



## The Impacts of Seismic Activities on Marine Life and its Environment

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### ABSTRACT

*Oil Exploration and drilling, a leading factor of seismic blasting occurs in a number of forms. Seismic blasting include among others; seismic exploration, laying of pipes and cables, creating underwater tunnels for mining and other geological purposes. During the blasting process several sources having different energy levels and frequency characteristics are used in land and Marine reflection surveys. The common types include explosives, vibroseis, airgun, watergun, boomers, sparkers etc. In the Niger delta region of Nigeria, seismic activities for oil and gas production and transportation is daily taking place. This activity has posed marine and sea floor hazards on the immediate environment. Also these blasting activities has adverse effects on man, water quality, marine animals, marine birds, aquatic plants, fish, marine mammals and the entire marine environment. Crops and vegetation around the marine environment cannot thrive well due to the exploration impact, invasion of oil/spill, gas flare, hydrocarbons and metals. These work discusses the effects of seismic activities on its immediate environment and the mitigation measures that can be taken to reduce this hazardous trend.*

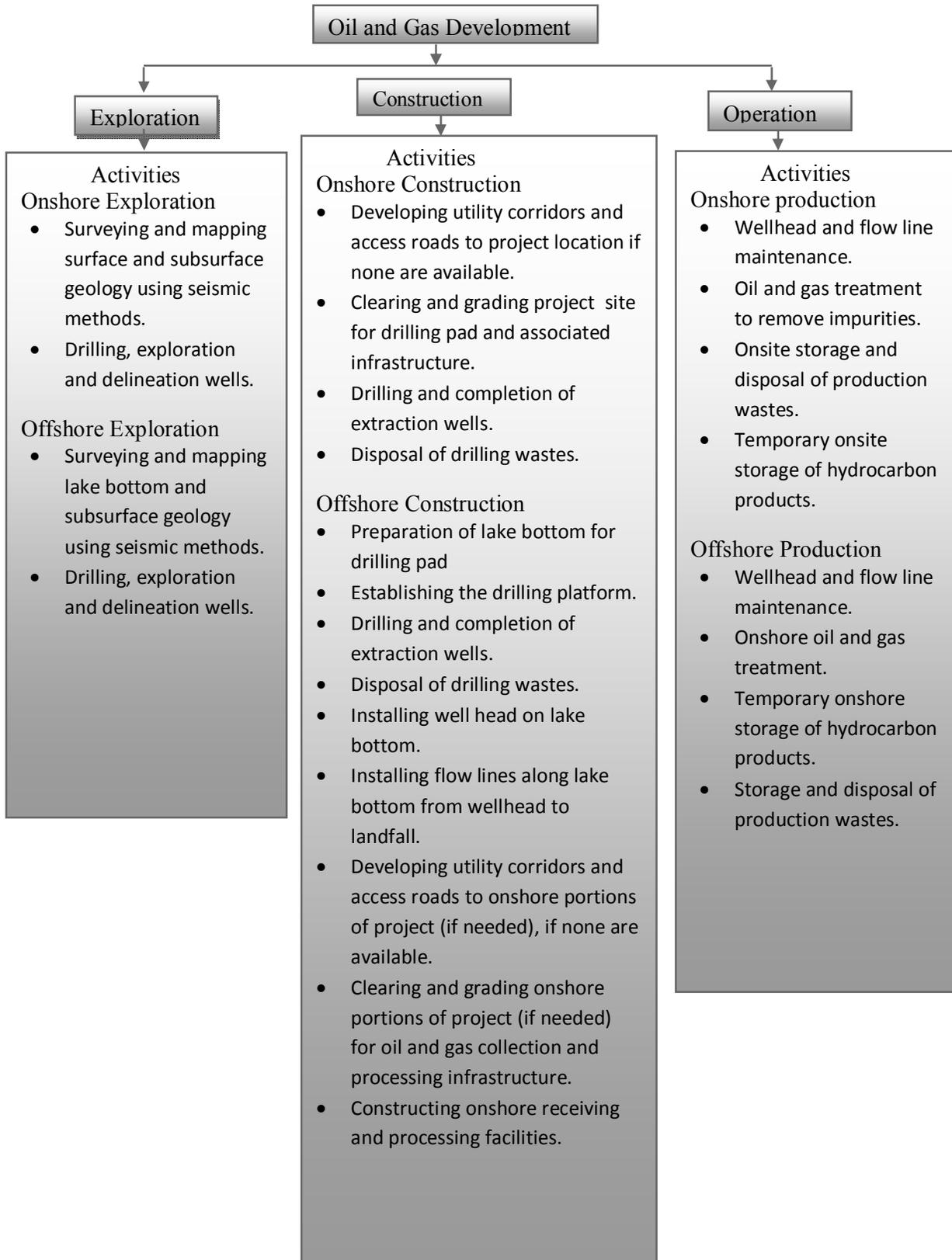
**KEYWORDS:** Oil Exploration, Seismic Blasting, Sea floor Hazard, Marine Environment, Mitigation, Hazardous Trends.

### INTRODUCTION

Seismic surveys are used by the onshore/offshore oil and gas industry to help determine the location of oil and gas deposits beneath the seafloor. Land-based seismic surveys are typically conducted in winter and use two ground pressure tracked vehicles or use helicopters in remote operations. The method involves sending energy into the earth using an explosive charge or other energy wave-generating device such as vibroseis.

These surveys utilize large, specialized ship which tows an array of powerful air guns to generate sound wave by firing off explosive blast of air directly at the sea floor. Depending on density, wave bounces back from the various rock layers and are received by listening devices called geophones. Impulses are recorded on computer tape, processed on high speed computers, and displayed in the form of a seismic reflection profile. In another method, explosives are lowered into drill holes and detonated, or they may be suspended in stakes above the ground (Poulter method). The drill holes are drilled either with track-mounted drills or with drills slung into position by helicopters. For 3-D seismic operations, holes are drilled typically 25 feet deep with 5 pounds of explosive set at the base of the hole. Geophysicists then analyze the profile. Exploration of offshore areas is more difficult since scientists cannot explore the sea bottom in person. They must use a variety of means to gather the necessary information about the area of interest. Side-scan Sonar fathometer recordings, shallow coring programs and geophysical surveys are tools often used in marine exploration programs. Offshore seismic surveys are typically conducted with the use of air guns to produce the energy impulse. Shore-based helicopters, which can land on the vessel's helideck, resupply the operation and transfer crew when necessary. Marine seismic equipment consists of a sound source (air gun array), sound detectors (hydrophones), amplifiers and recording system and a navigation system. An airgun array is towed directly behind the ship at a depth of 30 to 40 ft. the airgun array consist of several sub arrays, each of which consist of several airguns of various sizes. Hydrophones are pressure detectors housed in a long streamer cable (up to 2 miles) which is towed behind the ship at depths between 20 and 40 feet. For some seismic surveys, the detectors and cables are placed directly on the bottom where they remain stationary as the shooting boat traverses across them. A typical seismic survey last

2-3 weeks and covers a range of about 300-600 miles. The intensity of sound waves produced by firing of seismic airguns can reach up to 250 decibels (dB) and can be as high as 117 dB over 20 miles away.



The sound intensity produced by a jackhammer is around 120dB, which can damage human ears in as little as 15 seconds. Exploration activities may include the following: examination of the surface geology, geophysical survey programs, researching data from existing wells or drilling and exploratory well. It is important to remember also that it is not only oil exploration and drilling that is a leading factor of seismic blasting (activities); but it occurs in a number of forms; for example, seismic blasting can include laying pipelines and cables, creating underwater tunnels for mining or other geophysical purposes. Others are onshore and offshore construction, production storage and disposal of production waste, maintenance and transportation.

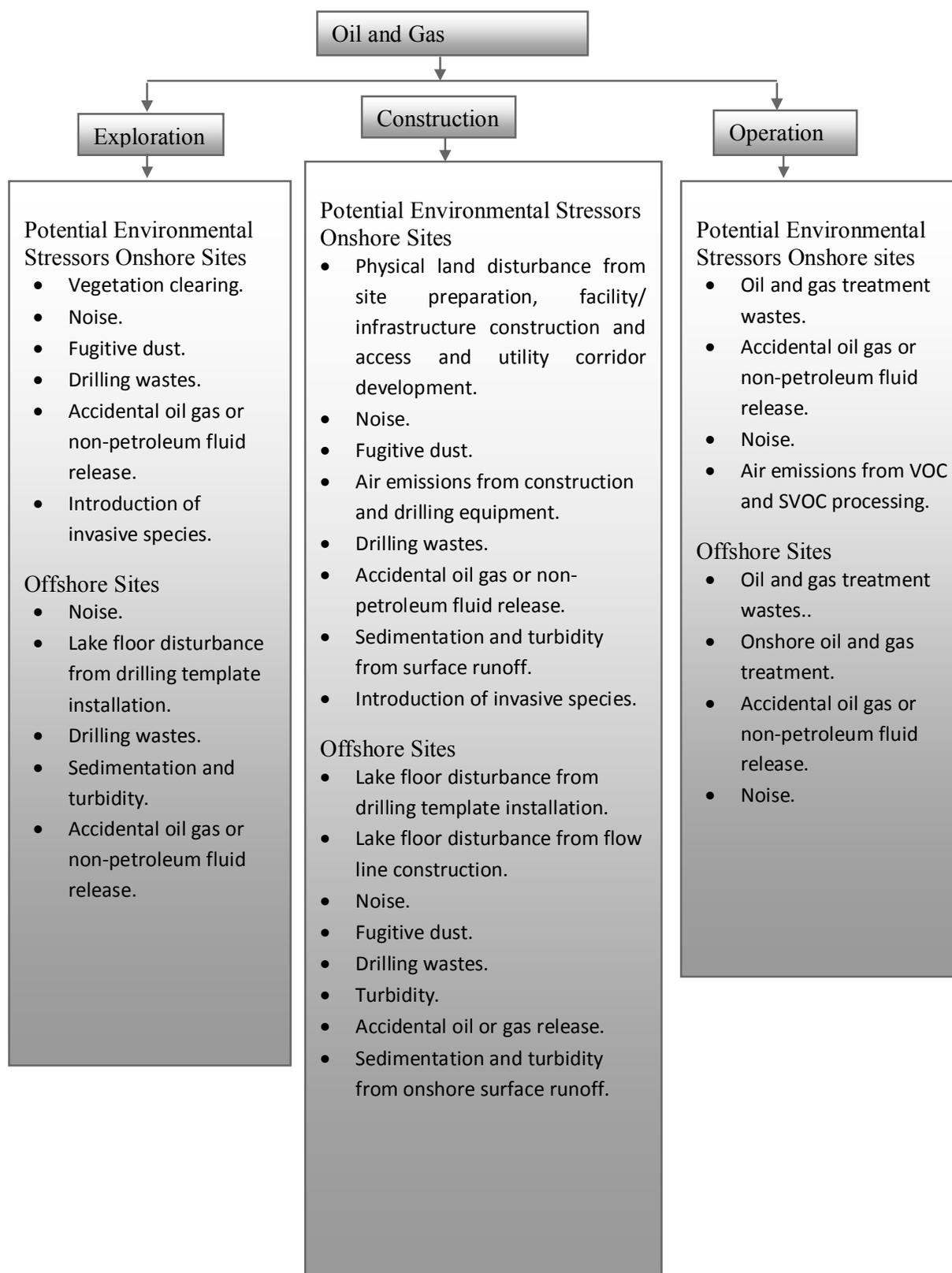
In the Niger delta region of Nigeria, oil and gas exploration, development, production and transportation is daily taking place. These activities have posed marine and seafloor hazards on the environment.

The table below fig. (1) and (2) highlights activities associated with different aspects of oil and gas development. Marine birds These activities has an adverse effect posed environment stressors that has adversely affected water quality, marine animals, aquatic plants, fish, marine mammals and the entire marine environment. Crops planted around the marine environment cannot thrive well as a result of the invasion of oil, hydrocarbons and metals.

Fig. (2) Highlights environmental impacts potentially associated with different aspects of oil and gas development.

### LITERATURE REVIEW

Potential impact on marine life and its environment in the exploration phase include degradation of stream banks and other wintering areas at stream crossings. Potential impact in later phase includes habitat loss due to gravel removed and facility citing, and fish are killed due to oil spills and seismic activities [1]. On shore seismic operation could cause direct injury to fish resource in the lakes and streams [2]. Pressure waves from high explosion such as ammonium nitrate will kill and injure fish, near the explosive site [3]. Over pressure of 30-40 psi will kill fish with swim bladders, and 3-4 psi will kill juvenile salmononids. Shock wave from explosion can also shock and destroy fish eggs at sensitive stage of development [2,4]. It has been noted that "seismic blasting is highly intrusive and damages and kills fish, whales and other marine life in close proximity to the guns." At greater distance, it can cause disorientation and interfere with communication. Unlike humans and other terrestrial animals, marine mammals rely on sound instead of sight as their primary sense. Dolphins, whales and seals utilize their sense of hearing to locate prey, avoid predators, and choose migration routes and to communicate across long distances. The noise associated with seismic survey can affect the ability of these animals to detect natural underwater sound, thereby disrupting these critical activities [5]. Noise and disturbance that may affect marine and costal birds include geophysical survey (air guns, and surface explosion), construction, support vessels, aircraft over flights, drilling and production. The intrusion into colonies of sea birds can result in reduced productive success. Egg hatchings and fledgling are particularly vulnerable to seismic activities which may result in loss of eggs or young, dispersion from the nest site or rookery, and disruption of vital parent-offspring bonds [6]. The types of discharge resulting from oil and gas activities include oil spills, drilling mud's, cuttings and formation waters. Potential effects that may alter surface water quality parameters includes seismic activities, lubricants or chemicals, increase in erosion and sedimentation causing elevated turbidity and suspended solid connection. Industrial activities may affect water quality characteristics including pH, magnesium, sodium, iron, nitrates, chlorine and fluoride [7]. Researchers have lately been interested in the question on how vessels impact affects marine animals and other habitat. The use of acoustic deterrence devices over the years has increased and many fear that there is a danger that these devices are being over used and driving marine animals away from nature habitat thus increase the risk of low birth numbers and general species decline. [8]. Man made ocean noise has undisputedly increased in the last century. Like many other forms of pollution, acoustic pollution has the capability of causing real harm to our marine mammals and other forms of marine life. In the Niger Delta region of Nigeria where oil exploration and production is a daily routine, two major forms of discharge from seismic activities possed devastating consequences to marine life and its environment. These include oil spills and gas flaring.



### **GAS FLARING**

Gas flaring refers to the burning of natural gas that is associated with crude oil when it is pumped up from the ground. A gas flare; alternatively known as a flare stack, is an elevated vertical conveyance found accompanying the presence of oil wells, gas wells, rigs, refineries, chemical plants, natural gas

plants and landfills. Gas flares are created when oil companies burn off extra gas that escapes as a result of oil drilling. Gas flaring not only wastes a potentially valuable source of energy (natural gas), it also adds significant carbon emissions to the atmosphere. Moreover, flaring combustion is typically incomplete, releasing substantial amount of soot and carbon mono oxide, which contributes to air pollution problems.

Gas flares have potentially harmful effects on the health and livelihood of the communities in their vicinity as they release a variety of poisonous chemicals including nitrogen dioxide, sulphur dioxide, volatile organic compounds like benzene, toluene, xylene and hydrogen sulphide, as well as carcinogens like benzopyrene and dioxin. Humans exposed to such substances can suffer from a variety of respiratory problems. These chemicals can aggravate asthma, causes breathing difficulty and pain as well as chronic bronchitis. Benzene known to be emitted from gas flares in undocumented quantities is well recognized as a cause for leukemia and other blood-related diseases.

Gas flares are often located close to local communities, and regularly lack adequate fencing and protection for villagers who may risk working near heat of the flare. Many of these communities claim that nearby flares cause acid rain which corrodes their homes and other local structures, many of which have zinc-based roofing. Nigeria currently flares 75% of the gas it produces. The other discharge is oil spills.

The Department of Petroleum Resources estimated 1.89 million barrels of petroleum were spilled into the Niger Delta between 1976 and 1996 out of a total of 2.4 million barrels spilled in 4,835 incidents. A UNDP report states that there has been a total of 6,817 oil spills between 1976 and 2001. In 2010 Baird reported that between 9 million and 13 million barrels have been spilled in the Niger Delta since 1958.

### **OIL SPILL**

Oil spills are a common event in Nigeria and occur due to a number of causes including: corrosion of pipelines and tankers (accounting for 50% of all spills), sabotage (28%), and oil production operations (21%), with 1% of the spills being accounted for by inadequate or non-functional production equipment. The largest contributor to the oil spill total, corrosion of pipes and tanks, is the rupturing or leaking of production infrastructures that are described as 'very old and lack regular inspection and maintenance'.

A reason that corrosion accounts for such a high percentage of all spills is that as a result of the small size of the oil fields in the Niger Delta, there is an extensive network of pipelines between the fields, as well as numerous small networks of flow lines. The narrow diameter pipes that carry it from well heads to flow stations allowing many opportunities for leaks. In onshore areas most pipelines and flow lines are laid above the ground. Pipelines which have an estimate life span of about fifteen years are old and susceptible to corrosion.

Sabotage (bunkering) and theft though oil siphoning has become a major issue in the Niger Delta States as well, contributing to further environmental degradation. Oil spillage has a major impact on the ecosystem into which it is released. An estimated 5 to 10% of Nigerian mangrove ecosystem has been wiped out either by settlement or oil. Spills in populated areas often spread out over a wide area, destroying crops and aquatic cultures through contamination of the ground water and soils. The consumption of dissolved oxygen by bacteria feeding in the spilled hydrogen also contributes to the death of fish.

The loss of mangrove forest is not only degrading life for plants and animals, but for humans as well. These systems are highly valued by the indigenous people living in the affected areas. Mangrove forests have been a major source of wood for local people. They also are important to variety of species vital to subsistence practices for local indigenous groups, who unfortunately see little to non of the economic benefits of petroleum. Mangroves also provide essential habitat for rare an endangered species like the manatee and pygmy hippopotamus.

Also people in the affected areas complain about health, including breathing problems and skin lesions, many have lost basic human right such as health, access to food, clean water and an ability to work. The Niger Delta is an important ecosystem that needs to be protected, for it is a home to 36 families and merely 250 species of fish, of which 20 are endemic, meaning that they are found

nowhere else on earth. Fish populations are declining as they are being depleted faster by blasting activities.

Ocean noise pollution is also exacerbated by drilling, construction, offshore oil and gas production rigs, underwater explosions to test ship strength and acoustic deterrent and harassment devices. The cumulative effects of these multiple sources of ocean noise pollution on marine mammals are unknown. There has been limited scientific work to establish exactly how much man-made ocean noise has increased in recent times. But what evidence there is, gives cause for concern. One study indicates that levels of man-made noise have doubled in each of the past decades. The study in question, at a site in the Pacific off the southern California coast, found a low frequency noise increasing totaling 10-12dB over those decades [16]. One study showed that airgun activity contributes significantly to ocean sounds propagated deep into the Atlantic were detected more than 3,000km from their sources.

This work will attempt to address the effect of oil and gas exploration, development, production and air transportation on marine life and its immediate environment in a typical oil producing area like Niger delta of Nigeria. The mitigation measures that can be taken to reduce this hazardous trend are also considered.

### SEISMICS

When the earth is quake, the elastic energy is released and sends out vibrations that travel throughout the Earth. These vibrations are called Seismic waves. The study of how seismic waves behave on the Earth is called Seismology. Waves generated during Seismic blasting are called Seismic waves.

Seismic studies is the study of the earth rocks/and the study of elastic properties of the rocks. Seismic studies involved essentially the generation of waves and their propagation. The movement of the waves always timed to obtain velocity of the waves.

There are majorly two types of seismic waves: body waves and surface waves. Body waves can be propagated inside a material whereas surface can be propagated along an interface. There are two types of body waves; compressed and shear waves. The velocity of P and S waves are given in the following expressions

$$V_p = \sqrt{\frac{4}{3} \frac{\mu + k}{\rho}} \quad (1)$$

$$V_s = \sqrt{\frac{\mu}{\rho}} \quad (2)$$

K = bulk modulus,  $\mu$  = poisson Ratio,  $\rho$  = density. Surface waves consist of love and Raleigh waves. Methods of generating Seismic waves which include the use of explosives, vibroseis etc had major disadvantages. It kills sea lives, creates noise and damage the environment at the immediate vicinity.

### RESULT AND DISCUSSION

Primary effect that may impact on marine life and the environment include drilling and production discharges, seismic activities, gas blowouts, oil spill, habitat loss etc.

#### Impact on Fish

The powerful sound wave generated by seismic survey can have a variety of harmful effects on fish. Within close range, seismic survey has been found to kill adult fish as well as larvae and fish egg. Scientific study have also shown that air gun blast can cause a variety of sublethal impact on fish such as damaging orientation system and reducing their ability to find food. Researchers have noted disturbances in the migration routes of salmon and other anadromous species as a result of seismic operation [14,15]. Seismic survey can cause physical damage to fish ears and other tissues and organs such as swimming bladders. Although such effect may not kill fish immediately, they may lead to reduced fitness, which increase their susceptibility to predation and decrease their ability to carry out important processes. If a natural gas blow out occurs, marine fish, eggs and larvae near the blow out point probably would be killed. Natural gas condensates in the water column would be hazardous to any fish, eggs, or larvae that were exposed to high concentration. There are at least five possible ways (oil spills) can affect fish pollution: (1) eggs larvae can die in spawning or nursery areas due to coating

or direct toxic effects (c) adult can die or fail to reach spawning grounds; (3) spawning behavior may be changed; (4) local food species of the fish or larvae may be adversely affected or eliminated; and (5) sub-lethal effects may reduce fitness and affect the ability to endure environmental stress

Seismic surveys not only threaten commercial and subsistence fishing by harming fish resources, but also by interfering with fishing operations and dramatically affecting catch rates. Studies have shown that seismic operations have greatly reduced catches of fish around areas where air guns were being fired. This studies have demonstrated reduced catches over 20 miles away from the source with catch reductions continuing five days after the testing was complete.(See Table 1 below).

**Table 1: Reduction in fish catches rates as a result of seismic survey activity.**

Species	Gear type	Noise level of seismic testing	Catch reduction	Source
Atlantic cod ( <i>Gardus morhua</i> )	Trawl	250 decibels (dB)	46-69% lasting at least 5 days	Engas et al. 1993
Atlantic cod ( <i>Gardus morhua</i> )	Longline	250dB	17-45% lasting at 5 days	Engas et al. 1993
Atlantic cod ( <i>Gardus morhua</i> )	Longline	Undetermined, 9.32 miles from source	55-79% lasting at least 24 hours	Lokkeborg and Soldal, 1993
Haddock ( <i>Melanogrammus</i> )	Trawl	250dB	70-72% lasting at least 5 days	Engas et al. 1993
Haddock ( <i>Melanogrammus</i> )	Longline	250dB	49-73% lasting at least 5 days	Engas et al. 1993
Rockfish ( <i>Sebastes</i> spp.)	Longline	223dB	52%- effect period not determined	Skalski et al.,1992

### Impact on Birds

About 100 species of waterfowl, shorebird and seabirds occur in the coastal waters or the Niger Delta [4]. Sitting of onshore facility such as drill pad, road, and oil storage facility could eliminate or alter some preferred bird's habitat such as wetland. The construction of offshore pipeline could have temporary effects on the availability of food sources of some sea ducks with a mile or two of the construction area due to turbidity and removal of prey organisms along the pipeline route [9]. Noise and disturbance may affect marine and coastal birds. Repeated air-traffic disturbance of concentration of feeding and molting water fowl and shorebirds on coastal lagoons and other wetland may reduce the ability of migratory birds to acquire the energy for successful for migration [9]. In the event of natural gas exploration and fire, bird in the immediate vicinity would be killed. It is not likely that toxic fumes would affect birds or their food source except those very near to the source of the blowout.

Direct oil contact alone usually is fatal and often results in substantial mortality of many birds. Oiling of birds causes death from hypothermia, shock, or drowning. The direct effect of oil on a bird is to clog the fine structure of its feathers, which is responsible for maintaining water-repellence and heat insulation. (NRC 1985). Hundreds of thousands of marine birds are estimated to have died as a result of contact with oil spill from the Exxon Valdez [10].

### Impact on Marine Mammals

The sound generated by seismic surveys are colossal, peaking momentarily at up to 259dB at source. Moreover, they are repeated approximately every 10 seconds for weeks or months at a time. Not surprisingly, marine mammals have been recorded as fleeing from seismic survey sites. Habitat loss would be limited to temporary disturbance to some sea otters and harbor seals in the near shore environment associated with construction of pipelines and transport facilities. Noise and disturbance activities that may affect marine mammals in the sale area includes geophysical survey, marine dredging and construction, support vessels, aircraft over flight, offshore drilling and production. If a natural gas blowout occurred with possible explosion and fire, marine mammals in the immediate

vicinity of the blowout could be killed. Natural gas and gas condensates that did not burn in the blowout could be hazardous to marine mammals. Spilled oil can affect mammals through direct contact with the skin surface, inhalation of petroleum hydrocarbon, vapours, injection or through interference with normal behavior. Laboratory studies on phocid seals have also demonstrated that petroleum hydrocarbon may be transported by the blood and distributed to many tissue including blubber, muscle and liver [11].

#### **Impact on water quality**

For offshore operation, non hazardous waste that cannot be returned to the surface is treated and discharged. Drilling method for onshore and offshore wells are similar but disposal of by products varies. For onshore operations, most drilling waste are disposed of under ADEC's solid waste disposal program, or shipped out of state, by product or drilling and production activities include muds and cutting, produced water and associated waste (non hazardous) and some times oil spills that might contaminate and pollute the water.

#### **Impact on land habitat**

Effects of constructing production pads, roads, and pipelines include direct loss of acreage due to gravel infilling, and due to impoundment and diversion of water. A secondary effect of construction activities includes dust deposition, which may reduce photosynthesis and plant growth, and downstream saltation and sedimentation, which can affect plant viability. If natural gas blowouts occur, plants in the immediate vicinity may be destroyed.

Spilled oil affects vegetation depending on time of the year, type of vegetation and terrain. Spilled oil will migrate both horizontally and vertically. This flow depends on factors including the volume spilled, type of cover (plant or snow), slope, presence of cracks or troughs, moisture content of soil, temperature, wind direction and velocity, thickness of the oil, discharge point, and the ability of the ground to absorb the oil [12]. If the oil penetrates the soil layer and remains in the plant root zone, longer-term effect, such as mortality or reduced regeneration would occur.

#### **Impact on marine animals**

Scientific studies have established that some man-made sounds can injure some marine animals, disrupt or mask crucial sound on which they depend and also cause behavioral changes. Louder "acoustic harnessing device"(AHD) can create a problem of habitation. Prolonged exposure to AHDs that emit up to 200 DB of sound in the 5-30khz range (AHD) cause hearing loss in the animals ranging from temporal threshold shift to permanent threshold shift and an increase in pathological stress. As a result the animals are more likely to be separated from their young, who in turn, will become easier prey for natural predators. That intense noise exposure may cause death or physical injury, even at low levels for some vulnerable species (including, temporary or permanent hearing) as well as increased leading to detrimental consequences for animals immune system and reproductive health.

#### **Impacts on man**

Gas flares have potentially harmful effects on the health and livelihood of the communities in their vicinity, as they release variety of poisonous chemicals including nitrogen dioxide, sulphur dioxide, benzene, carcinogens like benzopyrene and dioxine. Human exposed to such substances can suffer from a variety of respiratory problems. These chemicals can aggravate asthma as well as cause leukaemia and blood- related diseases. Many of these communities claim that the nearby flares cause acid rain which corrodes their homes and other local structures, many of which have zinc- barred roofing.

People living in the oil spill affected areas complain about health issues including bathing problem and skin lesions, many have lost basic human right such as health, access to food, clean water and an ability to work.

Generally, seismic activities lead to;

- Depletion of arable farm land destroys economic and crops, thus reduces farmer's access to land/food.
- The action has rendered the areas inhabitable and lead to the exodus of man and animals.
- Oil spill and drilling wade contaminate source of drinking water.
- Network of pipe connections, well heads and floor stations restricts the activities of the dwellers.
- Kill fish which is a source of protein and deny the fishermen from fishing as a means of livelihood.

## **MITIGATION MEASURES**

### **Mitigation measures on fish**

Protection from drilling and production discharge-lessees must use appropriate methods for disposal of mud, cutting and produced waters. Protection of fish habitat, including fish over watering areas-lessees must avoid altering streams bank and obtain approval for the location of crossings on fish streams.

Protection from seismic activities-lessees must follow requirement for explosive during onshore seismic activities, and are prohibited from using explosive with a velocity greater than 914.4 metre per second in marine waters Oil spill prevention and control-lessees must prepare contingency plans addressing prevention, detection, and clean up oil spills. Lining, diking and briffer zones are required to separate oil storage facilities from marine and freshwater supplies.

### **Mitigation on birds**

Prevention or and responsive counter measure for oil spills are particularly critical to assure protection of bird. Habitat loss avoidance-lessees must identify and avoid sensitive areas site facilities outside of key wetlands. Permanent facilities must be sited minimum distance from stream and water bodies. Disturbance avoidance-surface entry, siting of permanent facilities, and aircraft operation should be avoided in the vicinity of nesting sites. Bald Eagle-lessees must comply with the guidelines of the Bald eagle act of 1940, as amended.

### **Mitigation on marine mammals**

The use of explosives for seismic activity should be restricted in marine waters. Lessees are required for implement oil spill prevention, control, and counter measures plans.

### **Mitigation measures to protect water quality**

Drinking water protection: A freshwater aquifer monitoring well with water quality monitoring should be required down gradient of a permanent storage facility unless alternative acceptable technology is approved by ADEC [13].

Drilling waste - underground injection of drilling muds and cuttings is preferred method of disposal. Disposal of produced water to freshwater bodies, intertidal areas, and estuarine water is prohibited. Oil spill prevention and control-lessees are advised to must prepare contingency plans addressing prevention, detection and cleanup of oil spills. Lessees must include in their oil spill contingency plans, method for detecting, responding to, and controlling blowouts, the location and identification of oil spill cleanup equipment; the location and availability of suitable alternative drilling equipment; and a plan of operation to mobilize and drill a relief well. Pipeline must be designed and located to facilitate cleanup.

### **Mitigation of the effect on land habitat**

Wetland protection-Lessees must avoid siting facilities in key wetland and identified sensitive habitat areas. Drilling waste - underground injection of drilling mud's and cutting is preferred method of disposal. For onshore development, produced waters must be injected. Surface discharge of drilling wastes into water-bodies and wetland is prohibited. Oil spill prevention and control-lessess are advised to prepare contingency plans addressing prevention, detection, and cleanup of oil spills. Pipelines must be designed and located to facilitate cleanup.

### **Mitigation on man**

Desperate move should be taken to avoid oil spill and gas flaring oil the Niger Delta. The move by the federal government to stop gas flaring should be intensified and implemented. Oil pipe lines should be maintained and bunkering should be discouraged to stem the tide of oil spill and its effects on man.

## **RECOMMENDATIONS**

- Government should adopt effective measures to compel industries stop gas flaring and oil spill.
- Researchers should innovate better ways of engaging in seismic operations rather than using explosives.
- Oil and gas development during exploration, construction and operation processes should be done with utmost care to reduce its effects on marine life and its environments.

- Government and industry should step in by providing funding to research institutions to develop methods of screening noise caused by seismic blasting in time it may be possible to reduce destructive exposure of seismic blasting and help save marine animals.
- Bunkering, pipeline explosions gas flaring oil spills should be properly checked and minimized.

### CONCLUSION

There are no doubt that seismic activities/blasting impacts negatively on marine life and its environments. This activity affects man, fish, marine habitat, birds marine animals and mammals, water and air quality etc. however, care should be taken to reduce this impacts using the recommendations spelt out in this work. In addition gas flaring, oil spills and pipeline explosions must also be reduced to the barest minimum.

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