



# Fish Behavioral Responses to External Stimuli and Fishing Method Research

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## ABSTRACT

Fish behavioral responses to external stimuli serve as a critical basis for designing and optimizing fishing methods, directly impacting catch efficiency, resource assessment, and fisheries management. Since the 1950s, international academic circles have advanced this field through major conferences (e.g., Hamburg 1957, London 1963) and systematic research, notably led by the United States, Russia, Japan, and Norway. China has published works such as Fish Behavior and Fishing Technology and Fish Ethology since the 1980s, achieving significant progress in phototaxis, acoustic-electrical stimulation, and feeding behavior. Research has progressively expanded into interdisciplinary applications including aquaculture, ecological conservation, and bionics. Fish responses to external stimuli (light, sound, electromagnetic fields, water currents, etc.) vary by species. For instance, the sixline wrasse exhibits extreme sensitivity to water currents, the American whitefish detects ultrasonic waves to warn of predators, and Japanese eels rely on geomagnetic navigation for spawning. Building on these behavioral traits, fisheries have developed multiple behavioral control technologies: reducing bycatch through net-based isolation barriers, guiding migratory fish away from hydroelectric turbine units using underwater strobes, protecting dolphins from gillnet entanglement via ultrasonic devices, and employing phototaxis and electric field effects for light-based trapping and electrofishing techniques. However, existing technologies still face challenges, such as isolation devices affecting trawl efficiency and fish developing adaptations to persistent stimuli. Future research should focus on understanding fish perception mechanisms (e.g., auditory sensitivity and directional orientation), optimizing stimulus signal types and sustainability, and deepening fundamental studies on behavioral memory to advance the precision and ecological friendliness of fishing methods.

## KEYWORDS

Fishery; Fish Behavioral Responses; Fishing Method.

## 1. BASIC INFORMATION

The behavioral responses of fish to external stimuli constitute a critical aspect for consideration in the study of fishing methods. Understanding the mechanisms underlying these responses decisively influences the effectiveness of fishing operations. Without accurate data in this field, designing new fishing gear or developing novel fishing techniques is inconceivable. Since the 1950s, this issue has been addressed at nearly every major international fisheries technology conference, including Hamburg (1957), London (1963), Reykjavik (1970), and the 1977 International Marine Science Conference in Hamburg. Particularly noteworthy was the 1992 Bergen Symposium on Fish Behavior

Related to Fishing Methods, where 58 papers analyzed fish behavior in trawl, purse seine, set nets, and longline fishing operations. It underscored the necessity of applying knowledge of fish behavior in selective fishing, stock assessment, and fisheries management. At the national level, modern fish behavior research began to develop rapidly on the European continent before World War II. After the war, with the movement of talent, it also took root in the United Kingdom, particularly at the University of Oxford and the University of Cambridge. Today, the United States leads in the most systematic and in-depth research on fish behavior. In the field of fisheries science, countries with developed offshore fisheries, such as Russia, Japan, and Norway, also boast commendable research efforts.

## **2. DOMESTIC RESEARCH PROGRESS**

Specifically in China, some institutions have introduced courses on fish behavior, and the number of professionals engaged in this field continues to grow. Since the 1980s, publications such as *Fish Movement and Fishing Technology* (Mao Shaolian, 1985), *Selected Papers on Phototaxis Physiology in Fish and Marine Animals* (He Daren, 1988), *New Fishing Technologies: Acoustic, Optical, and Electrical Methods in Fishing* (Xia Zhangying, 1991), *\*Fish Behaviorology\** (He Daren, 1998). Chinese scholars have conducted extensive research on fish phototaxis, visual-motor responses, reactions to acoustic and chemical stimuli, feeding sensations and predatory behavior, conduct in electric fields, and responses to artificial reefs, bubble curtains, trawl nets, and mesh panels, achieving significant research outcomes. With the deepening of our understanding of the ocean and the development of new materials and physical methods, research on behavioral responses has reached a new level. This research extends far beyond fisheries science. Studying fish behavioral responses to external stimuli not only enriches the theoretical foundations of animal behavior, fish physiology, and fish ecology but also holds significant practical applications in aquaculture, fish ecology, conservation, and biomimicry. Moreover, it intersects with environmental science, signaling biology, fish neuroscience, and evolutionary biology, making it a quintessential interdisciplinary field.

## **3. STIMULI, BEHAVIORAL RESPONSES, AND FISHING METHODS**

For fish, external stimuli encompass light, sound, electromagnetic waves, chemicals, water currents, temperature, and more—though sensitivity varies by species. For instance, the giant sixline wrasse inhabiting the northwest Pacific Ocean possesses multiple lateral lines on its body surface, enabling exceptionally acute perception of subtle water current changes. This trait is closely linked to the complex hydrographic environment of its rocky reef habitat. Generally, humans can hear frequencies up to 20 kHz, but the American shad can detect the ultrasonic echolocation signals of its predator, the dolphin, at distances of up to 187 meters. These signals reach frequencies of hundreds of kilohertz. This ability provides timely warning, significantly reducing the likelihood of the American shad being captured [1]. Japanese eels exhibit seemingly random spawning sites in the Pacific Ocean. However, detailed research reveals a striking correlation between their distribution and geomagnetic field intensity. This indicates that eels can locate optimal spawning grounds by detecting subtle variations in the Earth's magnetic field.

Correspondingly, how to artificially stimulate fish to respond behaviorally according to human intent—that is, controlling fish behavior—has become a primary challenge for fisheries research institutes. For instance, the issue of bycatch began attracting worldwide attention in the early 1990s. Bycatch not only increases sorting labor intensity, reduces the quality and value of target catches, and impacts fishing operations' economic efficiency, but also, since bycatch often consists of juvenile fish—a food source for tuna, salmon, swordfish, dolphins, sea lions, and other marine life—its capture drastically reduces the replenishment rates of both target and non-target species. This has a significant ecological impact on certain species within marine areas [2]. To mitigate this issue, humans have

developed selective fishing methods by installing barrier screens within nets. This allows fish entering the net to be diverted out without compromising shrimp capture efficiency. Second, human-built hydroelectric dams often act as roadblocks on migratory fish routes. Installing underwater strobe lights before turbine units scares fish away from the machinery or even guides them into specially constructed fishways, achieving conservation goals [3]; The final example leverages dolphins' heightened sensory frequency compared to most fish. Equipping large drift nets with ultrasonic speakers emits warning signals inaudible to common fish, thus maintaining catch efficiency. Dolphins, however, perceive the sound as jarring and avoid the area, thereby preventing them from encountering the nets [4]. All three examples employ stimuli to deter fish. Conversely, certain methods leverage fish's tendency to approach external stimuli for attraction purposes. The phototaxis response exemplifies this: within a direct current electric field of specific intensity, fish align parallel to the electric lines and swim toward the anode. This inspired the invention of netless electrofishing: white lights lure bamboo sharks, while red lights beneath the suction pump's fishing apparatus concentrate them. Activating the anode creates an electric field around the pump's rubber hose funnel, successfully guiding the bamboo shark school onto the fishing vessel [5]. Similarly, exploiting squid's phototaxis, light-based squid fishing has become a mature operation.

However, the effectiveness of these methods remains limited. While isolation grids achieve good separation, they reduce trawl speed, increase operational hazards, and cause some shrimp bycatch [6]. Fish may adapt to prolonged flashing lights, becoming desensitized to human warning signals. These challenges compel fisheries researchers to delve deeper into fish behavioral responses to external stimuli and fishing methods. Key areas include: how to replace stimulus signals to achieve long-term sustainable effects; how to better leverage fish memory of stimulus responses; and further investigation into fish sensory characteristics—such as sensitivity, directional localization, and perception mechanisms—which remains crucial foundational work. Taking auditory perception as an example, while audiograms have been developed for dozens of fish species, no clear scientific patterns have yet been established. This suggests that human research into fish auditory systems may require greater depth and sophistication.

## ACKNOWLEDGEMENTS

This work was financially supported by Fund (NO.LOF 2024-01) of Key Laboratory of Open-Sea Fishery Development, Ministry of Agriculture and Rural Affairs, P. R. China.

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