

# Interpreting the movement behaviour of the flapper skate across the water column by Markov switching autoregressive models

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**Abstract:** The flapper skate (*Dipturus intermedius*) is an apex predator that used to be widely distributed in the North East Atlantic. Due to its size and non-selective distribution, all age classes of the flapper skate have constantly been part of the by-catch of ground trawling fisheries throughout the years causing a 90% decline of the population. To test appropriate conservation measures to help the species recolonize its former range, Data Storage Tags (DSTs) were applied on 18 individuals in the Sound of Jura (Scotland). Four tagged individuals were recovered after different time spans ranging from two weeks to twelve months. DSTs collected pressure levels every two minutes. Pressure data were then converted into depth values, showing skates' behaviour across the water column. The four series of depth exhibit high autocorrelations at the higher lags, with a slow decay, and asymmetric cycles. Both issues suggest to handle the series as realizations of a stochastic regime switching process. Hence, Markov switching autoregressive models have been applied. Covariates were also incorporated into the model through the Markov chain: the transition probabilities are time-varying and dependent on dynamic categorical variables, such as daylight duration and lunar cycles (a proxy for the tidal cycle). Only the shortest series has been analysed at the moment. A two-state hidden Markov chain was selected, representing different regimes of animal movement, i.e., state 1 for resting or horizontal swimming or slow ascending and descending; state 2 for fast ascending and descending. Daylight duration is the environmental covariate that better explains the hidden state dynamics: higher activity during the night is often related to foraging activity for predators of crustaceans and fish. The flapper skate uses the whole water column throughout the year suggesting that areas of high densities should be closed to fisheries at all depths to conserve this species.