IN THE HIGH COURT OF SOUTH AFRICA
(WESTERN CAPE DIVISION, CAPE TOWN)

Case No ...../2024

In the matter between

AUKOTOWA FISHERIES PRIMARY CO-OPERATIVE LIMITED	**First Applicant**
THE GREEN CONNECTION	**Second Applicant**
NATURAL JUSTICE	**Third Applicant**

And

DIRECTOR-GENERAL: DEPARTMENT OF MINERAL AND PETROLEUM RESOURCES	**First Respondent**
MINISTER OF FORESTRY, FISHERIES AND THE ENVIRONMENT	**Second Respondent**
TGS GEOPHYSICAL COMPANY (UK) LTD	**Third Respondent**
MINISTER OF MINERAL AND PETORLEUM RESOURCES	**Fourth Respondent**

EXPERT AFFIDAVIT: MICHELLE FOURNET

I, the undersigned,

MICHELLE E H FOURNET

do hereby make oath and say:

1. I am an adult female residing in New Hampshire, New England, in the United States of America.

2. I hold various degrees and am employed as an Assistant Professor, Marine Bioacoustics and Behaviour Lab in the Department of Biological Sciences, College of Life Science and Agriculture, at the University of New Hampshire in the United States of America. I attach hereto, as Annexure "**MF1**", a copy of my Curriculum Vitae. I respectfully submit that I am qualified by my qualifications, training and experience to express the expert opinions which are set out in the report referred to below.

3. The facts contained in this affidavit fall within my personal knowledge, except where I indicate otherwise and are, to the best of my knowledge, true and correct. To the extent that I rely on information supplied by others, I believe that such information is true and correct.

4. I authored the report titled "Marine Acoustic Ecology Expert Comments on "Environmental Basic Assessment Report: Proposed Orange Basin Reconnaissance Permit", a copy of which is attached hereto as Annexure "**MF2**".

5. I further confirm that the report is to the best of my knowledge and belief true and correct.

MICHELLE E H FOURNET

This signed and sworn before me at Durham, NH on this 13th day of November 2024 by the deponent who has acknowledged that she knows and understand the contents of this affidavit, that she has no objection to taking the prescribed oath and that the prescribed oath is binding on her conscience.

AMY LAU
Notary Public - New Hampshire
My Commission Expires
August 18, 2026

NOTARY PUBLIC

Name: Amy Lau

Designation: Notary Public

Date: November 13, 2024

NF

Michelle E.H. Fournet, Ph.D.
University of New Hampshire
Department of Biological Sciences, College of Life Science and Agriculture
Durham, NH, USA,
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(A) PROFESSIONAL PREPARATION

Institution	Area	Degree & Year
Oregon State University	Wildlife Science	Ph.D., 2018
Oregon State University,	Marine Resource Management	M.S., 2014
University of Alaska, Southeast	Biology/Anthropology	Post-Bac, 2011
Boston University,	Theatre Arts	B.F.A., 2014

(B) POST GRADUATE APPOINTMENTS

2023- present	Assistant Professor of Marine Bioacoustics, Department of Biological Sciences
2022-2023	Associate Director for Education, Center for Acoustics Research and Education, Institute for Earth Ocean and Space, University of New Hampshire,
2022-2023	Visiting Assistant Professor of Acoustic Ecology, Department of Biological Sciences, University of New Hampshire
2018-2022	Postdoctoral Associate, K. Lisa Yang Center for Conservation Bioacoustics, Cornell University
2018	Instructor, Oregon State University

(C) SELECTED PUBLICATIONS *(19 peer reviewed publications since 2015, H index = 11)*

Laute, A, Glarou, M, Dodds, F, Gomez Røsand, SC, Grove, T, Stoller, S, Rasmussen, MH, and **MEH Fournet**. (2023*).* Underwater sound of three unoccupied aerial vehicles (UAV) at varying altitudes, horizontal distances, and sea states. Journal

Laute, A, Grove, TJ, Rasmussen, MR, Smith, A, Loisa, O, and **MEH Fournet**. (2023) Impact of Covid-19 on acoustic habitat, vessel activity, and humpback whale calling behavior on an Icelandic foraging ground. Marine Ecology Progress Series

Fournet, MEH, Stabenau. E, Madhusudhana .S, and AN Rice. (2022). Altered acoustic community structure indicates delayed recovery following ecosystem perturbations. Estuarine, Coastal and Shelf Science. 274:107948.

Fournet, MEH, Silvestri, M, Clark, CW, Klinck, H, and AN Rice. (2021). Limited vocal compensation for elevated ambient noise in bearded seals: implications for an industrializing Arctic Ocean. Proceedings to the Royal Society: Biological Science. 288: 20202712

Fournet, MEH, Stabenau, E, and AN Rice. (2019). Relationship between salinity and sonic fish advertisement behavior in a managed sub-tropical estuary: making the case for an acoustic indicator species. Ecological Indicators 106: 105531

Fournet, MEH, Matthews, LP, Gabriele, CM, Haver, S, Mellinger, DK and H Klinck. (2018). Humpback whales (*Megaptera novaeangliae*) alter calling behavior in response to natural and manmade sounds. Marine Ecology Progress Series. 607: 251- 268. DOI:10.3354/meps12784

(D) SELECTED GRANT RECORD *(Total support ~$850k since 2012)*

2023 National Geographic Explorers Grant (PI, $20,000)
2022 Generations Trust Grant in Support of Research (PI, $25,000)
2022 Dale Prouty Sponsored Gift in Support of Tropical Research (PI, $100,000)
2021 Dale Prouty Sponsored Gift in Support of Polar Research (PI, $100,000)
2021 Atkinson Foundation COVID-Rapid Grant, (Co-PI, $12,000)
2021 Jammy Heal Foundation Research Grant, (PI, $2500): Functional Communication in Southeast Alaskan Humpback Whales
2020 Cornell University, Cornell Migrations Initiative Grant (Co-PI, $15,000)
2019 Templeton Foundation, Diverse Intelligences Development Grant (Co-PI, $15,000)
2018 Templeton Foundation, Diverse Intelligences Grant (Co-PI, $293,000)
2015 Merlin Foundation Research Grant (PI, $10,500): Investigating the Impact of Anthropogenic Noise on Humpback Whale Communication and Behavior
2015 National Park Foundation Alaska Coastal Marine Grant (project participant; $275,709):): Investigating the Impact of Anthropogenic Noise on Harbor Seal and Humpback Whale Communication and Behavior in Glacier Bay National Park, Southeast Alaska

(E) SYNERGISTIC ACTIVITIES

Reviewer (Scientific Journals): Behavioral Ecology and Sociobiology, Conservation Biology, Conservation Science and Practice, Endangered Species Research, Frontiers in Marine Science, Journal for the Acoustical Society of America, Journal of Comparative Psychology, Marine Biology, Marine Mammal Science, North Pacific Research Board, Polar Biology, Royal Society Open Science, Scientific Reports. Reviewer (Funding Agencies): North Pacific Research Board, Graduate Women in Science.

(F) FELLOWSHIPS AND ACADEMIC AWARDS

2018 Laurel Diversity Fellowship ($3500)
2018 Savery Outstanding Doctoral Student Award for Excellent in Natural Resources Research
2018 Hatfield Marine Science Center Outstanding PhD Student Research Award
2017 OSU Graduate School Travel Award for Excellence in Research ($1,500)
2017 Mamie Markham Research Fellowship ($9,000)
2017 The Wildlife Society: Oregon Chapter Advanced Graduate Student Scholarship ($500)
2017 OSU Chairmen's Leadership Award
2016 Thomas G. Scott Scholarship for PhD Student Excellence ($2,000)
2016 Oregon Lottery Merit Scholarship ($2,250),
2016 OSU Fisheries and Wildlife Shining Star Award for Service and Teaching
2015 Coombs-Simpson Memorial Fellowship ($500)
2015 OSU Fisheries and Wildlife Bruce Coblentz Teaching Assistant Award
2014 Hatfield Marine Science Center Student Teaching Award
2013 Oregon Sea Grant Robert E. Malouf Marine Science Fellowship ($10,800)
2012 Joan Crebbin Memorial Fellowship ($3,000)

Conference Awards: (9) conference level awards including (4) awards for best oral presentation at national/international conferences

MARINE ACOUSTIC ECOLOGY EXPERT COMMENTS ON "ENVIRONMENTAL BASIC ASSESSMENT REPORT: PROPOSED TGS ORANGE BASIN RECONNAISSANCE PERMIT"

Michelle Fournet, M.S., PhD

TABLE OF CONTENTS

1 OVERVIEW

This document provides commentary and expert opinion on the scientific soundness of activities related to a planned seismic campaign in the Orange Basin region off the west coast of South Africa. Specifically, it examines whether Appendix 3.5 – "TGS: SOUTH AFRICA ORANGE BASIN 3D SEISMIC SURVEY SOUND TRANSMISSION LOSS MODELLING" (hereafter referred to as the "Acoustics Specialist Report") and Appendix 3.1 –"PROPOSED 3D SEISMIC SURVEY IN THE ORANGE BASIN OFF THE WEST COAST OF SOUTH AFRICA: BIODIVERSITY AND ECOSYSTEM SERVICES ASSESSMENT" (hereafter referred to as the "Marine Ecology Report")—both in support of the document "ENVIRONMENTAL BASIC ASSESSMENT REPORT: PROPOSED TGS ORANGE BASIN RECONNAISSANCE PERMIT, PASA REFERENCE: 12/1/040" (BAR)—adequately assess the environmental impact of anthropogenic noise associated with seismic operations and related maritime activities. This document includes commentary on the appropriateness of the content in the Acoustic Specialist Report and the Marine Ecology Report for developing mitigation strategies outlined in Section 9 ("Environmental Impacts Assessment," EIA) within the BAR, and the suitability of the proposed mitigation strategies in addressing potential harms related to sound produced by the proposed seismic operations.

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1.1 PROJECT DESCRIPTION

TGS Geophysical Company (UK) Ltd is planning a seismic campaign in the Orange Basin off of the west coast of South Africa, pending the approval of the Reconnaissance Permit and vessel availability (the "project"). The Reconnaissance Permit Area spans approximately 57,400 km², located about 120 km offshore from St Helena Bay, extending to around 230 km offshore from Hondeklip Bay across several petroleum license blocks.

The survey will utilize a single 100 m seismic ship equipped with seismic sources and streamers, supported by up to two escort vessels of unknown size, and is expected to last around 70 days. The towed hydrophone streamers would be 8,000 meters in length and 2,000 meters, approximately the area of 3,000 football fields. The seismic pulse would be discharged every 2-6 seconds continuously during exploration operations at source levels (loudness at the source) between 200-255 dB re 1 µPa; for reference this is among the loudest produced anthropogenic sounds on the planet and is in the range of military weapons or explosions.

1.2 SUMMARY OF OPINION

The Acoustics Specialist Report and the associated Marine Ecology Report solicited by TGS fail to adequately demonstrate that anthropogenic noise generated by the proposed seismic campaign will not have significant ecological consequences for marine organisms and habitats at the permit location. This is primarily due to (1) the failure to recognize the anthropogenic noise from the project as chronic, (2) the failure to consider the full spatial extent of the noise generated by the project, (3) the omission of an assessment of underwater ambient sound conditions at the site prior to the proposed activities, (4) the failure to evaluate potential impacts on the broader marine community, including population-level effects, and (5) the failure to incorporate the most up-to-date and relevant scientific recommendations for assessing industrial noise impacts on marine ecosystems.

Consequently, the mitigation actions proposed in the associated Environmental Impact Assessment (EIA) are based on an inaccurate assessment of noise impacts and fail to meaningfully address the potential or likely impacts of anthropogenic noise on the marine environment related to the seismic exploration. Moreover, the mitigation actions proposed in the EIA fail to address the full range information contained in the specialist reports and reiterated within the text of the EIA, this willful omission results in even less comprehensive or appropriate mitigation measures.

1.3 PRIMARY FAILURES OF THE BAR and ASSOCIATED SPECIALIST REPORTS

1. Inadequate Premise and Limited Scope of Impact
   The Acoustics Specialist Report is founded on a flawed temporal premise and exhibits a narrow scope that fails to comprehensively address the complexities of anthropogenic noise impacts on the environment. As the primary resource used to assess mitigation needs associated with anthropogenic sound, the report is severely lacking. The fault of this should be attributed to TGS- who commissioned the report and determined the scope assigned to the contracting agency.

2. Appropriateness of Inference in Marine Ecology Report
   The Marine Ecology Report uses the outputs of the Acoustics Specialists Report in concert with data from a desk study to assess acoustic impacts on the marine environment; as such it contains the same flaws as the Acoustics Specialist Report and additionally underestimates the severity of seismic survey noise impacts. The report suggests insufficient mitigation strategies that fail to consider population-level impacts, soundscape level impacts, or chronic impacts associated seismic operations.

3. Insufficient Mitigation Measures within the EIA
   The proposed mitigation measures do not adequately address the potential acoustic impacts of the proposed project on the marine ecosystem, leaving significant risks unmitigated. The best available science was not considered when assessing the impact of the project, the scope of the available information was overly narrow, and the EIA selectively omits information included in the specialist reports and the broader literature.

2 GENERAL INTRODUCTION TO ANTHROPOGENIC NOISE IN THE MARINE ENVIRONMENT

Anthropogenic noise refers to sound generated by human activities, including infrasonic (below the range of human hearing) and ultrasonic vibrations (above the range of human hearing), as well as sounds within the human audible range. Anthropogenic noise poses a significant threat to organisms that rely on sound for vital life functions such as foraging, breeding, migration, and social interaction. Its effects are particularly severe in marine ecosystems, where sound travels vast distances with minimal energy loss. Most marine species have evolved to depend on sound as their primary sensory modality.

Social cetaceans and seabirds, including whales, dolphins, and penguins, rely on acoustic signals for communication, foraging, and social cohesion. Bottom-dwelling animals, fish, and invertebrates also respond to environmental sounds; for example, larval stages of various species use sound cues to time their transition from open water to benthic habitats. Alterations to the marine soundscape impact how marine animals interact with their environment, have the potential for both short term individual harm, and may result in shifts in long-term population dynamics.

Anthropogenic noise impacts ecosystems by disrupting communication, displacing species from critical habitats, altering foraging and predator-prey behaviors, increasing physiological stress, causing physical harm (including hearing loss), and even leading to mortality. Assessing these effects requires an interdisciplinary approach, combining ecology, resource management, acoustics, and statistics. Research on marine responses to noise has documented behavioral changes, auditory impairments, increased mortality, and reduced reproductive success. As such, any activity that generates noise may have significant ecological consequences, underscoring the need for comprehensive environmental impact assessments.

2.1 RELEVANT DEFINITIONS AND EXPLANATIONS

Characterizing Sounds

When determining the impacts of noise on an organism or an ecosystem, the sound must first be characterized. Sound is broadly characterized according to the following:

1. Duration: how long each signal lasts
2. Frequency (or pitch): how high, low, or broadband (simultaneously high and low) a sound is
3. Pulsivity: whether a sound is impulsive (like a series of bangs from fireworks) or continuous (like traffic noise)
4. Chronic versus discrete: Does the noise occur in a single short time period (like a jackhammer outside of an apartment window for a morning) or does it persist over long time periods (like an apartment which abuts a train track with trains passing by every day for many years).

Inappropriately characterizing noise has severe implications on individuals or organisms, and improper characterization can hide ecological impacts that may be significant. For example:

1. Duration: It would be misleading to characterizing the duration of a fireworks display that took place from 7pm until 11pm as having an average duration of 1.1 seconds (the length of time of a single firework).
2. Frequency: It would be misleading to say that simultaneously blowing 10,000 dog whistles (which are too high pitched for humans hear) would not impact a mother dog and her pups that were feeding 1 meter from the whistle blowers, simply because it doesn't substantially contribute to overall low frequency sound levels.
3. Pulsivity: It would be misleading to say that animals were capable of adjusting the timing of their calls to vocalize in between sound signals, if the sounds were continuous and there was no break between sounds.
4. Chronic vs. discrete: It would be misleading to say that the sound of a jackhammer outside of a bedroom window would have negligible effects on the apartment residents because it only occurred for three hours, when in reality the sound of the jackhammer occurred for three hours every day at 3am for 20 years.

Determining Ecological Baselines

To assess whether elevated noise levels associated planned human activities will impact an ecosystem, it is crucial to understand the environment's sound profile prior to the proposed human interference. This process is referred to as "determining the baseline soundscape," defined as the acoustic condition of a site before anthropogenic disturbance.

Components of a Baseline Soundscape Assessment: A baseline soundscape assessment should provide a thorough analysis of the sonic environment prior to proposed anthropogenic activities, focusing on spatial and temporal variations in sound levels and frequencies. Key components include:

1. **Identification and Characterization of Natural Sound Sources**: This includes biophony (sounds from living organisms), geophony (natural environmental sounds), and anthrophony (human-generated sounds).

2. **Data Collection Across Habitats and Seasons**: The assessment should capture sound data across different habitats and seasonal variations within a proposed site, enabling the detection of changes in sonic diversity and diel sound patterns associated with alteration.
3. **Evaluation of Sound Pressure Levels**: This includes assessing sound levels across ecologically relevant frequency ranges and identifying key signals, correlating these findings with ecological functions.
4. **Establishment of Reference Points for Ambient Noise Levels**: Identifying pre-project sound levels and sources is essential for future impact assessments and for effective project management and harm prevention. In the absence of pre-project sound levels, contributions of the project to the soundscape cannot be assessed, and preventative mitigation cannot be employed.

Mischaracterization or omission of baseline soundscape elements can significantly impact ecological interpretation, leading to negative ecological consequences across several scales. For example:

1. **Erroneously Assigning Acoustic Baselines**: An urban task force tasked with determining whether traffic noise affects the foraging habitat of a rare bird compares ambient noise levels during moderate traffic and a period with a single tractor-trailer truck. They conclude noise has no impact based on equivalent noise levels. However, a second task force compares recordings from a traffic-free Sunday morning and a Monday rush hour, revealing a 300% increase in ambient noise due to traffic—an important change that would be overlooked with a mischaracterized baseline.
2. **Omitting Frequency Analysis**: The same task force examines whether new power lines interfere with bat echolocation (ultrasonic frequencies >20 kHz). They report a small increase in average sound levels between 1 kHz and 30 kHz, concluding the noise increase is not ecologically significant. However, noise levels in the bats' communication range exceed 400% when power lines are active, indicating that their findings could lead to hearing loss in bats.
3. **Omitting Temporal Patterns of Sound Sources**: A contractor records baseline sounds for only 10 seconds each hour over a single autumn day, outside the typical mating and migration seasons. Consequently, the report lacks data on these critical signals and inaccurately concludes that elevated noise levels won't impact them. In reality, migrating and mating animals acoustically present for several months each year were simply not recorded.

3 SPECIFIC COMMENT AND CRITIQUE OF SPECIALIST REPORTS

3.1 INADEQUATE PREMISE AND LIMITED SCOPE OF ACOUSTICS SPECIALIST REPORT

3.1.1 Appendix 3.5 – "TGS: South Africa Orange Basin 3D Seismic Survey Sound Transmission Loss Modelling" (Acoustics Specialist Report), prepared by Environmental Impact Management Services Inc. (EIMS), presents a Sound Transmission Loss

Modeling (STLM) study to assess the spatial extent of noise impact on marine fauna within the proposed survey area off the West and South-West Coast of South Africa. This report was commissioned by TGS and used as the basis for risk assessment and mitigation planning associated with the proposed project.

3.1.2 The science contained within the report appears to be thorough. Due to fundamental flaws in its initial assumptions and the project scope requested by TGS, however, the Acoustics Specialist Report fails to accurately represent the real-world impacts of 3D seismic exploration on the marine soundscape and marine organisms within and beyond the proposed permit area. The report is based on incorrect premises regarding both the temporal and acoustic characteristics of the noise. EIMS' study focuses on the impact of discrete, 24-hour, pulsive noise on low-frequency sound levels in an otherwise pristine marine environment. Specifically, EIMS was tasked with identifying zones of impact from single airgun pulses and the cumulative effects of multiple airgun pulses over a 24-hour period (Acoustics Specialist Report, p. i).

3.1.3 In reality, the proposed project involves chronic pulsive noise coupled with continuous vessel noise over several months (70 days), significantly raising ambient sound levels in the low and mid-frequency ranges that affect marine mammals, fish, and invertebrates, both within and beyond the proposed project area. If the project were limited to 24 hours and only involved airguns, the study's assumptions might be valid. However, the cumulative effects of sustained high-intensity noise from multiple sources over 70 days are far more impactful than the short-term effects modeled in the report.

3.1.4 The Acoustics Specialist Report's failure to consider the added impacts of multiple sound sources on both direct (injury) and indirect (behavioral) effects on animals significantly undermines the assessment and its use for determining robust mitigation plans. The study exclusively considers the threats posed by airguns, primarily modeling the temporary threshold shifts (temporary deafness, TTS) and permanent threshold shifts (permanent deafness, PTS) associated with their use, with moderate to minimal consideration for behavioral impacts. However, additional sound sources—including two support vessels, a seismic ship measuring 100 meters in length, and generator noise on the ship—are also critical sources of noise associated with the proposed project. Recent research investigating marine mammal response to noise associated with seismic operations indicates that the behavioral response to seismic vessels is at the same magnitude as the airguns themselves[1] Notably, while airgun noise is generally considered low-frequency (<200 Hz), the frequency range produced by vessels is broader (also including mid-high frequency components), which were not included in the noise impact assessment. Noise from these additional omitted sources contributes to the overall ambient sound levels, collectively affecting the acoustic environment that marine organisms rely on for survival.

3.1.5 No baseline soundscape assessments were made for the proposed permit region within the Acoustics Specialist Report nor the BAR. No effort was made to quantify the naturally occurring sound levels for this region, the sources of naturally occurring sounds, or the seasonal and temporal cycles in ambient sound levels that may serve as

ecologically important cues. Given that marine organisms use sound for navigation, prey detection, predator avoidance, and foraging, alterations to the natural soundscape within and beyond the permitted region may have severe ecological consequences. In the absence of known natural ambient noise levels, it is not possible to assess how much the proposed activities will increase ambient noise levels in the soundscape—and therefore also not possible to assess underwater noise impacts.

3.1.6 The contribution of this project to the ambient soundscape is particularly relevant given that airguns produce some of the loudest known underwater sounds on the planet[2,3] and in some cases, can be detected 4,000 kilometers from the source[4]. The Acoustics Specialist Report failed to quantify how many total square meters would be ensonified as a result of the proposed project (see Wood 2010 for an example)[5]. However, based on the modeling reported, the detection of airguns is certain to expand beyond the permitted area and into the Critical Biodiversity Areas (CBA) and Marine Protected Areas (MPA) within and beyond the permitted area (Acoustics Specialist Report, Figure 17; Marine Ecology Report, Figure 42). Additionally, seismic and support vessels will operate beyond the limits of the proposed permit region, transiting through both CBAs and MPAs. The contributions of these sound sources to sensitive habitats were not modeled or addressed. Soundscape impacts and ensonification ranges were not solicited by TGS, and would have indicated a much broader spatial impact of the project than is currently reported.

3.1.7 Noise produced from industrial activities cannot be physically contained underwater and may inundate critical biodiversity locations proximate to proposed operations and associated vessel activities. This requires careful consideration given the known impact of noise on marine mammals (stress, behavioral responses, reduction in foraging[6]), fish (behavioral responses, physiological responses, antipredator responses, death[7,8]), larval invertebrates (reduction in settlement, larval deformation [9–11]), and pelagic zooplankton (death[12]). Anthropogenic noise within CBAs and MPAs may harm, alter, or lead to death or population decline across a wide range of organisms and life stages that make up both ends of the trophic web. Because noise cannot be contained to the project site due, the impacts of noise are further reaching than the directing region of interest and must include coastal and adjacent pelagic areas as well.

3.1.8 An adequate baseline assessment of the acoustic properties of the soundscape—including biological sources of ambient sound, environmental sources, and ambient sound levels—is needed to complete an assessment of underwater noise impacts. Broader-scale sound propagation modeling, including the total range of ensonification associated with airguns and general project operations (seismic ship returning to port, support vessels, aircraft), throughout both pelagic and coastal habitats – inclusing seismic ship travel routes – is essential for adequately assessing project impact, risk, and mitigation strategies. This is particularly relevant for the Child's Bank, the Tripp Seamount, Cape Canyon and Cape Valley, which will likely experience changes in ambient soundscape conditions associated with the project. The report models ensonfication up to 200 km, and notably the project is associated with high noise values up to that range (e.g., Acoustics Specialist Report, Figure 17).

3.1.9 The Acoustics Specialist Report overlooks the broader ecosystem-scale consequences of injuries caused by anthropogenic noise. The report focuses primarily on direct physical injuries to marine organisms, such as hearing damage from airgun blasts. This is not a comprehensive assessment. Temporary or permanent hearing loss, stress, and direct or indirect death in fishes and invertebrates are all physical consequences of anthropogenic noise exposure. However, the repercussions of such injuries extend beyond individual organisms and can affect entire ecosystems. When marine mammals or fish experience hearing loss, their ability to communicate, navigate, and locate predators or prey is compromised. This impacts their survival and can also disrupt predator-prey dynamics within the ecosystem, leading to population imbalances. Additionally, both injuries and anthropogenic noise in isolation can lead to stress responses in affected species, potentially resulting in altered reproductive success and decreased population resilience. The failure to adequately assess these ecosystem-level consequences limits the understanding of how noise pollution can disrupt ecological interactions and degrade marine biodiversity.

3.1.10 In addition to the direct impacts on individual animals, the report fails to consider the population-level consequences of behavioral changes induced by noise exposure. Noise from airgun activities can lead to significant shifts in the behavior of marine species. Responses of fishes to anthropogenic noise include reduction of anti-predator response, which leave individuals at higher risk of being eaten, acoustic masking of breeding sounds which may impact species at the population level, and reduced breeding success [8,13,14].Marine mammals may alter their vocalization patterns, leading to reduced communication effectiveness. Fish may also exhibit changes in schooling behavior or abandon critical habitats due to increased noise levels. Such behavioral changes can affect reproduction rates, survival, and population dynamics over time. Furthermore, if key species alter their foraging behaviors or habitats, the repercussions can cascade through the food web, impacting other species reliant on them. The Acoustics Specialist Report's neglect of the consequences of behavioral shifts and their population-level impacts undermines the comprehensive assessment needed to understand the full ramifications of the proposed project on marine ecosystems.

3.1.11 The report also fails to quantify the number of marine animals likely to be acoustically impacted by airgun and other anthropogenic noise sources, missing an opportunity to address critical factors such as sex and behavioral state that influence vulnerability to noise exposure. Research indicates that certain demographics, such as nursing females, may be more sensitive to noise due to their specific behavioral contexts [15]. To fully understand the implications of noise exposure, it is essential to estimate the proportion of populations that could be affected by the proposed activities, particularly for vulnerable species. Furthermore, long-term consequences for impacted individuals can include decreased reproductive success and altered migration patterns[16,17], which can lead to population declines over time. A robust assessment would not only quantify the number of individuals affected but also evaluate the potential implications for population viability, particularly in the context of ongoing anthropogenic pressures[18]. This level of analysis is critical for informing appropriate mitigation strategies and ensuring the long-term sustainability of marine populations.

3.1.12 Since the release of the Acoustics Specialist Report, more recent scientific studies have emerged that challenge the premise of using blanket sound exposure level (SEL) or sound pressure level (SPL) thresholds to assess the impacts of anthropogenic sound on marine animals (Southall 2024). The Acoustics Specialist Report heavily relies on Southall (2019) to justify using these thresholds to determine varying levels of risk, while omitting the caveats included in the 2019 publication. Southall 2019 states that "***The approaches [in Southall (2019)] are not applicable in evaluating potential auditory effects of chronic noise exposure over periods of weeks, months, or years***." [19]

3.1.13 In the updated guidelines, Southall (2024) again explicitly states that "simplistic received level-only step-function 'thresholds' indicating a binary lack or presence of response for any sound type are outdated and inconsistent with the best scientific information available"[18]. The Acoustics Specialist Report relies on exactly these binary thresholds, despite strong scientific evidence that this method is flawed[18,19]. Moreover, Southall (2024) highlights the issue of appropriately assessing the temporal scale (chronic impacts versus acute impacts) as a major flaw in the method used in the Acoustics Specialist Report. According to Southall (2024), "Where the acute exposure-response severity scale-based assessment approach really falls short is in the evaluation of repeated or sustained exposures for aggregations and/or local populations of animals on broader spatial and temporal scales." Given the multiple months of sound exposure to this ecosystem (70 days), this should be considered a chronic rather than acute sound source.

3.1.14 Beyond the 2024 publication, which the agency responsible for the Acoustics Specialist Report may not have had access to, Southall (2021) offers clear recommendations on acoustic exposure and the types and severity of behavioral responses, focusing on vital rates during acute events. Notably, Southall (2021) was not cited in the Acoustics Specialist Report, despite the report's goal of determining zones of impact for behavioral responses Acoustics Specialist Report, p. i). Given the Acoustics Specialist Report's reliance on Southall (2019), it should be assumed that the work of Southall—internationally regarded as industry standard and best practice—is considered reliable by EIMS. The omission of the most recent work is yet another indication that the Acoustics Specialist Report fails to reach the necessary depth to be used for reliable environmental impact assessment. These flaws can be predominantly associated with the scope of the project as requested by TGS.

Summary of Comments on Acoustic Specialist Report:

1. **Inaccurate Assumptions in Acoustic Specialist Report:** The report is based on incorrect assumptions, primarily focusing on short-term impacts from 24-hour airgun pulses. However, the actual project will involve 70 days of chronic, high-intensity noise, including both airguns and continuous vessel noise, leading to significantly higher impacts than modeled.
2. **Underestimated Noise Sources:** The study overlooks the noise contributions from multiple sources, including support vessels and generator noise, which affect both low and mid-frequency ranges critical to marine fauna and elicit behavioral responses. These omitted noise sources exacerbate the overall impact of seismic operations on the marine soundscape.

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3. **Lack of Baseline Soundscape Assessment:** No baseline data on natural ambient noise levels or soundscape characteristics in the project area were collected, making it impossible to accurately assess how much the proposed activities would increase ambient noise levels.
4. **Broader Spatial Impact Unaccounted For:** The report fails to quantify how far noise will travel beyond the project area, particularly into Critical Biodiversity Areas (CBAs) and Marine Protected Areas (MPAs), where noise could have far-reaching ecological consequences.
5. **Insufficient Consideration of Ecosystem-Level Consequences:** The report focuses primarily on direct physical injuries (such as hearing loss) but does not adequately address the indirect effects on behavior, communication, and predator-prey dynamics, which could disrupt entire ecosystems.
6. **Failure to Address Behavioral and Population-Level Impacts:** Noise-induced behavioral changes, such as altered communication or abandonment of critical habitats, are not properly assessed. These changes could lead to population-level consequences, affecting reproduction, survival, and overall ecosystem stability.
7. **Outdated Noise Thresholds and Methodologies:** The report relies on outdated sound exposure thresholds that fail to account for the chronic nature of the project's noise impacts. More recent scientific guidelines suggest that this approach is insufficient for assessing long-term impacts on marine animals.
8. **Missing Quantification of Impacted Marine Animals:** The report does not estimate the number of marine animals likely to be affected by the noise, nor does it consider the heightened vulnerability of specific demographics, such as breeding males or nursing females, to noise exposure.
9. **Need for Scaled Sound Propagation Modeling:** The report requires a broader-scale sound propagation model and an assessment of the full spatial and temporal extent ensonification.

3.2 COMMENTS ON APPROPRIATENESS OF INFERENCE IN MARINE ECOLOGY REPORT

3.2.1 Appendix 3.1 – " PROPOSED 3D SEISMIC SURVEY IN THE ORANGE BASIN OFF THE WEST COAST OF SOUTH AFRICA: Biodiversity and Ecosystem Services Assessment " (Marine Ecology Report), builds on the information provided in the Acoustics Specialist Report. As such, it shares same shortcomings, as well as additional issues with scope, depth, and inappropriate inference of acoustic information and application to mitigation strategies.

3.2.2 The Marine Ecology Report mirrors the shortcomings of the Acoustics Specialist Report by considering TTS an acceptable impact after mitigation, despite significant unknowns regarding the consequences of temporary hearing loss for affected populations and species. The Marine Ecology Report fails to account for the potential impacts of repeated noise exposure over multiple days, which could have more serious long-term effects that those assumed in the report. Established methodologies, such as those from Wood (2010) and Southall (2024), provide

guidance on assessing environmental impacts based on sex and behavioral states. However, the Marine Ecology Report neglects to incorporate these variables or critically **to estimate the total proportion of marine populations of any species likely to be affected by the 70-day project**. This omission occurs, despite the acknowledgement that portions of the proposed permit area are ecologically valuable for critical species and are in some cases considered vulnerable to human activities (Marine Ecology Report, "3.4.2 Conservation Areas and Marine Protected Areas"). Instead, the report applies the same simplistic binary threshold approach as the Acoustics Specialist Report, without considering chronic impacts or population level consequences.

3.2.3 In the case of marine mammals, prolonged exposure to noise is associated with chronic stress, internal and external injuries, displacement from breeding and foraging areas, altered migratory patterns, and permanent hearing loss [17,20-23]. Despite the vulnerability of local cetacean species such as humpback whales, sperm whales, Bryde's whales, and beaked whales found in the proposed permit area (Marine Ecology Report, Table 7) neither the Marine Ecology Report nor the Acoustics Specialist Report adequately addresses the risks associated with chronic noise exposure for these animals at the individual or population level. The assumption was made that animals would likely leave the area, but there was no quantitative estimation of the number of individuals impacted, the probability of habitat abandonment, the change in probability associated with age, sex, or behavior state (e.g. cows and calves versus adult males). This is particularly critical for data deficient species (fish, invertebrates, benthic organisms in abyssal regions) and deep diving odontocetes expected to use much of proposed region.

3.2.4 The Marine Ecology Report and associated EIA recommendations (BAR Section 9: Environmental Impact Assessment) fail to adequately suggest mitigation measures that will address the acute risks of seismic operations to the marine environment. The proposed measures, including a 500 m buffer around sensitive areas, a 500 m mitigation zone, Marine Mammal Observers (MMO), Passive Acoustic Monitoring (PAM), and operational responses based on animal proximity, are inadequate. For example, the report acknowledges that certain species, including beaked whales, are at risk of fatal acoustically induced decompression sickness —a behavioral response with an acute outcome (Marine Ecology Report, p. 67). Very high frequency cetaceans, which includes most odontocetes and beaked whales and will be impacted at ranges of 650 m (injury) and 3.8 km (behavioral responses), yet the mitigation zone is only 500 m. This is a clear misalignment between the proposed mitigation strategies and the data driven spatial extent of impact to marine species. Per the information included in the Marine Ecology Report, this misalignment may result in odontocete fatality.

3.2.5 Similarly, the Marine Ecology Report downplays the impact of noise on invertebrates and prey species, and the report suggests ineffective mitigation strategies to minimize the impact of seismic operations. While the report acknowledges the physiological and behavioral responses of squid (Marine Ecology Report, "4.3.6 Impacts of Seismic Noise

on Marine Invertebrates")— a primary prey source for marine mammals, including beaked whales, in Southeast African waters [24,25]—it incorrectly downplays squid mortality as having a LOW impact due to temporal and spatial scale. The report claims the impact on squid would be REGIONAL and IMMEDIATE- 1.5 months, but mortality is permanent and behavioral responses of surviving squid will likely occur beyond the permitted region, as the acoustic influence zone (2–5 km) extends beyond the survey area during operations (EIA, p. 215, area (Acoustics Specialist Report, Figure 17; Marine Ecology Report, Figure 42). The loss of squid would significantly affect trophic interactions, especially in a system already low in food sources. The report's claim that the removal of squid (a scarce resource) is low impact, is akin to draining a desert oasis and labeling the impact low because water is rare there anyway.

3.2.6 Additionally, the proposed mitigation measure intended to minimize harm to cephalopods —"Terminate seismic shooting upon observing any obvious mass squid mortalities estimated by the MMO as a direct result of the survey"—is ecologically unsound. Squid, which are found at depth, are neutrally or negatively buoyant and will not float to the surface for meaningful observation [26]. Even if they did float to the surface, they are highly camouflaged and ship movement would scatter them, making detection by the MMO virtually impossible. This suggestion that MMO's would be capable of reporting squid mortality is unrealistic, and the consequences of squid mortality are ecologically meaningful.

3.2.7 Impacts to Plankton and Ichthyoplankton were considered MEDIUM before mitigation, and LOW after mitigation. However, the proposed mitigation measures – for example no seismic operation within 5 km of important ecological areas – directly minimize the duration or extent of high source level sounds inundating the marine soundscape (see Figure 45a, Marine Ecology Report for a visualization of spatial scale, see also Madsen et al 2006)[27]. Noise associated with seismic operations will extend well beyond 5km, and vessel noise within ecologically vulnerable areas may have meaningful impacts that were omitted from this assessment. Fishes exposed to anthropogenic noise experience reduced anti-predator responses, leaving them more vulnerable to predation, acoustic masking of breeding sounds, reduced breeding success, temporary or permanent hearing loss, stress, and death[17,28,29]. Many larval invertebrates and fishes, such as corals, shellfish, and crustaceans, rely on sound to locate suitable habitat for settlement—the transition from their pelagic phase to a permanent location.[30–37] Acoustic masking of environmental cues within MPAs CBAs or other vulnerable habitats exposed to both seismic and vessel sounds may disrupt this process for key structure-building organisms.

3.2.8 Importantly, like the Acoustics Specialist Report, the Marine Ecology Report fails to consider **population-level consequences for any species** of interest. It makes no effort to quantify the number of individuals affected by the proposed activities or to assess the potential short- and long-term impacts on population dynamics. These omissions minimize the overall consequences of the proposed seismic activities. Understanding population-level impacts is critical, as disruptions to even a small number of individuals can have cascading effects on the species' reproductive success, genetic diversity, and

long-term survival, or may have meaningful trophic implication as prey species (like squid) grow scarce.

3.2.9 Lastly, the Marine Ecology Report fails to quantify soundscape properties in relation to other oceanographic features, such as bathymetry and currents. Since sound is the primary way marine organisms interact with their environment, the omission of a basic soundscape description and the potential impacts of the proposed project on it is a significant oversight.

Summary of Comments on Marine Ecology Report:

1. **Inadequate Consideration of Temporary Threshold Shifts (TTS)**: Based on mitigation suggestions the Marine Ecology Report TTS an acceptable post-mitigation outcome and fails to address the long-term consequences of temporary hearing loss to individuals of specific species or populations. There is also no consideration for the cumulative effects of multiple days of noise exposure. It overlooks more detailed approaches, such as assessing impacts based on species' sex and behavioral states, and neglects to estimate how much of the marine population will be affected by the 70-day project.
2. **Chronic Noise Exposure Risks**: The report downplays the significant risks of prolonged noise exposure for vulnerable cetacean species (e.g., humpback whales, sperm whales, beaked whales). It fails to assess how chronic noise might cause stress, injuries, altered migration patterns, and permanent hearing loss. There is also no quantitative estimation of how habitat alteration might affect these species.
3. **Insufficient Mitigation for Acute Noise Impacts**: The mitigation strategies proposed, including a 500 m buffer zone, are insufficient to minimize acoustic impacts to marine speices (e.g, beaked whales and cephalopods). This highlights a failure to align mitigation efforts with the real world risks.
4. **Failure to Address Population-Level Impacts**: The report does not estimate how many individuals will be affected or assess the broader population-level consequences of direct or indirect harm, which downplays the long-term impacts of seismic exploration to this marine ecosystem.
5. **Omission of Soundscape Analysis**: The report neglects to assess the soundscape in relation to key oceanographic features (e.g., bathymetry, currents), despite sound being critical for marine organisms' interactions with their environment.

Overall, the report underestimates the severity of both acute and chronic noise impacts on marine life and offers inadequate mitigation strategies without accounting for population-level or soundscape effects.

3.3 INSUFFICIENT MITIGATION MEASURES PROPOSED WITHIN BAR SECTION 9 "ENVIRONMENTAL IMPACT ASSESSMENT" (EIA)

Throughout, the EIA fails to effectively propose mitigation measures that will address the acoustic impacts of seismic operations on the marine environment. Broad criticisms of the BAR's approach to mitigating acoustic impacts as well as specific criticisms on mitigation measures are below.

Broad Criticisms Associated with BAR Section 9. Environmental Impact Assessment (hereafter "EIA")

3.3.1 Failure to Address Habitat Variability: The BAR fails to adequately account for the variability in habitat sensitivity within the proposed permit region. The region in question displays significant bathymetric variability (BAR, p. 46), with habitat use and biodiversity differing greatly throughout the area (Marine Ecology Report, p. 19). For example, the Marine Ecology Report highlights the continental slope region (200–2000 meters in depth) as likely to support cetaceans and endangered fishes (Marine Ecology Report, Table 1 & p. 50), yet, the EIA (BAR, Section 9 "Environmental Impact Assessment") does not propose targeted mitigation measures for activities on the continental slope. Environmental mitigation measures should consider different operational behaviors based on habitats expected to harbor higher biodiversity or be home to species of concern.

Different marine habitats support distinct species assemblages, each with its own sensitivities to human-induced disturbances. The lack of appropriate mitigation in certain regions could result in physical damage to sessile organisms that inhabit specific habitats but lack the ability to abandon an environment when seismic operations commence. Alternatively, mobile organisms like cetaceans are more likely to congregate along continental slopes where nutrient upwelling attracts prey (Marine Ecology Report p. 50). Ignoring habitat-specific sensitivities increases the risk of disrupting critical ecological processes.

3.3.2 Inconsistencies within the BAR: The BAR and associated EIA contain inconsistencies. For example, the BAR proposes a long-term soundscape analysis for acoustics mitigation (BAR, p. 259) but fails to specifically include this measure in mitigation plans or to indicate spatial and temporal extent as part of the preventive strategies. The BAR also specifically acknowledges the need to minimize ambient sound levels associated with seismic operations (BAR, p. 245), yet requires no concrete mitigation measures regarding implementing technological or operational adjustments.

The EIA makes broad recommendations without considering the specific environmental conditions or the species most at risk at any given location or time of year. For example, seismic operations are proposed for January-May to minimize impact to baleen whales and commercially important fisheries – yet the BAR states that "it should also be kept in mind that some of the migratory species are now present year round off the West Coast, and that certain baleen and toothed whales are resident and/or show seasonality opposite to the majority of the baleen whales" (BAR, p 244). Despite this acknowledgment, these data were not meaningfully incorporated into planning or mitigation.

Effective EIAs should provide consistent, integrated, and transparent evaluations of all potential risks. A fragmented approach can result in a gross underestimation of cumulative or synergistic effects, where multiple stressors interact to amplify the harm caused.[38]

3.3.3 **Overly Optimistic Reliance on MMOs and PAM** The EIA fails to provide a clear scientifically driven, adaptive plan for real-time responses based on monitoring during the seismic survey. The existing plan incorporating real-time monitoring data (e.g., Passive Acoustic Monitoring (PAM) or Marine Mammal Observers (MMOs) is touted as a catch all to mitigate nearly every acoustic impact. MMOs, however, are limited in the scope and scale of their observations and PAM only captures loudly vocalizing animals (essentially omitting invertebrates and fish). Research indicates that the visual extent of MMOs from large ships is limited to 1 km, [5,18] yet per the Acoustics Specialist Report and the Marine Ecology Report acoustic impacts to marine mammals occur well beyond this range. MMOs are tasked with documenting mammals, fish, turtles, seabirds, fishes and invertebrates. This is both unrealistic and unreasonable. Many species of concern (e.g., odontocetes like sperm whales or beaked whales) have dive times in excess of one hour and surface intervals of less than a minute[39,40], making them hard to sight. Invertebrates, like squid, are negatively or neutrally buoyant[41] and aren't likely to be at the water's surface. Similarly, most fish species can't be reliably cited from a ship observation platform. Thus, while MMOs and PAM operators are crucial for reducing seismic operation impacts, they are not a panacea to address all potential risks.

3.3.4 **Incorrect Temporal Scale** The EIA focuses on short-term acoustic impacts (seconds to hours), despite the project involving approximately 70 days of seismic operation. This narrow focus disregards the long-term implications of chronic noise exposure. Prolonged anthropogenic[20,42,43] noise can lead to cumulative effects such as chronic stress, hearing damage, and altered behavioral patterns in marine species.[17] These chronic impacts, especially over the course of two months, are more likely to disrupt population dynamics, such as habitat avoidance or disrupted breeding patterns, which were overlooked in the assessment. Noise from the seismic survey is both chronic and spatially far-reaching, making the EIA's temporal scope inaccurate (See Commentary on Acoustics Specialist Report).

3.3.5 **Unknowns Are Disregarded** The EIA does not sufficiently account for unknown variables, including species-specific responses, role of behavioral states, lack of biodiversity data and ecosystem sensitivities. Uncertainty is inherent in ecological impact assessments, particularly when dealing with complex, dynamic marine ecosystems. It is essential to adopt the precautionary principle in such cases, ensuring that mitigation measures err on the side of caution to protect ecosystems from unforeseen consequences [18,44]. By failing to address these unknowns, the EIA underestimates in the scoring system and in its overall assessment the potential impacts of the seismic activity on species and habitats. The failure to collect baseline data significantly increases uncertainty; despite this, the EIA does not recommend commissioning ecological studies to address biological unknowns.

3.3.6 **Disregard for Far-Field Sound** The EIA does not adequately consider the effects of far-field sound, which can propagate over long distances and affect distant marine life. On page 58 of the BAR states that for areas that "receive the sound in the far field only, no detrimental effects to the communities or to individual benthic species are expected" (BAR, p. 58). However, seismic noise can travel thousands of kilometers [4], disrupting long-range communication among marine species such as cetaceans.[45] Far-field sound from seismic airguns will extend well beyond the immediate operational area, including into Critical Biodiversity Areas (CBAs) and Marine Protected Areas (MPAs) (see commentary on Acoustics Specialist Report and Marine Ecology Report), yet the EIA does not quantify the extent or ecological consequences or far field sound, nor does the EIA recommend broader scale acoustic modeling.

3.3.7 **Generalized Masking Effects** The EIA, acknowledges the importance of acoustic masking to marine organisms (BAR, p. 198) but overgeneralizes the effects of noise masking, failing to account for species-specific auditory ranges and behavioral needs. Different marine species rely on unique frequency ranges for communication, predator detection, and prey location [35,42,46–49]. A generalized approach that does not differentiate between species' auditory sensitivities can result in inadequate mitigation. For instance, what may be a moderate disturbance for one species could be catastrophic for another. Masking effects should be assessed separately for each species, given their varying hearing thresholds and reliance on the sonic environment.

3.3.8 **Disregard for Chronic Impacts** The EIA does not sufficiently consider the long-term effects of temporary injuries, such as hearing loss, resulting from seismic exposure. Temporary hearing loss can have severe long-term consequences if it impairs an animal's ability to communicate, forage, or avoid predators. Chronic exposure to noise may also lead to habitat abandonment or reduced reproductive success, ultimately affecting population resilience.[17,42,50] Seismic operations, particularly over 70 days, will result in chronic, not just temporary, impacts, leading to long-term harm to individuals and populations that depend on the proposed permit region.

3.3.9 **Disregard for Cumulative Impacts of Project Stressors** The EIA does not adequately consider the cumulative impacts of multiple noise sources, such as airguns, vessels, and ambient noise, over the duration of the 70-day seismic survey. Despite including a discussion on Cumulative Impacts (e.g., BAR section 9.2) generally, the BAR adopts a siloed approach in assessing risks. Per the EIA impact assessment protocol, the criteria required to score a "High" Cumulative Impacts is stated as: "Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/ definite that the impact will result in spatial and temporal cumulative change" (BAR, Table 39). Yet there is no transparent measure assessing the interactive impact of each potential threat. Instead, the TGS appeared to assess risks in isolation rather than integrating them. For instance, there is no apparent analysis concerning the impact to species that

experience temporary hearing loss (TTS) alongside habitat displacement- and although this would change the temporal and spatial scale of impact that is not reflected in the mitigation assessment. Similarly, the combined effects of anti-predator behaviors triggered by vessel noise and physiological stress associated with seismic noise may change reproductive output in fishes, which would alter the temporal scale of impact – but this scientific probability did not appear to change the risk assessment rating. This piecemeal approach – or at the very least the lack of transparency pertaining to how cumulative impact criteria were scored – significantly underestimates the true impact of the proposed activities.

3.3.10 **Disregard for Cumulative Impacts of Possible Multiple Projects** The EIA fails to propose adequate mitigation to prevent the impact of multiple exposures to marine organisms in association with other proposed survey projects in the region (e.g., Searcher and Gx Technologies). This scenario – multiple projects occurring simultaneously – was not quantitatively modeled within the Acoustics Specialist Report, addressed in the Marine Ecology Report, and therefore adequately assessed in the EIA. The EIA within the BAR considers the impact of the proposed exploration project isolation, with one brief mention of isolated impacts of multiple project (BAR, p. 211). This is a gross oversight that requires comprehensive consideration and mitigation strategies based in realistic data to remedy.

Each additional project in or near the proposed survey region is associated with a set of risks that compound when they occur in close spatial or temporal proximity. Most mitigation measures proposed to address the impact of anthropogenic noise in the EIA would be minimized or completely invalidated by the presence of additional exploration. Part of the EIA mitigation plan hinges on there being a 'safe place' for marine organisms to retreat to avoid the impacts of extremely high amplitude sound, or by minimizing the spatial and temporal scale of sound exposure associated with the project. These assumptions are untrue if multiple project occur simultaneously. The scale of sound propagation greatly exceeds the proposed 40 km mitigation zone proposed to account for the occurrence of simultaneous projects (BAR, p. 211). Moreover, depending on the temporal scale of the other project, this would extend the overall high noise exposure to the environment, rendering the modeled SEL in the Acoustics Report incorrect, increasing the probability for both PTS and TTS for marine organisms, and increasing the probability for elevated stress levels in marine organisms at a regional level. Noting that the sound of seismic exploration, vessels, and other anthropogenic noise sources can travel for hundreds or even thousands of miles, the 40km buffer between ships would have minimal mitigation impact. No additional mitigation measures were proposed (e.g. adjusting the timing of operations, altering seasonality, stopping in the presence of other operations, etc.).

3.3.11 **Flawed Scoring System** The EIA employs a scoring system that does not allow for population-level impacts or the meaningful incorporation of uncertainty. In data-deficient situations, this scoring system biases the assessment toward assuming minimal impact, leading to underestimation of real risks. There is a need to factor in

uncertainty and variability in population responses to ensure a precautionary approach is taken.

3.3.12 Inadequate Mitigation Zone The EIA's reliance on a 500 m mitigation zone is insufficient to protect marine life from the harmful impacts of seismic noise. The Acoustics Specialist Report explicitly indicates that behavioral impacts are expected for marine mammals at distances up to 3.8 km from the array source and for fish at 1.3 km. Similarly, a zone of 2-5 km is necessary to avoid significant impacts on squid and other cephalopods (BAR, p. 215). A 500 m zone does not adequately mitigate the risk of injury or behavioral disruptions, especially given the repetitive use of airguns over 70 days. The BAR and associated specialist reports failed to incorporate the best available statistical methods to model habitat abandonment or avoidance, which would provide a more accurate assessment of indirect impacts[18,19,51,52]

3.3.13 Failure to Use Best Science The EIA fails to incorporate the best available scientific practices in its mitigation strategies. For example, in the absence of comprehensive biological surveys, best practice recommends assuming the presence of sensitive species and applying conservative mitigation measures to avoid harm. The reliance on outdated scientific recommendations from the Acoustics Specialist Report results in insufficient mitigation strategies. The Specialist Report critiques this failure to integrate the latest scientific guidelines, such as those from Southall et al. (2021), which provide more accurate frameworks for assessing long-term noise impacts (Specialist Report, p. 57).

Selected section specific comments associated with proposed mitigation within the EIA

9.3.1.1 ACOUSTIC IMPACTS OF SEISMIC SURVEYS ON MARINE FAUNA

This section outlines the importance of sound in the marine environment and the broad impacts of the noise associated with seismic operations to the marine environment and fauna. The following specific points are made (p. 128, statistics per the BAR):

1. **Shipping noise** is a significant and persistent source of anthropogenic sound, particularly at low frequencies, and can propagate over large distances, affecting vast marine areas.
2. The **Application Area** for the proposed project lies within busy shipping routes, where ambient noise is expected to be high (90-130 dB) due to shipping traffic.
3. **Seismic surveys** use intense sound sources, which can also propagate over great distances, with sound transmission being influenced by factors like water depth, distance, and ocean conditions. Sound pulses change in character due to reflective boundaries (sea surface, seafloor, etc.).
4. In **shallow waters**, seismic sound can travel up to 75 km, while in **deep water**, detection ranges can exceed 1,000 km under ideal conditions.
5. **Marine animals' auditory masking** occurs when background noise interferes with their ability to detect important environmental sounds. The duration and repetition of seismic impulses can affect animals' hearing thresholds

Despite the BAR's identification of these threats, most of these concerns are not adequately addressed by the proposed mitigation measures. Below is a point-by-point consideration of these omissions.

1. ***Shipping noise:*** *is a significant and persistent source of anthropogenic sound, particularly at low frequencies*. Despite this, the BAR neither commissioned the modeling of noise associated with the seismic ship and vessel operations, nor conducted a baseline soundscape analysis to measure the potential changes associated with seismic operations. Mitigation measures did not include vessel speed limits or daily maximum hours a day of use, both which would minimize vessel noise associated with shipping operations. The EIA within the BAR determined pre-mitigation impact of vessel noise on marine fauna to be "LOW" however, there is no empirical data to support this.

2. *The* ***Application Area*** *for the proposed project lies within busy shipping routes, where ambient noise is expected to be high (90-130 dB) due to shipping traffic.* TGS failed to measure the *in situ* contributions of vessel noise to the proposed permit area or the adjacent areas likely to be ensonified by seismic operations. It is not possible to test this claim, or to assess how the proposed operations will alter baseline soundscapes. In the absence of *a priori* measurements and comprehensive modeling. While vessels within an environment are loud, seismic operations including vessel operation and have been demonstrated to elevate ambient noise conditions in all known cases, and in broader frequency ranges than anticipated. [4,53–58] Per the Acoustics Specialist Report, ambient sound values will well exceed the 90-130 dB range within and beyond the permitted area in association with seismic operations (Acoustics Specialist Report, Table 11).

3. ***Seismic surveys*** *use intense sound sources, which can also propagate over great distances, with sound transmission being influenced by factors like water depth, distance, and ocean conditions. Sound pulses change in character due to reflective boundaries (sea surface, seafloor, etc.).* In keeping with this point, the Acoustic Specialist Report indicated that "the directivity of received noise is dominated by the directionality of the source array." Simply put, the direction the sound is produced in, dominates the direction the sound impacts. Despite this, no mitigation measures were suggested to restrict directionality of sound sources to minimize impact to biologically sensitive areas within and beyond the proposed permit zone.

4. *In* ***shallow waters****, seismic sound can travel up to 75 km, while in* ***deep water****, detection ranges can exceed 1,000 km under ideal conditions*. While this statistic is an underrepresentation (seismic has in certain context been detected for up to 4,000 km [4]), the BAR is correct that seismic sound can be very far reaching. Despite this acknowledgment, and the demonstration in the Acoustic Specialist Report that loud persistent sound sources associated with the proposed project are up to at least 200 km (maximum modeled distance), there were no concrete mitigation measures suggested that would minimize the acoustic energy input into the ocean throughout the project or to assess impact at a broader spatial extent.

5. ***Marine animals' auditory masking*** *occurs when background noise interferes with their ability to detect important environmental sounds. The duration and repetition of seismic impulses can affect animals' hearing thresholds.* It is true that the sound associated with seismic operations can mask critical sounds; behavioral responses also include altering the timing of calling – which may also interfere with important information transfer. Additionally (though unaccounted for in the Acoustics Specialist Report) the seismic ship and support vessels will also mask sounds. Moreover, animals experiencing temporary hearing shifts, will have altered decreased hearing sensitivities, thus increasing the likelihood and impact of masking. Despite these realities, mitigation measures do not adequately prevent the elevation of ambient sound that will lead to masking at broad scales or at altered thresholds, or indeed measure changes in the soundscape from baseline levels. Further, while the zones of behavioral response were modeled in the Acoustics Specialist Report, zones of masking were not solicited by TGS for the report.

9.3.1.1.1 NOISE IMPACT ON WHALES AND DOLPHINS

The overall assessment of seismic noise impact on cetaceans was calculated based on the impact to the individual, rather than the population, thus downplaying the potential impact to cetaceans over broader temporal scales. The proposed mitigation zone falls well below the zone of acoustic response expected for physiological, behavioral, or masking impacts. The Acoustics Specialist Report indicates that behavioral impacts are expected in cetaceans at 3.8 km from the array source. The maximum zones of temporary threshold shifts (TTS, temporary deafness) for very-high-frequency cetaceans are within 650 m of the source (Acoustics Specialist Report, p. i). Under normal operations, TTS zones for low-frequency cetaceans extend up to 5 km from the survey lines. Based on the research available and integrated into the BAR, a 500 m zone is insufficient to prevent injury to animals, especially given the repetitive use of airguns over 70 days. This strategy does not minimize harm. Similarly, because it is currently unknown how the seismic operations will elevate ambient sound (no baseline soundscape analysis was conducted) or how far the sound is expected to travel (lack of total ensonificaiton range) it is not possible to calculate the potential range over which cetaceans will experience acoustic masking. Lastly, while MMOs and PAM operators are extremely useful in mitigating negative impacts on marine mammals, many species (e.g., deep diving odontocetes) surface after long (>60 minute) dives and are extremely difficult to identify at distances greater than 1 km, thus minimizing the effectives of MMOs for long range impacts.

9.3.1.1.6 NOISE IMPACTS ON MARINE INVERTEBRATES

Despite the information contained in the Marine Ecology Report indicating the potential impact of seismic operations on marine invertebrates, and squid specifically (death, injury, displacement), and the acknowledgment that the zone of acoustic impact of for cephalopods is broad (2-5 km, BARp. 204) the BAR and its associated reports erroneously claim that impact of seismic on invertebrates is LOW (see specific comments on the Marine Ecology Report on squid). The proposed mitigation, that MMO would watch for mass squid mortality is functionally meaningless. Squid are neutrally buoyant and therefore would not float to the surface; even if squid did float, given the size of the ship, the water current associated with vessel transit, and the camouflage of the animals, mass mortalities of squid wouldn't be visible from the seismic ship.

9.3.1.1.7 NOISE IMPACT ON PLANKTON

The EIA indicates that pre-mitigation impacts on planktonic communities (the base of the marine food web) would be MEDIUM pre-mitigation. Indicating, by the TGS' admission a potentially biologically meaningful impact. Despite this the BAR states that the "Application Area is located far offshore, it is not deemed necessary to implement mitigation measures to avoid the key spring spawning periods thereby mitigating potential impacts on plankton to some degree." (BAR, p. 204). Put plainly, the mitigation plan is to do nothing; yet according to the EIA this will reduce the threat from MEDIUM to LOW. This is unreasonable, and not based in science.

9.3.1.2.1 IMPACTS OF NON-SEISMIC NOISE (VESSEL AND HELICOPTER NOISE)

The significance of non-seismic noise is said to be "low" before and after mitigation. This cannot be assessed according to the BAR's own criteria in the absence of a baseline soundscape analysis. Vessel noise, particularly as it reaches CBAs, MPAs, and regions of ecological importance (seamounts and caverns containing deep water corals), will alter the soundscape in potentially meaningful ways. This could impact larval recruitment, predator-prey dynamics, and beyond. The EIA, and the reports it relied on for assessment, failed to quantify, model, or predict, elevated ambient noise associated with vessel or aircraft within or beyond the proposed permit area. The assumption that this noise does not meaningfully impact the environment cannot be assessed. No mitigation was suggested, this course of action is not based on scientific information.

4 SUGGESTIONS FOR REASSESSMENT OF NOISE IMPACTS

NOTE This is a **minimal selection** of suggested assessment and mitigation measures pertaining to acoustics impacts associated with the proposed seismic operations. These measures alone will not be sufficient to minimize the acoustic impact to the marine environment within and beyond the proposed permit region. These suggestions are needed in order to **assess** if or how to develop mitigation plans to minimize acoustic impacts. .

1. **Comprehensive Soundscape Analysis (1-Year Minimum) Prior to Project Implementation**
   Objective: Conduct a thorough baseline analysis of the soundscape within the habitat over a minimum of one year before project activities begin. This will help establish a baseline understanding of natural noise levels and seasonal variations, providing critical context for assessing the potential impact of the project's noise on the ecosystem.

2. **Model Full Spatial and Temporal Range of Ensonification for All Sound Sources**
   Objective: Model the full spatial and temporal extent to which anthropogenic sounds associated with the proposed project will inundate marine soundscapes, including the ensonification range for airgun operations within the proposed permit area, as well as the ensonification associated with seismic ship and support vessel transit within and beyond the proposed permit area.

3. **Inclusion and Consideration Population Level Impacts and Associated Uncertainty**
   Objective: Acknowledge the necessity of modeling population level impacts (including estimated proportion impacted) and incorporate uncertainty in population density

estimates for the relevant species (e.g., marine mammals, fish, etc.) by developing multiple density scenarios. This includes:

a. Assessing the risk to species under a range of plausible population densities, especially considering variability in population numbers.
b. Where available, use population abundance data and apply variability factors to estimate the proportion of the population that could be exposed to noise during the project's operational period (e.g., 70 days).

4. **Separate Mitigation for Direct (Injury) and Indirect (Behavioral) Impacts of Noise**
Objective: Differentiate between the direct impacts (e.g., physical injury) and indirect impacts (e.g., behavioral disturbances) of noise exposure on species and propose mitigation for each
    a. For **direct impacts**, model potential injury thresholds based on noise exposure.
    b. For **indirect impacts**, consider the latest version of the **probabilistic disturbance approach**, which incorporates various behavioral states (e.g., feeding, resting, migrating) and estimates the time spent in each state. This method will help refine understanding of how noise affects species' daily activities.
    c. Develop mitigation relevant to spatial and temporal ranges of each.

5. **Exposure and Risk Assessment Based on Behavioral States**
Objective: Rather than adopting a blanket seasonal approach, model exposure levels and risks based on species' behavioral states (e.g., breeding, feeding, migration) and proportion of the population engaged in each activity. This will allow for the development of an **operation schedule** that minimizes noise during critical behavioral periods, thus reducing potential disruptions.
    a. The model should take into account how noise influences different states, adjusting operations to align with periods when species are least sensitive to noise.

6. **Integration of Southall et al. (2024) Recommendations**
Objective: Implement the recommendations outlined by Southall et al. (2024) on managing anthropogenic noise. The study critiques current regulatory approaches adopted in the BAR which rely on simple thresholds for noise exposure criterion. Southall et al (2024) calls for more nuanced criteria that consider species-specific and context-dependent responses, including behavioral responses.

7. **Required Evaluation of Proposed Mitigation Measures**
Objective: Evaluate the effectiveness of proposed mitigation strategies for both **direct** and **indirect** impacts that include uncertainty. This should involve a **comparative analysis** of different mitigation approaches, such as noise reduction technologies, spatial or temporal restrictions, and habitat protection measures. The evaluation should include:
    a. Quantitative and qualitative assessments of the potential success of each measure.
    b. A comparison of the potential impacts before and after the implementation of mitigation measures.

c. Consideration of adaptive management approaches based on scientifically based zones of impact to allow for adjustments if initial mitigation measures prove inadequate.

8. **Incorporation of Real-World Detection Probabilities of Marine Mammal Observers into Risk Assessment and Mitigation Strategies**
   Objective: Integrate **real-world detection probabilities** of Marine Mammal Observers (MMOs) into the risk assessment process and the development of mitigation strategies. These detection probabilities can vary significantly based on factors such as:
   a. **Species size** (larger species are easier to detect)
   b. **Group size** (larger groups are more noticeable)
   c. **Time of day** (e.g., detection can be lower during low light conditions such as dawn, dusk, or night)
   d. **Observer experience** (more experienced observers are likely to have higher detection success)
   e. **Animal behavior state** (for example, animals in more active states may be easier to spot than those resting or submerged)
   f. This incorporation will help **refine risk assessments** by accounting for the inherent variability in detection rates and potential missed detections, especially during times of high operational noise or challenging environmental conditions. Additionally, it ensures that mitigation measures (such as shutdowns or noise reduction) are based on more realistic expectations of detection success, thereby improving overall protection for marine mammals.

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