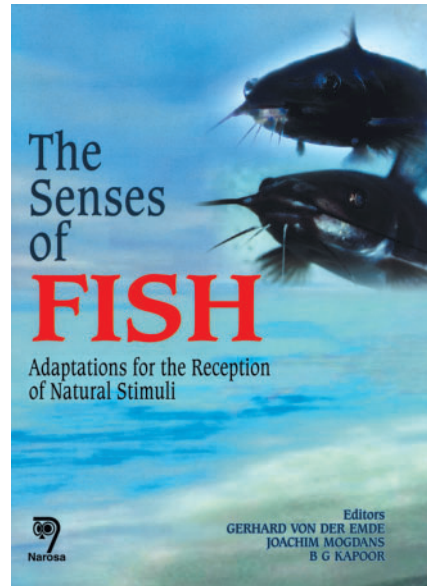


## HUMAN VIEWS ON THE ALIEN SENSORY WORLDS OF FISH



### The Senses of Fish: Adaptations for the Reception of Natural Stimuli

Edited by Gerhard von der Emde, Joachim Mogdans and B. G. Kapoor

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All animals face the challenge of representing their surroundings in order to behave appropriately and survive the dangers of the outside world. Constraints posed by different environments result in different evolutionary solutions to this problem. *The Senses of Fish: Adaptations for the Reception of Natural Stimuli*, edited by von der Emde, Mogdans and Kapoor, reviews adaptations observed in six of the senses that enable fish to perceive the world around them: vision, olfaction, taste, audition, lateral line and electroreception. The book illustrates how members of the largest vertebrate class modify their sensory organs in order to receive the most informative signals from the widely diverse habitats that fish occupy.

The first two chapters of *The Senses of Fish* deal with fish vision. In a comprehensive and very well documented chapter, Evans deals firstly with species adaptations to light intensity, wavelength

and polarization and secondly with individual adaptations observed during development or during daily and seasonal cycles. Particularly interesting are the descriptions of retinal adaptations of fish that live at different depths at different phases of their life cycle, and individual changes in photopigments matching the dominant light wavelength in freshwater and ocean water during migration. In the next chapter, Sillman and Dahlin raise the possibility of color vision in sharks and sturgeons, discussing the appearance of diverse photopigments at different ages in the duplex retina of these fish.

Chapters 3–5 are devoted to chemical senses. In an article nicely illustrated with scanning microscopy of receptor morphologies, Hansen and Reutter introduce the three modalities of chemoreception: olfaction, solitary chemosensory cells and taste. This chapter, focusing on general structural and functional aspects of chemoreceptors, is followed by an analysis of taste- and olfaction-oriented behavior by Valentincic. In a very interesting chapter, Nevitt and Dittman describe an appealing example of brain plasticity and outline a working model of olfactory imprinting in salmon.

Many aquatic animals, including fish, have developed complex mechanosensory and electrosensory systems exploiting the fact that water conducts mechanical waves and electricity, and the largest part of the book is devoted to analysis of these systems. These senses enable fish to construct a representation of a world that is alien to us. Mechanosensory systems are very differently organized in humans and fishes, and electroreception is unique to aquatic and amphibious animals.

Sound and lateral line detection are extensively covered in six chapters of the book. Lu's chapter on neural mechanisms of hearing focuses on peripheral coding of simple sounds and the mechanisms that might be used for directional hearing, while the chapter by Yan stresses the usefulness of brainstem auditory responses for evaluating hearing in fish and the role of the gas holding structures as prereceptor mechanisms. An entire chapter on sound production and acoustic communication by Ladich complements the brief discussion of neural processing of communication sounds in Lu's chapter. Finally, Higgs reports on the recent discovery that fish are able to detect ultrasound and discusses the most likely neuroethological significance of this finding: avoiding predation by echolocating cetaceans.

The roles of lateral line and electroreception for sensory reconstruction of the external world of fish are being unveiled now that the biophysics of sensory imaging is understood and biologically relevant stimuli are being employed. The two chapters by Janssen and by Mogdans, Kröther and Engelmann dealing with the ecology and the adaptations respectively of the lateral line system for the detection of hydrodynamic stimuli in running water detail their most recent findings within a clearly drawn general framework.

In a very informative chapter, Keller describes the biophysical basis, peripheral aspects and submodalities of electroreception and Tricas and Sisneros dig into the ecological functions and adaptations of one of these submodalities – passive electroreception – in elasmobranchs. Wilkens devotes his chapter to a beautiful example of sensory adaptation: the rostral ampullary electrosense of the paddlefish. These fish feed by opening their mouths wide and engulfing microscopic organisms while swimming in the turbid waters of the Mississippi River, guided by the electric fields generated by zooplankton. A flat, greatly elongated and eye-catching rostrum of approximately one third of the fish's length protrudes like a snout and serves as an electrosensory 'antenna' to sense the zooplankton's electric signals. Plankton-generated electric fields, behavioral evidence for their detection by fish and functional and morphological characteristics of electroreceptors and primary afferents are finely described in

this chapter, making it one of the highlights of the book.

In addition to the chapters on different sensory modalities, Wagner's more general chapter comparing sensory brain areas of deep sea and seafloor-dwelling species reveals how these creatures cope with the deep sea and sea floor, environments that are hardly conceivable by the human mind. Adaptations to dim light, high hydrostatic pressure, low temperature and sparse food supplies are reflected by relative volumes of deep sea fishes' sensory brain areas. While vision emerges as the dominant sense in actively swimming deep sea fauna, olfaction seems more important in the more passive species living near the bottom of the sea.

Finally, the book ends with a highly interesting biographical essay on scientific drive by Mary Hagedorn, essential reading for field biology students eager for adventure and discovery. She shares with the reader a part of her scientific life for which graduate school had not prepared her, concluding: *'When we step out of the controlled environment of the laboratory, we step into the chaotic events of life that surround our field endeavours. It is fascinating, humorous, surprising, bug-bitten, frustrating, beautiful, physically demanding, emotionally and intellectually gratifying, and sometimes wrenchingly sad. But it is life intersecting science in a synergistic way by broadening our perspective on political, social, economic, and religious beliefs, and ultimately enriching and humanizing our science.'*

Given the wide scope of the book, the

treatment of each topic and the number of biological examples given are necessarily somewhat limited. However, the chapters are succinct and well-balanced, and can be read independently. The book focuses mainly on peripheral sensory structures and behavior, highlighting phylogenetic and ontogenetic adaptations to different habitats. Brain circuits and computations involved in sensory processing are not extensively considered. These caveats aside, *The Senses of Fish* is an excellent reference book, taking a comparative approach to the study of fish senses in relation to the ecological pressures that result in individual adaptation and evolution.

In summary, the book provides a comprehensive treatment of the peculiar sensory systems of fish and presents a good collection of well-discussed examples of the ontogenetic and phylogenetic adaptations for sensory perception in the wide-ranging habitats that fish occupy. Comparative neuroscience and ecology researchers and graduate students will find this volume most useful, but all chapters are pitched at a level that is understandable by biology undergraduates as well. I trust that colleagues will agree with me that *The Senses of Fish* is well worth reading.

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**Angel Caputi**  
Department of Integrative and  
Computational Neurosciences, IIBCE,  
Uruguay  
angel@iibce.edu.uy

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