

Malaysian Torpedo Scads (Ikan Cincaru) Forecasting Using Time Series Analysis

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Abstract

Forecasting, which can be done in a several ways, such as statistical methods and machine learning techniques, involves making predictions about future values based on historical data. This study presents a thorough investigation into the forecasting of Malaysian Torpedo Scad catch data using time series analysis, addressing the crucial requirement for accurate predictions in the context of fisheries management and sustainable harvesting practices. The study primarily employs statistical methods, specifically the Box-Jenkins, exponential smoothing, and naive methods using SPSS, Minitab and Microsoft Excel software, to model the temporal patterns inherent in the catch data. Given the seasonal periodic fluctuations observed in monthly Malaysian Torpedo Scad (Ikan Cincaru) data, IBM SPSS software is used to forecast catch data for 2022, Autoregressive Integrated Moving Average (ARIMA) approach is used in the Box-Jenkins model, Simple Seasonal Exponential Smoothing method, and Seasonal Naive method. A dataset comprising 132 observations from January 2011 to December 2021 is utilized to build the models. Among the three methods, Exponential Smoothing emerges as the most effective model, with the Simple Seasonal Exponential Smoothing exhibiting the lowest values for Root Mean Square Error (RSME), Mean Absolute Percentage Error (MAPE), and Mean Absolute Error (MAE)—389.805, 11.751%, and 271.024, respectively.

1. Introduction

Many people, especially those from lower and moderate socioeconomic strata, include Malaysian torpedo scads in their diets. The main reason for this popularity is that the fish is inexpensive in comparison to other seafood selections. Torpedo scads from Malaysia is widely consumed since it is affordable and easily accessible to a wide range of people. But, given its significant contribution to offering a priced and wholesome source of protein for a sizable section of the population, it is imperative to avoid both overestimating and underestimating the fish's significance. Maintaining equilibrium between the acknowledgement of its nutritional significance and economic

worth [1] guarantees a more precise comprehension of the influence of Malaysian torpedo scads on the regional culinary customs and the welfare of various consumer demographics.

Forecasting is the technique that uses the historical data as a reference to make the prediction. Forecasts that only indicate what a future might look like if it makes no major changes to its tactics and strategy are typically insufficient for planning purposes [2]. There have multiple techniques have been applied in fishery Dataset including ANN-linear [3], autoregression integrated moving average (ARIMA) [4], seasonal ARIMA (SARIMA)[5], Stepwise multiple regression [6], Simple exponential smoothing (SES)[7], Machine learning technique [8], ARIMA-ANFIS-WOA Hybrid [9], ARIMA-ANN[10], Hybrid VMD-IBES-LSTM model [11], Exponential Smoothing[12], Holt-Winters and NNAR models[13], ETS[14] and Correlated Random Walk[15].

There is a past researcher that suggests no method is ideal for all landings and recommends comparing structural approaches for fishery resource management [16]. This paper evaluates forecasting technique using annual fishery production data that implies Box-Jenkins approach, exponential smoothing, and artificial neural network. The Box-Jenkins model is a polynomial model that uses transfer functions to express relationships between input, output, and noise for a given system [17]. As we know, Box-Jenkins methods are commonly used techniques that can be applied in many of the fields. For example, there are researchers that used the box Jenkins approach to forecast carbon dioxide emissions [18], crude oil production [19].

Exponential smoothing method is a method of forecasting moving averages by providing easy-to-analyse weighting. There is a past researcher that used Holt-Winters exponential smoothing to study a Covid-19 prediction model [20]. There is also a past study that develops a web system for determining tuna fishing locations in Indonesia using Naïve Bayes and Support Vector Machine, achieving a 96.6 percent accuracy rate, though Naïve Bayes excels in some areas [21].

Malaysian is a developing country where the location of the country surrounded by the sea, hence, there is a need to forecast Malaysian torpedo scads (ikan cincaru) catching data for future use in decision-making on supplying and pricing the fish. Data on its monthly catches was gathered from January 2011 to 2022. Given that the data show seasonality-periodic oscillations, ARIMA was selected in Box-Jenkins to anticipate the catching data for the year 2022. Other previous studies were done in using forecasting method with the statistics technique in worldwide according to various fields of studies [22, 23, 24, 25].

The goal of this research is to analyse the monthly catching data of Malaysian torpedo scads by using box Jenkins, simple exponential smoothing, and naïve method to forecast Malaysian torpedo scads-catching data and to evaluate the forecast performance, amount the three methods using forecast accuracy measures.

2. Material and Methods

2.1 Malaysian torpedo scads (ikan cincaru) catching data

Data on the catch of Malaysian torpedo scads (ikan cincaru) spanning from January 2011 to December 2022 were gathered from the Department of Fisheries (DoF) website [26]. The dataset comprises a total of 144 observations, with 132 observations designated for training data and 12 for testing data. This study employs three approaches that is the Box-Jenkins method, exponential smoothing method, and the hybrid method. The primary software utilized is Microsoft Excel, Minitab, and IBM SPSS that leverage its expert modeler tool, a black box tool that streamlines the modelling process.

2.2 Box-Jenkins Method

Before using ARIMA, ensure the time series data is stationary, split the data for training and testing, carefully select model parameters, validate assumptions, and evaluate performance on the testing set. When a time series displays a seasonal pattern, the following ARIMA of order (p, d, q) as shown in Equation 1 will be applied [27].

$$\phi_p(B)\nabla^d y_t = \theta_q(B)a_t \quad (1)$$

where ϕ , θ represent the moving average (MA) and autoregressive (AR) parameters. In the meantime, p , d , and q represent the orders of autoregressive, $AR(p)$, difference, and moving average $MA(q)$. The anticipated variable is y_t , d is the degree of differencing required to make the time series stationary, and the random error at a time is ε_t .

2.3 Exponential Smoothing

Simple Exponential Smoothing is a forecasting method that predicts future values based on past observations, giving more weight to recent data points, and using a simple weighted average approach with a smoothing parameter. There are many types of exponential smoothing but in this study the use of simple seasonal

exponential method, is because of the existing seasonal component in the series. The simple exponential smoothing is shown in Equation 2 [28]:

$$l_1 = \alpha y_1 + (1 - \alpha)l_0 \quad (2)$$

where α indicate for an alpha between 0 to 1, y_1 as the observed values and l_0 as the smoothed estimate for level 0.

2.4 Naive Method

The naïve forecasting method represents one of the simplest and intuitive approaches to predicting future values in time series analysis. The naïve forecasting approach uses the previous observation of a time series to predict the current period's value [29]. For highly seasonal data, a similar approach is helpful. every estimate based on the most recent value seen during the same season that is the same month the year before. The seasonal naïve as shown in Equation 3 [30]:

$$\hat{Y}_{T+h|T} = \hat{Y}_{T+h-m(k+1)} \quad (3)$$

where m represents the seasonal period, and k is the integer part of the number of complete years in the forecast period prior to time $T+h$.

2.5 Performance evaluation

The indicators that follow will be used to assess the performance of the Box-Jenkins approach, the exponential smoothing method, and the hybrid method such as Root Mean Square Error (RSME) [31], Mean Absolute Percentage Error (MAPE) [32], and Mean Absolute Error (MAE) [33],

$$RMSE = \sqrt{\frac{\sum_{t=1}^n (y_t - \hat{y}_t)^2}{n}} \quad (4)$$

$$MAPE = \frac{\sum_{t=1}^n \frac{|y_t - \hat{y}_t|}{y_t}}{n} \times 100 \% \quad (5)$$

$$MAE = \frac{\sum_{t=1}^n |y_t - \hat{y}_t|}{n} \quad (6)$$

where y_i and \hat{y}_t are the corresponding observed and predicted values, and n is the amount of data.

3. Result and Discussion

A time series plot of monthly data for Malaysian torpedo scads (ikan cincaru) was produced, displaying data from January 2011 to December 2022, to identify whether the data exhibits a trend or seasonality. The time series plot of the data can be observed below. Time series plot is the crucial step where the initial step before proceeding the forecasting. From the time series plot, the initial assumption can be done where it interprets the component of the data whether it has trend, seasonality or any pattern that can be categories using this plot. The monthly data of Malaysian torpedo scads (ikan cincaru) catching data show a down and slightly rising trend with no seasonality where it can also be computing that data has irregular pattern, as shown by the time series plot in Fig 1. The Box-Jenkins Method, Simple Seasonal Exponential Smoothing and Seasonal Naïve Method were used to determine the number of Malaysian torpedo scads (ikan cincaru) that were caught throughout the next year, which ran from January to December.

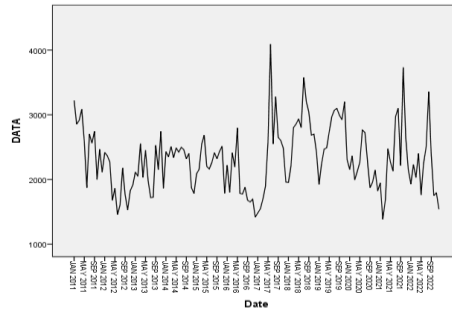


Fig. 1 Time series plot

Based on Fig. 1, it concluded that there is no seasonality in the series but after obtain Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) that shows in Fig. 2 and Fig. 3 respectively, where it shows seasonal components by using Malaysian torpedo scads (ikan cincaru) catching data. It can conclude there is seasonality in this series and the series is not stationary.

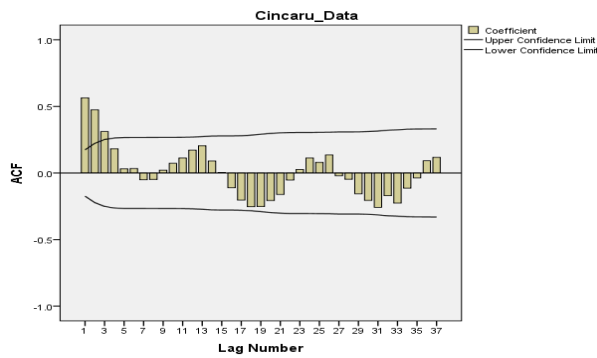


Fig. 2 Autocorrelation Function (ACF) Plot

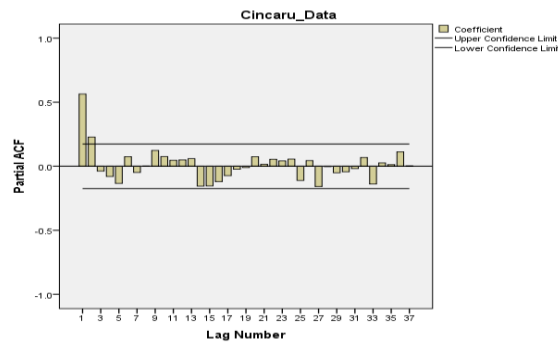


Fig. 3 Partial Autocorrelation Function (PACF) Plot

It knows that time series plots are initial assumption where it depends on personal interpretation which no proof that can verify the assumption. So, more test needed to be done to delve down into more detail.

3.1 Stationary Test

There are two criteria for stationarity which is the mean and variance need to be consistent or constant which represent stability. A visual review was carried out by using time series plot for Malaysian torpedo scads (ikan cincaru) catching data shows in Fig. 1. The series does not show stability on variance or mean where the series do not fluctuate around zero or one value neither the series fluctuate at the same height, which indicates that the variance or mean is not constant. It is found that the time series is not stable based on the graphical analysis which a personal assumption or interpretation. To proof the assumption, Box – Cox transformation have been applied in Fig 4.

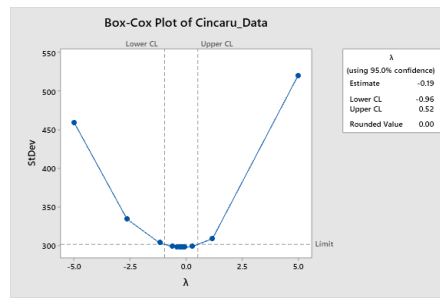


Fig 4 Box-Cox Transformation Plot

The result of Box-Cox Transformation contains the value of lower and upper control limit where the value are -0.96 and 0.52 respectively. According to the interval of lower and upper control limit where there are not included the value of 1 which means that the value is not constant. So, it can be concluded that the assumption by using time series plot is accurate. Next, Box-Cox Transformation also contains the value of rounded value which also indicates value of lambda with the value of zero. The transformation can't be done because lambda is used to do the transformation. So, it is known that for zero estimated lambda \ln Transformation or natural log (base e) is used. Meanwhile, Fig 5 shows the time series plot of Malaysian torpedo scads (ikan cincaru) catching data after Natural log has been applied.

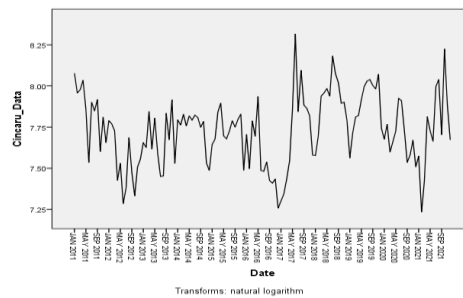


Fig. 5 Time Series Plot of Malaysian Torpedo Scads (After Log Applied)

The result of the time series plot after the transformation shows the slight similarity with the initial time series plot but with stable variance where it can be seen from the height of the fluctuation in series. Next, to substantiates the accuracy of the graphical analysis, affirming the necessity for differencing. Consequently, the time series plot of the first differencing and natural log transformation of the catching data for Malaysian torpedo scads (ikan cincaru) is presented in Fig 6.

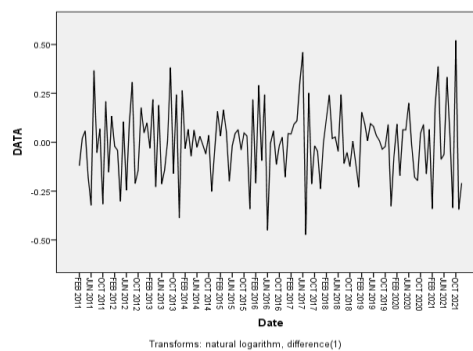


Fig 6 Time Series Plot of the First Differencing (After Natural Log Transformation)

After applied natural log transformation and first differencing the time series plot result shows that the stationary series where the series fluctuate around the zero value and the height of the fluctuation is consistent over time. It can conclude that both variance and means have been fulfilling the stationary criteria where both mean and variance are constant.

3.1 Box-Jenkins Method

The initial Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) in Fig. 2 and Fig. 3 respectively shows the present of seasonal component in the series but after applied the natural log transformation and first differencing, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) in Fig 7 and Fig 8 respectively shows where the seasonal component is no longer evident which prove that the steps have successfully removed the seasonality. To determine the order of model, the significant lags in ACF and PACF plot need to be used.

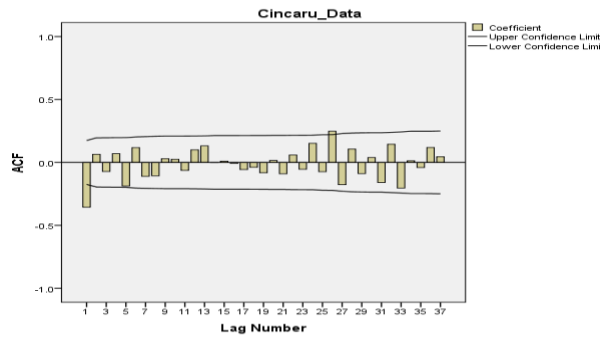


Fig. 7 Autocorrelation Function (ACF) Plot (After Transformation)

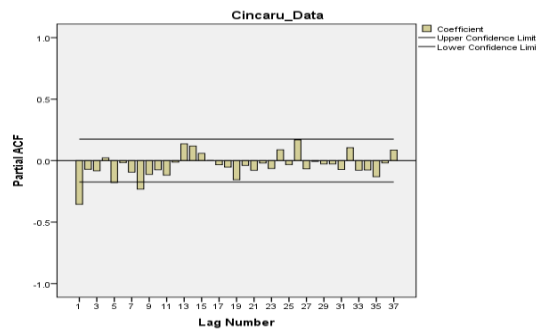


Fig. 8 Partial Autocorrelation Function (PACF) Plot (After Transformation)

Fig. 7's ACF plot shows two possible assumptions, whether cut off lag 1 and an exponential pattern decay at zero. From the PACF figure in Fig. 8, also rise two assumptions where at first glance there is exponential decay to zero or also cut off at lag 1. The model may readily determine based on the outcome obtained. The model's summary is displayed in Table 1.

Table 1 The summary of the model

	ACF	PACF	Model
Non – Seasonal (p,d,q)	Cut off at lag 1	Exponential decay to zero	MA (1)
	Exponential decay to zero	Cut off at lag 1	AR (1)

Two initial models were identified, as indicated in Table 1. The following is a list of the recognized ARIMA models.:

1. ARIMA (0, 1, 1)
2. ARIMA(1, 1, 0)

From Table 2 it is clearly shown that only ARIMA (0, 1, 1)has met the assumption of the model where R-squared values need to be close to value 1, the lowest value of RMSE, MAPE, MAE and Norm. BIC indicates the better model except Model significance (p -value) Ljung Box where the value is smaller than 0.05. ARIMA (0, 1, 1) fulfill majority of the required value to become a best model.

Table 2 Result of Comparison between Models

Fit statistics	ARIMA (0, 1, 1)	ARIMA (1, 1, 0)
R-squared	0.266	0.257
RMSE	423.180	425.760
MAPE	13.761	13.867
MAE	314.597	315.894
Norm. BIC	12.133	12.145
Model significance (p-value) Ljung	0.013	0.072
Box		
AR parameters estimate		-0.357
p-value		0.000(-4.338)
MA parameters estimate	0.404	
p-value	0.000(4.973)	

The forecasted plot of ARIMA (1, 1, 0) through the Box-Jenkins method is shown in Fig 9 with the forecasted result shown in Table 3.

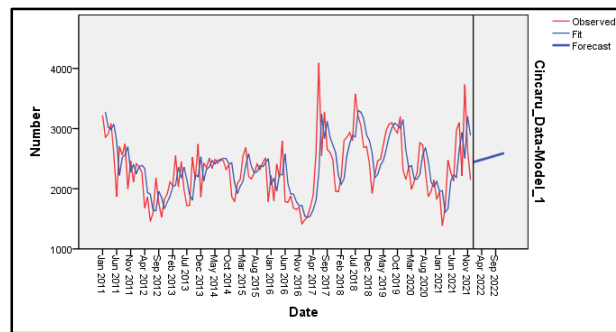


Fig. 9 Forecasted Result

Table 3 The Forecast value from January 2022 to December 2022 by using the Box Jenkins Method

Time	Forecast Value
Jan 2022	2351
Feb 2022	2304
Mar 2022	2348
Apr 2022	2359
May 2022	2382
Jun 2022	2401
Jul 2022	2421
Aug 2022	2442
Sep 2022	2462
Oct 2022	2483
Nov 2022	2504
Dec 2022	2525

3.2 Simple Seasonal Exponential Smoothing Method

IBM SPSS software provides black box tools called the expert modeler that can help to implement simple seasonal exponential smoothing to get optimal results. According to the SPSS output, it concludes that the residual sequence is white noise where the Ljung-Box Q test is significantly significant with the p-value is 0.109. Table 4 shows the forecast value and the observed data, fitted value and time series for the forecasted value as shown in Fig. 10.

Table 4 The Forecast value from January 2022 to December 2022 by using the Exponential Smoothing Method

Time	Forecast Value
Jan 2022	2492
Feb 2022	2433
Mar 2022	2719
Apr 2022	2733
May 2022	2907
Jun 2022	2755
Jul 2022	2900
Aug 2022	3015
Sep 2022	2815
Oct 2022	2789
Nov 2022	2861
Dec 2022	2374

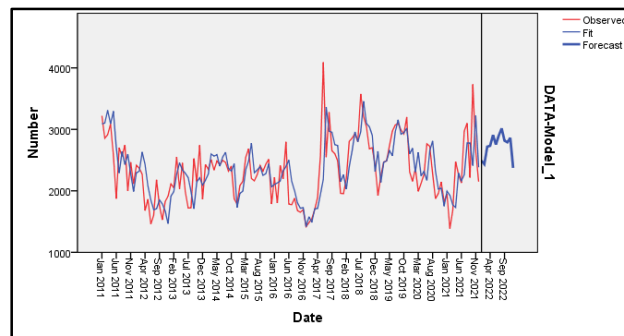


Fig. 10 Forecasted Result

3.3 Seasonal Naïve Method

Naïve forecasting the one-step-ahead forecast is determined by taking the most recent actual value in the time series as the predicted value for the next time step. In other words, the naïve method assumes that the future behaviour of the time series is best represented by its most recent observation, making it a straightforward yet limited strategy for forecasting. While this approach lacks sophistication, it serves as a baseline for comparison with more advanced forecasting models, providing a quick and easy reference point for assessing the performance of more complex methodologies. The seasonal naïve forecasted values have been obtained using Microsoft Excel software are presented in Table 5 and the time series plot illustrating the forecasted values is depicted in Fig 11.

Table 5 The Forecast value from January 2022 to December 2022 by using the Seasonal Naïve Method

Time	Forecast Value
Jan 2022	1947
Feb 2022	1386
Mar 2022	1680
Apr 2022	2474
May 2022	2268
Jun 2022	2130
Jul 2022	2972
Aug 2022	3099
Sep 2022	2216
Oct 2022	3732
Nov 2022	2648
Dec 2022	2149

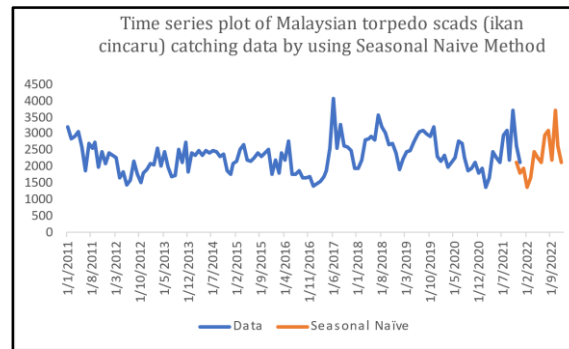


Fig. 11 Forecasted Result

3.4 Performance Evaluation

To identify the model that exhibits the highest accuracy in forecasting the data, a comparison has been conducted among the performances of the three models. The evaluation of each method's performance is presented in Table 2, utilizing metrics such as Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), and Mean Absolute Error (MAE).

Table 6 Comparison of the Measure's Accuracy

Parameter Estimator	Box Jenkins	Exponential Smoothing	Naïve
RMSE	444.316	389.805	622.668
MAPE	13.715	11.751	21.990
MAE	314.468	271.024	490.842

Table 6 shows the Exponential Smoothing produces the lowest value of RMSE, MAPE and MAE compared to the Box-Jenkin and Naive Method. So, it concluded that the best method is exponential smoothing method where the lowest value indicates the best result.

4. Conclusion

In conclusion, this study employed the Box Jenkins method, Simple Seasonal Exponential Smoothing, and Naive method for predicting the catching data of Malaysian torpedo scads (ikan cincaru). The accurate data predictions generated are invaluable for governmental bodies, fisheries management, and citizens, enabling them to prepare effectively for anticipated seasonal fluctuations. While the methods utilized are well-suited for short-term forecasting, it is acknowledged that they may not be universally appropriate for long-term predictions. The study focused solely on monthly data of the total Malaysian torpedo scads caught, overlooking potential influencing factors and facing challenges in finding adaptable methods.

Traditional forecasting methods in Malaysian torpedo scads catch data are complex due to environmental changes, seasonal shifts, and human activities. Accurate forecasting models are needed due to the unpredictability of the relationship between torpedo scads and their environment. Investigate the impact of environmental factors (e.g., sea temperature, currents, and weather patterns) on the abundance of ikan cincaru. Seasonal patterns in catch data are influenced by reproductive cycles and human activities, providing insights for sustainable fisheries management and conservation efforts. Extend the forecasting horizon to make long-term predictions, considering the sustainability of the ikan cincaru population.

Conflict of Interest

The authors declare that there are no conflicts of interest pertaining about the publication of this paper. They affirm that there are no financial, personal, or professional relationships or interests that could potentially influence or bias the content of the manuscript. This declaration underscores the commitment to transparency and integrity in the dissemination of research findings.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation : Involvement of 5 authors.

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