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Research on Aquatic Animal Behavior and Environmentally Friendly Fishing Techniques

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Abstract

The research on "Aquatic Animal Behavior and Environmentally Friendly Fishing Techniques" aims to achieve sustainable fisheries development by understanding the behavioral patterns of aquatic animals during fishing operations and designing fishing gear and methods with high selectivity and minimal environmental impact. This research, grounded in fish behavioral responses to external stimuli like sound, light, and electricity, has been pursued internationally for decades. Advances in observation technology have led to the development of various devices (e.g., TEDs, BRDs) that reduce bycatch and protect juvenile fish. Current research has identified key factors affecting post-capture fish survival rates (e.g., entrapment duration, hook type) and explored leveraging behavioral differences (e.g., using ultrasound to deter dolphins) to enhance selectivity. However, existing studies are largely confined to single-stimulus experiments, with limited understanding of deeper mechanisms such as multi-factor interactions in complex marine environments, fish schooling communication, and behavioral perception. Future research must transition from single-factor analysis to comprehensive multi-factor studies, delving deeper into fish behavioral mechanisms. On one hand, this foundation should drive the development of novel eco-friendly fishing gear and establish a theoretical framework for resource conservation. On the other hand, economically viable and easily scalable fishing solutions must be proposed. Through pilot demonstrations, these efforts should tangibly enhance the ecological efficiency and sustainable development of China's coastal and offshore fishing industries.

Keywords

Fish Behavior; Fishing Methods; Bycatch; Sustainable Development.

1. Background

Research on "Aquatic Animal Behavior and Environmentally Friendly Fishing Techniques" primarily aims to understand the behavioral patterns of aquatic animals during fishing operations. By identifying behavioral differences among various fish species and sizes, researchers can design targeted environmentally friendly fishing gear and methods. This approach enables efficient capture of target species, safely displace or release non-target species, and minimize environmental impacts during operations. This establishes a robust practical foundation for sustainable fisheries.

2. Research Status

Understanding aquatic animal behavior serves as a critical basis for designing fishing methods and gear. The behavioral responses of target species to external stimuli-such as sound, light, electricity, fishing gear, and its components- This determines the capture efficiency and

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environmental friendliness of the fishing methods and gear employed. Major international fisheries technology conferences, such as the Hamburg (1957), London (1963), and Reykjavik (1970) World Gear Conferences, as well as the Hamburg (1977) International Marine Workshop, have all addressed the relationship between fish behavior and fishing methods. During the same period, 17 countries, including Europe and the United States, represented by ICES (International Council for the Exploration of the Sea), initiated foundational research on ecologically sustainable fishing methods. Advances in underwater observation equipment, photographic technology, and deeper understanding of marine fish ecology and behavior led to significant progress in gear selectivity research, primarily aimed at protecting juvenile fish and releasing bycatch.

At the 1992 Bergen Conference on Fish Behavior and Fishing Methods in Norway, numerous scholars analyzed fish behavior during trawling, purse seining, gillnetting, and longline fishing operations through tank experiments and mathematical modeling. They emphasized the necessity of applying fish behavior knowledge to selective fishing, stock assessment, and fisheries management [1].

In recent years, environmentally responsible fishing has become a global priority in gear and method research. Nations worldwide are intensifying studies on ecological fishing technologies to ensure sustainable exploitation of resources within their exclusive economic zones. Leading European and American countries, including Norway, the United Kingdom, and Denmark, have developed various selective fishing gear devices based on fish behavior control technologies. These include Trawl Efficiency Devices (TEDs), Separation devices for catch (SURF-BRD), bycatch reduction devices (BRDs), size-selective catch devices (Sort-x), and selective shrimp trapping devices (Disela II). These devices have played a positive role in preventing the incidental capture of juvenile and non-target fish in shrimp trawling, releasing juvenile fish and sea turtles, and more.

An important aspect of environmentally responsible fishing is the practical protection of target fish individuals through optimized gear design. Therefore, the survival rate of target fish after release following capture serves as a key indicator. In this regard, Vande et al. conducted research on gillnets [2], identifying water temperature, entrapment duration, and fish size as primary factors influencing survival rates. For skipjack tuna in purse seine operations, survival rates correlate with catch density within the seine and entrapment duration [3]. In longline fishing, survival depends on species, handling methods, and gear type. Generally, hook penetration depth, hooking location, and removal techniques significantly impact the subsequent survival of released fish [4]. Swallowed hooks may cause greater injury than those hooked in the mouth. Hook design can influence survival rates; for instance, round hooks offer greater protection than traditional barbed hooks. Leveraging dolphins' higher sensory frequency range compared to most fish, equipping large drift gillnets with ultrasonic transducers emits alerts inaudible to fish while deterring dolphins through high-frequency sound waves, thereby preventing entanglement [5].

Studying fish behavioral responses to external stimuli is not only closely related to fisheries science but also plays a significant role in aquaculture, fish ecology, conservation, biomimicry, and numerous other fields.

3. Existing Challenges

Research on aquatic animal behavior within environmentally friendly fishing technologies involves multiple disciplines and their intersections, including environmental science, signaling, fish neuroscience, and evolution. With deepening human understanding of the ocean and advancements in new materials, monitoring, electronics, and information technologies, extensive research has been conducted on fish phototaxis, visual-motor responses, reactions to

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acoustic and chemical stimuli, feeding sensations, predatory behaviors, and responses to bubble curtains, trawl ropes, and net panels, yielding considerable progress.

However, most previous studies have been single-stimulus factor investigations based on tank experiments, observations, and theoretical calculations. The behavioral responses and patterns generated by the interaction of multiple stimuli-such as light, sound, electromagnetic fields, chemicals, water currents, and temperature-on different fish species under varying marine environmental conditions remain largely unexplored. Similarly, questions persist regarding the swimming direction of large fish schools when startled or stimulated, whether and how fish or schools communicate information in response to external stimuli, as well as the behavioral responses, memory, sensitivity, directional orientation, and perception mechanisms of different fish species to various external stimuli. These areas require further in-depth and long-term exploration and research.

4. Future Outlook

Although decades of research have been conducted on aquatic animal behavior within environmentally friendly fishing technologies, most studies to date remain single-factor investigations. This has yet to establish a theoretical foundation capable of supporting new environmentally friendly fishing techniques. Achieving the ideal requirements of effective conservation and practical feasibility remains distant. Current research must therefore proceed pragmatically, aligning with the developmental status of the fishing industry. On one hand, by studying the behavioral mechanisms of fish schools, gaining insights into the relationship between fish behavior and external environments-particularly their response patterns to fishing gear and its components-to design and develop ecologically friendly gear that facilitates the release and escape of bycatch species. This will establish a theoretical framework and technical methods for marine fishery ecological conservation and fishery resource management in China. Simultaneously, new fishing techniques that are simple to implement and profitable for fishermen should be proposed, with pilot projects, demonstrations, and widespread adoption to follow. This approach will genuinely enhance the sustainable utilization of nearshore fishery resources, the development of new offshore resources, and the level of ecologically efficient fishing technology, thereby achieving the healthy and sustainable development of China's nearshore and offshore fishing industries.

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