

Non-linear signal processing for underwater acoustics: theory and oceanographic applications

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Abstract

Lobsters, whales and submarines have little in common. Except that they produce low-frequency sounds, like many other marine occupants that use sound for communication, foraging, navigation and other purposes. However, unraveling and using the underwater cacophony is not at all simple. This is particularly true for low-frequency ($f < 500$ Hz) propagation in coastal water (water depth $D < 200$ m), because the environment acts as a dispersive waveguide: the acoustic field is described by a set of modes that propagate with frequency-dependent speeds. In this context, to extract relevant information from acoustic recording, one needs to understand the propagation and to use physics-based processing. In this presentation, we will show how to analyze low-frequency data recorded on a single hydrophone. We will notably review modal propagation and time-frequency analysis. We will then show how those can be combined into a non-linear signal processing method dedicated to extract modal information from single receiver, and how such information can be used to localize sound sources and/or characterize the oceanic environment. The whole method will be illustrated on several experimental examples, including geoacoustic inversion on the New England Mud Patch and baleen whale localization in the Arctic.

Biography

Julien Bonnel received the Ph.D. degree in signal processing from Grenoble Institut National Polytechnique, Grenoble, France, in 2010. From 2010 to 2017, he was an Assistant/Associate Professor with Laboratoire des Sciences et Technologies de l'Information, de la Communication et de la Connaissance (Lab-STICC, UMR CNRS 6285), Ecole Nationale Supérieure de Techniques Avancées de Bretagne, ENSTA Bretagne, Brest, France. Since September 2017, he has been an Associate Scientist with Woods Hole Oceanographic Institution, Woods Hole, MA, USA, where he got tenured in September 2020. His research interests in signal processing and ocean acoustics includes time–frequency analysis, source detection/localization, geoacoustic inversion, acoustical tomography, passive acoustic monitoring, bioacoustics and impact of noise pollution on marine life.

Dr. Bonnel is a Fellow of the Acoustical Society of America (ASA), and an Associate Editor for the Journal of the Acoustical Society of America. He was the recipient of the 2019 A.B. Wood Medal from the Institute of Acoustics (U.K.), the 2020 R. Bruce Lindsay Award from the ASA (USA).