APPLICATION OF ARTIFICIAL INTELLIGENCE AND TIME SERIES ANALYSIS ON STRUCTURE AND TRENDS OF EX-VESSEL FISH VALUE OF SELECTED SPECIES IN LAKE VICTORIA (KENYA)

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Introduction

A number of logistic, financial and administrative challenges make it difficult collect adequate and suitable data in order to apply classical fisheries management strategies. Consequently, the more data intensive classical fisheries biological and economic (bio-economic) models do not provide adequate and reliable analytical results for fisheries management. Alternative models are required to deal with the data poor situations in Lake Victoria but also to provide a robust approach to fisheries modelling. The surplus production model provided the only target reference point mentioned in the Law of the Sea Convention, the Maximum Sustainable Yield (MSY), which until the 1970s was regarded in most world areas as the appropriate target for management. The broad generality provided by this simple biomass model allowed early application of economic theory (Gordon, 1954) and led to the Maximum Economic Yield (MEY) as a 'target reference point' to the left of MSY on the fishing effort axis. The objective of this study was to demonstrate that data poor fisheries can still be modelled using Artificial Intelligence (AI) and Machine Learning Algorithms such as supervised feed-forward Artificial Neural Networks (ANN) and Time Series Decomposition/Analysis to demonstrate that ex-vessel fish value depends on the fish species, biomass and foreign exchange rate over time. The main aim of the study was to analyze monthly fish value of the major commercial species to determine which species have significant impact on the total fish value from Lake Victoria (Kenya), determine the cyclic movement and trends as an alternative to the data intensive classical fisheries bioeconomic models such as Gordon-Schaefer. The application of AI and ANN do not mot make any assumptions about any model and uses the data to learn, test and validate the network, thereby eliminating the need for pre-determine model, while Time series decomposition/Analysis resolves the long term data into its cyclic, trend and irregular movements in order to determine composite annual indices of fish value on monthly basis and offers potential for future predictions.

Methods

The dataset used for this study was drawn from the Fisheries Statistical Bulleting 1996 to 2013 published annually by the State Department of Fisheries, Aquaculture and the Blue Economy (SDFA&BE). The resolution of the data was on a monthly basis, thereby providing 216 monthly data series used in this analysis (Fig. 1). The fish catch and value (KES and US$ was used in developing an ANN by partitioning the data into training, testing and validation sets. The training data set was used to develop a feed forward ANN architecture using an iterative algorithm that minimizes the errors between the target and predicted outputs. The testing data set was then used to test the robustness of the network by presenting the set to the developed network and comparing the various types of network errors between the training and testing set. Finally, validation set was used to confirm that the network produces consistent outputs when compared to the testing set.

Time series analysis and decomposition of the fish value over 12 month seasonal period giving the following outputs: i) Component analysis of raw, de-trended and seasonally adjusted fish value data for the time series period; ii) Seasonal analysis of total fish value giving seasonal indices of fish value on a composite 12 month period over the entire time series; iii) De-trended composite indices by 12 month seasons for entire time series; iv) Percent variation of seasonal fish value indices by composite 12 month seasonal period; v) Residuals be season to determine the amount of dispersion and random errors in the time series data; vi) Potential time series trend data on fish value based on linear regression, growth curve, quadratic model and S-Curve (logistic model).

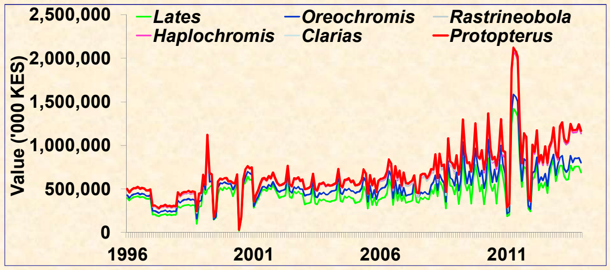

Figure 1: Monthly catch data from 1996-2013 of the major species from Lake Victoria Kenya

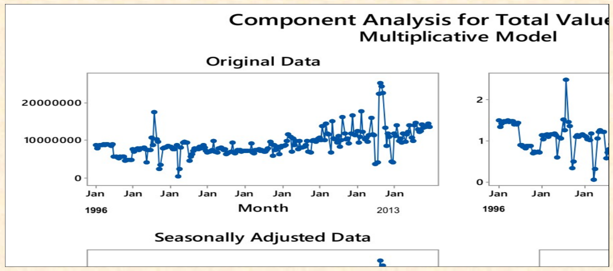

Figure 3: Multiplicative decomposition of time series fish value of selected species showing original, de-trended, seasonally adjusted and seasonally adjusted/de-trended

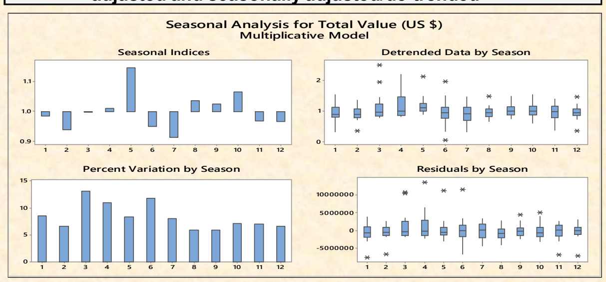

Figure 4: Seasonal fish value indices, de-trended indices, percentage variation and residuals by season of selected fish species from Lake Victoria (Kenya)

Results

The ANN design for fish value analysis was based on monthly fish catches for *Lates, Oreochromis, Rastrineobola, Haplochromis, Clarias* and *Protopterus* and KES exchange rate to the US $ as numerical variables. The categorical variables used in designing the network were the years and months. The results of importance showed that the time (years), month and US $ exchange rate contributed 40.9-50%, 16.0-16.3% and 2-16.4% respectively while *Lates* and *Rastrineobola* contributed 10-14% and 7-8% respectively to the network architecture while using KES/US $ as the fish value (Fig. 2).

The total fish value showed considerable monthly and annual fluctuations that persisted even after de-trending and seasonally adjusting the fish value data. This is an indication of strong seasonality and random noise in the time series of landed fish value but is also a reflection of the seasonality in fish abundance since the value is based on landings. For both seasonally adjusted and de-trended fish value data, it became clear that both effects were removed and hence warranting further examination of value indices (Fig. 3).

Based on the results of decomposition and the effects of removing seasonality and trend, a detailed time series decomposition showed that the fish value follows a 12 month cycle with two peaks in April-May and August-September and low values in June-July and November-February. These two peaks can possible be attributed to rainfall patterns and their effects on fish productivity. Based on the 216 data points, the seasonal indices of fish value show a cumulative annual cycles and rhythms and lacustrine bio-physical dynamics that is eventually reflected in the catch and fish value (Fig. 4).

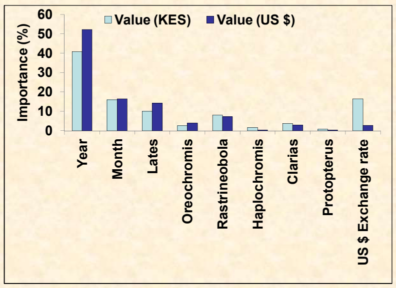

Figure 1: Relative importance of variables on the ANN of total fish value

Conclusions

In conclusion, there is a need by management to quantify potential long-term trade-offs between maximising yield, either by biomass or economic gain, while limiting the risk of possible reproductive failure of the current open access equilibrium fishery in in the Lake Victoria

Acknowledgements

We would like to acknowledge the support for data analysis provided by the DVC Division of Research, Innovation and Outreach Prof. B. Estambale for facilitating the data processing and analysis and the JOOUST ICT for providing facilities for computation and data analysis and specifically Mr. Donatus Abwao for the time spent in developing the framework of analysis.

References

Gordon, H.S. (1954). Economic theory of a common property resource: the fishery. *J. Political Econ.* 75: 274–286.

Schaefer, M. (1954). Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Bull.I-ATTC/Bol. CIAT*, 1(2): 27-56

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