Modelling and forecasting monthly CPUE from small scale fishery in Cyprus

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Abstract

Univariate seasonal ARIMA models were developed using monthly standardized CPUE time series of small scale fisheries from four fishing areas in Cyprus waters for the period 1980-2005. The high values of coefficient of determination R^2 of the forecasted values for one year ahead (2006) , with a range of error rates 1.6-6.4% in three areas, is an important goal for modelling CPUE time series from small scale fisheries, considering the limitations there are in a multispecies approach. In case of Cyprus, short term forecasting of catches or CPUE is quite important especially for the summer period where the demand in fresh fishery products is higher.

Introduction

Cyprus fishery is mainly multispecific with small scale fishery being the main fishing category, playing a major role as in most locations of the Mediterranean (Juntunen *et al*. 2008). The main gears used are trammel nets, set gillnets and set longlines.

Modelling and forecasting of catch data, is therefore essential for management purposes of this fishery. Seasonal Autoregressive Integrated Moving Average (SARIMA) models, are referred as suitable tools for accurate predictions of landings (Prista *et al.* 2011), which in this study were applied on standardized catch per unit effort (CPUE) data from four areas, using univariate SARIMA models.

Method

Standardized monthly CPUE (kg/day) from 1980 to 2005 were log-transformed [log(CPUE+1)] to stabilize the variance, and used to develop SARIMA models *(p, d, q)(P, D, Q)₁₂* for each of the four study areas (Fig.1).

Models were developed following the three step procedure (Box & Jenkins 1976), which is:

a) model identification,

b) parameter estimation and

c) diagnostic checking of the model.

For each area, data of the last 12 months for 2006 were used for testing the forecasting performance of the established models. The analysis was conducted in R using library (TSA).

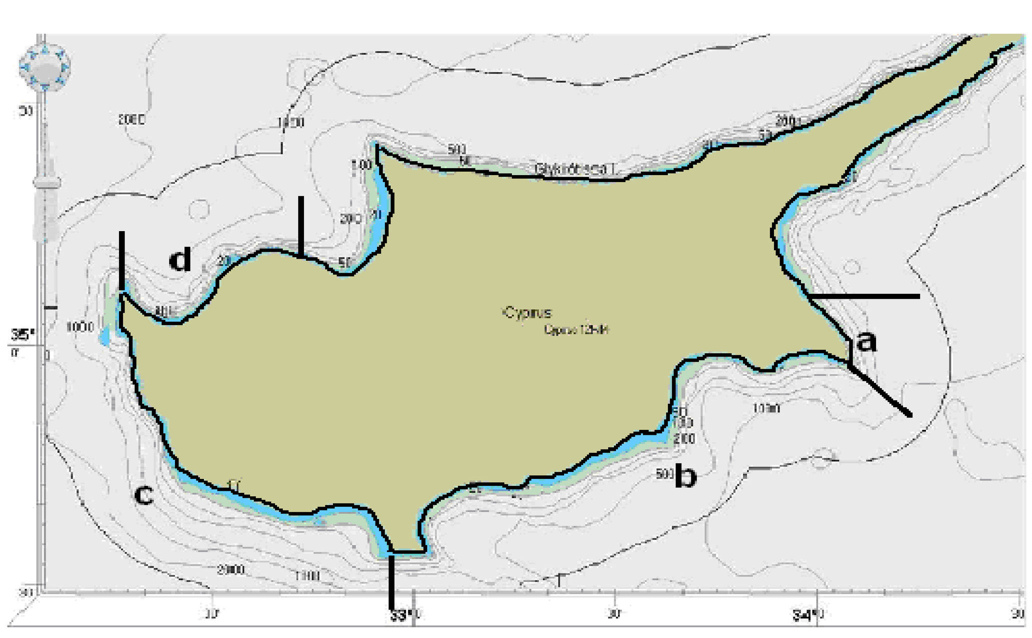

Figure 1. Cyprus fishing areas for small scale fishery (a, b, c and d)

Results

The fitted models proved to be adequate in the following regular (p, d, q) and seasonal terms (P, D, Q)12 (Table 1), giving high values of coefficient of determination R^2 with 0.9109, 0.9806, 0.982 and 0.9895 for areas [a], [b], [c] and [d] respectively. Moreover, the absence of significant autocorrelation (ACF) in the residuals (Fig. 2) as well as the results of Ljung-Box test (P>0.05) (Table 1), did not indicate any inadequacy in the fitted models

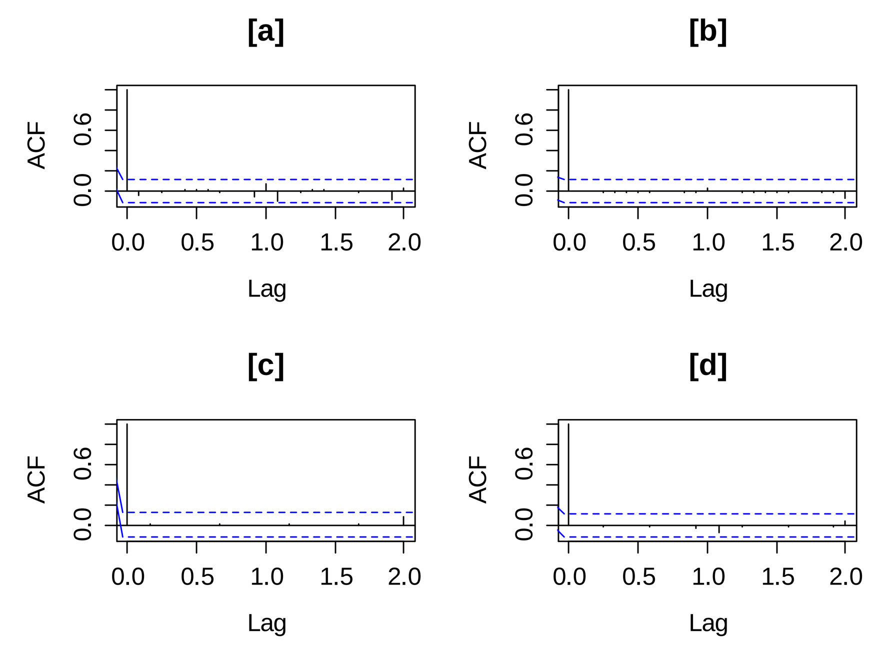

Figure 2. ACF plots of the SARIMA models residuals for areas [a], [b], [c] and [d].

Table 1. Parameter estimates for SARIMA models .

Area	[a]		[b]		[c]		[d]	
Univariate SARIMA	$(0,1,0)(3,3,3)_{12}$	std.er.	$(0,1,2)(1,0,2)_{12}$	std.er.	$(1,2,1)(3,1,1)_{12}$	std.er.	$(1,1,2)(2,1,2)_{12}$	std.er.
Parameter								
AR1					0,0081	0,0635	0,0129	1,5062
AR2								
MA1			0,0096	0,0567	-0,999	0,0053	-0,0088	1,5043
MA2			0,0034	0,0571			0,0042	0,0655
SAR1	-1,7031	0,1249	1,0006	0,0002	-0,7166	0,055	-0,1785	0,0683
SAR2	-1,4608	0,1265			-0,5789	0,0556	0,338	0,0575
SAR3	-0,5172	0,1119			-0,9398	0,0576		
SMA1	-1,2221	0,1124	-1,5451	0,0581	0,0162	0,0764	-1,0001	0,0913
SMA2	-0,4906	0,2141	0,47	0,0659			-0,0767	0,0985
SMA3	0,8851	0,1216						
R^2-model	0,9109		0,9806		0,982		0,9895	
AIC	-743,24		-1708,75		-1193,3		-1411,64	
X^2	0,4287		0,0021		0,0056		0,0022	
p-value	0,5126		0,9636		0,9405		0,9623	
R^2 - pred. log(CPUE+1)	0,931		0,9995		0,9985		0,999	
R^2 - pred. CPUE	0,7178		0,9708		0,8951		0,9121	

Using the monthly log-transformed CPUE values of 2006, the forecasting performance of the fitted models was adequate for areas [b], [c] and [d], as the coefficient of determination R^2 was calculated 0.9995, 0.9985 and 0.9990 respectively (Table 1, Fig. 3). The error rates of forecasting had ranges of 1.6-5.7%, 1.8-6.4% and 1.6-5.7% for areas [b], [c] and [d] respectively (Table 2).

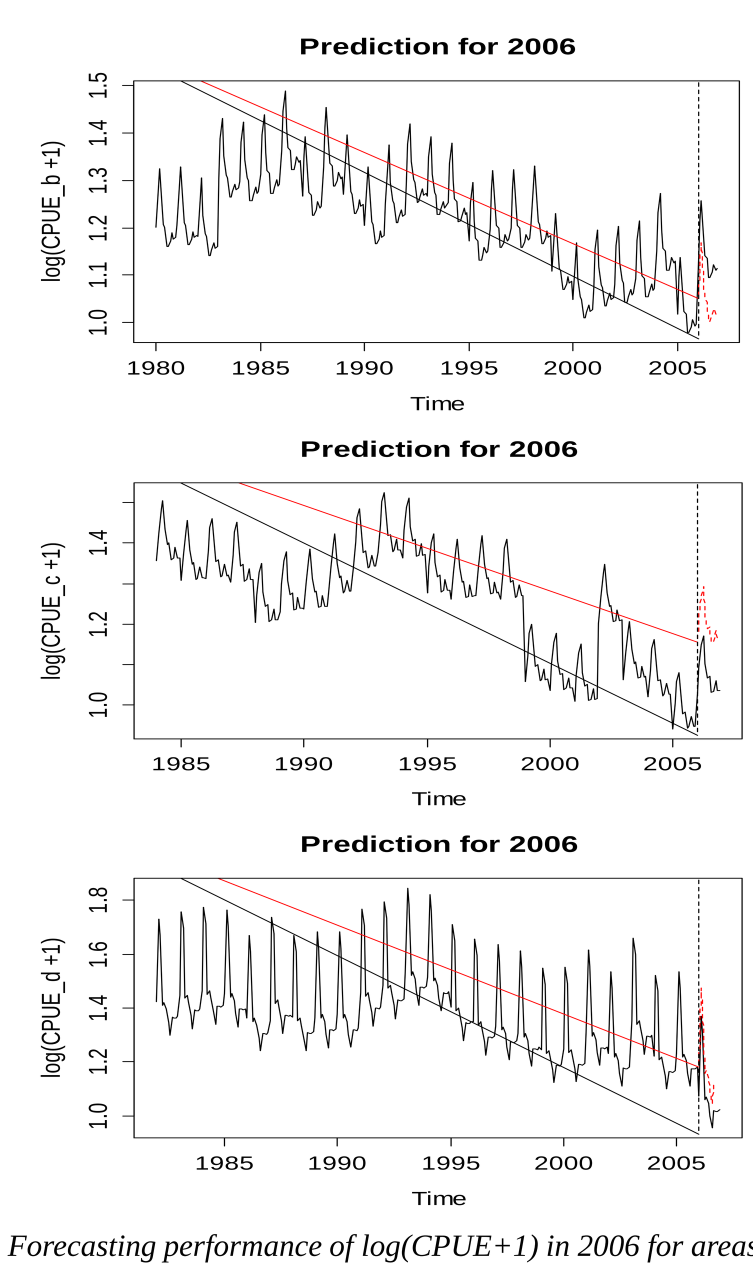

Figure 3. Forecasting performance of log(CPUE+1) in 2006 for areas [b], [c] and [d]

Table 2. Predicted values of log(CPUE+1) for 2006 for areas [b], [c] and [d] .

Area	[b]		[c]		[d]	
SARIMA	$(0,1,2)(1,0,2)_{12}$		$(1,2,1)(3,1,1)_{12}$		$(1,1,2)(2,1,2)_{12}$	
Month	Predicted	Std.error (%)	Predicted	Std.error (%)	Predicted	Std.error (%)
January	1,0428	1,5919	1,1455	1,7983	1,1673	1,5763
February	1,1258	2,0963	1,2126	2,4163	1,4739	1,7640
March	1,1681	2,4827	1,27	2,8346	1,4138	2,2563
April	1,0886	3,0773	1,2927	3,2258	1,1567	3,1901
May	1,0494	3,5735	1,2229	3,8270	1,168	3,5360
June	1,0436	3,9383	1,1888	4,3237	1,1424	3,9566
July	1,0023	4,4298	1,1931	4,6601	1,0949	4,4662
August	1,0026	4,7277	1,1528	5,1700	1,0474	4,9933
September	1,0137	4,9620	1,1566	5,4816	1,1136	4,9749
October	1,0302	5,1543	1,1842	5,6578	1,1118	5,2527
November	1,0172	5,4758	1,1582	6,0784	1,1103	5,5210
December	1,0209	5,6911	1,1594	6,3567	1,117	5,7296

Conclusions

The high values of R^2 in model fitting as well as in forecasting the monthly values of standardized CPUE for one year ahead (2006) in three of four areas of study, is an important step for modelling time series of small-scale fisheries CPUE data for the first time.

Short term forecasting of catches or CPUE is quite important especially for the summer period where the demand in fresh fishery products is higher. The fact that for the months of spring and summer there are accurate forecasts of monthly CPUE with small ranges of low error rates (3.6-4.7%, 3.8-5.2% and 3.5-5% for areas [b], [c] and [d], respectively) [Table 2], is quite important for the tourism industry as well as for the local market of Cyprus.

The results show that there are perspectives to use SARIMA models on a single species approach from small-scale fisheries in Cyprus.

The above results support the conclusions of Lloret *et al.* (2000) that univariate ARIMA have better forecasting ability for catch data of target demersal and benthic species, especially for the long-lived species.

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