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Review Article

Marine Foulers and Borers: A Persistent Threat to the Fishing Industry

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Abstract

Marine foulers and borers are considered a major threat to the worlds fishing fleet and associated fishing gear. This paper provides the findings on this subject looking at the effects of these organisms in relation to their biology, impacts on the ears, and costs incurred within the industry. The literature surveys today's prevention methods including antifouling technologies and maintenance procedures but also future methods and their effectiveness. Further, it captures ecological concerns of eradicating marine foulers and borers while stressing on measures that are conducive environmentally. Based on the ideas presented in this paper, the primary risks that originate from the presence of these organisms and the current practices to mitigate them can be described comprehensively using the results of the latest scientific researches and techniques available in the industry. The aim is to increase the fishing industry's knowledge of management and reduction of society's negative impact on the environment and foster a sustainable future for marine operations.

Keywords: Marine Foulers; Marine Borers; Hull Fouling; Antifouling Coatings; Economic Impact

Introduction

The fishing industry, which is perhaps the most important sector of the world's output, is confronted with a number of obstacles concerning its sustainability and productivity. Damage from marine fouler and borer species is one of the issues that consistently drives up the cost of fishing gear and boats. It has previously been determined that species such as barnacles, algae, mussels, shipworms, and gribbles that dirty or bore holes in boats pose a serious threat to maritime operations [18].These creatures provide a double threat to the fishing industry: they physically damage boats, increasing drag force, eroding hulls, and necessitating frequent repairs; on fishing gear, they diminish the gear's useful life and limit capacity.

They go on to say that every one of these problems has a significant negative impact on the economy. Some of them include higher fuel costs, lower catch rates, and more equipment management and operation expenses. The fishing industry loses billions of dollars annually as a result of the significant marine challenges of fouling and boring [14]. This is due to the fact that the fishing business globally is estimated to be worth $150 billion year [7]. The life history of these animals must be examined in this article in order to fully comprehend the effects that marine foulers and borers have on fishing vessels and gear, as well as the mode and extent of the harm that they cause. Additionally, the economic effects of these animals' invasion on the fishing industry must be taken into account.

In addition to this, it will investigate the existing mitigation measures, the new technologies, and the environmental factors that are associated with these challenges.

Biology of marine foulers and borers

Marine foulers

Fouling organisms in marine environments are comprised of a wide variety of species that attach themselves to submerged surfaces. The process of fouling normally takes place in phases, starting with the production of a biofilm that is made up of bacteria and microalgae, and then moving on to the settling of bigger species [1]. These are the primary categories of marine foulers:

- **Microfoulers**: Bacteria, diatoms, and protozoa.
- **Soft macrofoulers**: Algae, soft corals, and sponges.
- **Hard macrofoulers**: Barnacles, mussels, and tubeworms.

In the case of maritime constructions for example, one group offers the following challenges and the other offers a different crop of challenges. However, microfoulers are also involved in the establishment of slime layers which may improve the surface roughness needed especially by larger organisms. Soft macrofouler such as algae may considerably enhance the formation of thick mats, and thereby enhance the drag encountered by boats. Branching hard macrofoulants, such as barnacles and mussels, not only raises the drag coefficient but also acts as potential abradants that can hollow out protected covers and the substrates beneath them [19].

Overwhelmingly, the existence patterns of these organisms involve a free-swerving planctonic phase in their development and then a juveniles phase in which they fix themselves to stones. Their distribution patterns as well as development rates are, to a significant extent, influenced by environmental factors such as the type of water salt, temperature and nutrient in the water. it is expected that climate change could cause changes in these factors that would potentially exacerbate fouling organism range into areas that have not been affected in the past [17].

Marine borers

Borers in marine environments are organisms that are capable of degrading wood and causing severe damage to wooden buildings in marine environmental settings. The following are the two basic categories of marine borers:

- **Molluscan borers :** Primarily shipworms (Teredinidae).
- **Crustacean borers :** Mainly gribbles (Limnoriidae).

Shipworms are bivalve mollusks that penetrate wood by utilizing a pair of shells located near their front end. They have the ability to grow up to 1.8 meters long and construct intricate systems of tunnels within wooden buildings [9]. Gribbles are little crustaceans, usually about 1-4 mm in length, that construct shallow tunnels on the outside of wood. Although each gribble may inflict less harm than shipworms individually, their combined impact maybe substantial, resulting in the degradation of wooden surface [10].

Gaining a comprehensive knowledge of the biology and life cycles of these species is essential for formulating efficient preventative and mitigation techniques in the fishing industry.

Impact on fishing craft

Hull fouling

Hull fouling is a major problem caused by marine organisms in the fishing business. The presence of organisms on a vessel's hull might result in many issues:

- **Increased drag :** Fouling organisms roughen the hull surface, increasing frictional resistance as the vessel passes through the water. Research has shown that significant fouling may lead to a rise in fuel consumption of as much as 40% [2].
- **Reduced speed :** The higher resistance caused by fouling leads to a reduction in the speed of the vessel, which may provide significant challenges for fishing operations that depend on punctual arrivals to fishing grounds or markets.
- **Increased fuel consumption :** To counteract the effects of increasing drag, boats must use more fuel, resulting in elevated operating expenses and heightened environmental consequences.
- **Compromised maneuverability :** Excessive fouling may have an adverse effect on a vessel's maneuverability, possibly compromising safety during fishing activities.

A study of the Japanese fishing fleet highlighted the severe economic impact of fouling, with heavy barnacle accumulation resulting in a 40% increase in fuel costs, translating to an annual expense of $150 million [2].

Damage to wooden structures

Wooden boats, which are common in small-scale and artisanal fisheries, are particularly vulnerable to marine borers:

- **Structural weakening :** Shipworms have the ability to construct complex systems of tunnels within wooden hulls, which may greatly damage their overall strength and stability. In the most severe instances, this may result in a complete and disastrous collapse of the hull.
- **Increased maintenance :** Regular inspection and maintenance are essential for identifying and resolving borer damage, which may result in higher levels of downtime and maintenance expenses.
- **Shortened lifespan :** Continued infestation by borers may greatly diminish the longevity of wooden vessels, requiring more frequent replacements and raising the total expense of fleet administration.

According to reports, whole groups of wooden fishing boats have become unusable within a period of ten years because of uncontrolled damage caused by borers.

Impact on vessel systems

Marine foulers, located outside the hull, may negatively impact many essential systems that are vital for the functioning of a fishing vessel:

- **Cooling systems** : Marine creatures that accumulate may obstruct the flow of saltwater into intake systems and internal pipes, so diminishing the effectiveness of engine cooling mechanisms and possibly causing excessive heat buildup.
- **Sensors and instruments :** The formation of fouling organisms on sensors, such as depth sounders and speed logs, could affect their precision, possibly impacting navigation and fishing activities.
- **Propulsion systems :** Fouling on propellers can significantly reduce their efficiency, further contributing to increased fuel consumption and reduced speed.

Impact on fishing gear

Nets and traps

Fishing nets and traps are especially vulnerable to the impacts of marine fouling:

- **Reduced catch efficiency :** Fouling organisms have the potential to obstruct the openings of nets, resulting in decreased water flow and increased visibility to fish. This, in turn, leads to a reduction in capture rates [8].
- **Increased weight :** The excessive accumulation of fouling organisms increases the weight of nets and traps, making their deployment and retrieval more challenging. Additionally, it has the ability to modify their original form and impair their intended function.
- **Accelerated degradation :** Net materials may experience accelerated deterioration due to fouling, resulting in a shorter lifetime and higher replacement costs.
- **Altered selectivity :** Alterations in the mesh size caused by fouling may impact the ability of nets to selectively collect fish of a certain size, which may result in unintentional capture of non-target species or fish that are too small.

Lines and ropes

Marine fouling also impacts fishing lines and ropes.

- **Reduced strength :** Accumulation of fouling may lead to the deterioration of lines and ropes via increased friction and corrosion of the materials.
- **Increased visibility :** Fouled lines may be more conspicuous to fish, perhaps leading to decreased capture rates in some fisheries.
- **Handling difficulties :** Severely contaminated ropes might provide more difficulties in their manipulation, thus impeding fishing activities and increasing the likelihood of harm to crew members.

Fish aggregating devices (FADs)

Fish aggregating devices (FADs), often used in some fisheries, are especially susceptible to fouling as a result of their extended presence in marine ecosystems.

- **Altered attractiveness :** Although a certain amount of fouling may improve a fish aggregating device's (FAD) capacity to lure fish, an excessive amount of growth can alter its properties and perhaps diminish its efficacy.
- **Structural integrity :** Excessive fouling may have a negative impact on the buoyancy and structural stability of Fish Aggregating Devices (FADs), which may result in their loss or malfunction.

- **Environmental concerns :** Severely contaminated fish aggregating devices (FADs) that get detached might transform into marine debris, posing a significant threat to marine ecosystems.

Economic implications

The cumulative consequences of marine organisms that attach and bore into fishing vessels and equipment result in substantial financial repercussions for the fishing sector.

Increased operational cost

- **Fuel consumption :** Hull fouling results in an augmented resistance to the movement of a fishing vessel, leading to an increase in fuel consumption. This increase in fuel consumption might constitute a significant proportion of the vessel's operating expenses.
- **Maintenance and cleaning :** Continual cleaning and maintenance are necessary for vessel owners to eliminate fouling organisms and fix damage caused by borers. These activities incur continuing expenses.
- **Gear replacement:** The rapid deterioration of fishing gear caused by fouling requires more frequent replacements, leading to higher equipment expenses.

Reduced Productivity

- **Decreased catch rates :** Once fishing gear becomes fouled, its effectiveness may decrease, resulting in less catches and thus lower pay for fishermen.
- **Increased fishing time :** Reduced efficiency may need longer periods at sea for vessels to attain the same catch, hence augmenting operating expenses.
- **Lost fishing opportunities :** The allocation of time towards maintenance and cleaning activities results in a reduction of fishing possibilities, which in turn has a direct negative effect on revenue.

Fleet management challenges

- **Vessel downtime:** Performing routine maintenance and repairing fouling and borer damage leads to longer periods of inactivity for ships, which negatively impacts the overall efficiency of the fleet.
- **Fleet renewal costs :** If wooden boats are heavily infested with borers, fleet owners may need to replace them more often, resulting in substantial capital expenses.
- **Compliance costs :** Complying with stricter environmental requirements on antifouling procedures may be a substantial financial burden for fishing fleet owners.

The economic impact of maritime fouling and borer damage on a worldwide scale is enormous. Estimates indicate that fouling alone may result in yearly costs of up to $56 billion for the global shipping industry, with a considerable share of this burden falling on the fishing sector [13]. In underdeveloped nations, where traditional fishing is a primary means of subsistence, the economic consequences might result in substantial socio-economic difficulties, such as unemployment and inadequate access to food [12].

Current mitigation strategies

The fishing industry utilizes many measures to minimize the effects of marine foulers and borers.

Antifouling coatings

Antifouling paints and coatings are the major means of protecting vessel hulls against maritime fouling:

- **Biocide-based coatings :** These coatings gradually release harmful compounds to inhibit the adhesion and proliferation of fouling organisms. Restrictions have been imposed on some biocides, such tributyltin (TBT), due to concerns over their environmental consequences, notwithstanding their effectiveness [3].
- **Foul-release coatings :** These non-toxic coatings provide a lubricious surface that hinders the attachment of organisms. They are especially efficient for ships that consistently maintain a certain speed, since the movement of water aids in the removal of organisms that are only loosely attached [4].
- **Biomimetic coatings:** These coatings are designed to imitate the surface characteristics of creatures that are resistant to fouling, such as shark skin or lotus leaves, by drawing inspiration from natural antifouling systems [15].

Mechanical cleaning

Regular maintenance of hulls and gear is essential for effectively controlling fouling:

- **In-water cleaning :** Divers or remotely operated vehicles (ROVs) have the capability to clean the hulls of vessels while they are still in the water, which helps to minimize the need for dry-docking.
- **Dry-docking :** Regular extraction of vessels from the water enables meticulous cleaning and examination, which is especially crucial for treating borer damage in hardwood vessels.
- **Gear cleaning :** Regular maintenance and drying of fishing equipment while not in use may effectively control the accumulation of unwanted substances and prolong its durability.

Material selection

Selecting suitable materials may help reduce the effects of foulers and borers:

- **Borer-resistant woods :** Certain tropical hardwoods possess inherent resistance to borer infestation and are suitable for the building of wooden vessels.
- **Non-wooden construction :** Utilizing materials such as fiberglass, steel, or aluminum for constructing vessels eradicates the potential for borer damage.
- **Synthetic gear materials :** Contemporary artificial materials used in fishing equipment may exhibit greater resistance to fouling and deterioration in comparison to conventional natural fibers.

Operational practices

Implementing certain operating measures may effectively address fouling and borer issues:

- **Speed management :** Increasing the average speed at which a vessel travels may assist in minimizing the buildup of fouling on the hull.
- **Reduced idle time:** Reducing the amount of time that boats remain inactive in port may decrease the chances for fouling organisms to settle.
- **Fresh water immersion:** Whenever feasible, immersing equipment in freshwater may effectively eradicate marine fouling organisms.

Emerging solutions and future directions

Ongoing research is being conducted to find innovative solutions for the issues provided by marine foulers and borers in the fishing sector.

Advanced materials and coatings

- **Nanomaterials :** Nanostructured materials and coatings have potential in developing surfaces that effectively prevent fouling at the microscopic scale [5].
- **Bio-inspired solutions :** Additional investigation into natural antifouling systems has the potential to provide more efficient and ecologically sound solutions.
- **Smart coatings:** The objective is to create coatings that possess the ability to adjust to different environmental conditions or be triggered from a distance in order to release antifouling chemicals at the appropriate time.

Biological control

- **Natural predators :** Promoting the existence of indigenous predators of fouling species in marina ecosystems might effectively regulate fouling levels.
- **Probiotic approaches :** The introduction of advantageous microorganisms that compete with or hinder the growth of fouling species is a subject of continuous investigation.

Ultrasonic and electromagnetic systems

- **Ultrasonic fouling prevention :** Researchers are now developing and testing systems that produce ultrasonic waves to deter the settling of fouling organisms.
- **Electromagnetic fields :** Ongoing research is being conducted on the use of electromagnetic fields to discourage the growth of fouling organisms. However, the implementation of this technology in practical settings is still restricted.

Predictive modeling and management

- **Fouling prediction models :** Creating predictive models that can estimate fouling rates using environmental factors and vessel parameters might enhance the efficiency of cleaning and maintenance programs.

- **Integrated management systems:** By integrating various methods like as coatings, cleaning routines, and operational strategies customized for certain ships and operating circumstances.

Environmental considerations

While it is important to address the issue of marine foulers and borers in order to protect the fishing industry, it is as important to carefully evaluate the environmental consequences of antifouling techniques.

Toxicity of antifouling biocides

A significant number of efficient antifouling coatings depend on the emission of biocides, which may have adverse effects on marine creatures that are not the intended target. The prohibition of TBT-based paints, prompted by their significant ecological consequences, underscores the need of thoroughly evaluating the enduring ramifications of antifouling substances [3].

Invasive species transport

Contaminated vessels and equipment might unintentionally carry invasive species to unfamiliar habitats. Therefore, effective fouling control is not only a matter of economic importance but also a crucial part of conserving the marine ecology [16].

Cleaning waste management

The process of washing boats in water may result in the discharge of fouling organisms and paint particles into the marine environment. Ensuring the appropriate confinement and elimination of cleaning waste is crucial in order to reduce the environmental consequences [11].

Life cycle considerations

Antifouling coatings and treated materials have distinct environmental impacts throughout their manufacture, usage, and disposal processes. Life cycle evaluations may aid in the development of more sustainable methods for managing fouling and borer issues [6].

Conclusion

Marine organisms that accumulate and damage fishing equipment and boats provide a continuous and substantial problem for the fishing industry. The economic consequences of these creatures are significant, including higher operating expenses, decreased productivity, and difficulties in managing the fleet. Existing mitigating measures, which mostly focus on using antifouling coatings and performing regular maintenance, provide some respite but also raise environmental issues.

In order to keep up with the progress of the industry, it will be essential to adopt a comprehensive strategy for the management of marine organisms that cause fouling and boring. This strategy aims to integrate advancements in materials science and biotechnology with enhanced operational procedures and predictive management technologies. In addition, the creation of innovative solutions must meticulously consider the trade-off between efficiency and the influence on the environment, guaranteeing the enduring viability of both the fishing sector and marine ecosystems.

Future research should prioritize the development of eco-friendly antifouling treatments, enhancing our understanding of the biology of fouling and boring species, and establishing specialized integrated management systems for vessels under particular operating situations. In order to effectively tackle these difficulties, it will be crucial to foster more cooperation among the fishing industry, materials scientists, marine biologists, and legislators.

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