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REVIEW

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A Comprehensive Review of Fishing Craft Technology's Realistic Fish Behavior

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Abstract

Understanding fish behavior is critical to enhancing fishing craft technology. This is an informative review of the use of real-life fish behavior in modern fishing establishments, especially concerning issues of enhanced performance and progress towards responsible fishing and wildlife species protection. Here, we provide a brief overview of the biological and ecological aspects of fish behavior, followed by a discussion on high-tech fishing crafts that mimic or align with fish behavior. The review also addresses the effects of such technologies on both the fishing industry and the aquatic environment. Expounding the possibilities of future development within the given subject area based on available literature and critical evaluation of new technologies, this paper emphasizes the need for the integration of biological understanding and technological support for enhanced fishing rates and sustainable fishing. Characteristics of fish behaviour in the context of fishing practices increase the volume of production and the sustainability of fishing and fish stocks. This extensive literature review will provide valuable insights for future research and development of fish behavior-related fishing methods.

KEYWORDS

Fish Behavior, Fishing Craft, Challenges, Fishing Knowledge

INTRODUCTION

Fishing is an essential food supply and a major contributor to worldwide economic growth, making it one of humanity's oldest and most fundamental occupations. The relationship between fishing methods and fish behavior is complex, influencing everything from fishing vessel design to fish capture strategies. Historically, fishing has relied significantly on observational skills and experience. However, recent technological achievements have allowed for a more detailed understanding of fish behaviour, which has the potential to revolutionise fishing practices and improve environmental sustainability. As fishing techniques have advanced, so too has our ability to study and interpret the biological and ecological factors influencing fish behavior. Modern technological advancements, such as high-resolution sonar, underwater cameras, and behavioural modelling software, provide fresh insights into the intricate patterns of fish activity, such as eating habits, migration routes, and social relationships. Critical data from these technologies enables the design of fishing crafts and strategies that better align with fish behavior, potentially enhancing efficiency and minimizing ecological impact. This review aims to provide a comprehensive exploration of how contemporary fishing craft technology can integrate realistic fish behaviour to enhance both performance and sustainability. The review will commence by scrutinizing the fundamental biological and ecological aspects of fish behavior, encompassing the ways in which environmental factors like water temperature, salinity, and habitat structure impact fish behavior. This foundational understanding is essential for developing fishing technologies that are not only more effective but also more respectful of fish stocks and aquatic ecosystems. The paper will then explore recent advancements in fishing technology, focusing on innovations that leverage insights into fish behavior. Examples include advanced sonar systems that use sophisticated algorithms to detect and track fish more accurately, autonomous underwater vehicles that can monitor fish movements in real time, and smart nets and traps designed to minimise bycatch. These technologies represent a significant leap forward in fishing practices, offering the potential to optimise fishing efforts while reducing environmental impact. However, while these advancements in technology provide numerous benefits, they also present significant risks. If not handled appropriately, the enhanced efficiency provided by these technologies could lead to overfishing and the destruction of fish supplies. As a result, the evaluation will also discuss the broader implications of these technologies for the fishing industry and the environment. It will explore the importance of taking a balanced strategy that combines technological improvements with sustainable fishing techniques to ensure the long-term health of fish populations and aquatic ecosystems. In addition, the article will provide a critical review of existing research and upcoming technologies, as well as a framework for integrating biological insights with technological advances. This framework seeks to promote the development of efficient and sustainable fishing methods, emphasising the significance of ongoing study and adaptation to changing environmental conditions.

FISH BEHAVIOUR HAS A BIOLOGICAL AND ECOLOGICAL FOUNDATION

Fish behavior is shaped by a variety of biological and ecological factors, including sensory perception, communication, social interactions, and environmental conditions. Key behaviours relevant to fishing include schooling, migration, predator-prey interactions, and foraging.

1. **Sensory Perception and Communication:** To forage and avoid enemies, the given fish are capable of seeing, smelling, and perceiving their environment through lateral line organs. Understanding these sensory systems is crucial, as they can potentially attract or repel fish from various objects or systems.

a. **Vision:** The ability of fish to see depends on the species since distinct species are located within different zones of light. Artificial lures like those mentioned above involve colour and movement patterns that tend to elicit predatory behaviour in fish. For instance, Marshall et al. (2003) conducted a study that reveals a variety of fish species with varying sightings, indicating that the lures cannot affect them equally.

b. **Olfaction:** Established facts reveal that fish rely on smell to find food, a mate, or, for that matter, anything hot or harmful. We develop lures like scented baits and chemical attractants based on our understanding of these pheromonal signals. Thus, research by Kasumyan and Doving (2003) sheds light on how various sorts of fish react to the chemical action and helps to determine the right bait composition.

c. **Lateral line:** This System also includes a system that allows fish to feel vibrations and pressure changes in water. The baiting mechanism also entails that fishing gear that creates precise vibrations can lure the fish by mimicking the prey's or other fish's signals. According to Coombs et al. (1988), there are some prospects for fish's mechanosensory capabilities and their use in fishing techniques.

2. **Social Interactions and Schooling:** Duty is a common social behavior among fish species that has several advantages, such as protection from predators and efficient foraging. Fishing nets and traps can incorporate schooling movements, which mimic natural stimuli and compel fish to gather in a specific area.

a. **Aggregation and Shoaling:** Implementations such as fish aggregating devices (FADs) rely on the tendency of fish to go to school, which will lead to an increase in fishing efficiency. In the same vein, Moreno et al. (2007) discuss FADs in pelagic fisheries and their effects on fish behaviour.

b. **Behavioural Mimicry:** Attracting fish or enabling their capture through mechanisms such as imitations of conspecifics or predators is another effect of technologies on fish movement. Pitcher and Parrish (1993) have conducted other documented studies on shoaling behavior that provide a relevant basis for establishing such technologies.

3. **Migration Patterns:** In this case, spawning, feeding, and other factors like water temperature and currents determine fish movement, which significantly impacts the availability of fish to fishing crafts. Fish finders and sonar systems, among other devices, aid in monitoring and forecasting movement patterns that increase catches.

a. **Spawning Migrations:** Knowledge of the timing and migration routes of spawning fish may assist fishers in locating the fish at their weakest points and most vulnerable times in the life cycle. According to Quinn and Myers (2004), articles and reviews shed light on the ecological and evolutionary basis of fish migration and its implications for fisheries management.

b. **Feeding Migrations:** It is necessary to consider some kind of feeding rhythm, such as, for instance, the rhythms of the year and of the day. Sims et al.'s (2006) research focuses on the aspects of foraging fish and their relevance to or with reference to fishing.

4. **Predator-Prey Dynamics and Foraging:** Some factors that relate to fish and fishing gear include the fish's response to predators, their methods of finding food, and their methods of catching them, all of which play a significant role in determining their exposure to fishing gear. Sensing devices that mimic the movements of prey or produce attractants can enhance the effectiveness of baited traps and fishing lines.

a. **Predatory Strategies:** Some techniques can involve copying the hunting behaviour of the predator to lure fish in the waters into the trap or nets. Lima and Dill's (1990) work has many applications in the behavioral ecology of predator-prey relations. Given the context of these applications, we can describe the adaptation as follows: Therefore, the concepts that were implicit in Lima and Dill's work remain relevant today. Furthermore, Lima and Dill's (1990) theoretical perspectives on the behavioural ecology of predator-prey relations can illuminate the present discussion in the following ways:

b. **Prey Attraction:** Due to their similar characteristics, fish find lures that resemble their natural prey attractive. Findings by Løkkeborg&Fernö (1999) on cod foraging have been used to influence the aspects involved in the construction of better lures.

FISHING BOATS AND TECHNOLOGICAL ADVANCEMENTS

1. Fish Finders and Sonar Systems: Imaging also captures the position and behaviour of fish or the abundance of fish in a certain area. The main and most efficient of these systems is the use of sound signals to help identify schools of fish and even individual fish and transmit this information to the fishers in real time.

a. Multi-beam sonar provides increased image quality and is effective at identifying the three-dimensionality of fish movements. MacLennan and Simmonds (2005) provided useful information about the principles and uses of acoustic technologies for fish detection.

b. Side-scan sonar is useful in the identification of schools of fish and in the imagery of the furthermost structures of the sea. Foote et al. (1996) emphasise the use of side-scan sonars as mapping tools in fisheries, as well as the pros and cons of such an approach.

2. Biomimetic Fishing Gears: To effectively attract and harvest fish, we develop biomass fishing tools based on their natural behaviours and physical characteristics. Some of the techniques used include nets with designs that resemble the hunters or bait that imitates the behaviour of the target species.

a. Lure Design: Experts have developed lures that mimic fish movements and appearances to improve fishing success rates. Vinyard (1980) conducted a study on the observation of fish on the artificial lures as part of the design of this equipment.

b. Net Design: Shaped nets that can change their forms or colours to imitate predator attack patterns are likely to drive the fish into capture areas more effectively. Wardle (1993) investigated fish behavior in relation to fishing gear to gain more information on such innovations.

3. Research demonstrates the benefits of using artificial intelligence to understand fish behavior and specific movements through machine learning algorithms. Most of these technologies should be capable of analyzing large volumes of data from sensors and cameras in order to provide fishermen with adequate information.

a. Behavioural Prediction Models: By forecasting fish behaviour based on various factors, these models increase fishing effectiveness. Brooks and Shindler (1995) explain how ecological relationship understanding is applied in fish stock assessments.

b. Automated Monitoring Systems: The application of machine learning to detect and monitor fish species using videos is improving. Chamoso et al. (2020) are a detailed article that shows the potential of artificial intelligence integration in fisheries surveillance and management.

4. Environmental Sensors and Data Integration: Present fishing crafts are fitted with environmental monitoring devices that look at water parameters, such as temperature and salinity, which affect fish activities and other characteristics. Using this data, it is possible to increase the fishing process's fitness through fish behaviour models.

a. Real-time Environmental Monitoring: Information input from sensors that monitor the physical and chemical conditions aids the fishermen in their decision-making. Baumgartner et al.'s (2003) work on Applications of Environmental Monitoring in Fisheries Management highlights these uses.

b. Data Integration Platforms: By combining environmental data with fish behavior models, naval applications can enhance fishing routes and techniques. The study by Walters and Martell (2004) highlights the importance of data integration in adaptive fisheries management.

THE FINDINGS REGARDING THE FISHING INDUSTRY ARE AVAILABLE

1. Increased Efficiency and Catch Rates: By imitating the actual behavioural pattern of fish, fishing crafts can achieve larger yields in a shorter timeframe while using relatively less fuel. It not only increases the efficiency of fishing activities to earn the greatest amount of revenue possible, but it also minimises the negative impact on fishing communities and oceans.

a. Optimised Gear Deployment: Studying fish behaviour is beneficial in ensuring the proper placement and timing of the gears. In their paper, Rijnsdorp et al. (1991) argue about aspects such as the impact of the physical environment and fish behavior on gear graduation tactics.

b. Fuel Efficiency: They help to eliminate localised traffic peaks, thus minimising the total fuel consumption and the overall emission rate at the same time. Anderson & Moore (1997), having scientifically reviewed and analysed the effects of efficient fishing on the economy, offer innovation in these advantages.

2. Sustainability and Conservation: Learning their behaviour and applying it during fishing will improve the discrimination between target and non-target species, thus decreasing its overall effect on non-target species. Reduced-impact technologies used in fishing to help reduce impacts on habitats and reduce rates of overfishing are important in fisheries management.

a. Selective Fishing Techniques: Technologies that use a selective approach that focuses on specific species and behaviours result in low bycatch levels. The publication by Hall et al. (2000) on bycatch reduction techniques shows a strong emphasis on the role of selective fishing.

b. Habitat Preservation: Methods that do not harm areas crucial for wildlife reproduction can maintain marine ecosystems. Kaiser et al. (2002) wrote a paper on the effects of fishing gear on benthic structures to improve utilization procedures.

3. The adoption of advanced fishing methods can enhance the economic viability of fishing, assist men in providing for their families, and enhance the nation's food supply. Training fishermen in the proper use of these technologies is imperative, given the significant changes in fishing methods' diversification.

a. Community Engagement: To enhance their technological adaptation, locals must develop and implement fishing technologies. According to Pomeroy and Berkes' (1997) general literature on co-management in the specific field of fisheries, community participation has some benefits.

b. Skill Development: Providing technology-based training, in particular, helps to improve fishermen's knowledge and efficiency. Regarding the socio-economic aspect of fishing technologies, the study by Béné (2006) raises the issue of capacity development.

CHALLENGES AND FUTURE DIRECTIONS

1. Technological Limitations: Despite the successes, there are still issues with the relevance, accuracy, and reliability of fish behavior models and the performance of aggregative systems. Therefore, there is still a need to carry out more studies in order to overcome the challenges mentioned.

a. Model Accuracy: Improving model predictability, obtaining more information, and refining algorithms can potentially address the challenging problem of supervisory control. The challenges of applying models in fishery management highlight some of the weaknesses studied by Hilborn and Mangel (1997).

b. Detection Reliability: Improving the detection systems' effectiveness and general performance, particularly in different settings, is important. Among such problems, Løkkeborg et al. (2002) reveal the specificities of a sonar system's performance in various conditions.

2. Fishing techniques pose significant ethical concerns due to their impact on fish stocks and the aquatic ecosystem. Fortunately, we pay attention to the use of technology, taking into account moral and ecological aspects.

a. Ethical Fishing Practices: Managing these technologies to prevent overfishing and fish welfare is crucial. Pauly et al. (2002) elaborate on the ethical aspects of the sector, addressing the above-stated problems of fisheries management.

b. Ecosystem Impact: It is critical to evaluate the various effects of fishing gear on the marine environment and minimize any negative consequences that may arise in the future. Jennings and Kaiser (1998) have provided some guidelines on how to reduce environmental impacts in two categories related to fishing's ecological effects.

3. Policy and Regulation: It is crucial to develop and establish regulations and policies for fishing technologies. Policies should encourage conservation and utilisation of technology in a way that is fair to everyone.

a. Regulatory Frameworks: Establishing international standards for fishing tools can help ensure proper practice. According to Garcia and Cochrane (2005), the principles of fisheries management entail regulatory measures.

b. Access and Equity: It is, therefore, necessary that innovative technologies are available to small-scale and artisanal fishermen for equitable development. Works by Béné et al. (2007) highlight the limitations and prospects of small-scale fisheries in reference to the issue of technology.

4. Interdisciplinary Collaboration: As a result, advancement in this field necessitates cross-disciplinary cooperation from biologists, ecologists, engineers, and fishermen. Finding overall solutions to the issues under analysis requires multi-disciplinary analysis and the involvement of all parties involved, both directly and indirectly.

a. Research Collaboration: It suggested that cooperative projects among the scientists can contribute to the development of new ideas about the fisheries' organisation and help to solve multifaceted problems in this sphere. The chances of interdisciplinary cooperation that Botsford et al. (1997) identify in their study provide insights into the advantages of preserving the marine ecosystem.

b. Stakeholder Engagement: It's crucial to involve all interested parties, such as fishermen, conservation-affiliated executives, and policymakers, in the development of technologies to prevent situations where experts solve problems with punitive measures but the end users hardly blame them. Defeo and Castilla (2005) also pointed out that, in the practice of community-based management in fisheries, the participation of stakeholders proved to be very critical in the successful management of the fisheries resources.

CONCLUSION

This is a significant advancement in fishing craft technology, as it incorporates realistic fish behaviours to improve efficiency and output, promote fishing sustainability, and enhance conservation efforts. These methods mimic the natural movements and behaviours of fish, reducing the impact of bycatch, improving the environment, and enhancing the fishing industry. However, several limitations in the literature and theories, such as technology restraints, moral issues, and the necessity of appropriate policy solutions, still persist. Only redirected effort, research, ongoing technology integration, and, most importantly, collaboration across disciplines can overcome these challenges for the future of sustainable fisheries.

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