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ENVIRONMENTAL CHALLENGES FOR OCEAN ENERGY GENERATION

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ABSTRACT

The world's depleting fossil fuels have put the globe into serious global warming concern. Normally, these fossil fuels emit greenhouse gases when burnt in most of the industrial processes and as well in automobiles. The earth's economic activities have therefore triggered high energy demand which has put the world into acute energy shortage. This global energy insecurity has attracted the technological research on how to ensure there is constant supply of energy owing to the increasing energy demand. Different energy resources have been identified which can help generate clean energy which emit near zero greenhouse gases such as SO_X, NO_X and CO_2. As the renewable energy sources come into play, they are also accompanied by several environmental impacts. This paper critically discusses different environmental challenges posed by the generation of energy via ocean energy technology and gives an insight on the proposed remedy. The challenges explored include; electromagnetic field in the ocean, toxicity caused by the technology, alteration of water currents and waves, benthic organisms' habitat alteration, noise impacts, strike and collision and water temperature increment.

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INTRODUCTION

Ocean energy generates electricity from water without building dams by the use of tides, waves, and ocean thermal gradients to drive turbines for electricity generation. It is seen as a green source of energy. However, increasing environmental conflicts have been realised with the upcoming of the ocean energy technology. According to the U.S. Department of Energy (2009) report, the technology poses challenges to the hydro environment in several ways which includes; alteration of the water habitat caused by cables laid in water and the new structures under the ocean and even the turbines which change the water flow pattern (Bryden *et al.* 2004), compromise of the water quality since a lot of suspended sediments and chemicals are released into the hydro-environment especially from the hydraulic fluids used on the turbines(Boehlert *et al.* 2008), increased death of fish and other aquatic creatures as they get hit by the blades of the moving turbine blades(Wilson *et al.,* 2007), increased noise effect from the sound produced by the moving blades and during pile driving in water affecting fish and other aquatic creatures (Nedwell *et al.,* 2003). As well, change in ocean water temperatures has been noted to be factors contributing to the death of the aquatic organisms in habitat around large scale ocean thermal energy conversion technology. These environmental impacts have met the ocean technology with a lot of questions on its advancement. Different researchers have critically looked into the possible environmental challenges of the ocean energy generation.

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Environmental challenges of ocean energy generation

Electromagnetic field in the ocean: According to the U.S. Department of Energy (2009) report, the electromagnetic fields around the equipment generating power and the cables running in the water pose a challenge to the aquatic life. The electric current travelling through the cables can induce the magnetic field in the surrounding which can further induce the secondary electrical field into the aquatic animals as they move around in water (CMACS, 2003).Some species of fish such as eels and sturgeon are very sensitive to electromagnetic fields and hence they cannot survive in any habitat within the electromagnetic field region. As noted by Lewis et., 2011,the electrical cables connecting the arrays pose a very big

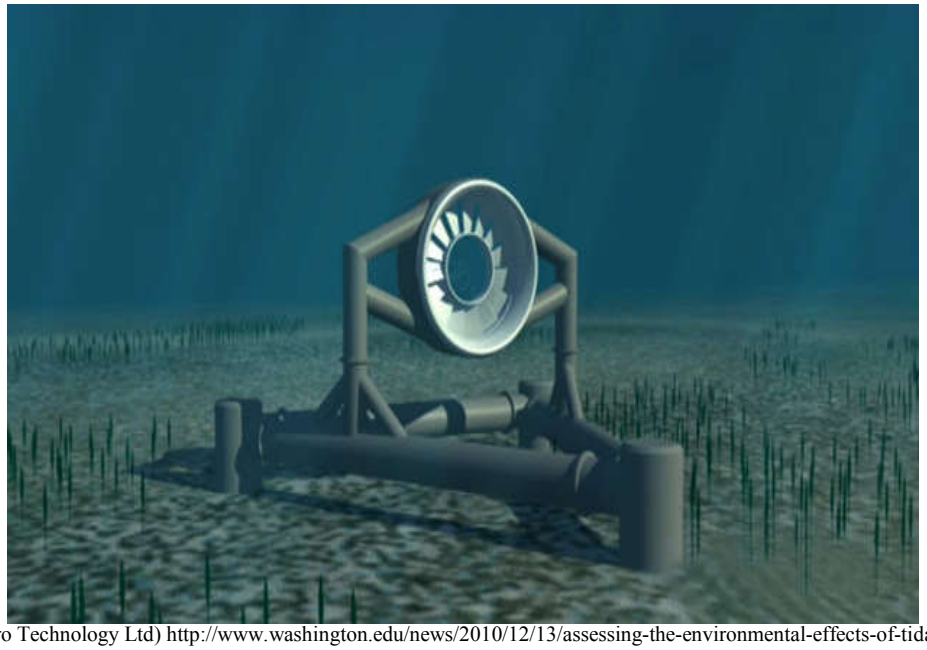
challenge to skates, rays and shark which uses electromagnetic field to move and get their prey. Sea turtles movements depends on the magnetic information, the interruption of the magnetic field may disorient their movement in their natural habitat especially along the cables or the structures which are electro magnetically active (Lohmann *et al.,* 2008). CMACS (2003), Lohmann *et al.* (2008), Lewis *et al.* (2011) and Lohmann *et al.* (2008) are concerned about the same effect which is the interference of the movement of some few species in the ocean. In order to avoid the interference, the cables can be buried deep in the ocean bed to avoid destructive magnetic effect since the ocean soil may act as an insulator that reduces secondary electromagnetic effect transmission. As well, a viable research can be done on such species affected by electromagnetic field and the cable lay out designed where they are not mostly found to minimise the effect.

Toxicity caused by the technology: According to Boehlert *et al.,* 2008, there is likelihood that, the hydraulic system of the turbines may have accidental leaks which can get in water and cause coatings on fish or any aquatic life. As well, another cause of leaks may result from accidental hitting of big ocean creatures by turbine blades which may release the hydraulic fluid into water that can even clog the fish gills leading to death. Boehlert *et al.* (2008) failed to note the fact that the entry into some turbines may be guarded to avoid massive breakdowns caused by big ocean creatures like shark and as well, the leakages have strict monitoring devices and in any case, it might be very minimal compared to the constant water volume that may mix with it and carry it to the surface owing to its density. Bio fouling is a major practice used to control the algae on the technology equipment which uses some dissolved chemicals which can release chemicals into water that may accumulate after some time and can cause disastrous effect on the health of the aquatic animals such as abnormal growth and impairment of their sensory organs. Lewis *et al.* 2011 admits that leakage caused by abrasion from anti fouling chemicals and paint together with hydraulic power take off oil leaks needs to be researched and well mitigated since they pose big threat to the aquatic echo system by killing aquatic living organisms. The marine technology also faces major environmental challenge that eats it up mechanically and chemically bringing down its efficiency due to the biofouling effect on the equipment and the cables (Sundberg *et al.,* 2005).This happens when there is corrosion caused by biofouling and moving water and sand particles eroding the metallic parts. To solve the problem of bio fouling and corrosion on metallic parts as noted by Lewis *et al.* (2011) and Sundberg *et al.* (2005), there should be proper research on a material that doesn't rust in the ocean and made of anti-fouling material characteristics. In ocean thermal energy conversion, dangerous chemicals such as ammonia and chlorine can be released into water due to failure that can be caused by malfunction or accidental collision by the ship (Pelc and Fujita, 2002), this can harm local organisms in that particular habitat. To avoid danger caused by accidents from boats and ship, the turbine locations should then be marked clearly on the water surface and ocean authorities in charge of ocean transport made aware of the turbine locations. This can avoid danger posed by leakages from hydraulic systems and ammonia as a result of accidental ship collision as noted by Pelc and Fujita (2002).

Alteration of Water currents and waves: According to Bryden *et al.* 2004, the technology networking which has several cables and structures submerged underneath the ocean interferes with the normal water current velocity. Some parts of the fixed structures resist the flow of water and hence lower velocity which interferes with the aquatic habitat. This reduction in velocity further interferes with the deposition of the ocean sediments and the organisms living underneath the water surface. Bryden *et al. (*2004) reasoning(the underground cables will destruct smooth water velocity) can only occur after short period of time since the cables which are buried in soil will not have soil heaping for long as the sediments are swept away by the water currents defining the natural ocean bed profile. Boehlert *et al.* (2008) indicates that the static structures gives a change in hydrodynamics such as wake and turbulence hindering further movement of the sediments and can provide good habitat for reef species which may encourage collision and striking by the movement of the rotor and the turbine blades. Boehlert *et al.* 2008 and Bryden *et al. (*2004) looks deeply into the static structures used to mount the turbine without considering and comparing their effects with the naturally occurring static structures like huge stones in the ocean. Both the natural or man-made static structures interfere with the ocean currents. Since the kinetic energy from the ocean current is being used, the current speed will reduce drastically causing the resultant habitat to be unbearable to the aquatic survival (Bryden *et al.* 2004). During the loss of the wave energy due to the reduction in velocity, there is change in the long shore currents resulting into low energy and width at the surface zone a condition that gives a change in beach resulting into sand erosion. Further to Bryden *et al. (*2004) idea, this sand erosion caused can be detrimental since it exposes the electric cable buried deep in the ocean bed and this may induce electromagnetic field into such a habitat.

Benthic Organisms habitat alteration: During mounting of the structures, laying of the cables and the foundation displaces virtually most of the aquatic plants and organisms of which some may either die or get new habitat for survival. The big structures also alters the water movement which further may not go well with the bottom dwelling species and as a result, there will be a lot of deposition experienced(U.S Department of energy,2009).The benthic organisms habitat is also altered due to the change in the flow of water, deposition, erosion and the movement of the sediments caused by new structures which are mounted at the bottom (Frid *et al.,* 2011). Building the structures in the ocean destroys completely the benthic organisms in such construction foot prints. An example of a 30 foot tidal turbine courtesy of Open Hydro Company shown on figure 1 can destroy completely the benthic organisms where it sits while some will have to move to better habitat for survival. It is evident that both U.S Department of energy (2009) and Frid C, et al(2011) sees the huge mass of the turbine components as a threat to the benthic organisms since they are heavy and have large surface area to sit on the ocean bed. This can kill most of the benthic organisms and displace those in the surrounding since the noise disturbance of the turbines during its operation may be disturbing. With the huge structures, there will be turbulence at the water current turning points on the static structures that will further sweep away benthic organisms.

Noise impacts: Water creatures rely completely on sound as a mode of signal in their daily lives. The importance of sound helps them in production, escape from hazards, navigation, feeding and communication (Weilgart, 2007). Noise produced by ocean turbines interfere with these activities and if it is too



(Open Hydro Technology Ltd) http://www.washington.edu/news/2010/12/13/assessing-the-environmental-effects-of-tidal-turbines/

Figure 1. Foot tidal turbine

http://inhabitat.com/underwater-kite-turbines-harvest-energy-from-ocean-waves/

Figure 2. A Ocean turbine with protruding tower and rotating blades (Jones, 2011)

much, it can even interfere with their hearing capabilities completely and hence they will be exposed to their predators (NRC, 2005). Weilgart (2007) and NRC (2005) concludes the importance of sound to the fishes and other aquatic creatures. It therefore follows that, if their hearing capabilities are impaired by sound, their mortality rate will be on the rise since they will be captured easily by predators. Also getting food will be a problem hence death will continue to be on the rise given that their sensory organs for food search and communication is impaired. During pile driving, the noise caused is a great threat to the fish and can even kill different species of fish within a close range to the noise source. According to the research done by Nedwell *et al.,* 2003, the fishes which were 400m away were not killed by the noise from pile driving while those within the range were killed. In a research done by Hastings and Popper 2005, it was found that fishes tend to live away from any place where there is pile driving since it interferes with their natural habitat. The research confirms that there is a lot of noise and vibration caused during the construction and decommissioning of the project which made several species of fish to stay away from such habitats. Nedwell *et al.* (2003) is not very accurate to conclude in his experiments that all the fishes killed were as a result of the noise. Some of the fish may have died out of natural death while some may have suffered from the ship vibratory sounds and found themselves within the research area. Popper and Hastings (2005) noted that noise was the main cause of abandoning the project area by the fish; other factors such as change of water turbidity may also have contributed to their migration and as well, general disturbance of new structures in the ocean could have facilitated their movement to conducive habitats.

Strike and Collision: Figure 2 shows the structural exposure risk of both flying birds and the aquatic creatures. There is tendency of collision in the ocean which brings high the mortality rate among fish and flying ocean birds (U.S. Department of Energy, 2009). The submerged structures and the protruding structures above the water in the ocean can give a threat to both aquatic life and the flying birds. The turbine blades also tend to hit the aquatic creatures as they move which may either kill them or leave them with injuries during collision (Wilson *et al.,* 2007). Wilson *et al.* (2007) notes that the thick sub-dermal layer of blubber in ocean mammals which protects most of their organs is not located evenly in their body and don't exist in their heads making them vulnerable to strikes. The conventional hydroelectric turbines which are enclosed inside a housing pose great danger to the aquatic animals since they provide no opportunity for any entrained organism to escape the strike from the blade (Deng *et al.,* 2005).All the authors have great concern about the death of aquatic organisms caused by the turbine blades and stationery structures, it is also worth noting that when such organisms die in the ocean and start decaying, the water quality will be compromised due to the decay of the organisms caused by micro bacteria. The gases produced during decay are also very toxic to the aquatic organisms.

Water temperature increment: In a large scale ocean thermal energy conversion, it is evident that the warm water generated will mix with the cold water and move towards the surface, a condition which will make cold water from the surface to sink into the bottom. As this mixing process continues for a long time, the water temperature at the bottom may rise resulting into a cool water surface (Avery & Wu, 1994). This increased temperature is very disastrous to the aquatic organisms since the local change of temperature between 3^0C to 4^0C causes mortality in fishes and corals (Pelc & Fujita, 2002). Avery & Wu (1994) and Pelc & Fujita (2002) did not consider the fact that there is continuous flow of ocean currents across the bed which can result into constant cooling of water across the ocean with incoming cold water. Their research is only viable with stagnant water. The increased temperature may also reduce hatching of eggs and thwart the larvae development, a condition that totally affects reproduction negatively (Kennish, 1998). On contrary, it is worth noting that most of the aquatic organisms breed in stil areas full of aquatic plants with low ocean currents velocity compared to the current velocity expected around the turbine area.

Conclusion

It is therefore evident to note that the emergence of ocean energy generation has posed significant environmental challenges to the aquatic life by inducing electromagnetic field in the ocean water due to current flowing through the cables, interfering with the water currents and waves from the new structures of the technology submerged into the ocean, interfering with natural habitat of benthic organisms which are as well displaced and destroyed by the technology structures, increased mortality rate of fishes and other ocean creatures which are either struck by turbine blades or collide with the technology structures and increased oceanic noise during commissioning, decommissioning and operation. Since ocean energy has a viable positive impact on energy security and reduction of the carbon footprint, more research is therefore needed to minimize the environmental impacts noted.

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