Under water hearing of human and aquatic vertebrates

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Preface

The sense of hearing is pre-eminently the sense for communication. Under water (UW), aquatic vertebrates explicitly make use of it. For human, the UW environment is biologically seen a hostile environment. This is a reason the more to gather as much as possible sensory information, both at short and long distance, allowing coping and anticipating adequately on this surrounding. Unfortunately, for human with respect to hearing, this is not very successful. As a result of the large difference between the propagation of sound in air and in water, only already for this reason human UW hearing will differ considerably with regard to hearing in air. All together, human is poorly equipped for UW hearing. And speaking UW is even entirely impossible.
In order to get insight in UW-audiology of human and animals it is necessary also to know the basics of UW-acoustics what is treated in Chapter I. Self-evidently, also the theory of acoustics in air will be discussed. In Chapter II, hearing of fish and aquatic mammals is treated. The sea mammals enjoy a particular popularity under sport divers and some knowledge of their hearing is therefore certainly in place. In Chapter III hearing of fish is discussed more closely. Warm-blooded animals have two senses, the auditory and equilibrium system of which the sensory receptors are hair cells. Much attention is given to hearing of fish because for the sport divers fishes are the aquatic animals of UW live which give the greatest pleasure of observing like diving practice proves. Fish and amphibians have a third system which utilizes hair cells, the lateral line system. With this system the flow of water along the body and also the disturbance of flow by nearby objects can be detected. This unique system does not have its equivalent in terrestrial animals. The lateral line hair cells have been the first hair cells of vertebrates of which the mechano-electric transduction was elucidated at subcellular level. This system will comes up for discussion in Chapter IV.
For a good understanding of human UW hearing, treated in Chapter VI, it is necessary to know something of the physiology and physics of the human hearing organ under normal circumstances, i.e. in the air at sea level. For this reason this will be treated firstly in Chapter V. Finally, sound communication of fish and aquatic mammals will be treated in the last chapter (VII).

This syllabus is intended for physicians, especially in otorhinolaringology, and for people with interest in the subject who have a science training, e.g. medical biology or medical physics. Some diving experience of the reader is considered as an advantage.

The syllabus was written for an ENT coarse of the Scott Haldane Foundation, but it covers more than can be addressed during the oral presentations. However, the aim was to present a review which covers the subject rather well and is detailed enough to give insight.
The syllabus has 3 levels of difficulty.
1. Textboxes in the main text are statements which one can adopt without further explanation. They can be considered as “take home messages”. They are understandable for everyone with a higher education.
2. The main text, resumed in the boxes, is such that exhaustive explanation and argumentation with formulas are restricted up to a minimum.
3. On a large scale footnotes are applied. Mostly they give more detailed information and some treat mathematical equations. They can be skipped because they are not necessary for understanding of the main text. However, sometimes they respect definitions.

For the major part of his carrier, the author was involved in the research of the electrophysiology and psychophysics of the auditory and visual system of animals and human. This resulted in many scientific publications and chapters in textbooks. A major part of this syllabus is based on these papers. His special interest in the sensory systems of fish and the convergence of multi-sensory sensory information can be found again in chapters III and IV.

N. Schellart, November 2012.

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