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Time Series Analysis and Forecasting of Production and Consumption of High-Value Fishery Products in Masbate, Philippines

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A B S T R A C T

The Island of Masbate, Philippines is established as a province that is diverse in marine and oceanic resources. Masbate, however, is also diverse in environmental and anthropogenic challenges which significantly affect its locals and economic status by limiting fish catch and produce, barricading for progress to develop within the locality. To address this problem, this research, thus, examined the relationship of trend patterns between the production and consumption of fifteen selected high-value fishery products in the Province with the utilization of the principles of time series analysis and forecasting. Time series is a valuable statistical method used for interpreting and forecasting future data values using historical data. Additionally, robust time series models, Moving Average, Exponential Smoothing, and ARIMA, were evaluated in the study to identify which one among the three is the best fit mathematical representation for the forecasting of production and consumption of Masbate's fishery products in 2023-2032— later it was revealed to be the ARIMA (1, 1, 1). After the evaluation, ARIMA (1, 1, 1) forecasted the future values of fish, crustaceans, and mollusks in Masbate for the next ten years; with fish and crustaceans having forecasted drops, and mollusks with an increasing, upward trend. Discussions and argumentations of results elaborated the highest and lowest values. Further, potential factors that might have caused the patterns' behavioural directions were concluded in the study. Overall, the findings of the research provide imperative insights for decision-making and future planning for sustainable fishery products in Masbate.

Keywords: Time Series, Forecasting, Fishery Products, Production, Consumption

1. INRODUCTION

Accomplishing a study that forecasted future economic trends of a province, particularly in its fishery sector, is an imperative tool and a driving force for future sustainability and effective policy- and decision-making, especially if implemented and maintained strictly. Thus, the proponents focused on the finishing of such study concentrated in the Province of Masbate, including all three of its separate major island groups. Based on the principles of time series analysis and forecasting, the research about the production and consumption of the selected, high-value fishery products in Masbate, Philippines was accomplished. To construct the best fit statistical forecasting model that perfectly captures the trend of consumption and production of the fifteen high-value fishery products in Masbate from 1993-2032— the publication and production of this research contributes to Masbate's concerns in fishery, as well as to future researchers planning to investigate a study related to this. By means of the novel, data-driven insights from the mathematical statistics concentrated on Masbate's extensive fishing livelihood that are provided by this research paper, the problems with underlying occurrences of influx and efflux, as well as shortages and surpluses, in fishery products can be discovered; the locality will, therefore, be able to search for a counteractive and proactive solution. Over time, this study will continuously contribute to a more progressive economy and to a sustainable future for the fishery sector of the Masbate Islands.

1.1 Statement of the Problem

The general aim of the study is to construct the best fit statistical forecasting model that perfectly captures the trend of consumption and production of the fifteen high-value fishery products in Masbate from 1993-2032. There are four specific objectives in this research which are: (1) Trend of the production and consumption of high-value fishery products from 1993 2022, (2) The significant effect of the consumption and production on both of their ratios by year, (3) Forecasted production and consumption of high-value fishery products in 2023-2025 using three statistical models, and (4) The best fit forecasting model to use for the production 5 and consumption of the selected high-value fishery products in Masbate for the next ten years, particularly in 2023-2032.

2. METHODS

2.1 Research Design

This study employed a descriptive-predictive design to understand the trends in consumption and production, as well as to determine their value using the best-fit time-series model.

2.2 Data Sources

In this study, data was obtained from Bureau of Fisheries and Aquatic Resources and Philippine Statistics Authority.

2.3 Research Procedure

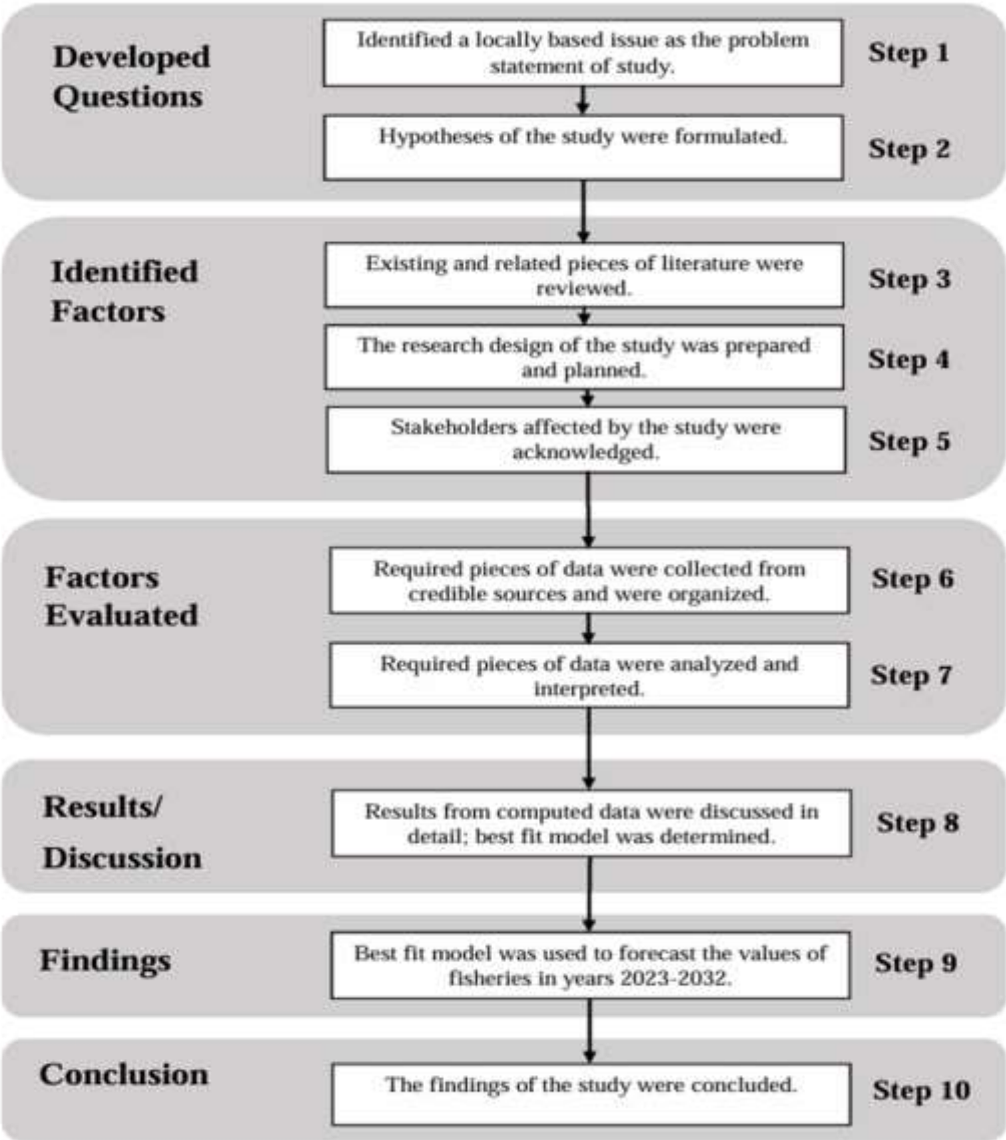


Figure 1. Flowchart of the Research

As shown in Figure 3, there is a total of ten stages classified into six groups in the framework of the research. Each preceding stage is required to be accomplished before moving on to the subsequent tasks. The process was performed as follows:

1. First— the research problem was identified. By analyzing the currently occurring problems circulating within the community-based scope, the general problem statement and specific objectives were generated. Afterwards, the formulation of the null and alternative hypotheses was done.

2. Second— factors, such as the review of related literature and preparation of the research design, were accomplished. The proponents conducted an intensive reading of closely related and already-published studies to their title. Then, they planned-out the blueprint of the research: the study's design. On the fifth step, they considered the contributors and the persons affected by the research.

3. Third— data gathering, interpretation, organization, computation, and analysis were conducted on the third grouped stage. Also, the comparative analysis was used to assess which is the best fit time series forecasting model among the three: Moving Average (MA), Exponential Smoothing (ES), and the Autoregressive Integrated Moving Average (ARIMA). After the comparison test, it was found out that the ARIMA (0, 1, 1) model is the most suitable time series model to use in the first three forecasted years; while, the ARIMA (1, 1, 1) is the most appropriate for the forecasting of future values in the next ten years.

4. Fourth— the results from the computed data were discussed in depth. Moreover, the discussion elaborated what the data signified; either an increasing, decreasing, or 16 stagnant direction. The time series models were used to illustrate the production and consumption of high-value fishery products in Masbate from the year 1993 to the succeeding year of 2025. Afterwards, the final and best fit time series forecasting model, the ARIMA (1, 1, 1), was determined. Since this study was the first to apply time series analysis and forecasting on the production and consumption of high-value fishery products in Masbate, this is considered as a novel discovery, in a sense that it adds new knowledge and data-driven insights to the development of the Province.

5. Fifth— on the ninth step, the ARIMA (1, 1, 1), which was proven to be the best performing and most accurate model among the three, was used to forecast the values of production and consumption of Masbate's selected fisheries in 2023-2032. Then, the pieces of computed, statistical data applied on the forecasting model were explained. Each visual graph and table had its own separate, supporting argumentations.

6. Sixth— on the final and tenth phase of the six grouped stages, the conclusions were drawn and were written thoroughly. Furthermore, the findings for the four objectives were also assessed, suggesting data-driven insights on future planning and decision making of stakeholders and policymakers regarding the production and consumption of high-value fishery production. After this, the research was considered complete and ready for publication.

3. RESULTS AND DISCUSSION

Section 1. Trend line of the Production and Consumption of High-Value Fishery Product in Masbate from 1993 to 2022

3.1 Trends of the Production and Consumption

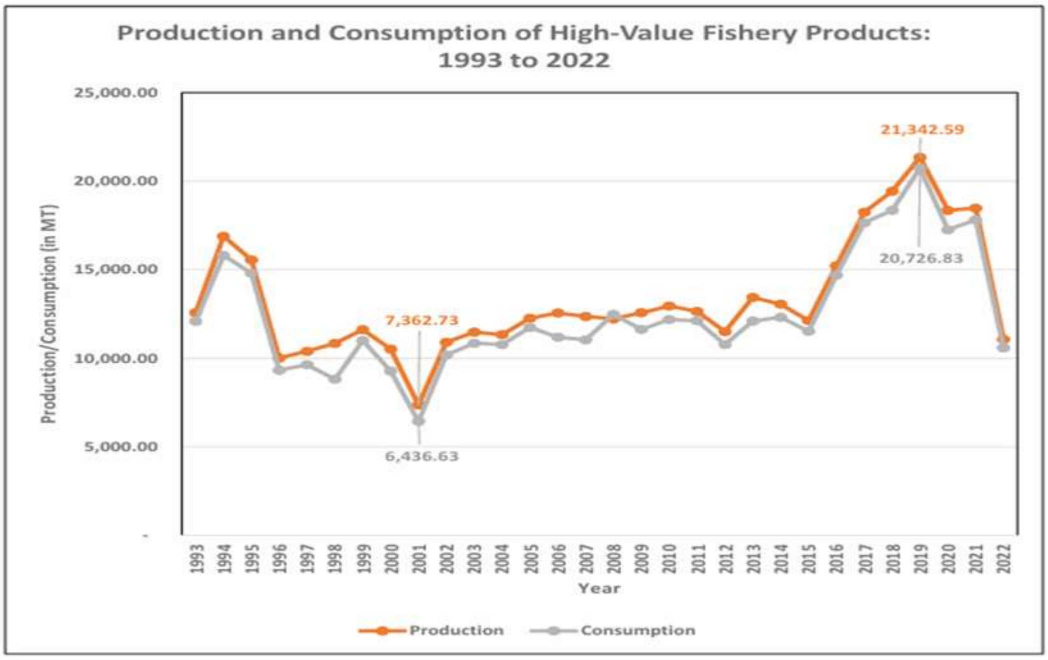
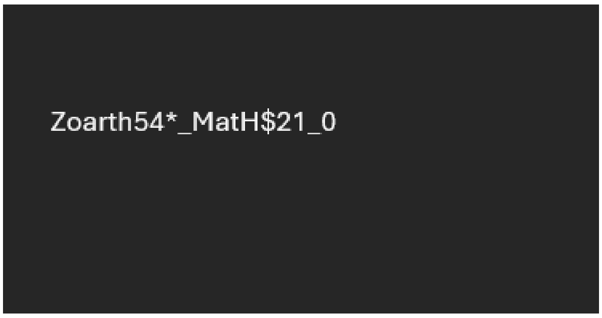


Figure 1. Trends of Production and Consumption of High-Value Fishery Products in Masbate from 1993-2022

Section 2.a Significant Linear Relationship of the Production of High-Value Fishery Products in Masbate

3.2 Ratio by year of Production



	Coefficients	Standard Error	T Stat	P-value
Constant	7123.044	3316.498	2.148	0.041
Ratio by Year of Production	6135.368000	3225.017	1.902	0.068

$R^2 = 0.118$

Table 1. Ratio by year in Production of High-Value Fishery Products in Masbate

3.3 Ratio by year of Consumption

	Coefficients	Standard Error	T Stat	P-value
Constant	8249.346	3047.334	2.707	0.012
Ratio by Year of Consumption	5007.698000	2944.301	1.701	0.100

$R^2 = 0.097$

Table 2. Ratio by year in Consumption of High-Value Fishery Products in Masbate

Section 2.b Significant Linear Relationship of the Consumption of High-Value Fishery Products in Masbate

3.4 Ratio by year of Production

	Coefficients	Standard Error	T Stat	P-value
Constant	6455.388	3369.945	1.916	0.066
Ratio by Year of Production	5990.416000	3276.991	1.828	0.079

$R^2 = 0.110$

Table 3. Ratio by year in Production of High-Value Fishery Products in Masbate

3.5 Ratio by year in Consumption

	Coefficients	Standard Error	T Stat	P-value
Constant	7113.315	3065.004	2.321	0.028
Ratio by Year of Consumption	5324.371000	2961.374	1.798	0.083

$R^2 = 0.107$

Table 4. Ratio by year in Consumption of High-Value Fishery Products in Masbate

Section 3. Forecasted Production and Consumption of High-Value Fishery Products for 2023-2025 using Different Time-Series Models

Moving Average (Production)

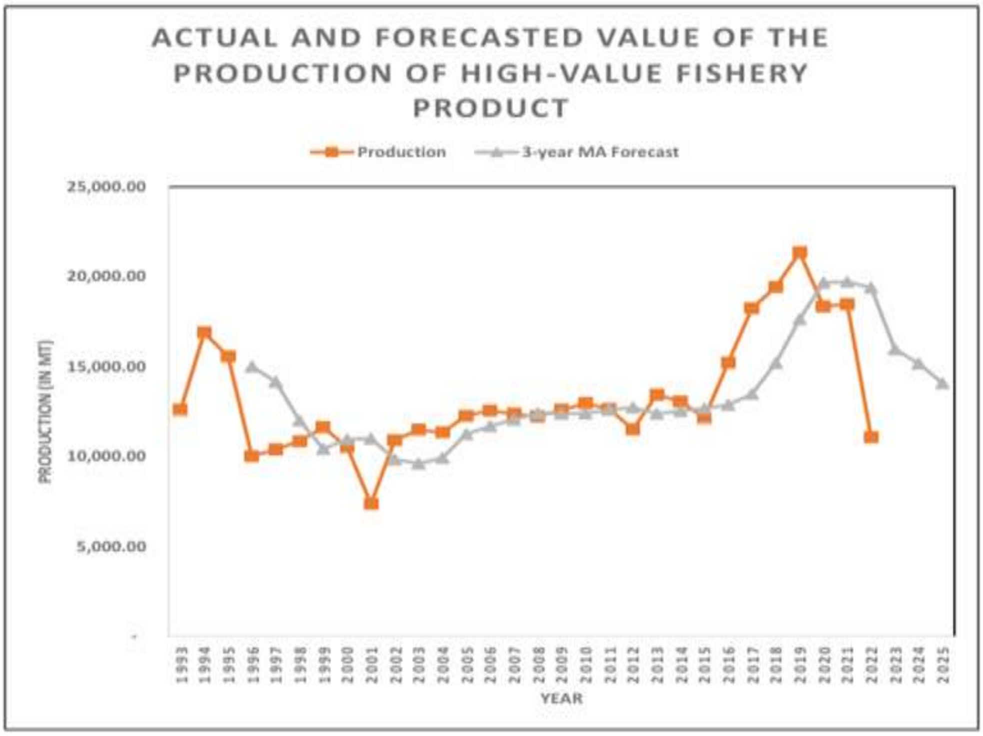


Figure 2. The Moving Average of the Production of High-Value Fishery Products

Moving Average (Consumption)

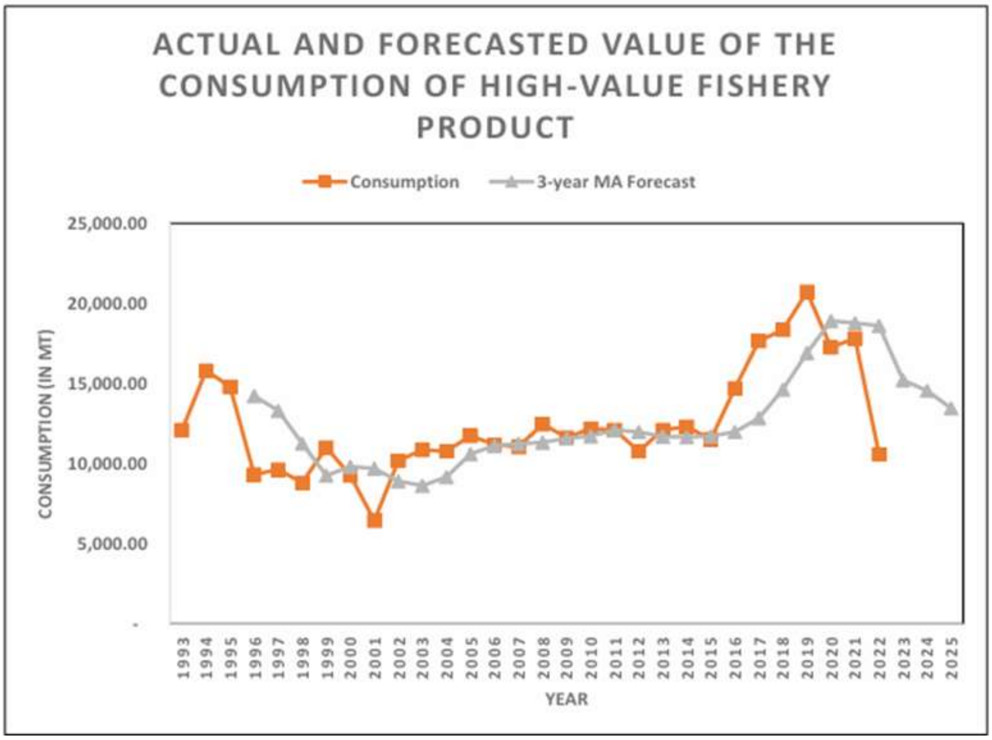


Figure 3. The Moving Average of the Consumption of High-Value Fishery Products

Exponential Smoothing (Production)

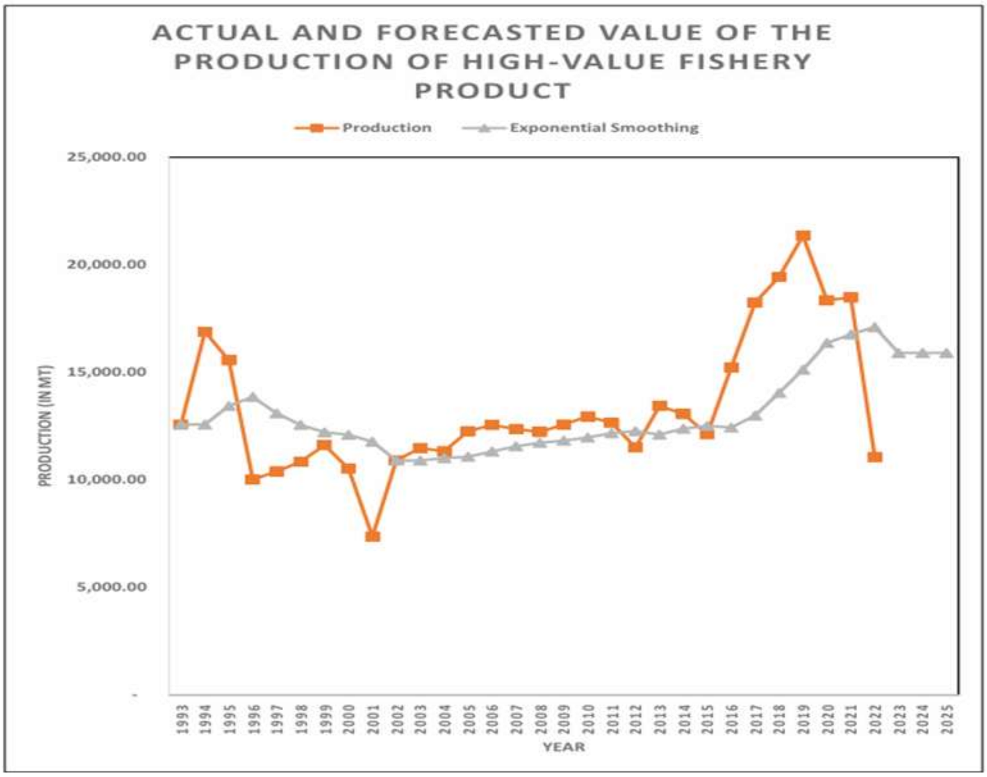


Figure 4. The Exponential Smoothing of the Production of High-Value Fishery Products

Exponential Smoothing (Consumption)

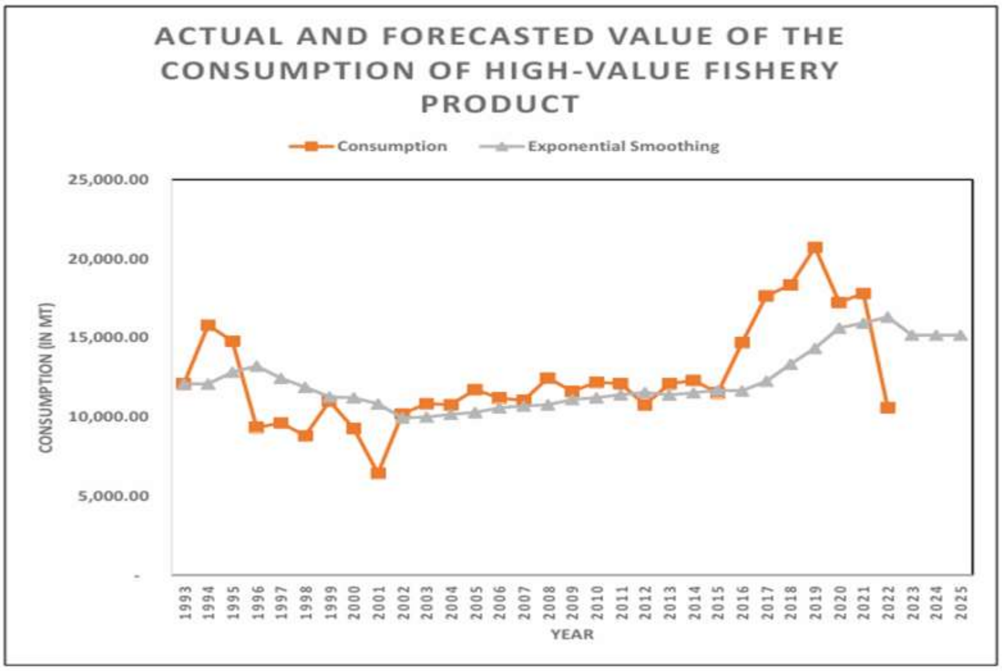


Figure 5. The Exponential Smoothing of the Consumption of High-Value Fishery Products

Autoregressive Integrated Moving Average or ARIMA (Production)

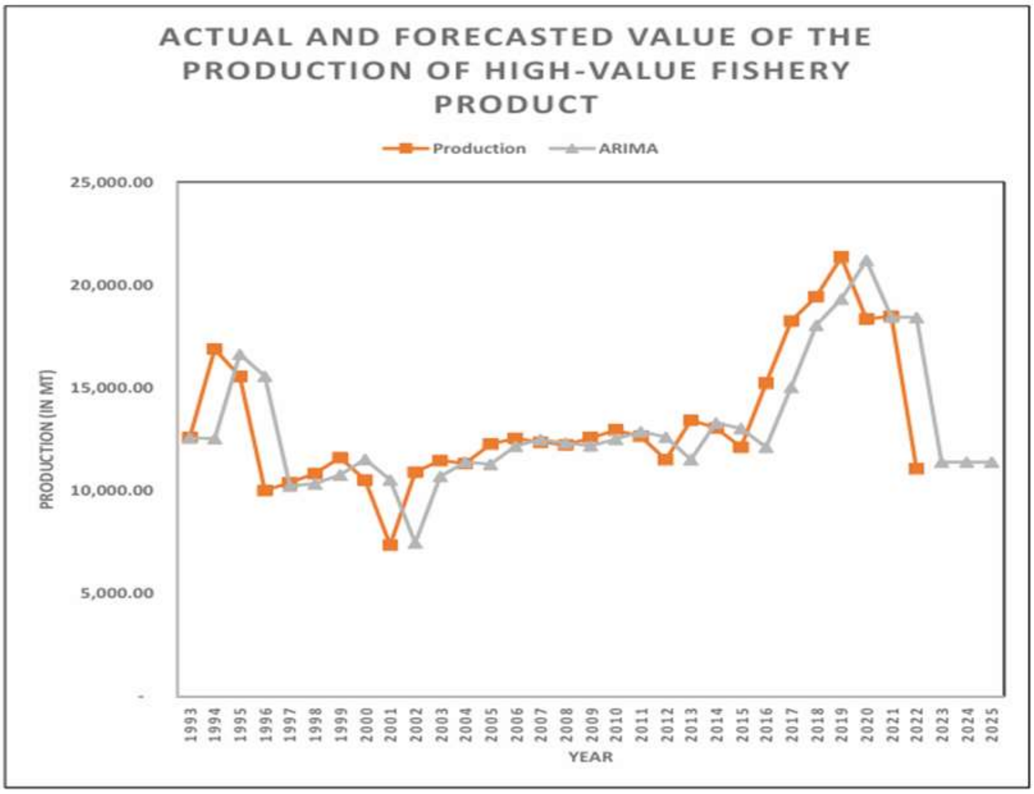


Figure 6. The ARIMA of Production of High-Value Fishery Products

Autoregressive Integrated Moving Average or ARIMA (Consumption)

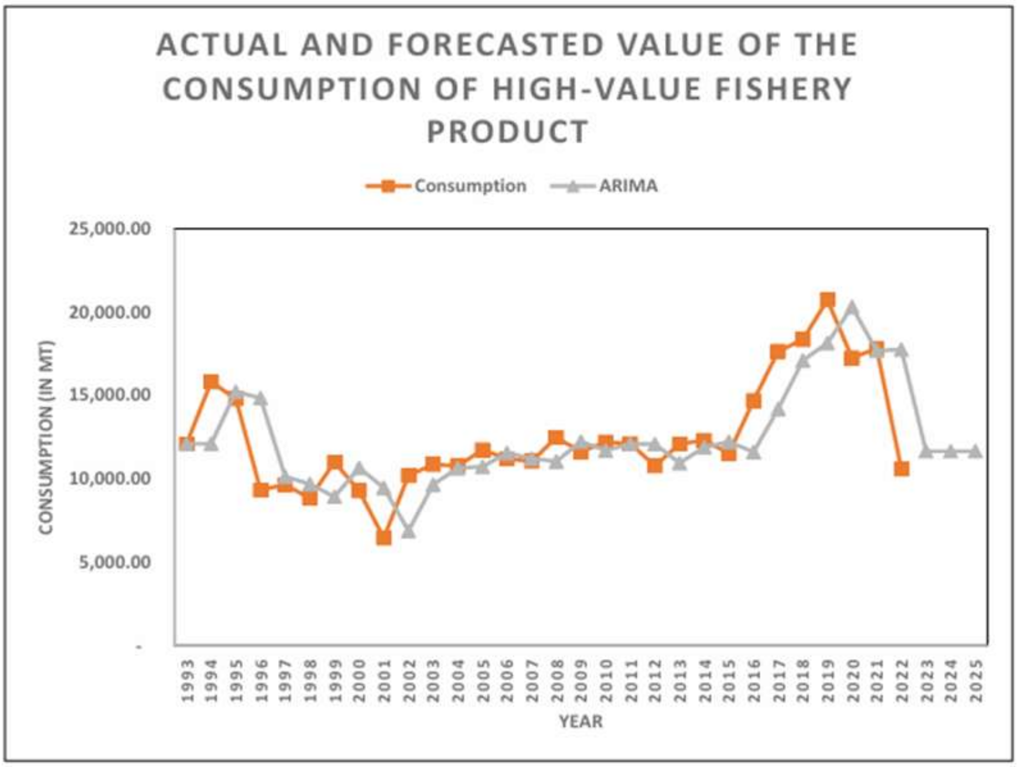


Figure 7. The ARIMA of Consumption of High-Value Fishery Products

Section 3. Best Fit Forecasting Model

Model	R^2	Measures of Forecasting Performance				Forecasted Production		
PRODUCTION								
		MAE	MSE	RMSE	MAPE	2023	2024	2025
Moving Average	NONE	1,926.23	7,399,728.33	2,720.24	15.61	15,963.41	15,168.21	14,066.68
Exponential Smoothing	NONE	2,091.00	7,784,306.08	2,790.04	15.80	15,896.90	15,896.90	15,896.90
ARIMA (0, 1, 1)	**23.67**	**1,644.88**	**5,890,399.92**	**2,427.01**	**13.24**	**11,395.02**	**11,393.79**	**11,391.69**
CONSUMPTION								
Model	R^2	Measures of Forecasting Performance				Forecasted Production		
		MAE	MSE	RMSE	MAPE	2023	2024	2025
Moving Average	NONE	1,961.29	7,353,755.63	2,711.78	17.08	15,220.81	14,542.71	13,451.53
Exponential Smoothing	NONE	2,122.66	7,813,817.90	2,795.32	17.49	15,175.97	15,175.97	15,175.97
ARIMA (0, 1, 1)	**39.4**	**1,743.74**	**5,906,962.14**	**2,430.42**	**15.09**	**11,658.55**	**11,655.54**	**11,650.93**

Table 5. Best Fit Forecasting Model of the Production and Consumption of High-Value Fishery Products

Table 5 showed the best fit forecasting models in the production and consumption of high-value fishery product for 2023-2025 in Masbate. Measures of forecasting performance were set to be the criteria to choose the best time series model, such as Mean Absolute Error (MAE), Mean Square Error (MSE), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). The model with the lowest values for these measures will be the best time-series model. Based on the summary statistics provided above, the Autoregressive Integrated Moving Average or simple ARIMA (0, 1, 1) is the best time-series model in forecasting the production of high-value fishery products for 2023, 2024 and 2025 (11,395.02 MT, 11,393.79MT and 11,391.69 respectively) as well as its consumption (11,658.55 MT, 11,655,54MT, 11,650.93 respectively) since it has the lowest MAE, MSE, RMSE and MAPE. The ARIMA (0, 1, 1) model for production and consumption denotes: 0 means there is no autoregressive terms, thus, the current value of the time series is not significantly influence by its past values; 1 means that the time series has been differences once to achieve stationarity, then the last value of 1 means that there is one lagged moving average term in the model. This is supported by literature that suggested that ARIMA models are widely used in various fields for their simplicity, efficiency, and flexibility in modelling time-series data. The parameters (0, 1, 1) show that this ARIMA model uses variation to achieve stationarity and a lagged moving average term to consider the dependence of the current value on previous values. The R square values for the ARIMA (0, 1, 1) in production and consumption denotes that about 23.67% and 39.40% respectively of the variability of production and consumption is accounted or explained for by the time (year). Putting it all together, ARIMA (0, 1, 1) is a way of analysing time-series data. In order to smooth out the data and account for any lingering patterns or impacts, it is stated that today's data is somewhat independent of yesterday's data (no strong relationship). Additionally, one-step variances have been taken into consideration.

Section 4. Forecasted Value of Fishery Products for 2023-2032 of ARIMA (1,1,1)

3.6 Forecasted Value (Fish)

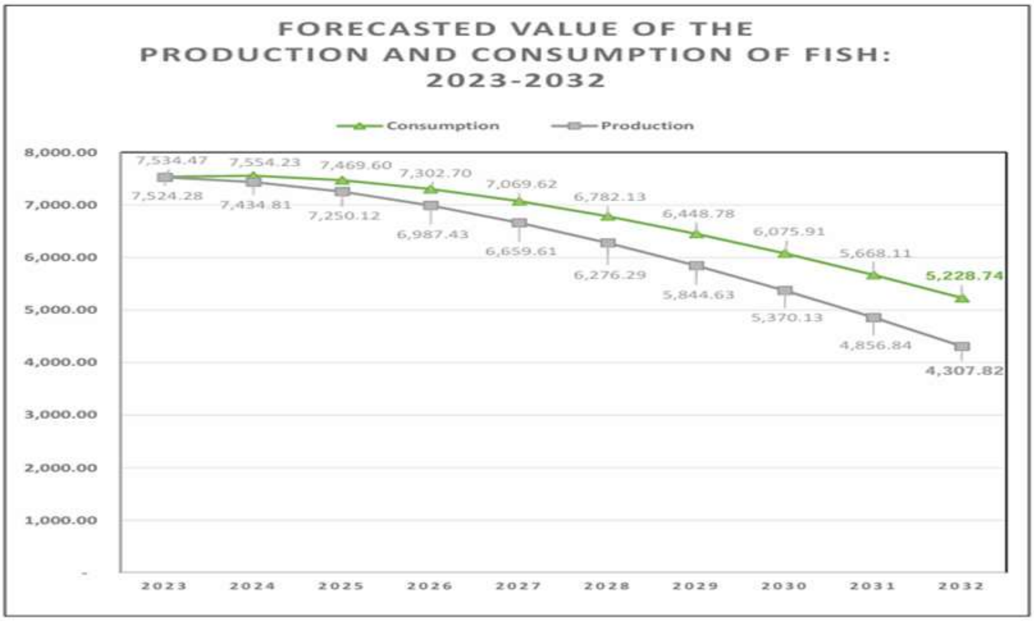


Figure 8. Forecasted Values of Production and Consumption of Fish Products in Masbate from 2023-2032

The graph showed the projected production and consumption values of Fish products from year 2023 to 2032. Over the years, the production and consumption have demonstrated fluctuation, with the lowest production and consumption on the year 2032 demonstrating a volume of 4,307.82 MT and 5,228.74 MT respectively. These forecasts provide valuable insight into the projected dynamics of Masbate's crustacean products, assisting in strategic planning and decision-making. This data revealed the decline of fish production and consumption in the next ten years which indicates that there is a need for effective strategic planning and investigation in the underlying mechanisms in this situation. In addition, this further suggests that the immense decrease of fish production needs to have strong considerations. Hence, if there is no action, the outcome would be a massive loss and degradation of resources, considering the fact that there are other factors that can influence this massive decrease. Thus, there should be an immediate action from the government to promulgate such as the strengthening the programs and projects in the fishery sector to address this critical issue.

4. Conclusion

The analysis of time series models to forecast the production and consumption of high value fishery products from 2023 to 2032 offers interesting findings. Moving Average models forecast drops, whereas Exponential Smoothing forecasts steady volumes. With production accounting for 23.67% of fluctuations and consumption for 39.40%, ARIMA models predict falling numbers. These results provide insightful information on market trends, but the model selection must be in line with the features of the data, and accuracy must be verified in context. The ARIMA (1, 1, 1) model stands out as the best option for forecasting the production and consumption of high-value fishery products in Masbate for the next ten years, particularly in 2023-2032. Moreover, the forecasted value of both production and consumption of high value fishery products using ARIMA (1,1,1) for the next ten years is alarming since it showed continuous decrease. With this, the Masbate’s fishery industry’s future planning and well-informed decision-making, these forecasts offer essential and beneficial data. Furthermore, these predictions provide a solid basis for strategic decisions and resource allocation in the Province's fishery industry due to their accuracy and dependability.

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