Biofouling of Artificial Structures

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In recent years, we have seen an increase in the adverse effects of treating the ocean like an unlimited resource. Underwater deserts are being formed caused by overfishing and the leaching of chemicals from our industrialized world. Invading the ocean with man-made structures like oil rigs and wind farms are also a cause for concern, as they can be potentially dangerous to the environment. As technology progresses, stronger platforms are being created allowing for these artificial structures to be placed further out to sea (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2010). However, more recent studies are showing that there is an unintentional consequence to these structures that seems to be extremely positive. These man-made structures are being transformed into reefs full of life, increasing biodiversity and productivity of the regions in which they are introduced (J rgensen, 2009). Unfortunately these structures are not going away as the need for more energy increases, however the introduction of these structures has lead to a positive impact on the ecosystem and are ideal for the future.

There are two specific artificial structures that have been introduced that have shown to be a beneficial addition the marine ecosystem. The first of these structures are the oil rigs. They are used to drill for oil at the bottom of the ocean from a raised platform above the surface. They were first created in Santa Barbra in 1896, looking like nothing more than a pier extending only 1,350ft from shore (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2010). Over time this method has created a multibillion dollar industry with rigs all across the world. A large concentration of these oil rigs exists in the Gulf of Mexico and is where the extent of their damage was brought to light. Millions of gallons of crude oil were released during the Deep Water Horizon incident decimating marine and coastal ecosystems (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2010). The second of the structures are offshore wind farms. According to the Bureau of Ocean Energy Management this is a more recent technology with the first farm placed off the coast of Denmark in 1991. A wind farm consists of multiple rows of turbines that protrude from the surface and are set up to take advantage of the wind in its area. They have grown increasingly in popularity over the years especially throughout Europe. The United States has even shown an increase in their interest with their “smart to start initiative” proposal creating wind farms off their coast as well (Bureau of Ocean Energy Management, 2014)

Through the creation of these structures we are seeing an unintentional consequence merging technology with biology. These structures are providing a large submerged substrate that promotes biofouling growth in the environment. This allows for the formation of complex reefs. Biofouling is when a hard substrate is introduced into a marine environment, organisms like barnacles and mussels colonize it. That in turn attracts other marine species and over time it will build up and create a reef (George, Philip, 1979). This is very similar to the succession of a terrestrial environment in that the first responders pave the way for future species. This is not specific to artificial structures as this applies to natural occurrences as well. A rock lying at the bottom is more than suitable for this effect (George, Philip, 1979).

First, the negative effects of these structures on marine organisms should be identified. It is important to note that these structures are disruptive to the environment no matter their outcome but looking at the after effects is more practical as these structures are not going away. A recent study assessing the impacts of the construction phase and operational phase of wind farms was done. They grouped marine organisms into three major groups, marine mammals, benthic organisms and fishes, and measured the impacts of the major disturbances on each group (ergström, *et al*, 2014). During the construction phase the disturbances included acoustic and sediment dispersal. The acoustic disturbances had the largest effect on marine mammals as they are very sensitive to sound. Besides normal construction noise, a machine called a pile driver is use to force support beams into the ocean floor. This happens to be extremely loud to marine organisms. The pile driver also displaces sediment and causes problems for visual predators as well as benthic organisms. After construction the disturbances seem to diminish but are still present including, acoustic noise caused by the everyday running of the turbines and the electromagnetic field created by the production of power (ergström, *et al*, 2014). Other notable adverse effects include a displacement of nearby fisheries either to these

structures or were forced to leave because of them. One can see the compared disturbances in figure 1. The negative effects of oil platforms, besides their similar construction, comes from their purpose (Wolfson, *et al*, 2014).

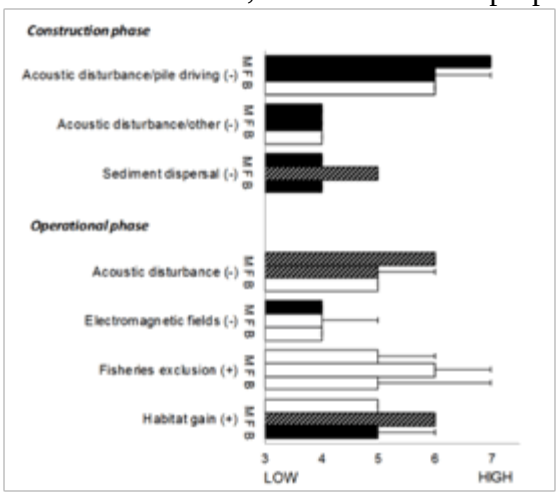

Figure 1: This figure depicts each effect during both the construction and operational phases of a wind farm. While also comparing these effects on three groups of organisms, marine mammals (M), fishes (F) and benthic organisms (B). Note: There are both negative and positive effects in this table. Also the shading is to be ignored (ergström, *et al*, 2014).

Although there are negative effects of these artificial structures, biofouling has created an unintentional consequence that is having increasingly positive impact on their surrounding areas. In the Gulf of Mexico, where we see a large concentration of oil rigs, the ocean bottom is naturally muddy and lacks the hard substrate that is required for a reef to form. This mucky bottom creates a desert in the ocean with very low productivity per square unit. With the addition of these artificial structures a solid substrate is introduced so that organisms can colonize. Since the placement of these structures population of fishes has increased to 20-50 times greater than before they were implemented. This has created an oasis in the middle of a desert (J rgensen, 2009). Currently the gulf has the largest artificial reef directly impacting the biodiversity, allowing a kind of oceanic reserve causing fish populations and size to increase. Threaten species are even seeing an increase in their numbers after being overfished. The Gulf's Red Snapper is seeing a recovery directly connected to the increase in artificial reefs in the area (Texas A&M University, 2014).

Overall, these offshore structures are proving to be valuable additions to the environment. Recent programs such as the “rigs to reef program” are pushing this idea forward and allowing for the creation of many artificial reefs to come. The “rigs to reef” program takes decommissioned oil rigs and turns them into artificial reefs. A member of the committee for the “Recreation, Environmental Enhancement and Fishing in the Seas” (REEFS), that was tasked at looking at these artificial reefs, stated “Extensive environmental analysis has demonstrated the value of converting offshore oil and gas structures and other appropriate materials into artificial reefs for everyone’s benefit. Current removal and destruction requirements are wasting a national resource of tremendous public and private value” (ergström, *et al*, 2014). In the coming years we will not see a decrease in the amount of offshore platforms as the need for energy increases. With programs like “rigs to reef” one can see a positive direction and outcome of this technology in the years to come. Possibly even accommodating these structures for the improvement of biofouling and the aggregation of species. Incorporate an artificial reef as part of the structures original purpose.

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