



**By Electronic and Priority Mail**

July 14, 2011

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National Marine Fisheries Service  
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Re: *Receipt of MMPA Incidental Take Application for Oil and Gas  
Geological and Geophysical Activities in the Gulf of Mexico*

Dear Mr. Payne:

On behalf of the Center for Biological Diversity, Earthjustice, Gulf Restoration Network, Natural Resources Defense Council, and the Sierra Club, and of our millions of members nationwide, I am writing to submit comments on NMFS' receipt of an incidental take application covering geological and geophysical exploration activities in the Gulf of Mexico. 76 Fed. Reg. 34656, 34656-34658 (June 14, 2011).

As you know, we are profoundly concerned about the impact of industry's high-intensity seismic exploration activity on the Gulf's marine mammals. Increasingly, the available science indicates that seismic airguns disrupt baleen whale behavior and impair their communication on a vast scale; that they harm a diverse range of other marine mammals in multiple ways; and that they significantly impact fish and fisheries, with unknown but potentially substantial effects on both coastal communities and marine mammal populations. The amount of seismic activity under consideration in this rulemaking is enormous, comprising dozens of surveys each year in what is the most intensively prospected body of water in the world. To make matters worse, all of these surveys are taking place in a context of chronic industrial noise: noise from the industry's support vessels, from its construction of offshore facilities, from its routine operations, and from its platform decommissioning. Moreover, many of the marine mammal populations that seismic operators are affecting—Bryde's whales, sperm whales, and bottlenose dolphins, among others—may already be seriously compromised by the *Deepwater Horizon* spill.

Given the sheer extent of activity in the Gulf, the substantial scientific concern about both seismic surveys and cumulative acoustic stressors, and the acute vulnerability of

Gulf populations, particularly in the wake of the *Deepwater* spill, it is vitally important that NMFS approach this rulemaking, and its associated environmental impact statement (“EIS”), carefully and conservatively. As you know, both NMFS and the federal courts have already recognized the spill as a significant event. For its part, the agency has re-initiated consultation under the Endangered Species Act in order to evaluate the effects of the spill on the Gulf shrimp fishery. Similarly, a federal judge recently found that NMFS violated the ESA when it failed to re-initiate consultation to determine the effect of the spill on a reef fish fishery that kills sea turtles. *Sea Turtle Conservancy et al. v. Locke*, No. 1:09-cv-00259 (N.D. Fla., July 5, 2011).

Unfortunately, BOEMRE’s application, while benefiting from a more rigorous modeling effort than was attempted in the past, contains a number of major flaws that require NMFS’ redress. The application adopts a single flat threshold for all species that assumes, insupportably, that take will not occur below 160 dB (RMS); it fails to account for cumulative impacts in any way; and it does not suggest any mitigation beyond the plainly inadequate safety zone monitoring and ramp-up that BOEMRE currently prescribes in the Gulf. NMFS must drastically improve this impact analysis, and, if a rule is to issue, must prescribe mitigation that reduces takes below the “small numbers” and “negligible impact” threshold, as the MMPA demands.<sup>1</sup> 16 U.S.C. § 1371(a)(5)(A)(i). Simply put, *current levels of seismic exploration in the northern Gulf of Mexico are not compatible with the MMPA*.

Our groups urge NMFS to take the following actions (discussed in further detail below), which we believe are required for compliance with applicable laws:

*Recommendations for Impact Assessment*

- (1) Thoroughly revise the thresholds that BOEMRE uses in its application to estimate sublethal behavioral take from airgun surveys, using species-specific thresholds for sperm whales, beaked whales, and certain other species; including masking effects in thresholds, especially for Bryde’s whales; ensuring that the thresholds used address take at received levels well below 160 dB (RMS); treating airguns as a mixed acoustic source behaving as both a multi-pulse source and a continuous noise source, depending on distance; and soliciting expert opinion in an open and transparent manner.
- (2) Properly model for both temporary *and* permanent threshold shift and other debilitating injuries, taking into account recent data that indicates higher risk of hearing loss in marine mammals than previously suggested.
- (3) Closely scrutinize BOEMRE’s assumption of 230 dB (RMS) as a “typical” source level for airgun surveys, obtaining data indicating the source levels of

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<sup>1</sup> The MMPA also requires NMFS to prescribe mitigation that achieves “the least practicable impact” on marine mammals, but this is a separate mandate. 16 U.S.C. § 1371(a)(5)(A)(i)(II)(aa). The “small numbers” and “negligible impact” standards must be met for the rule to issue at all, and therefore are not limited by considerations of practicability.

seismic arrays used over a representative period in the Gulf and determining if the use of this source level results in an undercount of take.

- (4) Meaningfully analyze the cumulative impacts of sublethal takes, adopting the conservative assumption that any substantial decrements in the communication range of Bryde's whales or the foraging success of sperm whales caused by seismic surveys will result in adverse, population-level impacts.
- (5) Consider the impacts of other activities and events in NMFS' impacts analysis, determining in particular whether the *Deepwater Horizon* spill establishes new baselines for population abundance and prey availability and for the capacity of certain species to withstand additional stressors.
- (6) Conduct additional research to determine the stock delineation of Gulf Bryde's whales, and proceed on the assumption that Bryde's whales constitute a distinct stock if tissue samples needed to make such a determination are not available.

#### *Recommendations for Mitigation*

- (1) Adopt area closures and restrictions for high-value habitat, including the Mississippi Canyon, DeSoto Canyon, coastal waters landward of the 20-meter isobath, and sperm whale habitat west of the Tortugas, and consider other areas based on the findings of the NOAA Working Group on Marine Mammal Hotspots.
- (2) Establish activity caps, by (1) considering multiple alternatives for reducing cumulative exposures (well below 160 dB) in each planning region to levels that satisfy both the "small numbers" and "lowest practicable level" requirements; and (2) by assigning seasonal or year-round caps that significantly reduce exposures for Bryde's and sperm whales, to address the clear potential for greater than negligible impacts on these species.
- (3) Require BOEMRE to eliminate unnecessary duplication of survey effort throughout the Gulf, by rejecting permit applications or requiring modification of permit applications that duplicate, in whole or in part, other surveys occurring in the same locations for the same or similar purposes; and consider requiring operators of 3D surveys to acquire, process, provide data in such a way as to obviate the need for high-resolution site surveys.
- (4) Require separation of seismic vessels to reduce the potential impacts of overlapping sound fields.
- (5) Consider actionable alternatives to accelerate the development and use of technological alternatives to existing airgun technology, as recommended by two recent workshop reports, such as by creating an adaptive management process by which such technologies or modifications can be required as they become available, deferring surveys in particular areas or for particular purposes, and providing regulatory incentives.

- (6) Require BOEMRE to (a) ensure that operators reduce the effective source levels of their surveys to the lowest practicable level, and provide an objective, transparent standard and oversight mechanism to ensure compliance; and (b) require operators to calibrate their airgun arrays before beginning a survey in order to minimize horizontal propagation of the noise signal, and report field-checked source levels to the agencies for purposes of transparency and compliance.
- (7) Expand the application of BOEMRE's existing marine mammal safety zone in the Gulf of Mexico, and recalculate safety zone distances in light of several recent studies on threshold shift and acoustic propagation.

## **I. IMPACTS OF AIRGUN SURVEYS AND OTHER G&G ACTIVITIES**

The ocean is an acoustic world. Unlike light, sound travels extremely efficiently in seawater; and marine mammals and many fish depend on sound for finding mates, foraging, avoiding predators, navigating, and communicating – in short, for virtually every vital life function. When loud sounds are introduced into the ocean, it degrades this essential part of the environment. Some biologists have analogized the increasing levels of noise from human activities as a rising tide of “smog” that has industrialized major portions of the marine environment off our coasts. This acoustic smog is already shrinking the sensory range of marine animals by orders of magnitude from pre-industrial levels.<sup>2</sup>

For offshore exploration, the oil and gas industry typically rely on arrays of airguns, which are towed behind ships and release intense impulses of compressed air into the water about once every 10-12 seconds.<sup>3</sup> A large seismic airgun array can produce effective peak pressures of sound higher than those of virtually any other man-made source save explosives;<sup>4</sup> and although airguns are vertically oriented within the water column, horizontal propagation is so significant as to make them, even under present use, one of the leading contributors to low-frequency ambient noise thousands of miles from any given survey.<sup>5</sup> It is well established that the high-intensity pulses produced by airguns can cause a range of impacts on marine mammals, fish, and other marine life, including broad habitat displacement, disruption of vital behaviors essential to foraging

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<sup>2</sup> Bode, M., Clark, C.W., Cooke, J., Crowder, L.B., Deak, T., Green, J.E., Greig, L., Hildebrand, J., Kappel, C., Kroeker, K.J., Loseto, L.L., Mangel, M., Ramasco, J.J., Reeves, R.R., Suydam, R., Weilgart, L., Statement to President Barack Obama of Participants of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals (2009).

<sup>3</sup> Deep seismic surveys are not used for renewable energy projects.

<sup>4</sup> National Research Council, *Ocean Noise and Marine Mammals* (2003).

<sup>5</sup> Nieuwkirk, S.L., Stafford, K.M., Mellinger, D.K., Dziak, R.P., and Fox, C.G., Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean, *Journal of the Acoustical Society of America* 115: 1832-1843 (2004).

and breeding, loss of biological diversity, and, in some circumstances, injuries and mortalities.<sup>6</sup>

The impacts of airgun surveys are felt on an extraordinarily wide geographic scale – especially on endangered baleen whales, whose vocalizations and acoustic sensitivities overlap with the enormous low-frequency energy that airguns put in the water. For example, a single seismic survey has been shown to cause endangered fin and humpback whales to stop vocalizing – a behavior essential to breeding and foraging – over an area at least 100,000 square nautical miles in size, and can cause baleen whales to abandon habitat over the same scale.<sup>7</sup> Similarly, airgun noise can also mask the calls of vocalizing baleen whales over vast distances, substantially compromising their ability to communicate, feed, find mates, and engage in other vital behavior.<sup>8</sup> The intermittency of airgun pulses hardly mitigates this effect since their acoustic energy spreads over time and can sound virtually continuous at distances from the array.<sup>9</sup> According to recent modeling from Cornell and NOAA, the highly endangered North Atlantic right whale is particularly vulnerable to masking effects from airguns and other sources given the acoustic and behavioral characteristics of its calls.<sup>10</sup> Repeated insult from airgun surveys, over months and seasons, would come on top of already urbanized levels of background noise and, cumulatively and individually, would pose a significant threat to populations of marine mammals.

Airguns are also known to affect a broad range of other marine mammal species beyond the endangered great whales. For example, sperm whale foraging appears to decline significantly on exposure to even moderate levels of airgun noise, with potentially

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<sup>6</sup> See, e.g., Hildebrand, J.A., Impacts of anthropogenic sound, in Reynolds, J.E. III, Perrin, W.F., Reeves, R.R., Montgomery, S., and Ragen, T.J. (eds), *Marine Mammal Research: Conservation beyond Crisis* (2006); Weilgart, L., The impacts of anthropogenic ocean noise on cetaceans and implications for management. *Canadian Journal of Zoology* 85: 1091-1116 (2007).

<sup>7</sup> Clark, C.W., and Gagnon, G.C., Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales (2006) (IWC Sci. Comm. Doc. IWC/SC/58/E9); Clark, C.W., pers. comm. with M. Jasny, NRDC (Apr. 2010); see also MacLeod, K., Simmonds, M.P., and Murray, E., Abundance of fin (*Balaenoptera physalus*) and sei whales (*B. borealis*) amid oil exploration and development off northwest Scotland, *Journal of Cetacean Research and Management* 8: 247-254 (2006).

<sup>8</sup> Clark, C.W., Ellison, W.T., Southall, B.L., Hatch, L., van Parijs, S., Frankel, A., and Ponirakis, D., Acoustic masking in marine ecosystems as a function of anthropogenic sound sources (2009) (IWC Sci. Comm. Doc. SC/61/E10).

<sup>9</sup> *Id.*; Weilgart, L. (ed.), Report of the workshop on alternative technologies to seismic airgun surveys for oil and gas exploration and their potential for reducing impacts on marine mammals, 31 Aug. – 1 Sept., 2009, Monterey, Calif. (2010) (available at [www.oceanos-stiftung.org/oceanos/download.php?id=19](http://www.oceanos-stiftung.org/oceanos/download.php?id=19)).

<sup>10</sup> Clark et al., Acoustic masking in marine ecosystems as a function of anthropogenic sound sources; Clark, C.W., Ellison, W.T., Southall, B.L., Hatch, L., Van Parijs, S.M., Frankel, A., and Ponirakis, D., Acoustic masking in marine ecosystems: Intuitions, analysis, and implication, *Marine Ecology Progress Series* 395: 201-222 (2009).

serious long-term consequences;<sup>11</sup> and harbor porpoises have been seen to engage in strong avoidance responses fifty miles from an array.<sup>12</sup> Seismic surveys have been implicated in the long-term loss of marine mammal biodiversity off the coast of Brazil.<sup>13</sup>

Airgun surveys are also known to significantly affect the distribution of some prey species, which could in turn displace marine mammals or have significant impacts on their foraging. For example, airguns have been shown to dramatically depress catch rates of some commercial fish species, by 40 to 80% depending on catch method, over thousands of square kilometers around a single array,<sup>14</sup> leading fishermen in some parts of the world to seek industry compensation for their losses. Other impacts on commercially harvested fish include habitat abandonment – one hypothesized explanation for the fallen catch rates – reduced reproductive performance, and hearing loss;<sup>15</sup> and recent data suggest that loud, low-frequency sound also disrupts chorusing in black drum fish, a behavior essential to breeding in this commercial species.<sup>16</sup>

In short, the G&G activities under review, and particularly the airgun surveys that presently represent the dominant means of offshore exploration, are likely to significantly impact commercial fisheries and the habitat of endangered whales and other marine mammals.

## II. COMPLIANCE WITH THE MMPA

The Marine Mammal Protection Act was adopted more than thirty years ago to ameliorate the consequences of human impacts on marine mammals. Its goal is to

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<sup>11</sup> Miller, P.J.O., Johnson, M.P., Madsen, P.T., Biassoni, N., Quero, M., and Tyack, P.L., Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico, *Deep-Sea Research I* 56: 1168-1181 (2009).

<sup>12</sup> Bain, D.E., and Williams, R., Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance (2006) (IWC Sci. Comm. Doc. IWC/SC/58/E35).

<sup>13</sup> Parente, C.L., Pauline de Araújo, J., and Elisabeth de Araújo, M., Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys, *Biota Neotropica* 7(1) (2007).

<sup>14</sup> Engås, A., Løkkeborg, S., Ona, E., and Soldal, A.V., Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*), *Canadian Journal of Fisheries and Aquatic Sciences* 53: 2238-2249 (1996); see also Skalski, J.R., Pearson, W.H., and Malme, C.I., Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes ssp.*), *Canadian Journal of Fisheries and Aquatic Sciences* 49: 1357-1365 (1992).

<sup>15</sup> McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.-N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J. and McCabe, K., Marine seismic surveys: analysis and propagation of air-gun signals, and effects of air-gun exposure on humpback whales, sea turtles, fishes, and squid (2000) (report by Curtin U. of Technology); McCauley, R., Fewtrell, J., and Popper, A.N., High intensity anthropogenic sound damages fish ears, *Journal of the Acoustical Society of America* 113: 638-642 (2003); Scholik, A.R., and Yan, H.Y., Effects of boat engine noise on the auditory sensitivity of the fathead minnow, *Pimephales promelas*, *Environmental Biology of Fishes* 63: 203-209 (2002).

<sup>16</sup> Clark, C.W., pers. comm. with M. Jasny, NRDC (Apr. 2010).

protect and promote the growth of marine mammal populations “to the greatest extent feasible commensurate with sound policies of resource management” and to “maintain the health and stability of the marine ecosystem.” 16 U.S.C. § 1361(6). A careful approach to management was necessary given the vulnerable status of many of these populations as well as the difficulty of measuring the impacts of human activities on marine mammals in the wild. 16 U.S.C. § 1361(1), (3). “[I]t seems elementary common sense,” the House Committee on Merchant Marine and Fisheries observed in sending the bill to the floor, “that legislation should be adopted to require that we act conservatively—that no steps should be taken regarding these animals that might prove to be adverse or even irreversible in their effects until more is known. As far as could be done, we have endeavored to build such a conservative bias into the [Marine Mammal Protection Act].” Report of the House Committee on Merchant Marines and Fisheries, *reprinted in* 1972 U.S. Code Cong. & Admin. News 4148.

The heart of the MMPA is its so-called “take” provision, a moratorium on the harassing, hunting, or killing of marine mammals. 16 U.S.C. § 1362(13). Under the law, NMFS may grant exceptions to the take prohibition, provided it determines, *inter alia*, that such take would (a) take only small numbers of marine mammals and (b) have only a negligible impact on marine mammal species and stocks. It should be noted that the “small numbers” and “negligible impact” determinations are legally separate and distinct requirements of the MMPA and may not be conflated. 279 *NRDC v. Evans*, F.Supp.2d 1129, 1150-53. Finally, in authorizing take under the Act, NMFS must prescribe “methods” and “means of effecting the least practicable impact” on protected species as well as “requirements pertaining to the monitoring and reporting of such taking.” 16 U.S.C. §§ 1371(a)(5)(A)(ii), (D)(vi).

#### **A. Impact Analysis**

We ask that NMFS take note of the following key points in conducting its impact assessment under the MMPA.

(1) *Threshold used to estimate sublethal behavioral take.*— In its 2011 application, BOEMRE uses a single sound pressure level (here, 160 dB (RMS)) as a threshold for behavioral, sublethal take in all marine mammal species. This approach simply does not reflect the best available science, and the choice of threshold is flawed and non-conservative in several important respects:

- The method represents a step backward from recent programmatic authorizations. For Navy sonar activity, NMFS has used a combination of specific bright-line thresholds (for harbor porpoises) and linear risk functions that endeavor to take account of risk and individual variability and to reflect the potential for take at relatively low levels. *E.g.*, 74 Fed. Reg. 4844, 4844-4885 (Jan. 27, 2009). In the wake of these past authorizations for acoustic impacts on marine mammals, BOEMRE’s reversion to a single, non-conservative, bright-line threshold for all species is simply not tenable.

- The 160 dB threshold is non-conservative, since the scientific literature establishes that behavioral disruption can occur at substantially lower received levels for some species. *See supra* at Section I; *see also Ocean Mammal Institute v. Gates*, 546 F. Supp.2d 960, 973-75 (D.Hawaii 2008) (citing evidence of impacts below behavioral harassment threshold to find threshold arbitrary and capricious).
- The use of a multi-pulse standard for behavior harassment is non-conservative, since it does not take into account the spreading of seismic pulses over time beyond a certain distance from the array.<sup>17</sup>
- The threshold's basis in RMS, rather than peak pressure, is non-conservative. Madsen (2005) criticized the use of RMS for seismic because of the degree to which pulsed sounds must be "stretched," which indeed BOEMRE recognizes in its application (2011 App. at A-2).<sup>18</sup>

NMFS must revise the thresholds and methodology used to estimate take. Specifically, we urge the following:

- (a) NMFS should employ a combination of specific thresholds for which sufficient species-specific data are available and generalized thresholds for all other species.<sup>19</sup> These thresholds should be expressed as linear risk functions where appropriate.
- (b) Species-specific thresholds for sperm whales should be based primarily on Miller et al. (2007), and such thresholds for beaked whales should be based primarily on Tyack et al. (2011); masking thresholds for baleen whales, including Bryde's whales, should be derived from Clark et al. (2009).<sup>20</sup> Data on species for which specific thresholds are developed should be included in deriving generalized thresholds for species for which less data are available.
- (c) In deriving its take thresholds, NMFS should treat airgun arrays as a mixed acoustic type, behaving as a multi-pulse source closer to the array

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<sup>17</sup> See Brower, H., Clark, C.W., Ferguson, M., Gedamke, J., Southall, B., and Suydam, R., Expert panel review of monitoring protocols in applications for incidental harassment authorizations related to oil and gas exploration in the Chukchi and Beaufort Seas, 2011: Statoil and ION Geophysical (2011).

<sup>18</sup> Madsen, P.T., Marine mammals and noise: Problems with root-mean-squared sound pressure level for transients, *Journal of the Acoustical Society of America* 117:3952-57 (2005).

<sup>19</sup> By "thresholds," we mean either bright-line thresholds or linear risk functions.

<sup>20</sup> Miller et al., Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales; Tyack, P.L., Zimmer, W.M.X., Moretti, D., Southall, B.L., Claridge, D.E., Durban, J.W., Clark, C.W., D'Amico, A., DiMarzio, N., Jarvis, S., McCarthy, E., Morrissey, R., Ward, J., and Boyd, I.L., Beaked whales respond to stimulated and actual Navy sonar, *PLoS ONE* 6(3):e17009. Dot10.1371/journal.pone.0017009 (2011); Clark et al., Acoustic masking in marine ecosystems:

Intuitions, analysis, and implication. *See also* Clark et al., Acoustic masking in marine ecosystems as a function of anthropogenic sound sources.

and, in effect, as a continuous noise source further from the array, per the findings of the 2011 Open Water Panel cited above. Take thresholds for the multi-pulse component should be based on peak pressure rather than on RMS.

(d) Finally, we recommend that NMFS solicit expert opinion on behavioral take thresholds in an open and transparent manner.

(2) *Potential for hearing loss and other debilitating injury.*— In its application, BOEMRE runs take numbers for two thresholds of “Level A” injury, the threshold “traditionally” used by NMFS for seismic surveys (180 dB (RMS)) and the threshold suggested by Southall et al. (2007) for multi-pulse sources (which it characterizes as 230 dB (flat)), but argues that the higher level should apply. We do not agree with BOEMRE’s rationale for adopting the higher level; even if a higher level were adopted for death and permanent injury, however, NMFS should retain a threshold no higher than 180 dB (peak) (assuming the agency uses a pressure level rather than energy level standard) in order to address temporary threshold shift, which, for several reasons, has received separate take analysis in prior noise authorizations. *E.g.*, 74 Fed. Reg. 4844, 4874 (Jan. 27, 2009). Furthermore, in determining thresholds for temporary and permanent threshold shift, NMFS must take account of a number of recent papers that suggest current thresholds are not sufficiently conservative. See *infra* at II(B)(7)(b).

(3) *Source level used to calculate take.*— In its application, BOEMRE posits 230 dB (RMS) as a “typical” source level for purposes of modeling takes from airgun surveys (2011 App. at 24), but more information and analysis are needed to determine whether this critical value is appropriate. *First*, BOEMRE does not submit, in its take application, any data supporting this approach. NMFS should require BOEMRE to provide data indicating the source levels and sizes of seismic arrays used over a suitable period in the Gulf of Mexico, and should make that information publicly available in the DEIS and proposed rulemaking.

*Second*, it is not self-evident that using a single “typical” or “average” source level is a reasonable and sufficiently conservative approach to NMFS’ take analysis. As BOEMRE recognizes, the effective source levels of industry arrays may run considerably higher or lower than the one used in BOEMRE’s modeling (2011 App. at 24). Given that impact areas grow exponentially with increases in source levels, the undercount that would result from excluding surveys with higher source levels could vastly exceed the overcount that would result from excluding surveys with lower source levels. For this reason, NMFS should conduct a sensitivity analysis to ensure that any representative level, or levels, chosen for modeling do not negatively bias the analysis towards an undercount of take. If there is negative bias, NMFS should modify the source level, or levels, and require BOEMRE to rerun the model or use a conservative corrective factor to estimate take.

- (4) *Cumulative acoustic impacts from G&G and other offshore oil and gas activity.* — Given the extent of seismic and other industry activity in the northern Gulf, it is plain that NMFS must carefully consider cumulative impacts in making its negligible impact determination under the MMPA. Unfortunately, BOEMRE's application does not make any attempt at cumulative effects analysis. Optimally, NMFS would translate sublethal takes into impacts on vital rates of individuals and ultimately on populations of Gulf marine mammals. Such an approach is consistent with the 2005 National Research Council report, "Marine Mammal Populations and Ocean Noise," and the means of accomplishing part of the NRC's analysis are now becoming available.<sup>21</sup>

With respect to airguns, the data already show that industry noise can disrupt the biologically significant behavior and shrink the communication range of baleen whales on a region-wide scale. As Dr. Chris Clark (Cornell) postulated in the report of the International Whaling Commission's Scientific Committee, such repeated and persistent acoustic insults over the large areas affected by airgun surveys should be considered enough to cause population-level impacts in at least some species of marine mammals.<sup>22</sup>

We recognize, however, that a complete quantitative analysis, encompassing each of the steps of the NRC's cumulative impacts model, may not yet be possible and that NMFS may need to rely on a more limited analysis based on the best available science. In conducting that analysis, NMFS should conservatively assume that any substantial decrements in the communication range of Bryde's whales caused by seismic surveys will result in adverse impacts on the stock. A conservative approach is justified given the available data and modeling on other baleen whale species, the potentially extreme vulnerability of the Bryde's whale stock, and the difficulty of obtaining empirical data on population-level impacts on wild marine animals.<sup>23</sup> The impacts of seismic exploration would occur in an already compromised acoustic environment, which should also be taken into account. NMFS should take a similar approach with respect to sperm whales, and likewise consider that any substantial decrement in foraging on that stock will result in adverse population impacts.

- (5) *Non-acoustic cumulative impacts from other activities.* — In determining whether the proposed activities will have a greater than negligible impact on Gulf species and stocks, NMFS must consider the impacts of other activities and

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<sup>21</sup> National Research Council (NRC), *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects* (2005).

<sup>22</sup> IWC Scientific Committee, Report of the 2004 Scientific Committee of the International Whaling Commission, Annex K: Report of the Standing Working Group on Environmental Concerns (2004).

<sup>23</sup> See, e.g., Taylor, B.L., Martinez, M., Gerrodette, T., and Barlow, J., Lessons from monitoring trends in abundance of marine mammals, *Marine Mammal Science* 23: 157-175 (2007).

events into its environmental analysis, including non-acoustic impacts from ship-strikes, bycatch and entanglements, the *Deepwater Horizon* oil spill, and other stressors on the same species and populations affected by offshore exploration activities. Most pressingly, NMFS should consider whether the *Deepwater Horizon* spill establishes new baselines for population abundance and prey availability and for the capacity of certain species to withstand additional stressors.

- (6) *Population status of Bryde's whales.*— It is imperative that NMFS determine the population structure of Gulf Bryde's whales before finalizing its authorization.

NMFS' December 2009 stock assessment puts the number of Bryde's whales left in the Gulf at fewer than 50 individuals —<sup>24</sup> a number that would leave it highly vulnerable, particularly if it constitutes a resident population as several studies have suggested.<sup>25</sup> The stock assessment notes that additional genetic, morphological, and/or behavioral data are needed to provide further information on stock delineation from Atlantic Bryde's whales. This information is critical not only because of the extremely small size of the stock, but because of the whales' reliable occurrence in the DeSoto Canyon, an area of interest for oil and gas exploration and production.

It is our understanding that NMFS' Southeast Regional Science Center is presently analyzing DNA samples of Gulf Bryde's and, to a lesser extent, of Atlantic Bryde's whales, and will produce a paper on the Gulf stock's genetics within several months. Investigators believe that samples from the Gulf are probably sufficient in number and data quality to make findings about delineation, but that more samples from Atlantic Bryde's whales must be analyzed before conclusions can be drawn. The next step for genetic research therefore requires expanding the available dataset on Atlantic Bryde's whales, by locating samples in archives in the U.S. and abroad (since the whales are not known to occur in high densities in the northwest Atlantic), and either obtaining those samples or working with other researchers to run the genetics.

Both the MMPA and NEPA require NMFS to obtain these genetic data. Under the MMPA, the agency must affirmatively find that BOEMRE's activities will have no more than a negligible impact of a species or stock. 16 U.S.C. §§ 1371(a)(5)(A)(i), (D)(i)(I). Clearly information on Bryde's whale stock

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<sup>24</sup> Waring, G.T., Josephson, E., Maze-Foley, K., and Rosel, P.E. eds., U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2010, at 489-92 (2010).

<sup>25</sup> Mead, J.G., Records of sei and Bryde's whales from the Atlantic coast of the United States, the Gulf of Mexico, and the Caribbean, *Reports of the International Whaling Commission Special Issue* 1:113-116 (1977); Schmidly, D.J., Marine mammals of the southeastern United States and the Gulf of Mexico, (1981) (Report No. FWS/OBS-80/41); Jefferson, T.A., and Schiro, A.J., Distribution of cetaceans in the offshore Gulf of Mexico, *Mammal Review* 27:27-50 (1997).

structure is essential to NMFS' analysis, since its ability to make a negligible impact finding depends significantly on whether the whales constitute a small, demographically discrete population of animals. Under NEPA, which NMFS must satisfy in issuing an MMPA authorization, the agency must obtain and disclose any information necessary to its analysis of environmental impacts or alternatives, unless the costs of doing so are exorbitant. 40 C.F.R. § 1502.22(a).

We therefore urge NMFS to conduct the comparative genetics, or else determine that the Atlantic population samples available in U.S. and foreign archives are not sufficient for any meaningful analysis. If the issue remains unresolved, NMFS must follow the delineation indicated in the most recent stock assessment, and proceed on the assumption that Bryde's whales constitute a distinct stock.<sup>26</sup> This will require NMFS, in issuing an authorization, to adopt whatever mitigation is necessary to reduce impacts on the Gulf's small Bryde's stock below the allowable threshold.

## **B. Mitigation Analysis**

### *(1) Area Closures and Restrictions*

There is general consensus that time and place restrictions designed to protect high-value habitat are one of the most effective means to reduce the potential impacts of noise and disturbance, including noise from oil and gas exploration.<sup>27</sup> In the Gulf of Mexico, areas of biological significance for marine mammals include:

*(a) Mississippi Canyon.*— It is well established, on the basis of historic whaling records, mark-recapture data, and extensive surveys including by GulfCet II and the Sperm Whale Seismic Study, that this area constitutes important habitat for the Gulf's small, biologically distinct population of sperm whales,<sup>28</sup> most likely due to the input of a nutrient-

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<sup>26</sup> Waring *et al.*, U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments at 489.

<sup>27</sup> Agardy, T., Aguilar Soto, N., Cañadas, A., Engel, M., Frantzis, A., Hatch, L., Hoyt, E., Kaschner, K., LaBrecque, E., Martin, V., Notarbartolo di Sciara, G., Pavan, G., Servidio, A., Smith, B., Wang, J., Weilgart, L., Wintle, B., and Wright, A., A global scientific workshop on spatio-temporal management of noise, Report of workshop held in Puerto Calero, Lanzarote, June 4-6, 2007 (2007); Dolman, S., Aguilar Soto, N., Notarbartolo di Sciara, G., Andre, M., Evans, P., Frisch, H., Gannier, A., Gordon, J., Jasny, M., Johnson, M., Papanicolopulu, I., Panigada, S., Tyack, P., and Wright, A., Technical report on effective mitigation for active sonar and beaked whales (2009) (working group convened by European Cetacean Society); OSPAR Commission, Assessment of the environmental impact of underwater noise (2009) (report issued as part of OSPAR Biodiversity Series, London, UK); Memorandum from Dr. Jane Lubchenco, NOAA Administrator, to Ms. Nancy Sutley, CEQ Chair (Jan. 19, 2010).

<sup>28</sup> *E.g.*, Townsend, C.H., The distribution of certain whales as shown by logbook records of American whalships, *Zoologica: Scientific Contributions of the New York Zoological Society* 19:3-50 (1935); Biggs, D.C., Leben, R.R., and Ortega-Ortiz, J.G., Ship and satellite studies of mesoscale circulation and sperm whale habitats in the northeast Gulf of Mexico during GulfCet II, *Gulf of Mexico Science* 18:15-22 (2000); Weller, D.W., Würsig, B., Lynn, S.K., and Schiro, A.J., Preliminary findings on the

rich, freshwater plume from the Mississippi Delta.<sup>29</sup> Nearly all sightings of females and mother-calf groups have occurred there, strongly suggesting it functions as a nursery ground.<sup>30</sup>

(b) *DeSoto Canyon*.— The DeSoto Canyon represents important habitat for Bryde's whales, the most commonly occurring baleen whale in the Gulf of Mexico, as well as habitat for sperm whale and other cetaceans. Nearly all known sightings of Bryde's whales have occurred in the canyon.<sup>31</sup> The stock size is estimated as well under 50 animals, leaving it highly vulnerable particularly if it constitutes a resident population as several studies have suggested.<sup>32</sup> It should be noted that BOEMRE's AIM Modeling projects Bryde's whale densities over a much larger area (2011 App. at A-44 to A-46), probably resulting in much lower levels of take than would be presumed to occur for surveys sited directly in the DeSoto Canyon.

(c) *Coastal waters landward of the 20m isobath*.— The coastal ecotype of bottlenose dolphin comprises more than 30 identified stocks across the Northern Gulf, many of which have best population estimates well below 100 individual animals;<sup>33</sup> and manatees are an ESA-listed species whose habitat choices are highly correlated to the absence of predominantly low-frequency sound.<sup>34</sup> These waters provide habitat for both species. The primary calving season for coastal bottlenose dolphins runs from

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occurrence and site fidelity of photo-identified sperm whales (*Physeter macrocephalus*) in the northern Gulf of Mexico, *Gulf of Mexico Science* 18:35-39 (2000); Baumgartner, M.F., Mullin, K.D., May, L.N., and Leming, T.D., Cetacean habitats in the northern Gulf of Mexico, *Fishery Bulletin, U.S.* 99:219-239 (2001); Jochens, A., Biggs, D., Engelhaupt, D., Gordon, J., Jaquet, N., Johnson, M., Leben, R., Mate, B., Miller, P., Ortega-Ortiz, J., Thode, A., Tyack, P., Wormuth, J., Würsig, B., Sperm whale seismic study in the Gulf of Mexico: Summary report, 2002-2004 (2006) (OCS Study MMS 2006-034).

<sup>29</sup> Davis, R.W., Ortega-Ortiz, J.G., Ribic, C.A., Evans, W.E., Biggs, D.C., Ressler, P.H., Cady, R.B., Leben, R.R., Mullin, K.D., and Würsig, B., Cetacean habitat in the northern oceanic Gulf of Mexico, *Deep-Sea Research* 49:121-142 (2002).

<sup>30</sup> E.g., Weller *et al.*, Preliminary findings; Jochens *et al.*, Sperm whale seismic study.

<sup>31</sup> Maze-Foley, K., and Mullin, K.D., Cetaceans of the oceanic northern Gulf of Mexico: Distributions, group sizes, and interspecific associations, *Journal of Cetacean Research and Management* 8(2):203-213 (2006).

<sup>32</sup> Mead, Records of sei and Bryde's whales; Schmidly, Marine mammals of the southeastern United States and the Gulf of Mexico; Jefferson and Schiro, Distribution of cetaceans in the offshore Gulf of Mexico.

<sup>33</sup> Waring *et al.*, U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments.

<sup>34</sup> Miksis-Olds, J.L., and Miller, J.H., Transmission loss in manatee habitats, *Journal of the Acoustical Society of America* 120:2320:2327 (2006); Miksis-Olds, J.L., Donaghay, P.L., Miller, J.H., Tyack, P.T., Nystuen, J.A., Noise level correlates with manatee use of foraging habitats, *Journal of the Acoustical Society of America* 121:3011-3020 (2007).

February through May, peaking in March and April, with a secondary calving season occurring in December.<sup>35</sup>

(d) *West of the Florida Keys and Tortugas*.— This area, which lies along the continental slope west of the islands, constitutes an area of consistent sperm whale concentration in the Eastern Gulf.<sup>36</sup>

(2) *Activity Caps*

NMFS must place meaningful caps on offshore activities that disrupt marine mammal behavior. As NOAA has found, “[t]here is currently a great deal of concern that a variety of human sources of marine sound (e.g., vessel traffic, seismic activity, sonar, and construction activities) are acting in a cumulative way to degrade the environment in which sound-sensitive animals communicate.”<sup>37</sup> Airguns in particular can cause low-frequency background noise to rise significantly over very large areas of ocean,<sup>38</sup> and the best available evidence indicates that such noise can interfere with foraging in some species at moderate levels of exposure,<sup>39</sup> and substantially interfere with the communication abilities of marine mammals, particularly baleen whales, at very considerable distances.<sup>40</sup> These effects cannot be eliminated through the use of area closures alone, especially given the long distances at which they may occur – well beyond the 160 dB isopleth proposed by BOEMRE as the threshold for Level B take.

(a) *Interim analysis*.— In the short term (i.e., for the present programmatic rulemaking), NMFS should (1) consider multiple alternatives and activity caps for reducing cumulative exposures (well below 160 dB) in each planning region to the lowest practicable level; and (2) conservatively assume that any substantial decrement in the communication space of baleen whales (particularly Bryde’s whales) or foraging ability of sperm whales (per Miller et al. 2009) will result in greater than negligible impacts on the species or population, and assign

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<sup>35</sup> Pers. comm., Dr. Tom Jefferson, with M. Jasny, NRDC (Jan. 2011).

<sup>36</sup> Mullin, K.D., and Fulling, G.L., Abundance of cetaceans in the oceanic northern Gulf of Mexico, 1996-2001, *Marine Mammal Science* 20:787-807 (2004).

<sup>37</sup> Memorandum from Dr. J. Lubchenco to Ms. N. Sutley.

<sup>38</sup> Nieukirk, S.L., Stafford, K.M., Mellinger, D.K., Dziak, R.P., and Fox, C.G., Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean, *Journal of the Acoustical Society of America* 115: 1832-1843 (2004).

<sup>39</sup> Miller et al., Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales.

<sup>40</sup> Clark and Gagnon, Considering the temporal and spatial scales of noise exposures; Clark et al., Acoustic masking in marine ecosystems as a function of anthropogenic sound sources; Clark et al., Acoustic masking in marine ecosystems: Intuitions, analysis, and implication.

seasonal or year-round caps that significantly reduce exposures for those whales. This analysis should integrate the product of the NOAA working group on mapping cumulative sound exposures in the U.S. OCS.

(b) *Complete quantitative analysis.*— NMFS should include, in any proposed rule, an adaptive management provision that allows it to prescribe activity caps based on a quantitative analysis of cumulative exposures from multiple anthropogenic noise sources; and should further require BOEMRE, through a monitoring program, to obtain the necessary data and sponsor the analysis of cumulative exposures, *e.g.*, through the use of a passive acoustic network.<sup>41</sup> Activity caps should reflect a conservative analysis of the cumulative sublethal effects of industry activities on whale communication ranges and other biologically important factors.

(3) *Eliminating Unnecessary Survey Effort*

NMFS should require BOEMRE to eliminate unnecessary duplication of survey effort throughout the Gulf, by rejecting permit applications or requiring modification of permit applications that duplicate, in whole or in part, other surveys occurring in the same locations for the same or similar purposes. This measure is consistent with the findings of the 2010 and 2011 Open Water Panels, which recommended requiring use of a common surveyor to eliminate redundancy in the Arctic.<sup>42</sup> In the Gulf where multi-buyer spec surveys are common, it may be more appropriate for BOEMRE to review applications for duplication, provided that standards and transparency and reporting requirements are set to ensure independent and rigorous review. We urge NMFS to ask BOEMRE to propose robust, transparent standards well in advance of the rulemaking, so that they can be tested and modified before being adopted by regulation.

Additionally, NMFS should consider requiring operators of 3D surveys to acquire or process data in such a way as to obviate the need for high-resolution

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<sup>41</sup> Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Thompson, M., and Wiley, D., Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Garry E. Studds Stellwagen Bank National Marine Sanctuary, *Environmental Management* 42:735-752 (2008). See also Clark and Gagnon, Considering the temporal and spatial scales of noise exposures; Clark *et al.*, Acoustic masking in marine ecosystems as a function of anthropogenic sound sources; Clark *et al.*, Acoustic masking in marine ecosystems: Intuitions, analysis, and implication.

<sup>42</sup> Burns, J., Clark, C., Ferguson, M., Moore, S., Ragen, T., Southall, B., and Suydam, R. (2010). Expert panel review of monitoring and mitigation protocols in applications for incidental take authorizations related to oil and gas exploration, including seismic surveys, in the Chukchi and Beaufort Seas; Brower *et al.*, Expert panel review of monitoring protocols in applications for incidental harassment authorizations.

site surveys. As BOEMRE notes in its 2011 application, data processing of 3D seismic data is increasingly capable of yielding useful near-surface information, eliminating “many of the needs previously met” by high-resolution surveys (2011 App. at 2). NMFS, in consultation with BOEMRE, should consider a measure ensuring that 3D surveys are conducted, and their data provided, in a manner consistent with this purpose, provided that such a measure does not have countervailing environmental costs; and the agencies should consider mandating relevant research on signal processing in their EIS.

*(4) Mitigating Effects of Overlapping Surveys*

NMFS should require separation of seismic vessels to reduce the potential impacts of overlapping sound fields. As NMFS has noted, “the zone of seismic exclusion or influence could be quite large [if seismic operations overlap in time], depending on the number, and the relative proximity of the surveys.”<sup>43</sup> It has been observed that the industry usually maintains an established distance between source vessels in order to avoid contaminating their own data. NMFS should prescribe vessel separation out to a conservative distance, requiring BOEMRE to review operating plans on a weekly or biweekly basis to ensure conformity with this requirement.

*(5) Alternative Technologies*

New technology represents a promising means of reducing the environmental footprint of seismic exploration. Industry experts and biologists participating in a September 2009 workshop reached the following conclusions: that airguns produce a great deal of “waste” sound and generate peak levels substantially higher than needed for offshore exploration; that a number of quieter technologies are either available now for commercial use or can be made available within the next five years; and that governments should accelerate development and use of these technologies through both research and development funding and regulatory engagement (Weilgart 2010; see also Spence 2007).<sup>44</sup>

NMFS and BOEMRE should thoroughly analyze source-based alternatives in their programmatic EIS. At the 2011 Arctic Open Water meeting, NMFS

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<sup>43</sup> NMFS, Biological Opinion: Oil and gas leasing and exploration activities in the U.S. Beaufort and Chukchi Seas, Alaska; and Authorization of Small Takes under the Marine Mammal Protection Act (2008).

<sup>44</sup> Weilgart, L. ed., Report of the workshop on alternative technologies to seismic airgun surveys for oil and gas exploration and their potential for reducing impacts on marine mammals, 31 Aug. – 1 Sept., 2009, Monterey, Calif. (2010) (available at [www.oceanos-stiftung.org/oceanos/download.php?id=19](http://www.oceanos-stiftung.org/oceanos/download.php?id=19)). See also Spence, J., Fischer, R., Bahtiarian, M., Boroditsky, L., Jones, N., and Dempsey, R., Review of existing and future potential treatments for reducing underwater sound from oil and gas industry activities (2007) (NCE Report 07-001) (prepared by Noise Control Engineering for Joint Industry Programme on E&P Sound and Marine Life).

indicated that the agencies are already intending to identify such technologies, determine when they are likely to become available, and assess the extent of their potential application and mitigative effect. But it is critical that they also consider a range of actionable alternatives needed to bring that technology into commercial use, such as: (1) mandating the use of identified measures under appropriate conditions; (2) creating an adaptive process by which such measures can be required as such measures become available; (3) deferring the permitting of surveys in particular areas or for particular applications where effective mitigative technologies could reasonably be expected to become available within the life of the EIS; and (4) providing regulatory incentives for use of these technologies as was done for passive acoustic monitoring systems in NTL 2007-G02. NMFS' rulemaking, with its "least practicable impact" and "small numbers" and "negligible impact" requirements, and with its adaptive framework, is an appropriate vehicle for most of these alternatives.

Ultimately, given the long distances that noise travels, alternative technologies may represent the best way to reduce cumulative exposures and impacts from airgun surveys in the Gulf of Mexico. But, as Weilgart et al. (2010) suggests, such a goal will not be achieved within any reasonable timeframe without significant regulatory engagement.

*(6) Other Source-Based Mitigation*

NMFS should require BOEMRE to (a) ensure that operators reduce the effective source levels of their surveys to the lowest practicable level, and provide an objective, transparent standard and oversight mechanism to ensure compliance; and (b) require operators to calibrate their airgun arrays before beginning a survey in order to minimize horizontal propagation of the noise signal, and report field-checked source levels to the agencies for purposes of transparency and compliance. As with the Arctic, NMFS should prescribe a protocol for taking measurements in the field, both for minimizing horizontal propagation and for verifying source level estimates.

*(7) Improving Safety Zones*

*(a) Application in Gulf of Mexico.*— NMFS should expand the application of BOEMRE's existing marine mammal safety zone in the Gulf of Mexico. As it stands under NTL 2007-G02,<sup>45</sup> the safety zone for Gulf seismic surveys applies only to "whales," a category that definitionally excludes delphinids and manatees – a policy that is inconsistent with every past NMFS authorization of seismic surveys and other types of ocean noise. Additionally, the measure applies west of 88° W. longitude only in waters deeper than 200 meters, an arbitrary exclusion that is likewise inconsistent

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<sup>45</sup> MMS Gulf of Mexico Region, Notice to Lessees: Implementation of seismic survey mitigation measures and protected species observer program (2007) (NTL 2007-G02).

with past MMPA authorizations. NMFS should prescribe a safety zone that covers all Gulf marine mammal species in all federal waters.

- (b) *Safety zone distances.*— NMFS should conservatively recalculate its safety zone distances in light of recent studies on hearing loss: (1) a controlled exposure experiment demonstrating that harbor porpoises are substantially more susceptible to temporary threshold shift than the two species, bottlenose dolphins and belugas, that have previously been tested;<sup>46</sup> (2) a modeling effort indicating that, when uncertainties and individual variation are accounted for, a significant number of whales could suffer temporary threshold shift beyond 1 km from a seismic source;<sup>47</sup> and (3) studies suggesting that the relationship between temporary and permanent threshold shift may not be as predictable as previously believed.<sup>48</sup>
- (c) *Best practices for maintenance and monitoring.*— More generally, NMFS should consider additional “best practices” for safety zone maintenance and monitoring, as set forth in Weir and Dolman (2007) and Parsons et al. (2009).<sup>49</sup>

### III. CONCLUSION

As always, we would welcome the opportunity to meet with you, your staff, and other relevant offices at any time to discuss these matters. For further discussion, please contact Michael Jasny of NRDC ([mjasny@nrdc.org](mailto:mjasny@nrdc.org)).

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<sup>46</sup> Lucke, K., Siebert, U., Lepper, P.A., and Blanchet, M.-A., Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli, *Journal of the Acoustical Society of America* 125: 4060-4070 (2009).

<sup>47</sup> Gedamke, J., Gales, N., and Frydman, S., Assessing risk of baleen whale hearing loss from seismic surveys: The effect of uncertainty and individual variation, *Journal of the Acoustical Society of America* 129:496-506 (2011).

<sup>48</sup> Kastak, D., Mulsow, J., Ghoul, A., Reichmuth, C., Noise-induced permanent threshold shift in a harbor seal [abstract], *Journal of the Acoustical Society of America* 123: 2986 (2008) (sudden, non-linear induction of permanent threshold shift in harbor seal during TTS experiment); Kujawa, S.G., and Liberman, M.C., Adding insult to injury: Cochlear nerve degeneration after “temporary” noise-induced hearing loss, *Journal of Neuroscience* 29: 14077-14085 (2009) (mechanism linking temporary to permanent threshold shift).

<sup>49</sup> Weir, C.R., and Dolman, S.J., Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard, *Journal of International Wildlife Law and Policy* 10: 1-27 (2007); Parsons, E.C.M., Dolman, S.J., Jasny, M., Rose, N.A., Simmonds, M.P., and Wright, A.J., A critique of the UK’s JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best practice? *Marine Pollution Bulletin* 58: 643-651 (2009).

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July 14, 2011  
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