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REVIEW AND COMMENT ON BASIC ASSESSMENT REPORT (BAR) ON THE PROPOSED 3D SEISMIC SURVEY OFF THE SOUTHEAST COAST, SOUTH AFRICA, BY CGG SERVICES, PROJECT REFERENCE 720.03122.00001.

This document provides expert comments and scientific opinion on the Final Basic Assessment Report and associated supplementary information for the application for an Environmental Authorisation (EA) by CGG Services SAS (CGG), a geophysical survey company, to undertake a speculative three-dimensional (3D) seismic survey within an area of interest in the Algoa/Outeniqua Basin off the Southeast Coast of South Africa. This document provides an analysis and comments by WILDTRUST marine scientists, namely Dr J. Harris, Dr J. Olbers, L. Guastella and Dr K. Wright, as requested by Natural Justice.

CGG is proposing to undertake the seismic survey under a Reconnaissance Permit, for which it has also submitted an application to the Department of Mineral Resources and Energy (DMRE). Any activities undertaken under a Reconnaissance Permit also requires an EA from DMRE. As part of the process of applying for an EA, a Basic Assessment process has been undertaken by SLR Consulting. The proposed Reconnaissance area is located roughly between Gqeberha in the east and a point approximately 120 km southeast of Plettenberg Bay in the west and is located between 45 km and 120 km offshore at its closest point, in water depths ranging from 200 m to more than 4 000 m.

Having reviewed the Basic Assessment Report (BAR) and associated information, it is our opinion that the proposal has fatal flaws, in that the survey area completely surrounds the Port Elizabeth Corals MPA, is in close proximity to Robberg MPA, Tsitsikamma MPA, Sardinia Bay MPA, Addo Elephant MPA, Amathole MPA, Dwesa-Cwebe MPA and Hluleka MPA, overlaps the Kingklip EBSA as well as trawling grounds and resident cetacean populations, whilst also putting migrating turtle populations at risk. The proposed mitigation measures, whilst being an attempt to minimise impacts, fall short in that the survey area itself is unsuitable for such a survey, from a marine ecological perspective. Should the activity be authorised, the likelihood of the reconnaissance activities causing direct harm to individual species, populations or ecosystems remains high, despite comments to the contrary by the Environmental Assessment Practitioner (EAP).

Furthermore, we bring attention to our **REPORT ON SCIENTIFIC BASIS FOR CONCERNS OF SIGNIFICANT HARM INFLICTED TO MARINE WILDLIFE BY THE SHELL SEISMIC SURVEYS ON THE WILD COAST OF SOUTH AFRICA** (Appendix A) provided as an expert report for the successful Shell seismic survey court interdict application in 2021, which resulted in Shell receiving a judgment that the seismic survey should cease immediately. This report provides a summary of key findings, referring to peer-reviewed literature on the physiological and ecological impacts of seismic survey activities on marine wildlife, with specific attention to the relevance of the information to the context of the Shell survey area, as well as

with regards to vulnerable and endangered species known to occur in the survey area at the time of year when the seismic survey is planned. Although the Shell report was prepared for a slightly different area, the findings are applicable in general with regards to seismic survey impacts, but most of the concerns identified are applicable to the proposed CGG seismic survey area. Having carefully considered the available information in this regard it is our opinion that seismic surveys do cause harm to both species and the ecology, and that significant direct harm to individual animals and harm to populations of endangered species is the most likely scenario in the case of the seismic survey planned for in the Algoa/Outeniqua Basin off the Southeast Coast of South Africa. It is our opinion that the risks have not been fully recognised and have not been rated correctly, and that it is inadvisable to authorise this activity given, in our opinion, significant unallayed concerns about the high likelihood of environmental harm.

We also set out in the table below further details of issues of concern from the CGG BAR and specialist reports and WILDTRUST's responses to these.

The below table refers to the Basic Assessment Report, compiled for CGG by SLR Consulting, and associated specialist reports and addresses concerns by the WILDTRUST:

	Issues from the BAR & specialist reports	**Concerns from the WILDTRUST**
1.	The survey area surrounds an MPA (Port Elizabeth Corals) and overlaps CBA's and EBSA's (e.g. Kingklip Ridge, border of Algoa-Amathole EBSA), trawling grounds and resident cetacean populations, whilst also putting migrating turtle populations at risk.	In its current form, the survey area makes a mockery of the MPA. Even though it provides for a 2 km buffer, this is deemed to be inadequate to protect this MPA, which will be bombarded by sound from all directions (albeit at different times). The overlapping of the survey area with fishing grounds, resident cetaceans and turtle routes needs to be addressed. as well as environmental damage to the sensitive marine environments that overlap the survey area.
2.	The NE corner of the Reconnaissance Permit Area overlaps with a small portion of the proposed Alexandria coastal belt/Algoa Bay Islands Nature Reserve Marine IBA, specifically aimed at protecting the African Penguin, Cape Gannet, Kelp Gull, Damara Tern and Roseate Tern (https://maps.birdlife.org/marineIBAs).	There are many endangered and vulnerable ecosystems in and surrounding the proposed survey area.
3.	The Agulhas Coarse Sediment Shelf Edge, Agulhas Sandy Outer Shelf, Agulhas Upper Canyon and Kingklip Koppies ecosystem types are considered 'Vulnerable' and the Kingklip Ridge ecosystem type is considered 'Endangered'.	There are many endangered and vulnerable ecosystems in and surrounding the proposed survey area, that the proposed seismic survey will place at risk of harm that is not mitigated adequately in the application.
4.	The inshore portions of the project area overlap with major fish spawning and migration routes, and ichthyoplankton abundance in inshore waters over the continental shelf (<200 m) is likely to be seasonally high. The inshore area of the Agulhas Bank, especially between the cool water ridge and the shore, serve as an important nursery area for numerous linefish species.	The overlap with major fish spawning and migration routes is of concern, and seismics might affect breeding.
5.	Further offshore throughout the project area, the pelagic environment is characterised by very low	Algal blooms of *Lingulodinium polyedrum* can cause phosphorescence, both inshore and

	productivity, with the low variability in water column temperature resulting in very low frequency of chlorophyll fronts. In the offshore portion of the project area, ichthyoplankton abundance is expected to be low.	offshore, suggesting more primary production than at first thought.
6.	Trawling activity (bottom and midwater and demersal longline) coincides with the area of interest between the 200 m and 1 000 m bathymetric contours, pelagic longline covers a wider area, squid generally occur up to 3 nautical miles from coast.	The overlapping of the survey area with fishing grounds, needs to be addressed.
7.	While no mandatory mitigation measures for turtles are included by the JNCC (2017), the consultants are to be commended for applying the precautionary principle, with mitigations to include cessation of seismic shooting for diving seabirds, turtles, slow swimming large pelagic fish (including whale sharks, basking sharks, manta rays), and for observation of any obvious mortality or injuries to the above, including squid and fish (specifically large shoals of tuna or surface shoaling small pelagic species such as sardine, anchovy and mackerel), when estimated by the MMO to be as a direct result of the survey.	However, observing turtles at the surface is unreliable in sea states above Beaufort 1 and detection rates decrease with increased distance from the vessel. Additionally, it is currently not possible to detect turtles below the surface where they might be most vulnerable due to the proximity of the seismic source and other survey equipment (Weir, 2007). Detection of turtles relies on human effort (diligence, skills and concentration), which is subjective and inevitably varies among MMOs, many of whom have little previous experience of detecting and identifying turtles at sea (Nelms, et al., 2016). Currently, there is no way of detecting turtles at night or in poor weather conditions. Turtle dives times can also be long, further limiting sightings, especially in the case of leatherbacks, Turtles are slow-moving and not that visible – in this extreme environment, may only be visible 5 to 10% of the time, and even then, it takes a trained eye. Likewise for manta rays. Tuna activity is more detectable, but perhaps only to Beaufort Scale 2.
8.	The noise modelling study indicates turtle mortality or probable mortality within 240 m of source. The results show that behavioural disturbance caused by the immediate exposure to individual pulses are predicted to be within 4.4 km from the array source for marine mammals of all hearing groups, and within 3.1 km from the array source for sea turtles.	Turtles are slow-moving and difficult to spot – see above arguments. Noise is modelled for the downward trajectory only, however, there is sideways and upward propagation of sound waves as well.
9.	Turtles get caught up in survey gear.	In addition to damage from airgun sound, a further potential physical impact for sea turtles from seismic surveys is entanglement in equipment, (Nelms, et al., 2016). Anecdotal reports of turtle entrapments in tail buoys and airgun strings during several offshore seismic surveys off west coast of

		Africa and eight olive ridley turtles (*Lepidochelys olivacea*) became entangled in Ocean Bottom Cable (OBC) gear off Gabon (Nelms, et al., 2016). Turtles are notorious for getting entangled in nets, ropes, etc. Ensure that 'turtle-friendly' tail buoys are used by the survey contractor or that existing tail buoys are fitted with either exclusion or deflector 'turtle guards'. Cover rope lanyards with plastic tubing to reduce the likelihood of entanglement.
10.	"The inshore population of Bryde's whale is resident year-round on the Agulhas Bank, with individuals undertaking occasional seasonal excursions up the East Coast in winter during the annual sardine migration. This species is likely to be encountered in the Reconnaissance Permit Area throughout the year, with peak encounter rates reported from Algoa Bay in March and May (autumn) (Melly et al. 2017). Smaller cetaceans in the area include the common dolphin and Indo-Pacific humpback and bottlenose dolphin dolphins, which tend to occur further inshore on the shelf but may be encountered in the shallower portions of the proposed survey area."	The surveys are likely to frequently encounter resident odontocetes such as common dolphins, striped dolphins and pilot whales, which are present year-round, and may encounter sperm whales in offshore areas. There is, therefore, a risk to resident whale and dolphin species.
11.	The impact of potential physiological injury to mysticete and odontocete cetaceans as a result of seismic sounds is thus deemed to be of **HIGH** intensity. Furthermore, as the duration of the impact would be limited to the SHORT-TERM (4-5 months) and be restricted to the survey area (REGIONAL), the **potential for physiological injury is therefore considered to be of MEDIUM** magnitude for resident mysticetes and odontocetes.	How can this be medium? The damage is done during the high intensity period, even though "short-term", which it isn't really (definitions?). Will they be forced to move out; will they come back? **Even though "short-term", what are the actual long-term impacts?**
12.	Due to the increasing numbers of southern right and humpback whales year-round off the southern African South Coast, the potential impact of behavioural avoidance of seismic survey areas by mysticete cetaceans is considered to be of HIGH intensity (resident species), across the Licence Area (REGIONAL) and for the duration of the survey (SHORT TERM – 4-5 months). Considering the distribution ranges of most species of cetaceans, the impact of seismic surveying in the Algoa Basin is considered of **MEDIUM** magnitude for both migrating mysticetes and for resident whales.	How can this be medium? The damage is done during the high intensity period, even though "short-term", which it isn't really (definitions?). Will they be forced to move out; will they come back? **Even though "short-term", what are the actual long-term impacts?** It is unacceptable to promote an attitude of "Tough luck for those that are residing there or migrating through"?

13.	The Underwater Noise Modelling Study undertaken for the proposed 3D survey area (Li & Lewis 2021) identified that the zones of behavioural disturbance for cetaceans caused by the immediate exposure to individual pulses was within 4.4 km from the array source, assuming a SPL criteria of 160 dB re 1µPa. Although behavioural avoidance of seismic noise in the proposed survey area by baleen whales is highly likely, such **avoidance is generally considered of minimal impact in relation to the distances of migrations of the majority of baleen whale species.**	We do not agree with the last sentence. This is not generally considered a minimal impact and the migration distances are irrelevant to the argument.
14.	Persistent disturbance of foraging behaviour in response to seismic noise can result in reductions in relative fitness of reproductive female Sperm whales leading to abortions and calf abandonment (Farmer et al. 2018), with mid-frequency sonars shown to reduced foraging efficiency in blue whales (Goldbogen et al. 2013). Species that feed intensively within a season and depend on dense prey concentrations can therefore experience significant population consequences	This places significant risks to the recovery rates of endangered populations.
15.	The fish most likely to be encountered on the shelf, beyond the shelf break and in the offshore waters of the Reconnaissance Permit Area are the large migratory pelagic species, including various tunas (see Figure 7-25, left), billfish (see Figure 7-25, right) and sharks (see Figure 7-26) (Van der Elst 1988; Smale et al., 1994) many of which are considered threatened by the International Union for the Conservation of Nature (IUCN), primarily due to overfishing" "Three species likely to be encountered in the Reconnaissance Permit Area, namely the great white shark *Carcharodon carcharias*, the whale shark *Rhincodon typus* and the shortfin mako *Isurus oxyrinchus*."	There are too many endangered and vulnerable species in and surrounding the proposed survey area that the proposed seismic survey will place at risk of harm that is not mitigated adequately in the application.
16.	"Majority of the benthic habitats in the Reconnaissance Permit Area falls within the 'Least Threatened' category, the inshore portions of the Reconnaissance Permit Area along the shelf edge are still considered 'Vulnerable' with the Kingklip Ridge habitat being rated as 'Endangered'. This unique ridge feature on the upper slope in the Southwest Indian Deep Ocean ecoregion, is 40 km long but only 500 m wide and rises from -700 m to -350 m. It supports potentially vulnerable deepwater coral and bryozoan species. The area inside of	There are too many endangered and vulnerable species in and surrounding the proposed survey area, that the proposed seismic survey will place at risk of harm that is not mitigated adequately in the application.

	the (cold) ridge forms part of the kingklip spawning aggregation area (Sink et al. 2019). 'Vulnerable Marine Ecosystem' (VME) provide a wide range of ecosystem services. The deep water habitats on the Agulhas Bank are thought to be characterised by a number of VME indicator species such as sponges, soft corals and hard corals. The combination of habitat types (soft sediments and rocky formations) results in a highly diverse benthic fauna.	
17.	Forty-five species of cephalopods have been recorded on the Agulhas Bank and the shelf break off the South Coast, the majority of which are cuttlefish (Lipinski 1992; Augustyn et al. 1995; Atkinson & Sink 2018).	Most jigging for squid takes place up to 3 nautical miles offshore. Although distant from the main sound source, the impacts haven't been quantified. Figure 2.34 in the fisheries report, the Area of Interest is overlaid on the squid fishery but it is shaded solid so the actual overlap cannot be seen.

	Mitigation measures	
18.	"*Ensure that at least two qualified independent MMOs are on board at all times. As a minimum, one must be on watch during daylight hours for the pre-shoot observations and when the acoustic source is active*."	The effectiveness of an MMO has been questioned throughout the process, with acknowledgment from the EAP on their inadequacies. At best, visual observations by MMO detect approximately 65% of large marine mammals, leaving over a third undetected. It can be argued that a greater percentage of small and juvenile cetaceans and turtles are missed due the extreme difficulty of spotting them. In addition, MMOs provide no mitigation effect for smaller species and those that are not detectable visually, including fish and zooplankton.
19.	*"Maintain a pre-shoot watch of 60-minutes before any instances of airgun testing. If only a single lowest power airgun is tested, the pre-shoot watch period can be reduced to 30 minutes"*	Our concerns around species that dive for prolonged periods, i.e. beaked whales who dive for up to 2 hours, and leatherback turtles, remain.
20.	"*Implement a "soft-start" procedure if testing multiple higher powered airguns. The "soft-start" should be carried out over a time period proportional to the number of guns being tested and not exceed 20 minutes; airguns should be tested in order of increasing volume. If testing all airguns at the same time, a 20 minute "soft-start" is required. If testing a single lowest power airgun a "soft-start" is not required*".	Our concerns around the use of "soft starts" as a proposed mitigation measure remain. While "soft starts" as mitigation for seismic impacts are likely to reduce the impact for highly mobile large animals, this is unlikely to be adequate for the many species that are prevalent in the area over the austral summer months and are unable to avoid the array or leave the area due to their lower mobility, such as smaller turtles, penguins, invertebrates, fish species and zooplankton.
21.	*"Implement a dedicated MMO and PAM pre-shoot watch of at least 60 minutes (to accommodate deep-diving species in water depths greater than 200 m"*	As highlighted in 19 above, our concerns remain around species that dive for prolonged periods, such as beaked whales and leatherback turtles.

22.	"*Terminate seismic shooting on: observation and/or detection of cetaceans, seals, turtles, diving seabirds, penguins and slow swimming large pelagic fish (including whale sharks, basking sharks, manta rays and devil rays), within the 500 m mitigation zone".*	While this may be adequate to prevent Permanent Threshold Shifts, there is still the risk of Temporary Threshold Shifts, which can have multiple knock-on effects on the fitness of the animal. In addition, there is no mitigation for smaller less visible species.
23.	"*Terminate seismic shooting on: observation of any obvious mortality or injuries to cetaceans, turtles, seals or mass mortalities of squid and fish (tuna or surface shoaling small pelagic species such as sardine, anchovy and mackerel), penguins, diving seabirds, when estimated by the MMO to be as a direct result of the survey".*	Post-impact termination is not a mitigation measure as the harm has already occurred.

	Procedural items	
25.	The non-technical summary has an incorrect name associated after you open up the file, referring to the Proposed offshore oil & gas offshore supply base and marine repair complex at Saldanha Bay IDZ, leading to a bit of confusion	Rename the file properly
26.	The marine fauna report (Appendix 6) is of such poor resolution that the mapping is illegible.	A request was made to SLR for a higher resolution copy (supplied). Fortunately, some of the maps were reproduced in the BAR Ch 7, therefore they could be cross-referenced.
27.	Some of the referencing is out-of-date, relying on previous reports produced for similar areas.	See special issue of Deep-Sea Research II (Vol. 208), Apr 2023. Report should be updated for more recent information.
28.	The coastal area in the vicinity of Mossel Bay has been recognised as one of seven areas in the biozone in need of additional protection based on the high endemism known to occur there and consequently much of the inshore regions between Wilderness and Cape Infanta have been rated as 'Endangered' and 'Critically Endangered'. These, however, lie over 200 km inshore and to the northwest of the Reconnaissance Permit area. **Extractive utilisation of marine resources has been identified as the greatest threat to biodiversity in these biozones (Lombard et al. 2004; Sink et al. 2012a).**	These references are mostly pre-seismic surveys (the most recent being 10 years ago). It would be interesting to see if the authors of these reports had a different view now?
29.	Even though loggerhead and leatherback populations are smaller (in nesting numbers) than most other populations, they are genetically unique (Dutton et al. 1999; Shamblin et al. 2014) and thus globally important populations in terms	1 to 5 of a clutch? Not quoted correctly. Estimated 1 to 2 out of 1 000 loggerhead turtle hatchlings survive to adulthood (Hughes, 1974). More recently, de Wet (2013) calculated "Loggerhead hatchling survivorship to adulthood was estimated

	of conservation of these species. As hatchlings are not powerful swimmers they drift southwards in the current, and may therefore be encountered in the inshore portions of the Reconnaissance Permit Area and therefore overlapping with the area of interest. It has been estimated that only 1 to 5 hatchlings survive to adulthood (Hughes 1974b; de Wet 2013).	at between 2 and 10 per 1000 hatchlings, the minimum requirement for an increasing population. The adopted sophisticated model shows that leatherbacks have a survival rate of 5 to 10 per 1 000 hatchlings" (de Wet 2013).
	Knowledge gaps	
30.	Whales & dolphins	"Rarely encountered dwarf and pygmy sperm whales, pygmy killer whales, Risso's and Frazer's dolphins, striped, spinner and Pan-tropical spotted dolphins, and several beaked whale species have distributions that overlap with the project area (Findlay et al. 1992; Best 2007); their occurrence is thought to be rare, but **insufficient data is available on the abundance and spatio-temporal distribution of these species to make an accurate assessment of their susceptibility to the proposed seismic exploration."** Striped dolphins hardly get a mention, just a listing of species likely to be encountered, but they can be quite numerous.
31.	Knowledge gap.	"The 2018 National Biodiversity Assessment for the marine environment (Sink et al. 2019) points out that very few national IUCN Red List assessments have been conducted for marine invertebrate species to date owing to inadequate taxonomic knowledge, limited distribution data, a lack of systematic surveys and limited capacity to advance species red listing for these groups."
32.	Knowledge gap.	Information on offshore benthic and pelagic invertebrates occurring in the general project area is sparse.
33.	Knowledge gap.	Turtles have been largely neglected both in terms of research and their inclusion in mitigation policies. Few studies have investigated the potential for seismic surveys to cause behavioural changes or physical damage, indicating a crucial knowledge gap (Nelms, et al., 2016).
34.	Knowledge gap.	In general, limited scientific data are available regarding the effects of sound for fishes and sea turtles.

ADDITIONAL COMMENTS

We do not believe that referring to an already noisy soundscape is a sufficient argument to justify the impact of the seismic surveys. In Environmental Assessments such as these, it is required that cumulative impacts, from all sound sources are adequately dealt with and investigated, including the additional impact that the seismic surveys will add to the 'already noisy soundscape'. Furthermore, the sound of seismic surveys occurs

at a high intensity and is sustained over long periods across a large area. The impacts cannot be reasonably compared with sounds such as ship engines.

The nature and behaviour of sound from the source is an airgun a few metres below the surface. Despite the fact that the airgun fires downwards, the pressure (and thus sound) waves will reflect, refract and echo in all directions, not just downwards, but in upwards and outwards as well. Water is a very good conductor of sound and pressure and its passage and the pressure outcomes are not as perfectly predicted as the statement would have us believe. It must be noted that:

- The sound wave that goes up and reflects back downwards, interacting with other produced waves, can produce both convergence areas (amplified sound pressure levels) and shadow areas (reduced sound pressure level areas). There may be small pockets where null sound pressure is created, but these pockets do not form a continuous zone in the 0-3 m depth zone. The physics show us that "loud" and "quiet" zones will occur at the surface, and underwater, as one moves way from the source.

- The sound pressure will also be carried upwards diagonally (not straight up) impacting turtle hatchlings / juvenile turtles in surrounding surface waters in a circle away from the airgun. Note that owing to their small size, it is extremely unlikely that turtle hatchlings, which drift in the Agulhas Current, will be visible to MMO's. The radius of impact and disturbance in this circle is likely to be at least a few hundred metres away from the source (the airgun) as there is scientific evidence that zooplankton are killed by the physical disturbance up to 1.2km away in surface waters. This indicates that there is a sound shock wave in the surface waters. There is also evidence that sperm whales can experience a loud or high sound pressure level (convergence) zone up to 1.62 km away from the source (Madsen et al. 2006)

It is recommended that the marine ecological specialist report be updated for more recent scientific literature and that the proponent reconsider the survey area, as the proposal, in its current form, is of high risk to the marine environment, in particular the more shallow part of the survey grid, which overlaps and is in close proximity to fishing grounds and resident cetaceans, and turtle and seal encounters are more likely. Furthermore, in the more shallow area, is where the sound impacts are much higher (due to less depth of water for the sound waves to propagate).

Furthermore, it is our opinion that a precautionary approach, i.e. not to issue an Environmental Authorisation, should be applied given the need for further studies and the lack of mitigation measures that properly prevent harm to species, populations and ecosystems, including endangered species.

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APPENDIX A

REPORT ON SCIENTIFIC BASIS FOR CONCERNS OF SIGNIFICANT HARM INFLICTED TO MARINE WILDLIFE BY THE SHELL SEISMIC SURVEYS ON THE WILD COAST OF SOUTH AFRICA

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6 December 2021

This report provides a summary of key findings in peer-reviewed literature on the physiological and ecological impacts of seismic survey activities on marine wildlife, with specific attention to the relevance of the information to the context of the Shell survey area, as well as with regards vulnerable and endangered species known to occur in the survey area at this time of year. Having carefully considered the available information in this regard it is our opinion that seismic surveys do cause harm to both species and the ecology, and that significant direct harm to individual animals and harm to populations of endangered species is the most likely scenario in the case of the seismic survey underway off the east coast of South Africa. Of specific concern is the impact on threatened humpback whales (at a particularly vulnerable stage for mothers and calves) in December, the impact (likely mortalities) on critically endangered (leatherback) and endangered (loggerhead) turtles (according to South African TOPS legislation) in February and March which are peak times when hatchlings are carried through the area from the iSimangaliso MPA nesting grounds. We conclude that these seismic surveys are inadvisable in December-March due to the presence of these species in the area over this time and inability of the prescribed mitigation measures preventing harm to individuals/populations. Furthermore, recent literature provides credible concern about ecosystem/food-chain impacts of seismic surveys, that may in turn have impact on fisheries the severity and localisation of which will depend on coincidences with spawning and juvenile recruitment events, and it is strongly recommended that further study on these impacts in the South African context are carried out in situ before proceeding with further seismic surveys of this nature.

Summary of Findings

- Based on peer-reviewed scientific literature, it is clear that physical damage to marine animals, including soft tissue trauma damage, embolisms, damage to organs used in balance and orientation, concussions, haemorrhaging, decompression sickness and both temporary and permanent threshold shifts to hearing ability have been directly linked to the kind and level of sound emitted during this nature of seismic surveys.
- There is plausible evidence to suggest that seismic survey activity is likely to affect the conservation status and recovery of populations of vulnerable and threatened species including (IUCN Red list species such as humpback whales), because sound and the ability to hear and interpret sound is critical for many species to reproduce (both vocalisations on breeding grounds and communications across large distances for mate detection). Therefore, it must be assumed that interference in sound perception or utilisation for communication (temporarily or permanently) had the potential to impact a species at the population level.
- Some species have been shown and documented to display physiological stress responses and behavioural changes to seismic activities, such as moving away rapidly, diving or remaining still. These responses are likely to increase their energy consumption and energy costs, reduce their time to forage, and/or affect their vulnerability to predation, thus having negative impacts on the survival of individuals (especially young or compromised animals) as well as the overall population growth and survival of a species (especially for threatened species that are already at risk of extinction).
- The impacts of seismic activities are most well studied for marine mammals, and evidence suggests that there are distinct avoidance responses such as leaving the area or ceasing to undertake everyday activities such as feeding in preferred areas. This is likely to negatively impact the "fitness" of an affected animal.

- The only existing field study in South Africa (that we have been able to find) on the impacts of seismic activities in our waters is illuminating in this regard. It presents clear evidence that the endangered, endemic African penguin avoided preferred feeding sites when a seismic survey was active nearby. This is particularly of concern for a species that is already stressed by prey depletion and the greater demand for them to forage further afield, and for which the prospect of extinction is significant.
- The phenomenon of energy-cost (from stress and avoidance behaviour) is of particular concern for some of the species expected to be encountered in the survey area in question, particularly the humpback whales (still at risk in December) together with their calves who are at risk of the airgun noise affecting their behaviour or interfering with the communication between mother and calf. Any impact on their energy reserves could impact on their condition (weight-loss and physiological condition) and affect survival of the animals during a vulnerable time (especially for lactating mothers and their calves) on their long migration to feeding grounds in Antarctica.
- In terms of physical harm (impact and damage due to collisions with the airgun array equipment towed in the water and the proximity of sound waves from the seismic survey), turtle hatchlings which are carried in the Agulhas current through the survey area from the nesting beaches of the iSimangaliso MPA, do not have the ability to avoid the arrays. Our opinion is that these animals will certainly pass through the area, not be detected by Observers and suffer extreme disturbance. The seismic survey should thus certainly not continue during February and March, and one needs to question if a National Environmental Management: Biodiversity Act, Threatened or Protected Species (TOPS) Regulations permit has been acquired to permit the "harassment" of these 2 species (leatherback and loggerhead turtles, which are recognised as Critically Endangered and Endangered species, respectively in the TOPS regulations.
- Recent research (2017) has shown significant mortality in zooplankton up to 1.2 km from a seismic survey array. Zooplankton forms the base of many important food webs in the marine environment. Depletion of zooplankton could thus have an impact on food for their predators (such as fish) as well as impact fish eggs and larvae (Ichthyoplankton) with potential local impacts on

species important in fisheries. This damage to zooplankton over 1km away from the survey array raises concern that a 500m buffer for other animals that are unable to move away from the sound, particularly small ones like turtle hatchlings, is far too small to ensure that damage is not inflicted (even if they were able to evade it).

- While "Soft starts" mitigation for seismic impacts are likely to reduce the impact for highly mobile large animals, this is unlikely to be adequate for the many species that are prevalent in the area over the 5 month planned survey period that are unable to avoid the array or leave the area due to their lower mobility, such as turtle hatchlings, invertebrates, some fish species and zooplankton. Many of these species are carried relatively passively in the Agulhas current and will be swept through the area helplessly.
- The finding about observer efficiency (from a scientific monitoring study conducted during the 2018/19 and 2019/2020 seasons on the “C1 population” humpback whales that traverse the survey grounds during their annual migration), suggests that even with trained observers up to 44% of humpback whales in an area went undetected. This casts doubt on the effectiveness and success of Marine Mammal Observer (MMO) sightings of the largest species (humpbacks) as a mitigation measure, indicating that it is most likely that whales go undetected. Furthermore, the detection rate for smaller species, such as dolphins, turtles etc. must be expected be much lower, obviating the effectiveness of visual observations to prevent harm to these species.
- It of also concern that the efficacy of Marine Mammal Observers (MMO) is likely to be low due to the nature of the offshore marine environment in the survey area (frequent high swells and winds affecting surface visibility), putting species who are missed by MMO's and PAM operators at extreme risk, particularly at night or during adverse weather conditions.
- Furthermore, the reliance on Observers to do visual sightings to supplement the PAM monitoring during the day, as a mandated mitigation measure, necessitates that we question the acceptability of continuing with survey activities at night. If the visual observations are useful (perhaps sighting large animals around 65% of the time) in addition to PAM, then why is it deemed acceptable to rely on PAM alone at night? It is our opinion that surveys should not occur between sunset and

sunrise each day if a real attempt of maximum avoidance of humpback whales and other cetaceans is the objective of this mitigation measure.

Seismic Surveys - Impacts on Marine Animals

Despite seismic surveys having been undertaken for decades in South African waters, together with the knowledge that some impact to marine fauna does indeed occur[1], there remains very little scientific research on the effects of seismic surveys, and in addition there are no legislated guidelines for seismic surveys in South African waters (Purdon 2018). Globally, seismic surveys' environmental impacts and consequences are slightly better documented, although not uniform in results or widely accepted within all sectors. The primary mitigation measures for seismic surveys in South Africa include soft-starts, which is a gradual and systematic increase in power of the airgun array undertaken to warn and drive mobile marine species, such as cetaceans (whales, dolphins and porpoises) and turtles away from the sound source before the full-power airgun blasts begin, thus attempting to minimise the negative effects of the airgun blasting activity. Various studies contest this assumption (McCauley et al. 2000; Weilgart 2013; Dunlop et al 2016) and have revealed a growing concern for animals that are unable to avoid or out-swim the airgun arrays.

Animals use sound critical to their life cycles (Jasny et al 2005) in three ways, by actively producing sound (Tyack 1981), by listening to sounds emitted by other living organisms (Clark et al 2009; Van Opzeeland 2010), and taking cues from physical or non-living factors producing sounds, contributing to the ambient background noise, such as wind, waves, swell, bubbles, currents, turbulence, earthquakes, rainfall, ice cracking or breaking (Hildebrand 2005). Many marine animals produce sound for communication, reproduction, aggression, defence mechanisms, antagonistic interactions, courtship, group coordination, orientation, navigation, and prey identification (Hildebrand 2005). They

[1] https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation: “to reduce the risk of deliberate injury to marine mammals”.

rely on producing a sound that is heard while hearing a sound and interpreting the sound for their survival.

Various physical responses to acoustic disturbance have been documented, with physical responses including soft tissue damage (Balcom and Claridge 2001), embolisms (Dolman and Simmonds 2005), damage to organs used in balance (André et al 2011), concussions in penguins (Cooper 1982), haemorrhaging (Evans et al 2001) and decompression sickness (Fernández et al 2005). Hearing impairment in the form of Temporary Threshold Shift (TTS) or Permanent Threshold Shift (PTS) has also been reported (Hildebrand 2005). Threshold shift refers to an increase in the minimum sound level required for an animal to hear a sound. A TTS is followed by successful recovery to normal hearing thresholds after a given period of time in the absence of that sound, while PTS is when the sensory hair cells in the inner ear are permanently damaged and lost making recovery impossible (Weilgart 2013).

Stress caused by disturbance is associated with a change in body chemistry (Jasny et al 2005) and can be equally disruptive as physical damage. Stress has implications on sexual maturation, inhibits growth, reproduction and general survival ability (Pickering 1992; McCormick 1999; Consten et al 2001). Perceptual effects can occur when there is an interference of sounds of interest to a specific animal but are being drowned out or masked by anthropogenic noise. The impact of this in the long term could have implications on breeding populations, thus on reproduction within a population (Erbe 2001). Many animals may have the ability to counteract this and make minor changes to their vocalisations and behaviour; however, these modifications may come at a cost in terms of energy expenditure (Tyack 2008) and are likely to reduce breeding productivity of the population. This is of particular concern for species that are threatened.

Behavioural responses to noise are dependent on various factors, such as age, sex, presence of offspring, location and an individual animals' previous encounter with a specific sound or noise. Behavioural responses may include modification of vocal behaviour, displacement from important

habitats, and other subtle responses, including increased breathing rates, change in dive duration, time spent at the surface, rapid or erratic movements (Bowles et al 1994; Lesage et al 1999; Williams et al 2002; Hastie et al 2003; Ng and Leung 2003; Aguilar de Soto et al 2006). These all with potentially high energetic costs (Williams et al 2006; Koper and Plön 2012).

Most scientific research on the impacts of seismic surveys has been conducted on cetaceans, and as a result, most mitigation measures are to protect these animals. In South Africa, this is no different. However, it is becoming more and more evident that mitigation measures are not adequate (Weilgart 2013). In the Gulf of Mexico, it was recorded that ~250 male fin whales appeared to stop singing for several weeks to months during a seismic survey. These animals resumed singing within hours or days after the survey ended (IWC 2007). The assumption is that male fin whales use vocalisations for reproduction by finding and attracting mates (Croll et al 2002); it can only be assumed that such an effect would be biologically significant (Weilgart 2013). In addition to this, a blue whale ceased calling in the presence of a seismic survey at 10 km away (Macdonald et al 1995). Conversely, a different group of blue whales appeared to have the opposite reaction. They changed their vocalisations (De Lorio et al 2010) by calling consistently more on days when the seismic surveys were actively ongoing, suggesting that seismic survey noise interfered with important signals used in their social interactions and feeding (De Lorio et al 2010).

Other reactions to seismic airguns can be subtle or hard to detect (Weilgart 2013) and it has been found that Sperm whales in the Gulf of Mexico did not appear to avoid a seismic airgun survey area but reduced their swimming effort and their tendency to reduce foraging effort (Miller et al 2009). It has also been documented that as a result of changes in behaviour, the result could be lower reproductive rates and have negative consequences for the population (Miller et al 2009). In comparison, bowhead whales showed no avoidance or change in vocalisations in the area of seismic surveys; however, their dive duration was shorter (Richardson et al 1986). In Brazil, a reduction in cetacean species diversity during 2000 and 2001 was noted with the increased occurrence of seismic surveys in the area being implicated in the possible cause of these animals vacating the area (Parente

et al 2007). In other areas, marine mammals have been recorded to avoid seismic noise by leaving an area (Castellote et al 2012; Weir 2008; Stone and Tasker 2006). The long term impacts of these changes in behaviour are unknown but potentially impact their ability to feed and/or reproduce as in some species, these life-history stages are site or habitat-specific.

McEwen and Wingfield (2003) suggested that all organisms must gather energy for growth and reproduction throughout their life cycle and that organisms must retain reserves for predictable changes such as seasons, and challenges that are less predictable such as disturbance, predation pressure, or social conflict. Often colloquially, this is referred to as the "fitness" of the animal. The accumulated cost in the balance between energy intake and demand is called the 'allostatic load', of physiological and behavioural mechanisms that enable allostasis or adaptation to these changes. McEwen and Wingfield (2003) use the word "allostasis" to signify mechanisms that allow an organism to regain equilibrium while dealing with external challenges; if energy demand is more than intake, then animals may activate a survival mode that may increase energy available, reduce energy demand, or both, to regain its energy balance. Implications on individuals and populations of this energy imbalance are unknown.

Several studies have reported negative impacts of acoustic signals from airguns on zooplankton (small, aquatic microorganisms living in the water column, including crustaceans, larvae, juvenile fish, juvenile invertebrates, eggs etc.) from more than 10m away (Kostyuchenko 1972; Kosheleva 1992; Parry *et al.* 2002) with some laboratory experiments on lobster larvae showing no impact at all (Day *et al.* 2016). However, Christian *et al.* (2003), showed retardation in some individuals in the development of snow crab eggs after being exposed to certain sound levels.

The effects of seismic noise on zooplankton were brought under the spotlight when McCauley *et al.* (2017) presented evidence from an *in situ* study which suggested that seismic surveys cause significant mortality to zooplankton populations. Zooplankton, unlike vertebrates, do not have hearing structures (although they can sense pressure change) and their bodies are generally the same density

as the surrounding water, so sudden pressure changes associated with seismic activities were presumed not to cause physical damage (Parry and Gason 2006). McCauley *et al.* (2017) disputed this and has shown zooplankton mortality at distances of up to 1.2km from the sound source.

Furthermore, the indirect effects of seismic activity on cetaceans is a concern. It is well known that the productivity and health of the oceans are under-pinned by marine plankton (Raymont 1983; Alcaraz & Calbet 2009). While forming the basis of the food webs, plankton has been implicated in links to climate change via their role in iron fertilisation and carbon sequestration through whales foraging on krill and subsequent defecation (Smetacek and Nicol 2005; Smetacek 2008; Nicol et al. 2010). In 2010, Pershing et al. suggested that over-fishing of large fish and commercial whaling had compromised the ocean's ability to store and sequester carbon, thus contributing to climate change. They indicated that populations of large baleen whales now store 9.1×106 tonnes less carbon than before commercial whaling and that protecting whales (and other large over-exploited species), would be a form of a carbon management scheme. The cascading and knock-on effects of seismic survey impacts between the upper (cetaceans) and lower reaches (plankton) of the food web, as each are being impacted are unknown. McCauley et al. (2017) noted that the ramifications of compromised larval recruitment could be massive for higher predators and for ocean health as a whole. While humpback whales do not feed in waters along the east coast of South Africa, other cetaceans such as killer whales, sperm whales and dolphins may be at risk.

South African Context

In South Africa, only a single focused study on the impact of seismic surveys has been undertaken. This study, off Gqeberha, was within the foraging area of the endangered, endemic African Penguin (*Spheniscus demersus*). Pichegru et al (2017) demonstrated that penguins avoided their preferred foraging areas during seismic surveys and foraged further from the survey vessel when in operation. Upon termination of seismic surveys, the penguins reverted to their normal behaviour (Pichegru et al (2017), a behaviour which was also observed in Gray whales (*Eschrichtius robustus*) off Sakhalin Island in Russia (International Whaling Commission 2005). However, the long term effects on

populations of this temporary retreat of the area are unknown. Furthermore, the cumulative effect of multiple, concurrent seismic surveys within the region may cause cumulative impacts.

Significant impacts on turtle species are a concern. Adult turtles may be less vulnerable to sound damage than cetaceans as the air spaces in their cochlear are smaller than those in cetaceans, making them less sensitive to sound shockwaves (Popper et al. 2014). However, while studies have shown that adult sea turtles have a moderate ability to move from an area being surveyed (Lenhardt 1994; O'Hara and Wilcox 1990), they are prone to TTS after exposure to sound within 1 km of a sound source, with signs of recovery only two weeks after injury (Lenhardt 1994). In a study undertaken on captive turtles, it was found that loggerhead turtles (*Caretta caretta*) responded to sound by swimming to the surface and remaining there or staying slightly submerged (Lenhardt 1994), as this area, regarded as a sound shadow, and is hypothesised as being where sound waves cancel each other out and the noise is at a minimum. Cummings et al (2004) disputed this saying that although near the surface, could be a place where animals take refuge, they are not in a 'zone of silence'. With an increasing exposure of sound levels, the behaviour of caged green (*Chelonia mydas*) and loggerhead (*C. Caretta*) turtles increased their swimming speed, potentially showing agitation to sound (McCauley et al 2000). Turtle behaviour is difficult to interpret (DeRuiter and Doukara 2012), given that some studies have reported that turtles do not display any signs of distress (Pendoley 1997). Globally the Leatherback turtle (*Dermochelys coriacea)* is vulnerable, but critically endangered in the Southwestern Indian Ocean where this subpopulation is declining (Nel 2010, 2012; Nel et al. 2013). Loggerhead (*Caretta caretta*) populations are globally vulnerable but near threatened in the southwest Indian Ocean (Lombard & Kyle 2014).

The nesting grounds of the southern African loggerhead (*Caretta caretta*) and leatherback turtle (*Dermochelys coriacea*) populations are located in iSimangaliso Wetland Park, on the northern KZN coast. In the Autumn months, adult turtles are moving towards their nesting beaches but stay inshore as to avoid the north to south flowing Agulhas current. Once they have completed their laying of eggs, they leave the shore and into the current to be carried south once again, and by late March, they will

be littered along the east coast in offshore waters. However, they have a moderate ability to avoid areas with an increase of noise in the water. Mitigation measures for turtles in seismic surveys include observers, although it is unclear how an observer would be able to observe these animals at such a distance (especially as large animals such as whales are only observed 44% of the time at best). A second mitigation measure is to install turtle devices to prevent them from becoming entangled in the gear. These devices are accepted as being useful for adult turtles; however, they would not prevent hatchlings from coming into contact with the seismic gear deployed, and this is of great concern.

Each year thousands of turtle hatchlings enter the sea from their nesting grounds, with their destination being determined by the Agulhas current along the entire east and south coast. The peak hatchling period for loggerhead hatchlings is in February, with their greatest density being slightly more inshore than leatherback hatchlings, which are more offshore within the survey area, with a peak hatchling period in March. These hatchlings live out their early years on and close to the surface, only being able to dive to depths of 2-3m. Turtle hatchlings cannot swim effectively or fast enough away if in close proximity to the sound source. Furthermore, hatchlings cannot be detected by Observers.

The seismic survey thus represents a significant risk to hatchlings of these two endangered turtle species which will be carried through the survey area during January-April, with peaks in February (loggerheads) and March (leatherbacks). There is no effective mitigation measure for these as they will not be visible to MMO's, and will not be able to evade the area.

Furthermore, the National Environmental Management: Biodiversity Act (10/2004): Threatened or Protected Marine Species Regulations, no. 40876 of 30 May 2017, may interpret that seismic surveys could be deemed as 'harassment' and the applicable permit for this activity would be required for TOPS listed species, including leatherback and loggerhead turtles, and Cetaceans.

Effectiveness of Mitigation [Marine Mammal Observers (MMO) and Passive Acoustic Monitoring (PAM)]

During the 2018 and 2019 humpback whale (*Megaptera novaeangliae*) migration period, Wilkinson (2021) estimated the relative abundance of migrating humpback whales sighted by trainer observers from two towers located 22m apart (both observers viewing the same area), located at 70m above sea level on a dune with a horizontal vantage length of approximately 20 km. Over the observation periods during the peak of migration, it was estimated that observers from both towers missed between 41-44% of whale groups while distance offshore decreased the probability of sightings. Assuming that the best percentage sighting (56%) was achieved within 1-5km of the observers' vantage point, then more than 40% of whales were missed. Given that this survey was done during the northward migration when mostly larger animals are present, the sighting success may be less when small calves are present as well (as would be the case in December). This begs the question of the efficacy and reliability of the mitigation method of Marine Mammal Observers (MMO), while assuming that whales (and other cetaceans) are thus regularly missed by MMOs and could be harmed.

Despite various organisations who provide MMO's on vessels having a zero tolerance policy of intimidation it is not uncommon for an MMO to complain that he/she has been subjected to coercion, harassment and intimidation. The EMPr states that: "*The MMO has the authority to stop the survey activities (including seismic shooting) in response to certain circumstances related to marine mammal risk. However, due to the cost associated with terminating activities (e.g. an entire survey line may need to be repeated), it is recommended that the decision to terminate firing be made by the operator in consideration of the MMO's advice. The MMOs must provide full reporting of all termination decisions (including behaviour and distance of marine mammals) in a daily close out report (Part B, p.8)".* This statement is highly problematic and reinforces the concern that "A risk-averse and cautious approach, which takes into account the limits of current knowledge about the

consequences of decisions and actions", a principle of the National Environmental Management Act, 107 of 1998, will not be applied in full.

Furthermore, bearing in mind the examples above, i.e. blue and fin whales ceasing to sing, the use of Passive Acoustic Monitoring (PAM) technology to detect cetaceans is baseless if cetaceans do not vocalise. As per best practice, in an effort to improve mitigation, PAM technology is complemented by visual searching over an area of 500m around the vessel by qualified Marine Mammal Observers (MMO). This technique is, however, also fatally flawed because it cannot be used at night, during rain and in sea states more than three on the Beaufort Sea State Scale. Therefore, both PAM and MMO's are insufficient to detect, with certainty, cetaceans within the surrounding survey area and these types of mitigation will only be effective for all affected species if airgun firing ceases between sunset and sunrise, and adverse weather conditions that limit visibility.

The cumulative and long-term effects of seismic survey sound is not entirely understood (Jasny et al 2005); however, it is accepted that ocean noise may have ecosystem-scale effects (Hildebrand, 2005) and the "knock-on" effects on animals, their prey and their predators will have consequences within the food chain (Koper and Plön 2012). It has been suggested that research and a critical review on mitigation measures (McCauley et al. (2017) as well as a better understanding of ecosystem-scale effects of sound (Koper and Plön 2012), especially at the lower trophic levels are imperative. Considering the ecosystem services provided by the fast-flowing Agulhas current and its associated diversity and biomass, mitigation and understanding should be a conservation imperative in South African marine waters. Up to now, there has been no effort in increasing the knowledge of the impact of these seismic surveys by industry or South African environmental departments despite them being known to have impacts on marine animals and having been undertaken in South African waters for a number of decades.

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