Marine Mammal Risk Assessment: Expert Working Group

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"Application of an Adapted, Relativistic Risk Assessment Framework to Evaluate Modeled Marine Mammal Noise Exposures Resulting from Gulf of Mexico OCS Proposed Geological and Geophysical Activities (Programmatic DEIS)"

FINAL DRAFT REPORT
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Original EWG Marine Mammal & Noise Risk Assessment Analytical Framework

Beginning in 2010, a collaboration of scientists working on different aspects of the effects of noise on marine mammals within the context of several key research and environmental impact assessment projects[1] began developing structured risk assessment methods with which to evaluate potential noise impacts. In 2013, researchers from Southall Environmental Associates (SEA), Marine Acoustics, Inc. (MAI), Sea Mammal Research Unit, Ltd. (SMRU Ltd), and Loggerhead Instruments began working together (with financial support from BP Exploration and Production, Inc. and Shell Exploration and Production Company) to further develop and formalize an explicit, systematic risk assessment methodology to evaluate potential effects of discrete acoustic exposure events (*e.g.*, proposed seismic survey activities) on marine mammals.

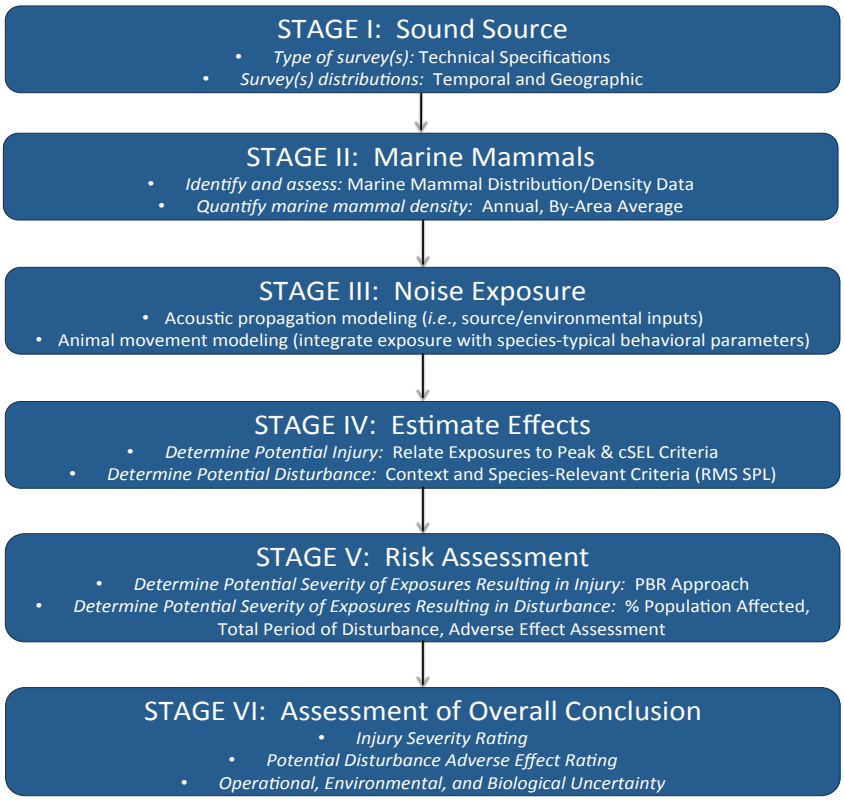
This process resulted in a risk assessment framework that was biologically-based and scientifically current while also deliberately designed to ensure consistency with and be easily integrated into U.S. regulatory assessments by adapting aspects of existing analytical methods. The objective was to develop a consistent, transparent, and structured process that included logical elements of previous assessment methods for estimating potential effects of noise on hearing and behavior, but to also integrate relevant biological, acoustical, ecological, and environmental contextual variables in evaluating the potential significance of noise exposure within the context of marine mammal populations. The original risk assessment framework was presented at the 21st Biennial Conference on the Biology of Marine Mammalogy[2]. This presentation is available in conjunction with this preliminary draft report; for those interested, this provides more specific details of the original framework than are given here. It was deliberately structured in a step-wise manner including elements (e.g., level A (injury) and B (behavioral) 'takes' based on specified criteria) that were generally consistent with current U.S. regulatory assessment methods (but included some specific proposed improvements). These basic approaches are represented within the first four stages of this assessment methodology shown in the simple flowchart below. As is somewhat typical of these kinds of evaluations (including that conducted within the draft programmatic EIS for the Gulf of Mexico OCS proposed geological and geophysical activities being considered here), animal distribution and activity parameters are evaluated using animal movement and noise propagation modeling to evaluate exposures predicted to result in injury (level A takes) or behavioral response (level B takes) according to specified exposure criteria. However, the EWG risk framework includes several additional stages which explicitly integrate evaluation of biologically, ecologically, and environmentally meaningful contexts by which to interpret potential responses in terms of

[1] Notably: Wood, J., Southall, B.L., & Tollit, D.J. (2012). PG&E offshore 3D Seismic Survey Project EIR – Marine Mammal Technical Report: SMRUL NA0611ERM.

[2] Ellison, W.T., Clark, C.W., Mann, D.A., Southall, B., and Tollit, D.J. (2015). A risk assessment framework to assess the biological significance of noise exposure on marine mammals. 21st Biennial Conference on the Biology of Marine Mammals, San Francisco, CA, USA, 13-18 December.

population characteristics, environmental parameters, and scientific uncertainty (stages V and VI).

Table 1. Analytical Stages of Original EWG Risk Assessment Framework



While the EWG recommended a number of key modifications in the first four stages based on recent scientific progress in understanding marine mammal distribution, behavior and hearing capabilities, in estimating noise exposure on marine mammals, their basic approach was generally consistent with existing approaches. The risk assessment (Stage V) aspect of the framework was the most innovative and novel development. It was intended to provide a biologically-relevant, population-based, contextual perspective in evaluating the severity and significance of exposures consistent with predicted injury (PTS) as a proxy for (MMPA) level A takes and behavioral responses predicted to result in level B takes.

For evaluating potential injury, the original EWG framework recommended that total permanent threshold shift (PTS) exposures be estimated using noise propagation and animal movement models (which allow for expected avoidance responses of animals at relatively high levels required to induce temporary threshold shift (TTS) and, using extrapolation methods, PTS). Exposures consistent with predicted injury (defined as PTS-onset) were identified using

specific exposure criteria based on the best available science, which included marine mammal group-specific auditory weighting functions. The total number of individuals within a species estimated to experience PTS was then evaluated relative to a population-based metric of potential severity, specifically the residual potential biological removal (PBR) specified for the particular stock within the most recent region-specific stock assessment report (SAR) for that species. Total PTS takes as a proportion of residual PBR were then used as the basis for assessing the severity of evaluated injury at the population level, with quantitative criteria used to determine potential risk as very low, low, moderate, high, or very high.

For evaluating potential behavioral disturbance and the significance thereof, the original EWG risk framework considered both the potential severity of exposure within the context of population size and disturbance duration, as well as the potential vulnerability of the species relative to biological, ecological, and environmental contexts of exposure.

Behavioral response severity was quantified in terms of the percent of the population affected and the total duration of a specified activity (*e.g.*, seismic survey). Deliberately coarse-resolution probability functions were developed for different types of animals and exposure contexts, some of which were actually applied within the DEIS modeling conducted for the GoMex DEIS. Given the resulting number of individuals predicted to experience behavioral response relative to the total population (% of population affected) and the total population size, the severity of response was then evaluated relative to magnitude-duration functions developed using a modified population consequences of disturbance (PCOD) severity function based on a series of simplifying assumptions. The resulting magnitude (within a population context) and duration of exposures were compared to these functions to determine (among five) relative risk levels.

Within a separate, parallel process, the EWG defined a series of biological, ecological, and environmental contextual factors in order to determine species-specific vulnerability. While some of these factors were quantitatively specified, others were necessarily subjective in nature. Collectively these factors were evaluated within a vulnerability scoring process in an effort to place the potential severity of exposure in the context of species-specific life history, biology, and other environmental factors known or believed to be meaningful factors. Similarly, the resulting vulnerability ratings were used to determine (among five) relative risk levels.

Predicted risk levels of exposure severity and context-specific vulnerability were then evaluated together to determine the overall predicted behavioral response risk. Specifically, the severity and vulnerability ratings were integrated to derive an overall evaluated risk using the following matrix; this was deliberately slightly skewed to weight exposure severity more heavily than vulnerability.

Table 2. Behavioral disturbance risk assessment matrix based on evaluated disturbance severity and context- and species-specific vulnerability

Disturbance Severity					
5					
4					
3					
2					
1					
Rating	1	2	3	4	5
Vulnerability					

Key	Color	Adverse Effects Rating
	Red	Very High
	Orange	High
	Yellow	Moderate
	Green	Low
	Blue	Very Low

Adapting the EWG Risk Assessment Framework to Evaluate DEIS Modeled Takes

The scope of exposure scenarios considered within the original EWG risk framework was intentionally narrow, focusing on relatively short-term, small-scale potential effects of discrete exposures (acute and single survey) on marine mammals from seismic airgun surveys in the GoMex. Many needed modifications, specific improvements, and areas for additional quantification within the structure of the risk assessment were identified, and through a partnership between BOEM and NOAA, a follow-on effort was initiated to expand upon and improve the original EWG framework. This recently-initiated and ongoing project (with most of

the original EWG members) is intended to expand upon the original (Ellison *et al*., 2015) risk assessment framework. The goals of this project are two-fold: (1) improve upon the original approach to evaluate discrete noise-generating activities and (2) integrate additional biological variables and consider potential longer-term, larger-scale potential effects of overlapping activities (*i.e.*, multiple activity types, multiple seasons, ecologically-meaningful spatial and temporal scales). Having begun at the beginning of 2017, this project is in the early stages of development and fully developed products, including a peer-reviewed publication of the fully-developed, modified risk assessment framework at both spatial and temporal levels, are not presently available.

In the course of this project, BOEM and NOAA also requested that the EWG develop and apply a modified version of the original assessment framework to evaluate the relative risk of potential injury and disturbance from modeled noise exposures calculated for the draft programmatic EIS (DEIS) for the Gulf of Mexico OCS proposed geological and geophysical activities. While this is also ongoing, substantial progress in this relativistic assessment has been made and this has been applied in evaluating selected scenarios using the modeled values provided within the DEIS. A final and more comprehensive application of this adapted risk assessment framework across all years modeled will be available later in the DEIS and rule-making process.

The preliminary draft summary of the modified EWG risk assessment methodology that has been developed to date is presented here, as well as our initial evaluation of overall relative significance. In this evaluation, the EWG reviewed all methods, assumptions, and results of the DEIS modelling of acoustic exposures resulting from specified levels of seismic survey activity (of multiple survey types) within (7) specified geographic zones of the Gulf of Mexico (see below: DEIS figure 110 on page D-159) and associated impact (PTS and behavioral response) estimates.

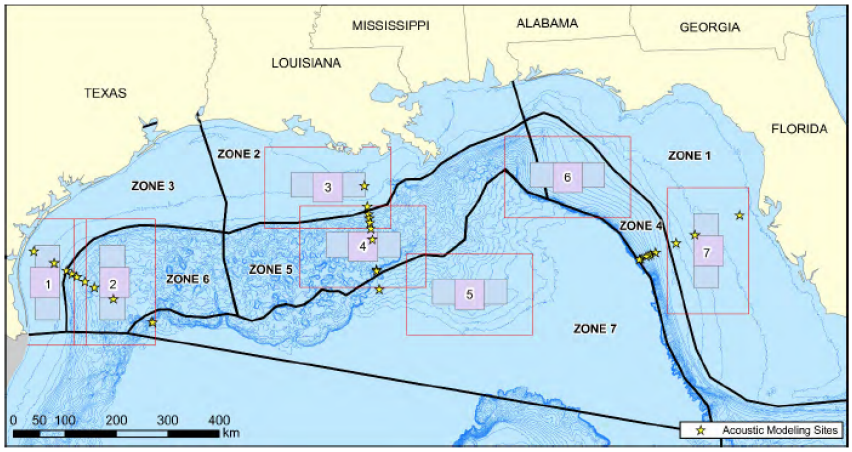


Figure 110. Gulf of Mexico project area. Black lines delineate the zones. Large, red rectangular boxes show the animal simulation extents for seismic surveys. Gray rectangles are the survey area extents for the 2-D and 3-D surveys. Pink squares are the survey extents of Coil surveys. Yellow stars show the acoustic modeling sites are along West, Central, and East transects.

The EWG evaluated the underlying model and potential impact assumptions and methods and considered how they mirrored or differed from the EWG risk assessment framework. The overall objective was to retain and apply key features of the original framework (*e.g.*, explicitly recognizing the importance of species distribution relative to activity spatial distribution, frequency spectrum in relation to different hearing capabilities, and temporal and contextual differences in exposure scenarios), while presenting evaluated risk in a relativistic manner in order to bridge the fairly substantial methodological differences in model results relative to those proposed in the original EWG framework.

Numerous aspects of the DEIS modeling were similar to (*e.g.*, the calculation of potential injury and behavioral responses; use of animal movement modeling) or even modeled directly after the original EWG framework (*e.g.*, the behavioral response probability step function approach described above). However, a number of substantial differences between the DEIS modeling conducted and the EWG risk assessment approach were also identified. Foremost, the DEIS considered many activities spread over large areas and occurring within two broad time periods per year (winter and non-winter). Given the absence of more specific temporal and spatial information on potential disturbance from multiple activities, a direct application of the existing EWG framework for discrete exposure events and locations within defined periods would be inappropriate and potentially misleading. Furthermore, the DEIS included several major differences in model assumptions that were inconsistent with methods recommended within the original EWG framework. Accordingly, the EWG derived a modified, relativistic risk assessment approach that utilizes the basic conceptual framework and fundamental perspective of evaluating potential severity of an effect within the context of population size, exposure context, and species life history patterns. The resulting analyses conducted here follow this approach for the purposes of evaluating DEIS model results in terms of both potential injury or disturbance.

In terms of potential injury, the DEIS modeling conducted does not assume that behavioral avoidance occurs at very high levels in assessing potential injury. This is a relatively well-documented phenomenon for a variety of marine mammals, as is reflected in the increasing response probability functions applied within the DEIS behavioral response modeling. The EWG concluded that this lack of aversion within animal movement modeling used in the DEIS has resulted in major overestimates of PTS (injury) in the current modeling results and derived an offset method accordingly (described below). Similarly, in terms of behavioral response probability, a significant model assumption was that populations of animals were completely re-set for each 24-h period. Daily level B takes were aggregated across all days as completely independent events, assuming populations turn over within each large zone every day completely. The EWG also concluded that this approach lead to substantial over-estimates of modeled behavioral disturbance given that all animals within the areas modeled are very unlikely to be completed replaced on a daily basis; a more reasonable approach could have been to use information on species-typical movement behavior to evaluate daily exposures and determine more realistic exposure probabilities accordingly across multiple days. A modified approach to using these factors to determine a species-typical offset of modeled daily

exposures was thus developed by the EWG, utilizing some exploratory analyses conducted within the DEIS to relate takes to those determined using a much longer time window for re-setting populations in operational areas.

Given these acknowledged differences from the original EWG framework approach, a modified approach was developed and applied to evaluate the relative risk of the specified levels of activity for different survey types in (7) different specified zones across years with different levels of activity. The EWG used a substantially modified version of the original framework given the issues identified above. It should be clearly stated that this is intended to evaluate *relative risk* within and between species from the predicted type and level of activities using species-specific biological, life history, and environmental factors within a comparable overall risk framework. These relative risk assessments are intended to provide the regulatory agencies a basis for evaluating which species may be at greater or less risk given the type, magnitude, and spatial location of proposed activities. They are also intended to evaluate which areas may represent higher or lower relative risk across a range of species, using a set of common assumptions and assessment methods. The EWG worked directly with BOEM, NOAA, and contractors who conducted the DEIS modeling to apply a revised version of the risk framework to the modeled results. Within the modeling conducted, different projected levels of overall survey effort were assumed within three evaluated annual scenarios. The EWG evaluated relative risk for these annual scenarios of potential survey activity within each zone that might occur within a single year, including: (1) the highest overall total number of survey days (**HIGH**); (2) an intermediate total number of survey days (**MODERATE**); and the lowest overall total number of survey days among the 10 years modeled (**LOW**). These are represented in terms of overall survey days by zone for each scenario in Table 3 below, but it should be noted that for each scenario certain years had more or less of different survey types within zones as well.

Table 3. Three different annual scenarios of survey activity for which noise exposure model results were evaluated in terms of relative risk by the EWG.

GoMex Zone	Total Survey Days (per year) for Each Scenario		
	HIGH Annual Scenario	**MODERATE** Annual Scenario	**LOW** Annual Scenario
Zone 1	1	0	0
Zone 2	263	446	258
Zone 3	34	34	2
Zone 4	0	158	62
Zone 5	747	441	512
Zone 6	265	111	113
Zone 7	975	712	714
TOTAL SURVEY DAYS	**2286**	**1902**	**1661**

It is important to note that within the DEIS, different survey activities within these total number of survey days were specified and modelled accordingly based on the nature of those activities. These model results accounting for the resulting differences within each nominal year and within each zone were applied accordingly based on the model results. The above table simply specifies the overall level of survey effort by zone within the HIGH, MODEATE, and LOW survey years.

Modified Relative Risk Assessment Evaluation of Potential Injury (Level A)

The modified EWG risk assessment methodology to evaluate relative risk among species and areas associated with potential injury was relatively similar to that used in the original EWG approach, with two specific differences. The DEIS modeling was recomputed from that presented in the original draft, in order to utilize the type-III auditory filters and new TTS/PTS onset levels as specified in the 2016 NOAA Acoustic Guidelines for all odontocete cetacean. These were not used in the original EWG framework (Ellison et al., 2015), but as it was designed in a step-wise modular format to enable such advances to be incorporated, was considered here for modeled exposures in terms of potential injury.

The modified DEIS modeling using these new weightings and thresholds were then aggregated for all survey types within each zone for a specified year, assuming different levels of activity. In order to account for what the EWG believes is substantial overestimates in modeled PTS given the lack of aversion in animal movement models, a nominal offset factor was applied based on published model result evaluation. Ellison et al. (2016)[3] demonstrated that animal movement models where no aversion probability was used overestimated the potential for high levels of exposure required for PTS by about five times. Accordingly, total level A takes calculated without accounting for behavioral aversion were multiplied by 0.2. Total resulting level A takes by zone and by species were then divided by the total zone population size.

In terms of evaluating relative risk from these calculations, the overall concept of relating them to PBR was generally retained, but not applied directly[4]. Because population sizes for each zone

[3] Ellison WT, Racca R, Clark CW, Streever B, Frankel AS, Fleishman E, Angliss R, Berger J, Ketten D, Guerra M, Leu M. Modeling the aggregated exposure and responses of bowhead whales Balaena mysticetus to multiple sources of anthropogenic underwater sound. Endangered Species Research. 2016 May 2;30:95-108.

[4] PBR is defined by the MMPA as "the maximum number of animals, not including natural mortality, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." While we do not expect PTS that might be accrued through exposure to seismic surveys in the Gulf of Mexico to result in mortality of marine mammals – PBR can serve as a good surrogate for population vulnerability/health and. Accordingly, PBR or a related metric can be used appropriately as a value against which to evaluate the potential severity to the population of a permanent impact such as PTS on a given number of individuals.

were determined within the DEIS using the Roberts et al (2016)[5] density assessments rather than using whole northern Gulf of Mexico SAR values, upon which PBR values are based, a modified approach was adapted. Within previous PBR assessments, this value varies between 0.6-0.9% of the population depending upon population confidence limits (higher with increasing confidence); values are typically 1/5 of these values for ESA-listed species. Given the use of densities different from the SARs and their associated PBR values, the EWG developed a comparable risk assessment approach to the original framework for both non-ESA-listed and ESA-listed (or MMPA depleted) species using this basic relationship of population size relative to PBR (e.g., considered equivalent to estimated X% of PBR). Within the original EWG framework, different and more precautionary magnitude-duration functions were used for ESA-listed species. Since these functions are not applied here, a generalized approach to relating the severity of potential injury to population level was applied for all species; differential values for evaluating severity for non-listed and ESA-listed species were used. Furthermore, a species ESA-listing status was integrated into the vulnerability ratings given below.

For non-ESA-listed species the associated relative risk levels were assessed by using the adjusted level A takes in relation to the zone-specific population size:

Very High – Level A takes >1.5% of zone-specific population (considered equivalent to estimated 200% of PBR)
High – Level A takes 0.75-1.5% of zone-specific population (equivalent to 100-200% of PBR)
Moderate - 0.375-0.75% of zone-specific population (equivalent to 50-100% of PBR)
Low - 0.075-0.375% of zone-specific population (equivalent to 10-50% of PBR)
Very Low - <0.075% of zone-specific population (equivalent to <10% of PBR)

For ESA-listed species the associated relative risk levels assessed are:

Very High – Level A takes >0.3% of zone-specific population (considered equivalent to estimated 200% of PBR)
High – Level A takes 0.15-0.3% of zone-specific population (equivalent to 100-200% of PBR)
Moderate - 0.075-0.15% of zone-specific population (equivalent to 50-100% of PBR)
Low 0.015-0.075% of zone-specific population (equivalent to 10-50% of PBR)
Very Low - <0.015 of zone-specific population (equivalent to <10% of PBR)

The results of our initial evaluation of DEIS modelled results provided to the EWG using the type-III weighted thresholds and PTS onset from the NOAA (2016) Acoustic Guidance are given below. Results are shown for each species within each of the (7) GoMex zones for the HIGH, MODERATE, and LOW year scenarios both separately and across years to allow an evaluation of species and zone-specific differences both within and across years. Zones for which no survey

[5] Roberts, J. J., Best, B. D., Mannocci, L., Fujioka, E., Halpin, P. N., Palka, D. L., ... & McLellan, W. A. (2016). Habitat-based cetacean density models for the US Atlantic and Gulf of Mexico. *Scientific reports*, *6*.

activity was proposed were not evaluated (evaluated risk: N/A). A further measure was taken to avoid potentially skewing results for areas in which very few individuals of a species were assumed to occur. Zones within which 5 or less individuals of a species were predicted to occur were also not evaluated (evaluated risk: N/A); an alternative approach that is being considered for this scenario is to apply a *de minimus* percentage of the overall population size versus a static small number.

Table 4. Overall evaluated RELATIVE INJURY risk for HIGH year scenario

	RELATIVE SEVERITY SCORES by ZONE						
Species Name	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7
Atlantic spotted dolphin	VERY LOW	MODERATE	LOW	N/A	VERY HIGH	LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	N/A	N/A	N/A	VERY LOW	LOW	LOW
Bottlenose dolphin	VERY LOW	HIGH	LOW	N/A	VERY HIGH	MODERATE	VERY LOW
Bryde's whale	VERY LOW	N/A	N/A	N/A	VERY LOW	VERY HIGH	VERY LOW
Clymene dolphin	N/A	N/A	N/A	N/A	VERY LOW	MODERATE	LOW
False killer whale	VERY LOW	HIGH	LOW	N/A	VERY LOW	MODERATE	MODERATE
Fraser's dolphin	VERY LOW	HIGH	N/A	N/A	VERY LOW	MODERATE	MODERATE
Killer whale	N/A	N/A	N/A	N/A	VERY LOW	LOW	HIGH
Kogia (dwarf, pygmy sperm whale)	VERY LOW	N/A	N/A	N/A	LOW	VERY HIGH	VERY HIGH
Melon-headed whale	N/A	N/A	N/A	N/A	VERY LOW	LOW	LOW
Pantropical spotted dolphin	VERY LOW	N/A	N/A	N/A	VERY LOW	LOW	HIGH
Pygmy killer whale	N/A	N/A	N/A	N/A	VERY LOW	MODERATE	MODERATE
Risso's dolphin	VERY LOW	N/A	N/A	N/A	VERY LOW	LOW	LOW
Rough-toothed dolphin	VERY LOW	HIGH	LOW	N/A	MODERATE	MODERATE	LOW
Short-finned pilot whale	N/A	N/A	N/A	N/A	VERY LOW	HIGH	LOW
Sperm Whale	N/A	N/A	N/A	N/A	VERY LOW	HIGH	MODERATE
Spinner dolphin	VERY LOW	N/A	N/A	N/A	VERY LOW	VERY LOW	VERY LOW
Striped dolphin	N/A	N/A	N/A	N/A	VERY LOW	MODERATE	MODERATE

Table 5. Overall evaluated RELATIVE INJURY risk for MODERATE year scenario

	RELATIVE SEVERITY SCORES by ZONE						
Species Name	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7
Atlantic spotted dolphin	N/A	HIGH	LOW	LOW	VERY HIGH	LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	N/A	N/A	LOW	VERY LOW	LOW	LOW
Bottlenose dolphin	N/A	HIGH	LOW	MODERATE	VERY HIGH	LOW	VERY LOW
Bryde's whale	N/A	N/A	N/A	VERY HIGH	VERY LOW	VERY HIGH	VERY LOW
Clymene dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	HIGH
False killer whale	N/A	HIGH	LOW	LOW	VERY LOW	LOW	HIGH
Fraser's dolphin	N/A	HIGH	N/A	LOW	VERY LOW	LOW	HIGH
Killer whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	VERY HIGH
Kogia (dwarf, pygmy sperm whale)	N/A	N/A	N/A	VERY HIGH	VERY LOW	VERY HIGH	VERY HIGH
Melon-headed whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	MODERATE
Pantropical spotted dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	VERY HIGH
Pygmy killer whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	VERY HIGH
Risso's dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	MODERATE
Rough-toothed dolphin	N/A	HIGH	LOW	LOW	LOW	LOW	HIGH
Short-finned pilot whale	N/A	N/A	N/A	LOW	VERY LOW	MODERATE	LOW
Sperm Whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	HIGH
Spinner dolphin	N/A	N/A	N/A	LOW	VERY LOW	VERY LOW	LOW
Striped dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	HIGH

Table 6. Overall evaluated RELATIVE INJURY risk for LOW year scenario

	RELATIVE SEVERITY SCORES by ZONE						
Species Name	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7
Atlantic spotted dolphin	N/A	MODERATE	VERY LOW	LOW	VERY HIGH	LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	N/A	N/A	LOW	VERY LOW	LOW	LOW
Bottlenose dolphin	N/A	HIGH	VERY LOW	LOW	VERY HIGH	LOW	VERY LOW
Bryde's whale	N/A	N/A	N/A	VERY HIGH	VERY LOW	VERY HIGH	VERY LOW
Clymene dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	HIGH
False killer whale	N/A	HIGH	VERY LOW	LOW	VERY LOW	LOW	HIGH
Fraser's dolphin	N/A	HIGH	N/A	LOW	VERY LOW	LOW	HIGH
Killer whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	VERY HIGH
Kogia (dwarf, pygmy sperm whale)	N/A	N/A	N/A	VERY HIGH	VERY LOW	VERY HIGH	VERY HIGH
Melon-headed whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	MODERATE
Pantropical spotted dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	VERY HIGH
Pygmy killer whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	VERY HIGH
Risso's dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	MODERATE
Rough-toothed dolphin	N/A	HIGH	VERY LOW	LOW	MODERATE	LOW	HIGH
Short-finned pilot whale	N/A	N/A	N/A	LOW	VERY LOW	MODERATE	LOW
Sperm Whale	N/A	N/A	N/A	LOW	VERY LOW	LOW	HIGH
Spinner dolphin	N/A	N/A	N/A	LOW	VERY LOW	VERY LOW	LOW
Striped dolphin	N/A	N/A	N/A	LOW	VERY LOW	LOW	HIGH

Table 7. Potential Injury Severity (Level A) – Overall evaluted relative risk by zone across years (HIGH, MODERATE, and LOW annual activity scenarios)

POTENTIAL INJURY (LEVEL A) - OVERALL EVALUATED RELATIVE RISK by ZONE (Across Years)

	ZONE 1			ZONE 2			ZONE 3		
Species Name	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW
Atlantic spotted dolphin	VERY LOW	N/A	N/A	MODERATE	HIGH	MODERATE	LOW	LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bottlenose dolphin	VERY LOW	N/A	N/A	HIGH	HIGH	HIGH	LOW	LOW	VERY LOW
Bryde's whale	VERY LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clymene dolphin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
False killer whale	VERY LOW	N/A	N/A	HIGH	HIGH	HIGH	LOW	LOW	VERY LOW
Fraser's dolphin	VERY LOW	N/A	N/A	HIGH	HIGH	HIGH	N/A	N/A	N/A
Killer whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kogia (dwarf, pygmy sperm whale)	VERY LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Melon-headed whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pantropical spotted dolphin	VERY LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pygmy killer whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Risso's dolphin	VERY LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rough-toothed dolphin	VERY LOW	N/A	N/A	HIGH	HIGH	HIGH	LOW	LOW	VERY LOW
Short-finned pilot whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sperm Whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spinner dolphin	VERY LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Striped dolphin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	ZONE 4			ZONE 5			ZONE 6		
Species Name	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW
Atlantic spotted dolphin	N/A	LOW	LOW	VERY HIGH	VERY HIGH	VERY HIGH	LOW	LOW	LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	LOW	LOW	LOW
Bottlenose dolphin	N/A	MODERATE	LOW	VERY HIGH	VERY HIGH	VERY HIGH	MODERATE	LOW	LOW
Bryde's whale	N/A	VERY HIGH	VERY HIGH	VERY LOW	VERY LOW	VERY LOW	VERY HIGH	VERY HIGH	VERY HIGH
Clymene dolphin	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	MODERATE	LOW	LOW
False killer whale	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	MODERATE	LOW	LOW
Fraser's dolphin	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	MODERATE	LOW	LOW
Killer whale	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	LOW	LOW	LOW
Kogia (dwarf, pygmy sperm whale)	N/A	VERY HIGH	VERY HIGH	LOW	VERY LOW	VERY LOW	VERY HIGH	VERY HIGH	VERY HIGH
Melon-headed whale	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	LOW	LOW	LOW
Pantropical spotted dolphin	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	LOW	LOW	LOW
Pygmy killer whale	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	MODERATE	LOW	LOW
Risso's dolphin	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	LOW	LOW	LOW
Rough-toothed dolphin	N/A	LOW	LOW	MODERATE	LOW	MODERATE	MODERATE	LOW	LOW
Short-finned pilot whale	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	HIGH	MODERATE	MODERATE
Sperm Whale	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	HIGH	LOW	LOW
Spinner dolphin	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW
Striped dolphin	N/A	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	MODERATE	LOW	LOW

	ZONE 7		
Species Name	HIGH	MODERATE	LOW
Atlantic spotted dolphin	VERY LOW	VERY LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	LOW	LOW	LOW
Bottlenose dolphin	VERY LOW	VERY LOW	VERY LOW
Bryde's whale	VERY LOW	VERY LOW	VERY LOW
Clymene dolphin	LOW	HIGH	HIGH
False killer whale	MODERATE	HIGH	HIGH
Fraser's dolphin	MODERATE	HIGH	HIGH
Killer whale	HIGH	VERY HIGH	VERY HIGH
Kogia (dwarf, pygmy sperm whale)	VERY HIGH	VERY HIGH	VERY HIGH
Melon-headed whale	LOW	MODERATE	MODERATE
Pantropical spotted dolphin	HIGH	VERY HIGH	VERY HIGH
Pygmy killer whale	MODERATE	VERY HIGH	VERY HIGH
Risso's dolphin	LOW	MODERATE	MODERATE
Rough-toothed dolphin	LOW	HIGH	HIGH
Short-finned pilot whale	LOW	LOW	LOW
Sperm Whale	MODERATE	HIGH	HIGH
Spinner dolphin	VERY LOW	LOW	LOW
Striped dolphin	MODERATE	HIGH	HIGH

Evaluation of Potential Behavioral Disturbance (Level B)

A substantially modified version of the EWG risk assessment framework was developed and applied in evaluating potential behavioral disturbance (Level B takes). The same overall approach of evaluating exposure severity relative to species-specific vulnerability accounting for biological and environmental risk factors was used, along with the existing risk assessment method of integrating these two different aspects of risk. However, substantial modifications in the severity and vulnerability ratings were made, given the identified differences in how the DEIS modeling was conducted and the EWG risk framework.

For exposure severity, the EWG magnitude-duration functions were not used, given how different the methods, assumptions, and scales are from what was originally developed for the discrete assessment. Rather, we developed a relativistic framework relating the total calculated level B takes to the area/zone specific population size and then evaluating this proportion to specified severity criteria common across species. First, the total modeled level B takes within the DEIS using the multi-step function probability approach developed by the EWG and applied within the DEIS (10, 50, 90% response probabilities for different exposure levels (e.g., 140, 160, 180 dB RMS for most marine mammals) for each survey type were calculated. These were determined seasonally within the DEIS modeling using winter case (S1) for 0.25 of the year and non-winter case (S3) for 0.75 of the year, which is explicitly derived here. These totals were multiplied for all survey types by the total survey days per year for each type within each zone.

In order to account for what the EWG concluded to be substantial over-estimates in modeled behavioral takes related to the model assumptions that the entire zone population was re-set in terms of level B takes daily (*i.e.*, all animals are replaced in the population over a period of up to seven days), a modified approach was used to evaluate modeled values. This issue was acknowledged within the DEIS and some exploratory analyses were conducted for a subset of species, where model results of daily takes were derived and compared using both 7-d and 30-d reset periods. The results for longer population re-set assumptions ranged from about 10-45% of the total number of takes calculated using the much shorter reset of individuals in the population, with differences relating to species-typical movement and residency patterns. Given that many of the evaluated survey activities, particularly some of the larger surveys for which the majority of the modeled takes occur, occur for 30-d or longer periods, the EWG felt that a method that better reflected these periods and avoided substantial re-counting of the same individuals was needed. The EWG utilized the subset of model results from both 7-d and 30-d reset periods to determine the appropriate differences (reductions) from daily takes calculated using shorter periods to scale the takes accordingly to better reflect what was assumed to be a more realistic 30-d reset interval. Following these corrections to the full set of DEIS modelled daily takes, which reduced the overall magnitude of modeled takes for all species by slightly more than double to up to ten-fold, the total scaled level B takes were divided by the zone-specific population. These proportions were used to evaluate the relative severity of modeled exposures based on the distribution of values across species to evaluate behavioral risk across species. It should be clearly noted that this does not reflect an

assessment of absolute risk in the context of a PCOD evaluation (*e.g.*, magnitude-duration functions derived within the original EWG framework), but rather is a simple. logical means of evaluating relative risk across species and areas. The relative rating using % of area population size were determined as:

Very High - Adjusted behavioral takes >800% of zone-specific population
High - Adjusted behavioral takes 400-800% of zone-specific population
Moderate - Adjusted behavioral takes 200-400% of zone-specific population
Low - Adjusted behavioral takes 100-200% of zone-specific population
Very Low - Adjusted behavioral takes <100% of zone-specific population

The exposure vulnerability rating seeks to evaluate the relative risk of a predicted effect given species-typical and population-specific parameters (biological context – *i.e.*, species-specific life history, population factors) and other relevant interacting factors (environmental context – *i.e.*, human or other environmental stressors). The EWG has made a number of improvements to the overall vulnerability risk assessment approach used in evaluating the DEIS results, which will also be integrated into the modified overall risk framework being developed in the overall project. These are intended to make clearer distinctions between the vulnerability risk assessment and severity risk assessment factors within the overall assessment process and to avoid including similar risk factors in both assessments. It should be recognized that the spectral, temporal, and spatial overlaps between noise-generating activities and animal distribution are the primary factors that drive the type, magnitude, and severity of potential noise effects on marine mammals. These considerations are inherent and fundamental in both the severity and vulnerability ratings and are deliberately integrated into both the severity and vulnerability assessments, albeit with a strategic approach to balance the weight of considerations between these two assessments. In discussion with both agencies, the EWG identified the utility of specifying and clarifying where and how the interactions between a potential disturbance and species within spectral (frequency), spatial (geographic), and temporal (time) dimensions are evaluated.

Given these considerations and modifications, and considering the large (11), original set of vulnerability rating factors, the EWG developed a simpler, modified set of vulnerability risk assessment metrics here. This approach includes four categories of factors within the same two overarching risk factors (species-specific biological and environmental risk factors) that were used originally. These values were selected in order to capture key aspects of the importance of spatial (geographic), spectral (frequency content of noise in relation to species-typical hearing and sound communications), and temporal aspects of exposures and receivers. Explicit numerical criteria for identifying severity scores are specified where possible, but others require qualitative judgments based on a reasonable interpretation of given aspects of the proposed activity and how it relates to the species in question and the environment within the specified area (as is typical of many forms of risk assessment).

SPECIES-SPECIFIC BIOLOGICAL RISK FACTORS

1. Masking Factor: Degree of spectral overlap between biologically important acoustic signals and predominant noise source of proposed activity (max: 7 out of 30)

Activity Specific Auditory Masking Factor	Score
Communication Masking: Predominant noise energy directly overlaps[6] species-specific signals utilized for communication.	+3
Communication Masking: Predominant noise energy partially overlaps species-specific signals utilized for communication.	+1
Foraging Masking: Predominant noise energy directly overlaps species-specific signals utilized in foraging (including echolocation and other foraging coordination signals).	+2
Foraging Masking: Predominant noise energy partially overlaps species-specific signals utilized in foraging.	+1
Navigation/Orientation Signal Masking: Predominant noise energy directly overlaps signals likely utilized in spatial orientation to which species is well capable of hearing	+2
Navigation/Orientation Signal Masking: Predominant noise energy partially overlaps signals likely utilized in spatial orientation to which species is somewhat capable of hearing	+1

2. Species Population Factor: Stock status, trend and size (max: 7 out of 30)

Species Population Factor (defined for area-specific stock)	Score
Population Status: Endangered (ESA) or depleted (MMPA)	+3
Population Status: Threatened	+1
Population Status: Neither Threatened nor Endangered	0
Trend Rating: Decreasing (last three stock assessment reports (SARs) for which new population estimates were updated)	+2
Trend Rating: Unknown (last three SARs) or data deficient	+1
Trend Rating: Stable (last three stock assessment reports (SARs) for which new population estimates were updated within 5%)	0
Trend Rating: Increasing (last three SARs)	-1
Population Size: Small (n <2500, as specified by IUCN designation)	+2

[6] Direct overlap means that the predominant spectral content of received noise exposure from activity specific sources is expected to occur at identical frequencies as signals of interest. Partial overlap means that secondary (lower-level) spectral content of received noise exposure from activity specific sources is expected to occur at identical frequencies as signals of interest.

3. Species Habitat Use and Compensatory Abilities: Degree to which activity within a specified area[7] overlaps with species habitat and distribution (max: 7 out of 30). As described above, seasonal data on distribution relative to survey timing should be included (as available)

Species Habitat and Temporal Factors	Score
Habitat Use: Specified area contains >30% of total region-wide estimated population (during defined survey period)	+4
Habitat Use: Specified area contains <30% and >15% of region-wide population	+2
Habitat Use: Specified area contains <15% and >5% of region-wide population	+1
Habitat Use: Specified area contains <5% of region-wide population	0
Temporal Sensitivity: Survey overlaps temporally with well-defined species-specific biologically-important period (*e.g.*, calving)	Up to 3

ENVIRONMENTAL RISK FACTORS

4. Other (chronic) noise and non-noise stressors: Magnitude of other potential sources of disturbance or other stressors that may influence a species response to additional noise and disturbance of the proposed activity (max: 9 out of 30).

Other Stressors	Score
Chronic anthropogenic noise: Species subject to high degree of current or known future (overlapping activity) chronic anthropogenic noise	+2
Chronic anthropogenic noise: Species subject to moderate degree of current or known future chronic anthropogenic noise	+1
Chronic anthropogenic risk factors (non-noise): Species subject to high degree of current or known future risk from other chronic, non-noise anthropogenic activities (*e.g.*, fisheries interactions, ship-strike; last SARs to serve as reference)	Up to 4
Chronic anthropogenic risk factors (non-noise): Species subject to moderate degree of current or known future risk from other chronic, non-noise anthropogenic activities	+2
Chronic biological risk factors (non-noise): Known presence of disease, parasites, prey limitation, or high predation pressure (last SARs to serve as reference)	Up to 3

[7] This is the area over which a specified activity is evaluated and a local population is determined. For the GoMex DEIS this is defined as each of the (7) zones.

An overall vulnerability rating is then based on total (aggregate) risk factor score according to the percentage of the possible total score, as identified within the table below.

Total risk factor score from Elements 1-4	Total Risk Probability (% of total possible)	Vulnerability Rating
24-30	**80-100%**	Very High (5)
18-23	**60-79%**	High (4)
12-17	**40-59%**	Moderate (3)
6-11	**20-39%**	Low (2)
0-5	**0-19%**	Very Low (1)

Finally, the severity risk rating (percentage of total population affected based on scaled level B values relative to zone population size) and vulnerability ratings (based on the above vulnerability rating assessment) were then integrated to derive an overall evaluated risk resulting from behavioral disturbance. This final integrated assessment was made using both the severity and vulnerability assessments using the approach developed in the original (Ellison *et al*., 2015) risk assessment framework, specifically the matrix given in Table 2.

The results of our initial evaluation of DEIS modeled results provided to the EWG using the methods described above are shown for each species within each of the (7) GoMex zones for the HIGH, MODERATE, and LOW annual scenarios. Results are shown in detail within years (with both severity and vulnerability ratings as well as the overall evaluated risk for each species and zone) and across years (in terms of overall evaluated risk) to allow an evaluation of species and zone-specific differences both within and across years. Zones for which no survey activity was proposed were not evaluated (evaluated risk: N/A). Also, zones within which 5 or less individuals of a species were predicted to occur were also not evaluated (evaluated risk: N/A).

Table 8. Severity and vulnerability ratings and overall evaluated RELATIVE risk for for **HIGH** year scenario

RELATIVE OVERALL BEHAVIORAL RISK SCORES by ZONE									
	ZONE 1			ZONE 2			ZONE 3		
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*
Atlantic spotted dolphin	VERY LOW	MODERATE	LOW	MODERATE	LOW	MODERATE	VERY LOW	LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Bottlenose dolphin (Coastal/Shelf/Oceanic)	VERY LOW	LOW	LOW	LOW	LOW	LOW	VERY LOW	LOW	VERY LOW
Bryde's whale	VERY LOW	HIGH	LOW	N/A	HIGH	N/A	N/A	MODERATE	N/A
Clymene dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
False killer whale	VERY LOW	LOW	LOW	MODERATE	LOW	MODERATE	LOW	VERY LOW	VERY LOW
Fraser's dolphin	VERY LOW	LOW	LOW	LOW	LOW	LOW	N/A	LOW	N/A
Killer whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Kogia (dwarf, pygmy sperm whale)	VERY LOW	LOW	LOW	N/A	LOW	N/A	N/A	LOW	N/A
Melon-headed whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Pantropical spotted dolphin	VERY LOW	LOW	LOW	N/A	LOW	N/A	N/A	LOW	N/A
Pygmy killer whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Risso's dolphin	VERY LOW	LOW	LOW	N/A	LOW	N/A	N/A	LOW	N/A
Rough-toothed dolphin	VERY LOW	LOW	LOW	MODERATE	LOW	MODERATE	VERY LOW	LOW	VERY LOW
Short-finned pilot whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Sperm Whale	N/A	MODERATE	N/A	N/A	MODERATE	N/A	N/A	MODERATE	N/A
Spinner dolphin	VERY LOW	VERY LOW	VERY LOW	N/A	LOW	N/A	N/A	VERY LOW	N/A
Striped dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
	ZONE 4			ZONE 5			ZONE 6		
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*
Atlantic spotted dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	MODERATE	LOW	MODERATE
Beaked whales (Cuvier/Blainville/Gervais)	N/A	LOW	N/A	VERY HIGH	MODERATE	VERY HIGH	HIGH	LOW	HIGH
Bottlenose dolphin (Coastal/Shelf/Oceanic)	N/A	VERY LOW	N/A	HIGH	LOW	HIGH	MODERATE	VERY LOW	LOW
Bryde's whale	N/A	HIGH	N/A	VERY HIGH	HIGH	VERY HIGH	HIGH	HIGH	VERY HIGH
Clymene dolphin	N/A	LOW	N/A	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
False killer whale	N/A	LOW	N/A	HIGH	LOW	HIGH	MODERATE	LOW	MODERATE
Fraser's dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	MODERATE	LOW	MODERATE
Killer whale	N/A	LOW	N/A	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
Kogia (dwarf, pygmy sperm whale)	N/A	MODERATE	N/A	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
Melon-headed whale	N/A	LOW	N/A	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
Pantropical spotted dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	MODERATE	LOW	MODERATE
Pygmy killer whale	N/A	LOW	N/A	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
Risso's dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	MODERATE	LOW	MODERATE
Rough-toothed dolphin	N/A	LOW	N/A	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
Short-finned pilot whale	N/A	LOW	N/A	HIGH	MODERATE	HIGH	MODERATE	MODERATE	MODERATE
Sperm Whale	N/A	MODERATE	N/A	VERY HIGH	HIGH	VERY HIGH	VERY HIGH	MODERATE	VERY HIGH
Spinner dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	MODERATE	VERY LOW	LOW
Striped dolphin	N/A	LOW	N/A	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
	ZONE 7								
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*						
Atlantic spotted dolphin	N/A	LOW	N/A						
Beaked whales (Cuvier/Blainville/Gervais)	HIGH	LOW	HIGH						
Bottlenose dolphin (Coastal/Shelf/Oceanic)	LOW	VERY LOW	VERY LOW						
Bryde's whale	N/A	MODERATE	N/A						
Clymene dolphin	LOW	LOW	LOW						
False killer whale	LOW	LOW	LOW						
Fraser's dolphin	LOW	LOW	LOW						
Killer whale	LOW	MODERATE	LOW						
Kogia (dwarf, pygmy sperm whale)	MODERATE	LOW	MODERATE						
Melon-headed whale	MODERATE	LOW	MODERATE						
Pantropical spotted dolphin	LOW	LOW	LOW						
Pygmy killer whale	LOW	LOW	LOW						
Risso's dolphin	LOW	LOW	LOW						
Rough-toothed dolphin	LOW	LOW	LOW						
Short-finned pilot whale	MODERATE	LOW	MODERATE						
Sperm Whale	MODERATE	MODERATE	MODERATE						
Spinner dolphin	LOW	VERY LOW	VERY LOW						
Striped dolphin	LOW	LOW	LOW						

Table 9. Severity and vulnerability ratings and overall evaluated RELATIVE risk for for **MODERATE** year scenario

RELATIVE OVERALL BEHAVIORAL RISK SCORES by ZONE									
	ZONE 1			ZONE 2			ZONE 3		
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*
Atlantic spotted dolphin	N/A	MODERATE	N/A	HIGH	LOW	HIGH	VERY LOW	LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Bottlenose dolphin (Coastal/Shelf/Oceanic)	N/A	LOW	N/A	HIGH	LOW	HIGH	VERY LOW	LOW	VERY LOW
Bryde's whale	N/A	HIGH	N/A	N/A	HIGH	N/A	N/A	MODERATE	N/A
Clymene dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
False killer whale	N/A	LOW	N/A	HIGH	LOW	HIGH	LOW	VERY LOW	VERY LOW
Fraser's dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	N/A	LOW	N/A
Killer whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Kogia (dwarf, pygmy sperm whale)	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Melon-headed whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Pantropical spotted dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Pygmy killer whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Risso's dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Rough-toothed dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	VERY LOW	LOW	VERY LOW
Short-finned pilot whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Sperm Whale	N/A	MODERATE	N/A	N/A	MODERATE	N/A	N/A	MODERATE	N/A
Spinner dolphin	N/A	VERY LOW	N/A	N/A	LOW	N/A	N/A	VERY LOW	N/A
Striped dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
	ZONE 4			ZONE 5			ZONE 6		
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*
Atlantic spotted dolphin	VERY LOW	LOW	VERY LOW	HIGH	LOW	HIGH	LOW	LOW	LOW
Beaked whales (Cuvier/Blainville/Gervais)	HIGH	LOW	HIGH	VERY HIGH	MODERATE	VERY HIGH	MODERATE	LOW	MODERATE
Bottlenose dolphin (Coastal/Shelf/Oceanic)	VERY LOW	VERY LOW	VERY LOW	HIGH	LOW	HIGH	VERY LOW	VERY LOW	VERY LOW
Bryde's whale	VERY LOW	HIGH	MODERATE	VERY HIGH	HIGH	VERY HIGH	LOW	HIGH	MODERATE
Clymene dolphin	MODERATE	LOW	MODERATE	HIGH	MODERATE	HIGH	LOW	LOW	LOW
False killer whale	LOW	LOW	LOW	HIGH	LOW	HIGH	LOW	LOW	LOW
Fraser's dolphin	LOW	LOW	LOW	HIGH	LOW	HIGH	LOW	LOW	LOW
Killer whale	LOW	LOW	LOW	HIGH	MODERATE	HIGH	LOW	LOW	LOW
Kogia (dwarf, pygmy sperm whale)	VERY LOW	MODERATE	LOW	HIGH	MODERATE	HIGH	MODERATE	LOW	MODERATE
Melon-headed whale	MODERATE	LOW	MODERATE	HIGH	MODERATE	HIGH	LOW	LOW	LOW
Pantropical spotted dolphin	VERY LOW	LOW	VERY LOW	HIGH	LOW	HIGH	LOW	LOW	LOW
Pygmy killer whale	LOW	LOW	LOW	HIGH	MODERATE	HIGH	LOW	LOW	LOW
Risso's dolphin	VERY LOW	LOW	VERY LOW	HIGH	LOW	HIGH	LOW	LOW	LOW
Rough-toothed dolphin	LOW	LOW	LOW	HIGH	MODERATE	HIGH	LOW	LOW	LOW
Short-finned pilot whale	LOW	LOW	LOW	HIGH	MODERATE	HIGH	LOW	MODERATE	LOW
Sperm Whale	MODERATE	MODERATE	MODERATE	VERY HIGH	HIGH	VERY HIGH	HIGH	MODERATE	VERY HIGH
Spinner dolphin	VERY LOW	LOW	VERY LOW	HIGH	LOW	HIGH	LOW	VERY LOW	VERY LOW
Striped dolphin	LOW	LOW	LOW	HIGH	MODERATE	HIGH	LOW	LOW	LOW
	ZONE 7								
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*						
Atlantic spotted dolphin	N/A	LOW	N/A						
Beaked whales (Cuvier/Blainville/Gervais)	HIGH	LOW	HIGH						
Bottlenose dolphin (Coastal/Shelf/Oceanic)	LOW	VERY LOW	VERY LOW						
Bryde's whale	N/A	MODERATE	N/A						
Clymene dolphin	LOW	LOW	LOW						
False killer whale	LOW	LOW	LOW						
Fraser's dolphin	LOW	LOW	LOW						
Killer whale	LOW	MODERATE	LOW						
Kogia (dwarf, pygmy sperm whale)	LOW	LOW	LOW						
Melon-headed whale	LOW	LOW	LOW						
Pantropical spotted dolphin	LOW	LOW	LOW						
Pygmy killer whale	LOW	LOW	LOW						
Risso's dolphin	LOW	LOW	LOW						
Rough-toothed dolphin	LOW	LOW	LOW						
Short-finned pilot whale	LOW	LOW	LOW						
Sperm Whale	MODERATE	MODERATE	MODERATE						
Spinner dolphin	LOW	VERY LOW	VERY LOW						
Striped dolphin	LOW	LOW	LOW						

Table 10. Severity and vulnerability ratings and overall evaluated RELATIVE risk for for **LOW** year scenario

RELATIVE OVERALL BEHAVIORAL RISK SCORES by ZONE									
	ZONE 1			ZONE 2			ZONE 3		
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*
Atlantic spotted dolphin	N/A	MODERATE	N/A	HIGH	LOW	HIGH	VERY LOW	LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Bottlenose dolphin (Coastal/Shelf/Oceanic)	N/A	LOW	N/A	MODERATE	LOW	MODERATE	VERY LOW	LOW	VERY LOW
Bryde's whale	N/A	HIGH	N/A	N/A	HIGH	N/A	N/A	MODERATE	N/A
Clymene dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
False killer whale	N/A	LOW	N/A	HIGH	LOW	HIGH	VERY LOW	VERY LOW	VERY LOW
Fraser's dolphin	N/A	LOW	N/A	MODERATE	LOW	MODERATE	N/A	LOW	N/A
Killer whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Kogia (dwarf, pygmy sperm whale)	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Melon-headed whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Pantropical spotted dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Pygmy killer whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Risso's dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Rough-toothed dolphin	N/A	LOW	N/A	HIGH	LOW	HIGH	VERY LOW	LOW	VERY LOW
Short-finned pilot whale	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
Sperm Whale	N/A	MODERATE	N/A	N/A	MODERATE	N/A	N/A	MODERATE	N/A
Spinner dolphin	N/A	VERY LOW	N/A	N/A	LOW	N/A	N/A	VERY LOW	N/A
Striped dolphin	N/A	LOW	N/A	N/A	LOW	N/A	N/A	LOW	N/A
	ZONE 4			ZONE 5			ZONE 6		
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*	*Severity*	*Vulnerability*	*Overall Risk*
Atlantic spotted dolphin	VERY LOW	LOW	VERY LOW	HIGH	LOW	HIGH	LOW	LOW	LOW
Beaked whales (Cuvier/Blainville/Gervais)	LOW	LOW	LOW	VERY HIGH	MODERATE	VERY HIGH	MODERATE	LOW	MODERATE
Bottlenose dolphin (Coastal/Shelf/Oceanic)	VERY LOW	VERY LOW	VERY LOW	MODERATE	LOW	MODERATE	VERY LOW	VERY LOW	VERY LOW
Bryde's whale	VERY LOW	HIGH	MODERATE	HIGH	HIGH	VERY HIGH	LOW	HIGH	MODERATE
Clymene dolphin	LOW	LOW	LOW	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW
False killer whale	VERY LOW	LOW	VERY LOW	MODERATE	LOW	MODERATE	LOW	LOW	LOW
Fraser's dolphin	VERY LOW	LOW	VERY LOW	MODERATE	LOW	MODERATE	LOW	LOW	LOW
Killer whale	VERY LOW	LOW	VERY LOW	HIGH	MODERATE	HIGH	LOW	LOW	LOW
Kogia (dwarf, pygmy sperm whale)	VERY LOW	MODERATE	LOW	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW
Melon-headed whale	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW
Pantropical spotted dolphin	VERY LOW	LOW	VERY LOW	MODERATE	LOW	MODERATE	LOW	LOW	LOW
Pygmy killer whale	VERY LOW	LOW	VERY LOW	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW
Risso's dolphin	VERY LOW	LOW	VERY LOW	HIGH	LOW	HIGH	LOW	LOW	LOW
Rough-toothed dolphin	VERY LOW	LOW	VERY LOW	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW
Short-finned pilot whale	VERY LOW	LOW	VERY LOW	MODERATE	MODERATE	MODERATE	LOW	MODERATE	MODERATE
Sperm Whale	LOW	MODERATE	LOW	VERY HIGH	HIGH	VERY HIGH	HIGH	MODERATE	HIGH
Spinner dolphin	VERY LOW	LOW	VERY LOW	MODERATE	LOW	MODERATE	LOW	VERY LOW	VERY LOW
Striped dolphin	VERY LOW	LOW	VERY LOW	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW
	ZONE 7								
SPECIES	*Severity*	*Vulnerability*	*Overall Risk*						
Atlantic spotted dolphin	N/A	LOW	N/A						
Beaked whales (Cuvier/Blainville/Gervais)	HIGH	LOW	HIGH						
Bottlenose dolphin (Coastal/Shelf/Oceanic)	LOW	VERY LOW	VERY LOW						
Bryde's whale	N/A	MODERATE	N/A						
Clymene dolphin	LOW	LOW	LOW						
False killer whale	LOW	LOW	LOW						
Fraser's dolphin	LOW	LOW	LOW						
Killer whale	LOW	MODERATE	LOW						
Kogia (dwarf, pygmy sperm whale)	LOW	LOW	LOW						
Melon-headed whale	LOW	LOW	LOW						
Pantropical spotted dolphin	LOW	LOW	LOW						
Pygmy killer whale	LOW	LOW	LOW						
Risso's dolphin	LOW	LOW	LOW						
Rough-toothed dolphin	LOW	LOW	LOW						
Short-finned pilot whale	LOW	LOW	LOW						
Sperm Whale	MODERATE	MODERATE	MODERATE						
Spinner dolphin	LOW	VERY LOW	VERY LOW						
Striped dolphin	LOW	LOW	LOW						

Table 11. Potential Behavioral Disturbance Severity (Level B) – Overall evaluted relative risk by zone across years (HIGH, MODERATE, and LOW annual activity scenarios)

	ZONE 1			ZONE 2			ZONE 3		
Species Name	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW
Atlantic spotted dolphin	LOW	N/A	N/A	MODERATE	HIGH	HIGH	VERY LOW	VERY LOW	VERY LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bottlenose dolphin	LOW	N/A	N/A	LOW	HIGH	MODERATE	VERY LOW	VERY LOW	VERY LOW
Bryde's whale	LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clymene dolphin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
False killer whale	LOW	N/A	N/A	MODERATE	HIGH	HIGH	VERY LOW	VERY LOW	VERY LOW
Fraser's dolphin	LOW	N/A	N/A	LOW	HIGH	MODERATE	N/A	N/A	N/A
Killer whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kogia (dwarf, pygmy sperm whale)	LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Melon-headed whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pantropical spotted dolphin	LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pygmy killer whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Risso's dolphin	LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rough-toothed dolphin	LOW	N/A	N/A	MODERATE	HIGH	HIGH	VERY LOW	VERY LOW	VERY LOW
Short-finned pilot whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sperm Whale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spinner dolphin	VERY LOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Striped dolphin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	ZONE 4			ZONE 5			ZONE 6		
Species Name	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW	HIGH	MODERATE	LOW
Atlantic spotted dolphin	N/A	VERY LOW	VERY LOW	HIGH	HIGH	HIGH	MODERATE	LOW	LOW
Beaked whales (Cuvier/Blainville/Gervais)	N/A	HIGH	LOW	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MODERATE	MODERATE
Bottlenose dolphin	N/A	VERY LOW	VERY LOW	HIGH	HIGH	MODERATE	LOW	VERY LOW	VERY LOW
Bryde's whale	N/A	MODERATE	MODERATE	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	MODERATE	MODERATE
Clymene dolphin	N/A	MODERATE	LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW
False killer whale	N/A	LOW	VERY LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW
Fraser's dolphin	N/A	LOW	VERY LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW
Killer whale	N/A	LOW	VERY LOW	HIGH	HIGH	HIGH	MODERATE	LOW	LOW
Kogia (dwarf, pygmy sperm whale)	N/A	LOW	LOW	HIGH	HIGH	MODERATE	MODERATE	MODERATE	LOW
Melon-headed whale	N/A	MODERATE	MODERATE	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW
Pantropical spotted dolphin	N/A	VERY LOW	VERY LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW
Pygmy killer whale	N/A	LOW	VERY LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW
Risso's dolphin	N/A	VERY LOW	VERY LOW	HIGH	HIGH	HIGH	MODERATE	LOW	LOW
Rough-toothed dolphin	N/A	LOW	VERY LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW
Short-finned pilot whale	N/A	LOW	VERY LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	MODERATE
Sperm Whale	N/A	MODERATE	LOW	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH
Spinner dolphin	N/A	VERY LOW	VERY LOW	HIGH	HIGH	MODERATE	LOW	VERY LOW	VERY LOW
Striped dolphin	N/A	LOW	VERY LOW	HIGH	HIGH	MODERATE	MODERATE	LOW	LOW

	ZONE 7		
Species Name	HIGH	MODERATE	LOW
Atlantic spotted dolphin	N/A	N/A	N/A
Beaked whales (Cuvier/Blainville/Gervais)	HIGH	HIGH	HIGH
Bottlenose dolphin	LOW	VERY LOW	VERY LOW
Bryde's whale	N/A	N/A	N/A
Clymene dolphin	LOW	LOW	LOW
False killer whale	LOW	LOW	LOW
Fraser's dolphin	LOW	LOW	LOW
Killer whale	LOW	LOW	LOW
Kogia (dwarf, pygmy sperm whale)	MODERATE	LOW	LOW
Melon-headed whale	MODERATE	LOW	LOW
Pantropical spotted dolphin	LOW	LOW	LOW
Pygmy killer whale	LOW	LOW	LOW
Risso's dolphin	LOW	LOW	LOW
Rough-toothed dolphin	LOW	LOW	LOW
Short-finned pilot whale	MODERATE	LOW	LOW
Sperm Whale	MODERATE	MODERATE	MODERATE
Spinner dolphin	LOW	VERY LOW	VERY LOW
Striped dolphin	LOW	LOW	LOW

DISCUSSION

The adapted, relativistic EWG noise risk assessment framework provides a number of important perspectives in evaluating the noise exposure modeling of GoMex exploration surveys conducted for the DEIS. This evaluation maintains the foundational perspective of the EWG that risk to a marine mammal population relates to the interaction of the extent of exposure (severity) and the overall vulnerability, which includes both species-typical parameters as well as other potential environmental stressors. It is emphasized that these results provide relative evaluations of risk given the substantial differences in assumptions between the modeling conducted and the EWG risk assessment framework. Even with certain quantitative compensations for what were interpreted by the EWG as overestimates of both predicted injury (level A) and behavioral disturbances (level B), many of the predicted effects occurred for substantial numbers of individuals within some zone-specific populations. For adjusted behavioral effects in our modified model, noise exposure takes on the order of several times the area population size were evaluated as only moderate levels of risk. This should be recognized as a relative evaluation scaled to the much lower and higher values observed across all species using the common assumptions in the model estimates and in the assessment approaches here. An evaluation of the overall, absolute severity of these takes in the context of the DEIS model assumptions is being addressed within the DEIS process by the regulatory agencies. Our application of this relativistic risk assessment approach here is intended to directly inform that process by providing a consistent and biologically-based contextual framework with which to evaluate relative risk given the model results and our common assumptions.

The resulting relative risk assessments presented above for potential injury and behavioral disturbance provide a number of insights in evaluating the DEIS model results and the significance of modeled takes. These include the following general and specific observations, some of which are relatively obvious yet important in nature and some of which are somewhat more counter-intuitive yet explainable for reasons relating to how the framework functions and how underlying assumptions in the DEIS model results were obtained.

General observations:

- The ability to evaluate relative risk with common assumptions in conditions where the total absolute evaluated takes vary substantially within and across years and areas illustrates the need for and strength of a population-based means of interpreting absolute takes. Putting population-normalized effects within a life-history and biological/environmental context serves to provide a more consistent, transparent, and ecologically-relevant means of interpreting modeled exposures.
- Spatial overlap between survey operations and animal distribution is centrally important in predicted relative risk of both injury and behavior. In areas where little or no activity occurs and/or animal density is predicted to be very low or zero, either no risk is evaluated or that evaluated is very low. This argues for a strong basis of simpler model

evaluations of potential effect that simply calculate spatial (and temporal) overlap between survey activities and animal distribution, including at greater resolution than conducted here.

- Temporal relationships between animal presence/behavioral state and survey timing are also likely critical important in determining relative risk of injury and behavior, for many of the same reasons. While this factor was evaluated here to some extent in terms of a temporal sensitivity vulnerability risk factor, using average survey activity within zones and by reflecting winter and non-winter seasons, the underlying model assumptions within the DEIS provide very coarse resolution on temporal factors. It is likely that true effects are highly sensitive to temporal relationships between activities and animal distribution and activity in ways that the modified EWG framework here is unable to capture because of the fact that the model assumptions evaluated temporal interactions on very coarse scales.
- Spectral similarities between the low-frequency energy of most of the survey activities here and species-typical hearing also have strong bearing on potential effects, both injurious and behavioral. Lower-frequency species, like Bryde's whales and sperm whales are among the species with some of the highest evaluated overall risk, particularly in terms of behavioral responses. While species-typical and zone-specific differences in vulnerability ratings are also important, between these two species the importance of animal distribution relative to survey activity spatial occurrence is clearly evident. Bryde's whales showing higher relative risk in a few areas where they are concentrated and sperm whales showing more moderate risk, but distributed across more areas, all with the same assumed levels of proposed surveys.
- Very high-frequency specialists are somewhat more likely to have higher evaluated relative risk of potential injury because of the dramatically lower exposure levels are predicted to be required for PTS onset (albeit with narrower auditory filters for SEL metrics); this is evident here in the relatively high risk evaluated in a number of scenarios for pygmy sperm whales
- Particularly sensitive species (notably beaked whales) are also more likely to have higher relative behavioral risk (as evident here) because of the much higher response probabilities used within the behavioral risk step functions derived from Ellison et al. (2015).
- A revised and complete evaluation of all years modeled in the revised DEIS will be evaluated using a potentially modified version of the EWG risk framework. This will include all years as well as provide an overall evaluated risk by species for each zone given the level of modeled activity.

Specific observations:

- Evaluated relative risk of potential injury and behavioral disturbance are not necessarily consistent within species and within zones given the same levels of activity. For species with greater low-frequency hearing sensitivity (*e.g.*, Bryde's whales) or lower predicted TTS/PTS onset (*e.g.*, pygmy sperm whales), potential injury risk may be greater than for

other species. Conversely, species with predicted greater behavioral response sensitivity (e.g., beaked whales) or species that are coping with other interacting potential stressors (*e.g.*, numerous delphinids in areas affected by the Macondo oil spill which have higher associated behavioral vulnerability) may have higher relative behavioral risk. Because there are different mechanisms involved in evaluating these different effects, one should not assume that relative differences in respective injury or behavioral risk within species will be similar, even within the same zones for the same years.

- This evaluation considered relative risk, and we developed a number of modified approaches that account for what we interpreted as likely to result in over-estimates of modeled takes (e.g., absence of behavioral aversion in PTS model predictions; use of 24-h reset in calculating behavioral takes). While we deliberately developed relativistic methods because of questions related to absolute take numbers, it is notable that even with these downward calculations based on different assumptions that a number of the take estimates represented large proportions or many times estimated zone-specific population sizes.
- Areas of the GoMex where little or no survey activity is predicted to occur or areas within which few or no animals of a particular species are believed to occur have very low or no potential risk of negatively affecting marine mammals.
- There are certain areas of the GoMex where generally high levels of survey activity are predicted to occur (e.g., Zones 5 and 6) across each of the annual scenarios. These areas predictably have higher overall evaluated risk across all species, with the highest levels of risk predicted for more low-frequency species (e.g., Bryde's and sperm whales) and more sensitive species (e.g., beaked whales and pygmy sperm whales). While the relative overall magnitude of activity may be lower across years, these areas remain relatively high in terms of overall activity and consequently are associated with higher overall risk across most species compared to other areas. Zones 5 and 6 were the only zones with very high levels of risk due to behavioral disturbance, identified for three species: Bryde's, beaked and sperm whales. These were identified in Zone 5 across all scenarios, and for just sperm whales in zone 6 for HIGH and MODERATE scenarios. Zones 4, 5, 6, and 7 all had very high levels of risk due to injury, but relative evaluated risk across species varied between zones and scenarios.
- Relatively high or very high risk for injury and behavior are in some cases predicted for several other species (e.g., bottlenose dolphins for potential injury; false killer whales for behavioral disturbance) in some contexts. These higher levels of risk are generally explained by the interaction of specific factors related to survey effort concentration and areas of heightened geographic distribution or specific factors related to population trends or zone-related differences in vulnerability.
- Across seasons, overall patterns of relative risk are relatively similar but do generally scale with the level of projected survey activity. Specifically, generally higher levels of overall risk are seen for the year with the highest number of overall survey days (HIGH) relative to an intermediate year (MODERATE) and the lowest overall year (LOW).

- However, the use of a total number of survey days can fail to predict differences within species and zones. For instance, while the MODERATE year has fewer overall total survey days than the HIGH year, yet there is a greater distribution of effort within Zone 2. This which results in higher overall behavioral risk for several species that are more strongly concentrated within that zone. Further, while overall survey days are substantially lower overall for the LOW annual scenario, this relative reduction does not occur proportionally for Zone 7 and potential injury in this zone is thus not decreased (even increasingly for a number of species).
- Finally, certain zones for which there is a consistently quite high level of projected activity (especially zone 5) are predicted to result in the relatively highest levels of overall risk, even in years with less projected relative activity compared to other years. Perhaps the most obvious and overarching conclusion to be derived from this risk assessment method is that this area with the highest overall relative level of activity is generally associated with the highest overall evaluated risk across most species considered. Further resolution of the spatial and temporal scales of overlap between survey activities and populations could enable a more refined evaluation of risk that could account for finer-scale habitat, seasonal, and other biologically-relevant factors.