Automated probabilistic echo solving: A scalable Bayesian inverse approach applied to echo integration

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Identifying scatterers is a perennial challenge in fisheries acoustics. Most practitioners classify backscatter based on direct sampling and frequency-difference thresholds, then integrate at a single frequency. However, this approach struggles with species mixtures, and discards multi-frequency information when integrating. Inverse methods do not have these limitations, but are not widely used because their species identifications are often ambiguous and the algorithms are complicated to implement. We address these shortcomings using a probabilistic, Bayesian inversion method. Like other inversion methods, it handles species mixtures, uses all available frequencies, and extends naturally to broadband signals. Unlike prior approaches, it leverages Bayesian priors to rigorously incorporate information from direct sampling and biological knowledge, constraining the inversion and reducing ambiguity in species identification. Because it is probabilistic, it can be trusted to run automatically: it should not produce solutions that are both wrong and confident. Unlike some machine learning methods, it is based on physical scattering processes, so its output is fully interpretable. Finally, the approach is straightforward to implement using existing Bayesian libraries, and is easily parallelized for large datasets. We present narrowband and broadband examples using simulations and field data from the Gulf of Alaska, and discuss possible extensions and applications of the method.

Poster Presentations

On the resiliency of an eastern boundary upwelling ecosystem exposed to multiple stressors: an acoustic approach

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The resistance of an east border upwelling system was investigated using relative index of marine pelagic biomass estimates under a changing environment spanning 20-years in the strongly exploited southern Canary Current Large marine Ecosystem (sCCLME). We divided the sCCLME in two parts (north and south of Cap Blanc), based on oceanographic regimes. We delineated two size-based groups ("plankton" and "pelagic fish") corresponding to lower and higher trophic levels, respectively. Over the 20-year period, all spatial remote sensing environmental variables increased significantly, except in the area south of Cap Blanc where sea surface Chlorophyll-a concentrations declined and the upwelling favorable wind was stable. Relative index of marine pelagic abundance was higher in the south area compared to the north area of Cap Blanc. No significant latitudinal shift to the mass center was detected, regardless of trophic level. Relative pelagic abundance did not change, suggesting sCCLME pelagic organisms were

able to adapt to changing environmental conditions. Despite strong annual variability and the presence of major stressors (overfishing, climate change), the marine pelagic ressources, mainly fish and plankton remained relatively stable over the two decades, advancing our understanding on the resistance of this east border upwelling system.

Ichthyological importance of shallow coastal areas for pelagic communities: contributions of echosounding

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Marine communities are strongly structured by bathymetry and distance from the coast. Shallow coastal areas host diverse and abundant fish communities and are subjected to strong anthropogenic pressures. However, assessments of good ecological status of pelagic fish populations do not generally take into account the ultra-coastal fringe of the coastline (<20m depth and <5km from coast). Data presented in this study were acquired in Brittany (France) during eleven acoustic surveys conducted in 2020 and 2021 using a splitbeam EK80 echosounder (70, 120 and 200 kHz). Pelagic fish shoals were extracted from the echogram and characterized by spatial (location in the water column), morphological (size and shape of the shoal) and acoustic descriptors. Shoal descriptors were compared between coastal and ultra-coastal areas, taking into account variability between sites, seasons and years. Results showed different shoal structures with notably smaller shoals of pelagic fish in the ultracoastal zone but with a stronger acoustic response, suggesting a higher density per school than offshore and/or different species. This study highlights the uniqueness of ultra-coastal areas for marine pelagic fish communities and underlines the need to integrate their monitoring into marine management and action strategies to improve management and protection systems for these biocenoses.

Sound-scattering layers related to pelagic habitat characteristics: the case

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