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RESEARCH ARTICLE

COMPARATIVE ASSESSMENT OF VISUAL AND PASSIVE ACOUSTIC DETECTION OF CETACEANS IN A 4-D SEISMIC OPERATION, AGBAMI, SOUTH-SOUTH OF NIGERIA

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ABSTRACT

The detection result of acoustic monitoring was compared to visual observations in a 4-D seismic survey. Data was collected on board The MV Osprey Explorer (Seabird)cruising at the speed of 4.6 ±4 nautical miles. Dedicated Marine Mammal Observers (MMO) and Passive Acoustic Monitoring (PAM) Operators undertook visual observations for marine mammals and turtles, and acoustic observations for marine mammals respectively for a period of seventy (75) days.441 hours 29 minutes of visual watches and 433 hours 36 minutes of acoustic detection effort was logged by MMOs and PAMs respectively, covering approximately 583km^2 in water depths ranging from 1200 m to 2000 m. 28 sightings of 58individual whales and dolphins were recorded by MMOs, while PAMs had 53 detections. Cetaceans recorded are *Megaptera novaeangliae* (the humpback whale), psueudo *rcinus orca* (false killer whales), *Globicephalamacrorhynchus* (short-finned pilot whale) *Tursiops truncatus* (Bottlenose dolphin), *Delphinus delphis* (Common dolphin), *Sousa teuszii* (Atlantic hump-backed dolphin), *Stenella attenata* (Stenella attenuate), some unidentified delpninids and the Green turtle (*Chelonia mydas*). While there were similarities in the detections by both methods there were also some noticeable contrast. There was no significant difference in the detection rate of animals.(p=0.05). However, there is a significant difference between the number of whales detected acoustically (p=0.05,) compared to those detected visually. These differences are likely, because most large whales often spend a greater part of their time under water and may exhibit avoidance behavior. The result demonstrates how the strengths and weaknesses of these two approaches complement each other.

INTRODUCTION

Global concern about emerging threat to the health of the planet earth, had given birth to many environmental movements some of which have principally focused on the health of the oceans and it resources. The extractive oil and gas industry often requires the use of seismic technology to accurately estimate the amount of hydrocarbon present below the seabed. The noise emitted by seismic guns have the potential to negatively impact the ability of cetations to forage or navigate (Weilggart, 2007; Slabberkooet *et al*., 2018). These concerns for the health of marine lives especially cetaceans and sea turtles have brought to the fore the need to regulate and mitigate where necessary the unbridled misuse of the global environment by man for the sustainance of the ecosystem services that these animals offer. Cetaceans spend their entire lives in the water and most of the times (>90% for most species) entirely submerged below the surface , when at surface, cetaceans bodies are almost entirely below the water surface, with only the blowhole exposed to allow breathing. This makes cetaceans more difficult to locate visually and exposes them to underwater noise both natural and anthropogenic essentially 100% of the time because their auditory organs are submerged in water (Angliss *et al*., 2006). Scientific census of cetaceans is often carried out through visual observation often aided with digital cameras and binoculars onboard marine vessels and aircrafts in expansive water bodies (Barlow *et al*., 1995). However, with the advancement of science and technology, there is the integration of visual and passive acoustic monitoring method which deploys an array of hydrophone. This has greatly reduced error margins in the estimation of cetacean population. (Sease and Loughlin, 1999).Some cetaceans species of toothed whales inhabit turbid or sometimes deep waters where there is lttle or no light penetration. The need to navigate, forage and garther information from the environment had given rise to the evolution of a specialized sense called echolocation in some species of ondontecetes (Robinson *et al*., 2007; Dunlop *et al*., 2008). These animals send out a sound into the water and then use the returning echo to identify the objects that have reflected the sound. The animal is able to decifer information about the size, shape, orientation, direction, speed, and composition of the object or landscape fom the various echo received. (Madsen *et al*., 2004; Dunlop *et al*., 2016).The Knowledge of this principle was exploited by science to develop passive acoustic monitoring (PAM) equipment which has greatly assisted scientist in the estimation of cetacean population especially in the night and during inclement

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weather situations. Passive acoustic monitoring using vessel deployed hydrophones was used to detect and track fin whales (Balaenoptera physalus) in the north atlantic sea (Moore *et al*. 1999). Shore-based visual census of the Bering chukchi-Beaufort stock of bowhead whales (*Baena mysticetus*) was augmented using passive acoustic method (Braham *et al*., 1980).

MATERIALS AND METHOD

Study Area

Fig 1. Study site

METHODOLOGY

Marine Mammal Observer (MMO) carried out dedicated watches for marine animals during daylight hours (06:00 to 18:00 UTC).Sightings of marine mammals were recorded in the Marine Mammal Sighting form. All marine mammal data were recorded on the standard record of JNCC marine mammal sightings spreadsheet; this include corresponding regulatory reference number, date, time, detection, type, position, depth, species, bearing to mammal, range to mammal, total number of individuals, presence of calves, behaviour of mammal, final direction of travel, air-gun source activity, exclusion zone entrance, time of closest approach, and action taken if any required including power down and/or loss of production was recorded. Photographs were taken at the maximum of individuals possible and dorsal fins for individual recognition and confirmation of group size and group composition, 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. Once specie was sighted an observer would use them to quantify group numbers, a strategy which allows more accurate species identification and note behaviors. Ranges were determined using a calibrated range finding ruler/stick (using the Heinemann Equation) and/or by using known distances as calibrations (Hadoran and Brett, 2014).

Passive Acoustic Monitoring (PAM) duties were carried out by the PAM operators located in the instrument room. PAM analysed the LF (low frequency), MF (medium frequency) and HF (high frequency) system visually while listening to the aural MF output through the headphones. Vessel position, vessel speed and air gun activity were recorded at regular intervals or whenever a change in activity occurred. Hydrophone depth information was available from the depth sensor.

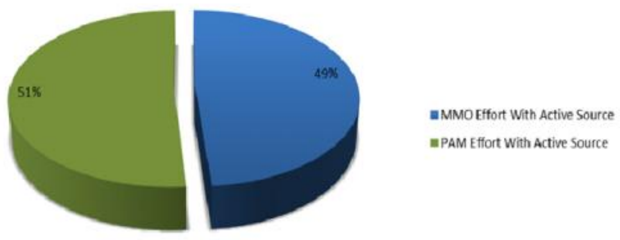

Figure 3. Activity During PAM Effort

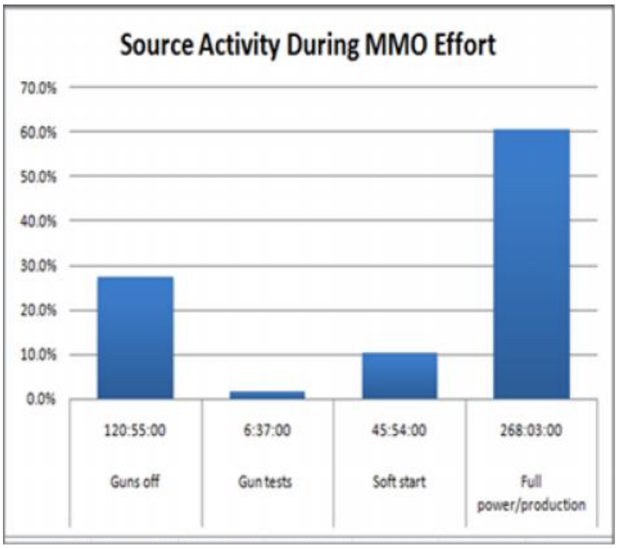

Figure 4. Distribution of PAM & MMO Effort with active source

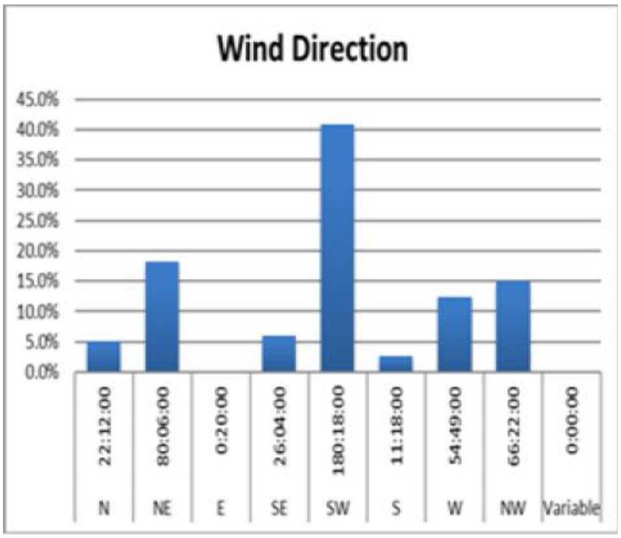

Fig. 5. Wind Direction

The navigation information was acquired from the instrument room in which the PAM operator is situated. LF and HF Click Detectors on the PAM system were monitored for indications of echolocation clicks from odontocetes (e.g. dolphin species, pilot whales, false killer whales). The amplitude range and appearance were adjusted as needed to maximize the vocalizations appearance above the pictured background noise. Two spectrograms displays were used to monitor for baleen whales at low frequency ranges (0-480 Hz spectrogram) as well as a (0-3000 Hz spectrogram) with Baleen Moan Detectors utilised. Other spectrograms were used to monitor for Odontocetes and delphinids at mid frequency (MF) ranges with Whistle and Moan Detectors utilised to indicate any

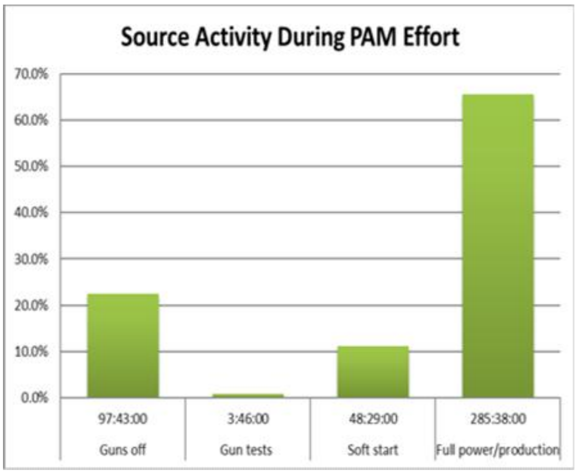

Fig 6. Wind force

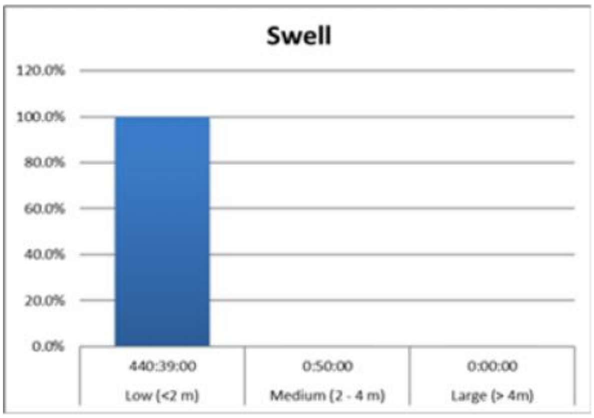

Fig 7. Sea State

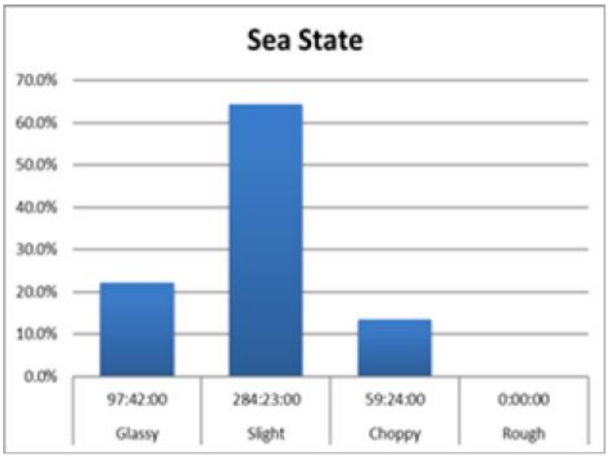

Fig 8. Sea swell

acoustic activity within the frequency ranges 0-24 KHz. A mid frequency (0-24 kHz) and high frequency (0-200 kHz) sound recorder allowed the operator to make recording of the various detections. A database interface was included in the model to receive outputs from the detector modules, GPS data, user input on PAM effort and detections, and information on Pam Guard's configuration settings and status. The GPS map display plotted the vessel's track, the location of animal detections, and showed the 500 m marine mammal exclusion zone around the vessel and a projection for 20 minutes ahead of the ship. Bearing lines to marine mammal detections could also be displayed on the map.

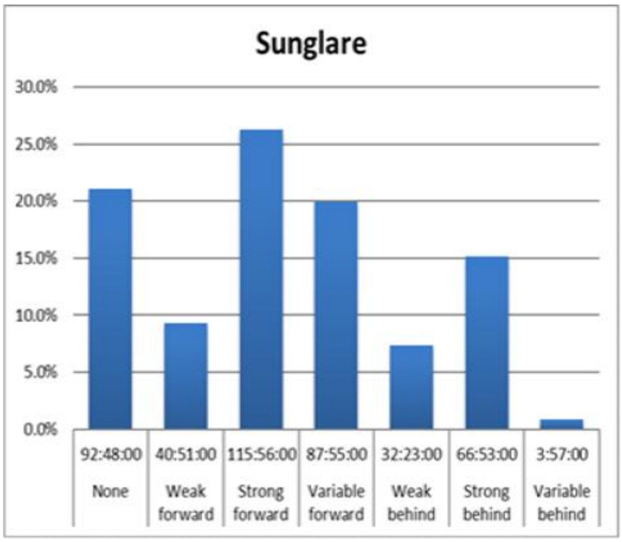

Figure 9. Visibility

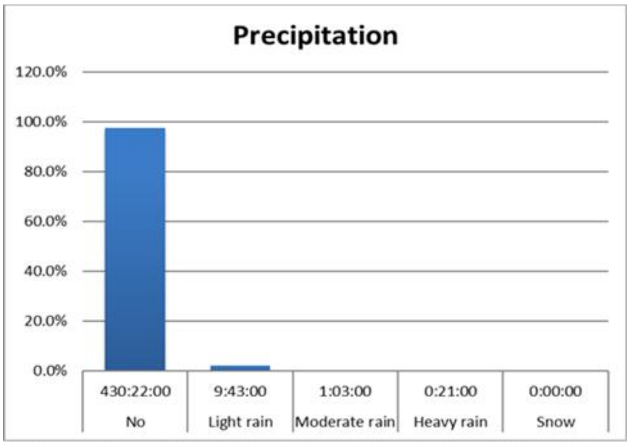

Figure 11. Precipitation

Adobe Audition was used for post analysis of the recorded detections, to obtain a higher resolution screen grab of the various detections as well as analyse the detection for details that are unobtainable in the pamguard real-time display. The PAM operator completed standardised JNCC recording forms throughout the survey (JNCC, 2017).

RESULTS

Surveys took place during 75 consecutive days over a period of four months, with visual observation from 06:00 t0 18:00 UTC and acoustic monitoring between 18:00 UTC to 06:00 UTC. Four hundred and fourty-one hour, twenty-nine minutes (441hr,29 min.) of visual observation were logged, out of which guns were active for 320hrs,34 min. (72.59%) and non-active for 120 hrs 55 min. (27.41 %), while passive acoustic monitoring logged four hundred and thirty-five hours, thirty-six minutes (435hrs,36 min). Seismic guns were active for 317 hrs, 13 min.(72.84%) and non-active for 118 hrs 23 min. representing 27.16 %.(Fig 2&3). Throughout the survey period Visibility was good, sungl are was high, beau fort scale was often less than 4 and precipitation was very low.(Fig 5,6,7,8,9,10 &11). Twenty-eight (28) sightings of 58 individual whales and dolphins were recorded by MMOs, while PAMs had 53 detections. Cetaceans recorded are *Megaptera novaeangliae* (the humpback whale), psuedo *cinus orca* (false killer whales), *Globicephala macrorhynchus*

Table 1. MMO Sightiings relative to source activity

Species	Full Power	Soft Start	Gun Tests	Not Active	Total Sightings
Common Dolphins (*Delphinus Delphis*)	3	2	-	-	5
Bottlenose Dolphin (*Tursiops truncatus*)	2	1	-	-	3
False Killer Whale *(Pseudorca crassidens)*	1	-	-	-	1
Short -Finned Pilot Whale *(Globicephala macrorhynchus)*	1	-	-	1	2
Humpback Whale *(Megaptera novaeangliae)*	1	-	-	-	1
Unidentified Delphinid	4	2	-	4	10
Unidentified Baleen Whale	4	-	-	-	4
Green Turtle *(Chelonia mydas)*	1	-	-	-	1
Unidentified Turtle Species	-	1	-	-	1

Table 2. PAM Detections Relative to source activity

Species	Full Power	Soft Start	Gun Tests	Not Active	Total Detections
Common Dolphins (*Delphinus Delphis*)	-	1	-	-	1
Bottlenose Dolphin (*Tursiopstruncatus*)	1	-	-	-	1
Possible Short-finned Pilot Whale (*Globicephalamacrorhynchus*)	1	-	-	-	1
Unidentifiable Delphinid	34	4	-	9	47
Unidentifiable Odontocete	2	-	-	1	3

(short-finned pilot whale) *Tursiops truncatus* (Bottlenose dolphin), *Delphinus delphis* (Common dolphin), *Sousa teuszii* (Atlantic hump-backed dolphin), *Stenella attenata* (Stenella attenuate), some unidentified delpninids and the Green turtle (*Chelonia mydas*).(Tables 1&2)

DISCUSSION

The study area has been the subject of considerable oil and gas activities for many years, and the area is also of great importance for a number of cetacean species (Olakunle and Myade, 2014). The survey was designed to detect the presence of cetaceans and sea turtles within the radius of 500m from the seismic gun (mitigation zone) and take appropriate action to mitigate against probable harm to the animals. However opportunistic data were taken to provide information on occurrence and species diversity of cetaceans within the surveyed area and also compare data obtained from visual and passive acoustic detections. Fifty-eight (58) individual cetaceans detected visually were insignificantly different from those detected acoustically (p=.05). This is attributable to high sunglare (Fig.10), the non-prevalence of strong trade winds (Fig.7) and low precipitation (fig.11), which consequently gave good visibility throughout the survey period (December to march). However there is a significant difference between the number of whales detected acoustically (p=0.05,) compared to those detected visually. This is likely, because most large whales often spend a greater part of their time under water and are most likely to avoid areas of noticeable human activity like seismic operations. The survey gave an opportunity to compare the visual side by side with the acoustic detection method. The result obtained corroborates the postulation of some earlier researchers who advocated the employment of the two methods complementarily to each other. This will invariably support the effort of environmentalist at promoting and protecting this group of animals especially during oil exploration activities, when poor visibility may not allow visual detection by marine mammal observers.

Conclusion

A successful use of passive acoustic method for detection, identification and population estimation of cetacean require a good knowledge of acoustics and statistics, hence there is a need to give indigenous scientists trainings that are interdisciplinary which will integrate Biology, Acoustics and Statistics. Because large whales spend a greater part of their time underwater and out of view and depend to a large extent on acoustic modality for their survival, we suggest the development of passive acoustic monitoring technique as a complimentary tool to visual monitoring, especially during oil exploration in Nigeria.

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