JUDICIAL REVIEW – ENVIRONMENTAL AUTHORISATION FOR EXPLORATION OF OIL AND GAS GRANTED TO SASOL / ENI – MARINE ECOLOGY EXPERT INPUT

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OVERVIEW: This report contains commentary and an expert opinion assessing the scientific soundness of activities relating to an exploration drilling program in exploration block ER236 proposed by Eni South Africa BV ("Eni") & Sasol Africa Limited ("SASOL", collectively "the Applicant"). Specifically, this report is concerned with whether Annex D1 Marine Ecology Study (hereafter 'the study') in support of the environmental impact assessment titled, "Exploration Drilling within Block ER236, off the East Coast of South Africa," dated December 2018, (EIA) adequately assessed the environmental impact of anthropogenic noise and vibrations associated with drilling operations and associated activities.

GENERAL INTRODUCTION: Sounds produced by human activities can be broadly defined as 'anthropogenic noise' (hereafter "noise" or "anthropogenic noise"). Anthropogenic noise, which includes both infrasonic and ultrasonic vibrations in addition to sound audible to the human ear, poses a well-established threat to organisms across taxa [1] that rely on sound for vital life functions including foraging, breeding, travelling, and socializing [2–8]. This threat is particularly pronounced in marine ecosystems where sound can travel great distances with little loss of energy and where - in the absence of human activities - many if not most marine species evolved to rely on sound as their principal sensory modality [9,10]. Among others, anthropogenic noise has been documented to limit acoustic communication, elicit changes in foraging behavior, alter predator-prey dynamics, induce physiological stress, and/or result in physical damage or death [2–4,10–16].

Assessing the impacts of anthropogenic noise and vibrations is a complex field of study requiring the integration of ecology, resource management, and physics. Compared to marine biology, oceanography, or fisheries ecology, acoustics is a relatively new field of study that is not regularly incorporated into traditional academic coursework, and therefore a comprehensive impact assessment that includes an investigation into the impacts of noise should include an acoustician on the assessment team. The EIA science team that completed the study did not include an acoustician.

For most marine organisms, sound is critical to life function. While this is in some cases obvious (e.g. social cetaceans rely on sound for communication and pod cohesion) [17], it is often less obvious that benthic fauna, fishes, and invertebrates also rely on or respond to sound in their environment (e.g. larval invertebrates and fishes use sound to know when/where to leave their pelagic life stage and settle into adulthood) [18,19]. The body of literature pertaining to how marine organisms respond to anthropogenic noise spans taxa and response type including behavioral responses, changes in organism presence or absence, physical responses including hearing loss, physiological responses including stress, mortality, and demographic shifts including reduced fecundity or larval development[1]. As such, any proposed activity that is believed to be sound producing may have significant consequences throughout the ecosystem. The study associated

with the EIA did not address the impacts of noise across taxa, but focused specifically on marine birds, mammals, and peripherally turtles.

SUMMARY OF OPINION: It is my opinion that the findings on the impacts of anthropogenic noise in the Annex D1 Marine Ecology Report have not been adequately assessed. A determination that noise impacts are 'minor' is premature. In my opinion, the study failed to address the following critical topics pertaining to the impact of anthropogenic noise:

1. Failed to consider the impacts of anthropogenic noise on commercially important species. This is significant because a reduction in commercial fish may have economic consequences.

2. Failed to consider the impact of anthropogenic noise on important prey species. This is significant because the drilling site is located near Marine Protected Areas (MPAs), Critical Biodiversity Areas (CBAs) and Ecologically and Biologically Significant Areas (EBSAs). Noise may endanger prey species in or en route to these areas. This could disrupt the base of the food web may be ecologically substantial throughout trophic levels.

3. Failed to adequately describe potential sound sources and amplitudes in a comparable and relevant way. This is significant because, without this information, the study was unable to understand noise impacts on important species or ecosystems including how far sound will travel.

4. Failed to include potential impacts of Vertical Seismic Profiling. This is significant because Vertical Seismic Profiling is an important sound source that the study entirely failed to analyze. Seismic profiling may have significant ecological implications ranging from behavioral shifts to death.

5. Failed to adequately quantify baseline ambient sound levels. This is significant because—given that marine organisms use sound for navigation, prey detection, and foraging—alterations made to the baseline natural soundscape will have ecological consequences that may be severe.

6. Failed to adequately quantify naturally occurring contributions to the marine soundscape. This is significant because, 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 to assess noise impacts.

7. Failed to adequately model/measure sound propagation in this region. This is significant because sound propagation may impact MPAs, CBAs, and EBSAs. This is particularly pertinent for example in the Protea Banks and Sardine Route , the first of which contains a cold-water coral system and the second of which is a major fish migration corridor. Larval corals rely on reef sounds to determine where to settle; disturbance to reefs and

associated soundscapes negatively impacts coral settlement, and thus continued reef building. Quiet biological sounds are used as a cue for foraging megafauna and anthropogenic noise at even low levels in these regions may mask biologically relevant sounds associated with predator foraging.

8. Failed to assess the risk associated with permanent soundscape alteration due to permanent changes on the seafloor due to drilling activities. This is significant because animals use the soundscape as a cue to inform migration, habitat suitability and settlement (i.e., where juvenile animals select to grow and populate).

9. Failed to consider the impact of vessel noise on marine areas outside of the immediate drilling range including coastal areas and along vessel routes. This is significant because, vessel noise outside of the direct drilling area may inundate MPA's, CBA's, and EBSA's. Vessel noise has a wide range of negative impacts on marine fauna throughout the food web. These impacts may be ecologically substantial.

10. Failed to consider the physiological effects of anthropogenic noise on sound sensitive species. This is significant because the study failed to consider how biologically critical behaviors that are important both for the fitness of the individual and overall population may be impacted.

11. Failed to adequately consider the timing of migration of protected species. This is significant because both humpback and right whales will be migrating during time periods that overlap with planned drilling operations. Noise can have significant impacts such as separating calves from mothers. This is particularly relevant given the recent decline in Southern right whale abundance and inter-calf-intervals and given that humpback cow-calf pairs are often among the last the migrate southward, and thus likely to be in the cohort that would be disturbed by noise in the month of November.

12. Failed to incorporate International Whaling Commission's (IWC) Resolution 2018-4, Resolution on Anthropogenic and Underwater Noise, which requires effective remediation of noise impacts when cost effective solutions are available and states a lack of information is not grounds for ignoring the potential threats of anthropogenic noise.

13. Failed to consider impact of noise on the ecosystem holistically, including a failure to consider the links between trophic levels (e.g., predator and prey), and links between ecosystems and economics (e.g., commercial fish and fisheries). This is significant because it omits some of the largest, though not immediately obvious, potential and cumulative impacts of noise on this ecosystem and the users who rely on it.

In order to assess the impact of anthropogenic noise and efficacy of proposed mitigation efforts pertaining to the specific project proposed by the Applicant several considerations must be included:

a. Ecologically/economically important species and trophic interactions

b. Sources of anthropogenic noise

c. Alterations anthropogenic noise will make to the natural soundscape

d. Sound propagation within the region

e. Physiological responses of organisms to anthropogenic noise

f. Behavioral responses of organisms to anthropogenic noise

g. Known impacts on faunal composition and migration

h. Interrelatedness of non-human organisms within an ecosystem and human users who rely upon them

ECOLOGICALLY/ECONOMICALLY IMPORTANT SPECIES AND TROPHIC INTERACTIONS: While substantial attention was paid in the study to the impact of noise in marine mammals and birds, little to no analysis was conducted on the impact of noise on other ecologically or economically important species. Anthropogenic noise from various sources (vessels, drilling, seismic profiling) has the potential to negatively impact both commercially important fish species as well as important prey species for birds, marine mammals, turtles and pelagic fishes [20]. 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, reduced breeding success [8,21,22], temporary or permanent hearing loss, stress [23], and directly or indirectly noise can result in death in fishes and invertabrates[24]. Given the importance of the region adjacent to the proposed drill site as a commercial line fishery and the proximity to Marine Protected Areas (MPAs), Critical Biodiversity Areas (CBAs) and Ecologically and Biologically Significant Areas (EBSAs), the risks to pelagic fishes, lower trophic level bait fish, and invertebrate prey species, may be both ecologically substantial as well as economically significant. A reduction in prey may have fitness consequences for predators. A reduction in commercial fish may have economic consequences for communities. This impact of noise to prey species and/or commercially important fish species was not included in the study. The study notes in Table 5 that:

> "*The fish most likely to be encountered on the shelf, beyond the shelf break and in the offshore waters of Block ER236 are the large migratory pelagic species, including various tunas (Figure 16, left), billfish (Figure 16, right) and sharks (Figure 17), many of which are considered threatened by the International Union for the Conservation of Nature (IUCN), primarily due to overfishing (Table 5).*"

The potential impact of noise on these species and their prey – including impacts to the "sardine run" which as the study notes is critically important to ecosystem function - should be considered but was not.

Similarly, the study acknowledges the possible presence of giant squid and other cephalopod species in this region [25]. The study notes that giant squid are a key prey source for sperm whales

who feed on them at depth. Research demonstrates that anthropogenic noise can have acute effects on cephalopods including immobilization, cessation of eating or mating, or egg laying, and changes in swimming behavior [26]. Atypical mass stranding events of giant squid that included measurable soft tissue damage have been documented following seismic surveys [26]. While it is clear that this project has not reported using air gun arrays, the use of Vertical Seismic Profiling (VSP) – which has not been fully clarified in the study (see SOURCES OF ANTHROPOGENIC NOISE below) – indicates that some seismic activity will occur. Given the high amplitude and instantaneous nature of profiling pulses, impacts of seismic profiling are relevant here, particularly for benthic and deep-water organisms (e.g., squid) that cannot be seen by ship-board observers and are subject to physical damage over short duration seismic activity. Broadly, squid are critical food sources for odontocetes in South African waters [25], and any negative impacts to this food source would have implications for odontocetes and sea turtles many of which, as noted in the study, have a year round presence in the proximity to proposed drilling activities, and also rely on squid as a food source. Given that squid are known to have physiological and behavioral responses, this should be considered by the Applicant, as their declines may impact protected species.

Moreover, many larval invertebrates and fishes including corals, shellfish, and crustacean species rely on sound to facilitate settlement (the act by which larval animals transition from their pelagic 'drifting' phase, to permanent locations[27,29-30]). Acoustic masking of habitat sounds may prevent important structure building organisms (i.e., cold water corals in canyon environments or corals in shallow coastal areas protected as either MPAs or CBAs) from locating suitable habitat. Several CBA's overlap with the proposed southern drilling site, and two MPA's are within 37 km- which may be close enough to be inundated with noise from the drill ship, is highly likely to experience noise from VSP, and may experience high noise levels associated with vessels. Anthropogenic noise in coastal areas associated with crew transit and supply tenders may impact noise sensitive organisms outside of the immediate drill site. Anthropogenic noise produced outside of the exact drilling range (including vessel and helicopter transfers) may inhibit settlement and recruitment of fishes and invertebrates in protected or sensitive areas. Areas outside of the direct drilling region (including MPAs, CBAs, and EBSAs) may experience long duration and loud noise from vessel tenders and helicopter transfers that cause physiological or behavioral responses. Moreover, many migratory organisms that seek refuge in MPAs, CBAs, and EBSAs will also have to transit through the drilling site in order to reach these protected regions. In general, the study failed to investigate potential impacts on trophic interactions and non-megafauna.

SOURCES OF ANTHROPOGENIC NOISE: Consideration of the different types of sound sources was included in the study that accompanied the EIA, however, inadequate consideration was paid to decibel (dB) units, properly cited units of relevant loudness for proposed activities, and duration of sound sources. Additionally, VSP – an important sound source – was omitted from the study without adequate justification.

The reporting of dB units in the study are inconsistent and often omitted altogether. The lack of specific information on dB units is a critical oversight. Decibels are measured relative to a reference pressure. This is typically re 1μPa in water and re 20 μPa in air. While it is fairly safe to assume these units are referenced to units in water, the study also reports dB that lack an

indication as how the sound pressure was measured. It is important to indicate whether the pressure being used to compute dB is root-mean-square (RMS), peak, or peak-to-peak pressure (www.DOSITS.org). Depending upon which measure is used, there can be a significant difference in the reported dB *value*. In general, for a given sound wave, measured peak values will be lowest, RMS values in the middle, and peak-to-peak will be highest; however, these are all referencing the same sound, and thus are 'experienced' identically to marine organisms. Using RMS values to measure transient sound (i.e. pulsed sounds, like those used in VPS) does not represent the energy of the noise pulse and it does not prevent exposure to high peak pressures [31]. Difference between RMS values and peak-to-peak values of the same sound can differ by as much as 23 dB, which equates to a 14 fold change in amplitude [31]. By not reporting how dB are calculated there is a significant risk or under or over reporting noise levels.

Further, dB are measured over a pre-selected bandwidth (e.g., 100-500 Hz) which both changes the ambient noise value and the interpretation of the value. A single 10 second period can be correctly measured as both 80 $dB_{RMS\ 10kHz\text{-}11kHz\ band}$ re 1μPa (a high frequency bandwidth above the vocalization range of most baleen whales) and 140 $dB_{RMS\ 10Hz\text{-}1kHz\ band}$ re 1μPa (a low-frequency bandwidth that encompasses baleen whale vocalizations). In the absence of an appropriate descriptors, however, it may appear that this unit of time is comparatively 'quiet' and unlikely to generate a strong ecological response (80 dB), while the reality is that low-frequency noise during this period is loud enough to mask biologically important sounds and is well above average ambient noise levels (140 dB in the relevant bandwidth). Reference units, indications of how sound pressure was computed, and over what bandwidth are essential for adequately assessing the impact of noise in this region. The study failed to consider this.

In addition to sound loudness, sound *duration* is a critical component to consider whether a sound will be masked or will cause physiological stress in an organism. Biological responses to elevated noise are not linked exclusively to amplitude but also to the amount of time sound is experienced. Studies have demonstrated that cumulative sound exposure level (SEL)- a unit of loudness that incorporates duration – can be used to predict the risk for hearing loss in marine mammals [2]. This implies that sounds received at lower levels for a longer duration may have similar effects as sounds received at higher levels for a shorter duration. This study failed to address how many hours per day vessels, helicopters and drilling activities would be noise producing, and any efforts to mitigate the total duration of noise output from drilling associated sources. Per the EIA *"and the drilling of one well is expected to take in the order of two months to complete."* This is a significant amount of time to flood the marine environment with noise, and no mitigation efforts were proposed to minimize duration. If additional wells are drilled, the issue obviously compounds. This was also not addressed in the study.

The study acknowledged that vessels, drillships, and helicopters would contribute to anthropogenic noise- however the values reported in the study were inadequately described and do not reflect source levels (loudness at the source of the sound) found in the literature. The study states

> *"The sound level generated by drilling operations fall within the 120-190 dB re 1 μPa range at the drilling unit, with main frequencies less than 0.2 kHz. For the current project, noise would be generated by a number of sources (e.g., heavy lift vessel, drill*

ship in transit and operational, semi-submersible drill rig, support vessels, helicopters and drill ship maintenance) with the noise levels ranging from 170 – 190 dB re 1 μPa depending on the drill unit and support vessels used (Croft & Li 2017)."

While it may seem like a minor detail, this is an underestimation of the drillship source levels (loudness at the source). According to Austin et al. (2018) drillship source levels at between to 191.8-193.3 $dB_{RMS\ 1/3\ octave\ bands\ 10Hz\text{-}32kHz}$ re 1 μPa [32]. Decibels are measured on a log scale. A 3.3 increase in Sound Pressure Level (SPL; the difference between the reported value in the study and the observed value from Austin et al.) is equivalent to an increase of 1.5 times. Put plainly, the drillship measured by Austin et al. 2018 was 1.5 times louder than the maximum loudness the study is reporting. This is a non-trivial change in loudness, which ultimately has an impact on the distance these sounds will travel, and thus potential impact. Accurate information regarding the source level of the exact equipment being proposed is essential to address this discrepancy. Notably, 190 dB *re 1 μPa* is also loud enough to impact organisms and would require significant mitigation- which was omitted from the EIA.

VSP is also likely to be significant energetic contributor to the ambient soundscape- although it was not carefully considered in this study. The study states that:

"Vertical seismic profiling (VSP) is a standard method used during well logging and can generate noise that could exceed ambient noise levels. VSP source generates a pulse noise level around 190 dB re 1μPa at 1m in the 5 to 100 Hz range and decreases rapidly with distance from the source. VSP uses a small airgun array; volumes and the energy released into the marine environment are significantly smaller than what is required or generated during conventional seismic surveys. The airgun array would be discharged approximately five times at 20 second intervals. This process is repeated, as required, for different sections of the well. A VSP is expected to take approximately 8 to 10 hours per well to complete, depending on the well's depth and number of stations being profiled. As standard industry mitigation measures would be implemented for VSP activities, and VSP operations are of very short duration, the impact is considered insignificant and will not be assessed further here."

Within this section, there is no citation to corroborate the accuracy of this statement. Because the details of the system have been omitted, noise levels and potential noise impacts cannot be assessed. This is an oversight. Sub-floor seismic exploration has been found to exceed amplitudes of 200 $dB_{peak\text{-}to\text{-}peak}$ re 1μP [33,34]. By the study's admission, surveys would take 8-10 hours each. Given the potential for six wells, this may equal up to as much as 60 hours of persistent high energy pulsed sound. Given the broad base of literature on the negative impact of seismic exploration on marine animals, not including this in the EIA is a significant oversight that may result in negative consequences ranging from the cessation of important behaviors including foraging and breeding, to death [26]. Seismic surveys are known to impact marine mammals by inducing behavioral changes and stress [15], and impact invertebrates that are a significant prey resource to both marine mammals, turtles, and fishes [26]. Thus, consequences associated with even short duration seismic surveys should not be overlooked.

Given the potential loudness of VSP, these sounds may propagate long distances and/or have intense localized effects. No effort was made to include the potential detection range of this sound source for this study, nor to quantify the potential impact to sound sensitive species that may fall within acoustic range, nor to mitigate impacts of VSP noise. (See SOUND PROPAGATION below).

ALTERATIONS ANTHROPOGENIC NOISE WILL MAKE TO THE NATURAL SOUNDSCAPE: While the study considered many baseline ecological and geophysical features of the proposed project region, no baseline soundscape assessment was made. Page 116 of the study states that:

> *"Natural ambient noise will vary considerably with weather and sea state, ranging from about 80 to 120 dB re 1 μPa (Croft & Li 2017)."*

While not technically incorrect, this statement broadly described ambient noise conditions and is insufficient to assess natural occurring ambient sound level in this region, or to compare natural ambient noise levels to this region. No effort was made to quantify what naturally occurring sound levels were for this region, what naturally occurring sources of sounds were present in this region, or what seasonal and temporal cycles in ambient sound levels exist that may be ecologically important cues. 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 therefor to assess noise impacts.

Given that marine organisms use sound for navigation, prey detection, and foraging, alterations made to the natural soundscape will have ecological consequences that may be severe. If this region is generally below average ambient noise levels, the relative change associated with the proposed activities may have more deleterious impacts than if the relative change in noise levels is minimal. An adequate baseline assessment of the acoustic properties of the soundscape including biological sources of ambient sound (biophony), environmental sources of ambient sound, and ambient sound levels is needed to complete an assessment of noise impacts. The Applicant did not assess this.

SOUND PROPAGATION: The study acknowledges that the sound generated by the proposed activities overlaps with the hearing of marine fauna. On page 118-119 section 4.3.4 the study states that:

> *"The noise generated by well-drilling operations in general and by the current project in particular, thus falls within the hearing range of most fish and marine mammals and would be audible for considerable ranges (in the order of tens of kms) before attenuating to below threshold levels.*

The actual range that the sound from this project is capable of travelling before attenuating before exceeding a biologically meaningful threshold can only be determined through either in situ sound propagation experiments or through propagation modeling. This was not done for this region. In section 4.3.4 on page 120 study states that:

"For another deep-water well-drilling project off the southern Namibian coast, it was estimated that noise from project activities would decrease to below the estimated median ambient background level (100 dB re 1µPa) within a distance of 14 - 32 km from the drill site, depending on the specific vessels used, the number of support vessels operating and the scenario."

While this may be true there are several issues with this statement. First, sound attenuation is site specific and is linked to bathymetry, water temperature, seasonality, and bottom substrate and density among other variables. Thus, propagation modeling from one area is not applicable to a different one. Second, this statement fails to include information on the ambient noise bandwidth, how the dB value was calculated (RMS, peak, or peak-to-peak). Third, in the absence of soundscape analyses it is unknown whether or not 100 dB is anomalously high for this particular region. Median ambient noise levels in this region may more regularly fall well below 100 dB re 1 μPa (in a given bandwidth, with a known pressure measurement). Finally, the southern Namibian coast lies in the Atlantic Ocean, while this site lies in the Indian Ocean. In this instance the Applicant assumes identical sound profiles for sites separated by hundreds of miles and in two different oceans. This is insufficient.

Given the amplitude of the sources and location of proposed activities, one also must consider the possibility of sound travelling great distances within the SOFAR (Sound Fixing and Ranging) channel. The SOFAR channel is a horizontal layer of water found in the ocean at which depth the speed of sound is at its minimum. Sound that enters this naturally occurring channel has the potential to travel for hundreds of kilometers. At mid-latitudes this channel occurs at between 800-1000 meters depth. Sounds produced at depth (such as drilling) can travel through this channel and possibly to great distances- upwards of 900 miles (see https://oceanservice.noaa.gov/facts/sofar.html). Alternatively, sound paths from a source near the surface (like vessels or drill ships) can come together, creating regions of higher sound pressure at about the same depth as the source at 50-60 km intervals away from the source (DOSITS.org). Given the proximity and direct overlap between the proposed drilling regions and MPAs, CBAs, and EBSA, noise will inundate important ecological habitats. The proposed drilling region overlaps exactly with areas that were designated by the KZN Biodiversity plan to be irreplaceable or optimal habitat. The likelihood of noise impacting marine systems in this context is particularly pertinent for the CBA in the Protea Banks area and the Sardine Route which are within approximately 30 km of the proposed drilling location. Protea Bank, based on the study report, contains a cold-water coral system. Larval corals rely on reef sounds to determine where to settle; disturbance to reefs and associated soundscapes negatively impacts coral settlement, and thus continued reef building [28,35,36]. The Sardine Route is an important migratory corridor for several fish species (including the location of the large scale "sardine run") - and thus is an important ecological feature whose disturbance may have far ranging ecological consequences. Moreover, quiet biological sounds associated with important prey species in mesopelagic regions – including habitats similar the MPAs adjacent to and the CBAs and EBSAs within the study region – appear to be used as a cue for foraging megafauna (see Baumann-Pickering et al. 2021 for details). Thus, anthropogenic noise at even low levels in these regions may mask biologically relevant sounds associated with predator foraging. The general risk associated with anthropogenic noise in biologically sensitive or protected areas cannot be effectively assessed in the absence of robust sound propagation models that estimate how far

sound travels in this region and what impact drilling, vessel, and helicopter noise may have on the underwater soundscape.

Moreover, while the Residual Impacts portion of section 4.3.4 of the study considers noise "reversibility" to be "High", alterations to the seafloor may permanently change how sound travels in this region. Alterations to the sea floor result in changed bathymetry and subsea substrate density, which impacts how sound travels (DOSITS.org). It is argued that this study will not cause permanent changes to the underwater soundscape, however alterations to the substrate may in fact result in a change in the quality of sound and distance sound is capable of traveling, and thus alters how natural sounds are perceived by marine organisms in this region. Animals use sound as a cue to inform migration [16,37], habitat suitability and settlement (i.e. where juvenile animals select to grow and populate) [35,36,38]. Permanent alterations to the seafloor may change the soundscape permanently. Sound propagation modeling should be used to assess the risk associated with permanent soundscape alteration.

Given the proximity, and in some cases, overlap between the proposed project region and MPAs, CBAs, and EBSAs, inappropriately assessed noise pollution may have deleterious impacts on sound sensitive species including odontocetes, baleen whales, turtles, fishes, and planktonic organisms that make up the base if the food web. Per the study:

> *"Block ER236 overlaps with three CBAs, namely iSimangaliso Wetland Park extension, and Offshore Areas 20 and 21. Of these the iSimangaliso Wetland Park extension, and Offshore Area 20 have irreplaceable CBAs, which fall within Block ER236. The southern area of interest for well drilling falls within the irreplaceable portion of Offshore Area 20."*

Noise produced from within the drilling site cannot be physically contained and will inevitably inundate critical biodiversity locations that overlap spatially with proposed drilling and associated vessel and helicopter activities and may also inundate nearby areas. This requires careful consideration given the known impact of noise on marine mammals (stress, behavioral responses, reduction in foraging[15]), fish (behavioral responses, physiological responses, antipredator responses, death[8,24]), larval invertebrates (reduction in settlement, larval deformation [19,26,39]), and pelagic zooplankton (death[40]). Said plainly, the potential for anthropogenic noise to impact ecologically important areas may harm, alter, or lead to death or population decline across a wide range of taxa and life stages that make up both ends of the trophic web. Because noise cannot be contained to the drilling site due to vessel and helicopter transfers, the impacts of noise are further reaching than the directing region of interest and must include coastal and adjacent pelagic areas as well.

PHYSIOLOGICAL RESPONSES Anthropogenic noise has the ability to cause physiological stress, alter metabolic rates, induce embolisms, alter life history traits, and cause permanent or temporary loss of hearing[6,12,21,23,41,42], Under the description of potential impacts (Section 4.3.4, page 117), the study acknowledges that noise may cause direct physical damage to hearing. Beyond this acknowledgement, no mention is made of the physiological impacts of noise in taxa either within or near the proposed drilling sight, or along the transit path for vessel and helicopter tenders. Moreover, because the study failed to adequately characterize sound sources and sound

source levels, it is not possible to determine if noise levels fall below that which would result in hearing loss. Similarly, the effects of duration (from helicopter noise, vessel noise, and drilling operations) was not quantified. The study states in Section 4.3.4 Page 20 that:

> "*Unlike the noise generated by airguns during seismic surveys, the emission of underwater noise from drilling operations and associated drill unit and tender vessel activity is thus not considered to be of sufficient amplitude to cause direct physical injury or mortality to marine life, even at close range"*

This disregards the role that duration plays in direct injury (hearing loss) in marine species. As noted above- longer duration exposure to lower amplitude noise can result in temporary hearing loss in marine mammals [2]. Further, consideration was not paid to fish (commercially and ecologically important) invertebrates (essential for trophic transfer and reef building), nor was uncertainty accounted for.

As a boundary-less medium, the ocean does not provide structure preventing the entrance or exit of organisms from impacted areas. Animals that experience a physiological response to noise when in close range to anthropogenic noise sources, may continue to experience that physiological response when they exit the region and travel to nearby MPA, CBA, and EBSA areas. Physiological responses alone and in combination with behavioral responses may result in population level cumulative effects that have not been analyzed in this study.

BEHAVIORAL RESPONSES: The study broadly refers to behavioral responses in the description of potential impacts (Section 4.3.4, page 117 of the Marine Study Annex in the EIA), but only directly considers masking of sounds and displacement, and offers minimal mitigation to avoid acoustic masking. There are several additional behavioral responses that were not considered that have important impacts for marine mammals, economically and ecologically important fish species, pelagic plankton, and invertebrates. Among these taxa, ambient noise results in the cessation of feeding in multiple cetacean species [14,43], the cessation of foraging activity in invertebrates and fishes [8,22,26], and the cessation of egg laying and reproduction in invertebrate and fish species (de Soto, 2016; Popper and Hastings, 2009). These biologically critical behaviors are as important to the fitness of the individual and health of the populations and have not been assessed in the study.

KNOWN IMPACTS ON FAUNAL COMPOSITION & MIGRATIONS: The Applicant proposed – but did not appear to commit – to conduct exploration and drilling activities between November and March; however according to the EIA team's report, both humpback whales and right whales will be present in summer months and again in the months of October and November (Table 1 and Table 9 within the Marine Study Annex). During this period these species will be departing higher latitude breeding grounds and migrating southward toward the Southern Ocean for foraging ("Southern Right Whale"; page 63, "Humpback Whale; page 64, Marine Study Annex). Cows with not-yet weaned calves are among this demographic. Cow-calf communication in both humpback whales and North Atlantic right whales is acoustically cryptic (quiet and travels across only a short distance); as a result cow-calves in these taxa are particularly susceptible to acoustic masking [44,45]. Because light doesn't attenuate well underwater, sound is often the only sensory modality available for maintaining communication. If cow-calf

communication is acoustically masked this may result in the separation of mother and calf at a critical nursing period during the calves first migration. This is particularly relevant given the recent decline in Southern right whale abundance and inter-calf-intervals ("Southern right whales", Marine Study Annex), and given that humpback cow-calf pairs are often among the last the migrate southward, and thus likely to be in the cohort that would be disturbed by noise in the month of November and/or any time of temporal overlap with drilling operations ("Humpback whale": Marine Study Annex).

Similarly, the proposed timeline for drilling overlaps temporally with the migration and nesting of loggerhead and leatherback sea turtles that come ashore to nest between mid-October and mid-January each year (Page 52, Marine Ecology Appendix) and overlap spatially with the proposed area of impact. The study states that:

> *" The southward and offshore extension of the iSimangaliso Wetland Park MPA was one of the network of MPAs approved by Cabinet on 24 October 2018. The inshore regions of the northern portion of Block ER236, coincide with the inter-nesting migrations for leatherbacks, but the areas of interest for well drilling lie offshore and to the south of the inter-nesting range."*(Page 52, Marine Study Annex)

Given this timeline of sea turtle nesting and proposed drilling, it is both likely and possible that turtles migrating inshore to breed will overlap with the proposed activities and be exposed to noise. This migration was not adequately considered, despite this population being " genetically unique…and thus globally important populations in terms of conservation of these species" (Page 52, Marine Study Annex). Further, leatherbacks and loggerheads, rely on pelagic prey species throughout their migration and non-nesting seasons. These prey species may be sensitive to anthropogenic noise (see above).

INCORPORATING UNCERTAINTY and NOISE MITIGATION: While much research on the topic of anthropogenic noise impacts is definitive, there are still many data deficiencies. As a result, many significant risks to marine fauna associated with anthropogenic noise likely exist though have not been thoroughly described. Section 2 of the International Whaling Commission's (IWC) Resolution 2018-4, Resolution on Anthropogenic and Underwater Noise – which the EIA specifically indicates as a relevant document for developing mitigation plans for this proposed project – states that the Commission

> *2. Further agree that, in line with the precautionary approach, the lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to address the effects of underwater noise (or other potential threats).*

Spoken plainly, a lack of information is not grounds for ignoring the potential threats of anthropogenic noise when cost effective solutions are available. In the case of the ENI proposed drilling project there is evidence from the literature that anthropogenic noise causes a significant biological threat to marine organisms throughout trophic levels (benthic fauna, fish, marine mammals, sea turtles), but there are also data deficiencies acknowledged within the study (e.g., Table 5, Table 6, Table 9 of the Marine Study Annex). The lack of research resulting from this exact region on these specific faunal communities is not grounds for ignoring potential noise

impacts, rather it is a greater indication for the need of baseline research in this region prior to development, and a need for careful mitigation measures.

Noise mitigation measures should include the two proposed within the study (hull cleaning, minimal low-altitude overflights) as well as those proposed by the International Maritime Organization and in the peer reviewed literature that were not included in the EIA or the study. Current proposed noise mitigations are inadequate. Mitigation should include reductions in ship speed (IMO, "Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life." *MEPC* (2014)), and/or convoying ships to reduce ambient noise [46]. The Applicant should commitment to reducing or ceasing drilling activities in the presence of sound sensitive species, and during summer months when marine mammal, fish, and turtle migration is likely to be impacted. An observer should be present at all times to identify noise sensitive species if/when they arrive so that drilling and associated operations can be paused. Noise cessation of significant duration (weeks to months) should be implemented in between drilling activities, if additional wells are approved. Engines, including generators, of vessels and helicopters should be disengaged when not actively transporting personnel. A firm commitment to noise mitigation beyond maintenance and overflights is essential.

INTERRELATEDNESS OF NON-HUMAN ORGANISMS WITHIN AN ECOSYSTEM AND HUMAN USERS WHO RELY UPON THEM: To best understand and mitigate the potential adverse effects of vessel noise on marine organisms requires a collaborative and integrated effort on the part of stakeholders, industry professionals, and scientists. Such efforts, known as an eco-centric approach, or an ecosystem-based approach, should seek to address environmental concerns *in context to and in connection with* both the ecological and social needs of targeted ecosystems. The applicant failed to do this throughout the study by instead isolating species and taxa with no reference to their interrelatedness. This is most obvious in the case of noise impacts on fish, which are both a prey species and commercially important, and invertebrate, which make up the base of the food web in some cases and are ecosystem engineers in others.

A primary tenet of an eco-centric approach is that the scope of mitigation and prevention. should address ecosystems in their entirety- including the role of humans. This includes the acknowledgment that human well-being is intrinsically connected through the delivery of ecosystem services across a range of scales to ecosystems themselves. In this regard the threat of pervasive anthropogenic noise in the region of interest is not only a hazard for marine organisms, but also a potential threat to the human stakeholders associated with the coastal ecosystem in which these marine organisms reside. There is ample need for continued investigation on the impact of anthropogenic noise associated with the proposed project in the eco-centric context. The resilience of the marine organisms in this region has not yet been quantified, and the potential ecological and social trade-offs of damaging or displacing organisms from this ecosystem are great.

OPINION: It is my opinion that the findings on the impacts of anthropogenic noise in the Annex D1 Marine Ecology Report have not been adequately assessed. In my opinion, the study did not include the relevant information needed to determine the impact of noise resulting from the proposed activities are ‘minor. The study failed to address the following critical topics pertaining to the impact of anthropogenic noise (reiterated from above):

14. Failed to consider the impacts of anthropogenic noise on commercially important species

15. Failed to consider the impact of anthropogenic noise on important prey species

16. Failed to adequately describe potential sound sources and amplitudes in a comparable and relevant way

17. Failed to include potential impacts of Vertical Seismic Profiling

18. Failed to adequately quantify baseline ambient sound levels

19. Failed to adequately quantify naturally occurring contributions to the marine soundscape

20. Failed to adequately model/measure sound propagation in this region, which may impact MPAs, CBAs, and EBSAs

21. Failed to consider the impact of vessel noise on marine areas outside of the immediate drilling range including coastal areas and along vessel

22. Failed to consider the physiological effects of anthropogenic noise on sound sensitive species

23. Failed to adequately consider the timing of migration of protected species

24. Failed to incorporate IWC Resolution 2018-4

25. Failed to consider impact of noise on the ecosystem holistically, including a failure to consider the links between trophic levels (e.g., predator and prey), and links between ecosystems and economics (e.g., commercial fish and fisheries).

EXPERTISE:

I am a postdoctoral research associate at the Cornell University K. Lisa Yang Center for Conservation Bioacoustics where I use bioacoustics to study human impacts on marine organisms. I have a PhD in Wildlife Sciences from the department of Fisheries, Wildlife, and Conservation at Oregon State University with a specialization in marine bioacoustics and underwater noise. I have a MS in Marine Resource Management from the College of Earth Ocean and Atmospheric Sciences at Oregon State University. My MS thesis focused on marine mammal bioacoustics and communication; my dissertation research investigated the impact of vessel noise on marine mammals. I am an author on over a dozen peer reviewed bioacoustic research articles on taxa ranging from humpback whales and harbor seals to toadfish. I have a decade of experience conducting marine bioacoustics research.

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