A REVIEW OF NOISE IMPACTS FROM OFFSHORE OIL-GAS PRODUCTION ACTIVITIES ON THE MARINE BIOTA

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1. INTRODUCTION

Marine noise originates from vessel traffic, oil-gas exploration activities, machinery and propeller noise, research activities, military sonar, and dredging [1]. Although noise pollution is not directly fatal, it adversely affects the regular and natural biota activities [2]. For example, the recent expansion of petroleum exploration in the coastal area poses a threat on the regional ecosystem.

In details, noise may come from three offshore oil-gas exploration and extraction activities: [i] exploration stage - mapping subsurface geology and resource reservoir using seismic operation with the release of compressed air from an array of airgun, drilling exploration and wells delineation for feasibility study; [ii] construction stage - preparing drilling pad, establishing drilling platform, drilling and completion of extraction wells, installing wellhead, other utility construction accessories; [iii] operation and maintenance [3].

It was discussed that noise from offshore drilling operation can hardly impact the marine lives compared to seismic noise [4]. Reported impacts from marine noise pollution can be summarized as: egg-larvae mortality, feeding and breeding problem, stress, damage of tissue and organs, masking, hearing loss, behavioral changes, communication problem, and the like [1,2,5]. The issue of marine noise impacts on biota is a relatively new research field which is in need of extensive efforts to quantify the impacts and support the related management.

2. A SURVEY AND DISCUSSION

In this section, previous studies on marine noise and its impacts related to offshore oil and gas activities are discussed with respect to monitoring and experimental investigations, modeling and risk assessment, and proposed mitigation measures.

2.1 The effects of noise on marine biota

Numerous observations have been reported on the effects of noise on marine biota. For example, the uses of sound by marine mammals are adapting to the ambient environment and navigation, communication and sensing, e.g. echolocation for tracking prey, mating and group interaction, vocalization and avoid predators [2,6]. Noise pollution affects marine mammals and fish to experience pathological effects, behavioral changes, and feeding-mating-breeding-nursing disruptions [5]. Temporary and permanent hearing loss, damage of tissue, trauma, stress, and food chain disruptions are also other possible impacts due to noise pollution from anthropogenic activities such as oil-gas production operations [7]. High intensity sound from such activities causes masking problem which is quite serious as it conceals the communicative sounds as well as biologically important sounds [1].

2.2 Monitoring and experimental studies

Experimental studies were mainly conducted in biological lab together with field monitoring actions by governmental and industrial agencies. For example, an archival acoustic recording tag called DTAG had been developed to monitor and track the behavioral changes and responses of less visible deep diving marine mammals with built-in sensors in the Mediterranean Sea and the Gulf of Mexico [8]. Impacts of anthropogenic noise e.g. oil and gas drilling noise on nervous and immune systems of marine mammals, e.g. whale and dolphin, were tested by analyzing their blood samples before and after the exposure to seismic sound [9]. For high-level sound, norepinephrine, epinephrine, dopamine, γ-glutamyltransferase levels increased while alkaline phosphatase decreased in white whale body. For dolphin, aldosterone increased and monocytes decreased after exposure to impulse sound, for tonal sound, the neural-immune changes were minimal. Shallow water ambient noise experiments were conducted in Eastern Canadian waters to show their temporal and spatial variations due to whale song, wind, shipping and drilling activities in oil platform [10]. Long term monitoring is vital for critical and sensitive species in areas of concern such as restricted migratory routes, spawning area, feeding-breeding-nursing grounds, and resting places [11].

2.3 Modeling and risk assessment

The relevant modeling studies include sound propagation modeling, simulation of the perceived sound by marine animal and consequent impacts on biota. It was shown that seismic sound amplitude originating from the trial of exploring oil-gas reserves decreases logarithmically with water depth from the source; at the greater distances, the amplitude diminishes and frequency spectrum broadens; attenuation is also influenced by ocean depth and other physical characteristics e.g. temperature, salinity, density, bed roughness [12]. A mathematical model was developed to predict oil industry generated acoustic noise propagation

into the sea sensed by mammals [13]; acoustic parameters e.g. peak pressure, peak-to-peak pressure, root mean square pressure, and sound pressure spectral level were measured in this study.

A multidisciplinary study was undertaken by the US Navy to develop a software workbench by integrating expertise from acoustics, oceanographic modeling, marine mammal biology, oceanography, naval operations, and environmental compliance; it was intended for simulating animal movement, estimating received acoustic time series along animal's track, predicting hearing loss related temporary threshold shifts (TTS) [14]. To demonstrate the noise impacts from sonar, shipping, oil exploration and drilling activities on marine environment, a time series stimulator was implemented fully incorporating Doppler effects to predict actual time series of a moving mammal and its auditory changes at lower frequencies [15].

2.4. Mitigation efforts

Several mitigation measures have been proposed to ensure the balance between resource extractions and maintaining good environmental poise. It stated that: (i) if any sensitive and critical species are present within the operation area, industrial activities can be delayed until suitable conditions are achieved (ii) even in the desirable condition, operations can be started gradually for warning the species; and (iii) visual observations can be scheduled every after a certain period [5]. New technologies have been reported being used to ensure efficient resource extraction activities. For example, new acoustical transducer systems, digital communication with system-tuned code-decode algorithms, smaller and more sensitive seismic instruments could be used for environmentally friendly offshore oil and gas activities [6]. Other reported remedies are with case-by-case scenarios, which include controlling seismic operations, uniform application of regulatory procedures, establishing larger exclusion zone, imposing moratorium where necessary, discovering alternative energy sources [7].

2.5 Regulatory aspects

The survey in this study indicates that noises from anthropogenic activities including offshore oil-gas exploration operations have much potential to endanger the marine biota, which are usually regulated. For example, there are extensive regulatory frameworks in the North America related to anthropogenic noise impacts on marine mammals including Marine mammal Protection Act, 1972; Endangered Species Act, 1973; and National Environmental Policy Act, 1969 [16]. It is regulated on, for instance, [i] the harassment of special fishes are prohibited; [ii] conservation of plants and animals listed as endangered or threatened should be promoted; and [iii] the environmental review of project activities including seismic operations is required.

3. CONCLUSION AND FUTURE MANAGEMENT

A survey and discussion have been conducted in this paper to address possible impacts on the marine biota resulting from offshore industrial activities, mainly oil-gas extraction activities. It indicates that effective management tools can greatly reduce the concerned problems. In response to the required future research needs, a technical framework is proposed based on a state-of-the-art review as given in Figure 1.

Technological innovations including new monitoring and warning systems, better transducer, more sensitive seismic device, tuned systems, and underwater telemetry can help in better maintaining the desired marine ecological conditions. While modeling the sound propagation, background sound sources are often neglected which could be incorporated to quantify the relevant risks and impacts. More case-by-case analysis with direct field investigations needs to be carried out with enough collected samples. The governmental agencies will continue to play an important role in the management action and decision-making with more scientific studies being promoted.

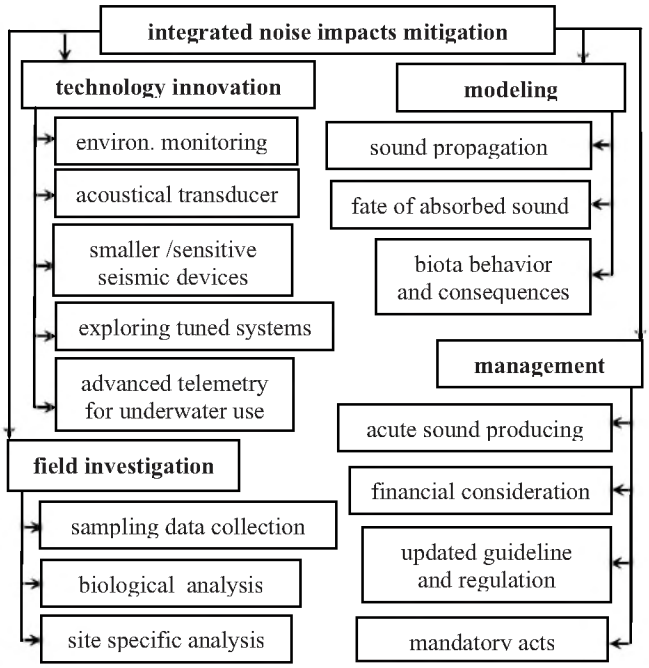

Fig. 1. A technical framework.

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