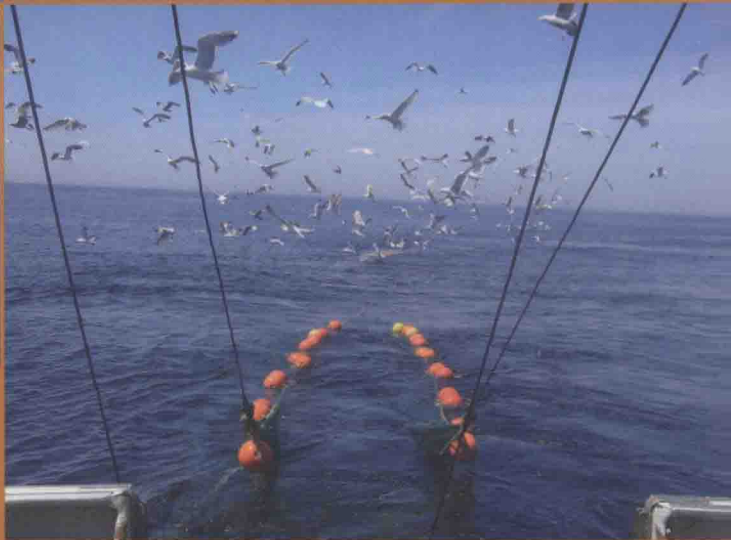


BEHAVIOR OF MARINE FISHES:

Capture Processes and
Conservation Challenges



PINGGUO HE

Behavior of Marine Fishes

Capture Processes and Conservation Challenges

Editor
Pingguo He



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Behavior of Marine Fishes

**Capture Processes and
Conservation Challenges**

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Preface

For hundreds of years, nets were considered to sieve or filter the fish from the water. Then in 1952, a breakthrough was made during the first diving observations when fish were filmed near a towed fishing net. Instead of being passively filtered by the net, the fish were orderly swimming ahead of the groundgear of a Danish seine net, being herded through the net funnel and actively escaping through open meshes of the codend. The new technologies and underwater cameras allowed SCUBA divers to observe and record that fish were reacting to nets in many different ways that were related to the biological characteristics of fish (e.g., species, size, sex, and state of maturity), environmental conditions of the fishing ground (e.g., temperature, seasonal changes, day/night length, tide, current, wind, depth, changing color and light levels, clarity of water, and bioluminescence), and operational parameters (e.g., towing speed, colors of twines, gear and ship sounds). With so many variables, two hauls may never be the same, making causes and effects very difficult to investigate with limited tows during experiments at sea.

Large aquaria and swimming tunnels were built so that many of these variables could be accurately controlled to allow experiments that measured the physiological limits of fish that were relevant when reacting to fishing gears under a variety of conditions. This research has included issues such as fish swimming capacity, schooling behavior, visual and hearing capability, bait odor distribution and chemoreception, electro senses, and learning and conditioning. Knowing the limits to the response abilities of fish gives us clues to help explain how

the different fishing gears have been developed by the fishermen to make use of the details of fish behavior to catch or release the fish. Small fish pass through the open meshes of a trawl because they are soon exhausted when trying to swim with the moving net. Selective trawls work with precise knowledge of this scale effect. They are towed at just above the sustained swimming speed of the size and species of targeted fish. Larger fish, which are not exhausted, swim away when the net is lifted, whereas smaller fish are quickly exhausted and pass through the meshes or over herding ropes and wires.

During the past 50 years, large amounts of data on fish behavior and fish capture processes have been collected. Interpretations of these data have generated a wealth of knowledge that has been applied to the catching and conservation of fish. The details of this developing knowledge tend to become scattered in refereed papers in different scientific journals and are often forgotten as time passes. It is important that every few years these papers are reexamined by experts and reinterpreted in relation to the current problems encountered in the world's marine fisheries. The refereed papers, as collected in this book, give the reader, scientist, or fisherman authoritative views, both retrospective and forward looking, on the issues facing global marine fisheries. Not only does the behavior of target and bycatch species need to be understood, but all species of megafauna, which include many protected species, that may interact with the fish capture processes. The behavioral details must be studied and avoidance procedures developed. It is thus very relevant that an up-to-date collection of

knowledge and a synthesis of fish behaviors, fish capture processes, and conservation issues are presented at a time when conservation is becoming the priority above and beyond the traditional values of marine resources. Currently and in the near future, all harvesting and extraction of our natural resources will need careful studies of the effects on the eco-

system and will involve detailed conservation measures in the capture fishery, including the avoidance or management of subjects like seabed damage, genetic selection due to size-selective fishing, damage to species diversity, and total fishing mortality.

Clement S. Wardle

Introduction

Humans might have started observing and interpreting fish behavior when they first threw rocks at a fish in a stream. Hunting has continued to this day, although increasingly sophisticated, in the wild capture fishery. During the course of fishing for various species under different conditions, a variety of fishing gears and methods have emerged. New materials and technologies have been invented and applied to design and construct gears and to study fish behavior, so as to capture fish more efficiently as well as to conserve fish for future use. Powered fishing boats and hauling equipment, synthetic gear materials, and echo-sounding equipment may be the most influential technologies in commercial marine capture fisheries, while echo-sounders and sonar, underwater cameras, and data storage tags have made great impacts on the study of fish behavior in the field. Modern fishing technologies, coupled with insatiable demands for seafood products, have caused great stress to fishery resources globally, which only a little over a century ago were still considered to be “inexhaustible.” Commercial fishing activity now occurs from the shoreline to depths exceeding several thousand meters, in the remotest of oceans, and even under polar ice caps.

Dramatic collapse of some of the world’s major fish stocks, notably Norwegian herring and Chinese greater yellow croaker in the 1970s and Newfoundland northern cod in the early 1990s, stunned many in the fishing industry, fishery research, and management arenas. Because recovery can take a long time, if they do recover (as seen in Norwegian herring), selective fishing for healthy

stocks while avoiding depleted stocks became one of the major management tools. As a result, the fishing industry is allowed to catch only fish of certain species and sizes and at specific locations and times. Consequently, the aim of understanding fishing gear and fish behavior turned from catching more fish to catching selected fish. Development of selective fishing gears to reduce bycatch and discards became the mainstream of marine capture fishery research. As a result, research on fish behavior, especially fish reaction to fishing gears, has flourished since the 1970s.

In a broad sense, fish behavior can be defined as the adaptation of fish to internal and external environments and to natural and artificial stimuli. In a narrower sense, related to fish capture, fish behavior can be considered the reaction of fish to physical and chemical stimuli associated with the fishing gear and its operation and the reaction to environmental changes in the forms of movement and distribution. Recognition of the importance of fish behavior in understanding and improving size and species selectivity and in realizing rational exploitation of the resource has encouraged applied fish behavior studies in the context of fish capture.

As one of the few remaining wild resource harvesting activities, fishing operations have increasingly been criticized for collateral effects on other animals and the marine ecosystem. Discards in world marine fisheries represent huge wastes of resources. It has become a moral issue as well as a threat to global food security. Fish population decline and endangerment of some of charismatic

megafaunal species related to fishing operations have caused great concern and become a challenge for both the fishing and research communities.

This book reviews and summarizes current understanding of fish behavior as it relates to capture processes in world marine fisheries and presents conservation challenges facing the fishing industry and fisheries researchers. It also illustrates potential technical solutions to the issues. The book is divided into three parts: (1) locomotive and sensory modalities relevant to capture; (2) fish behavior near fishing gears; and (3) conservation challenges in marine fisheries. The 13 chapters in the book were written by 22 leading researchers in the field and reviewed by 14 well-known experts, representing a total wisdom of 36 global scientists from 16 countries from Asia, Europe, and North America.

The first part of the book, covering the locomotion and sensory capability of fish, consists of three chapters. Chapter 1 (by Videler and He) reviews and summarizes fish swimming mechanisms, styles, and capabilities. Chapter 2 (by Arimoto, Glass, and Zhang) describes fish vision, underwater light and the visual environment, and how and how well a fish can see and visually respond to a moving or stationary object. Chapter 3 (by Anraku, Yan, and Babaran) describes underwater acoustic properties and fish hearing capability, as well as presenting examples of the application of sound and acoustic stimuli in controlling fish behavior. Information presented in these three chapters is frequently been referred to in later chapters when the behavior of fish near fishing gears is described and interpreted.

The second part of the book consists of six chapters that describe fish behavior near different fishing gears and the fish capture processes. The major commercial fishing gears included are otter trawl (Chapter 4 by Winger, Eayrs, and Glass), longline (Chapter 5 by Løkkeborg, Fernö, and Humborstad), fish pot (Chapter 6 by Thomsen, Humborstad, and Furevik), large-scale fish traps and setnets (Chapter 7 by He and Inoue), gillnet (Chapter 8 by He and Pol), and the theory and practice of fish catching using electricity (Chapter 9 by Polet). Each chapter starts with a review of the fishery and the fishing gear and describes fishing processes and fish behav-

ior near the fishing gear and then concludes with conservation issues and potential solutions related to the fishing gear type.

The third and last part of the book illustrates specific conservation challenges and solutions across fishing gear types and fisheries. The conservation issues reviewed include bycatch and discard in trawl fisheries (Chapter 10 by Graham), mortality of discards and escapees (Chapter 11 by Suuronen and Erickson), seabed effects of trawling (Chapter 12 by He and Winger), and fishery interactions with megafauna species (Chapter 13 by Rihan).

We have made great progress during the past 50 years in understanding fish behavior near fishing gears and in applying this knowledge in conservation-oriented fishing gear designs and operations. Yet there are still many things we do not know and we are still facing many challenges. As we enter the second decade of this century, conservation in marine fisheries will be placed in an even more prominent position, as greater attention is focused on the vast ocean, resulting in more rules and regulations to protect and preserve fisheries, ecosystems, and protected species. Further understanding of the behavior of fish and associated animals will be needed to achieve goals of conservation and sustainable utilization of marine fishery resources.

This book is intended as a reference for fishery researchers, students, managers, and conservation enthusiasts. It can also be used as a textbook for fishery courses at undergraduate and graduate levels.

I am grateful to Dr. Clem Wardle, the world-renowned fish behaviorist and retired Aberdeen Marine Laboratory researcher who wrote the preface for the book. His insight on the subject is valuable even 10 years after his retirement. I would like to thank all authors for their commitments to writing chapters and their timely completion of the manuscript. I would like particularly to thank the following reviewers for their critical reviews and helpful suggestions: Michael Davis (USA), Steve Eayrs (USA), Michael Fine (USA), Daniel Foster (USA), Emma Jones (New Zealand), Sven-Gunnar Lunnaryd (Sweden), Bob van Marlen (the Netherlands), Henry Milliken II (USA), Barry O'Neill (UK), Michael Pol (USA), Craig Rose (USA), Al Stoner (USA), Anna-Liisa Toivonen

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Pingguo He
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Behavior of Marine Fishes

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