators, there are no additional applications or approvals necessary. To support information requirements of right-of-way pipeline applications, high-resolution surveys must be run along proposed pipeline routes (both on lease and off lease) to identify potential geohazards and sensitive seafloor resources.

The MMS also needs geological and geophysical survey information to fulfill its statutory responsibilities to ensure safe operations, support environmental impact analyses, protect benthic and archaeological resources through avoidance measures, ensure fair market value for leases, make royalty relief determinations, and conserve oil and gas resources. When MMS reviews the acquired survey information and determines that resources of concern (e.g. archaeological or sensitive benthic resources) could be adversely affected, the operators/lessee must proceed in one of the following three ways:

1. employ specific operational procedures to protect the resources of concern;
2. adjust the location of the proposed activity(ies) to a distance necessary to prevent disturbance of the resource(s) of concern; or
3. perform additional investigations to establish that the potential resources of concern do not exist at the proposed site or will not be adversely affected by the proposed activity.

ARCTIC EXPERIENCE

During the 1980s, offshore oil leases in the Alaskan Beaufort Sea began to include stipulations requiring mitigation measures of varying types to reduce disturbance to autumn migrating bowhead whales (and to the subsistence hunt for that species). Specific requirements varied depending on the lease, area, date, etc., but sometimes included seasonal/geographic restrictions, special requirements concerning nighttime operations (or night startups), and various monitoring requirements. More recent seismic surveys in the area have been subject to regulatory action coordinated by the NMFS, including extensive monitoring and mitigation requirements. In the Alaskan Beaufort Sea from 1996 to 2001, over the course of six seismic surveys (varying in duration from 3½ to 12 weeks per year), there were 112 shut downs for marine mammals in 1996 (Harris et al., 2001) and 104 in the other five seasons combined. All but one of the shut downs were for seals. Bowhead whales almost always remained far enough away from the operating airguns to avoid the need for shut downs (Moulton et al., 2002). LGL and Greenridge 1996-1998 monitoring data indicated that bowhead whales were rarely seen within a radius of 20 km of seismic operations and sighting rates were significantly lower during seismic operations than when no seismic operations were occurring. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km. Seismic surveys conducted since 1996 were done with relatively small arrays of airguns (320 to 1500 in^3), in part to minimize impacts on bowheads. This does not appear to be the case for new surveys proposed in the Chukchi and Beaufort Seas. For example, Shell proposes to use a 3147 in^3 airgun array operating at a pressure of 2,000 psi.

Mitigation Strategy

The most recent effort by MMS to address seismic survey activity in the Arctic is the draft Programmatic Environmental Assessment for Seismic Surveys in the Chukchi and Beaufort Seas (MMS 2006-019). The bowhead whale seasonally occurs within multiple areas of both the Chukchi Sea and Beaufort Sea OCS Planning Areas and occurs in areas that could be impacted from seismic survey

activities. This population stock of bowheads is the most robust and viable of surviving bowhead populations and, thus, its viability is critical to the long-term future of the biological species as a whole. When designing a mitigation strategy for proposed seismic surveys in the Chukchi and Beaufort Seas, MMS included in its deliberations the following points:

Potential effects on females, females with calves, and calves less then one-year of age merit special consideration. Baleen whales are a relatively long-lived, late maturing group of species with relatively low reproductive rates, and high maternal investment in young. In a species such as a bowhead whale, where the periods of body growth, maturation, gestation, maternal care, and intervals between reproductive attempts are all long, the ability of the female to provide adequate care to her offspring during its period of dependency is critical to the continued recovery and the long-term viability of the population.

Potential effects on "key habitat types" such as those used for calving, feeding, breeding, and resting, and those portions of the migratory pathway where the movements of the whales are constrained (e.g., the spring lead and polynya system in bowheads) merit special consideration. Whales do not use all portions of their range in a random fashion. Thus, impacts in all portions of the range are not of equal importance.

The considerable potential longevity of the bowhead, coupled with its migratory use of the habitat, is important to consider in evaluating potential effects, and especially cumulative effects, of the proposed action. Unlike shorter-lived species, individual bowheads may experience multiple disturbance effects from seismic surveys at different locations within the same season, at the same general location but at different times during the same year, and/or over different and multiple years. Many bowheads may have already been exposed to multiple anthropogenic sources of sound.

Uncertainty should be acknowledged explicitly because it may point to areas that require monitoring and consideration of adaptive management. While some sources of uncertainty cannot be reduced (e.g., the potential effects of long-term exposure to elevated noise levels) we can reduce overall uncertainty about potential impacts on baleen whales through requirements for monitoring coupled with an adaptive management approach whereby mitigations are tailored to conditions that are discovered through monitoring.

Where there is uncertainty, the status of the population, relative to the species, and other important characteristics of the population, provide guidance into whether the analyses should be conservative and how cautious the shape of the action should be. As previously noted what is referred to as the Western Arctic stock (by NMFS) or as the Bering-Chukchi-Beaufort (BCB) Seas stock (by the International Whaling Commission [IWC]) of bowhead whale is the only stock of bowheads that is robust and well on its way to recovery from depletion due to commercial whaling. Thus, the population that could be exposed to the seismic surveys is important to the long-term viability of the species as a whole therefore, a conservative approach to the analyses and the shaping of the action is appropriate.

The bowhead's association with ice and its dependence upon the spring lead and polynya system make it problematic to extrapolate potential effects information from open water situations. Unlike a species with less constrained migratory pathways, bowhead whales are, over some of their migratory pathway, relatively fixed in at least part of the "road" they travel during spring migration.

The fact that the BCB stock of bowheads is hunted throughout most of its range needs to be considered in evaluating the potential effects that MMS actions could have on this species. Geographic areas that exist in between areas where bowheads are hunted and temporal periods in hunting areas in between periods when bowheads are hunted, may have more significance (e.g., as resting areas) to bowheads than they would if the species was not hunted. The fact that they are hunted may also heighten their response to anthropogenic acoustic disturbance at least in some instances.

Current status and response to other perturbations is informative about a potential response to the proposed actions. Based on available information, the bowhead population that may be affected is robust and resilient to a relatively steady lethal take in the subsistence hunt. This level of current mortality is below that which the IWC Scientific Committee believes is sustainable for this population. We do not expect any direct mortality on baleen whales from exposure to seismic surveys but acknowledge that mortality could occur (i.e., through vessel strikes). However, it is clear that this population has continued to recover, despite previous activities that caused disturbance and lethal take. This continued recovery is informative about its resilience at least to the level of disturbance and take that have occurred within the past 20 years.

The mitigation alternatives presented in the programmatic assessment are intended to provide a range of options, from which to develop a mitigation (and monitoring) strategy. The mitigation alternatives

are based upon (1) measures in the July 1999 and August 2001 incidental harassment authorizations from NMFS for marine geophysical permits in the Beaufort Sea OCS; (2) the protective measures in MMS' most recent marine seismic-survey exploration permits; (3) Arctic Open Water meetings in 1999 and 2001; and (4) the MMS' Biological Evaluation, dated 3 March 2006 (USDOI, MMS, 2006). All of the mitigation alternatives include existing Alaska OCS G&G exploration stipulations and guidelines and a variety of additional protective measures for marine mammals. All of the mitigation alternatives require: *field verification* of the noise level radii or exclusion zone isopleths, a specified *exclusion zone*; *ramp-up* procedures, *monitoring the exclusion zone* by NMFS approved visual observers (where the edge of the exclusion zone and beyond cannot be directly observed from the vessel, as would be the case with the 120-dB isopleth-exclusion zone, additional methods, such as passive acoustic monitoring and/or aerial or vessel-based surveys, would be necessary to effectively monitor the exclusion zone); *shutdown; reporting requirements* to provide the regulating agencies with specific information on the monitoring techniques to be implemented and how any observed impacts to marine mammals will be recorded, any shut downs due to a marine mammal entering the exclusion zone and provide the regulating agencies with information on the frequency of occurrence and the types and behaviors of marine mammals (if possible to ascertain) entering the exclusion zones; t*emporal/spatial/operational restrictions* based on the presence of a marine mammal in a particular place or time, or during a particularly sensitive behavior (for example, seismic activity would not occur in the Chukchi Sea spring lead system before 1 July, unless authorized by NMFS, to provide bowhead cow/calve pairs additional protection); and *monitoring of the seismic-survey area* with aerial monitoring surveys or an equivalent monitoring program acceptable to NMFS.

There are a range of exclusion zones presented in the programmatic environmental assessment.

1) A 120-decibel- (dB)-specified exclusion zone to avoid Level A (injury/harm) and Level B (behavior harassment) incidental takes of all marine mammals and extend the level of protection to avoid potential disturbances of cow/calve pairs and aggregations of bowhead whales that could occur due to their avoidance of the active seismic vessel. This isopleth approximates the zone where Richardson et al. (1999) found at 20 kilometers (km) almost total bowhead exclusion. Sound levels received by bowhead whales at 20km ranged from 117-135 dB re 1 µPascal root-mean-square (dB re 1µPa rms) and 107-126 dB re1µPa rms at 30km, and it is the level recommended by the 2001 Open Water meeting participants as where significant responses by bowhead whales in the Beaufort Sea occur.

2) A160-dB-specified exclusion zone. The intent is to protect marine mammals (including bowhead whales) against Level B (behavior harassment) incidental takes and Level A (harassment - injury) incidental takes if the seismic operator had not received incidental take authorization from the NMFS and/or FWS. The 160-dB isopleth is where Malme et al (1983; 1984) found migrating gray whales avoided seismic noise along the California coast, and it is used by NMFS to indicate where Level B harassment begins for impulse sounds, such as seismic.

3) A combined 160-dB- and 120-dB-specified exclusion zones. While the intent of this option is the same as the others it provides special protection for: (1) bowhead whale calves; (2) reproductive-aged female bowhead whales; (3) aggregations of whales; and (4) fall subsistence hunting of bowhead whales in the Beaufort Sea. The NMFS would determine if and when to expand the exclusion-zone isopleth from 160 dB to 120 dB, based on the presence of cow/calve pairs, aggregations of bowhead whales, and the timing and location of the subsistence hunt in both the Beaufort and Chukchi seas. Aerial or vessel-based surveys would reduce the uncertainty about how many and what type of bowhead whales (and other marine mammals) might be present.

4) A combination of exclusion zone isopleths of 180 dB (Level A harassment-injury) for cetaceans and 190 dB (Level A harassment-injury for pinnipeds). The 180-dB and 190-dB isopleths evolved when two expert panels (HESS, 1998; NMFS, 1999) determined that at an unknown higher sound pressure level (SPL) level, cetaceans and pinnipeds, respectively, could incur permanent hearing impairment (Level A harassment). These levels are used by NMFS to indicate where Level A harassment (injury) potentially begins.

Finally, seismic-survey operators must ensure their activities will not have an unmitigable adverse impact on subsistence-marine mammal-harvest activities and have the lowest practicable level of impacts on all marine mammals, per the MMPA. Exact requirements will be specified in the NMFS' incidental harassment authorizations. To help avoid causing adverse impacts on subsistence-harvest activities and fish and wildlife resources, MMS requires those oil and gas companies planning to conduct seismic operations in the Arctic Ocean to coordinate their activities with each other and with Alaskan Native communities and

tribes; village, city, and borough governments; and, subsistence resources commissions (Alaska Eskimo Whaling Commission, Eskimo Walrus Commission, etc.), as necessary.

Uncertainties

Sources of uncertainty exist and were identified in the programmatic environmental assessment. These include, but are not limited to scientific uncertainty about the potential effects of noise, especially repeated exposure to loud impulsive noise, on baleen whales. We also acknowledge that the effects of anthropogenic noise on baleen (or other cetacean) calves, especially newborn calves, are uncertain. Absent direct information in particular on potential effects on baleen calves, we draw on more general mammalian literature about potential effects on very young individuals.

There are no data, direct or indirect, on levels or properties of sound that are required to induce TTS in any baleen whale. However, in practice during seismic surveys, no cases of TTS are expected given the strong likelihood that baleen whales would avoid the approaching airguns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS. This assumes that the ramp-up (soft-start) procedure is used when commencing airgun operations, to give whales near the vessel the opportunity to move away before they are exposed to sound levels that might be strong enough to elicit TTS.

Limited data are available to characterize the current seasonal and temporal use of the Chukchi Sea area by bowhead and other whales, or to fully understand the importance of parts of the Beaufort Sea to bowhead whales. Thus, it is difficult to predict exposure in some parts of the area where seismic surveys could occur, and to understand fully the potential effects of any exposure.

There is uncertainty about the population structure of bowheads that use the Beaufort and Chukchi seas. Data indicate that what is currently referred to as the Western Arctic stock (by NMFS) or as the Bering-Chukchi-Beaufort (BCB) Seas stock (by the International Whaling Commission [IWC]) of bowheads is increasing in abundance and may have doubled in the last 25 years. There are scientific analyses indicating that BCB Seas bowheads may have reached or are approaching, the lower limit of their historic population size. No data are available indicating that, other than historic commercial whaling, any previous human activity has had a significant adverse impact on the current status of the BCB Seas bowheads or their recovery. The uncertainty of the stock structure adds some uncertainty to summaries of the status of bowheads that may be impacted by proposed seismic surveys. Recent data to evaluate bowhead use of the Chukchi Sea OCS Planning Area, or adjacent areas to the south, are lacking. We understand the IWC will be conducting an Implementation Review focusing on the stock structure of the BCB Seas bowhead stock with the goal of completing this at the 2007 annual meeting (IWC, 2005a). Two related intersessional workshops, one that occurred in 2005 and the spring of 2006, are focusing on this topic (IWC, 2005a; 2005b).

The uncertainty about the stock structure of bowheads that inhabit the Chukchi and Beaufort seas adds uncertainty to the analysis of potential effects. It is not currently clear whether one or more population stocks of bowheads potentially could be impacted by the proposed activities. If more than one population may be affected, it may be that the areas in which the two stocks are likely to be vulnerable to adverse effects varies. If there is more than one stock, it is not clear what the estimated population sizes of the potentially affected population stocks are. Discussion in the IWC (2004b) indicated that neither lifespan nor age at-sexual-maturity are certain. Lifespan may be greater than the largest estimates.

Recent systematic data about bowhead distribution and abundance in the Chukchi Sea OCS Planning Area are lacking. MMS funded large-scale surveys in this area when there was oil and gas leasing and exploration, but while surveys in the Beaufort Sea have continued, the last surveys in the Chukchi Sea were about 15 years ago. These data were summarized by Mel'nikov, Zelensky, and Ainana (1997), Moore (1992), Moore and Clarke (1990), and Moore, DeMaster, and Dayton (2000). Since that period, data indicate there have been significant reductions in sea-ice extent and a great decline in average sea-ice thickness. For these reasons, we acknowledge considerable uncertainty about the extent of current use of the Chukchi Sea by bowhead whales, especially during the summer months and the fall migration. Bowheads feed in the Alaskan Beaufort Sea, but the extent and location of that feeding varies widely among years and locations. However, the significance of feeding in particular areas to the overall food requirements of the population or segments of the population is not clear. Recent data on distribution, abundance, or habitat use in the Chukchi Sea Planning Area are not available, and there is little information about summer use in the Beaufort Sea.

Reported seal responses to seismic surveys have been variable and often contradictory, though they do suggest that pinnipeds frequently do not avoid the area within a few hundred meters of operating

airgun arrays. Brueggeman et al. (1991) reported that 96% of the seals they encountered during seismic operations in the Beaufort Sea were encountered during non-data acquisition activities, suggesting avoidance of active data acquisition operations. Miller et al. (2002) reported that, on average, seals sighted during active seismic periods in the Beaufort Sea were significantly farther from the vessel (210m) than those sighted during periods without airgun operations (150m). At the 210m distance, seals would have been exposed to sound levels of about 190 dB re 1 µPa (rms). Sighting rates of ringed seals from another seismic vessel in the Beaufort Sea showed no difference between periods with the full array, partial array, or no guns firing (Harris et al., 2001). Mean distances to seals sighted did increase during full array operations, however, suggesting some local avoidance at levels between 190-200 dB rms. By contrast, telemetry work by Thompson et al. (1998) (as cited in Gordon et al., 2004) suggests that avoidance and behavioral reactions to small airgun sources may be more dramatic than ship-based visual observations indicate.

GULF OF MEXICO EXPERIENCE

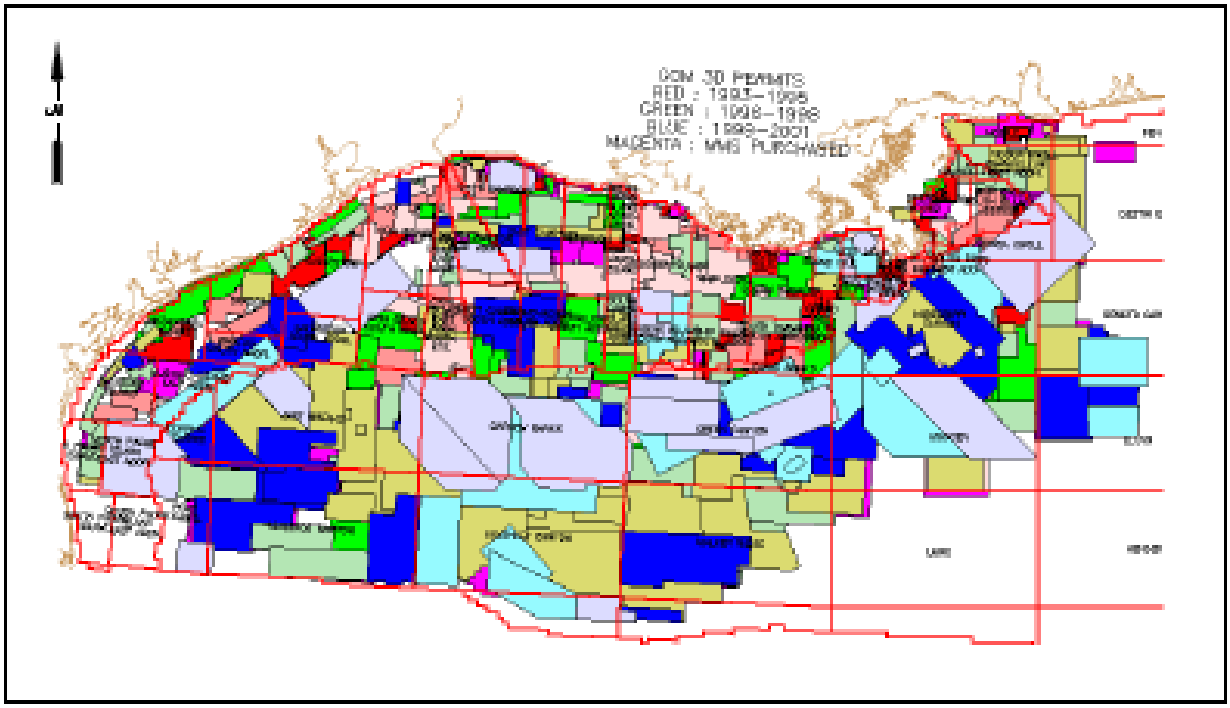
In the Gulf of Mexico (GOM) the oil and gas industry routinely uses airguns as a sound source for seismic exploration (Table 1 and Figure 1).

Table 1. Typical characteristics of seismic surveys in the Gulf of Mexico (MMS 2004-054)

Survey Type	Ship(s)	Ship Speed	Airgun(s)	Source Level (zero to peak)[1]	Firing Rate[2]	Streamers	Grid/Line Specing	Time to Complete
High resolution site survey (2D)	Single ship, 37m	3-3.5kn	Single airgun	229 - 233 dB re 1µPa at 1m	7-8 s (12.5m)	Single 600m streamer towed~ 700m behind ship	300 x 900m grid size; 129 linear km per block	2 days (lease block)
High resolution site survey (3D)	Single ship, 47	3-3.5kn	Tri-cluster of airguns	233 dB re 1µPa at 1m	7-8 s (12.5m)	Up to six streamers, 100-200m long	66 lines per lease block3	5 days (lease block)
2D seismic exploration survey	Single ship, 60-90m	4.5kn	Single source array of three 6-gun subarrays	233 to 240 dB re 1µPa at 1m	16 s (37.5m)	Single streamer, 8 -12km long	Lines 100-166km long, about 2km apart	Days, weeks, or months depending on survey area
3D seismic exploration survey	Single ship,80 – 90m	4.5kn	Dual source arrays, each consisting of three 6-gun subarrays	233 to 240 dB re 1µPa at 1m	16 s (37.5m); two sources, alternate firings	6 to 12 streamers, 3 - 8km long and spread out over 600 - 1,500m	Grid size 24x48m; lines 100-166km long, about 1 km apart	Days, weeks, or months depending on survey area
Ocean bottom cable	Several smaller ships	4.5kn	Same as for 3D	233 to 240 dB re 1	10s (25m); two	N/A	Parallel lines of cables 50m	Days, weeks, or months

survey			seismic (dual source)	µPa at 1m	sources, alternate firings		apart	depending on survey area
Vertical cable Survey	Two ships	4.5kn (or 6kn)	Same as for 3D seismic (dual source)	233 to 240 dB re 1 µPa at 1 m	10 s (25 m); two sources, alternate firings	N/A	Operational area 14 x 20 km; grid size 50 x 80m	Days, weeks, or months depending on survey area

Figure 1. Prelease 3-D seismic survey activity in the Gulf of Mexico, 1993 – 2001 (MMS 2004-054)



Twenty-nine species of marine mammals are known to occur in the GOM (Table 2) There are 28 cetacean species, which include seven mysticete (baleen whales), which are not common in the GOM, 21 odontocete (toothed whales and dolphins) species; and one sirenian species, the West Indian manatee. Their population status is indicated using categories adapted from Würsig et al., 2000. The sperm whale, considered to be common in the GOM, is the only endangered species of marine mammal likely to come in contact with offshore seismic activities in the GOM.

Table 2. Marine mammals of the Gulf of Mexico (MMS 2004-054)

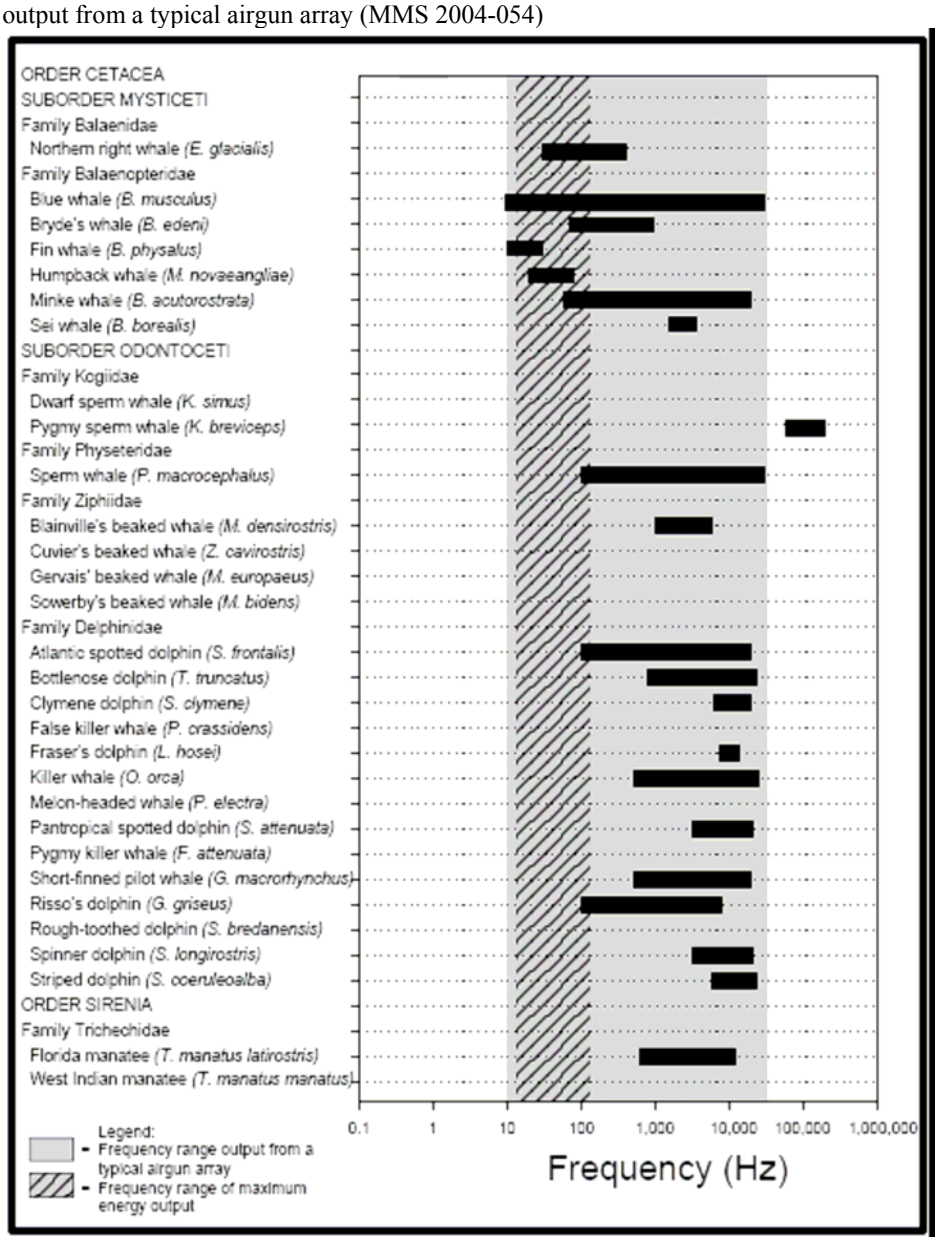
Scientific Name	Common Name	Management Status [a]	Population Status [b]
ORDER CETACEA	**WHALES AND DOLPHINS**		
SUBORDER MYSTICETI BALEEN WHALES			
Family Balaenidae	Right whales		
Eubalaena glacialis	Northern right whale	E, S	1
Family Balaenopteridae	Rorquals		
Balaenoptera musculus	Blue whale	E, S	1

Balaenoptera edeni	Bryde's whale	none	3
Balaenoptera physalus	Fin whale	E, S	2
Megaptera novaeangliae	Humpback whale	E, S	2
Balaenoptera acutorostrata	Minke whale	none	2
Balaenoptera borealis	Sei whale	E, S	2
SUBORDER ODONTOCETI TOOTHED WHALES / DOLPHINS			
Family Physeteridae	Sperm whales		
Physeter macrocephalus	Sperm whale	E, S	4
Family Kogiidae	Pygmy and Dwarf Sperm Whales		
Kogia breviceps	Pygmy sperm whale	none	3
Kogia simu	Dwarf sperm whale	none	3
Family Ziphiidae	Beaked whales		
Mesoplodon densirostris	Blainville's beaked whale	S	2-4c
Ziphius cavirostris	Cuvier's beaked whale	S	2-4c
Mesoplodon europaeus	Gervais' beaked whale	S	3
Mesoplodon bidens	Sowerby's beaked whale	S	1
Family Delphinidae	Dolphins (Delphinids)		
Stenella frontalis	Atlantic spotted dolphin	none	4
Tursiops truncatus	Bottlenose dolphin	none	4
Stenella clymene	Clymene dolphin	none	4
Pseudorca crassidens	False killer whale	none	3
Lagenodelphis hosei	Fraser's dolphin	none	4
Orcinus orca	Killer whale	none	3
Peponocephala electra	Melon-headed whale	none	4
Stenella attenuata	Pantropical spotted dolphin	none	4
Feresa attenuata	Pygmy killer whale	none	3
Globicephala macrorhynchus	Short-finned pilot whale	S	4
Grampus griseus	Risso's dolphin	none	4
Steno bredanensis	Rough-toothed dolphin	none	4
Stenella longirostris	Spinner dolphin	none	4
Stenella coeruleoalba	Striped dolphin	none	4
ORDER SIRENIA DUGONGS AND MANATEES			
Family Trichechidae	Manatees		
Trichechus manatus latirostris	Florida manatee	E	2d
Trichechus manatus manatus	Antillean manatee	E	2

a Management status:
E = endangered under the Endangered Species Act of 1973;
S = strategic stock under the Marine Mammal Protection Act of 1972, as indicated by Waring et al. (1999).
b Population status:
1 = extralimital- a species known on the basis of few records that are probably the result of unusual movements of few individuals into the region; 2 = rare - a species present in such small numbers throughout the region that it is seldom seen; 3 = uncommon – a species that does not occur in large numbers, and may or may not be widely distributed throughout the region in which it occurs; 4 = common - a species that is abundant and widespread throughout the region it occurs. (adapted from Würsig et al., 2000).
c Determining the population status of Blainville's and Cuvier's beaked whales, which occur in the Gulf of Mexico, is problematic. Würsig et al. (2000) classify their presence in the Gulf as rare. In contrast, NMFS notes that beaked whales are difficult to identify to species, they are hard to see, and they occur in small groups. In general, only Cuvier's beaked whales and adult male Blainville's beaked whales can be identified in the field. NMFS suggests that sightings of beaked whales in the Gulf are not rare or that uncommon. During all NMFS aerial and ship surveys combined, there have been sightings of about 75 beaked whale groups (15 as Cuvier's beaked whale, 36 as *Mesoplodon* spp., 2 as Blainville's beaked whale, and 22 as unidentified ziphiids). Another factor to consider is the sightability of beaked whales; they rarely leap out of the water or splash at the surface and are difficult to see unless seas are very calm (Beaufort sea state 0, 1). While a quantitative analysis has not been performed, in general,as the sea state decreases, the number of beaked whale sightings increases. The majority of NMFS surveys have been conducted in sea states that are not optimal for sighting beaked whales. Therefore, NMFS suggests that Blainville's beaked whale and Cuvier's beaked whale are at least uncommon, and depending on how abundance is viewed (group sightings or number of individuals), may in fact, along with Gervais' beaked whale, be common. Because of the difficulties distinguishing Gervais' and Blainville's beaked whale, it may be that if one species is truly rare, the other is without doubt common or uncommon.
d Excluding the Florida coast, the Florida manatee is considered rare in the northern Gulf of Mexico.

The three species or species groups in the GOM – sperm, Brydes, and beaked whales - are assumed to have some sensitivity to seismic noise (i.e. low frequency), particularly under those circumstances where these species do not move away from higher level exposure, and have deep-diving habitats, potentially placing them below an operational array within the zone of highest seismic sound pressure levels (Figure 2).

Figure 2. Vocalization characteristics of select baleen and toothed whales relative to maximum and total output from a typical airgun array (MMS 2004-054)



In calendar year 2003, the first year MMS required mitigation measures for seismic surveys (specific to sperm whales), MMS issued 106 permits for seismic surveys and there was one reported shutdown for sperm whales. In calendar year 2004, (MMS extended the mitigation measures to all whales and all water depths of the Eastern Planning Area) MMS issued 101 permits and seven shutdowns for sperm whales were reported. Analysis is preliminary and does not consider the water depth distribution of the permits or how many line miles were surveyed as a result of the permits. MMS realizes the importance

of analyzing the monitoring data from the GOM and will complete such an analysis after we have three years worth of data to assess.

Mitigation Strategy

Mitigation measures are presently required for seismic surveys in the GOM to protect marine mammals and sea turtles. In 2002, MMS consulted with the National Oceanic and Atmospheric Administration Fisheries Service (NOAA) under the Endangered Species Act (ESA) because some animals that inhabit the GOM are protected under the ESA (e.g. sperm whales, sea turtles). NOAA provided to MMS a biological opinion including non-discretionary measures designed to protect sperm whales from potential impacts of seismic surveys. MMS responded with a notice-to-lessees (NTL) No. 2003-G08, effective June 5, 2003, pursuant to 30 CFR 250.103, to explain seismic survey mitigation measures, including special ramp-up procedures and protected species observation and reporting. That NTL applied to all seismic operations through out the GOM OCS in waters greater than 200m (656 ft) in depth primarily to protect sperm whales. The measures applied to all on-lease seismic surveys conducted under 30 CFR 250.201 and all off-lease seismic surveys conducted under 30 CFR 251. Effective 1 March 2004, MMS revised its NTL to extend to all whales (excluding dolphins as defined by MMS to be all marine mammal species in the family Delphinidae. including, among others, killer whales, pilot whales, and all of the "dolphin" species.) and to waters less than 200m in depth in the Eastern Planning Area, to address the presence of Brydes whales in relatively shallow water near the 100-meter isobath off western Florida (MMS, 2004).

The MMS mitigation measures for the GOM initially were designed to mitigate effects of seismic activity on sperm whales, an exceptionally vocal marine mammal. Passive acoustic monitoring can detect submerged and diving sperm whales and some other marine mammal species when they are undetectable by visual means. Therefore, within the MMS GOM mitigation and monitoring measures the MMS "strongly encourages operators to participate in an experimental program by including passive acoustic monitoring as part of the protected species observer program." "Monitoring for whales with a passive acoustic array by an observer proficient in its use will allow ramp-up and the subsequent start of a seismic survey during times of reduced visibility (darkness, fog, rain, etc.) when such ramp-up otherwise would not be permitted using only visual observers." However, the use of passive acoustic monitoring does not relieve the operators of any of the mitigation requirements.

The GOM mitigation and monitoring strategy includes the following suite of tools; *ramp-up* (to warn marine mammals and sea turtles of pending seismic operations and to allow sufficient time for those animals to leave the immediate vicinity before seismic surveying begins), *visual monitoring* (trained observers to scan the ocean surface visually for the presence of marine mammals and sea turtles); *a pre-determined exclusion zone* (the area at and below the sea surface within a radius of 500 meters surrounding the center of an airgun array and the area within the immediate vicinity of the survey vessel); *mandatory shut-down* of operations when a whale is entering or observed within the exclusion zone (whales refer to all marine mammals in the GOM except dolphins or species in the family Delphinidae and manatees). The procedure to follow requires the observers to visually monitor the exclusion zone and adjacent waters for the absence of whales for at least 30 minutes before initiating ramp-up procedures. If no whales are detected, ramp-up procedures begin. No ramp-up may begin at night or when observers cannot visually monitor the exclusion zone for whales if the minimum source level drops below 160 dB re 1 mPa-m (rms). Ramp-up begins by firing a single airgun. The preferred airgun to begin with should be the smallest airgun, in terms of energy output (dB) and volume (in^3), gradually activating additional airguns over a period of at least 20 minutes, but no longer than 40 minutes, until the desired operating level of the airgun array is obtained. A minimum source level of 160 dB re 1 mPa-m (rms) for routine activities, such as making a turn between line transects, or for maintenance needs is permitted. This procedure may be conducted during periods of impaired visibility (e.g., darkness, fog, high sea states) and does not require a 30-minute visual clearance of the exclusion zone before the airgun array is again ramped up to full output. Ramp-up at night may be allowed only if PAM is in use.

With respect to visual observers, at least two protected species visual observers are required on watch aboard seismic vessels at all times during daylight hours (dawn to dusk) when seismic operations are being conducted, unless conditions (fog, rain, darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that the sea surface observations are not possible, operations are halted, visual observations must resume as soon as conditions permit. Operators may engage trained third party observers, utilize crew members after training as observers, or use a combination of both

third party and crew observers. During these observations, other than brief alerts to bridge personnel of maritime hazards, no additional duties may be assigned to the observer during his/her visual observation watch. No observer will be allowed more than 4 consecutive hours on watch as a visual observer and a "break" time of no less than 2 hours must be allowed before an observer begins another visual monitoring watch rotation. The MMS does not sanction particular trainers or training programs for observers. However, basic training criteria have been established and must be adhered to by any entity that offers observer training. Establishing and monitoring the exclusion zone and observing whale behavior assists in better understanding the degree of behavior reactions to seismic survey activities.

The importance of accurate and complete reporting of the results of mitigation and monitoring are critical to understanding the need for and effectiveness of the mitigation measures. Information on observer effort is important as mammal sighting and behavior data. To that end operators are required at a minimum to complete daily observer reports and survey report and a sighting report prepared for each sighting of a marine mammal or sea turtle made during seismic operations.

Uncertainties

There has been speculation, based on year-round occurrence of strandings, opportunistic sightings and whaling catches, that sperm whales in the GOM may constitute a distinct stock (Schmidly, 1981). The GOM population is provisionally being considered a separate stock for management purposes, although there is currently no information to differentiate this stock from the Atlantic Ocean stock(s). Additional morphological, genetic and/or behavioral data are needed to provide further information on stock delineation. The age distribution of the GOM sperm whale population is unknown.

There is little evidence that direct effects of anthropogenic causes of mortality or injury are significantly affecting the recovery of sperm whale stocks, yet the effect of these activities has only recently begun to be studied. Limited studies are currently being conducted to address the issue of noise generated from airguns and its impact, if any, on this and other marine species. Speculation existed before the Sperm Whale Seismic Study (SWSS) that sperm whales would react to low-frequency, intense sound pulses from seismic airguns at great distances and abandon large areas of Gulf waters in the presence of seismic surveys. SWSS findings clearly show this does not occur. Preliminary analyses of data indicate that some changes in foraging behavior of sperm whales may occur as a seismic vessel passes nearby. More observations of this type would help us to understand if the observations are context specific, statistically relevant, and eventually perhaps to understand whether the kind of observed changes are of any consequence to the sperm whale.

Results from the Tolstoy et al. (2003) field calibration show that, for deep water, the previously utilized 180 dB and 160 dB radii may be conservative (overestimated), based primarily on the measured 160 dB levels and underestimated for shallow water. The results indicate that in shallow water, reverberations play a significant role in received levels and future modeling of seismic energy propagation should account for this effect, especially in shallow waters. Additionally, the definition of what constitutes shallow water, and what constitutes deep water is a problem that should be tackled through both modeling incorporating reverberations, and through continued calibration measurements. Spectra show that, as expected, the majority of the energy from the seismic arrays is in the 5–100 Hz range. Levels at 1 kHz are 20–40 dB lower than those at the frequencies with peak energy, and levels continue to diminish significantly as frequency increases above 1 kHz. This is particularly noteworthy because of recent concern over the sensitivity of beaked whales to seismic sources (e.g., Malakoff, 2002). Beaked whales are believed to be sensitive to frequencies in the 1–20 kHz range and higher, and so it is important to realize that seismic sources have significantly reduced energy at those frequencies, however this assumption also needs to be tested.

SUMMARY OF UNCERTAINTIES AND INFORMATION NEEDS

Developing and improving mitigation depends upon our ability to understand the effect that is to be mitigated. Uncertainties about the effects of seismic survey activity on marine mammals are driven by several fundamental problems. The lack of baseline natural history, physiological, and behavioral data on most marine mammals makes it difficult to predict individual responses to seismic surveys. There are inherent fundamental problems in studying marine mammal behavior in the wild, such that some responses may either be undetected or require specialized monitoring. Few studies exist with direct well-controlled

data concerning the behavioral effects of seismic surveys on marine mammals. The few cases where behavioral responses to seismic airguns have been documented the mechanisms and implications are not clear. Finally, sample sizes are often small where behavioral changes are documented and very context specific making general conclusions difficult.

No documented instances of deaths, physical injuries, or auditory (temporary or permanent threshold shifts – TTS or PTS - or other physiological) effects on marine mammals from seismic surveys have been reported (MMS, 2004). However, it has been shown, experimentally, that threshold changes can be induced in both odontocetes and pinnipeds by exposure to intense short tones and sounds of moderate intensity for extended periods (Gordon et al., 2004). Exposures to single short pulses have not induced threshold shifts, though it is difficult to extrapolate from these findings to a typical seismic survey, where animals will receive many pulses over the course of an exposure. Given the current state of knowledge, it is not possible to reach firm conclusions on the potential for seismic pulses to cause threshold shifts or hearing damage in marine mammals. The lack of data on the exposure levels necessary to cause TTS in toothed whales when the signal is a series of pulsed sounds, separated by silent periods, is a data gap.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. At present, there is little direct evidence for biologically significant effects of seismic surveys on marine mammals; however, none of the research projects conducted to date have been scientifically capable of adequately testing for effects at this level (Gordon et al., 2004).

Of high importance is testing whether different marine mammal species avoid intense sources such as airguns at ranges sufficient to prevent injury and to test the effectiveness of ramp-up as a mitigation tool. Determinations of level of impact depend critically upon such untested assumptions, but these can be tested in the near-term using existing methods through a focused research program.

Management agencies intend to collaborate to develop standardized formats for the collection of monitoring data. These standardized systems should be rigorous enough to support the collection, aggregation, and analysis of scientific information. In conjunction, the Services will continue to develop and improve training and certification programs to ensure that observers are qualified to conduct effective monitoring, enabling data to be utilized.

Most monitoring and mitigation plans rely heavily on visual observers to sight marine mammals. There is a low probability of sighting many species under most conditions. Recent work has demonstrated that passive acoustic monitoring can enhance monitoring efforts, and there has been preliminary research on new techniques such as whale-finding sonar and radar. A high priority for improving the effectiveness of mitigation efforts involves research to test the effectiveness of these different methods and how to optimally integrate them.

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