Non linear forecast of anchovy (*Engraulis ringens*) catches in northern Chile: A multivariate approach

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The Humboldt current system is one of the most productive ecosystems of the planet, due to the horizontal advection of nutrients, and the large scale coastal upwelling induced by winds blowing predominantly towards the equator (Bernal *et al.*, 1983). The average Chilean fish landings in the past ten years is about 5.5 million tons per year and the pelagic fishery of northern Chile (mainly anchovy and sardine) represent about 42% (SERNAPESCA, 1951-2005).

The anchovy fishery is closely associated with fishing effort changes and environmental fluctuations such as cold-warm regime shifts (interdecadal fluctuations), *El Niño* events (interannual fluctuations), and coastal trapped waves (intra-seasonal fluctuations) (Yáñez *et al.*, 2005). It collapses during the *El Niño* event in 1972-73 while a remarkable increase in sardine landings is observed (warm period); after 1985 (cold period), the anchovy fishery present a notorious recovery as the sardine landings decreases (Yáñez *et al.*, 2003).

A problem associated with ecosystemic information is the complexity and non-linear behaviour, the variability of species, composition and abundance, affected directly by environmental changes, and also affected by the presence of predators, competitors and parasites. In ecology, the application of artificial neural networks (ANN's) for modelling starts at early 1990s, when data rarely meet parametric statistical assumptions and where non- linear relationships are prevalent, they perform better than linear models and generalize well to new data inputs (Özesmi *et al.*, 2006)

A first approach to the pelagic fisheries non-linear modelling was presented by Gutiérrez-Estrada *et al.* (2007) using a univariate ANN model considering anchovy catches of the previous six months. In this study the performance of artificial neural networks monthly forecast models for anchovy catches in northern Chile (18°21'S-24°S) considering twelve environmental variables, the fishing effort and the anchovy catches in the period between 1963 and 2005, was evaluated.

In order to discard the "noise" in the input layer a previous analysis of the data was carried out, using principal components analysis and a non-linear cross correlation technique. The model used is a feed forward multi layer perceptron architecture, trained with the Levenberg-Marquardt algorithm.

The results involved an ANN model (M1) with the sea surface temperature (SST) in Antofagasta (with 6, 7 and 8 months lag) and the SST in the Niño3+4 region (with 3, 4 and 5 months lag), and anchovy catches (of the 6 previous months) as inputs. Another ANN model (M2) considers both the same SST (and the same lagged months), anchovy catches (of the previous 3 months), and fishing effort (without lag) as inputs. The Antofagasta SST lag seemed to be related to the anchovy recruitment process that occur at age 5-6 months (Castillo *et al.*, 2002). While the Niño3+4 region lag seemed to be related to the equatorial coastal trapped waves remote effects that take place in the north of Chile approximately with a 120 days lag (Hormazabal *et al.*, 2002), affecting the anchovy availability.

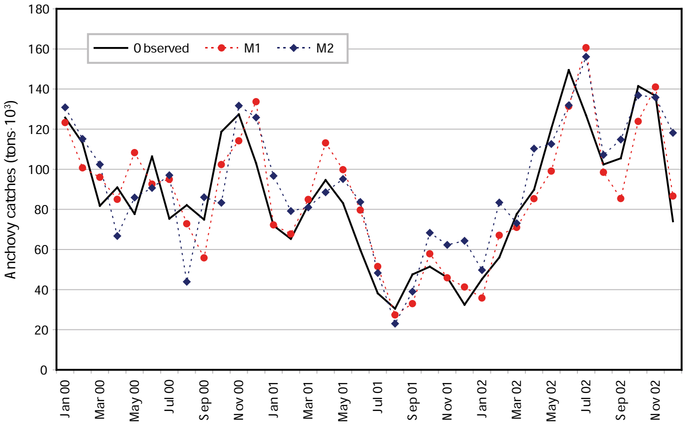

Figure 1. Observed and estimated anchovy catches in the external validation phase (2000-2002) for M1 (in red) and M2 (in blue) models.

The external validation process shows an explained variance of 78% and 69% respectively, the standard error of prediction (SEP, %) was lower than 23% in both models. The strong correlation among the estimated and observed anchovy catches in the external validation phases (Fig. 1) suggested that calibrated models (M1 and M2) captured the general trend of the historical data and therefore these models could be used to carry out an accuracy forecast.

References

Bernal P., F. Robles and O. Rojas. 1983. Variabilidad física y biológica en la región meridional del sistema de corrientes Chile-Perú. FAO Fisheries Report 291(3): 683-711.

Castillo J., J. Córdova, A. Saavedra, M. Espejo, P. Gálvez and M.A. Barbieri. 2002. Evaluación del reclutamiento de anchoveta en la I y II regiones de Chile. Informe Final FIP-IT/2001-11, 207pp.

Gutiérrez-Estrada J.C., C. Silva, E. Yáñez, N. Rodríguez and I. Pulido-Calvo. 2007. Monthly match forecasting of anchova Engraulis ringens in the north area of Chile: Non-Linear univariate approach. Fisheries Research 86: 88-200.

Hormazabal S., G. Shaffer and O. Pizarro. 2002. Tropical Pacific control of intraseasonal oscillations off Chile by way of oceanic and atmospheric pathways. Geophysical Research Letters 29(6): 10.1029/2001GL013481.

Özesmi S., C. Tan and U. Özesmi. 2006. Methodological issues in building, training, and testing artificial neural networks in ecological applications. Ecological Modelling 195: 83-93.

SERNAPESCA. 1950-2005. Anuarios Estadísticos de Pesca. Servicio Nacional de Pesca, Ministerio de Economía, Fomento y Reconstrucción, Chile.

Yáñez E., M.A. Barbieri and C. Silva. 2003. Fluctuaciones ambientales de baja frecuencia y principales pesquerías pelágicas chilenas. p.109-122. In: E. Yáñez (Ed.). Actividad Pesquera y de Acuicultura en Chile. Pontificia Universidad Católica de Valparaíso, Chile.

Yáñez E., C. Silva, A. Ordenes, F. Gómez, A. Valdenegro, N. Silva, S. Hormazabal, A. Montecinos, L. Cubillos, F. Espíndola, O. Pizarro and J.R. Cañón. 2005. Análisis integrado histórico ambiente-recursos, I-II Regiones. Informe Final Proyecto FIP Nº 2003-33, 478pp.