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RESEARCH ARTICLE

MITIGATION OF BIO-ACOUSTIC IMPACT ON CETACEANS DURING SEISMIC SURVEY IN NIGERIAN COASTAL WATERS

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ABSTRACT

The hydrocarbon rich Niger delta region of Nigeria is also home/breeding ground for some indigenous as well serve as calving grounds for some migratory marine mammal species. Exploration and production of this highly valuable resource often require seismic survey that generate sound that could negatively impact marine animals at close proximity. Hence, the need for a science based management to reduce risk of injury or fatality to these endangered species. This study aims at assessing and evaluating Scientific processes and procedure in place for minimising negative impact. Two Marine Mammal Observers (MMO) and One Passive Acoustic Monitoring (PAM) Operator undertook visual observations for marine mammals and turtles, and acoustic detections, in accordance with the JNCC (2017) and Department of Petroleum resources (DPR) guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys. Cumulative effort was 1298hrs 38mins. MMO observation hours totalled 696hrs 34mins. 49.31% of MMO observation effort took place while the source was active and 50.69% with the source inactive. The total number of airguns starts was 104 while seismic source was tested on 24 occasions each preceded with soft start. PAM detection effort totalled 602hrs 11mins. 56.22% of effort took place while the source was active and 43.78% with the source inactive. The total number of airguns starts was 120 while seismic source was tested on 32 occasions each preceded with soft start. Pre-shoot watches of 30 minutes were carried out in accordance with the mitigation guidelines preceding all soft starts. There were 11 marine mammal sightings and 14 acoustic detection of marine. No compliance issues. mitigation actions were taken twice to minimise risk of injury to animals.

INTRODUCTION

Offshore Exploration and production of oil and gas are indispensable for the energy required to drive the world economy. In order to exploit these resources, Seismic surveys are required. Despite the noise it introduces into the marine waters, it represents the best technology available for an accurate estimation of the quantity of hydrocarbon available for exploitation. Recent studies have documented that seismic sound emitted at a close range and of certain intensity is capable of temporarily impacting the auditory and physical health of marine mammals. Marine mammals constitute an invaluable component of the marine biota with great relevance because of the climate-regulating ecosystem services they provide, their cultural/recreational value and economic contribution to the lives of indigenous people (Guerra, 2019). However unmitigated ecosystem exploitation and unregulated anthropogenic activities had become a great concern to environmental right groups and scientists likewise because of the threats they pose to the lives of these animals. The emergence of environmental rights group had brought to the fore front the need for monitoring and mitigation.

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Harmful impact of anthropogenic noise to marine mammals is not in dispute but documented scientific information on the intensity and length of exposure that is deleterious is sparse. Despite the limited level of our current knowledge in this field, it is important to put in place mitigation measures that minimize the likely negative impact of noise pollution on these vital resources. Cetaceans are aquatic mammals that spend > 90% of their entire lives submerged below the water surface with their blow holes only above water for the purpose of breathing. This exposes them to natural and anthropogenic underwater noise all of the time because their ears are nearly always below the water surface (Angliss *et al*.,2006). Odontocetes (toothed whales) have developed specialized sense called echolocation that enable them to forage and gather information about their environment in turbid and deep water where no light penetrates (Robinson *et al*., 2007b). Cetacean are also known to use echo that is reflected back by the sound they send out to identify objects and their location. The differences in the returning echo provide the animal with information about the size, shape, orientation, direction, speed, and composition of the object or landscape (Madsen *et al*., 2004).Sound is used to communicate information about location and identity of individuals or groups, reproductive status, food sources, predation risk, and dominance.(Madsen *et*

al., 2005). For example, humpback whale males compete with other males through complex songs that can last for several hours, and females choose between males based on these vocalizations (Weir *et al*., 2007). Anthropogenic noise like those emitted by seismic guns have the possibility of negatively impacting the ability of cetaceans to communicate, navigate, and echolocate. Noise as a disturbance, if persistent and random is capable of reducing or out rightly obscuring the clarity of a signal (Dunlop *et al*., 2008 and 2016). The ocean is naturally noisy, but cetaceans are well adapted to these ambient noises. However, perception stimulus can be masked or blocked by the presence of another stimulus in the same range. Marine seismic surveys are some of the harshest anthropogenic noise cetaceans are subjected to (Gordon *et al*., 2003). Seismic surveys use reflected seismic waves to produce images of the Earth's subsurface(Gordon *et al*., 2003). The method requires a controlled seismic source of energy, such as dynamite or a specialized air gun. By noting the time, it takes for a reflection to arrive at a receiver, it is possible to estimate the depth of the feature that generated the reflection. In this way, reflection seismology is similar to echolocation (Richardson *et al*., 1995b). The reactions of cetaceans to seismic surveys have included surprise, fright, stress, and avoidance. Mysticeti and Odontocetes have also shown changes in behavior and vocalization patterns such as disruption of foraging, avoidance of particular areas, altered dive and respiratory patterns, and disruption of mating systems (Gordon *et al*., 2003). Past studies on the reactions of cetaceans to noise have shown widely divergent responses depending on the individual, age, sex, and theactivity in which the animals were engaged (Koblitz *et al*., 2012).

Developed economies, unlike their developing counterparts have well-articulated regulations in place to ensure minimal negative impact on the marine environment and safeguard the health of these marine dwellers. In contrast, most developing nations have little to non-existent regulatory framework that adequately mitigate emerging threat in their area of their jurisdiction within the maritime space. This may be attributable to dearth of information, expert and weak environmental regulatory institutions. Since marine mammals are not confined by national maritime borders there is a need for entrenched mitigation regulations in developing nations similar to what is obtainable in developed nations. This becomes more imperative in developing nations like Nigeria that are hydrocarbon rich and are host to International oil companies (IOC) that undertake intense oil exploitation. The Oil-rich southern region of Nigeria is home to some indigenous marine mammals and calving grounds to some migratory species. Olakunle and Anjuonu (2021), Protection for Nigerian cetaceans could be improved if internationally accepted guidelines and indigenous scientific knowledge is strictly applied in oil exploration activities of the oil rich regions which are also habitat to diverse cetacean species. This study aims at assessing and evaluating Scientific processes and procedure in place for minimising the negative impact of seismic survey in the study area.

MATERIALS AND METHODS

Study Area: The survey covers about 800 km2 located in the bight of Bonny (3°50' N & 70010' E to 4o50'N &800 40' E) in the oil rich south-south region of the Niger delta area of Nigeria. The Site is delineated OML (oil mining license). It consists of OML 67, 68, 69and 70 (Figure 3).

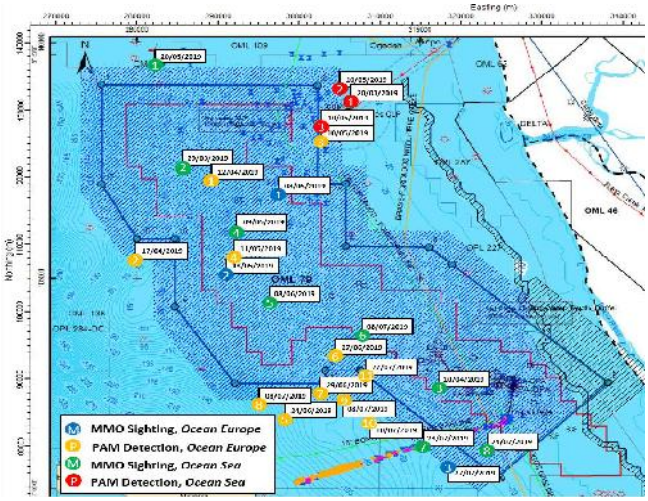

Fig 1. Survey area. With Spatial distribution of sightings and Detections of mammals

Survey Technique: Two experienced MMOs were stationed at the highest vantage points onboard the source vessel (14.5m a.w.1.), to collect data and enforce standard protocols in compliance with operational license obtained from DPR and apply JNCC regulations where the license terms are less explicit. The overall observation effort was 8,327 hours 36minutes accomplished over a of 26 months (Nov.2007-Dec.2009) covering 800km2. The presences of cetaceans were sought for before a survey line was started, and the start was delayed by at least 20 minutes if cetaceans are within 500 metres (mitigation zone). Data were collected throughout daylight hours. During marine mammal "search mode," the observers scanned 360º around the vessel with the naked eye and with binoculars. Scans focused on the area within 1 km of the air gun array (situated 180 or 340 m astern of the vessel) and on the 180º sector ahead of the ship in order to detect animals before they entered the 500 m exclusion zone around the air gun array. Photographs were taken at the maximum of individuals possible and dorsal fins for individual recognition and confirmation of group size with digital cameras equipped with 75-300 mm zoom lenses. Surveys were only undertaken in sea states of Beaufort wind scale of 4 or more nautical miles in visibility to ensure that few or no cetaceans present at the surface were missed. However, any cetaceans not at the surface were likely to be missed. Species were identified through Photo identification method which is the utilization of computer-assisted matching software for the identification of known species.

Hyot, (2018) thirty minutes Pre-Shooting Search within the mitigation zone precedes the start of shooting that is sequentially escalated referred to as Soft Start which must not be less than 15min but not more than 20 minutes. If no marine mammals have been spotted within the 500m mitigation zone the soft start may proceed. However, when animals are found within mitigation Zone, Soft start is delayed until 10 minutes after the animals have left the mitigation Zone. Any break in airguns activity during daylight hours or darkness exceeding 10 minutes requires another 20-minute ramp-up. If the break is for less than 10minutes and is during daylight hours then shooting can recommence without a ramp-up as long as the MMO/PAM operator is on watch and there are no marine mammals within the 500 m mitigation zone around the source arrays. The acoustic source was a towed source of 6 string arrays with a maximum operating volume of 5220 in^3.

The array comprised of 84 individual seismic elements ranging in volume from 60 to 220 in^3. The sub-array separation was 6 m, the source depth was 9 m and a shot point interval of 30 m was used.

RESULTS

The survey took place 20th of march to 27th of July, 2019 with a cumulative effort was 1298hrs 38mins (Fig 1). MMO observation hours totalled 696hrs 34mins. 49.31% of MMO observation effort took place while the source was active and 50.69% with the source inactive. The total number of airguns starts was 120 while seismic source was tested on 32 occasions each preceded with soft start. Pre-shoot watches of 30 minutes were carried out in accordance with the mitigation guidelines preceding all soft starts. PAM detection effort totalled 602hrs 11mins. 56.22% of effort took place while the source was active and 43.78% with the source inactive. There were 11 marine mammal sightings and 14 acoustic detection of marine. No compliance issues. mitigation actions were taken twice to minimise risk of injury to animals (Table 1)

Table 1. Effort, sightings, Detections, incidence and Non-compliance

Survey activities	Visual (MMO) Daylight/ Good Visibility	Acoustic (PAM) Night/ Poor Visibility
Overall Effort (Hours)	696:34	602:11
Effort with Guns (Hours)	330:06	338:49
Pre-Watch Periods (No.)	134	148
Sightings / Detections (No.)	4	4
Mitigation	2	0
Soft Start (No.)	104	120
Gun Tests (No.) Non-compliance Distressed animal	24 0 1	32 0 0

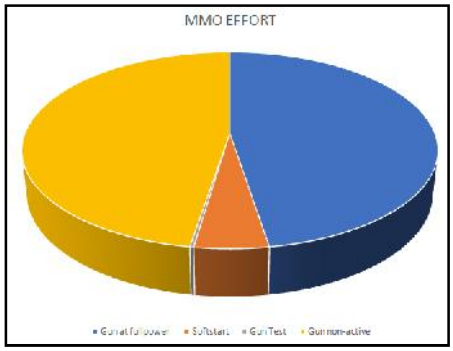

Figure 2. Distribution of MMO Efforts

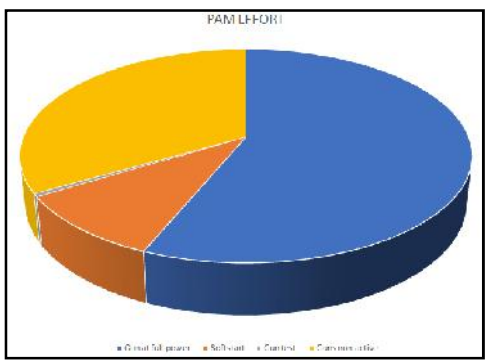

Figure 3. Distribution of PAM efforts

Table 2. Sightings

SPECIES	NUMBER	PERCENTILE
Bottlenose dolphins (Tursiops truncatus)	63	21.36%
common dolphins (Delphinus delphis)	72	24.41%
Long-beaked Com dolphins (Delphinus capensis)	57	19.32%
Dolphins- sousa teuszii	23	7.80%
Humpback whale (Megaptera novaeangliae)	13	4.40%
Sea Turtle (Lepidochelys olivacea)	1	0.33%
Unidentified whale	66	22.37
Total	295	100

DISCUSSION

Noise pollution unlike other forms are diffused and may take a longer time to become adequately observable. Nevertheless, past studies have recorded the negative impact of along-time exposure on feeding and fecundity. In the course of this study, few animals have shown behaviours that might be attributed to irritation traceable to noise or disturbance at a close proximity. The resultant impact of seismic noise on marine mammal had primarily revolved around the source vessels that carry the arrays of guns from where the sound is generated. Overall, the research into effects of seismic exploration on marine mammals is difficult and challenging. It involves several very different fields of science, from animal behaviour and physiology to airgun design, geophysics and visuals. Individually, these fields are complex and interactions between them even more so (Trocha *et al*., 2018; Marshake *et al*. 2017).

Mitigation measures carried out during the survey were in adherence with the guidelines of The Department of Petroleum Resources (DPR) stipulated in the consent license section relevant to the prevention of injury to marine mammals and sea turtles. There were three instances when mitigation actions were taken viz- softstart delay for 25 minutes to allow the exit of two juvenile humpback whales (*Megaptera noveangleae)* and 47 minutes for a school of 57 individual dolphins (*Delphinus capensis*) to exit the mitigation zone. The third instance required a slight alteration of the course of the vessel. A pilot whale (*Globicephala macrorhynchus*) entered into the mitigation zone while the guns were active. Though JNCC rules does not require a work stoppage, the vessel was advised to slightly alter her course because the animals manifested some sign of distress in form of irritation which might not necessarily be attributable to the seismic operation.Considering the fact that the survey location has a dense traffic concentration of supply vessels, security vessels and fishing boats, the cause of the observed distress in a single animal could not be attributed to the seismic operation only. Nevertheless, the onus was with the environmental regulators (MMO &PAM) responsible for the activity to assess and offer advice in accordance to stipulated guidelines. Daily, weekly and monthly report writing and submission helped in correcting operational infractions within a short time frame. Guidance on minimalising risk to animals was clearly communicated through tool Box meetings of various team leaders.

Conclusion

Marine mammal Protection has become a global area of discuss among climate change expert, this notwithstanding

knowledge in this field among African scientist has been lagging. For Nigeria to contribute her quota in the conservation of this invaluable resource, internationally accepted guidelines and indigenous scientifically drafted guidelines need to become an integral part of enforceable regulation for oil exploration activities of the oil rich regions which are also habitat to diverse cetacean species. A well-managed marine ecosystem in the south-south region of Nigeria will douse tension and promote peace between the international oil companies (IOC) and their host communities. We therefore recommend a continual fine tuning of the rudimentary regulatory framework available in a way that marries our local peculiarities with best international practices.

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