



Environmental Impact Analysis of Underwater Infrastructure Installation and Decommissioning

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Abstract: The increasing number of oil and gas exploration activities in the deep sea has made underwater infrastructure, such as underwater pipelines, manifolds, and risers, continue to increase in number. However, over time, not a few infrastructures have entered the end of operations and must go through a decommissioning process. Both during installation and decommissioning, these two activities have the potential to disrupt the marine environment, ranging from seafloor disturbances, increased water turbidity, to the risk of exposure to marine life to residual structural materials. This study aims to see how environmental impacts arise from the installation and decommissioning process of underwater infrastructure, as well as understand the factors that affect the magnitude of these impacts. The approach used is a literature review, by examining Environmental Impact Assessment (EIA) reports, several case studies of underwater projects, and marine environmental guidelines from IMO and OSPAR. The results of the study show that environmental impact is strongly influenced by the installation method chosen (trenching, jetting, or direct installation) and the decommissioning method applied (total lifting, partial lifting, or rig-to-reef), as well as local environmental conditions such as ocean depth and seafloor type. From these findings, the study also summarizes several mitigation measures that can be implemented so that environmental impacts can be reduced without neglecting sustainability aspects at each stage of the underwater infrastructure life cycle.

Keywords: Underwater Infrastructure; Installation; Decommissioning; Environmental Impact; Sustainability

1. Introduction

Increasing energy demand is pushing the oil and gas industry to continue expanding exploration into deep-sea areas. This makes underwater or underwater infrastructure, such as underwater pipes, manifolds, and risers, increasingly built to support production activities. However, as oil and gas fields age, many infrastructures have entered the end of their operations and must go through a decommissioning process, which involves the discontinuation of operations and the dismantling or removal of structures that are no longer in use. Both at the installation and decommissioning stages, both of these activities have the potential to disrupt the surrounding marine environment. Installation processes, such as excavation or jet jets to plant pipelines on the seafloor, can disrupt sedimentary structures and increase water turbidity. Meanwhile, the decommissioning process risks releasing residual material from the raised structure, which if not properly managed can have an impact on marine life [1].

This aspect of environmental impact sometimes receives less attention in many underwater projects, although there are already international guidelines such as those from the IMO and OSPAR that govern how such activities should be carried out in relation to environmental sustainability. This is the basis of the author's interest in raising this topic, in the hope of providing a clearer picture of the environmental impacts that may arise from the installation and discontinuation of underwater infrastructure [2].

2. Discussion of the Main Problem

The environmental impact at the installation stage of underwater infrastructure is most pronounced during

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the process of installing pipes on the seabed. Methods such as trenching and jetting, which are used to plant pipes to make them more protected, tend to stir up seafloor sediments, increasing water turbidity, especially if the installation site is adjacent to coral reefs or seagrass beds. Vessel and heavy equipment activities during this process also cause noise that can disrupt the surrounding marine life [3].

At the deactivation stage, the problem is a little different. Structures that have been on the seafloor for a long time usually become artificial habitats for marine life. If the structure is completely removed, the ecosystem that has already formed will be disrupted. On the other hand, if some structures are left in place (rig-to-reef), the ecosystem can indeed be maintained, but there is still a risk of material or residual substances that have not been completely cleaned up [4].

From this, it can be seen that the magnitude of the environmental impact depends heavily on the method chosen, both during installation and decommissioning. Ideally, the choice of method should not only consider cost and time efficiency, but also local environmental conditions. As a mitigation measure, a thorough environmental survey before installation, the selection of work methods that are suitable for seabed conditions, and the application of IMO and OSPAR guidelines from the planning stage, are essential so that the impact on the marine environment can be minimized.

3. Review and Criticism of Existing Approaches

So far, the commonly used approach in assessing the environmental impact of the installation and decommissioning of underwater infrastructure has still relied heavily on Environmental Impact Assessment (EIA) studies conducted at the beginning of the project. This approach is actually quite good as a first step, but in practice it is often only administrative, just to meet the licensing requirements, without actually being used as a reference in technical decision-making in the field. As a result, the results of EIA studies are often not aligned with the working methods that are ultimately chosen, as these decisions are more influenced by consideration of costs and processing time [5].

Most existing approaches still tend to separate installation impact assessment and decommissioning impact assessment, even though the two are actually interrelated in the infrastructure lifecycle. This fragmented approach makes decision-making less holistic, for example choosing a cost-efficient installation method, but it turns out to make the decommissioning process difficult in the future, or vice versa.

The criteria for choosing a decommissioning method, such as between total removal, partial removal, or rig-to-reef, are still in many cases still more influenced by cost considerations and the minimum regulations in place, rather than an in-depth study of the actual ecological conditions at the site. In fact, the environmental impact of each option can vary greatly depending on the characteristics of the local ecosystem, which should be the primary consideration, rather than just a secondary consideration after the technical and economic aspects [6].

The current approach also still relies on data and case studies that are common or derived from water conditions in other countries, such as the North Sea, which is a reference for many international guidelines (e.g. OSPAR). In fact, the characteristics of tropical waters such as those in Indonesia, with the presence of coral reefs and different biodiversity, certainly require a more specific approach to impact assessment and cannot fully adopt the standards developed for water conditions with different characteristics. From some of these critical notes, it can be seen that the current approach, although quite good as a basic framework, still has room for improvement, especially in terms of integrating environmental impact assessments in a sustainable manner throughout the infrastructure life cycle, as well as adapting the assessment criteria to the characteristics of the local marine environment.

In addition, most existing guidelines, such as those from IMO and OSPAR, tend to be general and do not fully accommodate the different characteristics of the marine environment in each location. In fact, the conditions of the seabed, ecosystem type, and biota sensitivity in one region can be very different from another, so a uniform approach (one size fits all) is considered inappropriate if applied without adjustments [7].

The commonly used approach in assessing the environmental impact of the installation and decommissioning of underwater infrastructure mostly refers to the Environmental Impact Assessment (EIA) document prepared at the beginning of the project. This approach has indeed become standard in the offshore oil and gas industry, but if you look further, EIAs are generally only prepared as a one-time assessment at the initial planning stage, although environmental conditions on the ground can change over time, especially for projects that last for decades until entering the decommissioning phase. In addition, installation impact assessments and decommissioning also tend to be separate, even though they are actually intertwined in the infrastructure lifecycle, so this fragmented approach makes decision-making less holistic.

The approach at the decommissioning stage is also inseparable from similar criticisms. Decisions between total or rig-to-reef removal are more often based on technical and economic considerations, while ecological

aspects, such as the value of ecosystems formed in the structure, have not been quantitatively included in the decision-making process. In addition, current approaches still rely heavily on data and standards from other water regions, such as the North Sea, which are referenced by the OSPAR guidelines, although the characteristics of tropical waters such as those in Indonesia are certainly different and require their own adjustments. This suggests that there is still a gap between regulatory approaches and real conditions on the ground, which needs to be a concern for future industrial research and practice [8].

4. The Author's Perspective or Argument

According to the authors, the root of the problem is not the lack of environmental regulations or guidelines, but rather the lack of integration between environmental assessment results and technical decisions on the ground. As long as the EIA is only positioned as an administrative requirement at the beginning of the project, without being actively involved in the selection of installation methods or decommissioning schemes, then the environmental impact will remain the number two consideration after cost and time factors.

The authors also argue that a uniform approach for all sites is less relevant to implement, given the characteristics of the highly diverse marine environment. Ideally, any underwater project should have a site-specific environmental study, rather than simply following general guidelines that do not always correspond to local conditions. Therefore, decisions such as the selection of trenching or jetting methods, as well as total lift or rig-to-reef options, should be born out of strong environmental considerations, not just technical and economic considerations.

5. Conclusion

At the installation stage, more disturbances arise from physical work processes such as digging trenches and jets that increase the turbidity of the water and potentially damage the surrounding sensitive ecosystems. Meanwhile, at the decommissioning stage, the real problem arises from the other side, which is how to respond to the ecosystem that has formed in the structure over the years of operation. The magnitude of the impact that occurs in the end is largely determined by the method chosen, and unfortunately the selection of this method is so far still more influenced by cost and time considerations than environmental considerations. Current approaches, such as the EIA and guidelines from IMO and OSPAR, are actually quite good as a frame of reference, but their application in the field is still administratively inclined and has not been fully integrated with technical decision-making. Therefore, the authors argue that the improvements that need to be made are not only adding new regulations, but ensuring that environmental studies are really involved from the very beginning of project planning, with an approach tailored to the characteristics of each site. In this way, the installation and decommissioning of future underwater infrastructure is expected to run not only technically and economically efficiently, but also more friendly to the preservation of the marine environment.

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