MARINE ACOUSTIC ECOLOGY EXPERT COMMENTS ON DRAFT ENVIRONMENTAL AUTHORISATION FOR THREE PROPOSED GAS-TO-POWER POWERSHIP PROJECTS LED BY KARPOWERSHIP SA (PTY) LTD –

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OVERVIEW: This report contains an expert opinion assessing the scientific soundness of documents and proposed management/mitigation actions relating to three Gas to Power - Powership Projects led by Karpowership SA (PTY) Ltd. The proposed project locations include: (1) Port of Ngqura (on the Southeastern side of South Africa), (2) Richards Bay (near Durban), and (3) in Saldanha Bay (near Cape Town on the West Coast of South Africa). The projects involve the generation of electricity by means of mobile powerships to be berthed in the marine environment. Additional components of the projects that will interact most directly with marine ecosystems include Floating Storage and Regasification Units (FSRU), gas pipelines, and Liquid Natural Gas Carriers (LNGC). Specifically, this report is concerned with whether the draft underwater noise assessments and background reports (hereafter 'the studies') and the associated draft Environmental Impact Assessment reports (DEIArs) and Environmental Management Program reports (EMPrs) adequately assessed the environmental impact of anthropogenic noise and vibrations associated with the proposed projects and associated activities. Anthropogenic noise will be broadly addressed, with specific emphasis on suitability of the studies and DEIArs to address impacts to the marine environment. Particular reference will also be made to acoustics-relevant findings made by decisionmakers in the Records of Refusal and subsequent appeal decision issued by the Department of Forestry, Fisheries, and the Environment of the Republic of South Africa after Karpowership's first application for environmental authorization for the same projects at each location.

These projects collectively compare acoustic measurements made at each location with a single technical study to predict possible noise levels emanating from the powership. All three DEIArs and studies repeat language, indicate similar mitigation strategies, and rely on the same scientific and technical references. As such, this report will address the three independent locales and the associated studies and DEIArs collectively, noting differences in the ecology of the three regions as needed.

This report comments specifically on the following documents and appendices:

1. DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT: The Proposed Gas to Power Powership Project at the Port of Saldanha Bay and associated evacuation route within Saldanha Bay Local Municipality, West Coast District, Western Cape. DFFE REF NO: 14/12/16/3/3/2/2006
    1. Appendix 6: DRAFT ENVIRONMENTAL MANAGEMENT PROGRAMME (EMPR) FOR THE PROPOSED GAS TO POWER VIA POWERSHIP PROJECT AT PORT OF SALDANHA BAY AND ASSOCIATED EVACUATION ROUTE WITHIN SALDANHA BAY LOCAL AND WEST COAST DISTRICT MUNICIPALITIES, WESTERN CAPE. DFFE REF NO: 14/12/16/3/3/2/2006

2. Appendix 9 B-2: Baseline Underwater Noise Assessment
3. Appendix 9 B-1: Underwater Noise Assessment

2. DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT: Proposed Gas to Power via Powership Project at Port of Richards Bay, uMhlathuze Local Municipality, KwaZulu-Natal DFFE REF NO: 14/12/16/3/3/2/2007
    1. Appendix 6: DRAFT ENVIRONMENTAL MANAGEMENT PROGRAMME (EMPR) FOR THE PROPOSED GAS TO POWER VIA POWERSHIP PROJECT AT THE PORT OF RICHARDS BAY AND ASSOCIATED EVACUATION ROUTE WITHIN UMHLATHUZE LOCAL MUNICIPALITY, KING CETSHWAYO DISTRICT, KWAZULU-NATAL DFFE REF NO: 14/12/16/3/3/2/2007
    2. Appendix 9 B-2: Baseline Underwater Noise Assessment
    3. Appendix 9 B-1: Underwater Noise Assessment

3. DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT: The Proposed Gas to Power Powership Project at the Port of Ngqura within the Coega SEZ, Nelson Mandela Bay Metropolitan Municipality, Eastern Cape DFFE REF NO: 14/12/16/3/3/2/2005
    1. Appendix 6: ENVIRONMENTAL MANAGEMENT PROGRAMME (EMPR) FOR THE GAS TO POWER VIA POWERSHIP PROJECT AT PORT OF NGQURA AT NELSON MANDELA BAY METROPOLITAN MUNICIPALITY, EASTERN CAPE. DFFE REF NO: 14/12/16/3/3/2/2005
    2. Appendix 9 B-2: Baseline Underwater Noise Assessment
    3. Appendix 9 B-1: Underwater Noise Assessment

Abbreviations will be used when referencing sites, studies, and the DEIArs and EMPrs. References to the project at Port of Richards Bay, uMhlathuze Local Municipality, KwaZulu-Natal will be indicated with RB, the project at Port of Ngqura within the Coega SEZ, Nelson Mandela Bay Metropolitan Municipality, Eastern Cape will be indicated with PN, and the project at the Port of Saldanha Bay, Saldanha Local Municipality, Western Cape will be indicated with PS.

SUMMARY OF OPINION: The Underwater Noise Assessments and associated Baseline Underwater Noise Reports (studies) failed to adequately demonstrate that noise will not have significant ecological consequences at the three proposed locations. This is in large part due to (1) the failure of the studies to acknowledge the anthropogenic noise associated with this project as chronic, (2) the failure of the study to adequately assess underwater noise conditions at meaningful temporal scales, and (3) the failure of the studies to consider impacts to the broader marine community, including benthic organisms and invertebrates. As such, the mitigation actions proposed in the associated DEIArs are founded on an erroneous assessment of noise impacts, and they fail to meaningfully address the possible or likely impacts of anthropogenic noise to the marine environment associated with the powership projects.[1]

[1] Powership projects here are defined as powership operations including the FSRU and LNGC.

I have structured my analysis within the following sections:

A. GENERAL INTRODUCTION TO ANTHROPOGENIC NOISE IN THE MARINE ENVIRONMENT
B. RELEVANT DEFINITIONS AND EXPLANATIONS
C. TECHNICAL FAILURES AND INSUFFICIENCIES ASSOCIATED WITH ACOUSTICS STUDIES
D. SPECIFIC FAILURES AND INSUFFICIENCIES ASSOCIATED WITH DEIAr ASSESSMENTS AND MITIGATION MEASURES
E. SUMMARY OF MAJOR FAILINGS OF THE UNDERWATER NOISE ASSESSMENTS AND ASSOCIATED EIARS AND EMPRS

A. GENERAL INTRODUCTION TO ANTHROPOGENIC NOISE IN THE MARINE ENVIRONMENT

Anthropogenic noise is sound produced by human activities, including infrasonic (below the range of human hearing) vibrations, and ultrasonic (above the range of human hearing) vibrations, and sound audible to the human ear. It poses a well-established threat to many types of organisms[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 most important sense [9,10]. Among its impacts, anthropogenic noise has been documented to limit acoustic communication, displace organisms, 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 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 a bioacoustician on the assessment team with deep knowledge of both the physics of sound as well as the impacts of noise on ecology. Because the properties of sound underwater vary significantly from the properties of sound in air or through land, a specialist is needed to assess underwater noise impacts on both the environment and ecology. Because regions and ecosystems are site specific and unique, assessments must be made relevant to a specific location.

For most marine organisms, sound is critical to life function. Social cetaceans and seabirds including whales, dolphins, and penguins rely on sound for communication, foraging, and pod cohesion [17]. Bottom-dwelling animals, fishes, and invertebrates also rely on or respond to sound in their environment. For example, larval invertebrates and fishes use sound to know when and where to leave their open water life stage and settle into adulthood [18,19]. Scientific literature on how marine organisms respond to anthropogenic noise includes behavioral responses, changes in organism presence or absence, physical responses including hearing loss, physiological responses including stress, mortality, and demographic shifts including reduced reproductive

success or larval development, and displacement[20–22]. As such, any proposed activity that is believed to be sound producing may have significant consequences throughout the ecosystem.

B. RELEVANT DEFINITIONS AND EXPLANATIONS

1. Characterizing Sounds

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

- Duration: how long each signal lasts
- Frequency (or pitch): how high, low, or broadband (ranging simultaneously high and low) a sound is
- Pulsivity: whether a sound is impulsive (like a series of bangs from fireworks) or continuous (like traffic noise)
- 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:

- 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).
- 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.
- 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.
- 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.

The major flaws associated with how the noise was characterized in the acoustics studies and the associated assessments can be directly related to (1) mischaracterization of chronic noise as discrete, and (2) lack of characterization of noise frequency and related impacts.

The acoustic studies only considered the impact of discrete, continuous noise (noise that continues for approximately 16.5 hours for a single day) on the broadband noise levels (high and low pitch) of an already impacted ecosystem. The reality is that the powership projects will generate chronic continuous noise that is likely to significantly elevate ambient sound levels in the low and mid-frequency ranges that matter most to most marine mammals, fish and invertebrates.

2. Determining Ecological Baselines

In order to determine if elevated noise levels will impact an ecosystem, it is necessary to first understand what the environment sounds like in the absence of human impacts. This process is expressed as "determining the baseline". The ecological baseline is defined as the ecological value of a site before anthropogenic disturbance. The following elements make up an acoustic baseline:

- Ambient sound levels in the absence of human disturbance
- Ambient sound levels measured in ecologically relevant frequency (pitch) bands
- Temporal patterns of natural sound at diel (daily) and seasonal scales

The absence or mischaracterization of any of the aforementioned baseline soundscape elements may have significant implications for ecological interpretation, and may lead to ecological weakening, or demise. For example:

- Erroneously assigning acoustic baselines: An urban task force is asked to determine whether traffic noise is elevating the foraging habitat of a rare bird in an urban park. The task force measures ambient noise levels when only a tractor trailer truck is driving alongside the park and then measures again during moderate traffic flow. Using the period with the tractor trailer truck as the acoustic baseline, the task force determines that noise has no impact since noise levels were equivalent between the two periods. A second task force challenges the results, and compares a traffic free recording (made on a Sunday morning at 9am) with a traffic-full recording (made on a Monday morning during 9am rush hour) and documents a 300% increase in ambient noise. In this case, there is a clear increase in ambient noise associate with traffic that would have been missed if the acoustic baseline has been mischaracterized.

- Erroneously omitting frequency analysis: The same task force is asked to assess whether the installation of new power lines will negatively interfere with bat echolocation, which occur in the ultrasonic frequency ranges (above the range of human hearing, or >20 kHz). They take measurements and then report that the average sound levels between 1kHz and 30 kHz are higher with the power lines present than without the power lines present, but only by a small amount. In reality, however, the noise levels in the bats hearing and communication range are more than 400% higher when the power lines are turned on, while noise levels in the low frequency range do not change. By averaging the high and low frequency ranges, the task force erroneously concludes that the elevation in noise levels is not ecologically meaningful. In practice noise levels at high frequencies with the addition of power lines are loud enough to cause hearing loss in bats.

- Erroneously omitting temporal patterns of sound sources: A contractor is tasked with quantifying a baseline soundscape. They make recordings for 10-seconds an hour in a habitat for one day in the autumn, outside the typical season when animals in this region are mating and migrating. As a result, the sound of migration and breeding animals is not included in the contractors' report. The contractor erroneously reports that there are no mating or migrating signals in this soundscape, and concludes that elevating noise levels won't have an impact on these sounds. However, for several months every year migrating and mating animals are acoustically present -- the contractors study simply did not record them.

These examples are directly analogous to the major flaws in the way the studies assess the baseline soundscape, which include (1) failure to document noise levels in the absence of anthropogenic noise, (2) failure to examine noise in relevant bandwidths, instead opting to average noise levels across broad bands in order to minimize relevant shifts in noise, and (3) failure to account for diel and seasonal variability in the natural soundscape that would reveal ecologically important sounds.

The acoustic studies considered noise levels containing vessels and other anthropogenic noise sources as the ecological baseline. The difference in noise levels between the undisturbed periods (no anthropogenic noise) and the predicted values (powership noise present) is as much as 40 dB (see baseline sounds in figures below and predicted values in the Underwater Noise Assessments); a 40 dB increase in noise is approximately the difference between a listening to a music on headphones on volume 5 out of 10, and a jet engine running 100 feet away – that is, a 1000-times increase in loudness.

C. TECHNICAL FAILURES AND INSUFFICIENCIES ASSOCIATED WITH ACOUSTICS STUDIES

The studies and technical reports associated with the DEIArs for the powership projects did not sufficiently address the impacts of noise to marine organisms found in and around each project site. Instead, the underwater noise assessments and reports were overly narrow, technically misleading, and minimized impacts to the marine environment through the omission of analyses. The studies misapplied critical scientific literature including noise thresholds and omitted most of the potential impacts of noise to marine organisms.

Further, and importantly, the studies failed to acknowledge in any capacity that the noise produced by the powerships would be long duration (16.5 hours/day over a 20-year period) and thus result in chronic noise impacts. As a result of these serious flaws, the Underwater Noise Assessment almost certainly underestimated the impacts of anthropogenic noise on the marine ecosystem.

These are two key examples among many demonstrating the insufficiency of the Underwater Noise Assessment, upon which an erroneous impact assessment and mitigation measures were then based. The following are the primary failures/insufficiencies of the underwater acoustics assessments and associated reports. These failures were consistent between the three proposed powership locations.

1. Failure to consider chronic noise impacts when determining impact to marine organisms *CRITICAL FAILURE*

The studies rely heavily on two pieces of peer-reviewed literature to support the assertion that noise impacts on cetaceans and fish will be negligible: Southall et al. (2019)[23] and Popper et al. (2014)[24]. However, this literature was misinterpreted because it was not intended to be used for assessing chronic noise exposure—like the kind of noise expected from the powerships—and

therefore cannot be applied to the current Underwater Assessment Studies. The assessment authors assert:

> "*Any risk to marine mammals or fish, as per the guidelines in Southall et al. (2019) and Popper et al.(2014) respectively, will be negligible. The lower order of effect defined in the guidelines, temporary threshold shift (TTS), would only occur when marine mammals of the most sensitive species (VHF cetaceans, i.e. porpoises) remained within 850 m of the Powerships operating at maximum capacity for a full 24 hours.*" (Underwater Noise Assessments)

However, the assessment fails to acknowledge the primary caveat included by Southall et al. (2019) which is that the number outlined in that publication **only applies to discrete sound exposure**. Southall et al. (2019) explicitly states that:

> "*The current criteria remain focused on the derivation of auditory weighting and exposure functions for the purpose of evaluating the potential fatiguing effects Marine Mammal Noise Exposure Criteria: Hearing, Weighting Functions, and TTS/PTS Onset 165 of discrete noise exposure (e.g., TTS/PTS).* ***These approaches are not applicable in evaluating potential auditory effects of chronic noise exposure over periods of weeks, months, or years****."* (Southall et al. 2019)[23]

Given that the expected duration of the powership project is estimated at 16.5 hours per day for 20 years, the associated noise should be defined as chronic (see definition on chronic noise in definitions section above). Noise that continues daily for 16.5 hours for a 20-year duration will undoubtedly impact marine organisms that evolved to rely on sound in an environment free entirely from anthropogenic noise. Given that the noise proposed by the powership activities will continue for decades, the values that the authors of the underwater noise studies rely on to assess the impact of anthropogenic noise on hearing do not apply. The values used in the report can be applied **only to short-term noise exposure.** In the 2019 publication, Southall et al. goes on to state that:

> "*As in human noise exposure criteria, [chronic noise] will require different methods and metrics other than the SPL or SEL metrics used here.* ***Separate criteria are needed to evaluate behavioral responses and broader-scale auditory effects (e.g., auditory masking) and physiological effects (e.g., stress responses).***" (Southall et al. 2019)[23]

Despite this caveat, the studies inappropriately apply the values from Southall et al. (2019) to determine that hearing loss will be negligible. This is not scientifically sound.

The same mistake is made when referring to Popper et al. (2014). The original caption to the exact table included used within the assessment studies to make this determination (Popper et al. (2014) includes the following caveat:

> "*As discussed in the text, there are no data on exposure or received levels that enable guideline numbers to be provided*" (Table Caption, Popper et al. 2014)[24]

The above caveat indicates that it is not possible to include guideline numbers (i.e., threshold decibel levels at which a given response would occur) for fish exposed to chronic anthropogenic noise. Despite this, the study authors rely on this publication and this table as a guide to determine that there is no impact of chronic noise to fish anyway. This is a critical error.

Table 2. Summary of the qualitative effects on fish from continuous noise, from Popper et al. (2014)

(N = Near-field; I = Intermediate-field; F = Far-field)

Type of animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking[4]	
Fish: no swim bladder	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder involved in hearing	(N) Low (I) Low (F) Low	See Table 5-3	See Table 5-3	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

[4] Masking is the inability of a species to hear a sound due to the relatively high level of another noise source.

Despite ample literature describing the need to consider chronic noise impacts and the need to consider effects beyond hearing loss, (e.g., The Effects of Anthropogenic Noise on Animals, 2018 Springer Press and others)[21,22,25,26] the Underwater Noise Assessments and Baseline Underwater Noise Reports fail to consider noise impacts beyond a 24-hour period in any capacity. The scientific assumptions made by the studies are only supported if the powerships run for a single day for the entire project duration. This highly significant flaw nullifies any inference based on these studies.

The failure to consider chronic noise is a significant and fatal flaw of the underwater noise assessment for several reasons. First, the study claimed negligible impact of hearing thresholds in marine fishes based on predicted noise values; however, it is known that chronic low intensity noise with values similar to those predicted by the noise report can cause significant reductions in the hearing capabilities of teleost fishes[27]. For example, one study found that the distance at which fish could acoustically detect reef sounds critical to their survival was reduced by half after being exposed to two-weeks of low-intensity noise at 120 dB re 1µPa (lower than predicted noise around the powership projects based on the studies).[27]

A reduction in hearing thresholds in ecologically or commercially important fish and invertebrates in these regions could have significant implications for commercial fishing. Larval

fish and invertebrates use sound to find nursery grounds, and to determine where to settle (where to take up residence for the growth portion of development). Reduced hearing capacity in fish and benthic organisms will make it difficult or impossible for these organisms to acoustically detect appropriate habitats. Failure to find the appropriate juvenile habitat results in death of larval and juvenile organisms. As a result, deafening will drive the decline of both the abundance and biodiversity of organisms that rely on sensitive areas like estuaries and mangroves.

In marine mammals, chronic noise is associated with elevated stress levels[12], various internal and external organ injuries[20], long term displacement from breeding and foraging regions[28,29], shifts in migratory pathways[30,31], and permanent hearing loss[32]. None of the underwater noise assessment studies considered these chronic noise exposure risks, despite the vulnerability of high frequency cetaceans in the area. Of particular note is the presence of humpback dolphins (*Steno plumbea*) in the RB region and humpback whales in the PS region. As noise sensitive cetaceans, humpback dolphins and humpback whales are highly likely to be disturbed by the impacts of chronic noise, including by experiencing chronic stress, possible reduction in reproductive capability, hearing loss, reduced immune function, displacement, and/or shifts in migration. The studies failed to consider these and other chronic impacts of noise on humpback dolphins and humpback whales. Disturbance to these charismatic cetaceans would also negatively impact the tourism industries in these regions.

This complete omission of a chronic noise assessment is particularly significant, as the inadequate assessment of noise impacts of critically endangered species, including humpback dolphins, was directly stated in the DEIAr Refusal and Appeal Denial document. I am of the strong opinion, that the revised DEIArs and the associated studies remain fatally deficient in the assessment of noise impacts on this and other vulnerable species, particularly due to their failure to consider chronic noise exposure.

2. **Failure to consider impacts of anthropogenic noise on marine life beyond potential hearing loss:**

The studies state directly that sound impacts on marine organisms extend beyond acute hearing loss: "*The main adverse impacts of underwater sound on marine species can be broadly summarised as… auditory injury (either permanent or temporary); and disturbance"* (Underwater Noise Assessments). Beyond this statement, however, the studies fail to address organismal disturbance of underwater noise other than hearing loss, despite the prominence of the topic in the scientific literature and the noise recommendation guidelines that the underwater noise assessments rely on[23,24].

Indeed, according to the studies, the noise associated with the powerships is negligible and "*No risk to fish in the Port of Richards Bay is expected as a result of underwater noise from the Powership installation."* (Underwater Noise Assessment, Richards Bay). The underwater acoustics studies for the Port of Ngqura and Saldanha Bay reach the same conclusion (Appendix 9 B2 p. 21 for each). Yet in reaching this conclusion, the studies have failed to assess the full range of relevant harms from the acoustic impacts of the powerships, categorizing harm only as hearing loss and failing to consider behavioral effects resulting from masking (defined as when a loud sound drowns out a softer sound or when noise is at the same frequency as a sound signal).

Table 1, below, taken from Popper and Hawkins, 2019 [16] shows some of the many potential effects of anthropogenic noise on marine animals. Of these, the underwater noise assessment addressed only hearing threshold shifts, despite an extensive body of literature of additional impacts associated with anthropogenic noise.

Effect	Description
Death	Sound exposure results in instantaneous or delayed mortality.
Physical injury & physiological changes	Physical injury results in temporary or permanent impairment of the structure and functioning of some parts of the body. Physiological changes result in increased stress or other effects that can lead to reduced fitness.
Hearing threshold shift	Loss of hearing, temporarily or permanently, results in decreased ability to respond to biologically relevant sounds.
Masking	Noise results in a decrease in detectability of biologically relevant sounds (*e.g.*, sounds of predators and prey, sounds of conspecifics, acoustic cues used for orientation).
Behavioural responses	Behavioural responses include any change in behaviour from small and short-duration movements to changes in migration routes and leaving a feeding or breeding site. Such responses are likely to vary from species to species, depending on numerous factors such as the animals normal behavioural repertoire, motivational state, time of day or year, age of the animal, *etc.* Some changes in behaviour, such as startle reactions, may only be transient and have little consequence for the animal or population.
No obvious behavioural responses	Animals may show transient or no responses, even if they detect the sound (*e.g.*, to a very low-level sound) or habituation may take place. However, even if there is no response, there is always the possibility that physical injury and physiological changes may take place without the animal showing overt changes in behaviour

Table 1. Potential effects of anthropogenic sound on animals, from Popper and Hawkins (2019)

None of many behavioral responses to masking were considered in the studies despite masking having important impacts for marine mammals, sea birds including the endangered African penguins, economically and ecologically important fish species, pelagic plankton, and invertebrates. Among these responses, ambient noise results in the cessation of feeding in multiple cetacean species [14,33], the cessation of foraging activity in invertebrates and fishes [8,34,35], and the cessation of egg laying and reproduction in invertebrate and fish species[26,16], and likely has similar negative consequences for diving birds that rely on sound for vital life function. These biologically critical behaviors are as important to the fitness of the individual as to the health of the populations and have not been adequately assessed in the studies (marine mammals and fish), or indeed considered at all (invertebrates, African penguins).

This failure of the studies and the DEIArs to specifically consider the ecological impacts of masking resulting from the projects' noise is particularly odd considering that the studies' own table (see Table 2 below) shows that the risk of masking and behavioral responses as a result of the projects is moderate to high. Despite this acknowledgment, and with no evidence, the studies consider the threat to be unsubstantiated.

As a result of these failings, the studies' conclusion that "*no significant disturbance effect to marine mammals as a result of underwater noise outside of the normal operational port noise is anticipated"*(Underwater Noise Assessments) cannot be justified, as it is not supported by the data provided in the assessment itself, or by the existing body of science pertaining to noise impacts on marine species. The fact that the DEIArs and EMPrs in turn fail to provide appropriate mitigation measures to avoid acoustic masking makes this lack of analysis of behavioral effects a fatal flaw in the studies.

3. **Failure to adequately monitor and describe the baseline marine soundscape at ecologically relevant timescales, including to assess seasonality:**

The acoustics studies quantified ambient baseline noise levels at two temporal timescales: 10-second spot recordings were made at multiple locations throughout each region, and a 48-hour continuous recording was made at one location in each region. All recordings were made in the month of either October or November, depending on the locale. This is insufficient to adequately describe the baseline natural soundscape. Sound is temporally variable as animals and environmental conditions shift in response to seasons, time of day, day of the week, and human activities. Ambient noise conditions in November will not be indicative of ambient noise conditions at other times of the year, missing significant sound sources that occur in autumn, summer, and winter. For example, mating is facilitated acoustically for most vertebrate and all known marine mammals. Mating occurs at specific seasons, and not exclusively in November. Similarly, commercial activity varies based on day of the week. Recordings made on Sunday mornings will not be indicative of sound levels during peak commercial activities during the week.

Moreover, this sampling design is woefully lacking. It is akin to monitoring weather at a single location over two days and claiming to have a comprehensive understanding of climate at that location. The 'long-term' monitoring that took place over only a 48-hour time period represents only approximately 0.05% of a complete annual cycle. Noise samples that were said to be indicative of regional ambient sound through each region spanned only 3 repetitions of 10-seconds each (*Background Noise Monitoring Reports*). As such each location was only acoustically monitored for a total of 6.5 minutes. Given that the powership project is expected to span 20 years, and to be operational for 16.5 hours per day, it is impossible that noise values collected over a 6.5-minute span in the month of November provide enough detail to make an adequate assessment to determine noise impacts on the marine system. Sound changes based on time of day, season, and ecological activity. Many signals only occur during specific seasons (e.g., mating, migration) that would not have been captured in such a short duration. Similarly, no effort was made to determine if these very limited samples were indicative of average anthropogenic noise contributions in this region, or if these samples were anomalously high or low. From the scientific methods perspective, this is an embarrassingly low duration sample size to be used to predict impacts that will span decades. Despite this, it was these 10-second spot

values that were used to determine both propagation and likely noise impacts spanning the 20-year project period.

4. **Failure to adequately characterize the existing soundscape**

The studies provided insufficient detail on the context of current sound in the project locations to understand the ecologically relevant impacts of adding the ships into those soundscapes. For example, there was no declaration made of what vessels or anthropogenic sources were present throughout the spot sampling.

Additionally, no effort was made to quantify the total hours per day that anthropogenic noise would contribute to the soundscape should the powership project be approved. The reports indicate that noise contributions will be limited because powership operations will not exceed 16.5 hours a day; however, the report failed to indicate how many hours per day the area is already anthropogenically altered. The addition of 16.5 hours a day of noise in these regions may result in continuous chronic noise in the project regions. This consideration – that an additional 16.5 hours may be a dramatic increase in the temporal noise budget resulting in continuous anthropogenic noise – was not included in the studies or the DEIArs.

Lastly, by the studies' own admission, the ambient noise levels reported during the 48-hour continuous sampling was likely artificially inflated by the mooring system used for the hydrophone. For example, the Baseline Noise Report from PS states that *"Slightly higher noise levels are to be expected using a surface-suspended hydrophone at mid-water, which increases the noise at low frequency and influences the overall noise level"* (Baseline Noise Report, PS, Page 9). These "slightly higher" levels are in fact 6-7 dB which is twice as loud or more than naturally occurring levels, so is in fact a substantial increase in noise. No effort was made to correct these values to accurately reflect the soundscape.

5. **Failure to adequately monitor and describe the baseline marine soundscape at ecologically relevant frequencies:**

Though the studies state that different animals are sensitive to noise in different frequency bands (see *Table -1 Underwater Noise Assessment*, Richards Bay, for an example), they failed to adequately consider the role of noise frequency (pitch), including by leaving it out of their modeling of noise increases. The aggregation of noise across very wide bands, as the studies did, is insufficient to assess noise impacts on marine organisms with specific hearing tolerances and ranges. This means that sound from the projects in frequency ranges that are ecologically relevant for specific species may have been ignored because they were washed out via averaging across too large a frequency range. Given the harms that could result to specific marine species as a result of sound in particular frequency ranges, even where that sound may be lower in decibels than the total sound of the project, this is a major deficit.

Without looking at the primary data directly, which was not provided in the assessments, it is not possible to infer whether there was a significant increase in ambient noise in ecologically relevant bands. However, it is both possible and likely that given the very wide bandwidth over which noise was calculated (1 Hz – 32 kHz) that ecologically significant increases in ambient

noise occurred in certain bandwidths but would have been 'averaged out' when considering noise across such a wide spectrum. This sort of averaging therefore erases ecologically significant information.

Fish, baleen whales, birds (including penguins which are exposed to underwater noise), and sea turtles will be sensitive to low and mid-frequency ambient noise. Though the studies failed to report band-specific ambient noise levels, the powership is likely to dramatically increase noise in these bands, while the higher frequencies may remain less impacted. Looking at the plots that show loudness as a function of pitch included in each Baseline Noise Report, this becomes much more obvious. Noise levels are consistently higher in the low-mid frequency ranges, but less so at high frequency (See Figures 1-3, below).

Standard soundscape analyses by default include examination of ambient sound across multiple frequency bands known as decidecade bands (also known as one-third-octave bands) to ensure adequate assessment of noise across the range of hearing of marine organisms. This allows the ecological significance of the sound to be assessed relative to the hearing level of the marine organisms at risk. The omission of such a frequency-specific analysis in the case of the powerships studies is misleading, as it minimizes noise impacts in the frequency bands most likely to disturb marine organisms. Because the noise levels reported were aggregated over a very wide frequency range (up to 32 kHz, well beyond human hearing) the noise is weighted toward frequencies that are higher than most marine organisms would biologically perceive. Noise levels should have instead been reported in decidecade (also known as one-third-octave bands) levels.

6. Failure to adequately identify baseline natural soundscape characteristics

Considering that one of the goals of the Underwater Noise Reports was to "*Conduct a study of the existing underwater noise soundscape (baseline)"* it is essential to include whether the noise present is the actual baseline (naturally occurring) or anthropogenically altered. Using 10-second samples of an existing disturbed state (vessel noise) as the baseline and comparing this with a predicted disturbed state (powership noise), erroneously suggests that there is 'no impact'in noise levels once the powership is operational. In reality, the studies show as much as a 40 dB difference in ambient sound levels between periods when there are no vessels present (the natural baseline), and predicted values associated with powership operations. A 40 dB increase in noise is translated as being 10,000 times louder. Without a doubt, the powerships causing the environment to be 10,000 times louder will have significant negative impacts on the marine environment.

In several cases, it was clear that the spot samples were made during periods of high noise. Per the example in the introduction, this would be akin to taking ones temperature when one already had a fever. For example, the RB spot samples were loudest near cargo ships (*RB, Baseline Underwater Noise Report*), yet these values were erronesouly used to represent the natural occuring soudscape against which disturbance was assessed. By looking at the data included in the reports, it becomes clear that the altered soundscape, instead of the natural baseline soundscape was incorrectly used to infer that the powership would have no impact. Looking at Figures 1, 2, and 3 below you can see that in the absence of vessels, the naturally occuring

soundscape is much lower. However, the spot samples similar to the higher levels shown in the figures were those used to model impact (*Underwater Assessments)*

The importance of frequency defintion in comparing baselines and altered soundscapes becomes clear when looking at these same plots, which compare quiet and noisy periods based on sound frequency (a.k.a. pitch). In these plots one can see that there are significant increases in ambient noise levels at all frequency ranges associated with anthropogenic noise, but that noise doesn't elevate equally across pitch. The plots in each study demonstrate that noise levels in ecologically relevant bandwidths (i.e., low frequency sound that would impact most cetaceans, fish, turtles, and invertebrates) increase as much as 38 dB in PN, 10 dB in RB, and 25 dB in PS when a vessel passes above periods of relative quiet. The plots, which appear in the Baseline Noise Reports but are not included in the Underwater Noise Assessments, demonstrate the dramatic increase in noise in ecologically relevant frequencies associated with specific additions of anthropogenic activities in these regions. The relatively noise-free periods (the lower lines on the graphs) should be considered the natural ecological baseline; this was not the case for the studies, which used the average ambient noise level as the baseline. Noting the variability in noise periods, one

can see how averaging noise levels across the frequency bands would have a ‘leveling’ effect on overall noise.

When the studies claim that a baseline is “natural” when it is in fact inflated due to the presence of vessels and associated activities, this has the effect of minimizing our perception of the noise impacts associated with the powership projects. This is problematic because the increases in sound associated with the project are in fact quite significant. Reminding the reader that decibels are logarithmic, **a 10 dB increase in ambient noise is indicactive of noise levels that are 10 times the intensity, while a 30 increase is 1000 times the sound intensity**. The increases in the soundscape generated by the powerships are therefore without a doubt ecologically meaningful.

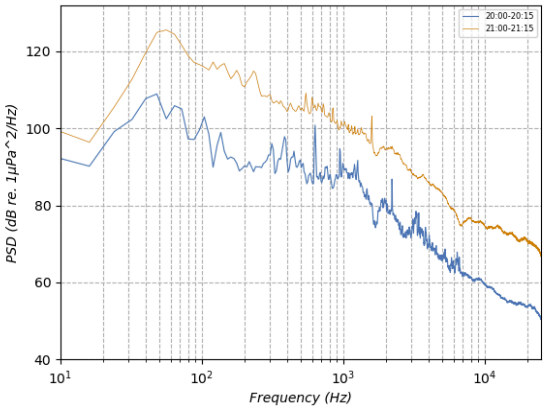

Figure 1- Narrow band frequency plot of a 15-minute sample taken from Richards Bay (Background Noise Monitoring). Yellow line indicates noise levels during a vessel passage, blue line indicates natural sound levels.

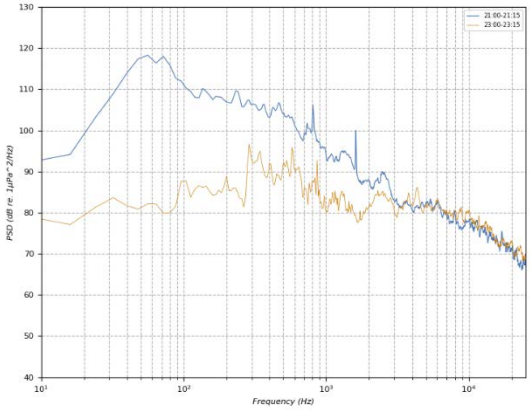

Figure 2- Narrow band frequency plot of a 15-minute sample taken from Port of Ngqura (Background Noise Monitoring). Blue line indicates noise levels during a vessel passage, Yellow line indicates natural sound levels

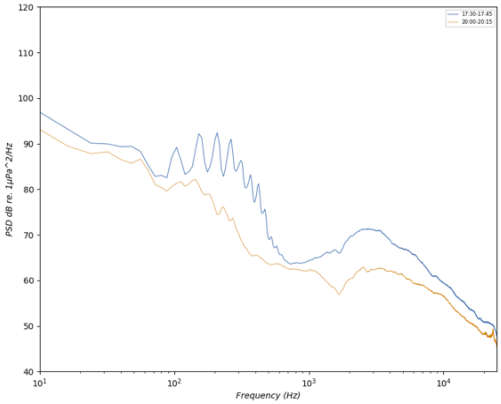

Figure 3- Narrow band frequency plot of a 15-minute sample taken from Port of Saldanha (Background Noise Monitoring). Blue line indicates noise levels during a vessel passage, Yellow line indicates natural sound levels

7. **Failure to consider impacts of noise on ecologically and commercially important species, including commercial fish/invertebrate species and trophic interactions:**

No specific analyses were conducted on the impact of underwater noise on ecologically or economically important species (see Underwater Acoustics Assessments and Baseline Acoustics Reports). Dedicated investigation of the impact of noise on sound sensitive marine species, including marine mammals, commercial fish and invertebrate species, and diving sea birds in particular did not occur. This means that socioeconomic and ecology assessments of the projects could not properly integrate the impacts of underwater noise from the projects, and therefore that the DEIAr had gaps and imbalances as a result.

Anthropogenic noise from various sources (powership operations, vessels, construction), has the potential to negatively impact species important for both small and large scale fisheries, as well as important prey species for birds, marine mammals, turtles and pelagic fishes [36]. Fishes respond to anthropogenic noise in several ways that reduce their fitness. For example, noise reduces their anti-predator response, leaving individuals at higher risk of being eaten. Acoustic masking of breeding sounds can also impact species at the population level, leading to reduced breeding success [8,34,37], temporary or permanent hearing loss, stress [38], and direct or indirect death in fishes and invertebrates[39]. In addition, and more problematic for fisherpeople than for fish, research shows that anthropogenic noise can negatively impact commercial catch rates in teleost fishes. [26,40]

The failure of the studies to include impacts of noise on prey species and fish species important for subsistence and commercial fisheries is particularly problematic given that all of the proposed sites of the powerships contains nursery areas, refuge areas and food sources for numerous marine biota, some of which are commercially important. The sites also all contain multiple sound sensitive marine organisms (including but not limited to pacific humpback dolphins (*Sousa plumbea*) in RB; humpback whales (*Megaptera novaeangliae*) in PS, juvenile fish in PN).

Anthropogenic noise from the operations site may inhibit settlement (habitat selection) and recruitment of fishes and invertebrates in nearby protected or sensitive areas, and thus impact their predators. Broadly, the regions adjacent to the proposed activities, including protected areas, aquaculture sites, national parks, and Critical Biodiversity Areas, may experience long duration (chronic) noise from vessels, powership operations, and/or construction that cause physiological and/or behavioral responses. These important zones include, among others, the *West Coast National Park Marine Protected Area (MPA) Network* which is within 5 km of the PS project site, *Addo National Park Marine Protected Area* which is less than 5 km from the PN site, and multiple *Critical Biodiversity Areas* which overlap (i.e. 0 km distance) with the proposed project site in RB. These noise impacts from the projects present ecologically and economically significant risks to pelagic fishes, lower trophic level bait fish, and invertebrate prey species. A reduction in prey may have fitness consequences for predators, including marine mammals. A reduction in commercial fish may have economic consequences for communities. Moreover, many migratory organisms that seek refuge in protected areas will also have to transit through the operation site in order to reach these protected regions, which may also affect them and in turn the tourism that depends on them.

The DEIArs highlighted the presence and value of invertebrates as a food source around the project areas, despite the studies' failure to address the impacts of noise to these species. Research demonstrates that anthropogenic noise can have acute effects on invertebrates including immobilization, cessation of eating, mating, or egg laying, and changes in swimming behavior.[35] Moreover, many larval invertebrates, as well as corals, shellfish, crustacean species, and fish, 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 from locating suitable habitat. As invertebrates are commercially important and are a critical food sources for marine mammals in South African waters [41], any negative impacts to this food source would have implications for megafauna, many of which have a year-round presence near the proposed activities.

In sum, the studies failed to investigate potential impacts of increased underwater sound on trophic interactions and marine organisms broadly, and failed to assess the commercial and ecological harms that project noise would be likely to cause.

8. Lack of site-specific sound propagation analysis

Sound propagation in the marine environment is highly context-dependent. Low frequency sound travels at a different speed and with a different level of interference than high frequency sound. In shallow water environments, and those with many bathymetric features (i.e. varied depths and seafloor types) – as is the case in the proposed powership sites – sound propagation can be complex and result in pockets of high amplification zones, and areas of sound shadows. Despite the highly site-specific nature of sound, no effort was made to adequately measure how sound will move through the specific environments surrounding the projects, and no effort was made to consider the differences in how sound travels as a function of frequency.

One of the largest oversights of the acoustics studies was the lack of acknowledgement that frequency (also known as pitch) plays in both the physics of sound and the biological impacts of sound. Failure to model how sound at different pitches propagates through the marine environment, amounts to continued ignorance of how far and at what distance sound will travel, and how far the impact will reach. Further, because the authors of the studies aggregated sound levels across very wide bandwidths, as discussed above, accurate biologically relevant propagation cannot be inferred based on their report.

While it is likely that the presence of the breakwaters minimizes sound transmission beyond these features, not enough information was provided in the report to determine if this is accurate because a full frequency specific propagation study did not take place. Full propagation modeling, that accounts for frequency-specific sounds is essential for determining impacts. This is a failure throughout the studies.

In Coega specifically, the inadequate soundscape characterization used to determine that noise levels at Jahleel Island would not be impacted because the island is 1000 m beyond the powership is erroneous. Audibility is determined by the loudness of a signal above the background sound levels. True background sound levels were not measured for this region and propagation not adequately modeled, therefore audibility cannot be assessed. Similarly, low frequency sound and high frequency sound do not travel the same in the marine environment. No

attempt was made to model noise levels in critical habitats in ecologically relevant frequency bands. The averaging effect (mentioned throughout) would minimize potentially high sound levels in relevant bands that likely would extend well beyond 1000 m from the powership.

Additionally, alterations to the seafloor associated with construction may permanently change how sound travels in these locales. Alterations to the seafloor result in changed bathymetry and subsea substrate density, which impacts how sound travels[47]. Substrate changes may result in a shift in the quality of sound and distance sound is capable of traveling, and thus alter how natural sounds are perceived by marine organisms in this region. As noted elsewhere, this shift would be meaningful to marine organisms, as they 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]. Sound propagation modeling should therefore be used to assess the risk associated with permanent soundscape alteration.

D. SPECIFIC FAILURES AND INSUFFICIENCIES ASSOCIATED WITH DEIAr ASSESSMENTS AND MITIGATION MEASURES

Stress: According to the Impact Management Action section of *Protection of Flora and Fauna* found in each of the EMPrs "*Noise pollution must be minimized to ensure faunal inhabitants are not stressed*." However, the Underwater Noise Assessments failed to include any quantitative or qualitative assessment methods, or commentary on the role of anthropogenic noise on faunal inhabitant stress. Therefore, it is not possible for this management action to be adequately assessed. Further, the proposed mitigation method, fortnightly awareness training and incident reporting, is insufficient to mitigate noise-driven stress on sonic fauna.

Unfounded DEIAr risk assessments: Because of failures and insufficiencies in the Underwater Noise Assessments, the DEIArs erroneously determined that underwater noise has "No impact". This is not scientifically sound. Further, it is directly contradicted by the results of the marine ecology and marine avifauna report impacts sections, which conclude that "The effects on the marine ecology in the receiving water body due to … increased noise and vibration levels" are "Medium-High" before mitigation and remain "Medium" after mitigation.

Contradictions also exist between the Tourism Impacts and Risks sections of the DEIArs and the Underwater Noise Assessments. The former designates the impact of noise on tourism to be low, without any assessment of the likely impacts of noise on targeted tourism species including humpback dolphins, penguins, and other marine megafauna. In contrast, the Underwater Noise Assessments suggested that disturbed animals would leave impacted areas in order to minimize noise exposure, which would negatively impact tourism operators as animals were displaced from current viewing locations.

Duration: The DEIArs and EMPrs lean heavily on the reduction of operational times from 24 hours to 16.5 hours per day. Given the lifespan of the project is predicted at 20 years, 16.5 hour run times per day still constitute chronic ambient noise that radiates throughout the marine environment. No assessment of chronic noise was made to determine long term impacts on marine fauna in the underwater noise assessment. Despite this, in the scoring table, *Impacts of*

increased noise on the marine ecology, the DEIArs indicate that any impacts are reversible. There is no research (field or desk) to support the supposition that chronic noise impacts such as those that would be generated by running the powerships 16.5 hours per day are reversible. As noted above, chronic noise impacts have been demonstrated to cause physiological stress, habitat abandonment, reduced foraging effort, hearing loss and potential population declines.[20,27,29–32]

Fishing Impacts: The RB DEIAr indicates that "the extent to which fish will be affected [by noise] is unknown" (RB, DEIAr, Page 303) and that it is possible that "fisheries may experience shifts in the physical distribution of populations of target species" (RB, DEIAr, Page 303). The report goes on to state that "overall catches will not necessarily be affected as any displacement would only occur over a relatively short range, expected to be of the order of hundreds of metres." (RB, DEIAr, Page 303) This conclusion that displacement is only expected to occur over a relatively short range is not supported by scientific knowledge, and is based on the faulty evaluation in the Underwater Noise Assessment, which failed to consider long-term noise impacts. As noted above, even low level chronic noise impacts catch rates and hearing in many fish species[27,42] According to the most updated literature on the subject:

> "*It is not only the level of the sound but also its frequency range, rise time, duration, repetition rate, and a number of other parameters that may be important in determining [noise] effects*" – (Hawkins and Popper (2018)[22]

The DEIArs'conclusion that commercial fisheries will go relatively unaffected by the projects is therefore unfounded, according to existing knowledge of noise impact on fishes.

Impacts to Invertebrates: Both the RB DEIAr and the NP DEIAr cite de Soto (2016) when they state that "marine invertebrates may be impacted by underwater noise; however, that evidence is limited (see NP, DEIAr, Page 286 and RB, DEIAr Page 242). This is a misrepresentation of the literature. Evidence on the impact of noise on invertebrates is overwhelming, despite the topic being understudied. De Soto 2016 states directly in the abstract of the aforementioned manuscript that "studies show that the noise effects on marine invertebrates range from apparently null to behavioral/physiological responses to mortalities"[35]. The de Soto literature review goes on to document 10 studies demonstrating behavioral and/or physiological impacts on invertebrates associated with anthropogenic noise, and only two studies demonstrating that invertebrate catch rates were not impacted by noise (though these studies include the caveat that additional noise impacts were likely, though not measured)[35].

While it was not possible within the scope of this report to assess every ecological citation pertaining to noise, this pattern of downplaying or directly misinterpreting existing scientific literature (as seen above in the case of Southall et al. (2019) and Popper et al. (2014)) were rampant throughout the DEIAr and associated studies.

Incorporating Uncertainty: Both the studies and the DEIAr failed to account for reasonable uncertainty or to propose effective long term mitigation. The lack of concrete data on noise impacts, does not justify a failure to propose mitigation measures. Many significant risks to marine fauna associated with anthropogenic noise likely exist, but have not yet been thoroughly described. Section 2 of the International Whaling Commission's (IWC) Resolution 2018-4,

Resolution on Anthropogenic and Underwater Noise states that the Commission, "*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 proposed projects 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 birds, sea turtles). A lack of research in this exact locale on these specific faunal communities is not grounds for ignoring potential noise impacts. Rather, it is a greater indication of the need for baseline research and in this region prior to development, and a need for careful mitigation measures.

Monitoring and mitigation should be done year-round to identify noise-sensitive species if/when they arrive so that construction activities and associated project operations can be paused. A firm commitment to noise mitigation throughout the 20-year life of the project is essential. This includes establishing maximum noise thresholds that are frequency dependent and that incorporate duration, and concrete mitigation strategies for how the Applicant will respond when noise thresholds and duration thresholds are approached and met.

E. SUMMARY OF MAJOR FAILINGS OF THE UNDERWATER NOISE ASSESSMENTS AND ASSOCIATED EIARS AND EMPRS

The following list summarizes the primary failings of the Underwater Noise Assessment studies and associated DEIArs and EMPrs. This list is not comprehensive, but highlights some of the primary failures of the underwater noise studies and their associated DEIArs.

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

   There is a documented scientific risk to commercial fisheries associated with anthropogenic noise[40,42,43].

2. Failed to address the impact of anthropogenic noise on important prey species. This is significant because the proposed sites are in close proximity or directly adjacent to Marine Protected Areas (MPAs), National Park, and Critical Biodiversity Areas. Noise may endanger prey species in or *en route* to these areas. This could disrupt the base of the food web and may be ecologically significant throughout trophic levels.

3. Failed to quantify baseline natural sound levels at ecologically relevant timescale or frequency levels at any of the three proposed sites. This is significant because sound is seasonably variable.

The studies rely on less than 48 hours of recordings during periods of moderate to high anthropogenic activities as a baseline. This is not enough time to consider ecological soundscape baselines which are seasonally variable, or to consider seasonally variable migration and breeding practices that are reliant on sound.

4. Failed to adequately quantify naturally occurring contributions to the marine soundscape and compare the addition of the powerships project and all other industrial noise in the bay or port to this baseline. The studies defaulted to sound levels of anthropogenically altered soundscapes as the ecological baseline. This is significant because comparing elevated noise associated with the proposed activities to an already elevated soundscape artificially deflates the impact of noise associated with proposed industrial projects and encourages excessive noise contributions to an already stressed ecosystem.

   The need for a baseline is analogous to knowing a person's basal body temperature. Because we know that human bodies have baseline temperatures of 98.6 degrees, we can understand that someone with a temperature of 103 degrees has a significant fever and is sick. If we wrongly assume based on taking someone's temperature when they are already sick that they have a baseline of 102 degrees, then we may wrongly ignore the threat of a fever at 103 degrees.

5. Failed to adequately model sound propagation in the project zones, despite ample scientific resources in existence to do so. This is significant because in the absence of sound propagation modeling a site-specific noise assessment is not possible and anthropogenic noise may impact protected areas and/or sound sensitive species.

   The underwater noise report eschewed actual propagation modeling and instead took 10-second sound samples to demonstrate a lack of impact. This is scientifically unsound and is analogous to taking 10-second snippets of an individual's behavior and claiming to extrapolate their entire life history. Further, no effort was made to consider frequency specific propagation. While not all frequency bands are likely to propagate, no effort was made to determine if biologically significant increases in relevant frequency bands occurred as a function of noise.

6. Failed to assess the risk associated with permanent soundscape alterations due to permanent changes on the seafloor due to construction 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).

7. Failed to consider the physiological effects of anthropogenic noise – and stress in particular – on sound sensitive species including marine mammals, diving seabirds, invertebrates, and fish. This is significant because the studies failed to consider how biologically critical physiology that is related to the fitness of the individual and overall population may be impacted.

8. Failed to consider the impact of noise on the behavior of protected or sound sensitive species- including marine mammals. Noise can have significant impacts such as reducing

foraging efforts in cetaceans, separating cetacean calves from mothers or causing groups of animals, including those that are valuable to tourism, to be displaced.

9. 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.

10. Failed to incorporate best science into assessment of underwater noise impacts. This is significant because the results of the DEIAr mitigation efforts are not based on reliable scientific information, and therefore may not adequately protect sensitive ecosystems.

For all of these reasons, the Underwater Noise Assessments and associated Baseline Underwater Noise Reports (studies) failed to adequately demonstrate that noise will not have significant ecological consequences at the three proposed locations. As such, the impacts assessment and mitigation actions proposed in the associated DEIArs are founded on an erroneous assessment of noise impacts, and fail to meaningfully address the possible or likely impacts of anthropogenic noise to the marine environment associated with the powership projects.

EXPERTISE:

I am the Associate Director for Education for the Center for Acoustics Research and Engagement at the University of New Hampshire and the director of the Sound Science Research Collective. I spent four years as a postdoctoral research associate at the Cornell University K. Lisa Yang Center for Conservation Bioacoustics where I used 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 16 peer-reviewed bioacoustic research articles on taxa ranging from humpback whales and harbor seals to toadfish and barnacles. I have a decade of experience conducting marine bioacoustics research.

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