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POLICY INSIGHTS 58

CALMING THE WAVES: USING LEGISLATION TO PROTECT MARINE LIFE FROM SEISMIC SURVEYS

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EXECUTIVE SUMMARY

Seismic surveys, which are conducted during oil and gas exploration, produce low-frequency high-intensity noise. These surveys have been shown to negatively impact marine fauna around the world to varying degrees. Operation Phakisa is a South African government initiative created to unlock the ocean's economic potential while maintaining environmental integrity. It aims to do this by increasing productivity in several sectors, including oil and gas exploration. South Africa, which is home to unique and diverse marine faunal species, needs to increase its efforts to protect them from acoustic pollution during seismic surveys. One way to do this is by forming an independent regulatory board to create and implement a legislative framework delineating best practice guidelines using current scientific information.

INTRODUCTION

In an effort to alleviate poverty and uplift the economy, the South African government initiated Operation Phakisa as a fast-results delivery programme focused on stimulating economic growth and boosting employment. The Oceans Economy Lab – the first project launched under the Operation Phakisa programme – has been fast-tracked in order to help grow gross domestic product from ZAR[1] 54 billion ($4.27 billion) in 2010 to ZAR 170 billion

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($13.43 billion) in 2033. It aims to do this through increasing productivity in six sectors: marine transport and manufacturing; offshore oil and gas; aquaculture; marine protection services and ocean governance; small harbours development; and coastal and marine tourism.[2]

Seismic surveys, conducted to locate oil and gas reserves, have been carried out in South Africa's oceans since the 1980s and are gaining notoriety for their negative impact on marine fauna. They have already been proven to adversely affect the critically endangered African penguin in South Africa.[3] Other studies worldwide have shown them to negatively affect cetaceans, fish, pinnipeds and turtles.[4] South Africa's oceans are rich in biodiversity, as its exclusive economic zone (EEZ) stretches across three oceans – the Indian, Atlantic and the Southern. These warm and cold oceanic systems provide habitats for a wide range of species (37 cetaceans, five turtles, 181 cartilaginous fish species and diving seabirds such as the African penguin),[5] a third of which are endemic to South Africa.[6] A further increase in offshore oil and gas exploration – a specific focus of the Oceans Economy Lab – could put South Africa's diverse marine ecosystem at risk.

As a result of the documented impacts of seismic surveys on marine fauna, several countries have taken steps to minimise these impacts. The first country to implement regulations formulated by the Joint Nature Conservation Committee (JNCC) was the UK, in 1995.[7] The well-documented limitations[8] of the JNCC guidelines encouraged countries such as New Zealand and Brazil to formulate their own mitigation guidelines. In South Africa, before any activity that might harm the environment is undertaken an environmental impact assessment (EIA) must be completed. Currently, the company undertaking the EIA of the proposed seismic survey also draws up the mitigation guidelines (generally based on the JNCC guidelines). If South Africa is to maintain environmental integrity, mitigation guidelines for seismic surveys specific to the country, and based on the most recent scientific data, need to be implemented.

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It is important to develop mitigation guidelines both locally and regionally. For example, if a seismic survey were to be carried out in Mozambique close to its border with South Africa during the turtle breeding season, it could affect turtle migration from foraging sites to their nesting sites at iSimangaliso Wetland Park World Heritage Site. This would result in potential harm to the loggerhead (near-threatened) and leatherback turtles (critically endangered).[9] In addition, since the International Whaling Commission's moratorium on whaling in 1986, populations have begun to recover.[10] However, in the northern hemisphere anthropogenic activities continue to result in the decline of cetacean species such as the critically endangered northern right whale,[11] reinforcing the need for adequate protection for all cetaceans. In recognition of this, the Oceans Economy Lab proposes the expansion of marine protected areas (MPAs) from 0.5% to 5% of the EEZ.[12] These are critical habitats for marine fauna and require protection from the impact of seismic surveys. Owing to the dynamic nature of marine fauna, guidelines for protecting them outside MPAs are also essential.

The purpose of this policy insight is to provide a brief introduction to seismic surveys and their effects on marine vertebrates, in particular cetaceans. This is followed by a review of the current legislation in South Africa relating to acoustic pollution from seismic surveys. The policy insight then evaluates current guidelines

used by other countries and makes recommendations for local and possibly regional seismic survey mitigation guidelines.

THE SCIENCE OF SOUND

The ocean in its natural state is very noisy, with sounds produced by such agents as waves, wind, rain, ice and marine fauna. Within the ocean, natural physical and biological processes produce sound that encompasses a wide range of frequencies, from earthquakes at 5Hz to harbour porpoise whistles at 150 000Hz. Frequency can be separated into narrowband sound, such as sonar (small range of frequencies), and broadband sound, such as seismic surveys (large range of frequencies). Frequency and loudness are the two most important measurements scientists use to measure sound. Loudness, or sound pressure level (SPL), is measured in decibels (dB)[13] and microPascals (µPa).[14] Decibels are not an absolute unit of measurement and vary with changing mediums such as air and water. Consequently there cannot be a direct comparison between SPL in water and SPL in air.[15] Another distinguishing factor of sound is that when it propagates through a medium it loses pressure (dB), resulting in a difference of dB between the source level (the process producing the sound) and the receiver level (sound received). Loss of dB intensity is also affected by factors such as the temperature, salinity and sediment type the sound is travelling through.[16] These characteristics of sound play a pivotal role when trying to manage the effects of acoustic pollution on marine fauna.

SEISMIC SURVEYS

The industrialisation of the 20th century has led to an increase in human-induced noise in the oceans.[17] Seismic surveys add to this cacophony of anthropogenic sound, producing some of the loudest, most impulse-intensive man-made sounds in the ocean. Typically these are high-intensity, low-frequency sounds produced by 'sparkers', 'boomers', 'pingers', 'chirp sonar' or 'air guns', the latter being the most common source.[18] An air-gun array is towed behind the source vessel, usually 10m below the surface. These arrays are made up of between three and six subarrays, with each subarray consisting of between four and eight individual guns. Altogether between 12 and 48 air guns simultaneously release a volume of air under high pressure to produce a sound wave in the form of one large bubble. The sound wave propagates in several directions (see Figure 1) and occurs every 10 to 15 seconds, generally at frequencies below 100Hz.[19] Figure 1 shows the source level of the air gun. Over the years, as surveys have moved into deeper water, this level has increased up to 260–262dB re 1 µPa. The high intensity and low frequency of these pulses travel long distances – up to 4 000km from the source – by moving through seabed sediment and re-emerging in the water.[20]

Figure 1(A) indicates the process of a seismic survey and at what level the dB re 1µPa are released within different directions.[21] Figure 1(B) indicates the hearing frequency (kHz) of marine vertebrates (from top to bottom): Atlantic cod (which has an average range of hearing in relation to other fish), elasmobranch, African penguin, loggerhead turtle, sirenians (manatees and dugongs), fur seals, true seals, high-frequency cetaceans (porpoises, river dolphins, pygmy/dwarf sperm whales, *Cephalorhynchus* species, and some *Lagenorhynchus* species), medium-frequency cetaceans (dolphins, toothed whales, beaked whales) and low-frequency cetaceans

FIGURE 1 THE RELATIONSHIP BETWEEN SEISMIC SURVEYS AND MARINE FAUNA

FIGURE 1(A)

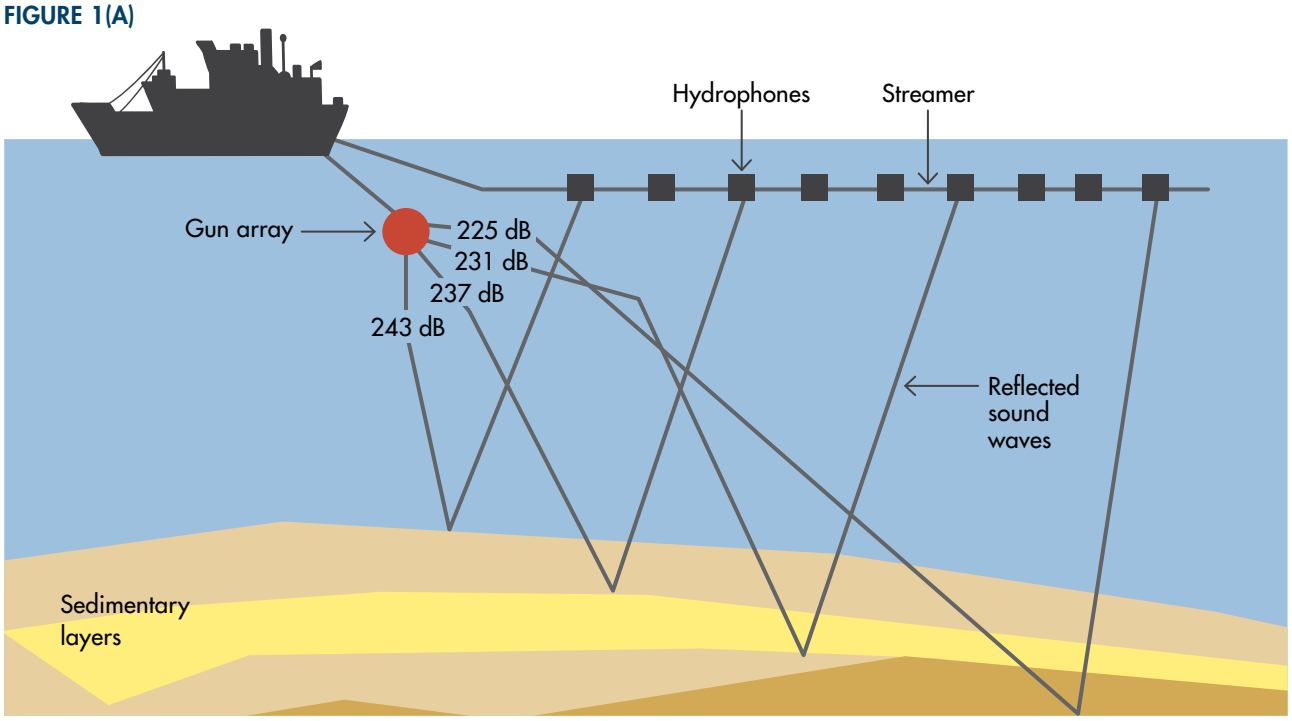
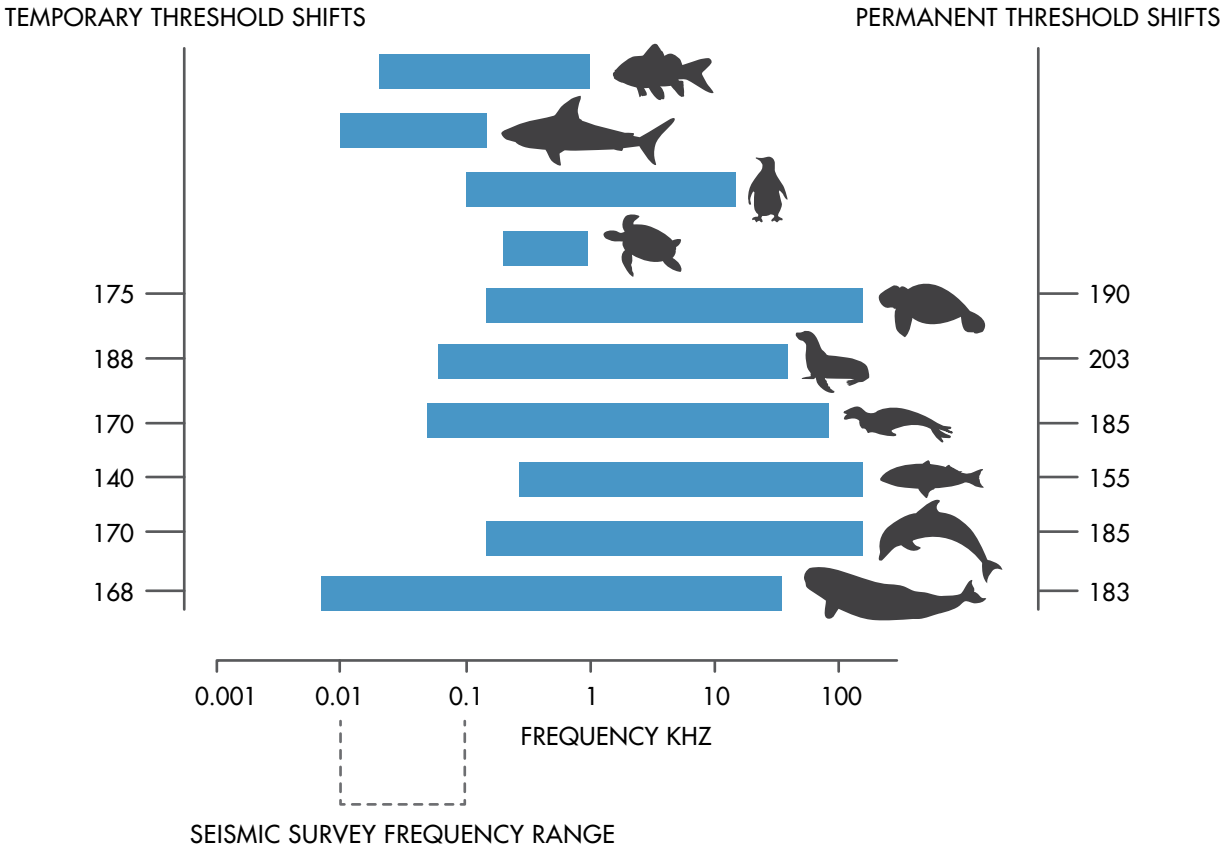


FIGURE 1(B)



Source: See endnote 63

(baleen whales). Where figures exist for temporary threshold shifts (TTS) and permanent threshold shifts (PTS), they are located next to the respective marine vertebrate. The x-axis indicates the frequency (kHz) range of seismic surveys in relation to marine vertebrate hearing (even if the frequency of seismic surveys does not overlap with the hearing frequency of the animals, they could still be affected by the dB of the sound produced, resulting in TTS, PTS or behavioural changes).

IMPACTS ON MARINE FAUNA

Marine fauna have evolved over millions of years, using sound as their primary sensor for navigation, foraging, orientation, predator avoidance, habitat selection and communication. Baleen whales, sea turtles, most fish species, penguins and invertebrates hear at lower frequencies, whereas porpoises and dolphins hear at higher frequencies, often inaudible to humans.[22] Studies have shown that marine fauna, from zooplankton to blue whales, are all affected by seismic surveys – either directly or indirectly.[23] Harmful effects of anthropogenic sound on marine fauna can manifest in three primary ways: physical or physiological responses, masking and behavioural responses.

Physical or physiological responses

Seismic surveys can cause physical or physiological damage to marine fauna. There is, unfortunately, little to no literature indicating mortality of cetaceans from seismic surveys. Most examples come from the effects of sonar used by navies. Sonar induces fatal bends (formation of gas bubbles within tissues) causing mass strandings of beaked whales and sometimes other cetaceans.[24] Presently there is no direct evidence relating cetacean strandings to seismic surveys, but there is a potential impact. For other taxa such as zooplankton, krill larvae and fish larvae there have been documented mortalities from seismic surveys. Adult fish and invertebrate studies have shown physiological damage to tissue and ears.[25] Auditory damage to marine fauna is classed as TTS or PTS. PTS occurs when there is irreversible damage to the ear. TTS occurs when the damaged ear is able to recover. For TTS there is some data available for fish, cetaceans and pinnipeds, whereas for PTS there is no data for marine mammals and only some on fish.[26] Recently the National Oceanic and Atmospheric Administration extrapolated the SPL for TTS and PTS in marine mammals (see Figure 1 for details).[27] More research needs to be conducted on extrapolating PTS and TTS values for other taxa.

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Masking

Masking occurs when the ambient noise level of the ocean is raised, creating a difficult environment for hearing.[28] This has implications for marine fauna, as interpreting biologically important sounds becomes problematic. Processes such as prey detection, predator avoidance, habitat interpretation, mating calls, mother-calf bonding and mother-calf recognition can be hampered. Because many marine vertebrates communicate at low frequencies, similar to those produced by seismic surveys and commercial shipping, they could be more susceptible to masking. The long-term effects of masking may be detrimental to the overall population.[29]

Behavioural responses

This occurs at a certain threshold when the sound emitted initiates a change in behaviour. Studies have confirmed negative behavioural responses to seismic surveys in a variety of species, including fish, invertebrates, turtles, penguins, pinnipeds, baleen whales, dolphins and porpoises.[30]

Masking and behavioural changes may have lasting effects on marine populations and consequently on the whole local ecology. Masking could displace marine fauna from their feeding and breeding grounds, and could affect mating and protection of young. It could also affect the ability to find food. Little is known about the cumulative effects of prolonged seismic surveys on a species or population level.[31] This is something that the precautionary principle – 'When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically'[32] – if adopted, could address in part.

GLOBAL AND SOUTH AFRICAN LEGISLATION

Over the last few decades, international recognition of the effects of acoustic pollution on marine fauna has begun to increase. This issue is now being addressed through international conventions and organisations, regional guidelines and country-specific laws. If a country is party to these conventions it is required to adhere to the regulations.[33] The UN Convention on the Law of the Sea (UNCLOS) in Article 192 indicates that member states have the 'obligation to protect and preserve the marine environment'.[34] Although UNCLOS does not specifically mention any regulations in respect of acoustic pollution from seismic surveys, it does say in Article 65 that '[s]tates shall cooperate with a view to the conservation of marine mammals and in the case of cetaceans shall in particular work through the appropriate international organizations for their conservation, management, and study'.[35]

Both the Convention on Biological Diversity (CBD) and the Convention on Migratory Species (CMS) have addressed acoustic pollution. In 2011 the CMS published steps to reduce the effects of acoustic pollution on cetaceans and migratory species.[36] It encourages member states to prevent adverse effects of acoustic pollution, ensure that EIAs take into account the full impacts of acoustic pollution and use best available practices and mitigation methods.[37] In 2012 the CBD released an in-depth report on the effects of acoustic pollution on marine fauna and, in particular, on biodiversity. It then provided some mitigation recommendations for specific noise-producing activities such as seismic surveys.[38] The Conference of Parties for the CBD states that it recognises the effects of acoustic marine pollution and encourages global participation in the battle to reduce anthropogenic noise.[39]

South Africa is a member of UNCLOS, the CMS and the CBD. Regionally South Africa is a signatory to the Abidjan and Nairobi conventions. Both use the UNCLOS definition of pollution – '"pollution of the marine environment" means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life …' – but neither

addresses acoustic pollution directly. In South Africa, the Environmental Impact Assessment Regulations of the National Environmental Management Act (NEMA) requires an EIA for all proposed activities.[40] This means that before a seismic survey is conducted an impact assessment is required by the governing body, the Petroleum Agency of South Africa (PASA). For seismic surveys there are no specific guidelines that an EIA has to follow. Currently a monitoring plan, based on the JNCC guidelines, is supplied through the EIA and involves area planning, technical requirements and mitigation guidelines.

CURRENT MITIGATION GUIDELINES AND BEST PRACTICE

Legislated guidelines are important as they are not open to misinterpretation and are formulated on the best available science. As resource extraction increases there is a push to develop global guidelines.[41] Mitigation guidelines for seismic surveys usually contain three phases: pre-survey planning, technical requirements and real-time monitoring.[42]

Pre-survey planning

Many countries, including South Africa, require an EIA to be conducted before a seismic survey is allowed to take place. Yet EIAs are not always transparent and are often established without adequate expertise, funding or time. This could lead to poor-quality EIAs, resulting in inadequate protection of marine fauna. In an effort to produce more robust EIAs countries such as Brazil and Argentina have delineated specific EIA guidelines for seismic surveys. Brazil, which has the most advanced legislation in Latin America, requires that sound propagation modelling, the employment of independent consultants, accumulative impacts, identification of sensitive areas, auditing of the monitoring plan and public consultation all be undertaken before a survey takes place.[43]

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- **Sound propagation modelling:** This is important to determine how far the sound travels and at what dB re 1µPa, to identify sound levels that could cause behavioural changes, TTS and PTS. Propagation modelling, which varies depending on the depth, salinity, temperature and sediment structure of the seabed, can help to determine the size of the exclusion zone (EZ). Validation of these models is advisable but not always possible.[44]
- **Independent consultants:** To provide real-time monitoring, marine mammal observers (MMOs) and passive acoustic monitors (PAMs) should be hired. They should be independent of the contractor and the contracting company undertaking the survey to ensure independence and objectivity.[45]
- **Accumulative impacts:** Oil and gas exploration activities do not always employ only air guns for seismic surveys. They may also use other noise-creating methods to obtain information, such as multi-beam sonar, chirps and pings. The necessary support vessels also create noise. If the exploration survey is going to produce multiple types of sound the EIA must take this into consideration. Other accumulative impacts include other seismic surveys being conducted in the area, drilling, shipping, etc., which also need to be factored into the EIA.[46] If the offshore oil and gas survey is going to use other methods, such as multi-beam sonar, then the full effects of these need to be addressed. For example, it has been suggested that multi-beam sonar may be linked to mass strandings.[47]

- **Sensitive areas:** These include breeding, feeding or migration habitats. South Africa restricts seismic surveys during the breeding season, from 1 June until 1 November. However, there have been instances where surveys have been allowed to continue into the breeding season. This underlines the need for preventive legislation. Brazil has permanent restrictions on seismic surveys in areas where there are endangered species such as the manatee and seasonal restrictions during turtle, southern right whale and humpback whale breeding seasons.[48] South Africa should follow suit and protect its African penguin foraging sites and cetacean and turtle breeding areas. Buffer zones should be demarcated and EZs enforced to ensure that the noise level does not reach a detrimental threshold.
- **Auditing of the monitoring plan:** In some countries such as Brazil the MMO/PAM operators follow Brazilian legislated guidelines, whereas in others the guidelines are stipulated by the EIA. For both methods, the MMO/PAM operators report to a regulatory board. In Brazil, the company undertaking the EIA audits the reports.[49] In South Africa PASA is the auditing entity.
- **Public consultation:** This is required for transparency and occurs in most countries, including South Africa. However, the timeframe for comment is often too short to allow informed responses.[50]
- **Other parameters that an EIA could stipulate:** The EIA could enforce the use of alternative quieter technology such as vibroseis rather than the conventional airguns.[51]

Technical requirements

These are stipulated by the EIA (in South Africa) or by country-specific guidelines.

- **Soft-start (SS):** This is the incremental build-up of energy, starting from the smallest single gun and adding sources until full power is reached over a certain time period. It is based on the assumption that animals will move away when the noise becomes unpleasant. Guidelines should be specific about the length of SS required and how the ramp-up is conducted. For example, California requires an addition of 6dB per minute. South Africa needs to look at drafting and implementing guidelines for SS, otherwise the SS could continue for unnecessarily long periods or increase in harmful increments.[52]
- **Gun tests:** These are carried out at various energy levels to test the range of individual guns, from a single gun to the whole array. Criteria should be established for guidelines that cover required SS and pre-shoot watches.[53]
- **Allowable silent period:** These periods occur to allow for maintenance, repairs and sound recordings. Countries such as Brazil have set their minimum allowable silent period at five minutes. Other countries, such as New Zealand, allow 20 minutes, after which a pre-shoot watch and SS are required. South Africa needs to implement a standard procedure based on best practice for operation shutdowns.[54]
- **Line changes:** There are varying requirements for line changes, especially at night. Some countries (UK) require continued use at full power. Others (the state of California) use night vision binoculars and some (Canada) use PAM and a warning gun at low power. Each of these methods has its advantages and disadvantages. For example, the warning air gun has been shown to attract

cetaceans rather than drive them away.[55] South Africa, which normally uses PAM at night, should establish its own criteria for line changes based on the best available science.

Real-time monitoring

An independent company provides MMOs and PAMs to reduce the effects of seismic surveys on marine fauna by implementing mitigation measures through real-time monitoring. MMOs observe for marine fauna during daylight hours. PAM operators use acoustic means to detect the presence of cetaceans during periods of poor visibility and at night-time.

- **MMO/PAM observer requirements and certification:** MMO and PAM operators should be suitably qualified. According to a number of reviewers, there should be a minimum of two MMOs and preferably three, so that two are on watch at all times and at least one PAM operator works at night. It was suggested that best practice would be that two of the MMOs have a minimum of 10 years' experience.[56] In South Africa, the EIA stipulates the number of MMO and PAM operators required for the survey. MMOs and PAMs need to be suitably qualified and experienced with qualifications such as the JNCC course or Protected Species Observer course. These courses are, however, only a few days long and experience could be gained by shadowing a qualified observer. Ideally South Africa should implement its own MMO/PAM course with qualifying criteria such as marine biology degrees, number of observation hours and exams.
- **Shifts:** Best practice for MMO shifts is two hours. In Brazil, they rotate between three observers taking two-hour shifts.[57]
- **EZ or shutdown zone:** The EZ or mitigation zone is a radius around the source of sound in which mitigation measures take place if marine fauna are detected. The size of this zone varies depending on the country's regulations or the EIA requirements. In Australia the EZ is 3 000m whereas in Brazil there is an observation radius of 3 000m, with delays and power-downs occurring at 1 500m and shutdowns at 500m. Generally speaking, many countries adhere to the JNCC regulations, which state that the EZ must be 500m. Countries such as Canada have implemented a radius based on suggested behavioural and harmful effects occurring at 160dB re 1µPa. There is, however, some debate over the level at which this should be implemented. Figure 1 shows the most recently produced levels that cause TTS and PTS. A scientific workshop that addressed the critically endangered western grey whales suggested that 120dB re 1µPa be used to create the EZ. The New Zealand guidelines state that below 180dB re 1µPa there is unlikely to be temporary or permanent damage to cetaceans. It has also been suggested that this figure corresponds well to a 1km radius, which renders the 500m radius unsuitable.[58] South Africa's EZ is based on the JNCC guidelines, and is generally 500m. This practice should be reviewed to protect vulnerable and critically endangered species, especially if the survey is being conducted close to sensitive areas. If the EZ becomes too large for the MMO to cover then additional MMOs should be placed on the support and guard vessels that travel with the seismic survey vessel.
- **Pre-shoot watch:** This varies from 30 minutes for shallow waters (<200m) to 60 minutes for deep waters (>200m). These times are based on the diving

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length of cetaceans and consequently their visibility.[59] South Africa needs to stipulate adequate criteria for the pre-shoot watch, so that deep-diving whales (such as sperm whales, which can dive for up to an hour) are suitably protected.

- **Delays:** These are delays in the start of SS owing to the presence of marine fauna in the EZ. EIAs should stipulate clearly the length of time the EZ should be clear before SS can begin or the length of time the EZ must be clear of marine fauna after a delay has occurred. If this is not stipulated it can lead to excessively long SS, resulting in unnecessary noise production.[60]
- **Shutdowns:** These are the complete shutdown of airguns when a species that requires mitigation as per the EIA or country-specific guidelines enters the EZ. Over the last few years, South Africa through the EIA process has required shutdowns for all cetaceans, turtles and sometimes diving seabirds (including penguins). Other countries, such as Brazil, have legislation that requires shutdowns for all marine mammals and turtles.[61] South Africa needs to stipulate exact criteria for shutdowns and cement this in legislation.
- **Night-time requirements:** PAM is compulsory for night-time operations in New Zealand during level 1 surveys. In other countries, a mitigation gun (the firing of a single low-power gun) is used instead. PAM should be encouraged 24 hours a day and be compulsory at night. Yet PAM has limitations and requires cetaceans to be vocal. It does not identify turtles, diving seabirds or cetaceans that are not vocal. The EIA should encourage the use of a combination of alternative technologies, especially in sensitive areas. For example, active acoustic monitoring, thermal imaging, and radio detection and ranging are additional technologies that could be used. South Africa is known for its bad weather and rough seas and the use of multiple technologies during the day is advisable.[62]

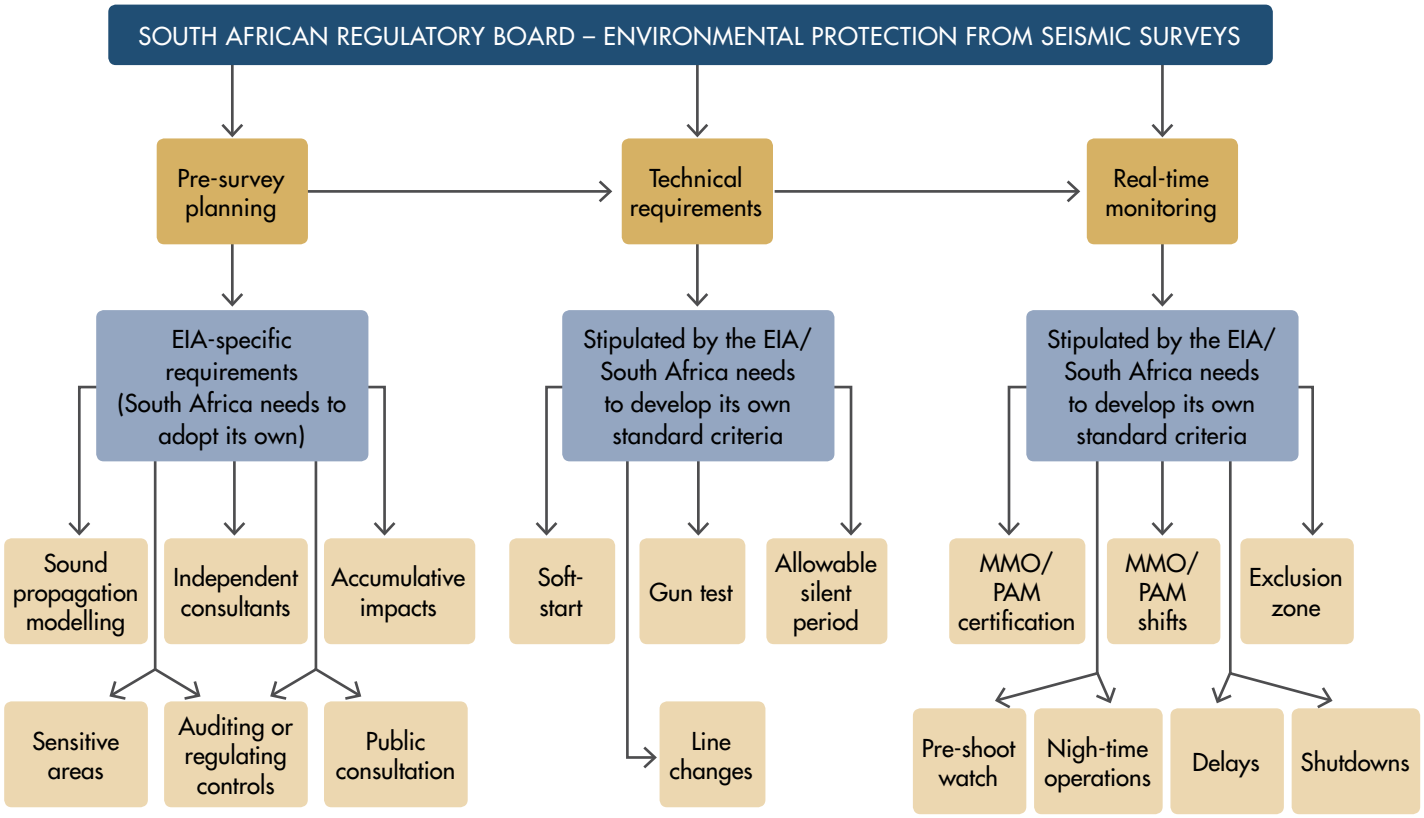
Figure 2 (see page 11) highlights areas on which South Africa could focus to try to formulate its own legislation and accompanying guidelines in order to reduce noise pollution.

CONCLUSION

With the Oceans Economy Lab underway it is the ideal time for South Africa to draft its own legislated guidelines for seismic surveys

With the Oceans Economy Lab underway it is the ideal time for South Africa to draft its own legislated guidelines for seismic surveys. If it does, it may be able to persuade other countries in the region to adopt them as well, through, for example, the Abidjan and Nairobi conventions. Since many marine species are migratory, regional guidelines would help preserve ecosystem integrity as a whole. To maintain environmental integrity, South Africa needs to place more emphasis on the protection of all its acoustically vulnerable species. Because seismic surveys are not the only activities in our oceans that cause acoustic pollution, activities such as mining, dredging, port expansion, drilling and commercial shipping could adopt similar regulations. South Africa ideally needs to form its own independent and transparent regulatory board, consisting of qualified and experienced members, to set criteria for EIAs, technical requirements, real-time monitoring and survey auditing. Its criteria should then be cemented as regulations and finally as a policy, to prevent misinterpretation.

FIGURE 2 AREAS THAT SOUTH AFRICA NEEDS TO ADDRESS TO FORMULATE ITS OWN GUIDELINES FOR SEISMIC SURVEYS



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14 Pressure produced by the acoustic waves.

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