

# A REVIEW OF SEISMIC MITIGATION MEASURES USED ALONG THE COAST OF NORTHERN SOUTH AMERICA, FROM NORTH BRAZIL UP TO COLOMBIA

*Reference Document  
for the MaMa CoCo SEA  
Steering Committee*  
**2015**

This review was co-financed by:



**GREEN HERITAGE FUND SURINAME**



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Marine Mammal - Sperm whale with calf Picture: © GHFS Archive

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The Green Heritage Fund Suriname  
would wish to thank all MMOs and reviewers  
who were so kind as to spend their valuable time  
in providing feedback at our request.

# SUMMARY

This review includes an analysis of different mitigation measures used during seismic surveys in the Northern part of South America (here referred to as the MaMa CoCo SEA region, which is short for **Marine Mammal Conservation Corridor** for Northern South America), which covers an area from North Brazil (west of the Amazon Estuary) up to Colombia and involving eight countries (Brazil, France (French Guiana), Suriname, Guyana, Venezuela, Colombia, Aruba, Curaçao, Trinidad and Tobago). Mitigation measures used within the (wider) region and those used internationally (New Zealand, Australia, UK, Gulf of Mexico) are also included for comparison.

This review highlights the following topics that are generally part of seismic mitigation guidelines, e.g. exclusion or mitigation zone (EZ), pre-watch period (PW), soft start (SS), gun-tests, line change, mitigation gun (MG), shutdowns (SD)/power down (PD) or Pause, Species of Concern (SoC) and the role of Marine Mammal Observers.

There are three phases involved in this review:

- (1) Analysis of different mitigation measures used during seismic surveys in the MaMa CoCo SEA region;
- (2) Forwarding the analysis to a selection of professional MMOs and representatives (from various institutes/Universities) for comments. These are specifically MMOs that have worked within the MaMa CoCo SEA region, or those that have extensive experience with seismic surveys in tropical regions. The information requested from the MMOs/reviewers is to grade the different measures in the summary (e.g. from poor, moderate, good to best practices);
- (3) Embedding of the comments from (anonymous) MMOs and Reviewers into the Reference Document. The latter is developed specifically to open discussion in order to select and produce draft Regional Seismic Mitigation Guidelines.

The Green Heritage Fund Suriname (GHFS) has been leading this analysis closely working together with an international team of researchers-environmentalists who, under auspices of the Regional Activity Centre of the SPAW Protocol of the Cartagena Convention, are working to produce a regional set of guidelines for seismic surveys within the Caribbean Sea. The drafting of a regional set of guidelines takes place in consultation with the country representatives of the steering group of the MaMa CoCo SEA and a broad range of stakeholders in marine seismic survey operations.



Marine Mammal - Bottlenose dolphins Picture: © GHFS archive

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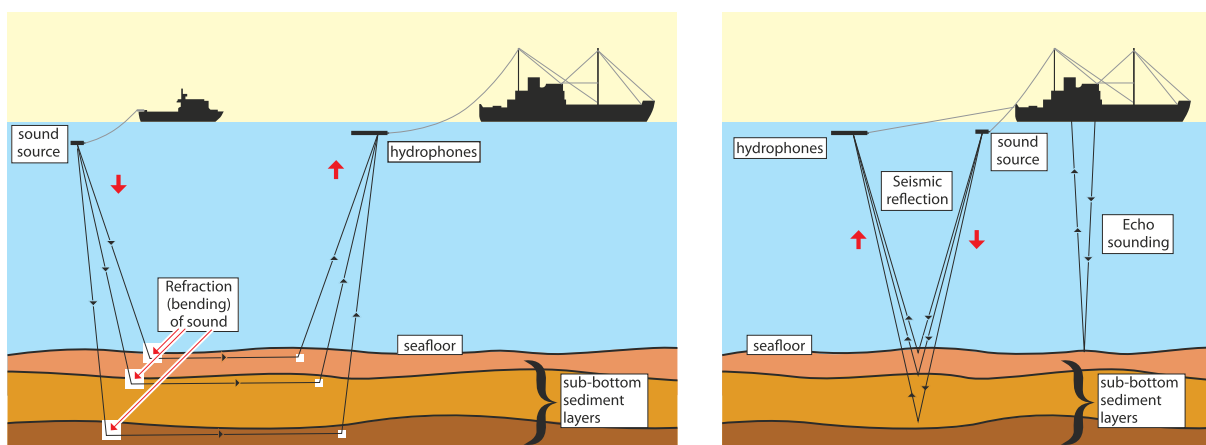
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# INTRODUCTION

There is increasing concern regarding the potential effects of the airgun sound produced during geophysical seismic surveys (Box 1) on marine mammals. Cetaceans, seals and manatees all rely on sound for fundamental biological and ecological aspects of their lives (e.g. communication, finding prey, capturing prey, navigation, avoiding predators).

During the MaMa CoCo SEA meeting in Paramaribo (CAR-SPAW-RAC, 2013) it was recognised that regional guidelines are urgently needed in order to minimise acoustic disturbance to marine mammals from seismic survey operations within the region from North Brazil (west of the Amazon Estuary) up to Colombia involving eight countries (Brazil, France (French Guiana), Suriname, Guyana, Venezuela, Colombia, Aruba, Curaçao, Trinidad and Tobago).

There are no regional guidelines for the MaMa CoCo SEA region, nevertheless seismic operations take place, and are increasing. For example in Suriname the first seismic surveys started from as early as 1960 and the first Marine Mammal Observers (MMOs) were stationed on board seismic survey vessels operating off Suriname in 2004. In French Guiana seismic surveys started in 1964 and continued with some breaks in between up to this date, and in the case of Trinidad, seismic surveys have been carried out since 2001 (Naranjit & Higgins, 2014).



Source: <http://www.dosits.org/people/examineearth/exploreforoilandgas/>

There is increasing concern regarding the potential effects of the seismic sound produced during geophysical seismic surveys on marine mammals. Marine mammals rely on sound for all of the fundamental biological and ecological aspects of their lives including navigation, prey location and capture, predator avoidance and communication (including during migration and reproduction).

**Seismic surveying** is widely used in the marine environment, mainly by the oil and gas exploration and production industry, to define and analyse subsurface geological structures. Seismic surveying uses a technique that directs acoustic energy (sound) into the rock beneath the sea floor from equipment towed behind a purpose-built seismic vessel. The sound source is produced by air-guns which generate short, intense pulses of sound directed at the seafloor.

**Airgun arrays** typically produce high amplitude sound with source levels in the region of 220–248 dB re 1  $\mu$ Pa @ 1 m. The acoustic output has highest energy at relatively low frequencies of 10–200 Hz, which overlaps extensively with the low frequency sound produced by baleen whales in the 12–500 Hz bandwidth. Airgun arrays may also produce significant high frequency sound energy, with airgun sound dominating frequencies up to 22 kHz within a few kilometers of the source (from Weir & Dolman, 2007).

**Box 1.** Seismic surveying and source levels produced by Airgun arrays.

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Apart from countries like Brazil and Colombia where local mitigation measures are currently adopted, for the remaining countries no mitigation guidelines exist. Nevertheless, some countries and oil companies have voluntarily adopted mitigation measures during past surveys, such as Soft Starts (SS), i.e. the gradual increase in the seismic source as stipulated from low power to the required working power (Full Volume) and the use of experienced and/or certified MMOs. However, information regarding the number of seismic surveys actually conducted within the MaMa CoCo SEA region, their noise exposure and set of mitigation measures is largely unavailable (and beyond the scope of this study).

Recently, an extensive review of scientific literature and reports was carried out by Naranjit & Higgins (2014) on the effects of offshore seismic surveys on marine fauna in Trinidad & Tobago. A similar review was carried out by Pusineri (2014) in French Guiana related to activities of the oil industry and cetaceans. It is obvious that although there is a growing body of knowledge illustrating the risks seismic surveys present to marine life, these risks are still poorly quantified in general. Another problem is that there is little knowledge available for most of the species that inhabit the waters of the MaMa CoCo SEA region and even the most basic knowledge about the presence/absence of species is often incomplete (e.g. De Boer, 2013).

Therefore the most important priorities are (1) the development of a regional set of mitigation measures to minimise acoustic disturbance to marine mammals from seismic survey operations; (2) the establishment of an effective long-term ongoing biological monitoring before, during and after seismic surveys in order to provide information on species occurrence, seasonal/temporal distribution and reactions to the seismic noise; and (3) the investigation into the effectiveness of mitigation measures and MMOs (e.g. Simmonds and De Boer, 2014). Finally, the collected data should be monitored in order to help define ‘sensitive areas’ or ‘seasons’ for closure to seismic operations, which are the most effective and precautionary mitigation against seismic noise (e.g. Weir & Dolman, 2007).

**Table 1.** Overview of seismic surveys and mitigation guidelines used within the MaMa CoCo SEA region.

Country	Survey type <sup>1</sup>	Guidelines
Aruba	2D seismic survey	There are no guidelines - best international practice has been used (JNCC + local additions)
Curaçao	2D seismic survey	There are no guidelines - best international practice has been used
Venezuela, Aruba & Curaçao	2D seismic survey	Seismic survey to gather information on island arc movements/ geometry (NMFS)
Colombia	2D & 3D seismic survey	Seismic Guidelines
Venezuela	2D & 3D seismic survey	There are no guidelines - best international practice has been used
Trinidad & Tobago	2D survey	Draft Guidelines (April 2014) under review
Guyana	2D & 3D seismic survey	There are no guidelines - best international practice JNCC/MMS
Suriname	2D, 3D (deep-water), 3D (shallow-water), River Seismic	There are no guidelines - best international practice: JNCC + Local additions & JNCC/BOEMRE
French Guiana	3D (deep-water)	There are no guidelines - best international practice: JNCC + Local additions
Brazil	All Offshore seismic operations	IBAMA
Gulf of Mexico	All Offshore seismic operations	BOEMRE
UK	All Offshore seismic operations	JNCC (2010)
New Zealand	Level 1 & Level 2 seismic surveys	New Zealand Department of Conservation (DOC)
Australia	All Offshore seismic operations	Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1 - September 2008

1 Offshore seismic Surveys Only, Not Including Site, Borehole or VSP Surveys

# Methods

## Part 1 - Analysis of different mitigation measures used during seismic surveys in the MaMa CoCo SEA region

Information regarding seismic surveys was requested from MaMa CoCo SEA representatives and other sources<sup>1</sup>.

Information was sought regarding the specific requirements of marine seismic surveys, such as

- (1) Observer requirement;
- (2) Observer certification;
- (3) Species of concern (including all marine fauna);
- (4) Size of the Mitigation/Exclusion Zone (EZ);
- (5) Required period of observation (e.g. pre-watch or all daylight hours);
- (6) Pre-watch period (the period of watch before the start of the soft-start/ramp up – this is usually 30 to 60 minutes);
- (7) Soft Start (SS) period (this is usually 20 to 40 minutes);
- (8) Delay period of soft start;
- (9) Shutdown or power-down requirements and which species are concerned;
- (10) Re-start after shutdown or power-down procedures;
- (11) Seismic source and mitigation measures at night time;
- (12) line change & gun-test regulations;
- (13) Allowable silent period;
- (14) Closed seismic zones or sensitive areas;
- (15) Reporting & Database requirements;
- (16) Authority;
- (17) Planning stage;
- (18) Recommendations/other (e.g. other marine fauna).

On a global scale, several countries currently enforce statutory industrial guidelines within their own national waters to include marine mammal mitigation measures during offshore seismic operations. A detailed outline of the international ‘best practices’ used by four of these nations (United Kingdom-UK, New Zealand-NZ, Australia-AU & Gulf of Mexico-GOM) is included in this review. These guidelines were selected due to their (1) long-term existence; (2) extensive use in tropical regions (UK, AU & GOM); and (3) good examples of areas which have mitigation measures reflecting large whales in ‘breeding grounds’ and/or ‘sensitive areas’.

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<sup>1</sup> Internet, MMOs, MMO recruiting agencies, oil companies, various marine institutes

## **Part 2 – Comments from a selection of professional MMOs and representatives (from various institutes/Universities).**

For the online survey MMOs were selected, particularly with experience within the MaMa CoCo SEA region, or extensive experience surveying within the tropical regions. The main information requested from the selected MMOs was to grade the different mitigation measures identified in Part 1 of this study (e.g. grade the mitigation measures from poor, moderate, good to best practices).

The aim was to receive comments from at least 4 or 5 professional MMOs, and in addition to receive feedback from several representatives (from now on called ‘reviewers’).

A total of 11 reviewers were approached. In addition, the survey was available for viewing by all representatives of the MaMa CoCo SEA Steering group and representatives from institutes/universities. The review was presented as an online survey (Survey Monkey). The survey was launched in late October 2014 and continued until April 2015.



Picture: © GHFS archive

# RESULTS

## Part 1 - Comparison of marine mammal mitigation measures used within the region

In total 17 different sets of mitigation measures originating from various seismic surveys and existing guidelines were used (Table 1) and these are detailed in Appendix I.

Within the MaMa CoCo SEA region two countries currently have their own seismic mitigation guidelines: Brazil and Colombia.

A third country (Trinidad & Tobago) has a draft set of guidelines currently under review (Naranjit & Higgins, 2014).

The remaining countries (Aruba, Curaçao, Venezuela, Guyana, Suriname and French Guiana) have no mitigation guidelines in place. However, a wide variety of mitigation measures have been adopted during recent seismic surveys.

A summary of mitigation measures per country is provided in Appendix 1-2



Elasmobranch - Smooth Hammerhead Shark Picture: © GHFS archive

Except for Brazil (IBAMA) and Colombia (CO) where the seismic mitigation guidelines are mandatory, the mitigation measures used within the MaMa CoCo SEA region have largely been based on international 'best practice'. The UK (JNCC) & GoM (MMS) or a 'cocktail' of both have been voluntarily implemented in French Guiana (FG), Suriname (SUR), Guyana (GUY), Aruba & Curaçao (A&C) and Venezuela (VE).

- **Species covered:** New Zealand (NZ), United Kingdom (UK), Gulf of Mexico (GoM), Brazil (BR), FG, SUR, Venezuela (VE) and A&C all apply measures to all marine mammal species. Australia (AU) to 'whale' species only, Colombia to cetaceans and Trinidad&Tobago (TT) to those species they list as 'Species of Concern'.

- **Marine turtles** are included in measures of GoM, BR, CO, TT, FG, SUR, VE and A&C. The JNCC (UK) also recommends measures for turtles but this is not mandatory.
- **Large elasmobranchs** (Sharks, rays) are covered in mitigation measures in French Guiana (FG), 'significant fish movements' also in TT and the UK recommends this for basking sharks.
- **MMOs:** All countries require MMOs to be trained or experienced. The UK requires MMOs to be JNCC certified, in the GOM these are Protected Species Observers (PSO) certified, in NZ MMOs are independent and TT requires dedicated observers. FG, SUR, Aruba all specify JNCC-certified MMOs and in some cases PSOs certification is also required (SUR, FG, VE, A&C). An academic degree (CO, SUR, BR) and/or > 10 years' experience (SUR) is required in some cases.
- **Hours of watch:** Within the region, all daylight hours are covered by MMOs. Maximum hours of watch the MMOs are to work per day should not exceed 12 hours (NZ) and regular breaks are specified (TT, BR & GoM).
- **Number of MMOs:** At least 1 MMO is required (UK) or 2 (UK when >12 hrs daylight; NZ, GOM, CO, FG, SUR, Aruba) or 3 MMOs (BR, SUR, VE, A&C). TT, Aruba & VE recommend additional MMOs on supporting/scouting vessels.
- **The Exclusion or Mitigation zone (EZ)** is 500m for most countries. AU has three zones: an observation zone (3km), a Low Power Zone (1-2km) and a Shutdown zone (500m). NZ has 1-1.5 km for Species of Concern and other marine mammals have an EZ of 200m. One survey in TT had a 5km EZ whilst another survey covering A&C and VE applied an EZ of 3500m in waters of < 100m.
- AU and TT propose that the EZ is based on acoustic threshold levels defined by **sound propagation modeling**.
- **Pre-watch period:** In waters deeper than 200m a pre-watch period of 60 minutes applies (UK) and 30 minutes in <200m. Same applies for FG, SUR, VE, A&C and possibly GUY (no details available). A 30 minute period regardless of the water depth is used in AU, NZ (but 10 minutes for Fur Seals), GoM, BR, CO but 60 minutes is proposed for TT.
- **The Soft Start (SS)** is 20 - 40 minutes. In AU this is 30 minutes. One survey off VE-A&C specified that this should at least be 6 dB per 5 minutes until operating levels were reached. In TT it is proposed that the sound pressure level at the start of the SS should not exceed 130dB re 1 µPa at 1m.
- **The delay of the Soft Start** is 20 minutes after the marine mammal (mm) is last seen within the EZ (UK). Although, this is 30 minutes after a 'whale' is last seen (relating to Low Power and Shutdown Zone in AU). In NZ the SS commences when the animal is outside the EZ or 30 minutes after the animal is last seen within the EZ (with a special requirement for fur seals, i.e. 10 minute delay). A 30 minute delay is also implemented in GoM, BR for mm & turtles and CO (for cetaceans and turtles). In TT the SS commences

after cetaceans or significant movements of fish are outside the area or a 30 minute delay applies, although this is 60 minutes for 'deep divers'. The SS can commence until a marine turtle is outside the zone (TT). In FG the delay of the SS is 20 minutes after seeing a marine turtle or shark/ray within a zone of 200m or until a cetacean is out of sight. A 20 or 30 minute delay applies for mm + turtles in SUR, VE, A&C.

- **Shutdown:** All nations except the UK require a shutdown when a 'species' is observed within the EZ. The range of shutdown zones varies from 200 to 5000 metres: For 'whales' a shutdown is implemented within 500m (AU+GoM) and voluntary shutdowns can be implemented for turtles (GoM). In BR and CO there is a shutdown for mm and turtles within 500m. In TT a shutdown could be implemented when 'whales' were inside 5 km but in the draft guidelines it is proposed that a shutdown can be implemented for a 'Species of Concern type II' when inside the EZ of at least 500m. In NZ a shutdown is implemented for mm or Species of Concern with calf (1.5km) or without calf (1km) although these zones are smaller for 'level 2 surveys' (e.g. 1km and 600m). In FG a shutdown of 5-8 shots is implemented for marine turtles and shark/rays within 200m but surprisingly not for mm. A shutdown for mm or turtles in apparent distress or when in direct heading to the seismic source or for 'whales', manatees and turtles when inside the EZ is used in SUR. In VE it is recommended to have a shutdown for mm and turtles within the EZ. In Aruba this applies for 'whales' and is recommended for turtles. A survey in A&C and VE implemented a Power-Down for animals (mm) inside the EZ although when 'in acute stress, injury or in a mortal state' a shutdown is required.
- To 're-start after a shutdown' different methods were used throughout the region. For the majority there is a delay until the animal is outside or 30 minutes after last seen within the EZ and starting with a SS (AU, NZ, GoM, CO, VE). For TT it is proposed that a 60 minute delay should be implemented for 'deep divers' and for turtles one should wait until the animal is outside the EZ. In A&SUR a 20 or 30 minute delay is followed by a SS. During a river survey in SUR the SS commenced as soon as the animal was outside the EZ. A survey in VE, A&C implemented a 15 minute delay for small odontocetes and 30 minutes for mysticetes/large odontocetes after last seen within EZ.
- **Poor visibility<sup>2</sup> or night-time operations:** Night-time seismic operations are permitted by the UK, Australia, GOM, and NZ but with specific conditions. Brazil does not allow operations to start at night. The JNCC preferably only commence seismic operations during daylight, but Passive Acoustic Monitoring (PAM) is recognized as a mitigation tool. NZ recommends the use of PAM and AU only allows operations if three or fewer Power- or Shutdowns have occurred in the previous 24 hours. GoM uses a mitigation gun and PAM is accepted as mitigation tool but not required. CO permits night-time operations with PAM or mitigation gun. TT suggests that PAM monitoring may be more effective from a non-source vessel. In FG&A, PAM is recognized and in SUR low-frequency PAM monitoring was carried out but in another survey a mitigation gun was used instead. In VE it is recommended to not allow operations at night and during a survey in VE & A&C

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2 **Good conditions** are generally defined as sea state  $\leq 3$  or 4 and visibility  $\geq 1.5$ km.

night-vision & PAM were used. In FG night-vision binoculars were tested and not found useful.

- **Line changes:** If line turns take less than 20 minutes, then operations continue at full power. If >20 minutes then the source is terminated followed by SS before the next line (UK, BR, CO, TT, FG, SUR, VE). Firing with mitigation gun during line turns may be implemented in AU, NZ, GOM, BR, FG (depending on source volume).
- **Allowable silent period:** When the source terminates for more than 10 minutes a SS is required to recommence operations (UK, NZ, TT, FG, SUR, VE, A&C). This period differs for GoM (20 minutes) and BR (5 minutes).
- **Closed seismic zones:** The UK, AU, BR, CO and NZ recommend that areas/times important for marine mammal species migration, breeding, nursing and feeding be avoided if possible. AU has a closed area in the Great Australian Bight for southern right whales and Australian fur seals. BR has seasonal closed areas for breeding humpback & right whales, Franciscana dolphin, turtle nesting season and manatee areas. Aruba adopts a 3km buffer zone from the coast.
- **Reporting:** All require accurate and complete reporting (sightings forms and final/summary report) submitted within reasonable timeframes. The GoM requires any whale-induced shut-down to be reported to the MMS within 24 hours of the shut-down. VE and SUR (in some cases) forward reports and thematic maps to stakeholders & NGOs. NZ requires that the authorities are informed when Species of Concern are more abundant than anticipated in order to adjust mitigation measures.
- **Database:** The database (Sightings, Effort, Operations) is forwarded to authorities (UK, AU, NZ, GoM, BR, CO, FG). TT proposes that this can be made publicly available. In SUR this was made available to a PhD student for analysis & publication as part of an inventory. Data forthcoming from a survey in A&C & VE was analysed and published.
- **Planning stage:** BR and CO have a formal permit or environmental assessment process for offshore seismic operations. TT also include this in their draft guidelines. In most cases, the likelihood of injuring or disturbing mm & turtles is assessed as part of Environmental Impact Assessment (UK, AU, NZ, BR, CO, TT, SUR, VE, A&C) and in some cases a permit is required. An EIA on request of the fishery committee to assess impact of seismic survey on fish population is required in FG.
- **Scouting survey:** In Aruba a scouting survey prior/during seismic survey is required. TT, SUR & AU carried out sound propagation modeling to define/confirm sound levels and EZs.
- In some countries it is required to have **turtle guards** fitted to tail buoys (FG, SUR).
- In FG there is a requirement to reduce lights on deck at night to avoid **seabird** strandings. In SUR & A, a reduction in speed of vessels in transit is required to avoid collisions, especially in near-coastal regions and turtle breeding sites and manatee habitat.

# RESULTS

## Part 2 – Comments from a selection of professional MMOs and representatives (from various institutes/Universities).

A total of six reviewers conducted the survey. Two reviewers completed the survey on 20 October, another two reviewers conducted the survey in early November (2&7 November), another reviewer did this on 6 December and the last reviewer completed the survey on 23 April 2015. Five of the reviewers were professional MMOs and of these four had experience working in tropical regions and three reviewers also had previous experience working within the MaMa CoCo SEA region.

The following is a summary of comments and grading for each mitigation measure.

### 1. Observer requirement on source vessel

Three reviewers (from now on presented as 'n=3') graded the use of only one experienced MMO as 'poor'. The majority of the reviewers graded the use of 2 or 3 MMOs on board the source vessel as important ('best': n = 5) and highlighted the importance of 'independent' MMOs (n = 4). In addition, it was noted that the MMOs needed previous experience of surveying in tropical waters (n = 1). The experience of working as a marine mammal scientist (rather than solely working as MMO) was graded 'good' (n = 1) or 'best' (n = 3) and this experience was classed to be at least 3 years (n = 2), 7 years (n = 1) or > 10 years of experience (n=2). It was further noted that it is recommended to have two MMOs on watch during start-up of the source (n=3) and that at least two MMOs should be present on the source vessel and that it may be beneficial to have one additional MMO placed on board a scouting/support vessel (n=1). The technical limitations of the PAM equipment currently in use was raised as a concern (n = 2) and it was highlighted that PAM was initially designed to be conducted from a support vessel as this is more effective (e.g. better range and suitability to determine bearing and range to acoustic detections) (n=2). The use of 1 or 2 optional PAM operators used at night time was graded 'moderate' (n=1), 'good' (n=1) or 'best' (n=2). It was further commented that one experienced MMO and an experienced PAM operator is adequate for general surveillance during pre-watches. It was also noted that the number of bunks/cabins available on board is often a deciding factor.

### 2. Certification of MMOs

Three reviewers graded the use of a trained crew member as 'poor'. The main comment given was that crew members have a conflict of interest on board and no impartiality (n=2). One reviewer classed it as 'poor' to have the local authority approve the MMO and another reviewer that the MMO would solely be certified as a 'Protected Species Observer'. The other reviewers (n=5) all stated that the 'MMO should be 'PSO & JNCC certified' and the Lead MMO should have an Academic degree (MSc) in Marine Biology'. 'Specialized observers: marine biologists, fisheries, oceanographers & trained crew' (n=1) or 'Undergraduate in biology or similar; with statistics course; certified technical training and 1 year experience/

certified in fisheries and/or MMO' (n=3) were also recognised although it was highlighted that previous experience on board a seismic survey vessel was very important together with specific training (n=3).

The following comment was given: 'A key aspect of being an MMO is excellent communication with seismic crews and project managers as it is not just a question of having marine or fisheries experience'. 'MMO's have to be confident and sometimes make big decisions on board in a short space of time when under a lot of pressure - this is an area where trainees often struggle so one should be wary of sending out very young/inexperienced students/trainees unless they have experienced MMOs to work with'. 'Experienced MMOs should be able to make judgment calls with regard to restarting the source if an animal is observed leaving the safety zone - Many MMOs if too emotive or inexperienced think it is good to stop a survey at any excuse - however, this just adds on extra time to a survey and extends the environmental impacts in terms of general vessel(s) noise and pollution'.

### 3. Species covered

The Species covered varied in grading amongst the reviewers. Nevertheless, most reviewers stated that it was important to have at least 'whales' (n = 2) or otherwise 'marine mammals & marine turtles' covered as Species of Concern (n = 4) including 'manatees' (n = 1). On one occasion, the inclusion of 'elasmobranchs' (sharks/rays) was highlighted as 'moderate'. Some reviewers welcomed that the 'Species of Concern' should be categorised into five



Marine Turtle - Olive Ridley Turtle Picture: © GHFS archive

different hearing groups each with their own specific Mitigation Zone for monitoring (n = 3). Two reviewers commented that more research is needed into mitigation measures for marine turtles.

### 4. Mitigation Zone/ Exclusion zone (EZ)

Two reviewers were of the opinion that a mitigation zone of 500m was 'poor', other reviewers classed 500m as 'best' (n=2), 1000m as 'good' (n=1) or 5000m as 'best' (n=1). One reviewer

commented that a zone of 5000m is difficult to visually survey except for very large whales (spouts) in good sighting conditions. Another reviewer commented 'that mitigation zones should be no more than 500 metres around the source - any greater and most MMO's would struggle to accurately judge/measure distance and it would be very unlikely to see the smaller cetaceans'. A further comment was made with regard to the fact that 'a higher number of streamers are being used in recent surveys (e.g. the amount of streamers pulled by a seismic survey) and that this has led to an increased distance of the seismic source relative to the MMO which hampers the ability to visually cover the mitigation zone'.

An option for three zones depending on water depth [(1) zone=3500m in waters <100m; (2) zone=1350m in water depths 100–1000 m; and (3) zone=900m in waters >1000m] was highlighted (n=3). One reviewer commented that this is a suitable measure and avoids any seismic activity close to the coast and/or in rivers. An alternative was graded as 'best' where there are two zones: (1) 500m (for shut down); and (2) 1000m (for delay of soft start) (n=1), and several recommendations of different zones for different species (n=3). There was one comment 'that the mitigation zone should be based on acoustic threshold levels through sound propagation modelling'. A problem was outlined that 'there will be different water depths and bottom characteristics within one seismic area – and therefore it is anticipated that the zones will change in size depending on the locality within the study area. This should be avoided as this is potentially confusing - better to select one or two zones'.

## **5. Required period of observation (Pre-Watch)**

Most reviewers highlighted the need for monitoring during all daylight hours (n=6) with 24 hours monitoring (MMO/PAM; n = 4). It was commented on the fact that 'Continuous visual observations or monitoring with echo-sounder cannot be combined and that echo-sounders are not designed to detect marine mammals'. Observations should be carried out by 1 MMO on watch & 1 MMO on break with a duration of watch that should not exceed 12 hours (n=3). It was commented that 'an MMO should not act also as PAM or vice versa – this often leads to lengthy watches (6 hrs on PAM followed by 6 hrs on MMO) and definitely should not be conducted at the same time'. It was stated that 'a watch should not exceed 3 hours and preferably be limited to two hours - MMO's work in different ways, some will sit at a bridge wing, inside the vessel with air conditioning but limited visibility. It is best to be outside where possible, but in the tropics this can be very hard going as a result of heat/glare'.

## **6. Pre-watch period**

A pre-watch period of '30 minutes in water depth < 200m; 60 minutes in depth > 200m' was classed as 'best' practice (n=3) or '60 minutes' (n=4) (best/good practice), although a pre-watch period of '10 minutes' was opted for fur seals (n=1). It was further commented that 'MMOs are not qualified/certified to operate the ship's radar and that this is not a reliable method of detecting marine mammals'.

## **7. Soft-Start (SS) duration**

One reviewer classed a SS of '20 minutes' as 'poor' whilst a SS of '20-40 minutes' was classed as 'good' or 'best' (n=2). It was further noted that 'the Sound pressure level at the start of

the Soft Start should not exceed 130dB re 1  $\mu$ Pa at 1m and then should slowly build until Full Power is reached' (n=2) although one reviewer classed this as a 'poor' measure. It was also opted that 'a Soft Start should increase by approximately 6 dB per minute' (n=2). It was further commented that 'given the technical limitations of PAM a 'super soft start' could be used during hours of darkness. This would entail a soft start of one hour, raising the noise level by 8% every 5 minutes until the 55th minute, when it would increase by 12% to its maximum'.

## **8. Soft-Start (SS) delay period**

A delay until cetaceans are 'out of sight' or a delay for elasmobranches/turtles (and not marine mammals) were classified as 'poor'. The majority of the reviewers favoured a delay of '20 or 30 minutes' after the animals were last seen or after they had left the mitigation zone (n = 4). The 'best' measure was 'species specific': (1) A 30 min delay after 'Species of Concern' is last seen in mitigation zone; (2) a 60 min delay for 'deep diving whales'; (3) until a 'marine turtle' is outside the zone (n = 2).

## **9. Shutdown requirement**

A 'power-down (to only one airgun) when 'marine mammals' are in mitigation zone with a full shutdown only when animal is injured or in a mortal state or in acute distress' was classed as 'poor' (n=1) and 'a voluntary shut-down for 'sea turtles' (to be approved by client) was not recommended (n=2). It was commented that 'shutdown requirements should be clear prior to the survey as there is no time to call up a client rep/party chief and ask for permission to shutdown'.

A shutdown for 'Species of Concern' (n=1) or 'cetaceans, manatees and turtles' (n=4) inside the mitigation zone were most popular (classed as 'good or best'). A specified shot-point pause for 'turtles & elasmobranches' (sharks/rays) was believed to 'may work in some cases and are 'better than nothing', however, it can confuse animals, so best to shutdown a bit longer until animal is well clear from the zone'.

It was highlighted to 'shutdown only if 'marine mammal or turtle' is directly heading towards source or is in apparent distress' (n=1). It was commented that 'experienced MMOs should make judgment calls based on the behaviour of animals and that this may be a very useful protection measure and management tool that allows shutdowns to be made where necessary but also allows the survey to continue when animals are behaving 'normally' and transiting through the survey area. This means that no undue shutdowns are implemented and so the survey will finish in good time'.

It was further outlined that a 'shutdown mitigation requirement needs a 24 hour constant coverage so one needs two experienced MMOs and one or two PAM operators'. Furthermore, it was highlighted that more research is needed into Turtle mitigation.

## **10. Re-start after shutdown**

For turtles and elasmobranches it was classed to be 'good' to go back to full-power operations after shot-point pause (n=1). It was also highlighted that 'one should always re-start with a

Soft Start and that a re-start can only occur if visibility is good (no fog, rain), and there are no marine mammals or turtles inside the zone' (n=2). The 'best' measure was found to be 'species specific': 'A 30 minute delay after last seen in mitigation Zone; or a 60 minute delay for 'deep diving whales'; or wait for 'turtle' to be outside the zone' (n=3). Second best was to 're-start with a Soft Start after 20 minutes from last sighting inside the zone' (n=2).

## **11. Night-time seismic operations**

No start of operations at night or during bad weather (rain, fog), unless 'mitigation gun' is used was classed as 'poor' (n=1) and 'moderate' (n=1). No start up at night time was classed as 'good' (n=1) or at least not after a 'shutdown' (n=1) or at least 'not in areas of high sensitivity' (n=2). The 'best' measure was to only commence seismic activities during the hours of daylight. In two cases it was highlighted that 'night-time operations are allowed with PAM or low-frequency acoustic monitoring'. Another reviewer selected that 'if no PAM available and no seismic operations in previous 24 hours then at least 2 hours of MMO watching during last daylight with no marine mammal sightings within the zone'. It was further commented that 'given the technical limitations of PAM a 'super soft start' could be used during hours of darkness - This would entail a soft start of one hour, raising the noise level by 8% every 5 minutes until the 55th minute when it would increase by 12% to its maximum'. It was also commented that 'a Spotter vessel/aircraft searches the night-time survey area ahead of the survey (during daylight) - this type of surveying ahead is not recommended as marine mammals can move fast through the area and enter the prospect area at night' (n=1).

## **12. Night-time mitigation**

The use of night-time binoculars then Soft Start was classed as 'poor' (n=2) and it was commented that 'these do not work due to limited range'. A concern was raised regarding the use of a Turtle Detection Device (ATS DSP Receiver to monitor turtles equipped with VHF radio transmitter using a single frequency 150.101 MhZ) as 'these will only work on females that carry a tag and not detect males and untagged-females, although such a measure is a great tool to allow us to learn more about turtle migration and should be used on board seismic vessels'.

The 'best' measure was 'a Soft Start & PAM, or use of mitigation gun at least one hour before Soft Start if PAM is not available' (n = 3). It was highlighted as 'best' to have PAM from a non-source vessel ahead of seismic vessel as this is more effective (n=2). It was further commented that 'given the technical limitations of PAM a 'super soft start' could be used during hours of darkness. This would entail a soft start of one hour, raising the noise level by 8% every 5 minutes until the 55th minute when it would increase by 12% to its maximum'. It was also classed as 'best' to have no Soft Start in darkness or heavy fog/high seas (when the mitigation zone is not visible).

## **13. Line changes (> 500 cubic inches)**

It was not favoured by one reviewer that 'when line change is less than 40 minutes to change Shot-Point Interval (< 5 min)'. Similarly, it was stated that it is wrong 'to Power down to the lowest possible setting ('mitigation gun') - and that then no pre-watch is needed and one

can go straight into a Soft Start' as a 'pre-watch is always needed before a Soft Start'. Another option for line changes was to 'Terminate or power down for mitigation' (n=4), however, it was highlighted that 'a special permit is often needed for the use of a mitigation gun'. The 'best' measure was 'when line change is more than 20 minutes then terminate source and commence soft start before the Start of Line' (n=3). It was commented that 'when MMO's are on watch throughout all daylight hours that this will benefit such operations as pre-watches become immaterial (as one was already on the look-out)'.

#### **14. Allowable silent period**

There was contradiction whether or not to keep the 'mitigation gun' running during a silent period (during night time) (classed as 'poor': n=2 & 'good': n=2). It was commented that this was especially important due 'to the technical limitations of current PAM equipment'. The 'best' measure was that 'when the silent period exceeds 5 minutes, operations should commence with a Soft Start' (n=3), although some reviewers favoured a silent period of '10 minutes' (n=2).

#### **15. Closed seismic zones**

The 'best' measure was that there should be seasonal limitations in some areas or that there should be seasonal closed areas for breeding whales, turtle nesting & manatee habitat (n=3). Another stated that 'no seismic operations to take place in Marine Mammal Sanctuaries and limited in Areas of Ecological Importance'. It was also highlighted that 'no Seismic operations should occur in waters with a depth <12m' (n=1) and that there should be a buffer zone of 3 km from the coast that does not allow seismic operations (n=1). Furthermore, it was found important that no seismic surveys should be planned in areas of whale breeding, calving, resting, feeding, migrating (n=1).

#### **16. Reporting**

It was classed 'poor' to only have a final report sent to the client at the end of the survey, and that a draft report needs to be sent to the authorities within 90 days after survey 'was found too long' (n=1). It was found most important that the 'Daily report sent to client, final report sent to client and authorities' and it was recommended that 'Daily reports to Client, Weekly report to all concerned and a Final report to all concerned within 5 working days after completion of the survey' or at least < 60 days (n=1). It was also highlighted that 'one should inform the authorities of the presence of Species of Concern' (n=1) in order to adjust mitigation measures (e.g. increase mitigation zone etc). It was also found important that 'reports and thematic maps should be forwarded to stakeholders' (n=1).

#### **17. Database requirements**

It was classed 'poor' that Raw data sheets should be submitted to authority in less than 14 days after survey ends 'since raw data sheets are difficult to be interpreted by non-experts' (n=2). It was found important that 'when possible, database is forwarded to scientist for analysis and publications' (n=4). The 'best' requirement was that 'a spread-sheet + report should be made publicly available' (n=2) or that 'the database should be made available to

industry & local authority & available upon request' (n=1). It was also highlighted that 'the JNCC database (effort, sightings & seismic operations) should be used and forwarded to authorities after end of job'. It was also noted that 'seismic surveys often take place in remote offshore areas where MMO observations may be the only recent source of information on marine mammals'.

## 18. Local additions

The following local additions were highlighted as important, from 'best' to 'moderate' these were:

- A pre-operational meeting (outlining all mitigation measures) should take place immediately prior to the survey involving the client, MMOs, client representatives and seismic crew. It was further commented that 'this is very important, not the least because it gives the MMO an opportunity to gauge the sincerity of those in attendance with a view to enforcing the agreed regulations'.
- If turtle is (briefly) seen ahead of the vessel but still outside the mitigation zone then the approximate position of the turtle should be used as a 'reference point'. When the mitigation zone reaches this point, request delay of Soft Start/Shutdown.
- Turtle guards should be fitted on tail buoys. It was highlighted that 'this is standard practice nowadays, but should be checked on board by the MMO'.
- A watch of two hours should be followed by a break of up to 2 hours.
- Sound propagation modelling should be carried out prior to the survey to define the range of the mitigation zone. This should also be tested in the field when seismic survey is taking place.
- Good surveying conditions are: visibility > 1.5km and sea state < 4
- Reduce lights on deck at night to avoid seabird strandings (on deck).

It was classed 'poor' that 'Support vessels should help with monitoring for wildlife and slow down speed during transits in sensitive coastal areas (nesting areas for turtles, etc.)' (n=1) as 'this should be the task of an independent observer'.

## 19. Planning stage

It was highlighted that 'a scouting survey should be carried out before the seismic survey takes place' (n=2) and that 'a Marine Mammal and Sea turtle monitoring plan should be part of Environmental Impact Assessment (EIA)' (n=2). It was found important that 'a High quality EIAs must be an intrinsic part of project planning even where this is not required by law' (n=2). A 'best' planning stage was (1) Minimise exposure/use lowest practicable power levels; (2) Environmental Impact Assessment (EIA) to assess likelihood of injuring/disturbing Protected Species; and (3) apply for permit from local authorities (n=3) and that 'this should be done even where this is not required by law'. Furthermore, it was highlighted that 'no seismic surveys should be planned in areas when/where whales are likely to be breeding, calving, resting, feeding, migrating' (n=2).

# CONCLUSIONS

This review presents an analysis of national guidelines and mitigation measures used on board seismic surveys within the MaMa Coco Sea region. The measures/requirements were compared to each other, amongst other criteria. This review suggests amendments to or inclusion of additional local mitigation measures.

In several aspects, the reviewers had mixed views regarding the different mitigation measures and it was found that some mitigation measures appear to not always be effective in terms of protection of marine animals against severe acoustic disturbance from sound associated with seismic surveys.

Specific issues highlighted by the reviewers included:

- Regional Guidelines should be enforced by ‘independent’ personnel. Crew members or those MMOs hired directly through the seismic contractors have a conflict of interest on board and no impartiality.
- A certification and training programme for MMOs is needed together with the standardisation of data collection and ensuring the professional independence of experienced MMOs.
- Mitigation Zones are difficult to cover visually when these become too large. It is potentially confusing to have too many different zones for different species.
- Additional MMOs should be placed on support vessels (and/or aircraft) in addition to MMOs on the source vessel as this allows for a better coverage of specifically the larger mitigation zones and also allows the scouting for marine animals ahead of the seismic survey.
- A high quality Environmental Impact Assessment process should be developed, including consultation with other stakeholders, prior to submitting a permit.
- More research is needed into mitigation for marine turtles.
- It was highlighted that no seismic surveys should be planned in areas of whale breeding, calving, resting, feeding or migrating.
- The use of Passive Acoustic Monitoring as well as visual observations may be useful for night time/bad visibility although one should bear in mind that there are technical limitations to the current PAM equipment; PAM was initially designed to take place onboard support vessels as this is more effective (range/bearing/distance).

- The MMO data quality should be improved and at least one MMO must have an academic degree (MSc) and also at least 3 years of experience working as MMO and/or up to 7-10 years of marine mammal research. The minimum number of observers required should be increased and setting maximum working hour standards for each observer (3 hours maximum, but preferably two hours when working outside in tropical regions) although the number of bunk spaces available on board may affect this.
- Survey data should be submitted to a central database and making such data freely accessible.
- A pre-operational meeting (outlining all mitigation measures) should take place immediately prior to the survey involving the client, MMOs, client representatives and seismic crew. It was further commented that 'this is very important, not the least because it gives the MMO an opportunity to gauge the sincerity of those in attendance with a view to enforcing the agreed regulations'.
- More research is needed regarding Sound propagation modelling to define the range of the mitigation zone and how this can be implemented in the study areas concerned where bathymetric features may vary.
- It was highlighted that the Brazilian legislation (Normative Statement IBAMA/ICMBio N° 01/2011) establishes periods of restriction to the exploration and production of oil and gas (seismic, drilling for oil, marine geotechnical drilling, installation of pipelines and units, repumping of oil, gas and water production) in priority areas for sea turtles conservation along the Brazilian coast. The land boundary of these areas extends from the high tide line to 200 meters (or 50 m in urbanized areas) towards the mainland, while the marine boundary extends up to 15 nautical miles seaward for seismic activities and drilling of wells. For installation of pipelines and marine geotechnical drilling, maritime boundaries are located at points located within 3 nautical miles.
- During the SOLAMAC 2015 (Society of Latin American Specialist in Aquatic Mammals) conference in Cartagena de Indias, Colombia in December 2014, a pre-meeting workshop was held on Impacts of Seismic Surveys on Marine Ecosystems. The conclusions of the workshop were presented in the plenary session of the Symposium: Impact of seismic surveys on marine ecosystems, particularly marine mammals, during the SOLAMAC Conference. There was a discussion on which Marine mammal observer guidelines were more complete and the Brazilian model seems to have a transparent process in which observers have to always provide their sightings to a national data base managed by the Government which is later used to decide upon important areas for marine mammals. The Brazilian guidelines were considered the most advanced seismic guidelines currently available in this region, which are adapted to local circumstances, species and ecosystems. They form a good basis for all countries to start from and adapt to their specific national circumstances. The Steering Cie members of the MaMa CoCo Sea Steering Cie present in a meeting held after the Symposium thought it would be useful to use the Brazilian guidelines as the basis for developing regional guidelines (see for further information Box 2).

- Finally, seismic surveys often take place in remote offshore areas where MMO observations may be the only recent source of information on marine mammals. MMO data collected during seismic survey operations can provide useful qualitative data on the seasonal distribution of observed species within the region, as well as identifying migration routes and habitat use (e.g. calving areas). Such observations can also provide information on sighting probability. In addition, observations from seismic vessels can provide information on the behaviour of animals around seismic vessels at different sound levels, and generally provide insight into the impacts of seismic surveys on these species.



Elasmobranch - Manta Ray Picture: © GHFS archive

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For each measure or requirement we selected the ‘best’ and ‘good’ graded measures/requirements as indicated by the six reviewers (Table 2). However, this is not meant as a fixed set of guidelines but as an initial step that will open discussion.

We hope that the suggestions presented here will go some way towards developing a Regional set of Guidelines for long-term, adaptive, integrated management of the marine environment within the MaMa CoCo SEA region.

During the SOLAMAC 2015 (Society of Latin American Specialist in Aquatic Mammals) conference in Cartagena de Indias, Colombia in December 2014, a pre-meeting workshop was held on Impacts of Seismic Surveys on Marine Ecosystems. The idea behind this workshop was to have a platform where scientists and the petroleum industry could meet and discuss about the risks of hydrocarbon exploration to the environment, and specifically the impacts of Seismic Surveys and how to mitigate the impacts. The four objectives of the meeting were: 1. to assess the state of current knowledge of the effects of seismic surveys on the health and behaviour of some animal groups; 2. to review current procedures and mitigation actions implemented; 3. to review the status of existing legislation at the national, regional and international levels; 4. to propose measures, which serve as input to establish national regulations. Cristián de Haro (Argentina), Darlene Ketten (USA) and Catalina Gómez (Colombia) were the panelists who presented on the following topics: how marine seismic surveys and offshore exploitation developments take place in Colombia; the hearing systems of marine mammals and the implications for underwater acoustic impacts; a standardized framework for assessing risks of cumulative impacts of anthropogenic stressors arising from marine projects; an overview of offshore hydrocarbon exploration in Latin America and mitigation actions. Three working group discussions ensued with the following themes: mitigation measures; development of legislation in Latin America; and, impacts on marine ecosystems. The conclusions of the workshop were presented in the plenary session of the Symposium: Impact of seismic surveys on marine ecosystems, particularly marine mammals, during the SOLAMAC Conference. There was a discussion on which Marine mammal observer guidelines were more complete and the Brazilian model seems to have a transparent process in which observers have to always provide their sightings to a national data base managed by the Government which is later used to decide upon important areas for marine mammals. The general conclusions of the workshop were that for Colombia, there are no specific studies of the impacts of seismic activities or acoustic waves on different groups of fauna in the Colombian marine environment. Currently, mitigation actions in Colombia (and other countries in the region), are limited to those suggested by the Join Nature Conservation Committee, including preliminary observations, the soft start and stopping of the operations when an individual is detected within an exclusion zone of 500 meters from the airguns. Such regulations are imposed by the environmental authorities, but are not officially laid down in regulations or laws. What is necessary in addition to the guides to good practice for seismic surveys are stronger policies formulated for environmentally friendly operations. The workshop was considered to be successful and is deemed to strengthen the forums for discussion that seek to formulate basic documents to establish regulations in Colombia. For that reason it was deemed necessary to continue with this type of discussion, including new actors to encourage the collection of information and resource management legislation to regulate the activities of hydrocarbon exploration. The Brazilian guidelines were considered the most advanced seismic guidelines currently available in this region, which are adapted to local circumstances, species and ecosystems. They form a good basis for all countries to start from and adapt to their specific national circumstances. The Steering Cie members of the MaMa CoCo Sea Steering Cie present in a meeting held after the Symposium thought it would be useful to use the Brazilian guidelines as the basis for developing regional guidelines.

**Box 2** – Details on proceedings of a pre-meeting workshop regarding Impacts of Seismic Surveys on Marine Ecosystems. SOLAMAC 2015 (Society of Latin American Specialist in Aquatic Mammals) conference in Cartagena de Indias, Colombia in December 2014).

**Table 2** Overview of best/good mitigation measures and requirements as indicated by reviewers together with the Brazil guidelines included following the recommendations adopted by the Cie members of the MaMa CoCo Sea Steering Cie in November 2014.

Measure	Good	Good	Best	Best	Comment	Brazil
Observer requirement on source vessel	2 independent MMOs + 2 PAMs	3 trained MMOs (2 on watch during start up of seismic source), 2 PAMs.	3 independent MMOs; of which 2 MMOs have >10 years' experience in mm research	2 MMOs (stationed on source vessel); 1 MMO on scouting/support vessel; 1 PAM (during night-time)	For tropical regions and with > 12 hours daylight at least 2 MMOs	At least 3 observers, in order to have 2 MMOs on watch
Certification of MMOs	Undergraduate in biology or similar; with statistics course; certified technical training and 1 year experience/certified in fisheries and/or MMO	Experienced with Seismic and must be able to identify a Species of Concern	PSO, JNCC, Lead MMO with Academic degree (MSc) in Marine Biology	Professional, dedicated and experienced or specific training	It cannot be highlighted enough that MMOs should be dedicated and independent	Professional, dedicated and experience or specific training
Species covered	All whales (all species of baleen whales, beaked whales, sperm whales, pygmy and dwarf sperm whales (Kogia sp.))	Cetaceans, manatees & turtles	Species of Concern; these are categorised into five different hearing groups each with their own specific Mitigation Zone for monitoring	All whales (all species of baleen whales, beaked whales, sperm whales, pygmy and dwarf sperm whales (Kogia sp.))	More research is needed into pauses for Marine Turtles	Marine Mammals & Turtles
Mitigation Zone/ Exclusion zone (EZ)	Seismic source >427 cubic inches: Species of Concern with calves have a mitigation zone of 1.5km; Species of Concern have a mitigation zone of 1km; Other Marine Mammals have a mitigation zone of 200m	At least 500m; the mitigation zone should be based on acoustic threshold levels through sound propagation modelling	Three zones should be used: (1) an Observation Zone: 3+ km; (2) a Low Power Zone: 1-2 km [for delays/power down of source to single airgun]; (3) a Shutdown Zone: 500m [to implement a complete shutdown of seismic source]	500m (radius from the centre of the seismic source)	Different zones for different species (for Shutdowns)	500m (shut down); 1000m (SS delay)
Required period of observation (Pre- Watch)	Observations should take place at the highest point on vessel during pre-watch & Soft Starts; and preferably during all daylight hours		All daylight hours: 1 MMO on watch & 1 MMO on break. Duration of watch should not exceed 12 hours	24 hours (MMO/ PAM)	A watch should not exceed 3 hours and preferably be limited to two hours	All daylight hours
Pre-watch period	30 minutes for marine mammals; 10 minutes for Fur seal sp.		30 minutes in water depth < 200m; 60 minutes in depth > 200m	60 minutes		30 minutes
Soft-Start (SS) duration	The Soft Start should increase by approximately 6 dB per minute		20-40 minutes	The Sound pressure level at the start of the Soft Start should not exceed 130dB re 1 µPa at 1m; then slowly building until Full Power is reached	Given the technical limitations of PAM use of a 'super soft start' during hours of darkness (e.g. a soft start of one hour, raising the noise level by 8% every 5 minutes until the 55th minute when it would increase by 12% to its maximum)	20-40 minutes

Measure	Good	Good	Best	Best	Comment	Brazil
Soft-Start (SS) delay period	At least a 20 minute delay after 'marine mammal or turtle' is last seen within mitigation zone		This is species specific: (1) A 30 min delay after 'Species of Concern' is last seen in mitigation zone;			At least 30 min delay after animal last seen within EZ
Shut-down requirement	A specified shot-point pause for 'turtles & elasmobranchs' (sharks/rays)	A shutdown should be implemented when a 'Species of Concern with calf' is inside 1.5 km; for those without a calf this should be inside 1 km	(2) a 60 min delay for 'deep diving whales'; (3) until a 'marine turtle' is outside the zone	Shutdown for 'Species of Concern' when inside the mitigation zone	More research needed into Turtle mitigation	Marine Mammals & Turtles
Re-start after shut-down	Resume when animal is outside the zone; or at least 30 min delay after animal is last seen; starting with Soft Start	Back to full-power operations after shot-point pause for turtles/elasmobranchs	Shutdown for 'cetaceans, manatees and turtles' inside mitigation zone	Re-start with Soft Start after 30 minutes from last sighting inside the zone		
Night-time seismic operations	If no PAM available and no seismic operations in previous 24 hours then at least 2 hours of MMO watching during last daylight with no marine mammal sightings within the zone	No seismic operations at night	This is species specific: A 30 minute delay after last seen in mitigation Zone; or a 60 minute delay for 'deep diving whales'; or wait for 'turtle' to be outside the zone	Preferably only commence seismic during the hours of daylight		No start of operations at night or during bad weather (rain, fog), unless mitigation gun is on (160 dB re 1µPa-m)
Night-time mitigation	Passive Acoustic Monitoring (PAM) and Soft Start		Operations cannot commence at night in areas of high sensitivity	PAM from a non-source vessel ahead of seismic vessel is recommended as this is more effective		It may be allowed to continue with mitigation gun
Line-changes (> 500 cubic inches)	Use of mitigation gun during line changes, then Soft Start. (Mitigation gun with same shot-point interval and a minimum level of 160 dB re 1 µPa-m)			When line change is more than 20 minutes then terminate source and commence soft start before the Start of Line		When > 20 min then terminate, commence SS before SOL; In order to avoid delays, it may be allowed to use mitigation gun
Allowable silent period	When airguns have not been firing for more than 10 minutes, operations should commence with a Soft Start	It is recommended to leave the mitigation gun running during a silent period (during night time)	If the silent period exceeds 5 minutes, operations should commence with a Soft Start			5 minutes, then Soft Start

Measure	Good	Good	Best	Best	Comment	Brazil
Closed seismic zones	No seismic surveys should be planned in areas of whale breeding, calving, resting, feeding, migrating	No Seismic operations in waters with a depth <12m	There should be seasonal limitations in some areas	Seasonal closed areas for breeding whales, turtle nesting & manatee habitat		Seasonal closed areas: breeding humpback & right whales, Franciscana dolphin, turtle nesting & manatee habitat; No Seismic <12m water depth.
Reporting	Reports and thematic maps should be forwarded to stakeholders			Standardised format of report should be submitted <60 days after survey ends	Inform authorities of the presence of species of concern	Sent straight to IBAMA within 5 working days
Database	When possible, database is forwarded to scientist for analysis (and publications)	Database available to industry & local authority & available upon request	A spreadsheet + report should be made publicly available			IBAMA database
Local additions	Sound propagation modelling should be carried out prior to the survey to define the extent of the mitigation zone. This should also be tested in the field when seismic survey is taking place	If turtle is (briefly) seen ahead of the vessel but still outside the mitigation zone then the approximate position of the turtle should be used as a reference point. When the mitigation zone reaches this point, request delay of Soft Start/Shutdown	A pre-operational meeting (outlining all mitigation measures) should take place immediately prior to the survey involving the client, MMOs, client representatives and seismic crew	A watch of two hours should be followed by a break of up to 2 hours	Turtle guards should be fitted on tail buoys. This is standard practice nowadays but should be checked on board by the MMO prior deployment	IBAMA does not require PAM as mitigation measure
Planning stage	Marine Mammal and Sea turtle monitoring plan as part of Environmental Impact Assessment (EIA)	High quality EIAs must be an intrinsic part of project planning even where this is not required by law	No seismic surveys planned in areas when/where whales are likely to be breeding, calving, resting, feeding, and migrating	(1) Minimise exposure/use lowest practicable power levels; (2) Environmental Impact Assessment (EIA) to assess likelihood of injuring/ disturbing Protected Species; and (3) apply for permit from local authorities. This should be done even where this is not required by law		Consult, plan and permit needed



Elasmobranch - Blue Shark Picture: © GHFS archive

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## WEBSITES TO GUIDELINES

Australia guidelines (2008) <http://www.environment.gov.au/resource/epbc-act-policy-statement-21-interaction-between-offshore-seismic-exploration-and-whales>

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# **APPENDIX 1**

## **Summary of mitigation measures per country**

Guideline	United Kingdom	Australia
<b>Title of Guideline/ survey</b>	JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys	Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales
<b>Date</b>	August 2010	September 2008
<b>Observer requirement on source vessel</b>	1–2 dedicated MMOs, 3 yrs experience in sensitive areas	Proven experience whale observation & distance estimation
<b>Certification of MMOs</b>	JNCC (2010)	Trained crew member or MMO
<b>Species covered</b>	All marine mammals	All whales
<b>Mitigation Zone/ Exclusion zone (EZ)</b>	500m	(1) OZ-Observation Zone: 3+km, (2) LPZ-Low Power Zone: 1 or 2km, (3) SZ-Shutdown Zone: 500m
<b>Required period of observation (Pre-Watch)</b>	All Pre-Watches, but when 2 MMOs onboard then all daylight hrs	All daylight hrs during operations; or Daylight spotter vessel/aircraft searches ahead
<b>Pre-watch period</b>	30 minutes in waters < 200m; 60 minutes in waters > 200m	30 minutes
<b>Soft-Start (SS) duration</b>	20-40 minutes, Period between SS and SOL should not > 40 minutes	30 minutes
<b>Soft-Start (SS) delay period</b>	At least 20 min delay after animal last seen within EZ	At least 30 min delay after animal last seen within LPZ or SZ
<b>Shut-down</b>	None	When whale in OZ then second MMOs helps with lookout; when whale in LPZ - power down; when whale in SZ - shutdown
<b>Re-start after shut-down</b>	N/A	Resume when outside LPZ; or at least 30 min delay after animal last seen (starting with SS)
<b>Night-time seismic operations</b>	Preferably only commence seismic during the hours of daylight	Mitigation gun; or no SS in areas of high sensitivity; or spotter vessel/aircraft searches the night-time survey area ahead during daylight; or PAM
<b>Night-time mitigation</b>	SS - Commence seismic with PAM	SS - providing no ≥3 whales 'power-down' or 'shut-down' situations < 24 hrs
<b>Line-changes (&gt; 500 cubic inches)</b>	when > 20 min then terminate source and commence soft-start before SOL	Power down to the lowest possible setting (Mitigation gun) - if no whales then SS
<b>Allowable silent period</b>	When guns have not been firing > 10 minutes then SS	UNKNOWN
<b>Closed seismic zones</b>	Seasonal limitations in some areas; Seismic source not activated outside permitted area	No seismic surveys planned in areas of whale breeding, calving, resting, feeding, migrating & closed area in Gr Australian Bight for S. right whales & Australian fur seals
<b>Reporting</b>	Daily reporting to client, final report + database	Final survey report
<b>Database</b>	JNCC database forwarded to JNCC	Data send to Department of the Environment, Water, Heritage and the Arts
<b>Authority</b>	Department for Energy Climate Change (DECC)	Department of the Environment, Water, Heritage and the Arts
<b>Planning stage</b>	Minimise exposure/use lowest practicable power levels. EIA to assess likelihood of injuring/ disturbing European Protected Species, permit needed	No seismic surveys planned in areas when/ where whales are likely to be breeding, calving, resting, feeding, migrating
<b>Other?</b>	Recommended to adopt JNCC to turtles & basking sharks	EIA potential impacts if multiple seismic sources are operating in area
<b>Other?</b>	Different mitigation apply: Vertical seismic profile, site surveys, explosive, piling	Exclusion Zones may be extended depending on sensitive area
<b>Other?</b>		

Guideline	New Zealand (level 1 surveys)	New Zealand (level 2 surveys)
<b>Title of Guideline/ survey</b>	Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations - Level 1 surveys: >427 cubic inches	Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations - Level 2 surveys: 151–426 cubic inches
<b>Date</b>	November 2013	November 2013
<b>Observer requirement on source vessel</b>	2 MMOs independent/, 2 PAMs	2 MMOs; PAM optional
<b>Certification of MMOs</b>	Trained and qualified MMO (12 wks exp in NZ) during Level 1 surveys (>427 cubic inches)	Qualified MMO (or trained crew member)
<b>Species covered</b>	Marine Mammals & Species of Concern (SoC)	Marine Mammals & Species of Concern (SoC)
<b>Mitigation Zone/ Exclusion zone (EZ)</b>	Level 1 survey: *SoC+calves - 1.5km; *SoC (no calves) - 1km; *other mm - 200m	Level 2 survey: *SoC+calves - 1km; *SoC (no calves) - 600m; *other mm - 200m
<b>Required period of observation (Pre-Watch)</b>	All daylight hours: 1 MMO on watch & 1 on break. Duration of watch not > 12 hrs	All daylight hours: 1 MMO on watch & 1 on break. Duration of watch not > 12 hrs
<b>Pre-watch period</b>	*30 minutes; *10 minutes for Fur seal sp.	*30 minutes; *10 minutes for Fur seal sp.
<b>Soft-Start (SS) duration</b>	20-40 minutes	20-40 minutes
<b>Soft-Start (SS) delay period</b>	* until seen outside EZ or 30 min delay last seen within EZ; *until seen outside EZ; * Fur Seal - 10 min delay last seen within EZ	* until seen outside EZ or 30 min delay last seen within EZ; *until seen outside EZ; * Fur Seal - 10 min delay last seen within EZ
<b>Shut-down</b>	SoC+calves inside 1.5km; SoC (no calves) inside 1km	SoC+calves inside 1km; SoC (no calves) inside 600m
<b>Re-start after shut-down</b>	Until seen outside EZ or 30 min delay last seen within EZ (starting with SS)	Until seen outside EZ or 30 min delay last seen within EZ (starting with SS)
<b>Night-time seismic operations</b>	Permitted only with PAM; when arriving at location for the first time, no source activation at night/low vis	Permitted PAM; if no PAM&no seismic in <24hrs -then at least 2hrs of MMO watch during last daylight with no mm in EZs
<b>Night-time mitigation</b>	SS - Commence seismic with PAM	If no PAM, then SS - providing no ≥3 'delays'/shut-downs' < 24 hrs in good conditions
<b>Line-changes (&gt; 500 cubic inches)</b>	Terminate or power down for mitigation (permit needed)	Terminate or power down for mitigation (permit needed)
<b>Allowable silent period</b>	When guns have not been firing > 10 minutes then SS	When guns have not been firing > 10 minutes then SS
<b>Closed seismic zones</b>	No seismic in Marine Mammal Sanctuaries; limited in Areas of Ecological Importance	No seismic in Marine Mammal Sanctuaries; limited in Areas of Ecological Importance
<b>Reporting</b>	Standardised format (appendix 2) - <60 days after survey ends	Standardised format (appendix 2) - <60 days after survey ends
<b>Database</b>	Raw datasheets submitted to Director-General < 14 days after survey ends	Raw datasheets submitted to Director-General < 14 days after survey ends
<b>Authority</b>	New Zealand Department of Conservation	New Zealand Department of Conservation
<b>Planning stage</b>	Marine Mammal Impact Assessment	Marine Mammal Impact Assessment
<b>Other?</b>	Inform Director-General when higher numbers of Species of Concern than expected	Inform Director-General when higher numbers of Species of Concern than expected
<b>Other?</b>	Good conditions are sea state ≤3 and visibility ≥1.5	Different mitigation for Vertical seismic profile & borehole surveys (p. 19)
<b>Other?</b>		

Gulf of Mexico (GoM)	Brazil	Colombia
Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program	Guide for monitoring marine biota during seismic data acquisition activities (IBAMA)	2D, 3D seismic surveys
2011	April 2005	Unknown
2 or 3 Protected Species Observers (PSO)	At least 3 observers, in order to have 2 MMOs on watch	2 MMOs
PSO	Professional, dedicated and experience or specific training	Undergraduate biology or similar; Statistics course; Certified technical training; 1 year experience certified in fisheries and/or MMO
Marine Mammals & Turtles	Marine Mammals & Turtles	Cetaceans & Marine turtles
500m	500m (shut down); 1000m (SS delay)	500m
All daylight hours	All daylight hours	24 hours (MMO/PAM)
30 minutes	30 minutes	30 minutes
20-40 minutes	20-40 minutes	20 minutes
At least 30 min delay after animal last seen within EZ	At least 30 min delay after animal last seen within EZ	30 minutes after the last cetacean or sea turtle sighting within EZ
Whales (inside EZ); voluntary shutdowns for sea turtles	Marine Mammals & Turtles	Cetaceans & turtles within EZ
MM- 30 min delay then soft start		Re-start with SS after 30 minutes from last sighting
Mitigation gun: reduce source, same shotpoint interval, to min. level 160 dB re 1 $\mu$ Pa-m	No start of operations at night or during bad weather (rain, fog), unless mitigation gun is on (160 dB re 1 $\mu$ Pa-m)	Permitted with monitoring or mitigation gun
Mitigation gun+SS; No SS if level drops below 160 dB re 1 $\mu$ Pa-m; PAM is accepted as mitigation tool	It may be allowed to continue with mitigation gun	SS, PAM, or use of mitigation at least one hour before SS if PAM is not available.
Using mitigation gun will not require a 30-min visual clearance of EZ before SS to FP	When > 20 min then terminate, commence SS before SOL; In order to avoid delays, it may be allowed to use mitigation gun	Terminate source and commence SS before SOL
Leave mitigation gun running; or if silent period > 20 minutes then start with SS	5 minutes, then Soft Start	Unknown
None, see GOM	Seasonal closed areas: breeding humpback & right whales, Franciscana dolphin, turtle nesting & manatee habitat; No Seismic <12m water depth.	Certain areas at specific times have restrictions, this depends on permission
Daily/Bi-weekly/Final Reports to BOEM; Shutdown report within 24 hrs	Sent straight to IBAMA within 5 working days	Database (effort, sightings & seismic operations) and final report
MMS	IBAMA	Database (effort, sightings & seismic operations)
MINERALS MANAGEMENT SERVICE (MMS)	IBAMA: Brazilian Institute of Environment and Resources	Ministry of Environment, Housing and Territorial Development (MAVDT)
Unknown	Consult, plan and permit needed	Seismic survey needs to apply for permit
Watch of 4 hrs max followed by 2 hrs break SS only when conditions are good (no fog, rain)	IBAMA does not require PAM as mitigation measure	
	Work shift with a ratio of 1 hour and 30 minutes of observation and 30 minutes of rest	

Guideline	Trinidad & Tobego	Trinidad & Tobago
Title of Guideline/ survey	2D survey Report on Risk & Mitigation Measures to Marine Flora and Fauna, Loran-Manatee Offshore Development	Requirements for mitigation of acoustic disturbance from offshore seismic surveys to marine life
Date	2010	April 2014 (under review)
Observer requirement on source vessel	Dedicated observer	MMOs (in addition recommended for MMOs on non-source vessel)
Certification of MMOs	None	Experienced with Seismic & Must be able to identify a 'Type II Species of Concern'
Species covered	Whales/ Cetaceans/ significant fish movements	Species of Concern'; five different hearing groups with different 'Modelled EZ'
Mitigation Zone/ Exclusion zone (EZ)	5km	Minimum 500m; EZ - based on acoustic threshold levels through sound propagation modelling
Required period of observation (Pre-Watch)	Continuous visual or with echosounder	Continuous; Watch of 2 hrs max followed by at least 1 hrs break
Pre-watch period	Not specified	60 minutes
Soft-Start (SS) duration	20 minutes (at least)	Sound pressure level at SS should not > 130dB re 1 µPa at 1m
Soft-Start (SS) delay period	Until cetaceans/ significant fish movements are outside the study sector	* 30 min delay last seen in EZ; *60 min for 'deep divers'; *wait for Turtle outside EZ
Shut-down	Stop work if whales are within 5 km of the seismic survey vessel	Shutdown for Type II Species of Concern when inside EZ
Re-start after shut-down	Not specified but assumed with SS	SS * 30 min after last seen in EZ; *60 min for 'deep divers'; *wait for Turtle outside EZ
Night-time seismic operations	Not specified	PAM - Monitoring from a non-source vessel may be more affective
Night-time mitigation	Not specified, but assumed via SS and echosounder/ fish finder	SS - Commence seismic with PAM
Line-changes (> 500 cubic inches)	Not specified	When > SS-period then shutdown & commence soft-start before SOL
Allowable silent period	Not specified	When guns have not been firing > 10 minutes then SS
Closed seismic zones	Seismic surveys to be done outside of the major fishing seasons	Seismic source may not be activated outside the permitted survey area
Reporting	Unknown	A validation report (EZs) to EMA within 7 days;
Database	Unknown	Final Report within 1 month
Authority	Ministry of Energy & Energy Affairs	Spreadsheet file data + report publicably available
Planning stage	Seismic surveys to be done outside of the major fishing seasons	EMA - Environmental Management Authority
Other?		High quality EIAs must be an intrinsic part of project planning even where this is not required by law
Other?		Sound propagation modelling - define distance from source (EZ) & study area A pre-operations meeting with all personnel + client and rep
Other?		If turtle is ahead of vessel but >EZ, use appr position of turtle as reference point for delays/ shutdowns

Venezuela (recommended)	Guyana	Venezuela/ Aruba/ Curaçao
There are no legal guidelines - but these have been recommended in EIAs but not clear if they were adopted in the field	There are no guidelines but best international practise has been adopted during a recent survey (based on JNCC & MMS)	2D seismic survey to gather information on island arc movements & geometry
n/a	Autumn 2013	April-May 2004
One observer on each vessel - Seismic and support vessels (recommended)	No details are available	3 trained MMOs (2 on watch during start-up), 2 PAM
Specialized observers: marine biologists, fisheries, oceanographers & trained crew (recomm)	No details are available	Approved in advance by the National Marine Fisheries Service (NMFS, US)
Marine mammals & turtles (recommended)	No details are available	Marine Mammals (cetaceans and manatee) & Turtles
1000m (recommended)	No details are available	(1) 3500m in <100m; (2) 1350m in water depths (100–1000 m); and (3) 900m in >1000m
All daylight hours (recommended)	No details are available	All daylight hours & 24 hrs PAM
30-60 minutes (recommended)-visually and with radar	No details are available	30 minutes
20-40 minutes (recommended)	No details are available	At least 6 dB per 5-minutes until operating levels are reached
30 min delay after animal last seen within EZ (recommended)	No details are available	Until the EZ is free of marine mammals or sea turtles for at least 30 minutes
Marine mammals & turtles within EZ (recommended)	No details are available	Power-down (1 airgun) when marine mammals are in EZ; Shut-down when mm is injured/in a mortal state/acute distress
30 min delay then soft start (recommended)	No details are available	(1) EZ is visible and no marine mammals or turtles inside; (2) until 15 minutes (for small odontocetes and pinnipeds) or (3) at least 30 min (for mysticetes/ large odontocetes) after animals within EZ
No seismic operations at night (recommended)	No details are available	Permitted with monitoring; Night-vision & PAM; No start up at night after a shutdown. Crew on bridge notify MMO at night when marine mammal or turtles within EZ.
No seismic operations at night (recommended)	No details are available	Only SS after Power-down in > 100m depth if EZ is covered; No SS in heavy fog/high seas (EZ not visible)
		Unknown
Terminate (recommended)	No details are available	10 minutes
Unknown	No details are available	None
No restrictions	No details are available	A draft report to NMFS within 90 days after survey completion
Reports and thematic maps are forwarded to stakeholders (recommended)	No details are available	Published as scientific paper
Unknown	No details are available	US - National Marine Fisheries Service (NMFS)
Ministry of Environment and Renewable Natural Resources	No details are available	Incidental Harassment Authorization by NMFS
According to the Decree (Presidential Decree 1257), all activities potentially harmful for the environment must produce an EIA	No details are available	Extra MMOs on non-seismic vessel to document marine mammals or sea turtles in areas where the seismic survey vessel had been operating
It is unknown how effective the measures are and how effective it is to use trained personnel.	No details are available	The EZs for marine mammals were defined at 180 dB (re 1 µParks) isopleth that is based upon calibration measurements made for the airgun array in the Caribbean Sea and Atlantic Ocean.
		During the day, SS from a shut-down only possible if the entire EZ is visible (i.e., no fog and Beaufort Force <5).

Guideline	Aruba	French Guiana
<b>Title of Guideline/ survey</b>	2D seismic survey (based on JNCC guidelines and modified to fit local situation)	2D, 3D seismic surveys
<b>Date</b>	Feb-April 2013	n/a
<b>Observer requirement on source vessel</b>	2 MMOs (seismic vessel); 1 MMO scouting vessel (1 wk); 1 PAM (night)	MMTO, PAM (at least 1 MMTO on watch)
<b>Certification of MMOs</b>	JNCC (2010)	Yes, but not specified (assume PSO or JNCC)
<b>Species covered</b>	Marine Mammals & Turtles	Marine mammals, Turtles, Chondrychtyes shark/ ray/fish
<b>Mitigation Zone/ Exclusion zone (EZ)</b>	500m	*500 m for marine mammals; *200 m for marine turtles & chondrychtyes
<b>Required period of observation (Pre-Watch)</b>	All daylight hours	At highest point during pre-watch & SS periods; all daylight hours
<b>Pre-watch period</b>	30 minutes in waters < 200m; 60 minutes in waters > 200m	60 minutes
<b>Soft-Start (SS) duration</b>	20-40 minutes	20-40 minutes
<b>Soft-Start (SS) delay period</b>	At least 20 min delay after animal last seen within EZ	20 minutes after seeing any marine turtle or chondrychtyes within the 200m zone.
<b>Shut-down</b>	For whales within 500m (and turtles in 2014 survey)	If turtles or chondrychtyes are within 200m zone, air guns must stop for 8 shots (also during SS)
<b>Re-start after shut-down</b>	Not specified, but assumed to be 20 minutes delay after last seen inside EZ, then SS	Back to operations after 8 shot points (Full power or Soft Start)
<b>Night-time seismic operations</b>	Permitted PAM	Permitted with PAM monitoring
<b>Night-time mitigation</b>	SS - Commence seismic with PAM	SS, PAM
<b>Line-changes (&gt; 500 cubic inches)</b>	when > 20 min then terminate source and commence soft-start before SOL	Source volume>450cm <sup>3</sup> & >20min Line Change (LC): power down (1 gun 160db) then SS. If source volume < 450 cm <sup>3</sup> & > 40min LC then terminate & SS; if LC < 40min - change ShotPoint Interval (< 5 min)
<b>Allowable silent period</b>	When guns have not been firing > 10 minutes then SS	Unknown
<b>Closed seismic zones</b>	A bufferzone of 3 km from the coast	None
<b>Reporting</b>	Daily reporting to client, final report + data-base	Daily report (PAM, MMO) & Final report within one month of survey completion
<b>Database</b>	Unknown	Database available to industry & local authority & available upon request
<b>Authority</b>	Compania Arubano di Petroleo NV (CAP NV)	DEAL (Direction de l'Environnement, de l'Aménagement et du Logement)
<b>Planning stage</b>	Scouting survey, HSE plan and in agreement with Aruba Marine Mammal Foundation (AMMF)	EIA on request of fishery committee to assess impact on fish population (sampled before & after operations) for each season (dry and rainy season), for 2 yrs
<b>Other?</b>	A pre-scouting survey was carried out of one week during the seismic survey	Turtle guards fitted to tail buoys
<b>Other?</b>	During 2014 seismic survey, shutdown for turtles implemented	Reduce lights on deck at night to avoid seabirds strandings (on deck)
<b>Other?</b>	Use of Turtle Detection Device in 2014-survey (ATS DSP Receiver to monitor turtles equipped with VHF radio transmitter using a single frequency 150.101 MhZ)	

French Guiana - 3D deep water survey (2009)	Suriname	Suriname
3D seismic survey in deep water; University of Paris Sud (based on JNCC guidelines and modified to fit local situation)	3D seismic survey in deep water (based on JNCC)	2D & 3D seismic survey in shallow water
September 2009 - February 2010	May-Sep 2012	June-Sep 2013
2 MMOs	3 MMOs; of which 2 MMOs > 10 years experience & independent	2 MMOs, tropical water experienced and independent
PSO, JNCC	PSO, JNCC, Lead MMO with Academic degree (MSc) in Marine Biology	PSO, JNCC
Marine Mammals, Turtles & large elasmobranchs (sharks and rays)	Marine Mammals & Turtles	Marine Mammals (cetaceans and manatee) & Turtles
*500m for cetaceans; *180m for turtles/elasmobranchs	500m	500m
All daylight hours	All daylight hours	All daylight hours
60 minutes	60 minutes (waters > 200m)	30 minutes
20 minutes	20-40 minutes	20-40 minutes
*Until cetaceans are out of sight; *turtle/elasmo-branches > 180m	MM/Turtle - At least 20 min delay after animal last seen within EZ	MM/Turtle - At least 30 min delay after animal last seen within EZ
Turtles/elasmo-branches: 5 shot-points	Unless animal is directly heading towards source or is in apparent distress	Whales, manatees and marine turtles inside EZ
Full Power	MM- 20 min delay then soft start; Turtle-Full Power after 5 minute shot pause	MM/Turtle - 30 min delay then soft start
Permitted with monitoring	Permitted with low-frequency PAM monitoring	Mitigation gun
SS; Night-time binoculars were tested but not found to be useful	Night: SS - Low frequency acoustic monitoring by Western Geco	Night: SS - Mitigation gun
When > 20 min then terminate source and commence soft-start before SOL	When > 20 min then terminate source and commence soft-start before SOL	When > 20 min then terminate source and commence soft-start before SOL
When guns have not been firing > 10 minutes then SS	When guns have not been firing > 10 minutes then SS	When guns have not been firing > 10 minutes then SS
Unknown	None	None
Unknown	Daily reporting to client, final report + database to NIMOS	Daily reporting to client, final report + database to NIMOS
Unknown	JNCC database forwarded to PhD student for analysis	JNCC database forwarded to PhD student for analysis
DIREN (Regional environmental authority) [nowadays this is DEAL]	NIMOS (National Institute for Environment and Development in Suriname)	NIMOS (National Institute for Environment and Development in Suriname)
Unknown	Marine Mammal and Sea turtle monitoring plan as part of Environmental Impact Assessment (EIA)	Marine Mammal and Sea turtle monitoring plan as part of Environmental Impact Assessment (EIA)
Unknown	Turtle guards fitted to tail buoys	Turtle guards fitted to tail buoys
		Support vessel to Paramaribo, lookout for mammals/turtles, travel slow speed

Guideline	Suriname
Title of Guideline/ survey	2D River seismic survey
Date	Oct-Nov 2012
Observer requirement on source vessel	1 experienced MMO
Certification of MMOs	Yes (not defined)
Species covered	Marine Mammals (cetaceans and manatee) & Turtles
Mitigation Zone/ Exclusion zone (EZ)	500m
Required period of observation (Pre-Watch)	All daylight hours
Pre-watch period	30 minutes
Soft-Start (SS) duration	yes, not defined but assumed to be 20-40 minutes
Soft-Start (SS) delay period	MM/Turtle - At least 30 min delay after animal last seen within EZ
Shut-down	Cetaceans, manatees and marine turtles inside EZ
Re-start after shut-down	Until seen outside EZ and beginning with soft start
Night-time seismic operations	Unknown (assumed no seismic at night)
Night-time mitigation	Unknown (assumed no seismic at night)
Line-changes (> 500 cubic inches)	Not specified
Allowable silent period	Unknown
Closed seismic zones	None
Reporting	Daily reporting to client, final report + database to NIMOS
Database	Unknown
Authority	NIMOS (National Institute for Environment and Development in Suriname)
Planning stage	Marine Mammal and Sea turtle monitoring plan as part of Environmental Impact Assessment (EIA)
Other?	Not specified
Other?	Source Pressure Levels (SPL) measured at 500m from source on different locations in each river were taken
Other?	

JNCC	Joint Nature Conservation Committee	FP	Full Power
EZ	Exclusion Zone = Mitigation Zone	MMS	MINERALS MANAGEMENT SERVICE
min	Minutes	BOEM	
SS	Soft Start = Ramp up	GOM	Gulf of Mexico
SOL	Start of Line	IBAMA	
PAM	Passive Acoustic Monitoring	EIA	Environmental Impact Assessment
hrs	hours	Mit	Mitigation gun
OZ	Observation Zone	SPL	Source Pressure Levels
LPZ	Low Power Zone	AMMF	Aruba Marine Mammal Foundation
SZ	Shutdown Zone		

## **APPENDIX 2**

### **Specific requirements used in marine seismic surveys**

1. *New Zealand – Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations - Level 1 surveys: >427 cubic inches (November, 2013)*
2. *New Zealand – Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations - Level 2 surveys: 151–426 cubic inches (November, 2013)*
3. *Australia - Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (September, 2008)*
4. *Gulf of Mexico (GOM) - Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program (2011)*
5. *United Kingdom - JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys (August, 2010)*
6. *Colombia - Seismic Guidelines*
7. *Brazil – IBAMA Guide for monitoring marine biota during seismic data acquisition activities (April 2005)/Trinidad 2D - Report on Risk and Mitigation Measures to Marine Flora and Fauna associated with the Loran-Manatee Offshore Development (2010)*
8. *Trinidad & Tobago - There are no legal guidelines for the mitigation of seismic operations.*
  - a) *Requirements for the mitigation of acoustic disturbance from offshore seismic surveys to marine life in Trinidad and Tobago (draft, 17 April 2014).*
  - b) *Trinidad 2D - Report on Risk and Mitigation Measures to Marine Flora and Fauna associated with the Loran-Manatee Offshore Development (2010)*
9. *French Guiana - There are no legal guidelines for the mitigation of seismic operations in French Guiana.*
  - a) *Seismic survey based on JNCC & MMS (GoM) guidelines and modified to fit local situations*
  - b) *3D seismic survey in deep water; University of Paris Sud, based on JNCC guidelines and modified to fit local situation (September 2009)*
10. *Suriname – There are no legal guidelines for the mitigation of seismic operations in Suriname.*
  - a) *3D seismic survey in deep-water basin (May-September, 2012) with Guidelines based on JNCC (August, 2010) with local additions.*
  - b) *2D & 3D seismic survey in shallow-waters (June, August-September, 2013) with Guidelines based on GoM/JNCC with local additions.*

- c) *2D seismic survey in the Coppename, Suriname, Commewijne, Corantijn, and Saramacca Rivers in (October-November, 2012) with Guidelines based on GoM/JNCC and BMP (Best Management Practices) established for the specific region and species.*
- 11 *Guyana - There are no legal guidelines for the mitigation of seismic operations in Guyana. Best international practice has been adopted using a combination of JNCC & MMS Guidelines but no details are available.*
- 12 *Venezuela - There are no legal guidelines for the mitigation of seismic operations in Venezuela but all the mitigation measures that have been used in seismic operations in Venezuela have been in compliance with Presidential Decree 1257. The below mitigation measures have been recommended as part of previous offshore seismic surveys, but it is not clear how effective they are and if they were being implemented.*
- 13 *Aruba - There are no legal guidelines for the mitigation of seismic operations in Aruba. 2D seismic survey (February - April, 2013) with Guidelines based on JNCC (August, 2010) with local additions.*
- 14 *Venezuela/Aruba&Curaçao/Trinidad & Tobago - There are no legal guidelines for the mitigation of seismic operations in these countries. 2D seismic survey in the SE Caribbean Sea in April/May 2004 with Incidental Harassment Authorization by NMFS (National Marine Fisheries Service, US; Smultea et al., 2004). The main purpose of the study was to obtain seismic data to gather information on island arc movements and geometry.*

## 1 New Zealand – Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations - Level 1 surveys: >427 cubic inches (November, 2013)

The Department of Conservation (DOC) *Te Papa Atawhai* is the organisation with the responsibility to develop appropriate management procedures for minimising acoustic disturbance to marine mammals from seismic surveys and other potential anthropogenic impacts within NZ waters.

The 2013 *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code) has been developed by the DOC in consultation with a broad range of stakeholders in marine seismic survey operations in New Zealand.<sup>3,4</sup>

**Level 1 surveys (>427 cubic inches)** primarily include large-scale geophysical investigations that would routinely be employed in oil and gas exploration activities with dedicated marine seismic survey vessels, but may also apply to other studies using high-power acoustic sources. This level features the most stringent requirements for marine mammal protection, and is the main focus of the Code.

Specific requirements of level 1 seismic surveys:

- (1) *Observer requirement:* Two independent qualified MMOs & 2PAM onboard
- (2) *Observer certification:* Trained, i.e. recognized Marine Mammal Observation course (according to DOC standards) and passed an assessment process; & Qualified MMO (12 weeks experience in NZ waters).
- (3) *Species of concern (including all marine fauna):* Marine Mammals & Species of Concern (SoC) listed in Schedule 2.
- (4) *Size of the Mitigation/Exclusion Zone (EZ):* Species of Concern with calves have a mitigation zone of 1.5km; Species of Concern have a mitigation zone of 1km; Other Marine Mammals have a mitigation zone of 200m
- (5) *Required period of observation:* All daylight hours while the source is in the water, one MMO/PAM on watch and one MMO/PAM on break. The duration of watch should not exceed 12 hrs.

If the PAM system has malfunctioned or become damaged, operations may continue for 20 minutes without PAM while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM gear must be repaired to solve the problem, operations may continue

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<sup>3</sup> There are different mitigation measures for Vertical seismic profile & borehole surveys which are not included here.

<sup>4</sup> Level 3 surveys (<150 cubic inches) include all other small scale seismic survey technologies, and are considered to be of such low impact and risk—with nominal noise levels lower than commercial shipping—that they are not subject to the provisions of the Code.

for an additional 2 hours without PAM monitoring as long as all of the following conditions are met:

- It is daylight hours and the sea state is less than or equal to Beaufort 4
- No marine mammals were detected solely by PAM in the relevant mitigation zones in the previous 2 hours
- Two MMOs maintain watch at all times during operations when PAM is not Operational
- DOC is notified via email as soon as practicable with the time and location in which operations began without an active PAM system
- Operations with an active source, but without an active PAM system, do not exceed a cumulative total of 4 hours in any 24 hour period.

(6) *Pre-watch period*: The source cannot be activated during daylight hours unless: At least one qualified MMO has continuously made visual observations all around the source for the presence of marine mammals, from the bridge (or preferably an even higher vantage point) using both binoculars and the naked eye, and no marine mammals (other than fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no fur seals have been observed in the relevant mitigation zones for at least 10 minutes. In addition, Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalising cetaceans have been detected in the relevant mitigation zones.

(7) *Soft-Start (SS) period*: 20 to 40 minutes

(8) *Delay period of soft-start*:

- \* Species of Concern with calves - Until the Species of Concern with calves have moved to a point that is more than 1.5 km from the source; or despite continuous observation, 30 minutes has elapsed since the last detection of the group within 1.5 km of the source, and the mitigation zone remains clear.
- \* Species of Concern – Until the Species of Concern has moved to a point that is more than 1 km from the source; or despite continuous observation, 30 minutes has elapsed since the last detection of the Species of Concern within 1 km of the source, and the mitigation zone remains clear.
- \* Marine mammal – Until a marine mammal has moved to a point that is more than 200 m from the source; or despite continuous observation, 10 minutes has passed since the last detection of a New Zealand fur seal within 200 m of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200 m of the source, and the mitigation zone remains clear. If all mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, there will be no further delays to initiation of soft start.

(9) *Shut-down requirements*: Species of Concern with calves have a mitigation zone of 1.5km; Species of Concern have a mitigation zone of 1km; Other Marine Mammals have a mitigation zone of 200m

(10) *Re-start after shut-down procedures*: Same as outlined under (8)

(11) *Seismic source and mitigation measures at night time:* The source cannot be activated during night-time hours or poor sighting conditions (Sea state  $\geq 4$  or visibility  $< 1.5\text{km}$ ) unless: Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation, and the qualified observer has not detected vocalising cetaceans in the relevant mitigation zones (during daylight hours).

When arriving at a **new location** in the survey programme for the first time, the initial acoustic source activation must not be undertaken at night or during poor sighting conditions unless at least 2 hours of observations by MMO during last good sighting conditions of daylight hours preceded the planned operations, less than 20nm from start-up position; and a qualified PAM operator monitored for at least 30 minutes before activation.

Where there has been less than 2 hours of good sighting conditions preceding proposed operations (within 20 nautical miles of the planned start up position), the source may be activated if:

- PAM monitoring has been conducted for 2 hours immediately preceding proposed operations; and
- Two MMOs have conducted visual monitoring in the 2 hours immediately preceding proposed operations; and
- No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 2 hours immediately preceding proposed operations;
- No fur seals have been sighted during visual monitoring in the relevant mitigation zone in the 10 minutes immediately preceding proposed operations; and
- No other marine mammals have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 30 minutes immediately preceding proposed operations.

(12) *line-change & gun-test regulations:* Terminate or power-down for mitigation (permit needed)

(13) *Allowable silent period:* A maximum 10 minute interval is allowed before soft start procedures are required.

(14) *Closed seismic zones or sensitive areas:* No seismic planned in sensitive, ecologically important areas or during key biological periods where Species of Concern are likely to be breeding, calving, resting, feeding or migrating, or where risks are particularly evident such as in confined waters.

(15) *Reporting & Database requirements:* A final report in a standardised format (as shown in appendix 2 of the NZ guidelines) to be submitted less than 60 days after survey ends. Raw datasheets submitted to Director-General in less than 14 days after survey ends

(16) *Authority:* New Zealand Department of Conservation

(17) *Planning stage*: No person may carry out a Level 1 marine seismic survey in New Zealand continental waters unless he or she has, at the earliest opportunity but not less than one month before commencing the survey, submitted to the Director-General a written Marine Mammal Impact Assessment

(18) *Other*: Inform Director-General when higher numbers of Species of Concern are encountered during the survey than expected.

## **2 New Zealand – Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations - Level 2 surveys: 151–426 cubic inches (November, 2013)**

Level 2 surveys (151–426 cubic inches) provides for lower scale seismic investigations often associated with scientific research. As these survey programmes are normally conducted from smaller, sometimes multi-mode platforms using moderate power seismic sources or smaller seismic source arrays, the risks to marine mammals are decreased. Therefore the mitigation procedures are reduced accordingly.

(1) *Observer requirement*: Two independent MMOs onboard (PAM is not mandatory)

(2) *Observer certification*: Trained (crew member) or Qualified MMO (12 weeks experience in NZ waters).

(3) *Species of concern (including all marine fauna)*: as per level 1 surveys

(4) *Size of the Mitigation/Exclusion Zone (EZ)*: Species of Concern with calves have a mitigation zone of 1km; Species of Concern have a mitigation zone of 600m; Other Marine Mammals have a mitigation zone of 200m

(5) *Required period of observation*: All daylight hours while the source is in the water, one MMO/PAM on watch and one MMO/PAM on break. The duration of watch should not exceed 12 hrs.

(6) *Pre-watch period*: as per level 1 surveys

(7) *Soft-Start (SS) period*: as per level 1 surveys

(8) *Delay period of soft-start*:

\* Species of Concern with calves - Until the Species of Concern with calves have moved to a point that is more than 1 km from the source; or despite continuous observation, 30 minutes has elapsed since the last detection of the group within 1 km of the source, and the mitigation zone remains clear.

\* Species of Concern – Until the Species of Concern has moved to a point that is more than 600m from the source; or despite continuous observation, 30 minutes has elapsed since the

last detection of the Species of Concern within 1 km of the source, and the mitigation zone remains clear.

\* Marine mammal – Until a marine mammal has moved to a point that is more than 200 m from the source; or despite continuous observation, 10 minutes has passed since the last detection of a New Zealand fur seal within 200 m of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200 m of the source, and the mitigation zone remains clear. If all mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, there will be no further delays to initiation of soft start.

(9) *Shut-down requirements:* Species of Concern with calves have a mitigation zone of 1km; Species of Concern have a mitigation zone of 600m; Other Marine Mammals have a mitigation zone of 200m

(10) *Re-start after shut-down procedures:* Same as outlined under (8)

(11) *Seismic source and mitigation measures at night time:* The source cannot be activated during night-time hours or poor sighting conditions unless Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalising cetaceans have been detected in the relevant mitigation zones.

If no PAM onboard then start up can be initiated and active surveys may proceed at night or during poor sighting conditions only if:

- There have not been more than 3 marine mammal instigated shutdowns or delayed starts in the previous 24 hours of active survey operations in good sighting conditions; or
- If active survey operations were not conducted in the previous 24 hours, MMOs have undertaken observations within a radius of 20 nm of the proposed start-up position for at least the last 2 hours of good sighting conditions during the daylight hours preceding proposed operations and no marine mammals have been detected.

(12) *line-change & gun-test regulations:* as per level 1 surveys

(13) *Allowable silent period:* as per level 1 surveys

(14) *Closed seismic zones or sensitive areas:* as per level 1 surveys

(15) *Reporting & Database requirements:* as per level 1 surveys

(16) *Authority:* as per level 1 surveys

(17) *Planning stage:* as per Level 1 surveys

### 3 Australia - Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (September, 2008)

(1) *Observer requirement:* Trained crew member or MMO

(2) *Observer certification:* Proven experience whale observation & distance estimation

(3) *Species of concern (including all marine fauna):* ‘**Whales**’ includes baleen whales and larger toothed whales, such as, sperm whales, killer whales, false killer whales, pilot whales and beaked whales. [Other (smaller) dolphins and porpoises that have peak sensitivities in the higher frequency ranges are likely to be less disturbed by these lower frequency sounds and less vulnerable to acoustic trauma].

(4) *Size of the Mitigation/Exclusion Zone (EZ):*

For proposed seismic surveys that can demonstrate through sound modelling or empirical measurements that the received sound exposure level for each shot will not likely exceed 160dB re 1µPa2•s, for 95% of seismic shots at 1km range, the following precaution zones are recommended:

*Observation Zone:* 3+ km horizontal radius from the acoustic source.

*Low Power Zone:* 1 km horizontal radius from the acoustic source.

*Shut-down Zone:* 500m horizontal radius from the acoustic source.

For all other proposed seismic surveys:

*Observation Zone:* 3+ km horizontal radius from the acoustic source.

*Low Power Zone:* 2 km horizontal radius from the acoustic source.

*Shut-down Zone:* 500m horizontal radius from the acoustic source.

(5) *Required period of observation:* All daylight hours during operations; or Daylight spotter vessel/ aircraft searches ahead.

(6) *Pre-watch period:* 30 minutes

(7) *Soft-Start (SS) period:* 30 minutes

(8) *Delay period of soft-start:* Soft start procedures should only commence after the whale has been observed to move outside the *Low power zone*, or when 30 minutes have lapsed since the last whale sighting.

(9) *Shut-down requirements:* If a whale is sighted within the 3km observation zone an additional trained crew member or marine mammal observer should also be brought to the bridge to continuously monitor the whale whilst in sight. If a whale is sighted within or is about to enter the *Low power zone*, the acoustic source should be powered down to the lowest possible setting (e.g. a single gun). If a whale is sighted within or is about to enter the *Shut-down zone*, the acoustic source should be shut down completely.

(10) *Re-start after shut-down procedures*: Power-up of the acoustic source with soft-start procedures should only occur after the whale has been observed to move outside the *Low-power Zone*, or when 30 minutes have lapsed since the last whale sighting.

(11) *Seismic source and mitigation measures at night time*:

At **night-time** or at other times of **low-visibility** (when observations cannot extend to 3km from the acoustic source, e.g. during fog or periods of high winds), the following measures apply for start-up and operations:

- **Start up** may be commenced according to Soft-Start Procedure, provided that there have not been 3 or more whale instigated power-down or shut-down situations during the preceding 24 hour period; or if operations were not previously underway during the preceding 24 hours, the vessel (and/or a spotter vessel or aircraft) has been in the vicinity (approximately 10km) of the proposed start up position for at least 2 hours (under good visibility conditions) within the preceding 24 hour period, and no whales have been sighted.
- **Operations** may proceed provided that there have not been 3 or more whale instigated power-down or shut-down situations during the preceding 24 hour period.
- During **low visibility**, where conditions allow, continuous observations to spot whales should be maintained with a particular focus on the *Low power* and *Shut-down* Zones.

If sightings of whales have been frequent or are higher than were anticipated during the planning of the survey, the proponent should contact the Department to discuss appropriate night-time provisions and whether additional management measures should be employed for day and/or night-time operations.

(12) *line-change & gun-test regulations*: Operators should power down the acoustic source to the lowest possible setting when not collecting data, or undertaking soft start procedures (e.g. during line turns or when moving to another part of the survey area). The firing of a single gun during turns is an industry standard and is generally considered a reasonable precaution. This sound source may alert whales in the area to the presence of the seismic array and reduce chances of entanglement or contact.

(13) *Allowable silent period*: Unknown

(14) *Closed seismic zones or sensitive areas*: For seismic surveys operating in areas where the likelihood of encountering whales is **moderate to high**, the application of additional measures, to ensure that impacts and interference are avoided and/or minimised, are necessary: e.g. (a) use of MMO rather than trained crew member (MMOs should be trained and experienced in whale identification and behaviour, distance estimation, and be capable of making accurate identifications and observations of whales in Australian waters); (b) limiting soft-start procedures to daylight only; use of daylight spotter vessel/ aircraft; pre-survey research; and (c) increased precaution zones and buffer zones; and use of PAM. There is a closed area in the Great Australian Bight for southern right whales & Australian fur seals.

(15) *Reporting & Database requirements:* A report on the conduct of the survey, and any whale interactions, should be provided to the Department of the Environment, Water, Heritage and the Arts within two months of survey completion.

(16) *Authority:* Department of the Environment, Water, Heritage and the Arts

(17) *Planning stage:* When planning seismic surveys, avoid where possible areas where and when 'whales' are known or are likely to be migrating.

Assessing the likelihood of potential impacts on whales, thereby determining whether the proposed survey will have a **low likelihood** or a **moderate to high likelihood** of encountering whales. And of the survey areas lies within a **biologically important habitat** of a whale species, defined as breeding, calving, or resting areas, or confined migratory routes or feeding areas. In such habitats, displacement from areas or activities that are important to whale survival or recovery may have a greater impact than elsewhere.

Low likelihood: Spatially and temporally outside aggregation areas, migratory pathways and areas considered to provide biologically important habitat.

Moderate to high likelihood: Spatially and/or temporally proximate to aggregation areas, migratory pathways and/or areas considered to provide biologically important habitat.

(18) *Recommendations/other:* If sightings of whales have been frequent or are higher than were anticipated during the planning of the survey, the proponent should contact the Department to discuss appropriate night-time provisions and whether additional management measures should be employed for day and/or night-time operations.

#### **4 Gulf of Mexico (GOM) - Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program (2011)**

(1) *Observer requirement:* Two or three Protected Species Observers (PSOs)

(2) *Observer certification:* Visual observers who have completed a Protected Species Observer training program are required on all seismic vessels conducting operations in water depths greater than 200 meters (656 ft) throughout the GOM and are required on all seismic vessels conducting operations in OCS water depths less than 200 meters (656 ft.) in the GOM waters east of 88.0° W longitude.

Operators may engage trained third party observers, may utilize crew members after training as observers, or may use a combination of both third party and crew observers. No additional duties may be assigned to the observer during his/her visual observation watch (if conditions warrant more vigilant look-outs when navigating around or near maritime hazards, additional personnel must be used to ensure that watching for protected species remains the primary focus of the on-watch observers).

No observer will be allowed more than 4 consecutive hours on watch as a visual observer, a “break” time of no less than 2 hours must be allowed before an observer begins another visual monitoring watch rotation (break time means no assigned observational duties), and no person (crew or third party) on watch as a visual observer will be assigned a combined watch schedule of more than 12 hours in a 24-hour period. Due to the concentration and diligence required during visual observation watches, operators who choose to use trained crew members in these positions may select only those crew members who demonstrate willingness as well as ability to perform these duties.

(3) *Species of concern (including all marine fauna):* **Whales** mean all marine mammals in the GOM except dolphins (see definition below) and manatees. **Whales** include all species of baleen whales (Suborder *Mysticeti*), all species of beaked whales (*Ziphius cavirostris* and *Mesoplodon sp.*), sperm whales (*Physeter macrocephalus*), and pygmy and dwarf sperm whales (*Kogia sp.*). Of the baleen whales, only the Bryde’s whale (*Balaenoptera edeni*) is expected to be present in the northern GOM and is considered uncommon. This species has primarily been sighted in water depths less than 200 m in the eastern GOM. Sightings of other baleen whale species are highly unlikely. [Dolphins mean all marine mammal species in the Family *Delphinidae*. In the GOM, this includes, among others, killer whales, pilot whales, and all of the “dolphin” species.]

(4) *Size of the Mitigation/Exclusion Zone (EZ):* 500m

(5) *Required period of observation:* At least two protected species visual observers will be required on watch aboard seismic vessels at all times during daylight hours (dawn to dusk) when seismic operations are being conducted, unless conditions (fog, rain, darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that the sea surface observations are halted, visual observations must resume as soon as conditions permit.

(6) *Pre-watch period:* Visually monitor the exclusion zone and adjacent waters for the absence of marine mammals and sea turtles for at least 30 minutes before initiating ramp-up procedures.

(7) *Soft-Start (SS) period:* Initiate ramp-up procedures by firing a single airgun. The preferred airgun to begin with should be the smallest airgun, in terms of energy output (dB) and volume (in<sup>3</sup>). Continue ramp-up by gradually activating additional airguns over a period of at least 20 minutes, but no longer than 40 minutes, until the desired operating level of the airgun array is obtained.

(8) *Delay period of soft-start:* When no marine mammals or sea turtles are sighted for at least a 30-minute period, ramp-up of the source array may begin.

(9) *Shut-down requirements:* At any time a whale is observed within an estimated 500m (1,640 feet) of the sound source array (“exclusion zone”), whether due to the whale’s movement, the vessel’s movement, or because the whale surfaced inside the exclusion zone,

the observer will call for the immediate shut-down of the seismic operation, including airgun firing (the vessel may continue on its course but all airgun discharges must cease). The vessel operator must comply immediately with such a call by an on-watch visual observer. Any disagreement or discussion should occur only after shut-down.

(10) *Re-start after shut-down procedures*: You may recommence seismic operations and ramp-up of airguns only when the exclusion zone has been visually inspected for at least 30 minutes to ensure the absence of marine mammals and sea turtles.

(11) *Seismic source and mitigation measures at night time*: Do not initiate ramp-up procedures at night or when you cannot visually monitor the exclusion zone for marine mammals and sea turtles if your minimum source level drops below 160 dB re 1  $\mu$ Pa-m (rms). Monitoring for whales with a Passive Acoustic array by an observer proficient in its use will allow ramp-up and the subsequent start of a seismic survey during times of reduced visibility (darkness, fog, rain, etc.) when such ramp-up otherwise would not be permitted using only visual observers.

(12) *line-change & gun-test regulations*: The source level of the airgun array may be reduced, using the same shot interval as the seismic survey, to maintain a minimum source level of 160 dB re 1  $\mu$ Pa-m (rms) during line-changes. By maintaining the minimum source level, is it not required to conduct the 30-minute visual clearance of the exclusion zone before ramping back up to full output.

(13) *Allowable silent period*: Reducing source level, see (12); Periods of airgun silence not exceeding 20 minutes in duration will not require ramp-up for the resumption of seismic operations if: (1) visual surveys are continued diligently throughout the silent period (requiring daylight and reasonable sighting conditions), and (2) no whales, other marine mammals, or sea turtles are observed in the exclusion zone. If whales, other marine mammals, or sea turtles are observed in the exclusion zone during the short silent period, resumption of seismic survey operations must be preceded by ramp-up.

(14) *Closed seismic zones or sensitive areas*: Unknown

(15) *Reporting & Database requirements*: Daily/Bi-weekly/Final Reports to BOEM; Shutdown report within 24 hrs

(16) *Authority*: Minerals Management Service

(17) *Planning stage*: Unknown

(18) *Recommendations/other*: Monitoring for whales with a passive acoustic array by an observer proficient in its use will allow ramp-up and the subsequent start of a seismic survey during times of reduced visibility (darkness, fog, rain, etc.) when such ramp-up otherwise would not be permitted using only visual observers.

## 5 United Kingdom - JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys (August, 2010)

(1) *Observer requirement:* 1 MMO<sup>5</sup>; or 2MMOs when daylight hours > 12 (between 1st April and 1st October, north of 57° latitude), or the survey is in an area considered particularly important for marine mammals: 2 experienced MMOs (3 years experience) & 2 PAM operators are also required.

(2) *Observer certification:* A prerequisite for an MMO to be classified as a 'trained MMO' is that they must have received formal training on a JNCC recognised course.

(3) *Species of concern (including all marine fauna):* marine mammals

(4) *Size of the Mitigation/Exclusion Zone (EZ):* 500m

(5) *Required period of observation:* Where two MMOs are onboard a seismic vessel, JNCC would encourage collaboration to ensure that cetacean monitoring is undertaken during all daylight hours.

(6) *Pre-watch period:* The pre-shooting search should normally be conducted over a period of 30 minutes before commencement of any use of the airguns. In deep waters (>200m) the pre-shooting search should extend to 60 minutes as deep diving species (e.g. sperm whale and beaked whale) are known to dive for longer than 30 minutes.

(7) *Soft-Start (SS) period:* 20 to 40 minutes; the period of the start of the Soft Start to the Start of Line (SOL) should not exceed 40 minutes.

- Surveys should be planned so that, whenever possible, the soft-start procedures for site surveys and Vertical Seismic Profiles (VSP's) commence during daylight hours.
- Whilst it is appreciated that high resolution site surveys / VSP operations may produce lower acoustic output than 2D or 3D surveys it is still considered desirable to undertake a soft-start to allow for marine mammals to move away from the seismic source.
- For ultra-high resolution site surveys that only use a 'mini-airgun' (single airgun with a volume of less than 10 cubic inches) there is no requirement to perform a soft-start, however, a pre-shooting search should still be conducted before its use.

(8) *Delay period of soft-start:* A 20 minute delay from the time of the last sighting within 500 metres of the source to the commencement of the soft-start, in order to determine whether the animals have left the area.

(9) *Shut-down requirements:* No, if marine mammals are detected within 500 metres of the centre of the airgun array whilst the airguns are firing, either during the soft-start procedure or whilst at full power, there is no requirement to stop firing the airguns.

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<sup>5</sup> The MMO should be employed solely for the purpose of monitoring the implementation of the guidelines and undertaking visual observations to detect marine mammals during periods of seismic activity.

(10) *Re-start after shut-down procedures*: Not applicable

(11) *Seismic source and mitigation measures at night time*: PAM is considered to be the only currently available mitigation technique that can be used to detect marine mammals during darkness or periods of poor visual sighting conditions.

(12) *line-change & gun-test regulations*: Seismic surveys with an airgun volume of 500 cubic inches or more: If the line change time is expected to be greater than 20 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line. A pre-shooting search should also be undertaken during the scheduled line change, and the soft-start delayed if marine mammals are seen within 500 metres of the centre of the airgun array; Seismic surveys with an airgun volume of 180 cubic inches or less (site surveys): If the line change time is expected to be greater than 40 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line. The pre-shooting search should also be undertaken during the scheduled line change, and the soft-start delayed if marine mammals are seen within 500 metres of the centre of the airgun array. If the line change time is expected to be less than 40 minutes, airgun firing can continue during the turn, but the Shot Point Interval (SPI) should be increased (longer duration between shots). Ideally, the SPI should not exceed 5 minutes during the turn.

- If the intention is to test all airguns at full power then a 20 minute soft-start is required.
- If the intention is to test a single airgun on low power then a soft-start is not required.
- If the intention is to test a single airgun, or a number of guns on high power, the airgun or airguns should be fired at lower power first, and the power then increased to the level of the required test; this should be carried out over a time period proportional to the number of guns being tested and ideally not exceed 20 minutes in duration.

(13) *Allowable silent period*: After any unplanned break in firing for less than 10 minutes the MMO should make a visual assessment for marine mammals (not a pre-shooting search) within 500 metres of the centre of the airgun array. If a marine mammal is detected whilst the airguns are not firing the MMO should advise to delay commencement, as per the pre-shooting search, delay and soft start instructions above. If no marine mammals are present then they can advise to commence firing the airguns.

(14) *Closed seismic zones or sensitive areas*: For areas that are currently considered particularly important for marine mammals, for example in the UK this includes areas West of Scotland, the Moray Firth and Cardigan Bay. For these it is required that:

- The MMOs should be experienced MMOs, and that PAM should be used.
- The PAM system should be used to supplement visual observations, or as the main mitigation tool if the seismic survey activity commences during periods of darkness or poor visibility, or during periods when the sea state is not conducive to visual mitigation.

(15) *Reporting & Database requirements*: Database and A final report, the 'MMO report', should be sent to the JNCC after the survey has been completed.

(16) *Authority:* Joint Nature Conservation Committee

(17) *Planning stage:* As part of the environmental impact assessment, assess the likelihood of injuring or disturbing a European Protected Species. If marine mammals are likely to be in the area, only commence seismic activities during the hours of daylight when visual mitigation using MMOs is possible. Permit needed.

Plan surveys so that the timing will reduce the likelihood of encounters with marine mammals. For example, this might be an important consideration in certain areas/times, e.g. during seal pupping periods near Special Areas of Conservation for common seals or grey seals.

(18) *Recommendations/other:*

- Where possible, soft-starts should be planned so that they commence within daylight hours.
- During an undershoot operation, one vessel is employed to tow the seismic source and a second vessel used to tow the hydrophone array, although the main vessel will still tow the hydrophone array. The MMO may be too far away from the airguns to effectively monitor the mitigation zone, and it is recommended to place a MMO on the source vessel.
- The JNCC notes that other protected fauna, for example turtles, will occur in waters where these guidelines may be used, and would suggest that, whilst the appropriate mitigation may require further investigation, the soft-start procedures for marine mammals would also be appropriate for marine turtles and basking sharks.
- Only commence seismic activities during the hours of darkness, or low visibility, or during periods when the sea state is not conducive to visual mitigation, if a Passive Acoustic Monitoring (PAM) system is in use to detect marine mammals likely to be in the area, noting the limitations of available PAM technology (seismic surveys that commence during periods of darkness, or low visibility, or during periods when the observation conditions are not conducive to visual mitigation, could pose a risk of committing an injury offence).

## 6 Colombia - Seismic Guidelines

(1) *Observer requirement:* 2 MMOs

(2) *Observer certification:*

- Accreditation of undergraduate biology, ecology and related sciences
- At least one course in statistics or mathematics and/or the backing of an institution that has courses in mathematics and statistics
- Certified technical training MMO
- Specific experience minimum 1 year certified in fisheries and/or as MMO

(3) *Species of concern (including all marine fauna):* Cetaceans and marine turtles

- (4) *Size of the Mitigation/Exclusion Zone (EZ):* 500m
- (5) *Required period of observation:* 24hrs (MMO & PAM)
- (6) *Pre-watch period:* 30 minutes
- (7) *Soft-Start (SS) period:* 20 minutes
- (8) *Delay period of soft-start:* 30 minutes after the last cetacean or sea turtle sighting.
- (9) *Shut-down requirements:* Cetaceans and marine turtles within 500m
- (10) *Re-start after shut-down procedures:* The re-start begins after 30 minutes from the last sighting.
- (11) *Seismic source and mitigation measures at night time:* There are mitigation measures such as Soft Start, PAM, or use of mitigation at least one hour before Soft Start if PAM is not available.
- (12) *line-change & gun-test regulations:* The source is terminated during line-change.
- (13) *Allowable silent period:* unknown
- (14) *Closed seismic zones or sensitive areas:* Colombia has certain areas at specific times with restrictions for seismic operations.
- (15) *Reporting & Database requirements:* Database (effort, sightings and record of seismic operations) together with a final report with the results, analysis and recommendations is given to the authorities.
- (16) *Authority:* Ministry of Environment, Housing and Territorial Development (MAVDT)
- (17) *Planning stage:* There is a planning stage before the seismic survey receives a permit, to determine the requirements for the permit.
- (18) *Recommendations/other:* none

## **7 Brazil – IBAMA Guide for monitoring marine biota during seismic data acquisition activities (April 2005)**

- (1) *Observer requirement:* Minimal of 3 observers, in order to 2 MMOs can cover the all area at all times (both safety-500m and warning areas-1000m). Work shift: 1 hour and 30 minutes of observation and 30 minutes of rest.

- (2) *Observer certification*: Professional, dedicated and experience or specific training
- (3) *Species of concern (including all marine fauna)*: marine mammals & turtles
- (4) *Size of the Mitigation/Exclusion Zone (EZ)*: 500m (for shut-down) & 1000m (for delay SS).
- (5) *Required period of observation*: during all daylight hours and at all times (even if not firing)
- (6) *Pre-watch period*: 30 minutes
- (7) *Soft-Start (SS) period*: 20-40 minutes
- (8) *Delay period of soft-start*: a period of 30 minutes without seeing any marine mammal or turtle in the safety area and in the warning area, i.e., less than 1000 meters for the center of the air gun array.
- (9) *Shut-down requirements*: If a marine mammal or turtle is detected within 500m then shut down and restart firing only after pre-watch (including previous watching and ramp-up)
- (10) *Re-start after shut-down procedures*: Restart firing with soft start and 30 minute clearance.
- (11) *Seismic source and mitigation measures at night time*: Not allowed to start airguns at night unless a small gun (160 dB re 1  $\mu$ Pa-m) is kept active. No shooting initialized (not even a soft start) if it is too dark to undertake observation or if weather conditions are adverse (rain, fog, etc). If the shooting operation is interrupted, the restart must be during daylight and with the normal procedures (pre-watch and soft start).
- (12) *line-change & gun-test regulations*: Under special conditions, as an alternative mechanism in order to avoid delays in the operation schedule, it will be allowed to continue with low-power shooting during line change (i.e. mitigation gun equivalent to 160 dB re 1  $\mu$ Pa-m). The return to the operation power shall be accomplished progressively. If the line change time is expected to be greater than 20 minutes, airgun firing should be terminated at the end of the line then SS before the next line. If line change <20 minute, then continue at Full Power. SS before any gun test;
- (13) *Allowable silent period*: 5 minutes, then SS
- (14) *Closed seismic zones or sensitive areas*: Seasonal closed areas for breeding humpback and right whales, Franciscana dolphin, turtle nesting season and manatee areas. Seismic surveys in areas shallower than 12 meters are not allowed.
- (15) *Reporting & Database requirements*: Reports should be sent straight to IBAMA within 5 working days.

(16) *Authority:* IBAMA ( MINISTRY OF THE ENVIRONMENT, BRAZILIAN INSTITUTE OF THE ENVIRONMENT AND NATURAL RENEWABLE RESOURCES)

(17) *Planning stage:* Consult (<http://www.ibama.gov.br/licenciamento>), plan the activity in order to avoid overlapping the reproduction periods and areas of marine mammals & turtles, humpback whales and right whales. Permit needed.

(18) *Recommendations/other:* IBAMA does not require PAM as mitigation measure.

## 8 Trinidad & Tobago - There are no legal guidelines for the mitigation of seismic operations.

### *a) Requirements for the mitigation of acoustic disturbance from offshore seismic surveys to marine life in Trinidad and Tobago (draft, 17 April 2014).*

(1) *Observer requirement:* The number of MMOs on any source vessel must be sufficient to ensure that effective monitoring for Type II Species of Concern is performed throughout all daylight hours where visibility, sea condition and safety allow for this. Avoidance of observer fatigue is essential. In addition it is recommended for additional MMOs placed onboard a non-source vessel.

MMOs must be appropriately equipped with a range-finding stick, binoculars with a reticle, and/or other demonstrably accurate tools for determining the distance to an animal in real time (theodolite, range estimation software in conjunction with cameras etc.).

(2) *Observer certification:* Experienced with Seismic & must be able to identify a 'Type II Species of Concern'

(3) *Species of concern (including all marine fauna):* **Type I Species of Concern** refers to a species which is considered when planning mitigation for acoustic impacts of a seismic survey because it is recognised as being a species of high importance for which there is at least a moderate risk of impact to individuals or populations from anthropogenic sound. **Type II Species of Concern** refers to a Type I Species of Concern for which specific real time mitigation actions are required during a seismic survey. These species are listed in Appendix 1 of the guidelines.

(4) *Size of the Mitigation/Exclusion Zone (EZ):* At least 500m; five functional hearing groups are defined for the creation of mitigation zones: high frequency cetaceans, mid-frequency cetaceans, low frequency cetaceans, sirenians and turtles. The EZs are forthcoming from the sound propagation modelling during the planning phase. Each modelled mitigation zone will later be replaced by a validated mitigation zone within a week of first firing of the source at full power based on sound verification measurements of the source.

(5) *Required period of observation:* Continuous watch - the maximum duration for watches for an MMO is two hours, with no less than a one hour break between observation sessions to avoid efficiency reductions which could compromise detection rates.

(6) *Pre-watch period:* 60 minutes

(7) *Soft-Start (SS) period:* The sound pressure level at start of ramp-up should not exceed 130dB re 1  $\mu$ Pa at 1m. Where possible, ramp-up must be performed in such a way that the increase in loudness is approximately linear. For any seismic source where it is feasible the ramp-up should increase acoustic output at the source by appr. 6 dB per minute.

(8) *Delay period of soft-start:* The seismic source may not be started while a Type II Species of Concern is in the mitigation zone. For deep diving and particularly vulnerable or cryptic animals (Sperm Whales, Kogia sp. and all beaked whales) a delay of 60 minutes will apply after the animal is no longer detected in the mitigation zone. For all other Type II Species of Concern a minimum delay of 30 minutes will apply after the animal is no longer detected in the mitigation zone.

It is recommended that if a turtle is seen just ahead of a source vessel but outside the mitigation zone (for example if the mitigation zone is entirely astern of a vessel) the observer mark the approximate position of the sea turtle and request a delay when the mitigation zone reaches the point at which the sea turtle was last seen. This delay should continue until the point at which the sea turtle was last seen is outside of the mitigation zone. If the pause is longer in duration than the allowed silent period (13) then a full ramp-up will be required.

(9) *Shut-down requirements:* If at any time while the seismic source is active a Type II Species of Concern is detected within the applicable mitigation zone the seismic source shall immediately be shut down.

(10) *Re-start after shut-down procedures:* same as outlined under (8)

(11) *Seismic source and mitigation measures at night time:* PAM monitoring and Soft Start - PAM from a non-source vessel may, in some cases, be more effective than PAM deployed from a source vessel, for example if the source vessel is loud or does not allow for such an effective deployment.

(12) *line-change & gun-test regulations:* If the source is not required for data acquisition or testing for longer than the duration of ramp-up (including for line turns) then it must be deactivated and a full ramp-up conducted with the requisite pre-shooting search. If the source is not required for data acquisition or testing for less than the duration of ramp-up (including for line turns) then it should be activated at full power once every minute unless the normal shot point interval is greater than once per minute, in which case normal firing may be continued.

(13) *Allowable silent period:* If the source has not been fired (has been silent) for more than 10 minutes then a full ramp-up (soft start) will be required.

(14) *Closed seismic zones or sensitive areas:* Seismic source may not be activated outside the permitted survey area

(15) *Reporting & Database requirements:* The MMO and PAM final report must be submitted to the EMA within one month of the end of the seismic survey. All MMO and PAM data associated with the project must accompany the final report in the appropriate digital spreadsheet.

In the event of any non-compliance incident MMOs or PAM operators should prepare a short incident report and submit this to the Applicant.

(16) *Authority:* Environmental Management Authority (EMA)

(17) *Planning stage:* A high quality environmental impact assessments should be an intrinsic part of project planning even where this is not required by law. The seismic source may not be activated outside the permitted survey area.

Sound propagation modelling must be performed to determine the sound pressure levels and sound exposure levels in the vicinity of and inside the survey area as a result of the proposed activity of the seismic source:

Determine the area which may be impacted by the seismic survey which is used in determining temporal zonation (e.g. the Mitigation Zone).

When choosing and adjusting vessel(s), seismic source(s), other equipment and survey design to reduce sound output the Applicant must ensure that the best available technology and techniques are used to reduce overall sound output into the marine ecosystem from the seismic survey in the context of acquiring desired data (e.g. using airgun alternatives (such as marine Vibroseis) which have the potential to operate at a much lower sound pressure levels (and possibly sound exposure levels) and at a frequency range which is more restricted to those which are useful for the seismic survey.

(18) *Recommendations/other:* A pre-operations meeting must be attended by all personnel directly involved in mitigation measures (MMOs, PAM operators, seismic personnel who may be requested to perform an action such as a stop or delay). It is highly recommended that this meeting should also be attended by representatives of the Applicant.

The minimum required specifications for PAM equipment are given in the definition of PAM. The minimum requirements are:

- a. calibrated hydrophone arrays coupled with appropriate computer hardware and software systems that allow for a PAM operator to both visually and acoustically monitor for vocalising marine mammals;
- b. the ability to detect vocalising marine mammals at a distance of 1.5 km and within a frequency range of 1 Hz–180 kHz;
- c. an associated GPS system, calibrated depth sensor and a system for filtering unwanted noise.

Careful consideration should be given to the most appropriate type of PAM deployment for the operation to allow for optimum performance (for example standard towed array, source towed array, VSP hydrophone array or a remote buoy system). Monitoring from a non-source vessel in addition to monitoring from a source vessel is highly recommended.

***b) Trinidad 2D - Report on Risk and Mitigation Measures to Marine Flora and Fauna associated with the Loran-Manatee Offshore Development (2010)***

- (1) *Observer requirement*: Dedicated Observer
- (2) *Observer certification*: Not specified
- (3) *Species of concern (including all marine fauna)*: Whales, Cetaceans and significant fish movements
- (4) *Size of the Mitigation/Exclusion Zone (EZ)*: 5 km
- (5) *Required period of observation*: Continuous visual or with fish finder/echo sounder
- (6) *Pre-watch period*: Not specified
- (7) *Soft-Start (SS) period*: At least 20 minutes
- (8) *Delay period of soft-start*: Until cetaceans or significant fish movements are outside the study sector
- (9) *Shut-down requirements*: Stop work if whales are within 5 km of the seismic survey vessel
- (10) *Re-start after shut-down procedures*: Not specified but assumed with SS
- (11) *Seismic source and mitigation measures at night time*: Not specified, but assumed via SS and echosounder/ fish finder
- (12) *line-change & gun-test regulations*: Not specified
- (13) *Allowable silent period*: Not specified
- (14) *Closed seismic zones or sensitive areas*: Seismic surveys to be done outside of the major fishing seasons
- (15) *Reporting & Database requirements*: Unknown
- (16) *Authority*: Ministry of Energy & Energy Affairs

(17) *Planning stage*: Seismic surveys to be done outside of the major fishing seasons

(18) *Recommendations/other*: None

## **9 French Guiana - There are no legal guidelines for the mitigation of seismic operations in French Guiana.**

### ***a) Seismic survey based on JNCC & MMS (GoM) guidelines and modified to fit local situations***

(1) *Observer requirement*: MMTO & PAM, at least 1 MMTO on watch

(2) *Observer certification*: MMO are all certified (nothing specified). PAMs are trained with PAMGuard software and with marine mammal's identification from vocalisations. They are also trained with MSeis equipment. (<http://www.mseis.com/services/pam/>)

(3) *Species of concern (including all marine fauna)*: marine mammals, marine turtles, Chondrychtes (shark, rays, cartilaginous fishes).

(4) *Size of the Mitigation/Exclusion Zone (EZ)*: 500 m for marine mammals; 200 m for marine turtles and chondrychtes

(5) *Required period of observation*: At the highest point of the platform, during pre-watch periods and soft start period.

(6) *Pre-watch period*: 60 minutes

(7) *Soft-Start (SS) period*: 20-40 minutes

(8) *Delay period of soft-start*: 20 minutes after seeing any marine turtle or chondrychtes within the 200m zone. If marine turtles or chondrychtes are seen within the 200 m zone, during soft start, air guns must stop for 8 shots (not valid at night because these species do not vocalise)

(9) *Shut-down requirements*: Marine turtles and chondrychtes are concerned. If seen within the 200m zone, air guns must stop for 8 shots until they leave this mitigation zone.

(10) *Re-start after shut-down procedures*: back to full power/Soft start after the 8 shot-point pause

(11) *Seismic source and mitigation measures at night time*: PAM during the night (during pre-watch) and during line changes.

(12) *line-change & gun-test regulations*: Air gun volume > 450 cm<sup>3</sup>: if line change period > 20 min then air guns stop and leave small guns (160 db) running and 60 minutes of pre-watch and 20 minutes of soft-start are compulsory. Soft start delayed if marine mammals, chondrichthyes, marine turtles are seen.

If air gun volume < 450 cm<sup>3</sup>: : if line change period > 40 min then air guns stop and 60 minutes of pre-watch and 20 minutes of soft-start are compulsory. Soft start delayed if marine mammals are seen. : if line change period < 40 min, air gun can continue but the "Shot Point Interval" must increase to be less than 5 minutes.

(13) *Allowable silent period*: Unknown

(14) *Closed seismic zones or sensitive areas*: None

(15) *Reporting & Database requirements*: Specific forms are fulfilled daily and a daily report with all observations (PAM, MMO) and observation efforts must be sent. Final report within one month of survey completion. The final report must include:

- Date and place of the survey
- Total number and volume of air guns
- Frequency range (Hz), intensity (dB re., 1 μPa), shots intervals (sec.) and/or details on any acoustic energy used.
- Number and type of fleet used
- Records of all air gun use event
- Records of all MMO activities to detect marine mammals, chondrichthyes and marine turtles or any relevant observation (ex: marine birds). All details about the observation and the seismic activity must be specified.
- Details of any problem encountered during the survey, including non-conformity events. Any such event must be reported.

Database is available to the industry and local authority. Data can be made available upon request in some cases.

(16) *Authority*: DEAL (Direction de l'Environnement, de l'Aménagement et du Logement)

(17) *Planning stage*: Any oil&gas industry must declare which zone and which transect it plans to cover. Upon request from the fishery committee, an Environment Impact Assessment has been implemented to assess the impact of seismic survey on fish population (sampled before and after operation) for each season (dry and rainy season), for 2 years.

(18) *Recommendations/other*: Reduce the amount of lights at night (to reduce the stranding of seabirds on deck) and turtle-guards are fitted on tail buoys.

***b) French Guiana 3D seismic survey in deep water; University of Paris Sud, based on JNCC guidelines and modified to fit local situation (September 2009)***

- (1) *Observer requirement:* 2 MMOs
- (2) *Observer certification:* PSO & JNCC
- (3) *Species of concern (including all marine fauna):* Marine Mammals, Turtles & large elasmobranchs (sharks and rays)
- (4) *Size of the Mitigation/Exclusion Zone (EZ):* (a) 500m for cetaceans and (b) 180m for turtles/elasmo-branches
- (5) *Required period of observation:* All daylight hours
- (6) *Pre-watch period:* 60 minutes
- (7) *Soft-Start (SS) period:* 20 minutes
- (8) *Delay period of soft-start:* (a) Until cetaceans are out of sight; (b) turtle/elasmobranchs > 180m
- (9) *Shut-down requirements:* Turtles/elasmobranchs: 5 shot-points pause then back to full power
- (10) *Re-start after shut-down procedures:* Back to full power
- (11) *Seismic source and mitigation measures at night time:* Permitted with monitoring; Soft Start; Night-time binoculars were tested but not found to be useful
- (12) *line-change & gun-test regulations:* If the line change time is expected to be greater than 20 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line.
- (13) *Allowable silent period:* <10 minutes then back to Full Power, otherwise Soft Start
- (14) *Closed seismic zones or sensitive areas:* Unknown
- (15) *Reporting & Database requirements:* Unknown
- (16) *Authority:* DIREN (Regional environmental authority)
- (17) *Planning stage:* Unknown
- (18) *Recommendations/other:* None

## 10 Suriname – There are no legal guidelines for the mitigation of seismic operations in Suriname.

### ***a) 3D seismic survey in deep-water basin (May-September, 2012) with Guidelines based on JNCC (August, 2010) with local additions.***

- (1) *Observer requirement:* 3 MMTOs, 1 low-frequency PAM - 2 MMTO's on watch during daylight hours, one covering the port side and one covering the starboard side
- (2) *Observer certification:* JNCC, PSO & at least 2 MMOS > 10 years' experience & independent and Lead MMO with Academic degree (MSc) in Marine Biology
- (3) *Species of concern (including all marine fauna):* marine mammals & marine turtles
- (4) *Size of the Mitigation/Exclusion Zone (EZ):* 500m
- (5) *Required period of observation:* all daylight hours (low-frequency PAM during darkness)
- (6) *Pre-watch period:* 60 minutes (water depth>200m)
- (7) *Soft-Start (SS) period:* 20-40 minutes
- (8) *Delay period of soft-start:* MMTO will request a 20 minute delay (after last seen inside EZ) to the start of seismic activities if marine mammals or turtles are observed within 500 m of the survey vessel
- (9) *Shut-down requirements:* When marine mammals are clearly going to pass directly under the array when array is at full power or the animal is in any apparent distress'. In addition, a pause of the guns may be implemented in case 'marine turtles are clearly going to pass directly under the array when the array is at full power'.
- (10) *Re-start after shut-down procedures:* Wait 20 minutes until marine mammal last seen within EZ or back to full power after marine turtle is well beyond seismic source (5 minute pause).
- (11) *Seismic source and mitigation measures at night time:* Soft Starts & low frequency PAM monitoring
- (12) *line-change & gun-test regulations:* When the line change exceeds 20 minutes then terminate source and commence soft-start before the next start of line (SOL)
- (13) *Allowable silent period:* 10 minutes
- (14) *Closed seismic zones or sensitive areas:* none

(15) *Reporting & Database requirements:* JNCC Database and final report to client – database made available to PhD student to contribute to inventory of marine mammal species that occur off Suriname. Week reports to local NGOs

(16) *Authority:* NIMOS (National Institute for Environment and Development in Suriname)

(17) *Planning stage:* Marine Mammal and Sea turtle monitoring plan as part of EIA; permit needed

(18) *Recommendations/other:* Turtle guards fitted to tail buoys

***b) Suriname – 2D & 3D seismic survey in shallow-waters  
(June, August-September, 2013) with Guidelines  
based on GoM/JNCC with local additions.***

(1) *Observer requirement:* 2 MMOs

(2) *Observer certification:* PSO & JNCC

(3) *Species of concern (including all marine fauna):* Marine mammals & marine turtles

(4) *Size of the Mitigation/Exclusion Zone (EZ):* 500m

(5) *Required period of observation:* all daylight hours

(6) *Pre-watch period:* 30 minutes (water depth < 200m)

(7) *Soft-Start (SS) period:* 20-40 minutes

(8) *Delay period of soft-start:* A 30 minute delay from the time of the last sighting within 500 metres of the source.

(9) *Shut-down requirements:* Whales (as per GoM guidelines), manatees and marine turtles inside EZ

(10) *Re-start after shut-down procedures:* A 30 minute delay from the time of the last sighting within 500 metres of the source.

(11) *Seismic source and mitigation measures at night time:* Soft Start and mitigation gun

(12) *line-change & gun-test regulations:* When the line change exceeds a period of 20 min then terminate source and commence soft-start before the next Start Of Line (SOL).

(13) *Allowable silent period:* After any unplanned break in firing for less than 10 minutes the MMO should make a visual assessment for marine mammals (not a pre-shooting search)

within 500 metres of the centre of the airgun array. If no marine mammals are present then they can advise to commence firing the airguns.

(14) *Closed seismic zones or sensitive areas*: None

(15) *Reporting & Database requirements*: JNCC Database and final report to client – database made available to PhD student to contribute to inventory of marine mammal species that occur off Suriname

(16) *Authority*: NIMOS (National Institute for Environment and Development in Suriname)

(17) *Planning stage*: Marine Mammal and Sea turtle monitoring plan as part of EIA; permit needed

(18) *Recommendations/other*: Turtle guards fitted to tail buoys; Support vessel to Paramaribo should keep a lookout for mammals/turtles and reduce travel speed.

***c) Suriname – 2D seismic survey in the Coppename, Suriname, Commewijne, Corantijn, and Saramacca Rivers in (October-November, 2012) with Guidelines based on GoM/JNCC and BMP (Best Management Practices) established for the specific region and species.***

(1) *Observer requirement*: One experienced and certified observer

(2) *Observer certification*: Yes, but not clear what type of certification

(3) *Species of concern (including all marine fauna)*: Cetaceans, manatees and marine turtles

(4) *Size of the Mitigation/Exclusion Zone (EZ)*: 500m

(5) *Required period of observation*: all daylight hours

(6) *Pre-watch period*: 30 minutes

(7) *Soft-Start (SS) period*: Yes, but duration not clear (assumed to be 20-40 minutes)

(8) *Delay period of soft-start*: A 30 minute delay from the time of the last sighting within 500 metres of the source.

(9) *Shut-down requirements*: Cetaceans, manatees and marine turtles inside EZ

(10) *Re-start after shut-down procedures*: After visual clearance of the EZ beginning with a soft start

(11) *Seismic source and mitigation measures at night time*: unknown

- (12) *line-change & gun-test regulations*: unknown
- (13) *Allowable silent period*: unknown
- (14) *Closed seismic zones or sensitive areas*: None
- (15) *Reporting & Database requirements*: daily and weekly reports detailing marine mammals and turtles sighted, survey operations, and survey effort using standard International Association of Geophysical Contractors (IAGC) deck forms
- (16) *Authority*: NIMOS (National Institute for Environment and Development in Suriname)
- (17) *Planning stage*: Marine Mammal and Sea turtle monitoring plan as part of EIA; permit needed
- (18) *Recommendations/other*:

**11 Guyana - There are no legal guidelines for the mitigation of seismic operations in Guyana. Best international practise has been adopted using a combination of JNCC & MMS Guidelines but no details are available.**

- (1) *Observer requirement*:
- (2) *Observer certification*:
- (3) *Species of concern (including all marine fauna)*:
- (4) *Size of the Mitigation/Exclusion Zone (EZ)*:
- (5) *Required period of observation*:
- (6) *Pre-watch period*:
- (7) *Soft-Start (SS) period*:
- (8) *Delay period of soft-start*:
- (9) *Shut-down requirements*:
- (10) *Re-start after shut-down procedures*:
- (11) *Seismic source and mitigation measures at night time*:

(12) *line-change & gun-test regulations:*

(13) *Allowable silent period:*

(14) *Closed seismic zones or sensitive areas:*

(15) *Reporting & Database requirements:*

(16) *Authority:*

(17) *Planning stage:*

(18) *Recommendations/other:*

**12 Venezuela - There are no legal guidelines for the mitigation of seismic operations in Venezuela but all the mitigation measures that have been used in seismic operations in Venezuela have been in compliance with Presidential Decree 1257. The below mitigation measures have been recommended as part of previous offshore seismic surveys but it is not clear how effective they are and if they were being implemented.**

(1) *Observer requirement:* One observer per vessel (also non-seismic vessels, e.g. support vessels), the total number of observers depends on the number of support vessels to seismic (recommended)

(2) *Observer certification:* Specialized staff (marine biologists, fisheries scientists, oceanographers), as well as students, members of public/private institutions, with the aim of developing skilled jobs and reinforce the knowledge through research projects. As part of the programs of PDVSA (Petroleum of Venezuela) fixed vessel personnel are trained

(3) *Species of concern (including all marine fauna):* marine mammals and turtles, specifically larger whales such as humpback whale and Bryde's whale (recommended).

(4) *Size of the Mitigation/Exclusion Zone (EZ):* 1 km (recommended)

(5) *Required period of observation:* All daylight hours (specifically to avoid collisions) - recommended

(6) *Pre-watch period:* 30 – 60 minutes (recommended) - visually and with use of radar

(7) *Soft-Start (SS) period:* 20-40 minutes (recommended)

(8) *Delay period of soft-start:* A 30 minute delay from the time of the last sighting within EZ (recommended).

- (9) *Shut-down requirements*: Marine mammal & Turtle within EZ, then shut-down (recommended)
- (10) *Re-start after shut-down procedures*: After visual clearance of the EZ beginning with a soft start (recommended)
- (11) *Seismic source and mitigation measures at night time*: No operations at night (recommended)
- (12) *line-change & gun-test regulations*: Turn off source during line/changes (recommended)
- (13) *Allowable silent period*: Unknown
- (14) *Closed seismic zones or sensitive areas*: No restrictions
- (15) *Reporting & Database requirements*: Reports related to all identified marine mammals together with thematic maps are forwarded to stakeholders in order to enhance the biological information available.
- (16) *Authority*: Ministry of Environment and Renewable Natural Resources
- (17) *Planning stage*: According to the Decree (Presidential Decree 1257), all of the activities that are potentially harmful for the environment must design an Environmental Impact Assessment (EIA).
- (18) *Recommendations/other*: The measures used in Venezuela are theoretical. It is unknown how effective the implementation of the measures used are and how effective it is to use incorporation of personnel.

### **13 Aruba - There are no legal guidelines for the mitigation of seismic operations in Aruba. 2D seismic survey (February - April, 2013) with Guidelines based on JNCC (August, 2010) with local additions.**

- (1) *Observer requirement*: Two MMOs & 1 PAM operator (night time)
- (2) *Observer certification*: A prerequisite for an MMO to be classified as a 'trained MMO' is that they must have received formal training on a JNCC recognised course.
- (3) *Species of concern (including all marine fauna)*: marine mammals & turtles
- (4) *Size of the Mitigation/Exclusion Zone (EZ)*: 500m
- (5) *Required period of observation*: All daylight hours

(6) *Pre-watch period*: The pre-shooting search should normally be conducted over a period of 30 minutes before commencement of any use of the airguns. In deep waters (>200m) the pre-shooting search should extend to 60 minutes as deep diving species (e.g. sperm whale and beaked whale) are known to dive for longer than 30 minutes.

(7) *Soft-Start (SS) period*: 20 to 40 minutes; the period of the start of the Soft Start to the Start of Line (SOL) should not exceed 40 minutes.

(8) *Delay period of soft-start*: A 20 minute delay from the time of the last sighting within 500 metres of the source to the commencement of the soft-start, in order to determine whether the animals have left the area.

(9) *Shut-down requirements*: Yes for whales inside 500m (and turtles in 2014 survey).

(10) *Re-start after shut-down procedures*: Not specified but assumed to be 20 minute delay after whales last seen inside mitigation zone, and then commence Soft Start

(11) *Seismic source and mitigation measures at night time*: PAM

(12) *line-change & gun-test regulations*: If the line change time is expected to be greater than 20 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line.

- If the intention is to test all airguns at full power then a 20 minute soft-start is required.
- If the intention is to test a single airgun on low power then a soft-start is not required.
- If the intention is to test a single airgun, or a number of guns on high power, the airgun or airguns should be fired at lower power first, and the power then increased to the level of the required test; this should be carried out over a time period proportional to the number of guns being tested and ideally not exceed 20 minutes in duration.

(13) *Allowable silent period*: After any unplanned break in firing for less than 10 minutes the MMO should make a visual assessment for marine mammals (not a pre-shooting search) within 500 metres of the centre of the airgun array. If a marine mammal is detected whilst the airguns are not firing the MMO should advise to delay commencement, as per the pre-shooting search, delay and soft start instructions above. If no marine mammals are present then they can advise to commence firing the airguns.

(14) Closed seismic zones or sensitive areas: A3km buffer-zone from the coast

(15) Reporting & Database requirements: Daily reporting to client, final report + database

(16) Authority: Compania Arubano di Petroleo NV (CAP NV)

(17) Planning stage: Pre-scouting survey, HSE plan and in consultation with Aruba Marine Mammal Foundation

(18) Recommendations/other: A pre-scouting survey was carried out by one MMO during a one week period during the seismic survey. Use of Turtle Detection Device in 2014-survey (ATS DSP Receiver to monitor turtles equipped with VHF radio transmitter using a single frequency 150.101 MhZ)

## **14 Venezuela/Aruba&Curaçao/Trinidad & Tobago - There are no legal guidelines for the mitigation of seismic operations in these countries.**

**2D seismic survey in the SE Caribbean Sea in April/May 2004 with Incidental Harassment Authorization by NMFS (National Marine Fisheries Service, US; Smulter et al., 2004). The main purpose of the study was to obtain seismic data to gather information on island arc movements and geometry.**

(1) *Observer requirement:* 3 trained MMOs (at least one on watch during operation and 2 MMOs during start-ups) with a watch not exceeding 4 hours; 2 PAMs

(2) *Observer certification:* Approved in advance by the National Marine Fisheries Service (NMFS); All biological observers must be provided with and use appropriate night-vision devices, Big Eyes, and reticulated and/or laser range finding binoculars.

(3) *Species of concern (including all marine fauna):* marine mammals & turtles

(4) *Size of the Mitigation/Exclusion Zone (EZ):* 3500 m in shallow water (<100 m depth), 1350 m in intermediate water depths (100–1000 m), and 900 m in deep water (>1000 m).

(5) *Required period of observation:* All daylight hours MMO, 24hr PAM

(6) *Pre-watch period:* 30 minutes

(7) *Soft-Start (SS) period:* A rate no greater than 6 dB per 5-minutes until operating levels are reached

(8) *Delay period of soft-start:* Until the EZ was free of marine mammals or sea turtles for at least 30 minutes.

(9) *Shut-down requirements:* Power-down (to one airgun out of total of 20) when marine mammals are in EZ; Shut-down when marine mammal within the area is injured or in a mortal state, or is indicating acute distress

(10) *Re-start after shut-down procedures:* Not proceed with powering up the seismic airgun array unless the EZ is visible and no marine mammals or sea turtles are detected within the appropriate safety zones; or until 15 minutes (for small odontocetes and pinnipeds) or a

minimum of 30 minutes (for mysticetes/ large odontocetes) after there has been no further visual detection of the animal(s) within the EZ and the trained MMO on duty is confident that no marine mammals or sea turtles remain within the appropriate EZ.

(11) *Seismic source and mitigation measures at night time:* Permitted with monitoring; Night-vision devices (NVDs) & PAM; Airguns will not start up at night after a shutdown. Crew on bridge must notify the MMO, who is on standby during night-time operations, in case a marine mammal or turtles is sighted within EZ.

Soft Start cannot be initiated at night from a power down of an airgun array involving greater than 6 guns if in shallow water (<100 m (328 ft)). In that situation, the EZ would extend too large from the ship to effectively monitor visually at night. In waters deeper than 100 m (328 ft) a SS can commence at night if the 180-dB radius is either visible or the passive sonar has not recorded any mammalian vocalizations during the entire period of the power-down

(12) *line-change & gun-test regulations:* Unknown

(13) *Allowable silent period:* 10 minutes (a SS will be required after a "no shooting" period lasting 10 minutes or longer)

(14) *Closed seismic zones or sensitive areas:* None

(15) *Reporting & Database requirements:* A draft report will be submitted to the National Marine Fisheries Service within 90 days after the end of the survey

(16) *Authority:* National Marine Fisheries Service (NMFS)

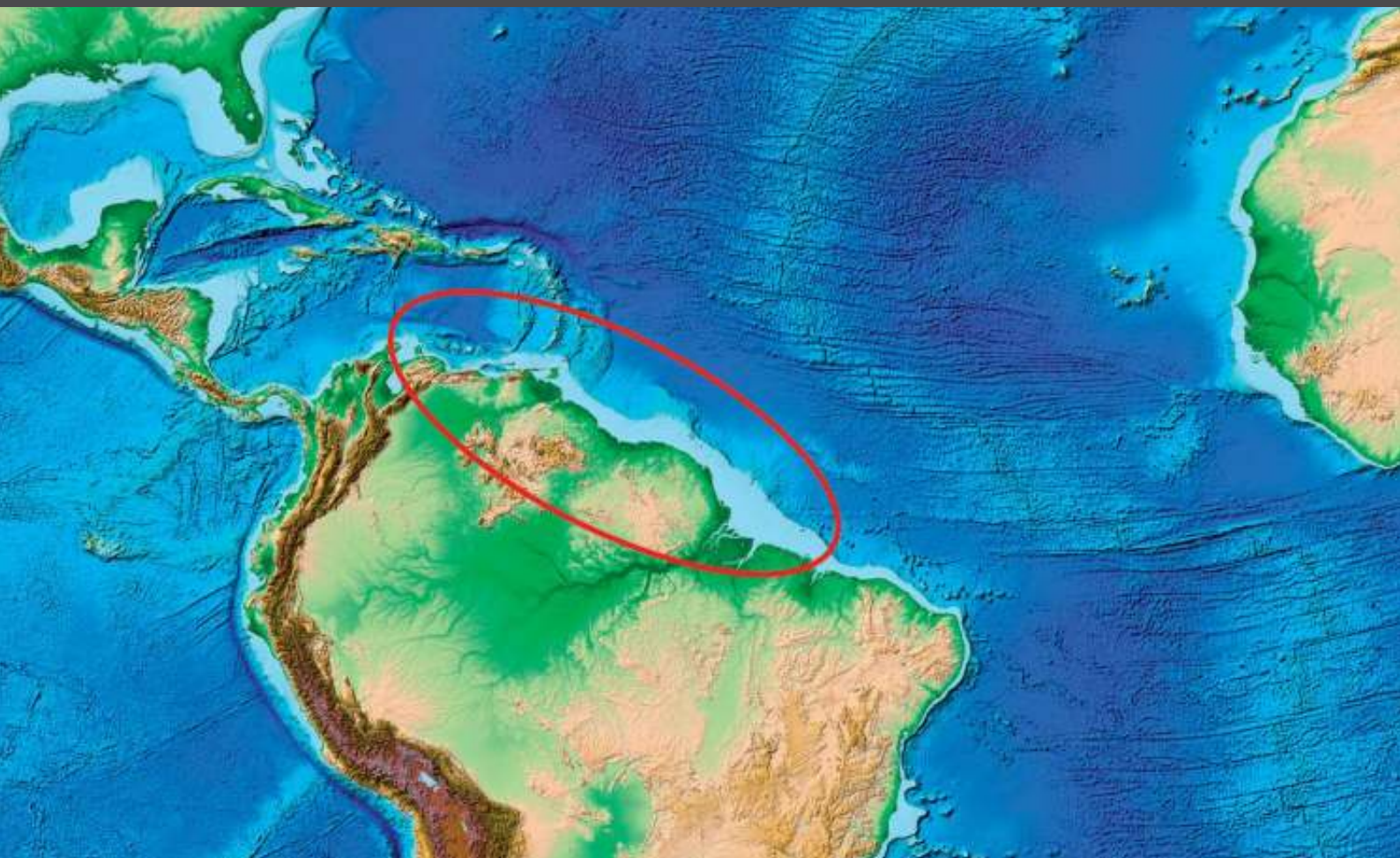
(17) *Planning stage:* Incidental Harassment Authorization by NMFS

(18) *Recommendations/other:* During the day, SS from a shut-down was only possible if the entire safety zone was visible (i.e., no fog and Beaufort Force <5).

Extra 2 MMOs on non-seismic vessel to document any potentially harmed or injured marine mammals or sea turtles in areas where the seismic survey vessel had been operating together with numbers and behaviour.

The EZs for marine mammals were defined at the 180 dB (re 1  $\mu$ Pa rms) isopleth that is based upon calibration measurements made for the airgun array in the Caribbean Sea and Atlantic Ocean.

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MaMa CoCo Sea Region