

FISH AND AQUATIC RESOURCES SERIES 16

Flatfishes

Biology and Exploitation

Second Edition

Edited by
Robin N. Gibson, Richard Nash,
Audrey Geffen and Henk Van der Veer



WILEY Blackwell

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Series editor's foreword

... flatfish, thirsting, trawled by grief

'Falling on Grass', by Elizabeth Biller Chapman

Fish researchers (a.k.a. fish freaks) like to explain, to the bemused bystander, how fish have evolved an astonishing array of adaptations; so much so that it can be difficult for such researchers to comprehend why anyone would study anything else. Yet fish are among the last wild creatures on our planet that are hunted by humans for sport or food. As a consequence, today we recognize that the reconciliation of exploitation with the conservation of biodiversity provides a major challenge to our current scientific knowledge and expertise. Even evaluating the tradeoffs that are needed is a difficult task. Moreover, solving this pivotal issue calls for a multidisciplinary consilience of fish physiology, biology and ecology with social sciences such as economics and anthropology in order to probe the frontiers of applied science. In addition to food, recreation (and inspiration for us fish freaks), it has, moreover, recently been realized that fish are essential components of aquatic ecosystems that provide vital services to human communities. Sadly, virtually all sectors of the stunning biodiversity of fishes are at risk from human activities. In freshwater, for example, the largest mass extinction event since the end of the dinosaurs occurred as the introduced Nile perch in Lake Victoria eliminated over 100 species of endemic haplochromine fish. But, at the same time, precious food and income from the Nile perch fishery was created in a miserably poor region. In the oceans, we have barely begun to understand the profound changes that have accompanied a vast expansion of human fishing over the past 100 years. The Wiley-Blackwell Series on Fish and Aquatic Resources is an initiative aimed at providing key, peer-reviewed texts in this fast-moving field.

Flatfishes, ubiquitous from the poles to the tropics, are instantly recognizable; yet some biologists regard them as just another advanced teleost, so why, we may ask, do they deserve a monograph and conferences all to themselves? In fact, flatfishes, defined as members of the monophyletic order of Pleuronectiformes, are endowed with a number of special and unique features (they underlie that instant recognition), and so your series editor is pleased to host this second edition of *Flatfishes: Biology and Exploitation* in the Fish and Aquatic Resources series. The first and second editions of this book grew out of a series of triennial international symposia on flatfishes held

since 1990: there is now need for a second edition on account of significant advances in the science of flatfishes since the first edition was published in 2005. The second edition is a brainchild of a small team of eminent editors: Robin Gibson, Richard Nash, Audrey Geffen and Henk Van der Veer. The 17 chapters are authored by 37 experts in the field of flatfish biology from 11 countries.

When the oldest fossils appeared in the Eocene (53 million years BP), flatfishes already exhibited a diversity that suggests the order evolved in the Paleocene from perchlike marine ancestors. Today there are about 820 flatfish species in 123 genera, but relations within the group remain problematic. In this book systematics and biogeography are covered in two chapters (Munroe). Common and Linnaean names from the international fish database FishBase are used, except where recently revised.

During development each flatfish metamorphoses from a rounded, symmetrical fish-like larva to the characteristic flattened adult, with head skewed to remain horizontal as the fish lies on either its left or right side; one eye recapitulates early flatfish evolution and migrates to the upper side. Left- and right-handed eye position appears to be no guide to flatfish taxonomic relationships and the functional advantage of eye handedness remains a mystery. A chapter reviews the evolution and development of this dramatic asymmetry (Suzuki and Tanaka).

In a chapter on reproduction (Rijnsdorp, van Damme, and Witthames), we learn that, because flatfishes live in intimate contact with sediments, the effects of human pollutants on flatfish ecology are large. For example, oil spills reduce ovary development and fecundity, aromatic hydrocarbons and polychlorinated biphenyls in sediments produce smaller eggs, and some pesticides, polychlorinated biphenyls, phthalates and alkyl phenols mimic estrogen and disrupt female reproductive cycles or feminize males.

A chapter is devoted to the fascinating behaviour of flatfishes (Gibson, Stoner, and Ryer). Flatfishes employ a 'swim-and-glide' energy-saving locomotion by undulating the body. The 90° rotation in their body position means that flatfishes control vertical direction by changing the angle of the body, tail, and median fins; horizontal direction is altered, rather clumsily, by using the pectoral fin on the eyed side as a rudder. The characteristic flatfish camouflage serves both against detection by their prey and by their predators. Camouflage is achieved partly by very rapid second-by-second colour changes, images falling on the upper part of retina causing three types of chromatophore to expand and contract, and partly by slower changes over a number of weeks to the number and pigmentation of chromatophores, thereby altering the pattern of spots and flecks. All flatfishes can bury themselves rapidly in the substrate to aid camouflage. When this is done a muscular sac forces fluid into the orbit, causing the eyes to protrude above ground. Indeed this key feature of flatfish functional anatomy is diagnostic for the order. Flatfish eyes are independently mobile, providing 360° vision. Flatfishes are ambush predators; they may leave the bottom to capture prey in the water column and then become vulnerable to being eaten themselves. Some species avoid this problem by luring prey with a wagging pectoral fin, whereas a few species, like angler fish, have evolved specialized food-attracting lures. Prey are engulfed and sucked in by the back pressure from the highly protrusible advanced perch-pattern jaws.

A chapter covering the trophic ecology of flatfishes (Link, Smith, Packer, Fogarty and Langton) points out that flatfishes are largely piscivorous or eat benthic invertebrates like crustaceans and polychaete worms, so they generally have a trophic level of 3 or

more. Some species specialize in eating the tips of bivalve siphons, especially when juvenile, whereas a few concentrate on echinoderms such as sand dollars and urchins. Flatfishes provide a tangible 'ecosystem service' for human benefit because they convert benthic production into a form suitable for consumption by higher predators and humans. Flatfishes are sought out as food by specialized predators such as sharks that can detect electrical impulses from their nervous systems.

Flatfishes have been eaten by humans for millennia; flatfish bones are found in ancient middens, flatfishes are portrayed in rock carvings and paintings from Europe to Australia, and clever, recurved hooks for catching large flatfishes are found among aboriginal peoples in the Pacific northwest and in northern Australia. Since the 1960s, almost 25% of all groundfish landings worldwide have consisted of flatfishes, and, in this book, the major Pacific, Atlantic and tropical flatfish fisheries each have their own chapters. Overall, the status of most fisheries is very poor and they are generally exploited way beyond levels of maximum sustainable production.

Atlantic flatfish fisheries (Walsh, Astarloa and Poos) paint a miserable story of over-exploitation. The huge plaice fisheries of the early twentieth century have been severely depleted, Atlantic halibut is almost extinct and valuable sole, turbot and brill fisheries are reduced to shadows of their former glory. Species such as the thin and watery-tasting Greenland 'halibut' (also misleadingly marketed as 'turbot') now dominate catches. The sad litany of stocks experiencing severe decline is accompanied by the realization that, over 80 years, these fisheries have been assessed and managed by some of the most advanced fisheries science in the world. As with other fish in the Atlantic, we have seen in the past an almost total failure of fisheries agencies to fulfil their mandate. However, in Europe, the jury is currently out on whether the corner has been turned. In the south Atlantic, flatfish stocks have been greatly overexploited, yet almost no good data exist with which to assess and manage the resources. An important exception to the generally dismal state of temperate flatfish resources is the Pacific halibut fishery, which has been managed conservatively by the International Pacific Halibut Commission for almost 100 years (see the chapter on Pacific flatfish fisheries by Wilderbuer, Leaman, and Zhang). Tropical flatfishes caught in fisheries (Munroe) tend to be small, taxonomically diverse and poorly known small individuals and species caught by commercial trawlers that generate huge and unreported amounts of discards.

Two new chapters for the second edition focus on flatfish life history strategies (Vinagre and Cabral). The final chapter (Geffen, Pittman and Imsland) concentrates on the synergies between aquaculture and the biology of wild flatfishes.

This second edition continues to present timely and comprehensive 'state-of-the-art' reviews of flatfish biology, ecology, fisheries and aquaculture and readers will find all the components of synoptic synthesis concerning the role of flatfishes in today's depleted marine ecosystems. It therefore continues to provide a unique single source of reference on this group for all practitioners, students and policy makers concerned with marine biology, fish ecology, fishery science, marine conservation, and fisheries management.

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Preface to the second edition

Instantly recognizable, flatfishes have long fascinated scientist and layman alike. The fascination stems principally from their unique asymmetric body form developed as an adaptation to a bottom-living lifestyle following metamorphosis from a bilaterally symmetrical larva. They are a relatively diverse group, over 800 extant species are currently recognized and are distributed from the Arctic to Australasia. This wide distribution, and the fact that they make important contributions to commercial and recreational fisheries in many parts of the world, means they have been the objects of research for more than a century. Over the past few decades there has been a surge of interest in all aspects of flatfish biology. This interest has found expression in, and been greatly stimulated by, the International Flatfish Ecology Symposia held triennially since 1990 and published initially (1991–95) in the *Netherlands Journal of Sea Research* and subsequently (1997 onwards) in the *Journal of Sea Research*. This large and growing body of information was synthesized into an authoritative account of the biology of this intriguing and economically important group of fishes in the first edition. That volume was well received but advances in knowledge and its application in all topics since then necessitated a second edition.

As before, the book brings together accounts written by internationally recognized experts in the field of flatfish biology. All the original chapters have been fully revised and updated and two new chapters on life-history strategies and the evolution and development of asymmetry have been added. The recent publication of a major work on flatfish culture and stock enhancement (Daniels & Watanabe 2010) rendered the original final chapter on aquaculture and stock enhancement largely redundant. That chapter has been completely rewritten and now concentrates on the synergies between studies of aquaculture and of the biology of wild flatfishes.

The first part of the book deals with systematics, distribution and life history strategies; the second with biology in the widest sense and covers development, ecology, growth and behaviour. The final five chapters describe and discuss aspects of exploitation including the major fisheries, management and assessment, and aspects of aquaculture. The volume therefore continues to represent a comprehensive review of the

current ‘state of the art’ in flatfish biology and an invaluable source of reference for fish biologists, fisheries scientists and managers, and students of marine biology alike.

Reference

Daniels, H.V. & Watanabe, W.O. (eds) (2010) *Practical Flatfish Culture and Stock Enhancement*, Wiley-Blackwell, Ames, IA.

Preface to the first edition

Instantly recognisable, flatfishes have long fascinated scientist and layman alike. The fascination stems principally from the group's unique asymmetric body form developed as an adaptation to a bottom-living lifestyle following metamorphosis from a bilaterally symmetrical larva. They are a relatively diverse group, over 700 extant species are currently recognised, and they are distributed from the Arctic to Australasia and beyond. This wide distribution, and because they make important contributions to commercial and recreational fisheries in many parts of the world, means that they are familiar to most people and have been the objects of research for more than a century. In recent years there has been a surge of interest in all aspects of the biology of this group. The interest has found expression in, and been greatly stimulated by, the International Symposia on Flatfish Ecology held triennially in the Netherlands (1990, 1993, 1996), the USA (1999) and the UK (2002). A symposium on North Pacific flatfishes was also held in Alaska in 1994. It now seems timely for this rapidly growing body of information to be synthesised into an authoritative account of the biology of this intriguing and economically important group of fishes.

The book brings together accounts written by internationally recognised experts in the field of flatfish biology. The chapters cover systematics and distribution; reproduction and recruitment; ecology and behaviour of the main life history stages; the major fisheries and their management; and the latest developments in flatfish aquaculture and stock enhancement. The volume therefore represents a comprehensive review of the current 'state of the art' in flatfish biology and will be an invaluable source of reference for fish biologists, fisheries scientists and managers, and students of marine biology alike.

1.1 Notes

Proceedings of the International Symposia were published as follows. First Symposium: *Netherlands Journal of Sea Research* 1991, **27** (3–4); 1992, **29** (1–3). Second Symposium: *Netherlands Journal of Sea Research* 1994, **32** (2–4); 1995, **34** (1–3).

Third Symposium: *Journal of Sea Research* 1997, **37** (3–4); 1998, **40** (1–2). Fourth Symposium: *Journal of Sea Research* 2000, **44** (1–2); 2001, **45** (3–4). Fifth Symposium: *Journal of Sea Research* 2003, **50** (2–3); 2004, **51** (3–4). *Proceedings of the International Symposium on North Pacific Flatfish*: Alaska Sea Grant College Program Report No. 95–04, University of Alaska Fairbanks (1995).