Forecasting fishing effort and catch from time series: tuna purse seining in Indian Ocean as a case study

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**Abstract**

Time series of catch and effort are compiled by fisheries management organizations for managerial purposes. In particular, time series of catch and fishing effort reports are important to estimate the biomass of a stock, its health status and the associated maximum sustainable yield. This knowledge underpins policies and regulations that limit stock exploitation, and guarantees the availability of new recruits and food in the future. The use of these time-series in forecasting fisheries is currently limited, because it is difficult to model all the factors that influenced the catch but that are necessary to forecast it properly.

In this paper, we propose a means to understand the upcoming fishing pressure under relatively stable enabling conditions; i.e. without new regulations, piracy activity in the major fishing locations etc. Our method can be used by regional as well as by global fisheries management organizations, because it looks at a catch series as a monodimensional signal. A key characteristic of stock time series is that they can be interpreted as non-stationary signals, i.e. their statistical properties (mean, variance etc.) change in time. Furthermore, an aggregated report for large geographic aggregates can have different statistical properties than reports for smaller aggregations in the same area.

The model we present aims at factoring complex and invisible events, e.g. laws and regulations, piracy activity, prices variation, pollution etc., under the hypothesis that one catch series is the sum of all of them. Our forecasting model is able to decompose a time series into several factors and detects patterns in its internal structure. In particular, it analyses and forecasts time series of (i) catch reports, (ii) fishing effort, (iii) catch-per-unit of effort, (iv) fishing activity latitudes and (v) longitudes. The model spatially aggregates several reports for a large area, in order to obtain one single time series of the barycentres of the fishing activity. It traces statistics for these trends and finds hidden periodicities in portions of them using iterative short-time Fourier analyses. If periodicities exist, the model uses several iterations of Caterpillar Singular Spectrum Analysis to extract the best signal components that allow forecasting the time series. To make our approach useful to non-experts in signal processing, we automatized the parameterisation of the sub-processes as much as possible.

As a case study, we focus on data of purse seine fishing activity catching yellowfin and skypjack tuna, published by the Indian Ocean Tuna Commission for the period between 1981 and 2013. We demonstrate that our approach is able to detect periodic patterns in the time series, and is more effective than other state-of-the-art approaches to forecast the time series in 2013, based on the data up to 2012. Furthermore, it complies with modern Science 2.0 advices for experiments reproducibility and repeatability, because it relies on a research e-Infrastructure to share data, experimental setups and results.