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6. Ethical and Deontological Concerns

This chapter presents the ethical principles and responsibilities considered during the development of Maris Habitats. It discusses engineering ethics, honest marketing, environmental protection, and liability related to the habitat structure and monitoring system

6.1 Introduction

This chapter outlines the ethical and deontological principles guiding the development of Maris Habitats, a smart artificial marine habitat designed to support marine life and collect environmental data. Since the project combines underwater structures, electronic components, and ecological restoration goals, ethical considerations must be included from the early design stage.

6.2 Engineering Ethics

Engineering ethics play an important role in the design and development of artificial marine habitats. According to professional engineering ethics, engineers should prioritize safety, public welfare, competence, and truthful communication **[1]**. In this project, these principles are applied not only to human users and installation personnel, but also to the marine environment affected by the system.

The Reef Block must be designed with sufficient strength, durability, and reliability to withstand marine conditions such as saltwater exposure, currents, wave forces, and long-term material degradation. Concrete and reinforced concrete exposed to marine environments can be affected by chloride ions, sulfate ions, magnesium ions, wave action, and corrosion processes **[2]**. Therefore, material choice and structural stability are not only technical issues, but also ethical responsibilities.

Engineers also have a responsibility to make sure that the Reef Block and the Smart Module do not create unnecessary risks for marine organisms, installation personnel, or the surrounding environment. The Reef Block should not damage the seabed or disturb existing ecosystems more than necessary. Instead, it should be designed to provide shelter, attachment surfaces, and spatial complexity that can support local marine life.

Another ethical consideration is the separation between the prototype and the final product. The current prototype is not intended for long-term deployment in deep marine conditions. It is designed to test the basic Reef Block concept, Smartlogger housing, sensing, and data logging. Presenting the prototype as a fully marine-grade final product would be misleading. Therefore, the team must clearly explain the technical limits of the prototype and identify what would need to be improved for real deployment.

Transparency is also part of responsible engineering practice. Environmental data collected by the Smartlogger should be accurate, calibrated when possible, and reported honestly. Even if the results do not show strong ecological improvement, the data should still be presented clearly because it can support future research and better decision-making in marine restoration.

6.3 Sales and Marketing Ethics

Sales and marketing ethics are important because Maris Habitats is presented as an environmental restoration and monitoring solution. The project should avoid greenwashing, which means making environmental claims that are exaggerated, misleading, or not supported by evidence **[3]**, **[4]**. The system should not be promoted as a complete solution that can fully restore marine ecosystems without long-term proof.

Instead, marketing communication should clearly explain what the system can realistically provide. Maris Habitats can support habitat creation, provide surfaces and cavities for marine organisms, and collect environmental data to observe how the Reef Blocks and surrounding conditions change over time. These functions should be communicated honestly to public institutions, companies, research organizations, and environmental partners. Marketing communication should also avoid broad environmental claims and instead explain specific and realistic benefits of the system **[5]**.

If monitoring data is offered as part of a service or subscription model, customers should be informed about what data is collected, how often it is collected, how it is stored, and what limitations the data may have. This is important because environmental data may influence restoration decisions, sustainability reports, or public communication. The data should not be used to make stronger claims than the system can support.

The duty of information transparency also means that customers should understand the difference between the basic Reef Blocks, the optional Smart Module, and additional monitoring services. Since the system is modular, not every Reef Block needs to include a Smart Module. This should be clearly explained so that customers can make informed decisions based on their budget, monitoring needs, and project goals.

6.4 Environmental Ethics

The project aims to support marine ecosystems while minimizing negative environmental impacts. Artificial habitats can help provide shelter and settlement surfaces for marine organisms, but they can also create risks if they are poorly designed, placed in unsuitable locations, or made from inappropriate materials. For this reason, site selection, material safety, structural stability, and long-term monitoring must be considered before deployment **[6]**, **[7]**.

Material selection is a key environmental concern. The Reef Block should be made from durable, non-toxic, and environmentally compatible materials that do not release harmful substances into the marine environment **[8]**, **[9]**. Since the structure will remain underwater for a long period, the material must also resist degradation caused by seawater exposure, chemical attack, and physical forces **[10]**.

The surface texture and shape of the Reef Block should also be considered. Studies on ecologically enhanced marine concrete structures show that changes in surface complexity and material composition can influence species richness, live cover, and the balance between local and invasive species **[11]**. Therefore, the design should avoid overly smooth and simple surfaces. Instead, it should provide cavities, roughness, and sheltered areas that can support local marine organisms.

The project also considers the risk of biofouling on sensors. While marine growth on the Reef Block is desirable, growth directly on sensor surfaces may reduce data accuracy and affect long-term monitoring reliability **[12]**. For this reason, the Smartlogger should include protective design features, such as removable housing, sensor guards, or maintenance access. Antifouling solutions should be chosen carefully to avoid harming marine life.

In addition, Maris Habitats can contribute to environmental awareness and education by collecting data related to the surrounding marine conditions. This data can help researchers, public institutions, and local communities better understand how artificial reefs interact with their environment over time. However, the data should be interpreted carefully and should not be used to claim ecological success without long-term observation.

6.5 Liability

Liability relates to the responsibility for possible consequences if the system does not perform as intended. In deontological ethics, responsibility is connected to the duty to act carefully, prevent foreseeable harm, and remain accountable for the consequences of a design **[13]**. Since Maris Habitats includes both Reef Blocks and a removable Smart Module, liability covers structural, environmental, and data-related risks.

The main external stakeholders affected by these risks include public institutions, coastal municipalities, research institutions, environmental NGOs, port authorities, aquaculture operators, marine infrastructure companies, and the marine environment itself. Therefore, liability is not only related to product failure, but also to the possible impact on customers, data users, maintenance operators, local ecosystems, and future restoration or monitoring decisions.

In Maris Habitats, liability risks related to movement, instability, and possible damage to the seabed are addressed through the physical design of the Reef Blocks and the Smart Module. The Reef Blocks are made from basalt fiber-reinforced concrete. Basalt fiber-based materials are considered suitable for marine applications because of their mechanical performance and resistance to chemical and environmental degradation **[14]**. The material and estimated Reef Block weight are intended to improve the stability of the structure on the seabed. Each Reef Block is estimated to contain approximately 30 kg of concrete, giving the structure a high self-weight that helps reduce the risk of displacement caused by currents or wave action. When several Reef Blocks are connected together, the total mass and contact area increase, making the overall habitat more resistant to movement under expected deployment conditions **[15]**.

The Smartlogger is designed as a removable monitoring box that can be attached to the Reef Block through the Smartlogger attachment without being permanently embedded in the concrete structure. This allows maintenance, battery replacement, and data retrieval without removing the main Reef Block from the seabed. To reduce the risk of the Smartlogger becoming loose or drifting away, it is mounted on the Smartlogger attachment and secured to the Reef Block with a chain or mechanical locking system. This keeps the Smartlogger connected to the Reef Block during operation while still allowing access for maintenance.

From a duty of care perspective, the project must also consider possible Smartlogger failure. If the box leaks, breaks, or records inaccurate data, the result may not only be a technical failure but also a problem for environmental interpretation. Incorrect temperature, pressure, pH, or water quality data could lead to wrong conclusions about Reef Block performance or local marine conditions. Since marine sensors can be affected by biofouling during long-term deployment, regular inspection, cleaning, calibration when possible, and data validation should be included before the data is used for reports or decision-making **[16]**.

The Smartlogger design helps reduce liability risks. Since the Smartlogger is separable from the Reef Block, electronic components can be removed, inspected, cleaned, repaired, or replaced without removing the whole Reef Block from the seabed. This reduces disturbance to marine life and lowers

the risk of leaving failed electronic components in the sea.

Responsibility also includes the duty to consider long-term degradation. Although the Reef Block is designed to remain in the marine environment for a long period, the final design must consider what happens if materials wear down, break, or lose performance over time. Concrete structures in marine environments can deteriorate due to seawater exposure, chloride and sulfate attack, salt crystallization, corrosion processes, and physical forces such as wave action **[17]**. The system should therefore be designed and documented so that maintenance needs, operational limits, and responsibilities are clear.

Clear documentation and transparent data management are also important parts of liability. From a deontological perspective, this is related to the duty of transparency and accountability. The project should define how the system is installed, how often it needs to be inspected, who is responsible for maintenance, and how collected data should be stored and interpreted. For ocean data projects, data management planning is recommended to ensure that collected data is properly stored, preserved, and documented **[18]**.

These stability and maintenance measures should be described in the product development chapter and further validated through technical drawings, prototype tests, or simple stability calculations before real deployment.

6.6 Summary

This chapter has examined the ethical and deontological considerations associated with the development of Maris Habitats. The main concerns include environmental protection, structural safety, data integrity, transparent communication, and responsibility for long-term maintenance.

Based on this ethical and deontological analysis, the team chose a modular Reef Block design with a removable Smartlogger. This design allows the Reef Block to remain underwater while the electronic components can be removed for inspection, maintenance, or replacement. This reduces disturbance to the marine environment and lowers the risk of leaving failed electronic parts in the sea.

The team also decided to distinguish clearly between the prototype and the final product. The prototype is intended to validate basic sensing and data logging functions in a controlled environment. The final product would require marine-grade sensors, pressure-resistant Smartlogger housing, antifouling measures, and long-term field testing. This distinction is important to avoid misleading claims about the current technical readiness of the system.

From an environmental perspective, the solution prioritizes durable and compatible materials, structural stability, and surface features that support marine organisms. From a data ethics perspective, the system should collect and report environmental data honestly, including its limitations. These decisions help ensure that Maris Habitats is developed as a responsible marine restoration and monitoring solution rather than only as a physical product.

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