Possible Risks to Marine Protected Species from the Construction and Operation of the Delfin LNG Offshore Terminal

Revised Report

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Table of Contents

List of Figures

1. Introduction

This assessment is focused on the Delfin LNG project's offshore activities and possible effects to marine mammals with additional considerations given to sea turtles and other protected species, particularly with respect to anthropogenic noise. Impacts to terrestrial wildlife from onshore noise are not considered here.

For offshore industry activities with construction and operations, there are several pathways of impact to protected species, including noise, chemical run-off, and physical habitat disturbance/alteration. However, for the majority of offshore industry activities, noise or modification of the habitat are the higher concerns. Because of the spatial extent of noise underwater (Urick 1983, 1986), direct or indirect noise impacts to marine mammals are often the most pressing management concern (Myrberg 1990, Richardson et al. 1995, National Research Council 2003, 2005, Nowacek et al. 2007, Tyack 2009). The principal concern of noise exposure for marine mammals is not so much lethality, but auditory injury (defined as Permanent Threshold Shift [PTS] or Temporary Threshold Shift [TTS]), and chronic sub-lethal stress responses induced by anthropogenic noise (Richardson et al. 1995, National Research Council 2005, Nowacek et al. 2007, Southall et al. 2021). The U.S. Marine Mammal Protection Act (MMPA) has specific provisions that regulate noise exposure to marine mammals, with thresholds for harassment (as defined by MMPA) of 160 dB (re 1µPa) for impulsive sounds and 120 dB (re 1µPa) for continuous sounds (Richardson et al. 1995), and recent modifications have been made to these criteria which take into account the estimated hearing sensitivity of different marine mammal species (NMFS 2018). Within the scientific community, it is recognized that the existing 160/120 dB statutory thresholds for impulsive and continuous noise sources (respectively) may oversimplify cetacean responses to and impacts from anthropogenic noise (Southall et al. 2021), as animals do not reform uniformly to different anthropogenic sound levels. Consequently, these threshold levels may be insufficiently protective for marine mammals from risk or harm. For example, an exposure level one or several dB below the regulatory threshold still may induce an adverse impact in some or many individuals; for example, it is possible that a 157 or 159 dB impulsive sound may elicit a stronger change in behavior that a 161 dB sound. Anthropogenic sounds below these established threshold levels can still have adverse behavioral or physiological impacts, and the context in which a marine mammal is exposed to anthropogenic noise is also important, such as the duration, combination, and types of sounds (Ellison et al. 2012). Consequently, the 160/120 dB thresholds may not be sufficient to protect marine mammals from adverse consequences of exposure to anthropogenic noise. In practice, it may be more appropriate to view the regulatory thresholds as a range or approximation, rather than an absolute threshold with a binary response depending on whether a noise source is above or below the threshold.

Risk assessments for marine mammal species associated with industry activities and particularly noise are typically based on the likelihood of occurrence of species in the project area and the noise levels to which these species will be exposed. However, across different sectors, risk assessments are not uniform in their calculation of quantitative or qualitative levels of risk or impact assessment, and many do not demonstrate what levels of risk are based upon. There is no standardize requirement for the level of quantitative rigor and model estimation that is included in a marine mammal risk assessment.

2. Delfin Project Overview

The offshore component of the Delfin LNG project would create a deepwater port for exporting liquified natural gas. The deepwater port takes advantage of two existing undersea pipelines (the U-T Operating System Pipeline and the High Island Operating System Pipeline). Construction of the deepwater port would involve pile-driving four 78" diameter pilings into the seafloor, which would allow for four permanently moored LNG vessels to receive the gas from the pipelines and transport it on to ships for export. A Final Environmental Impact Statement for the project (USCG 2016) describes the construction activities, the possible environmental consequences of the construction and operation activities, and best management practices intended to mitigate adverse impacts to protected species. Possible impacts from the construction include elevated noise associated with pile-driving, trenching to lay additional pipeline, or from construction-related vessels; as well as physical habitat disturbances and possible chemical run-off. In the context of marine protected species, the possible impact with the greatest spatial extent is the noise generated from the construction and operation of the terminal, which may exceed established or recommended exposure criteria for noise (Popper et al. 2014, NMFS 2018, Southall et al. 2021). Construction-related noise will be up to 23 months, distributed over two construction periods (USCG 2016; see Table 4.12-4). Operational noise for the terminal is likely to result from increases in vessel traffic, thrusters for positioning LNG cargo vessels, FLNGV liquefication, and offloading LNG to outgoing vessels (USCG 2016; see p. 6-24) and would continue for the life of the terminal (30 years).

3. Potential Marine Threatened, Endangered, and Sensitive ("TES") Species Concerns Related to Delfin LNG Project

Though there are up to 30 species of marine mammals found in the Gulf of Mexico (Mullin and Hansen 1999, LaBrecque et al. 2015), the vast majority of ESA listed species have only been observed incidentally and do not appear to be regularly found within the Gulf. However, regions of the Gulf of Mexico have been previously identified as "Biologically Important Areas" (BIAs) for two species of marine mammals, Rice's whales (previously considered a population of Bryde's whale) and bottlenose dolphins (LaBrecque et al. 2015). Despite the biological importance of these regions for Rice's whales and bottlenose dolphins, this identification is not a regulatory designation and offers no additional legal protections for the species (LaBrecque et al. 2015). However, Rice's whale is endemic to the Gulf of Mexico (Rosel and Wilcox 2014, Rosel et al. 2021), and does not occur outside of this region.

Sperm whales are a resident endangered species along the continental shelf edge across the Gulf of Mexico; female and juveniles spend the majority of their life cycle within the Gulf of Mexico, and bull males will migrate in from the broader Atlantic to reproduce (Mullin et al. 1994, Jefferson and Schiro 1997, Davis et al. 2002). There are several federally protected sea turtle species also found in the Gulf of Mexico (Carr 1969, Plotkin et al. 1993, McDaniel et al. 2000). For the purposes of this report, those species that are the greatest management and conservation concern to the Delfin LNG project are addressed here.

Other threatened or endangered marine wildlife species are found in the Gulf of Mexico, such as Gulf sturgeon, Nassau grouper, smalltooth sawfish, giant manta rays, oceanic whitetip sharks and manatees, but they are not regularly documented in the western Gulf of Mexico, and are not discussed further here. Additionally, these endangered fish and shark species do not have specific provisions under the U.S. Endangered Species Act (ESA) that regulate anthropogenic noise exposure from industry activities. The lack of inclusion of other protected species here does not diminish their conservation concern, nor imply that that no adverse effects are likely. A reasonable and precautionary multi-species monitoring program could help establish the probability of occurrence of these ESA-listed species near the Delfin project area, and if more robust mitigation measures may be warranted. While these species are not regulated to the same degree of specificity and technical detail for noise exposure or vessel strikes as for marine mammals or turtles, these industry activities may still represent possible risk of impact to these fish species and adversely impact their populations. There is presently a sufficient understanding of risk of acoustic exposure from anthropogenic sources to fishes and turtles (Popper et al. 2014) to guide impact assessments to these projected species. A better understanding of the spatial distribution and temporal occurrence of data deficient protected species that may occur around the Delfin LNG project site is needed to reduce adverse impacts to these species in the Gulf of Mexico.

Rice's Whale

The Rice's whale (*Balaenoptera ricei*) is the only baleen whale to regularly occur in the Gulf of Mexico. However, while it is the only resident baleen whale found in this region, the number of individuals in the species is extremely low, with only approximately 50 individuals (NMFS 2020, Hayes et al. 2021, Rosel et al. 2021); it is one of the cetacean species with the fewest numbers of individuals remaining. The species was only recently described as a new species based on morphological evidence (Rosel et al. 2021), and before this new species designation, it was recognized as a genetically distinct subpopulation of Western North Atlantic Bryde's whale (*Balaenoptera edeni*), found only in the Northern Gulf of Mexico (Rosel and Wilcox 2014). Since the Rice's whale was only recently recognized as a new species (NMFS 2021), there is little biological or management information presently available using this new taxonomic designation. Moreover, most of the information contained in the Delfin LNG EIS and permit applications relevant to Rice's whale was assembled before the species was listed as endangered and identified as a new species. However, all data previously described under the Bryde's whale species classification is relevant for the Rice's whale, but that represents only a very limited amount of scientific information available on the species. Even after the elevation to a distinct species status, Rice's whale species is still listed as an endangered species under the ESA (NMFS 2019, 2021). For the purposes of this summary, information on the species here is described under the identifier of Rice's whales, but all reference to Gulf of Mexico Bryde's whale are applicable to Rice's whales, such as in the most recent NOAA stock assessment reports (Hayes et al. 2021), as well as the Delfin LNG permitting documentation. There are still extensive data gaps on the life history and ecology of the species– such as population status and trends, foraging behaviors, habitat features, reproductive ecology, current and historical temporal and spatial distribution– that limit the implementation of an effective recovery plan for the species (NMFS 2020) and renders the species' potentially vulnerable to human activities. The Delfin LNG EIS was drafted before the vulnerability of Rice's whale was identified, and Delfin-related activities were not considered as much of a risk.

Although Rice's whales have been identified as the most regularly occurring baleen whale in the Gulf of Mexico for decades (Jefferson and Schiro 1997, Davis et al. 2002), the species has received little research attention compared to other baleen whales in U.S. federal waters. The population in the Gulf of Mexico was only discovered by scientists in the early 1990s (Mullin and Hansen 1999, Soldevilla et al. 2017). Little was known about the behavior or ecology of this population. Despite documentation of different species of baleen whale calls previously recorded, as well as recordings of other Bryde's whale populations (Oleson et al. 2003), and the recognized value of using passive acoustics for understanding baleen whales (Mellinger et al. 2007), the only acoustic recordings from the Rice's whale was obtained from a stranded juvenile undergoing rehabilitation (Edds et al. 1993). The paucity of acoustic data limits the ability of passive acoustic monitoring to understand aspects of the species behavior, understand temporal and spatial distribution patterns, or identify impacts to the species as has been done recently for several baleen whale species in the Atlantic (Davis et al. 2017, Davis et al. 2020), or for sperm whales in the Gulf of Mexico (Farmer et al. 2018a, Farmer et al. 2018b). The lack of historical passive acoustic monitoring of Rice's whales limits the scientific and management understanding of historical trends in the species (either for population size or movement patterns) or abundance estimates that have been done for other cetacean species. As a result, these data gaps on Rice's whales make it difficult to understand, manage, and mitigate impacts to the species.

The Deepwater Horizon oil spill created a new scientific interest and management concern for Gulf of Mexico Rice's whales. The Deepwater Horizon Natural Resources Damage Assessment (https://www.doi.gov/deepwaterhorizon/nrda) focused on assessing oil spill impacts to the population, but the lack of extensive previous data on the species constrained the ability to infer impacts. As a result of this renewed scientific and management mandate, the first passive acoustic recordings of the population were made (Rice et al. 2014a, Širović et al. 2014), thereby allowing for the use of passive acoustic monitoring to provide more information on the behavior, ecology and distribution of the population (Širović et al. 2014, Hodge et al. 2015b). Although the behavioral context in which these calls are produced is unclear, their frequency range of approximately 80-150 Hz is similar to other baleen whale calls (Rice et al. 2014a, Širović et al. 2014). The acoustic surveys for Rice's whales further corroborated their distribution in the northeast Gulf of Mexico, and neither acoustics nor ship-based surveys (Soldevilla et al. 2017) detected Rice's whales outside of their "core area" (Figure 1).

Beginning in February 2021, there was an officially declared Unusual Mortality Event (UME) for cetaceans in the Gulf of Mexico, which preceded and coincided with the Deepwater Horizon oil spill in April 2010 (Litz et al. 2014). The possible population impacts from the UME and Deepwater Horizon to Bryde's whales was not included in stock assessments until 2012 (Waring et al. 2012, 2013). The cetacean UME in the Gulf of Mexico ended July 31, 2014, and two stranded Rice's whales in 2012 were attributed to the UME (Hayes et al. 2018). The Deepwater Horizon oil spill was estimated to have caused up to a 22% decline in the population size (Hayes et al. 2018). In 2016, the National Marine Fisheries Service (NMFS) filed a petition for the Gulf of Mexico stock of Bryde's whales to be listed as endangered (Hayes et al. 2017), and the stock was officially listed as an endangered species in 2019 (50 CFR 224; NMFS 2019).

Despite continuing lack of observational data that prevents determining population trends, in 2011, Rice's whales were designated as a "Strategic Stock" for management purposes (Table 1), because average annual mortality and injury from human influences was greater than the established level of biological removal (Waring et al. 2012). Rice's whales are at chronic and/or acute risk from shipping traffic, oil spills, increases in noise, other human activities combined with changing oceanographic conditions within the Gulf of Mexico. A Strategic Stock designation recognizes the vulnerable or imperiled status of a whale population within U.S. waters, and requires annual assessments and a mandate for aggregating new information as it becomes available. However, this Strategic Stock designation is further influenced by the extremely low population size; with such a small population size, even a small number of mortalities represents an immense threat to the species' viability. Before the Strategic Stock designation, Rice's whales were only assessed every 3-5 years, which minimized the awareness of how data gaps impair the effective management of the species. Despite changes in the reported numbers of the estimated population size of Rice's whales in marine mammal stock assessment reports (Table 1), there are no statistically significant differences between survey years (Garrison et al. 2020), and it is unclear whether the population is actually stable or declining (Hayes et al. 2021). NMFS has not yet issued a formal recovery plan for Rice's whale, but has created an initial recovery draft plan for the protection and restoration of the Rice's whale species (NMFS 2020).

Table 1. Population estimates of Rice's whale (formerly Northern Gulf of Mexico Bryde's whales) reported in NOAA marine mammal stock assessment reports. The "estimated minimum number of individuals" is the most conservative estimate of population size and based on the best available scientific information on the population's abundance, whereas the "best estimate number" is the statistically most likely number of individuals in the population (see Hayes et al. 2021).

NOAA Stock Assessment Year	Estimated Minimum Number of Individuals (N_{min})	Average or Best Estimate Number of Individuals (N_{best} or $N_{average}$)	NOAA Stock Designation	Reference
1995	17	35	Not strategic	(Blaylock et al. 1995)
2003	25	40	Not strategic	(Waring et al. 2004)
2005	25	40	Not strategic	(Waring et al. 2005)
2008	5	15	Not strategic	(Waring et al. 2009)
2011	5	15	Strategic	(Waring et al. 2012)
2012	16	33	Strategic	(Waring et al. 2013)
2016	16	33	Review for ESA Listing	(Hayes et al. 2017)
2017	16	33	Endangered	(Hayes et al. 2018)
2020	34	51	Endangered	(Hayes et al. 2021)

As a shallower water baleen whale species, the depth ranges in which Rice's whales are known to reside are closer to the depths of the Delfin LNG site compared to other endangered cetaceans in the Gulf of Mexico. However, there are a low number of observations of Rice's whales west of Florida in the Gulf of Mexico (2003 SAR), and the majority of observed Rice's whales occur in the northeast Gulf of Mexico in an identified core area along the West Florida Shelf (Figure 1). In the 2001 SEFSC spring vessel surveys, there was a single observation of a Rice's whale west of Florida and outside of the "core area" (also referred to as a Biologically Important Area) due south of the Texas/Louisiana Border between the 100 and 1000 m isobaths (Waring et al. 2004, LaBrecque et al. 2015). The extensive acoustic and ship-based surveys (e.g., Rice et al. 2014a, Rice et al. 2014b, Širović et al. 2014, Hodge et al. 2015b, Soldevilla et al. 2017, Garrison et al. 2020) show that Rice's whales are found outside of the northeast Gulf of Mexico, though in much lower numbers than within the "core area." However, a summary of both sightings data and locations of stranded Bryde's whales or Bryde's-like whales between 1954-2019 shows that there have been 12 stranded individuals identified along the Louisiana coast (Figure *1*) (see Table 4 in Rosel et al. 2021). The stranding and observation data clearly indicates Bryde's whales occasionally occur in the western Gulf of Mexico (see Figure 4 in Rosel et al. 2021). However, from this information it is unclear how regularly Rice's whales occur in the western Gulf of Mexico. The Delfin LNG letter of concurrence from MARAD states that:

> “None of the 6 baleen whale species that use the Gulf of Mexico are known to occur in the shallow continental shelf waters off of Louisiana where project construction activities will occur. Therefore, the proposed construction-related activities will have no effect on these species.” (p. 13)

However, the stranded Rice’s whales or other unidentified baleen whales along the Louisiana coast suggest that the view represented in the letter of concurrence is an oversimplification of what the data suggest (Figure *1*) The nearest Rice’s whale strandings in Louisiana were 70 km north and 124 km northeast Delfin LNG site; both strandings were near high-traffic shipping lanes (see Figure 16 below), though the cause of strandings are unclear (Harris 1987). Given the clockwise circulation of the loop current in the Gulf of Mexico, it is unlikely that Rice’s whales passively drifted from the “core area” to the Louisiana coast.

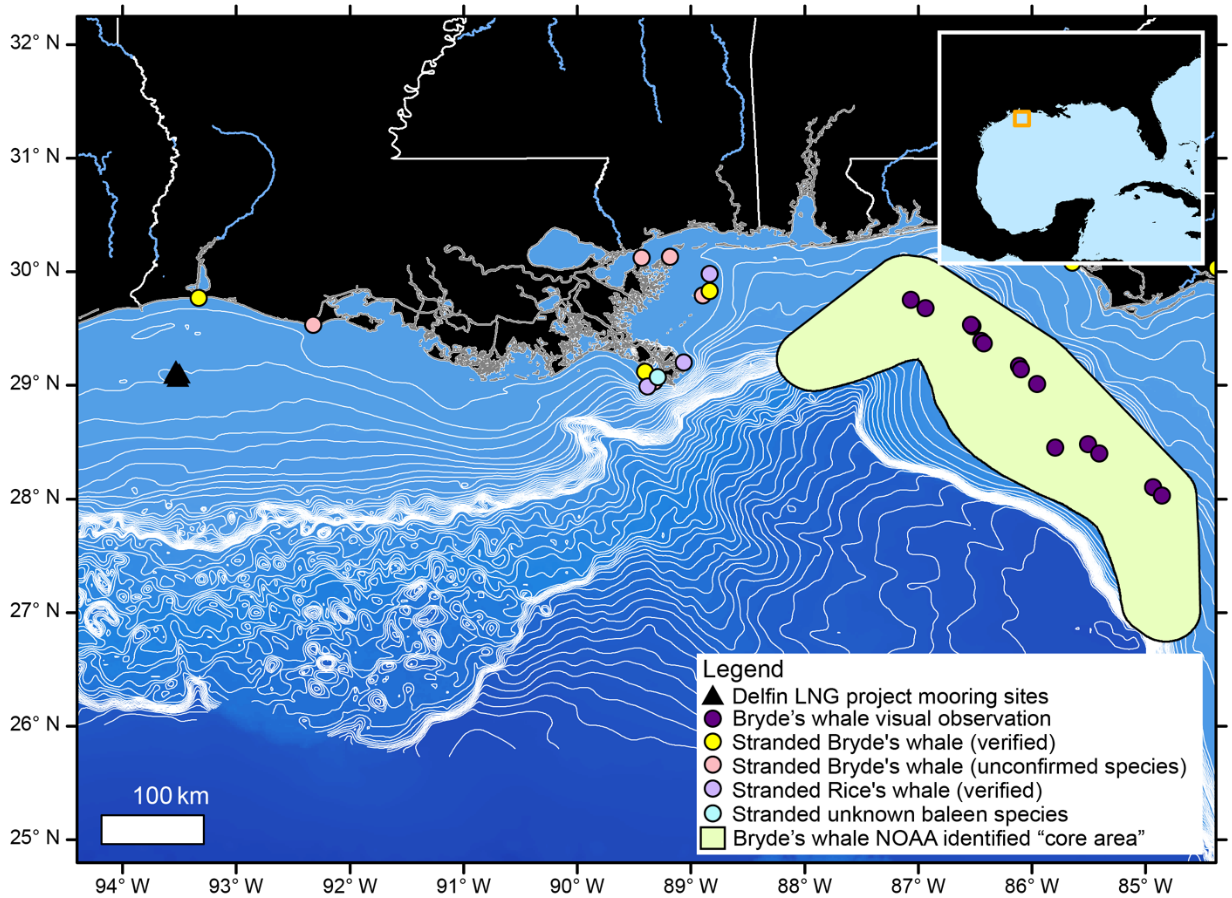

Figure 1. Records of Rice's/Bryde's/baleen whales in the Gulf of Mexico. Visual observations of Bryde's whales (purple circles) document this species primarily inhabiting the northeastern Gulf of Mexico; visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Rice's/Bryde's whale "core area" is shown in shaded green (data from marinecadastre.gov, accessed December 10, 2021). Whale stranding data are from Rosel et al. (2021) showing the confirmed and putative stranded Bryde's whales and Rice's whales found outside of the core area. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

Sperm whale

Sperm whales (*Physeter macrocephalus*) are the most regularly occurring large whale in the Gulf of Mexico (Hayes et al. 2021). Some portion of the population occurs in the Gulf year round (Mullin et al. 1994, Mullin and Hansen 1999), though there appear to be seasonal movements in the northern Gulf of Mexico (Morano et al. 2020). The resident animals forming pods in the Gulf of Mexico appear to be primarily females, with mature males seasonally migrating into the Gulf from the Western North Atlantic Ocean (Ortega-Ortiz et al. 2012, Hayes et al. 2021). In the Gulf of Mexico, sperm whales are primarily distributed across the continental shelf edge, where they feed on deep dwelling cephalopods (Ruiz-Cooley et al. 2004). While sperm whales are primarily found in deeper waters in the Gulf of Mexico, they are occasionally documented in shallower waters on the shelf, found in waters as shallow as 30-40 m (Figure 2). Sperm whales produce broadband clicks associated with foraging, prey capture and social behaviors (e.g., Watkins and Schevill 1977, Weilgart and Whitehead 1988, Goold and Jones 1995, Jaquet et al. 2001, McDonald et al. 2017). The nearest sperm whales observed to the Delfin LNG project site are 80 km south and 124 km southeast (Figure 2).

From an ecological impact perspective in the Gulf of Mexico, the response of sperm whales to environmental changes and anthropogenic stressors has been extensively studied (McDonald et al. 2017, Farmer et al. 2018b, Morano et al. 2020), which provides robust empirical basis for predicting population consequences from human disturbances (Ackleh et al. 2012, Ackleh et al. 2017, Farmer et al. 2018a). Work done on sperm whales can serve as an example of the types of studies and predictions that could be applied to other TES in the Gulf of Mexico.

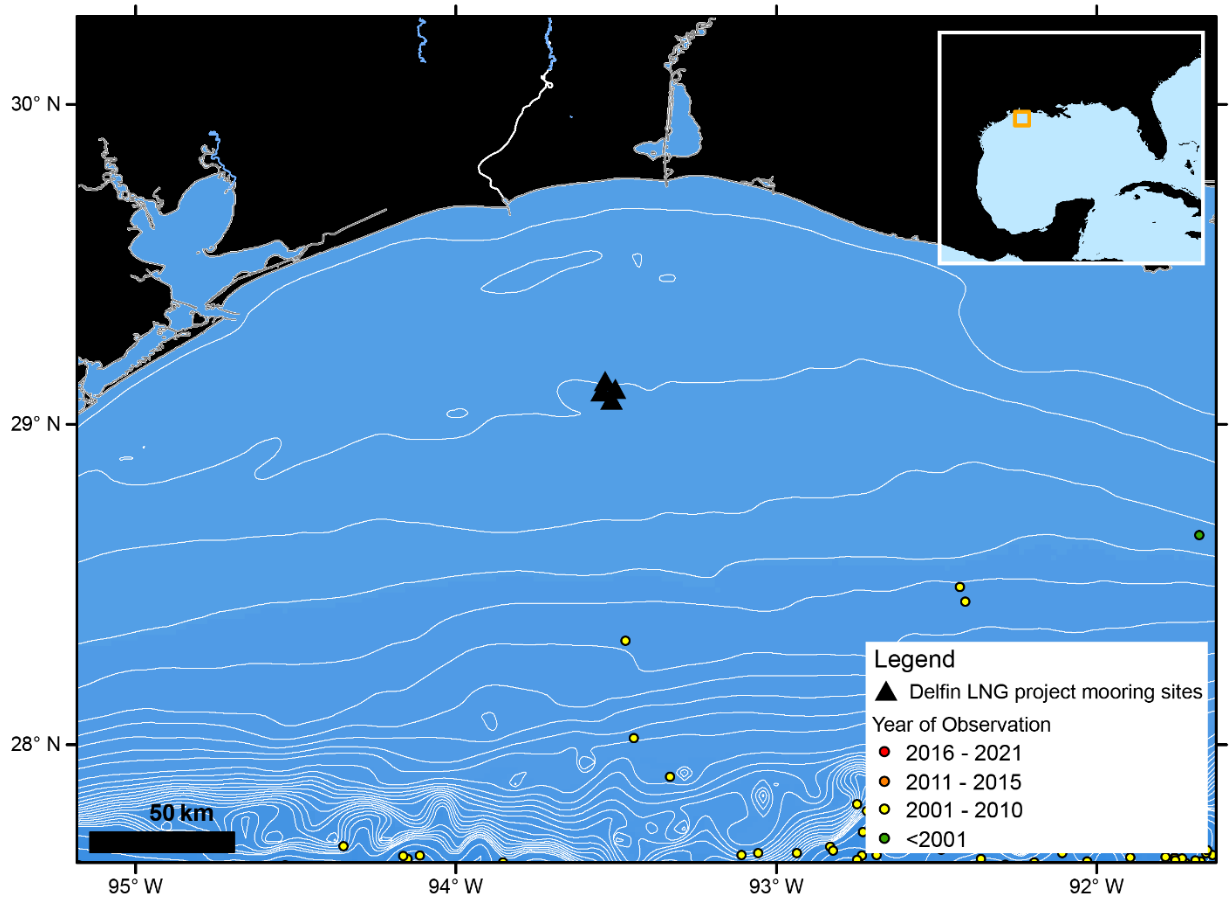

Figure 2. Records of sperm whale observations along the shelf edge in the Northern Gulf of Mexico. Visual observations of sperm whales (yellow circles) document this species primarily inhabiting deeper waters in the northern Gulf of Mexico; Visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

Bottlenose Dolphin

Bottlenose dolphins (*Tursiops truncatus*) are a broadly distributed odontocete found across the U.S. Atlantic and Gulf of Mexico. The specific population relevant to the Delfin LNG project is the Gulf of Mexico Western Coastal Stock, which is primarily found inshore in waters less than 20 m (Waring et al. 2016) (Figure 3). However, there are also separate dolphin stocks in the northern and eastern Gulf of Mexico. The current best population estimate for the Western Coastal Stock is 20,161 individuals, however population trends have not been evaluated (Waring et al. 2016).

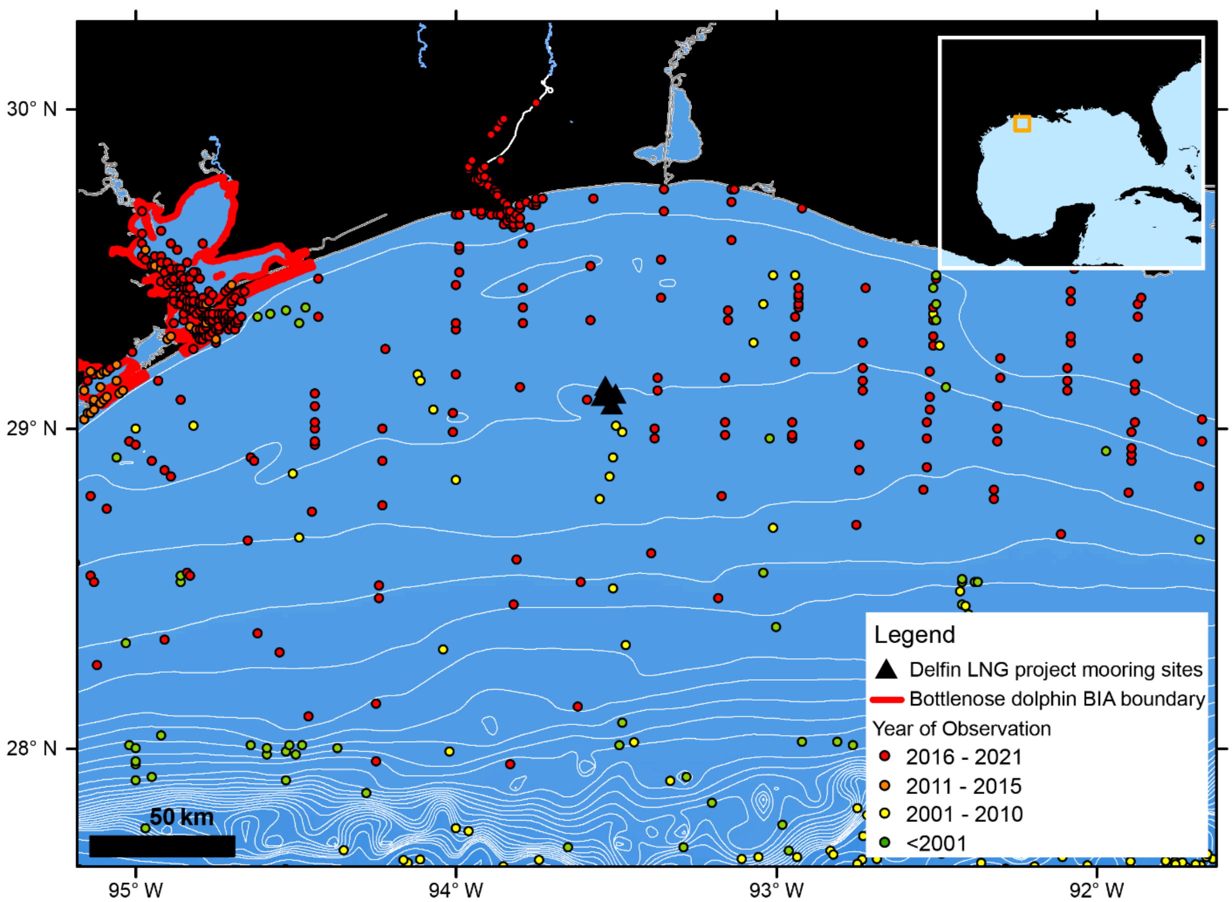

Figure 3. Records of bottlenose dolphin observations in the Northern Gulf of Mexico. Visual observations of dolphins (circles) demonstrate a broadly distributed population with highly concentrated sightings in the bays adjacent to the Gulf. Galveston Bay (with red border), to the northwest of the Delfin LNG offshore site is recognized as a Biological Important Area for this population (LaBrecque et al. 2015). Dolphin visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

Sea Turtles

Several protected sea turtle species, including Kemp's ridley, leatherback, green and loggerhead sea turtles are found throughout the Gulf of Mexico, nesting on beaches and making seasonal migrations across the Gulf of Mexico. All of these sea turtle species found in the Northern Gulf of Mexico are listed as endangered (NMFS 2013). The distribution of the four most common species documented in the northern Gulf of Mexico are shown below: Kemp's ridley (Figure 4), leatherback (Figure 5), loggerhead (Figure 6), and green sea turtles (**Error! Reference source not found.**). The EIS acknowledges the occurrence of sea turtle species (p. 3-18 – 3-21), but does not comment on the likelihood of distributional overlap with the project activities, only that there is the potential of hatchings being present for all listed sea turtle species in the Northern Gulf of Mexico (Table 3.3-2).

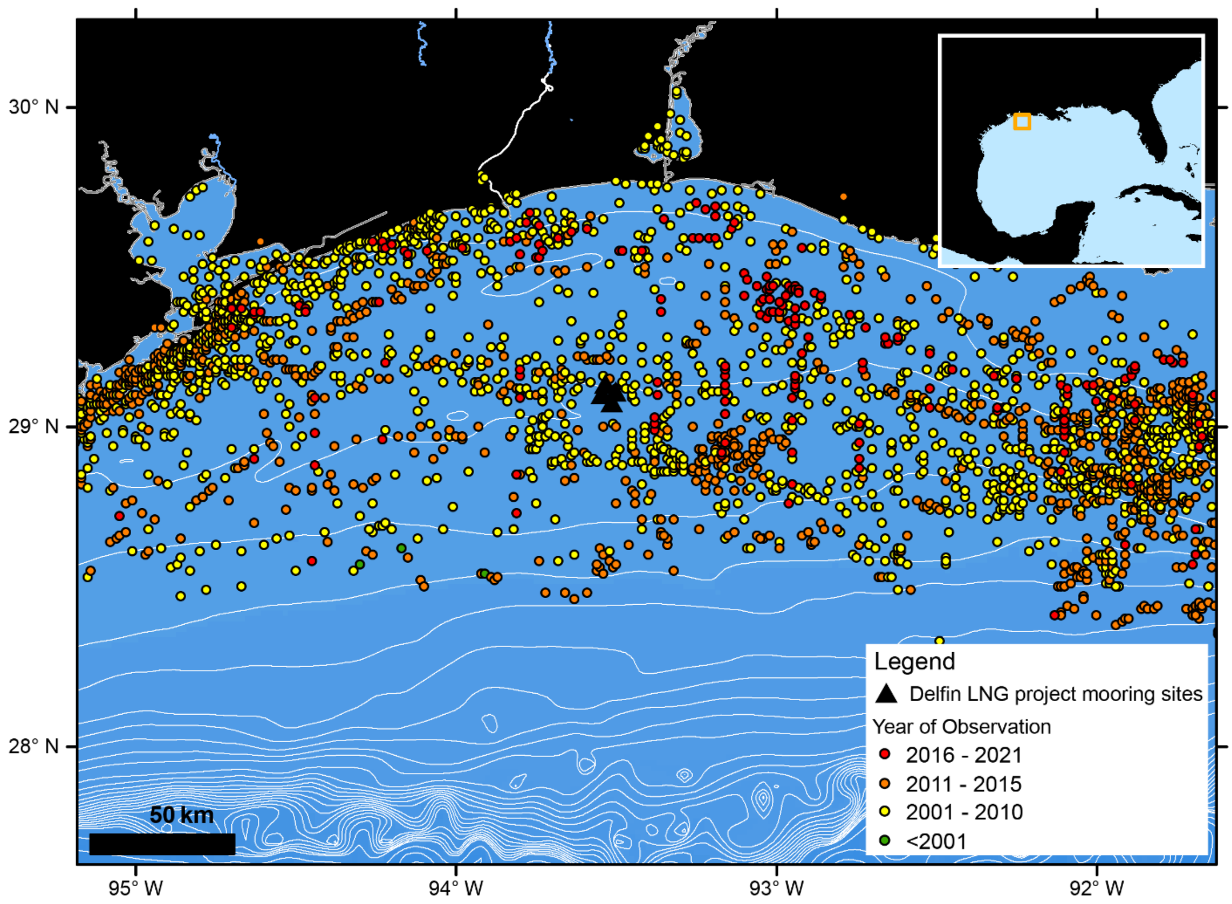

Figure 4. Records of Kemp's ridley sea turtle observations in the Northern Gulf of Mexico. Visual observations of Kemp's ridley (circles) demonstrate a broadly distributed population with several highly concentrated sightings. Kemp's ridley visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of

the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

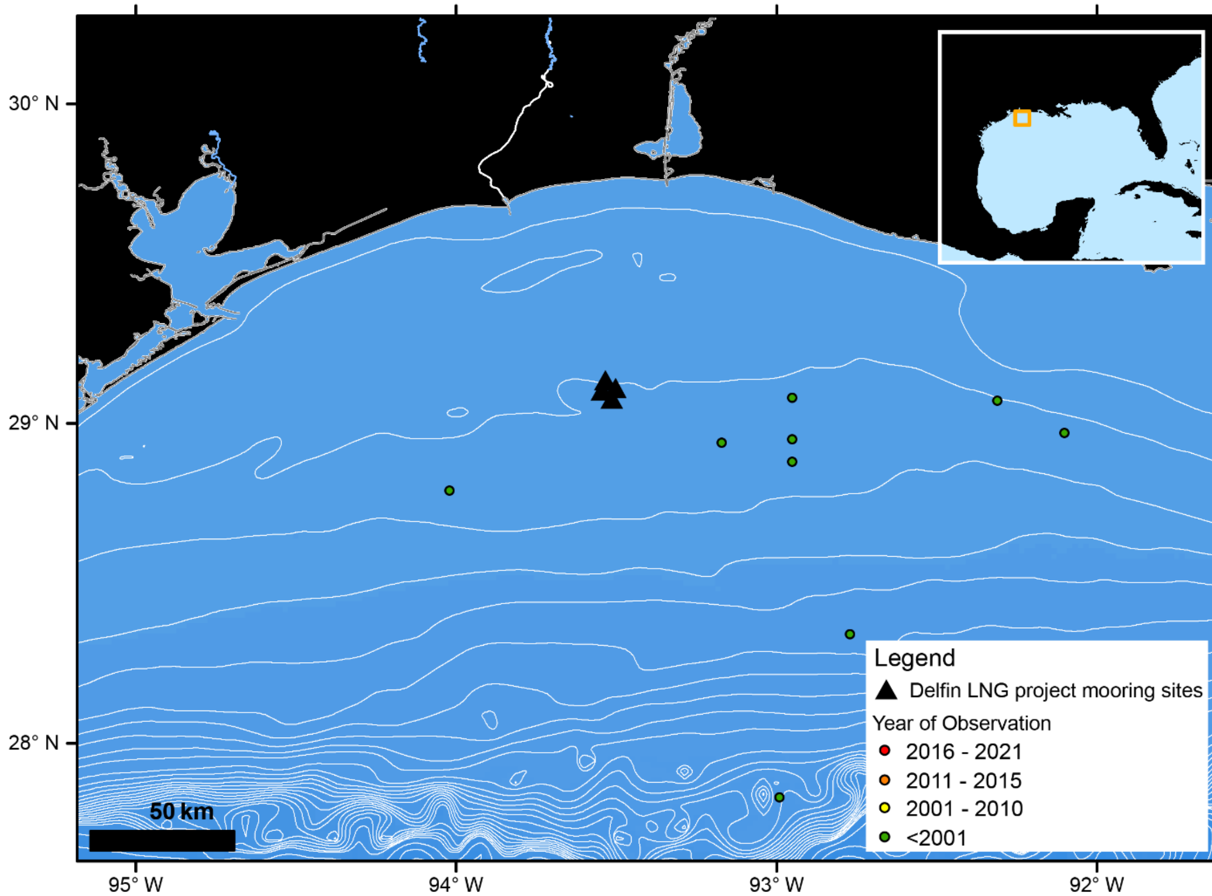

Figure 5. Records of leatherback sea turtle observations in the Northern Gulf of Mexico. Visual observations of loggerhead sea turtles (circles) demonstrate several observations in the northwestern Gulf of Mexico, in waters deeper than 20 m. Leatherback sea turtle visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

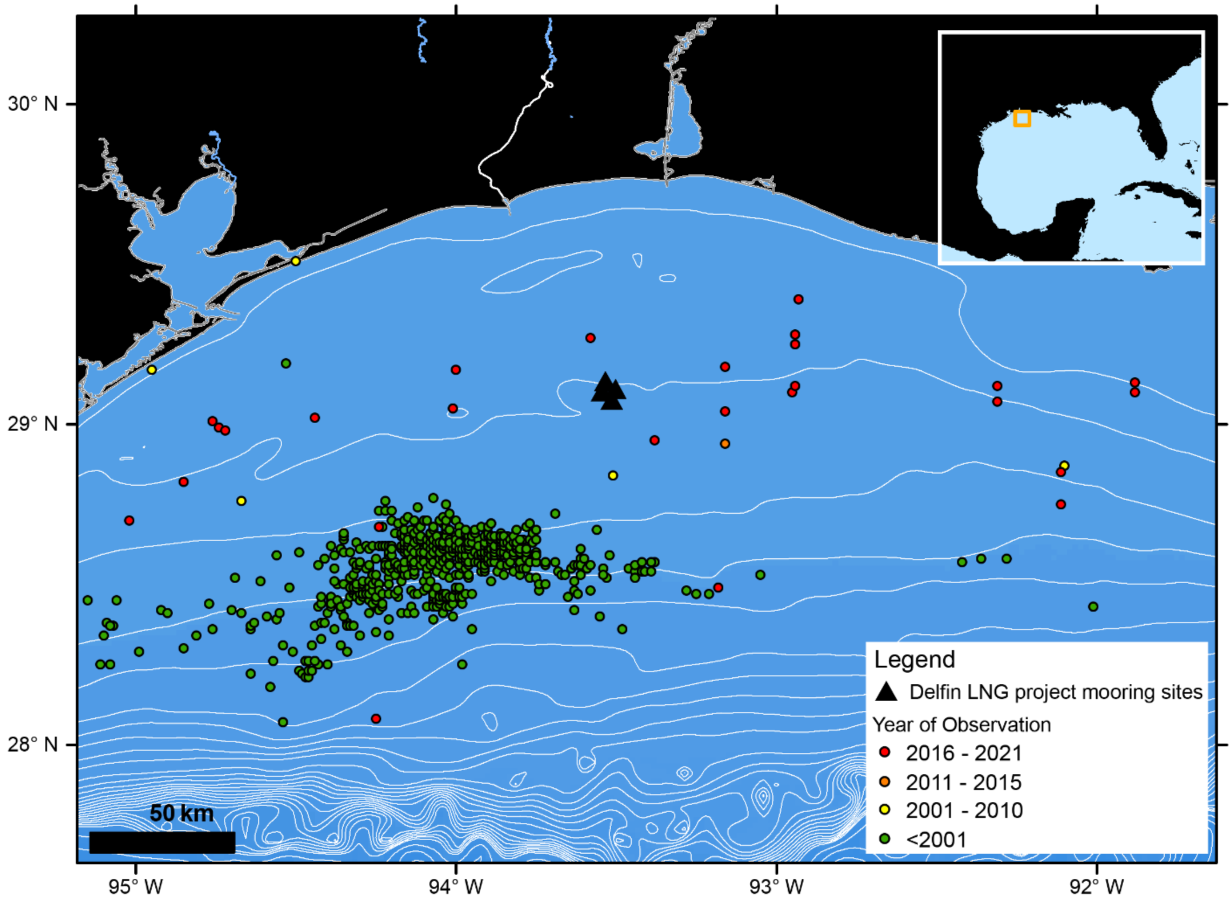

Figure 6. Records of loggerhead sea turtle observations in the Northern Gulf of Mexico. Visual observations of loggerhead sea turtles (circles) demonstrate regular occurrence in the northwestern Gulf of Mexico. Green sea turtle visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

4. Risks to TES from Delfin Activities

Construction and Operation Noise

The Delfin LNG EIS clearly articulates the provisions of the Marine Mammal Protection Act, and identifies that "The MMPA requires consultation with NOAA Fisheries if impacts on marine mammals are unavoidable" (USCG 2016, Section 1.5.3, pg. 1-17). The spatial observation data of marine protected species described above suggests the possibility of exposure to activities associated with the Delfin LNG terminal, which are discussed in more detail below.

Considerably more work has been conducted in the context of marine mammals protection than for sea turtles. However, recent guidelines provide guidance and exposure criteria for both taxonomic groups (Popper et al. 2014, NMFS 2018, Southall et al. 2021). Marine mammal hearing sensitivities differ between baleen whales and toothed whales, and cetaceans are often sorted into different hearing "functional groups" (National Marine Fisheries Service (NMFS) 2018, Southall et al. 2021), comprised of low-frequency cetaceans (baleen whales: 7 Hz – 35 kHz), mid-frequency cetaceans (dolphins and sperm whales: 150 Hz – 160 kHz), and high-frequency cetaceans (harbor porpoises: 275 Hz- 160 kHz) (summarized in Table 3.10-3 in USCG 2016, pg. 3-81). Empirical research on sea turtles suggests they are primarily sensitive to lower frequency sounds, and have a lower overall hearing sensitivity than marine mammals (Martin et al. 2012, Lavender et al. 2014, Popper et al. 2014).

There are several pathways of impact from elevated noise to marine protected species, ranging from permanent hearing loss (Permanent Threshold Shift, PTS) and temporary hearing loss (Temporary Threshold Shift, TTS) to behavioral harassment. Under MMPA, behavioral harassment is considered Level B harassment.[1] Because the threshold for behavioral harassment has the lowest regulatory noise threshold (120 dB for continuous sounds and 160 dB for impulsive sounds) compared to threshold levels for PTS/TTS, understanding the spatial extent of harassment sound levels can inform possible impacts to marine protected species that indicate if further consultation with NOAA is warranted.

The EIS provides estimates of the spatial extent of noise emanating from different construction and operational activities, and these are summarized below in the context of previous observations of marine protected species distributions. Complicating matters in the context of exposure criteria and additional noise contributions from the Delfin project for marine mammals is that there is already an extensive amount of anthropogenic noise in the Gulf of Mexico (Estabrook et al. 2016, Wiggins et al. 2016). Consequently, the spatial extent of noise levels presented in the EIS are based on theoretical sound propagation. While existing environmental and anthropogenic noise in the project location are described (USCG 2016, see p. 3-84, 4-45), it

[1] Under the U.S. MMPA, a Level A take (harassment) is any act that has the potential to injure or harm a marine mammal, and a Level B take (harassment) is any act that may disrupt any behavior of a marine mammal (see https://www.fisheries.noaa.gov/node/5311).

is unclear how these existing noise levels are quantitatively accounted for in the noise modeling predictions in the EIS. The EIS estimates peak background noise levels for the area at 150 dB (p. 4-42).

For construction activities, pile driving represents one of the highest source level activities. The estimated pile driving distance for TTS is 12,969 m (Table 4.3-3 in USCG 2016), and based on previous observation data, sounds from pile driving may expose bottlenose dolphins to TTS-inducing sound levels (Figure *7*). The estimated distance for other construction activities for Level B harassment for cetaceans is 21,975 m (Table 4.3-4 in USCG 2016), which would likely expose bottlenose dolphins to sounds above the noise threshold (Figure 8).

Elevated noise levels associated with operational vessel activities have the highest noise contribution. Operations-associated vessels are predicted to have a propagation distance of 63,293 m (Table 4.3-7 in USCG 2016), which, based on previous distributions may expose Rice's whales (Figure 9) and bottlenose dolphins occurring in the area (Figure 10). Additionally, noise from offshore supply vessel thrusters induce behavioral reactions for sea turtles at a distance of 686 m, risking exposure to Kemp's ridley sea turtles from elevated sound levels (Figure 11). Given the extensive temporal contribution of these sound sources for the life of the project, a predictive cumulative noise model with a 30 year duration should factor in chronic exposure of anthropogenic noise to marine mammals and sea turtles. Vessel noise is of immense concern to scientists and regulators, and is hypothesized to directly and indirectly impact the behavior, physiology and ecology of marine mammals and sea turtles (National Research Council 2003, Barlow and Gisiner 2005, National Research Council 2005, Samuel et al. 2005, Hatch et al. 2008, Jensen et al. 2009, Gervaise et al. 2012, Hatch et al. 2012, Putland et al. 2018, Pirotta et al. 2019).

Long term trends showing the relationship between noise and shipping traffic are difficult to quantify (Andrew et al. 2011). While there is a predicted positive correlation between an increase in ship traffic leading to increased noise levels, the quantification of precise noise levels as a function of the number of ships is more complex (Heitmeyer et al. 2003). Additionally, most of the dose-response estimates of the number of transiting ships and the associated noise contribution comes from using the Automated Identification System (AIS) for geographical positioning of vessels and establishing vessel tracks; however, vessels without AIS create an extensive amount of anthropogenic noise in coastal habitats (Hermannsen et al. 2019).

Because cetaceans use sound in a variety of behavioral contexts, anthropogenic noise can have varying effects on diverse taxonomic groups at different biological levels (Kight and Swaddle 2011). Noise radiating from ships is predominantly between 10-1000 Hz (e.g., Merchant et al. 2012), and vessel traffic can increase ambient noise levels in coastal habitats by more than 20 dB (Merchant et al. 2014). For both "low-frequency" (Rice's whale) and "mid/high frequency" cetaceans (sperm whales, dolphins), construction, operational, and vessel noise can directly interfere with intraspecific communication through the acoustic masking (Erbe et al. 2016). Data collected in the context of vessel noise exposure to marine mammals shows a decreased distance over which individuals can communicate, and a diminished efficacy of intraspecific acoustic communication, which, in turn may decrease social cohesion or reproductive advertisement (Hatch et al. 2012, Erbe et al. 2016, Putland et al. 2018). Exposure to chronic ship noise elevates physiological stress levels in baleen whales (Rolland et al. 2012). In the case of Rice's whales, with an extremely low number of individuals, decreased reproduction could have severe consequences for the population. For the mid/high frequency cetaceans that use echolocation for feeding, vessel noise can disrupt foraging patterns through decreasing the detectability of the reflection of echolocation clicks (New et al. 2013, Pirotta et al. 2015, Bailey et al. 2019).

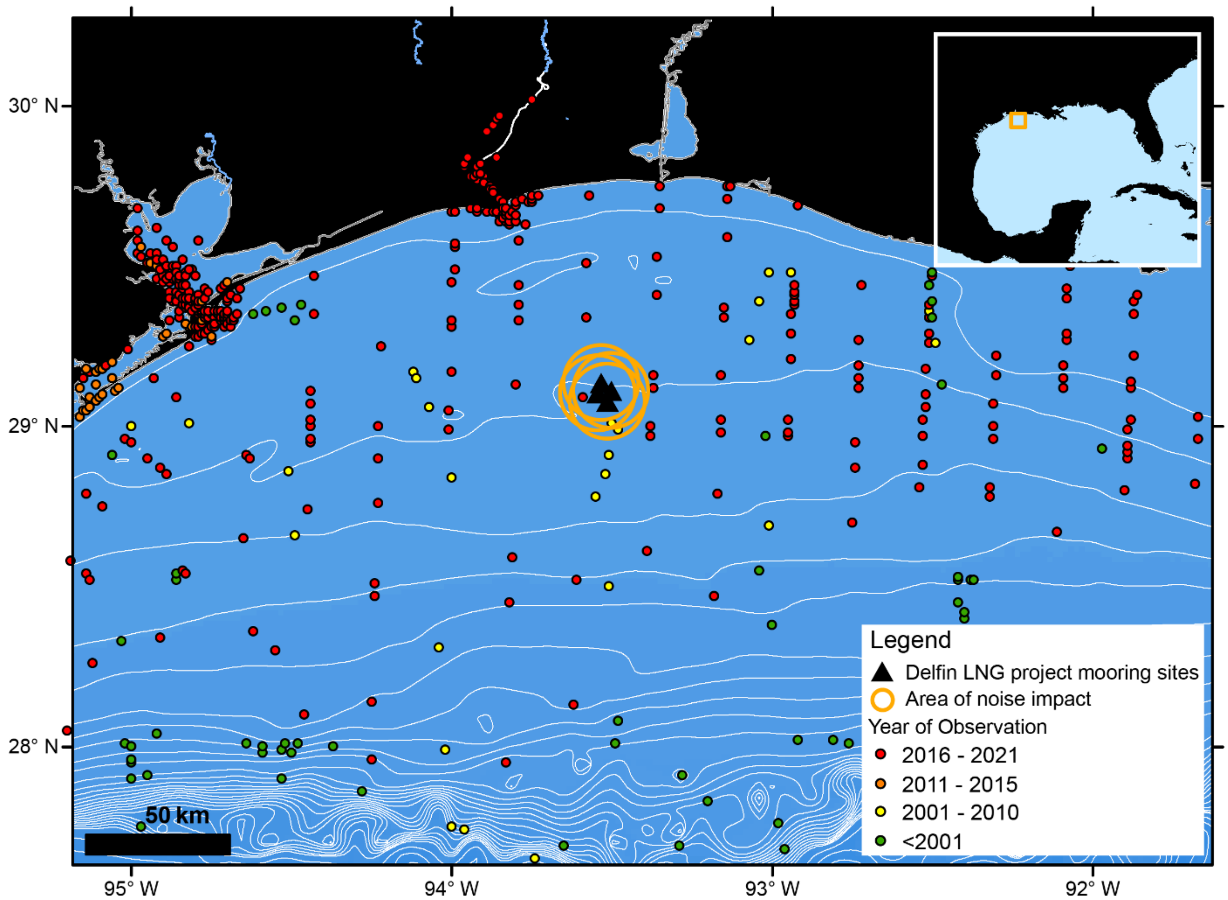

Figure 7. Spatial extent of pile driving noise at the Delfin LNG site relative to bottlenose dolphin distribution in the Northern Gulf of Mexico, with the TTS threshold levels for high-frequency cetaceans of 12,969 m (Table 4.3-3 in USCG 2016). Dolphin visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

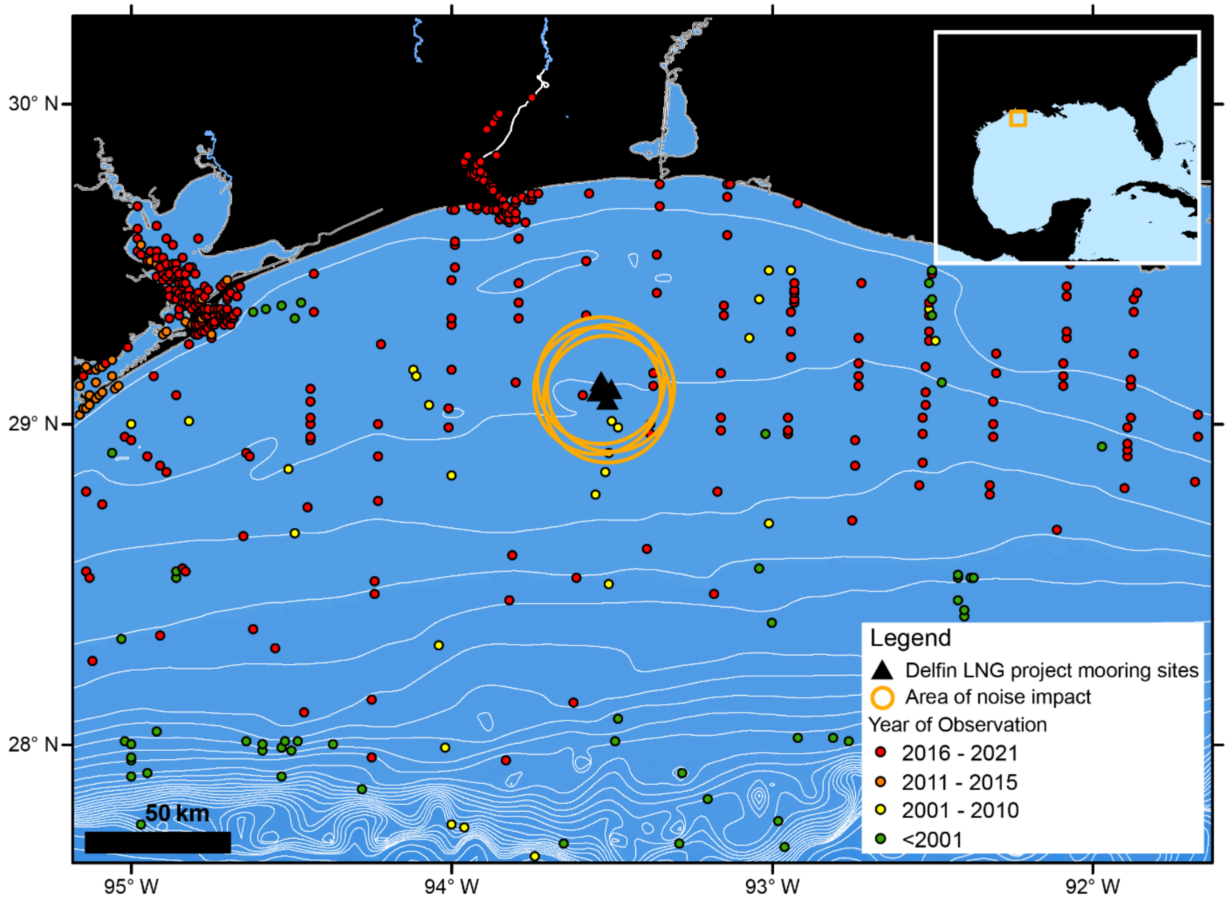

Figure 8. Spatial extent of construction noise at the Delfin LNG site relative to bottlenose dolphin distribution in the Northern Gulf of Mexico, with the TTS threshold levels for high-frequency cetaceans of 21,975 m (Table 4.3-4 in USCG 2016). Dolphin visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

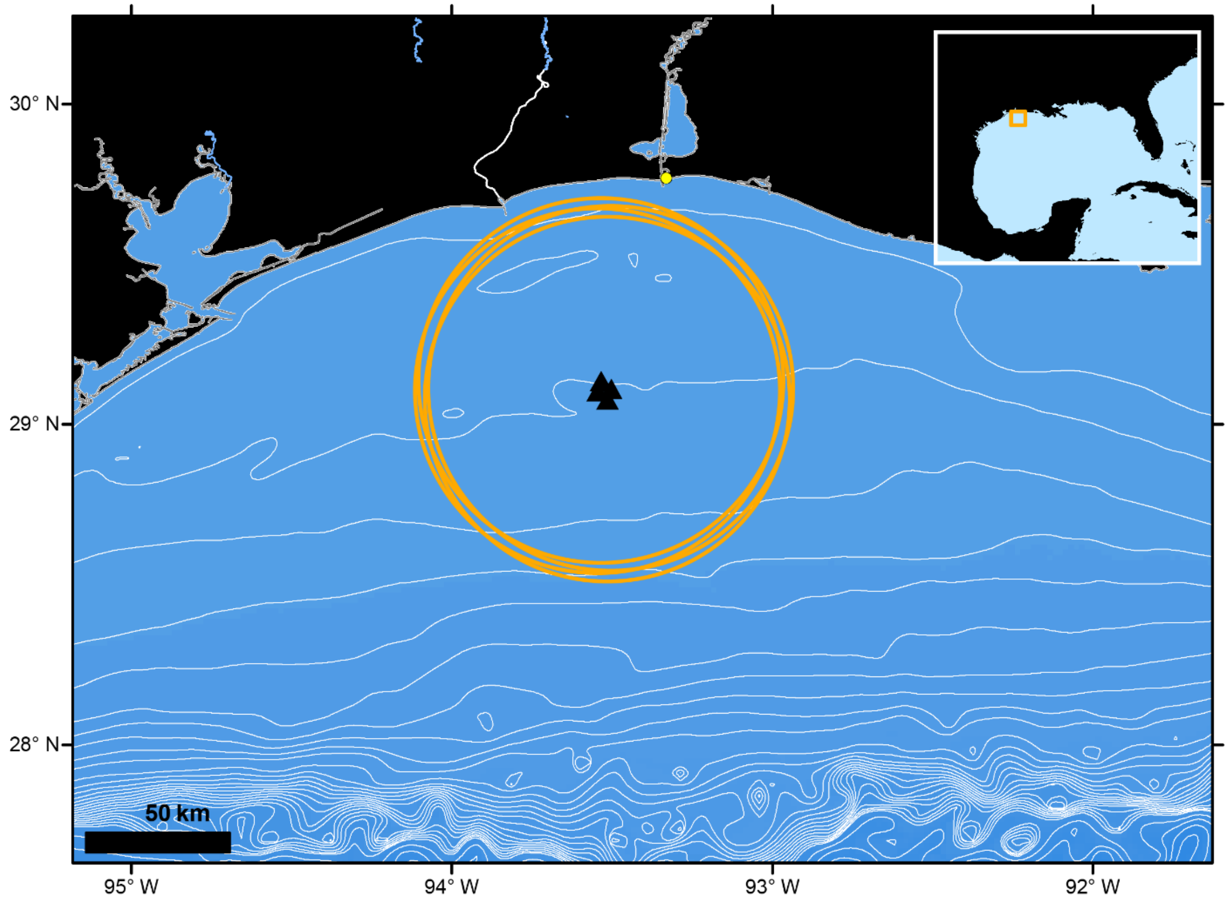

Figure 9. Spatial extent of operational vessel noise at the Delfin LNG site relative to documented Rice's whale occurrence in the Northern Gulf of Mexico, with the Level B harassment threshold levels for cetaceans of 63,293 m (Table 4.3-7 in USCG 2016). Rice's whale stranding data are from Rosel et al. (2021). The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

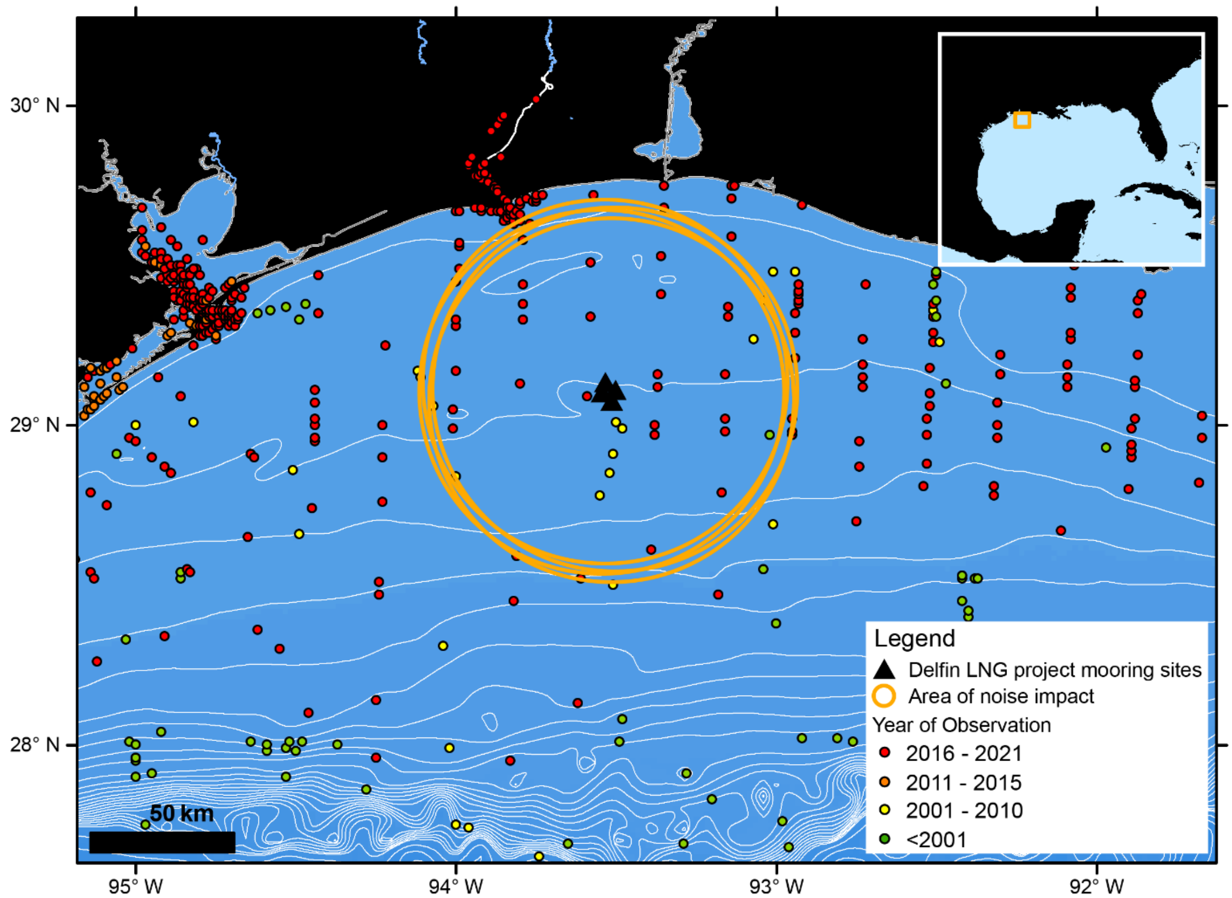

Figure 10. Spatial extent of operational vessel noise at the Delfin LNG site relative to documented bottlenose dolphin occurrence in the Northern Gulf of Mexico, with the Level B harassment threshold levels for cetaceans of 63,293 m (Table 4.3-7 in USCG 2016). Dolphin visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

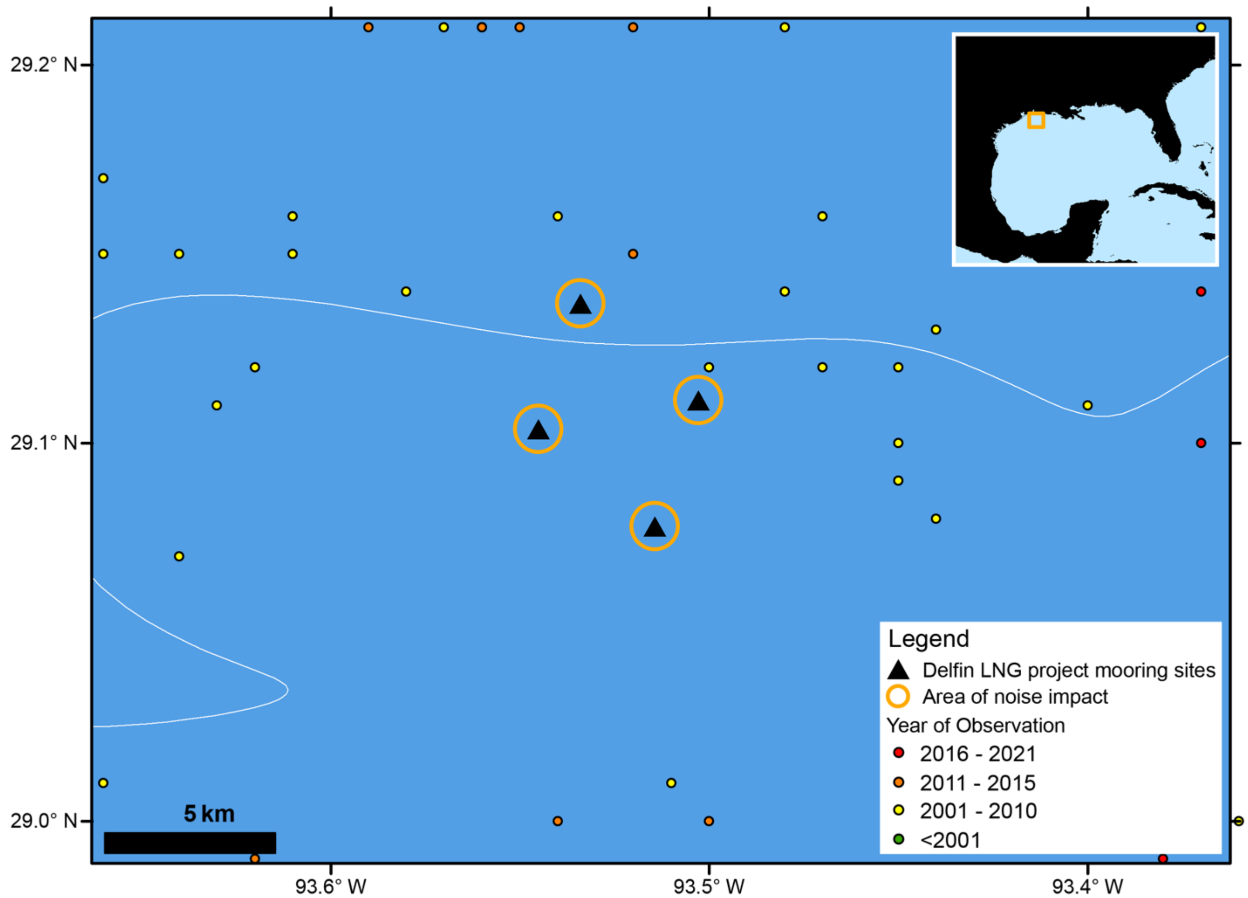

Figure 11. Spatial extent of offshore supply vessel thruster noise at the Delfin LNG site relative to documented Kemp's ridley sea turtle occurrence in the Northern Gulf of Mexico, with the behavioral reaction threshold levels for turtles of 686 m (Table 4.3-8 in USCG 2016). The bow thrusters are used to position vessels, and often has a higher sound level that noise from the ship's propeller or engine noise. Turtle visual survey data are from OBIS-SEAMAP (e.g., Halpin et al. 2006, Halpin et al. 2009) downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

Ship Strikes

The EIS identifies that the Delfin LNG moorings are in a region of the Gulf of Mexico with a high level of vessel activity, and the Delfin-related vessels would only represent a marginal increase. The data from the EIS were comprised of AIS traffic from 2013, but evaluation of 2019 AIS data for the project area suggests an already high level of shipping activity for all vessels (Figure *12*). Shipping related to Delfin construction and operations of the deepwater terminal would both increase and compound the effects of existing high levels of vessel traffic from cargo ships (Figure 13), tankers (Figure 14), and tugboats (Figure 15).

The probability of ship strikes to marine protected species is influenced by the amount of vessel traffic in an area, the size and speed of transiting vessels, the overlap between key habitats and shipping lanes, and the animal's diving behavior and time spent near the surface (Soldevilla et al. 2017). Results from a tagged Rice's whale individual shows that it spent 70% of its time within 15 m of the surface (Soldevilla et al. 2017), suggesting a vulnerability to ship strikes.

Even though the increase in vessel traffic for the facility is described as incremental, this still may represent an increased risk of injury or death to cetaceans. Rice's whales are particularly susceptible to vessel strikes, and there has been at least one documented ship strike fatality of a Rice's whale (Soldevilla et al. 2017). Cetacean fatalities from vessel strikes are often difficult to document, particularly for Rice's whales in the Gulf of Mexico (NOAA 2020). Consequently, for the Gulf of Mexico Oil and Gas Program Incidental Take Statement, vessel level of activity is used as a proxy indicator for the level of ship strike risk, rather than the number of injured animals (NOAA 2020). In the context of the Delfin LNG terminal, construction and operational vessel activity – both incremental and cumulative– associated with the deepwater port could be an effective indicator for evaluating the risk of Rice's whales to ship strikes associated with the Delfin LNG project.

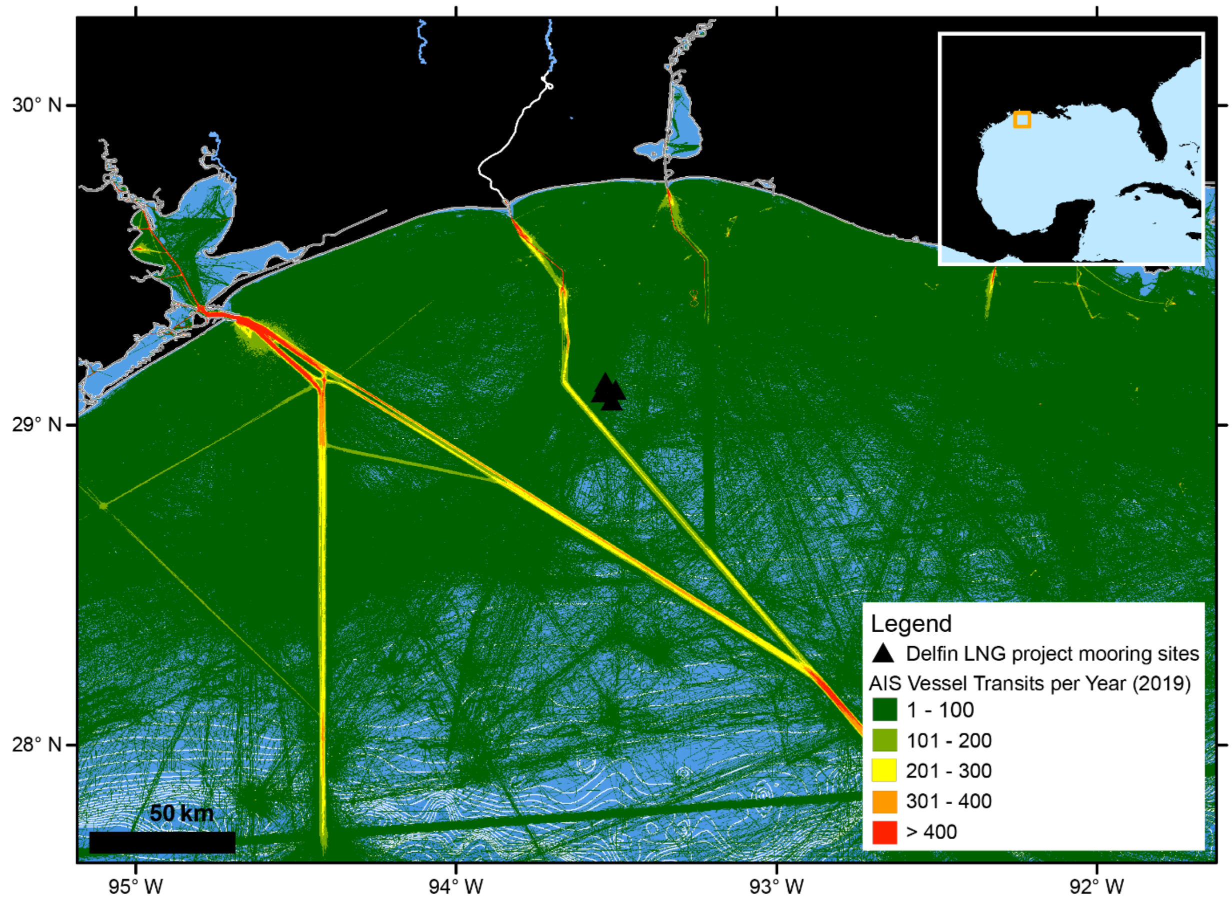

Figure 12. Annual counts of vessel transits in the Northern Gulf of Mexico in 2019. 2019 AIS data obtained from https://coast.noaa.gov/htdata/CMSP/AISDataHandler/2019/index.html downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

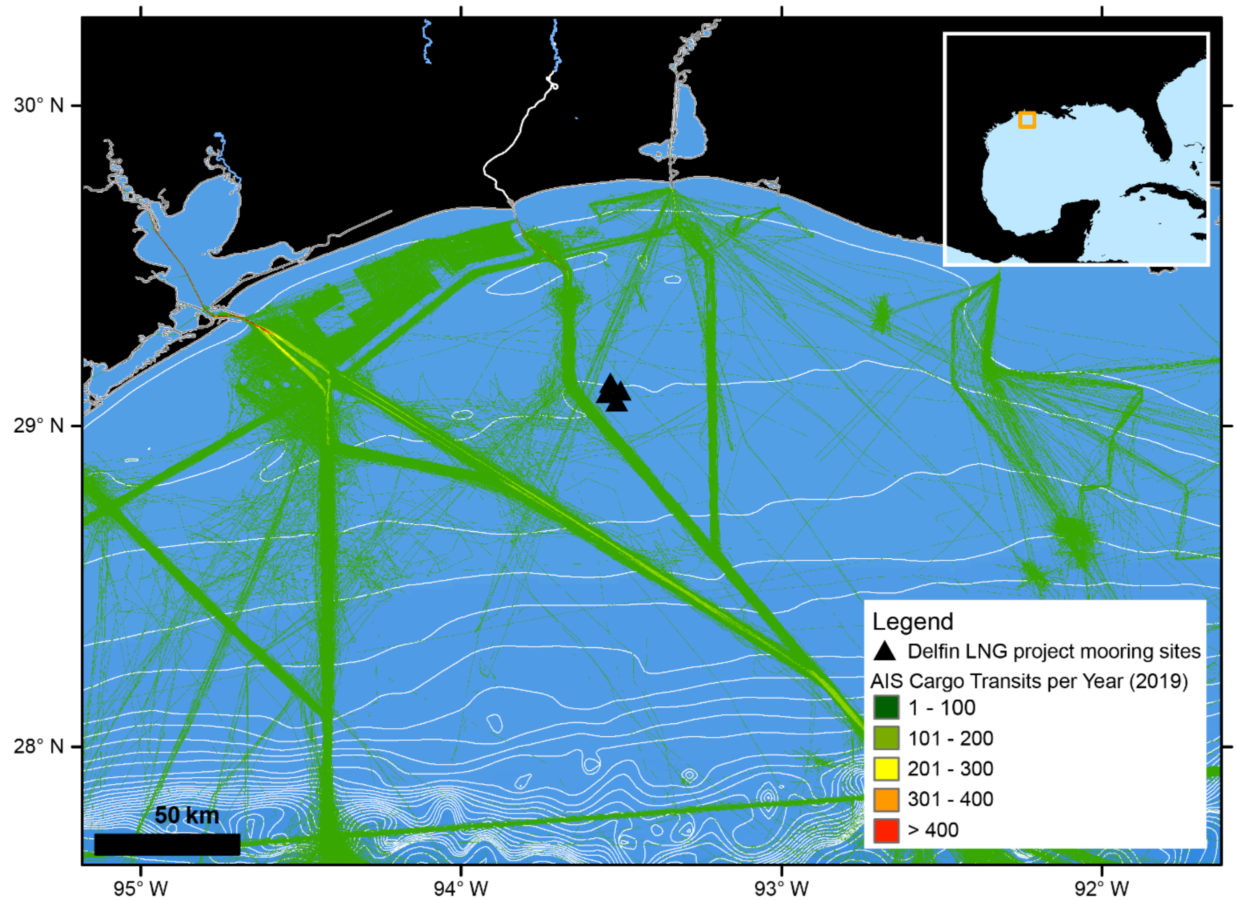

Figure 13. Annual counts of cargo ship transits in the Northern Gulf of Mexico in 2019. 2019 AIS data obtained from https://coast.noaa.gov/htdata/CMSP/AISDataHandler/2019/index.html downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

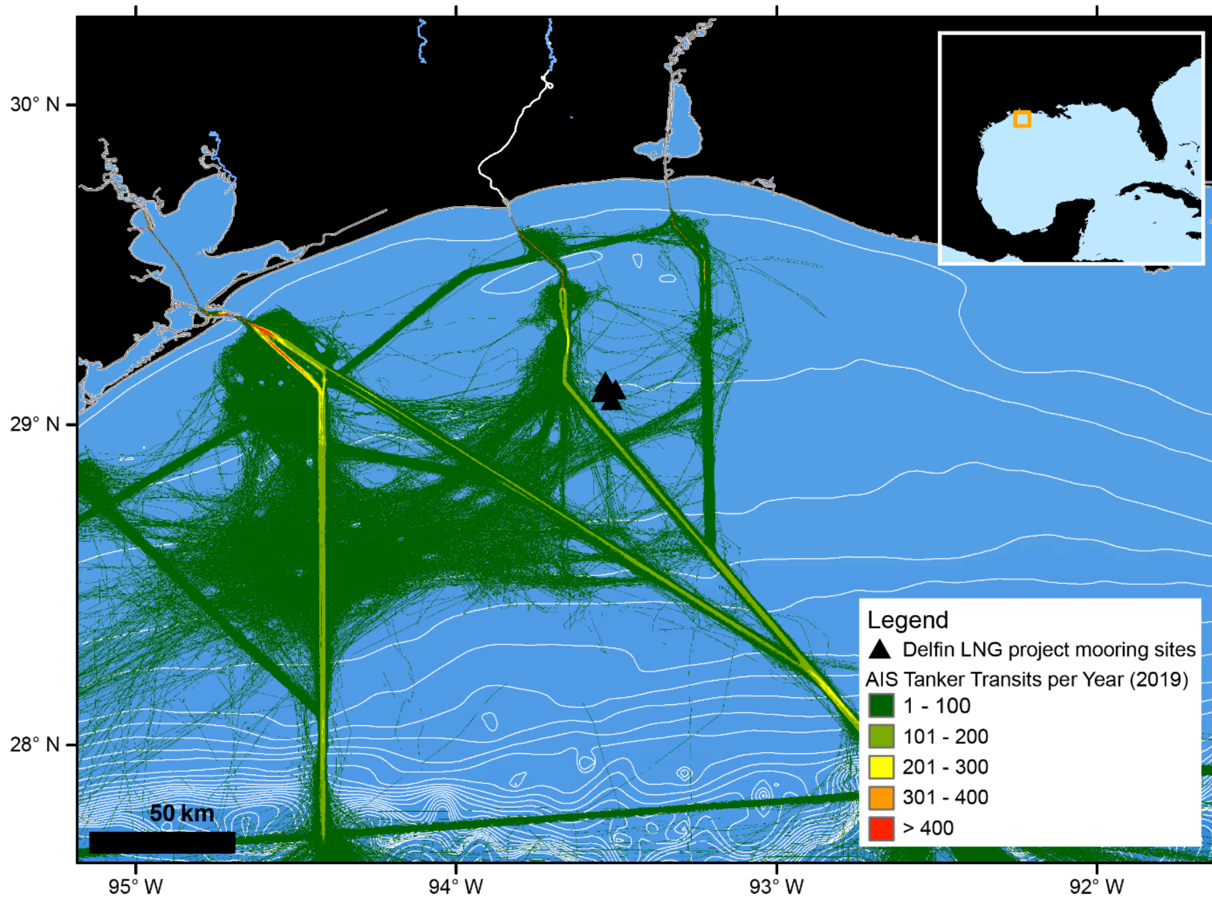

Figure 14. Annual counts of tanker transits in the Northern Gulf of Mexico in 2019. 2019 AIS data obtained from https://coast.noaa.gov/htdata/CMSP/AISDataHandler/2019/index.html on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

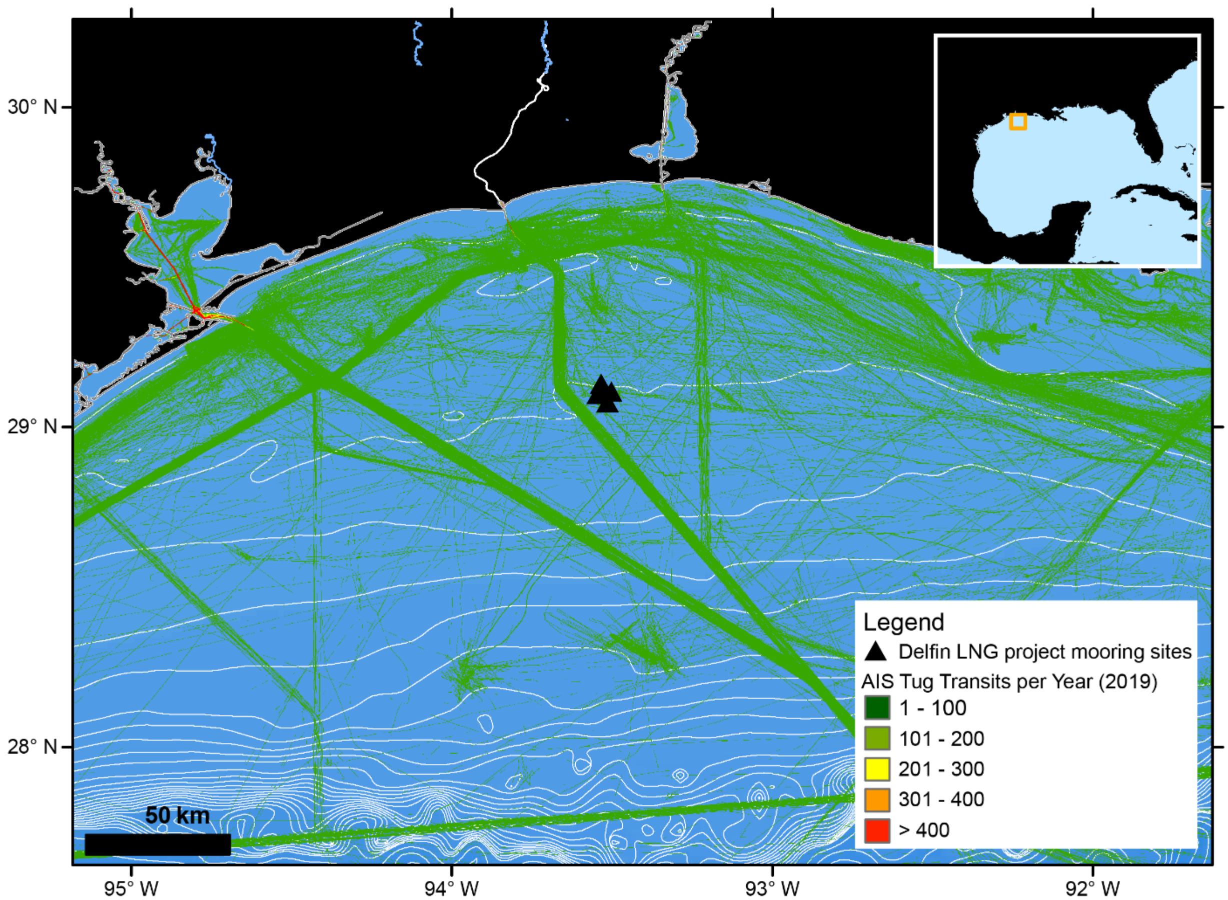

Figure 15. Annual counts of tugboat transits in the Northern Gulf of Mexico in 2019. 2019 AIS data obtained from https://coast.noaa.gov/htdata/CMSP/AISDataHandler/2019/index.html on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box.

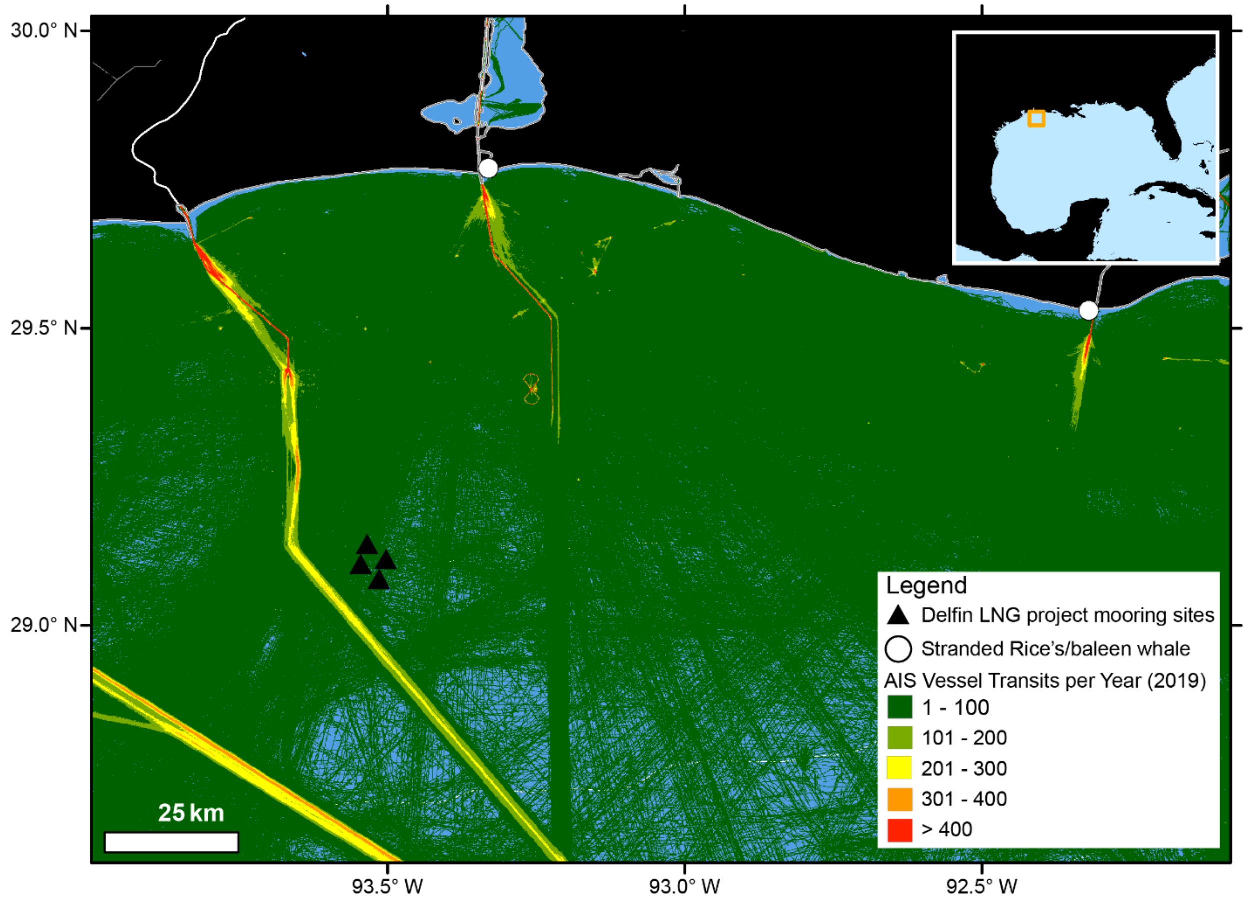

Figure 16. Location of historical stranded Rice's/baleen whales along the Louisiana coast and the annual counts of all vessel transits in the Northern Gulf of Mexico in 2019. 2019 AIS data obtained from https://coast.noaa.gov/htdata/CMSP/AISDataHandler/2019/index.html downloaded on December 10, 2021. The Delfin LNG project mooring sites are shown as black triangles, and the white lines represent 10 m isobaths (data from marinecadastre.gov). The inset in the upper left shows the broader view of the Gulf of Mexico and Caribbean Sea, with the area of the Delfin LNG site indicated by an orange box. Note – the location of the stranded Rice's/baleen whale at the base of busy shipping lanes does not necessarily indicate that a ship strike was the cause of the fatality.

Cumulative Effects of Multiple Stressors

The combination of multiple sound sources and the potential for cumulative impacts to marine protected species can be evaluated through creating a risk map of possible impact, by representing species population density along with exposure to elevated sound pressure levels (e.g., Merchant et al. 2018). Additionally, these cumulative effects may have synergistic impacts on marine TES. This approach may reveal a more contextualized risk framework to different species, rather than evaluating possible stressors individually. The cumulative effects imposed by multiple anthropogenic stressors is a major conservation and management concern in the study of marine mammals, and is a rapidly evolving field (National Academy of Sciences 2016).

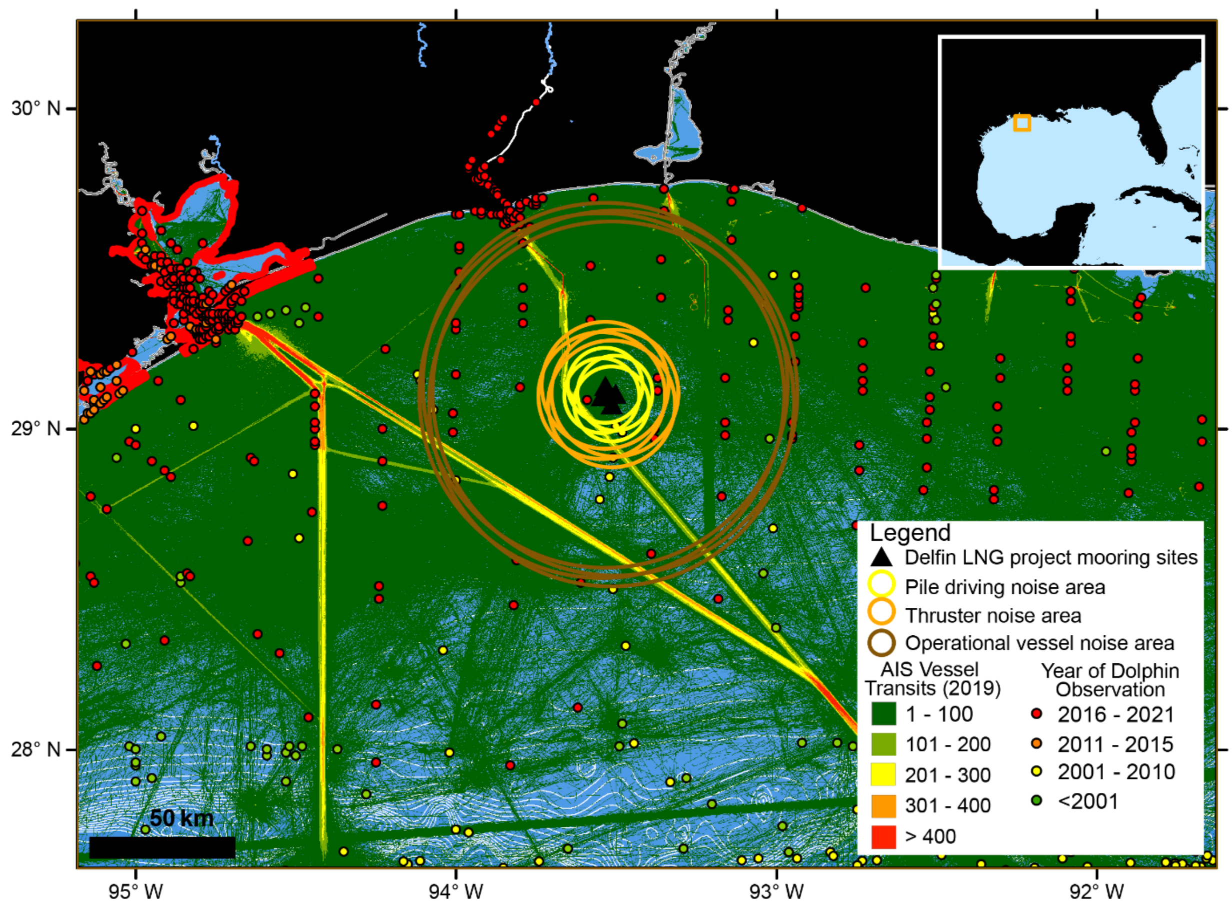

Figure 17. Spatial representation of possible cumulative anthropogenic stressors in and around the Delfin LNG project site relative to the documented distribution of bottlenose dolphins in the Northern Gulf of Mexico. Stressors here include vessel traffic as well as the predicted spatial extent of construction noises (pile driving and bow thrusters from construction vessels) and operational noise from LNGVs.

5. Recommendations for Seeking More information or Clarification

The publicly available spatial data on the occurrence of marine protected species suggest that there is a possibility of overlap between noise impacts from the Delfin LNG project and species occurrence, carrying with it a range of possible effects on species. Given the risk of exposure to whales and turtles from elevated sound levels, that, in some cases exceed the Level B take threshold, more advanced monitoring and mitigation strategies may be warranted to fully understand the impacts of Delfin LNG on protected species.

The EIS describes a number of mitigation measures (BMP-14 in USCG 2016, pg. 4-105) to reduce noise, yet the magnitude of decreased noise emission is neither estimated nor modelled. Additionally, noise mitigation measures have advanced significantly in recent years (Azzellino et al. 2011, Bohne et al. 2019), and this is not reflected in the Delfin LNG EIS. Therefore, re-evaluation of the implementation of mitigation measures for this project may be useful, given that review was completed in 2017. Some of the project's construction activities are described as occurring 24/7, yet depend on the use of Protected Species Officers/Marine Mammal Observers for visual observations of protected species. This is likely insufficient during nighttime operations. Additionally, construction and operation of other LNG terminals (such as the Northeast Gateway Pipeline Lateral) have utilized real-time acoustic detection of marine mammal species for ship strike and noise mitigation from operating vessels (Spaulding et al. 2010, Tyrrell et al. 2012); a similar dynamic mitigation system could be used at the Delfin LNG site. From the construction activities described in the EIS, it is unclear what their schedule may be, and if and how the timing of construction activities may impact the seasonal movement of marine TES in the Northern Gulf of Mexico.

There have been several requests for delays in construction associated with the Delfin LNG project, and these delays warrant a reassessment of the project timeline relative to a new construction date. Because many cetaceans and sea turtles exhibit strong seasonal occurrence patterns in the Gulf of Mexico (e.g., Morano et al. 2020), and elsewhere (e.g., Davis et al. 2017, Charif et al. 2020, Davis et al. 2020), it is unclear how the delayed construction of the deepwater port might intersect with seasonal occurrence patterns of marine mammals and sea turtles around the deepwater port. An updated construction timeline should be re-evaluated in the context of risks to marine protected species.

The EIS describes predicted noise fields associated with sound from the project's construction and operation. However, there are noise propagation model estimates within the EIS that warrant further evaluation, as the predicted distances of possible noise sources are not intuitive. For example, the EIS provides a description of the spatial extent of noise radiation associated with pile driving (see pg. 4-44) with spatial ranges that differ by several orders of magnitude for the TTS threshold for low, middle, and high frequency cetaceans:

> "For the marine mammal noise disturbance threshold of 160 dB (Table 4.3-2; Figure 4.3-1), the estimated distance was 857 m. Distances to the TTS cetacean thresholds are 10,887 m, 387.2 m, and 12,969 m for low, middle, and high frequency cetaceans, respectively."

The middle frequency bandwidth has significant overlap in frequency range with low and high frequencies, but it is unclear why the TTS disturbance range for middle frequency species is two orders of magnitude smaller than for low frequency or high frequency species (see Table 4.3-3). Additionally, given the differences in spatial extent for PTS and TTS, it is also unclear why Level B harassment has the same distance for all three groups, and why Level B harassment has a smaller distance than for TTS or PTS; the spatial extent for Level B harassment should be much greater than listed for low frequency and high frequency TTS. The same is true for construction vessel activities (4.3-4); middle frequency PTS and TTS distances seem too low relative to low frequency and high frequency TTS and PTS distances. However, the estimated distance for Level B harassment for construction vessels in Table 4.3-4 seems more appropriate compared to Table 4.3-3. A similar question applies to the noise associated with operational vessel activities (see Table 4.3-7). Without more detailed description of how noise models were run or what assumptions were made (see p. 4-45), it is difficult to understand the accuracy of these results.

Vessel noise interpretations (e.g., Figures 10, 11) model the sound propagation from the facility; however, the noise footprint for vessels transiting from ports to the facility is not considered in the EIS. It is likely that the noise footprint for estimating the propagation distance of vessel noise may be greater than depicted, and this should be reflected in an updated noise model, with an accompanying quantitative output and reflected in the updated EIS.

The Delfin LNG EIS and the Section 7 consultation describe that no likely adverse effects are predicted for threatened or endangered species for any of the construction or operational activities, but it is unclear what these assessments are based on. The EIS provides no data on the distribution or occurrence of marine protected species near the Delfin LNG site, and provides only qualitative assessments that endangered species will not be affected. Additionally, there is no basis provided for NLAA conclusions, and it is unclear how these claims are supported. Publicly available observation data for cetaceans and sea turtles in the Northern Gulf of Mexico in fact highlight the potential for interaction and exposure between marine protected species and Delfin LNG construction or operational activities. With some of the conceptual and modeling advances in understating population consequences to marine mammals from anthropogenic activities, it may be possible to model or estimate consequences of these stressors to marine TES in a predictive quantitative framework in order to justify the NLAA determination or reach a different conclusion (e.g., Farmer et al. 2018).

Notably, NMFS management paradigm for the endangered North Atlantic right whale provides, that based on population levels and the estimated potential for biological removal, as well as the mortality rate and low birth rate of the species, the mortality of a single individual can have dire consequences to the viability of the species (NMFS 2005, Hodge et al. 2015a). In the Gulf of Mexico, the Rice's whale population size is an order of magnitude smaller than right whales and the population trends are unclear. Human-induced fatality to Rice's whales may therefore have severe consequences to the species' survival. The short- and long-term consequences of noise impacts to cetacean populations are still unclear, but with a highly imperiled species such as the Rice's whale, a more precautionary approach may be warranted.

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