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Price behaviour and species diversification across fish markets in Andhra Pradesh, India

Shyam S. Salim[1]*, N. R. Athira[1], Lowrane Stanley[1] and S. S. Raju[2]
[1]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India.
[2]Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam, Andhra Pradesh-682 018, India.

*Correspondence e-mail: shyam.icar@gmail.com

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Original Article

Abstract

The study aims to identify the fish price and trade assessment of the fish species from 12 well-structured fish markets across Andhra Pradesh, including landing centres; retail and wholesale markets from August 2019 to December 2020. A structured survey schedule tool, Fish Market Price (FMP) was used. The Seasonal Autogressive Integrated Moving Average (SARIMA) model was employed to arrive at better forecast results. The outcome of the analysis revealed that certain higher-order SARIMA models were able to parsimoniously track the dynamic behaviour of real fish prices with acceptably accurate forecasts. The average species diversity of the different markets of Andhra Pradesh was 0.76. The study revealed that the reduction in the catches and rising costs of fishing coupled with high demand in export markets resulted in a substantial increase in prices in the domestic markets across the state. The high-value fishes registered stable prices compared to the low-value species. Factors such as freshness, availability and continued positive perceptions of fish and healthy food may prove more important than price rise in determining future demand for fish and fishery products.

Keywords: *Diversity Index, species diversity, market diversity, SARIMA*

Introduction

Fishing in India is an important sector, which has been recognized as a powerful income generator and substantial to fisheries worldwide (Yadava, 2001), apart from being an employment generator, which stimulates the growth of several subsidiary industries and besides a foreign exchange earner (Shyam, 2013; Shyam *et al*., 2014). In India fishing sector is a principal source of livelihood for a large section of the economically underprivileged of the country, especially in the rural coastal areas (Joshi, 1996). In India, fisheries and aquaculture are vibrant economic activities and have been one of the fastest-growing food production systems during the past few years (Shyam *et al.,* 2020). The fishery sector in India has been showing steady growth in the total gross value added and accounts for a share of 5.23% of the agricultural GDP of our country. (GoI, 2020). Thus the fishery sector plays a predominant strategic role in the economic activity and food security of our country through its contribution to national income, foreign exchange, food and employment (Shyam *et al.,* 2019). Among the nine maritime states and two union territories of the country, the state of Andhra Pradesh has the third longest coastline in India with nine coastal districts with 534 marine fishing villages situated along the coast of Andhra Pradesh and 234 fish landing centres (CMFRI-DoF, 2020). Andhra Pradesh ranks fifth in the contribution to the marine fish landings of the country, with landings of 5.64 lakh t, in addition to being the largest inland fish-producing state with 36.1 lakh t. The value of marine fish landings in Andhra Pradesh during 2020 at the landing centre level was 2553 crores and at the retail centre level was 3796 crores (CMFRI, 2020). The price movements in different fish markets depend on the inter-market movements and the available fish catch which in turn, is governed by the demand and supply factors. In this context, the present study aims to assess, the diversity of the species and markets across the state. The study also analyzes the degree of price stability for the commercially traded fish species across the major markets in Andhra Pradesh along with analysing the price realization and seasonal price behaviour of fishes.

Material and methods

The study covered 12 well-structured fish markets across Andhra

Pradesh, including landing centres, retail and wholesale markets, which are depicted in (Fig. 1). As the market is a major driver in the price determination of fish, this study aimed to develop an integrated fish market and price information system for India by mapping the markets on a ten-dimensional market structure. The different dimensions include location, access, timing, conduct, species, arrivals, disposals, infrastructural adequacy, regulations and intelligence. The study was based on the primary data collected from August 2019 to December 2020. A structured survey schedule tool, Fish Market Price (FMP) was developed for collecting the weekly prices of commercially traded marine and inland species. The primary data were collected regularly and systematically (twice or thrice a week) with the help of trained enumerators mostly from the fisher community. An in-depth analysis of the marine and inland species was done by categorizing the fish prices sorted weekly, accordingly as selecting four prices in a month *ie*, average prices of different species in 1 to 7 (first week), 8 to 14 (second week), 15 to 22 (third week), 22 to 30 days (fourth week) and are arranged concerning the small, medium and large size of the species of the respective markets. The average prices and price behaviour of each species (small, medium and large) were identified respectively in the different fish markets across the period. The max-min prices of the respective markets were also estimated concerning the different sizes of the species to understand the efficiency of the selected fish markets across the time. Price structure in the fish markets varies with different factors such as species, size, quality, and season. Different statistical and econometric tools such as diversity index, covariance analysis, and Seasonal Auto-Integrated Regressive Moving Average approach was employed for analyzing the data. The study locations of different markets of Andhra Pradesh are depicted in Fig. 1. plotted using ArcGIS Pro software.

Species-Market Price analytics

The Species Market Price (SMP) analytics describes the extent of diversification quantified for both species-wise and market-wise using the species/market diversity index in terms of availability, affordability and accessibility of the varied fish species in the markets (Shyam *et al.*, 2020). The diversity assessment was derived based on the species availability across and within markets. Accordingly, market diversity indicates the number of species available/ traded in a particular market and it ranges from 0 to 1. Similarly, the species diversity indicates the spatial distribution of a particular species across markets and it ranges

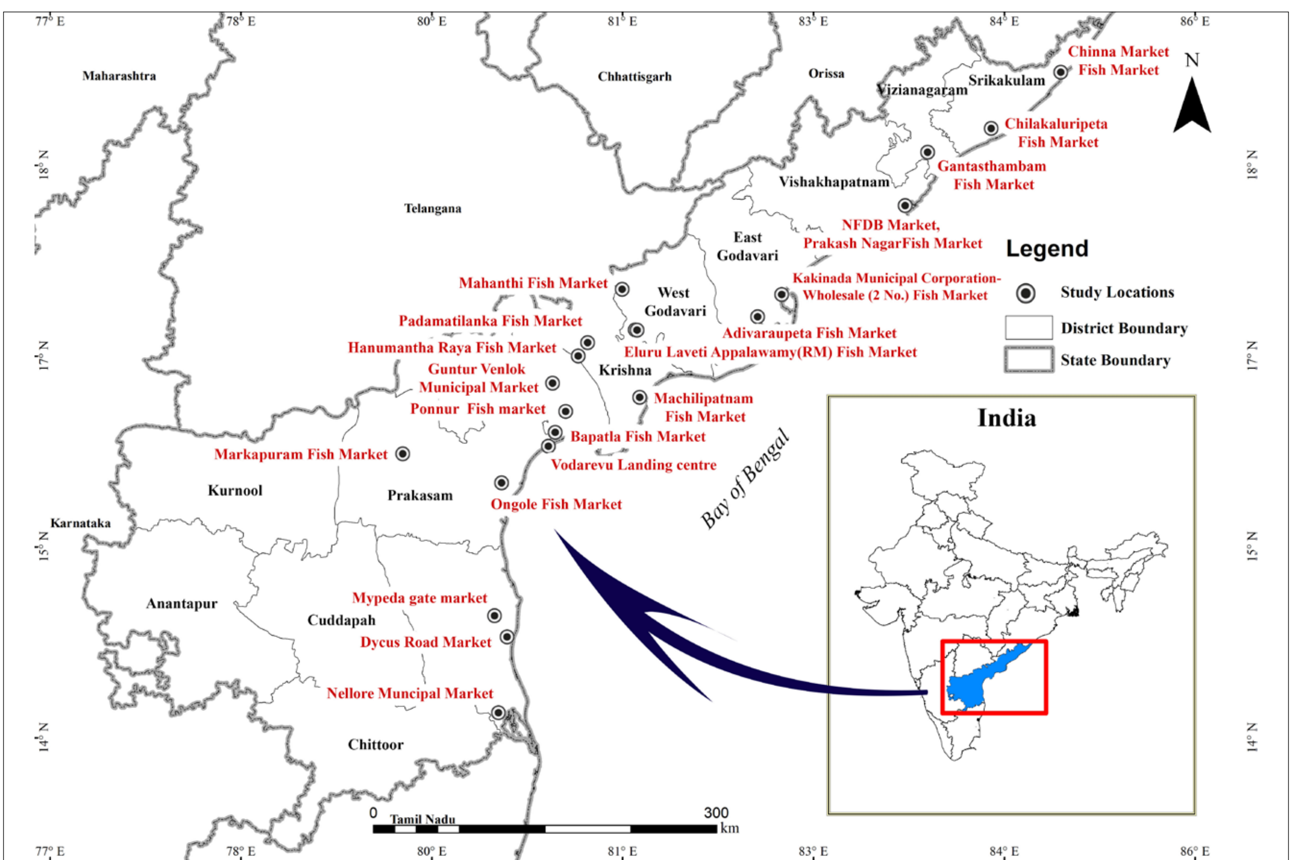


Fig. 1. Location of the study in Andhra Pradesh

from 0 to 1. A more market diversity index indicates more species traded within a market and similarly more species diversity index indicates the spatial spread of a particular species across markets. The diversification of the market, as well as species concerning the periods, have been measured using the Simpson Index of Diversity (SID). Simpson index is commonly used for the measurement of diversity, with values ranging from 0 to 1. The index ranges between 0-1, tending towards zero when there is specialization and towards one when there is complete diversification. The Simpson Index of Diversity is calculated using the following equation

$$\text{SID} = 1-\sum_{i=1}^{n} W_i^2 \quad \text{and} \quad W_i = \frac{X_i}{\sum_{i=1}^{n} X_i},$$

where X_i = Value of i^th^ species/ market

W_i = Proportionate value of i^th^ species/ market out of total species/ market.

Price Behaviour Estimation

The Seasonal Auto-Regressive Moving Average (SARIMA) method was employed for analyzing the price behaviour estimation over the period from August 2019 to December 2020. In time series forecasting, the SARIMA model has become more popular and is widely used due to its statistical properties alongside the Box–Jenkins methodology used in the model structure (Zhang, 2003; Wang *et al*., 2003). A preliminary investigation of the seasonal time series data was carried out using the summary statistics, time series plots, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). Stationarity of respective time series was checked using the Augmented Dickey Fuller (ADF) test, Kwiatkowski Phillips Schmidt Shin (KPSS) test, AFCs and PACFs. Seasonality and stationarity concerning seasonality were identified using respective ACFs and PACFs. Seasonal indices were calculated employing decomposition techniques. Identification of the preliminary models was completed using the respective ACFs and PACFs, while the appropriate order of differencing was identified based on the results of the tests for stationary. Model fitting was carried out using the R package 't series' by which Maximum Likelihood Estimates of the model parameters can be obtained. Model selection was carried out based on the corrected Akaike Information Criterion (AICC) which avoids the deficiencies associated with AIC.

Diagnostic checking of the selected model was completed through a residual analysis based on Residual plots, Normal probability plots of residuals, ACFs and PACFs of Residuals and Squared residuals and the Ljung-Box test on serial dependencies. Ljung–Box test is applied to the residuals of a fitted model, not the original series, and in such applications, the hypothesis to be tested is that 'residuals from the model have no autocorrelation'(Stoffer and Toloi, 1992). Based on the results of diagnostic checking the final modes were selected. If the selected model was not sound concerning the Residual analysis, then the next model choice was subjected to diagnostic checking. This procedure was continued until a parsimonious model was found. Forecasting and forecasting efficiency based on the least Mean Absolute Percentage Error (MAPE) was obtained by using R package forecasts. For computing MAPE, data during the period August 2019 to March 2020 was regarded as the training data and April 2020 to December 2020 was employed as the validation data set. If the forecasting efficiency was recognized as inadequate then diagnostic checking was repeated until a correctly specified model was found.

Results and discussion

Species and market diversity

The present study recorded a total of 21 species of fish, of which 10 species were of marine habitat, another 10 of inland habitat and the remaining one belonged to migratory habitat. The extent of diversification was quantified both species-wise and market-wise using the species/market diversity index (Shyam *et al.,* 2020). The diversity assessment was derived based on the species availability across and within markets. The fish fauna diversity across the different markets of the state during 2019-20 is depicted in Fig. 2.

The average species diversity of the different markets of Andhra Pradesh was 0.76. Of the 21 species traded across the different markets, anchovies, catla, king seer, mrigal, oil sardine, *Pangasius,* rohu, silver pomfret, tilapia and tiger shrimp registered species a diversity index of 1.0, which indicated that these particular species are available across all the markets of Andhra Pradesh including the landing centres, wholesale markets as well as retail markets, which have large trading opportunities. (Fig. 2). Higher species diversity indicated the

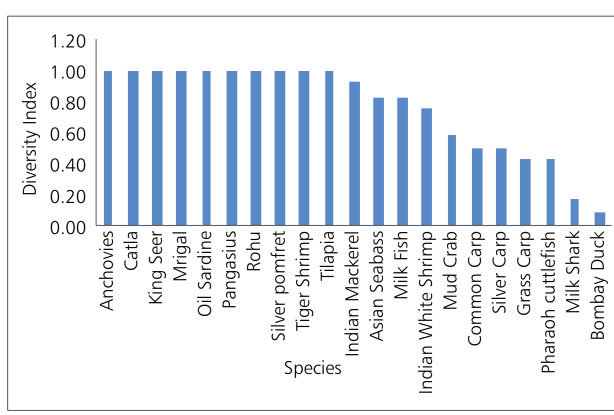


Fig. 2. Species diversity in Andhra Pradesh fish markets

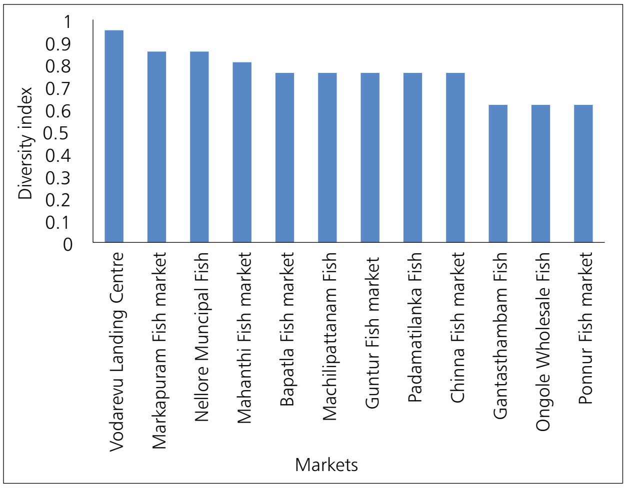


Fig. 3. Market diversity in Andhra Pradesh fish markets

spatial spread of the particular species within and across the markets. The high species diversity of these markets enhances the availability, affordability and accessibility of fish to consumers improving the fish consumption pattern. The results indicate that anchovies, catla, king seer, mrigal, oil sardine, *Pangasius,* rohu, silver pomfret, tilapia and tiger shrimp are the most common fish species found in different markets of Andhra Pradesh. The fish consumption studies in Andhra Pradesh (CMFRI, 2020) showed that among the various species, Seer fish and Pomfrets remain the most favoured fish with the highest diversity index of 0.54, followed by shrimps (0.53), mackerels and anchovies (0.51), which validates the results of the high species diversity of Andhra Pradesh as these are the most common species in the different markets of Andhra Pradesh. A higher market diversity index indicated more species traded within a market and likewise, the market diversity assessment results indicate that the average market diversity index of Andhra Pradesh was 0.76. This average market diversity indicates that of the 21 species traded, 76% were available in the different markets of Andhra Pradesh. It was found that the Vodarevu landing centre, Markapuram fish market, Nellore municipal fish market and Mahanati fish markets have the highest market diversity index. Vodarevu landing centre traded the maximum number of species (Fig. 3). Higher market diversity indicated its reach in terms of the availability of the different varieties of fish species. The richness of varied species and their availability among these markets enabled the consumers to enhance quality and taste preferences for accessing different varieties of species.

Price realization of different species

The price of fish fluctuates more widely in comparison with other agricultural commodities. The price realization across fish markets in Andhra Pradesh for the major traded species is shown in Fig. 4. The average price realization of major fishes traded indicated that among eleven species traded throughout the period, the highest average unit price was realized for tiger shrimp (₹635.61/kg; ranging between ₹555 and ₹690/kg. Similarly, the lowest average price was realized for Indian mackerel (₹99.55/kg; ranging between ₹85 and ₹110/kg. The price structure of major traded fishes across the major markets of Andhra Pradesh during the period is depicted in Fig. 5. From the analysis of price details of major fish species traded, price behaviour for various high-value species and low-value species was drawn. The price of fish differs according to their size, freshness and season of the year. The production area of the fish and market structure also influences the price of the fish. Alam *et al.* (2010) studied the fish marketing system in Swarighat, Dhaka, Bangladesh and revealed that the production area of the fish tends to influence the price of the fish. The price is also influenced by supply and demand and there are generally seasonal variations in prices with the highest in summer (March-May) and the lowest in winter (November-January), during the fish harvesting season in Khulna, Bangladesh (Rahman *et al.*, 2009).

The average price trend analysis of major traded species across the markets designates that tiger shrimp, King seer fish and silver pomfret realized the highest mean price of ₹626.43, ₹621.79 and ₹590.15/kg, respectively. During the monsoon period when there is greater availability of fish, the fish price realization was low and the price comparison of high-value species like tiger shrimps, pomfrets, and king seer were high compared to low-value fishes like oil sardine and Indian mackerel. Among them, the high-value fishes realised better stable prices compared to the low-value species. The retail prices soared exorbitantly compared to the landing centres during the post-monsoon period. This study exhibited that there exists a reduction in the catches of high-value fish, rising costs of fishing result in increasing prices. The demand for fish in both domestic and export markets also results in a substantial increase in marine fish prices in the domestic markets across the state. It also makes out that higher price spread for certain fish varieties which include packing, handling, transportation and value addition process or post-harvest operations. (Sathiadhas *et al.*, 2011; Panikkar and Sathiadas, 1989) have opined on the spatial and temporal variations in marine fish prices. According to the study the same fish variety would command different prices in the same market at the beginning of the day as well as when the market draws to a close.

Seasonal Price Behaviour

The price behaviour of the different species was estimated using the econometric modelling technique. It was based on the claim that the price of fish has increased over time and is frequently subjected to price fluctuations (Stoffer *et al.,* 1992). The analysis outcomes revealed that higher-order SARIMA models

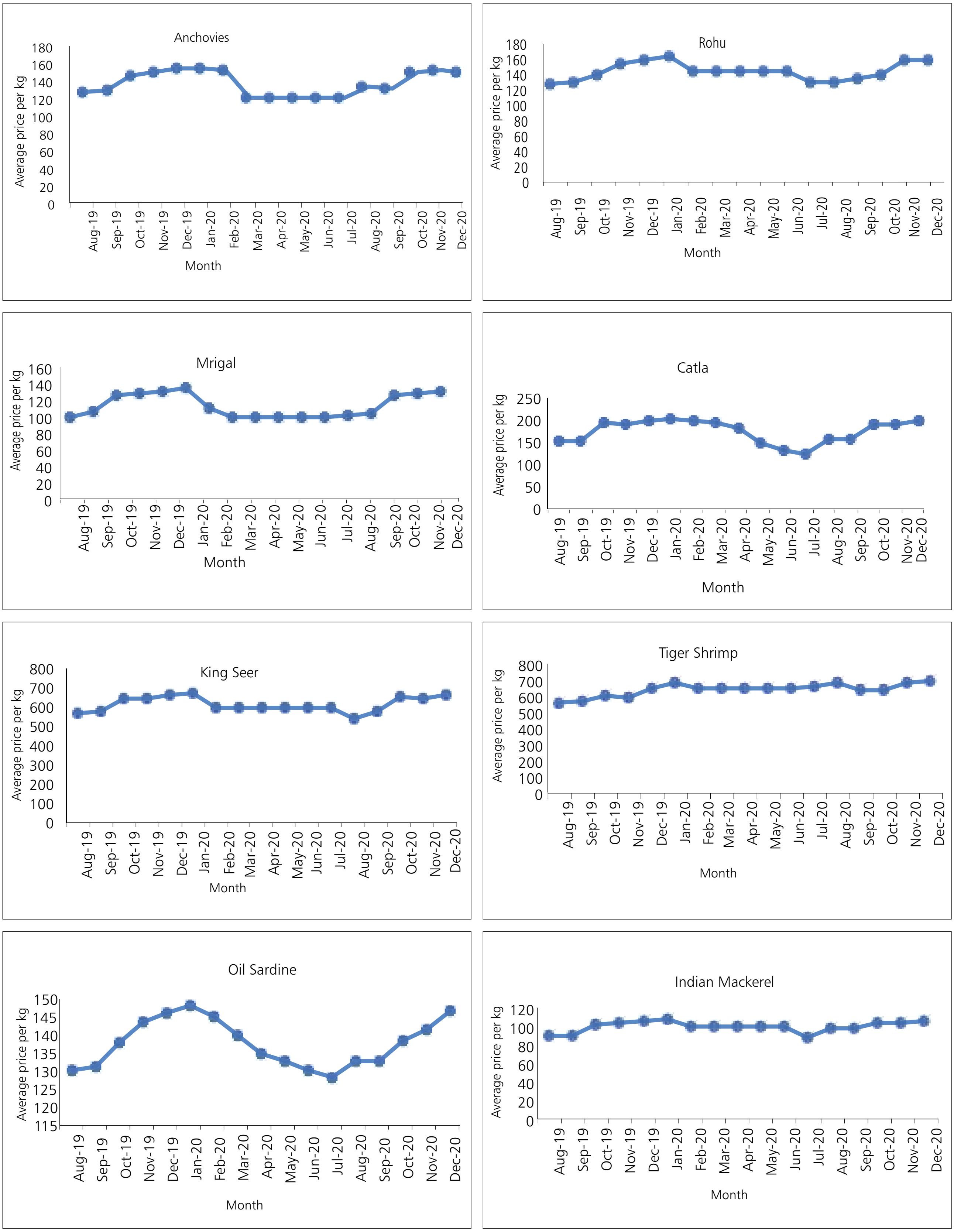


Fig. 4. Price realization across fish markets in Andhra Pradesh for major traded species

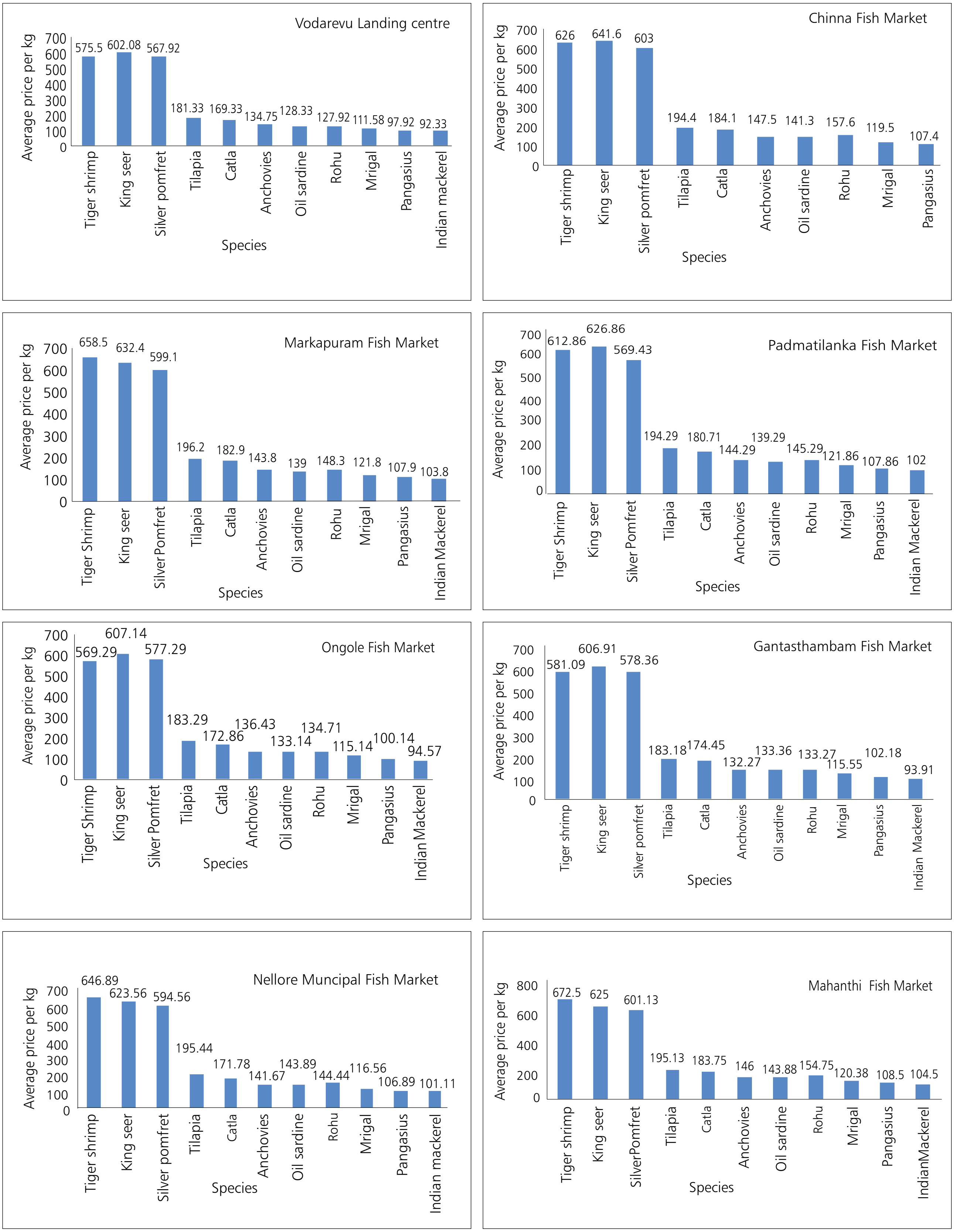
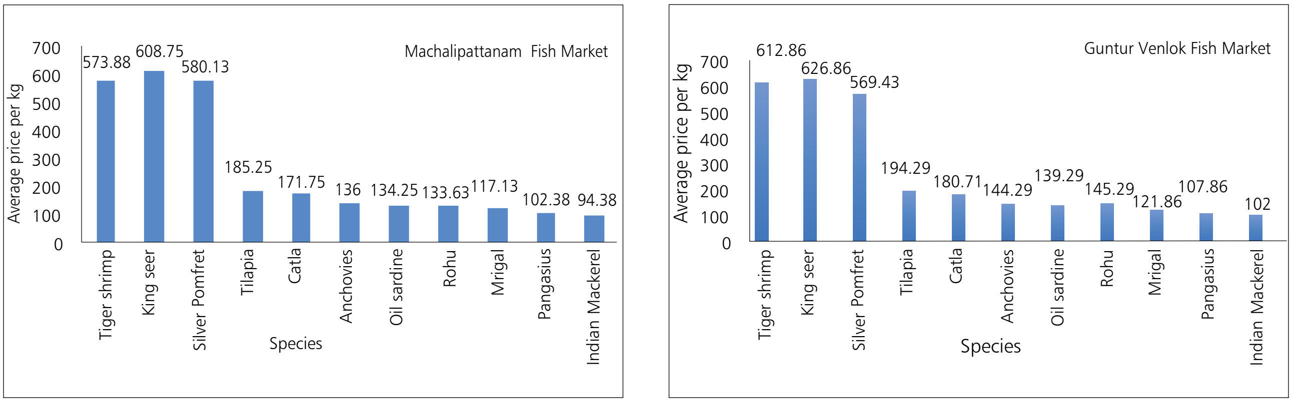


Fig. 5. Price realization of major fishes traded across selected markets of Andhra Pradesh. (cont....to next page)



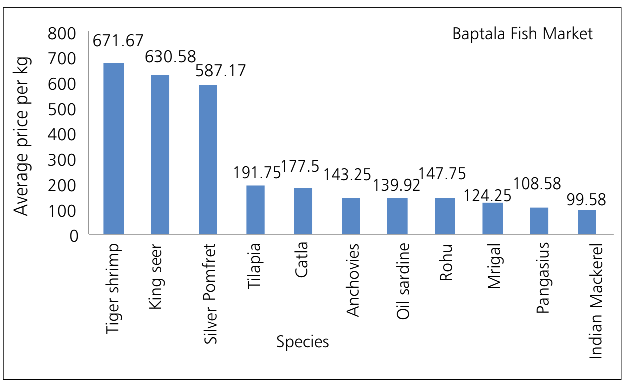


Fig. 5. Price realization of major fishes traded across selected markets of Andhra Pradesh.

were able to track the dynamic behaviour of the fish prices with accurate forecasts. The price of fish species has increased over time with steady seasonal patterns in real price changes with higher prices observed in the middle months of the year. The ADF test and the KPSS test results pointed out that the prices of the different species were found to be stationary (Table 1). Further, the ADF and KPSS tests as well as the ACFs and PACFs applied on respective first-order-differenced series (Table 2) revealed that it is sufficient to imply to make the respective series 'stationary'. Moreover, the ACFs and PACFs of the first-order differenced series indicated that seasonal differencing is required for the real prices of all the selected species. Also, the SARIMA model with d=1 and D =1 was appropriate for modelling the fish prices.

At the time of model fitting and selection, based on the least AICc, the SARIMA (4,1,3) $(0,1,1)^{52}$, SARIMA (3,1,3) $(1,1,1)^{52}$, SARIMA (4,1,3) $(0,1,1)^{52}$, SARIMA (3,0,4) $(0,1,1)^{52}$ and SARIMA (4,1,3) $(0,1,1)^{52}$ were found suitable and identified as the 'best-fitted models' for the real price of the different species selected for the study (Table 3.) Estimates of the 'best-fitted models' selected based on the least AICc for real prices of five different fish types are given in Table 3. Fairly high orders are apparent for ordinary AR and MA components of the models given in Table 3, suggesting that the current week's real prices are significantly serially dependent on the real prices which prevailed during the past few weeks. This evidence that the variability of real fish prices observed in several weeks at present would diffuse into the next week's fish prices. This is very important information for all the stakeholders involved in the fishing arena for better planning and management of the different activities involved from fish production to marketing. As depicted in the seasonal component of the models, it can be concluded that present seasonal variability in real fish prices is dependent on the variability observed in the fish price in the previous season where the seasonal length is 52 weeks–which means that each year the same general pattern of price fluctuations are seen. Forecasting errors of the SARIMA model for the species reported around 8%, which is a good indicator that these models would produce more accurate forecasts. Models developed for all the 11 species prices have comparatively high forecasting accuracy and it could be also noticed that the point forecast prices are adequately closer to the actual prices. All the actual prices were included in the 95% Coincidence Limits of the price forecasts,

Table 1. Estimates of ADF and KPSS tests to evaluate stationarity of real price series for original real prices

Species	ADF	KPSS	
		Trend	Level
Anchovies	-6.58**	0.0091	0.0095
Catla	-6.01**	0.0073	0.007
Indian Mackerel	-6.80**	0.0062	0.0067
King Seer	-6.34**	0.0069	0.0074
Mrigal	-7.22**	0.0073	0.007
Oil Sardine	-6.02**	0.0062	0.0067
Pangasius	-5.99**	0.0069	0.0074
Rohu	-5.63**	0.0056	0.0032
Silver Pomfret	-7.12**	0.0062	0.0067
Tiger Shrimp	-7.05**	0.0069	0.0074
Tilapia	-7.22**	0.0073	0.007

*Note: * p-value ≤0.05, ** p-value ≤0.01, *** For ADF test; H_0: The data is non-stationary and for KPSS test; H_0: Trend/Level is stationary*

Table 2. Estimates of ADF and KPSS tests for 1st Order differenced data

Species	ADF	KPSS	
		Trend	Level
Anchovies	-7.88**	0.0067	0.0091
Catla	-5.08**	0.0074	0.0073
Indian Mackerel	-10.80**	0.0067	0.0062
King Seer	-9.37**	0.0074	0.0069
Mrigal	-5.66**	0.0067	0.0073
Oil Sardine	-9.02**	0.0062	0.0067
Pangasius	-15.01**	0.0091	0.0095
Rohu	-11.43**	0.0086	0.0052
Silver Pomfret	-8.72**	0.0073	0.007
Tiger Shrimp	-9.85**	0.0062	0.0067
Tilapia	-12.12**	0.0069	0.0074

*Note: *p-value ≤0.05, **p-value ≤0.01, *** p-value ≤0.001, For ADF test; H_0: The data is non-stationary and for KPSS test; H_0: Trend/Level is stationary*

Table 3. Estimates of the AICc and MAPE of the Best Fitted Models

Species	SARIMA Model	AICc	MAPE(%)
Anchovies	$(4,1,3)(0,1,1)^{52}$	4548.18	12.33
Catla	$(3,1,3)(1,1,1)^{52}$	5881.10	10.83
Indian Mackerel	$(4,1,3)(0,1,1)^{52}$	3192.89	8.11
King Seer	$(3,0,4)(0,1,1)^{52}$	5688.77	9.11
Mrigal	$(4,1,3)(0,1,1)^{52}$	5353.99	11.07
Oil Sardine	$(4,1,3)(0,1,1)^{52}$	4865.33	9.36
Pangasius	$(3,0,4)(0,1,1)^{52}$	5524.02	10.56
Rohu	$(4,1,3)(0,1,1)^{52}$	4563.21	9.85
Silver Pomfret	$(4,1,3)(0,1,1)^{52}$	4451.63	8.95
Tiger Shrimp	$(3,1,3)(1,1,1)^{52}$	3256.12	4.56
Tilapia	$(3,0,4)(0,1,1)^{52}$	1025.98	5.65

Table 4. Forecast Values of Prices with comparing Actual Prices (Rs./kg)

Species	Estimate	Lo=95	Hi=95	Actual Prices
Anchovies	126.67	134.75	144.29	117.50
	129.17	143.25	147.50	130.71
	145.67	143.80	137.27	132.30
	149.75	141.67	136.43	149.43
	153.08	136.00	146.00	150.00
Catla	192.00	169.33	180.71	149.72
	192.33	171.75	182.00	153.17
	197.89	171.78	182.90	153.58
	198.00	172.86	183.75	157.29
	202.25	174.45	184.10	158.80
Indian Mackerel	103.67	93.91	102.00	89.17
	104.17	94.38	102.36	90.42
	105.67	94.57	103.80	97.20
	105.83	99.58	104.20	97.43
	108.58	101.11	104.50	99.55
King Seer	646.50	539.33	635.64	602.08
	649.29	571.00	626.86	630.58
	660.58	576.50	641.60	632.40
	662.11	577.71	606.91	623.56
	675.75	582.00	607.14	608.75
Mrigal	127.17	111.58	119.50	98.33
	127.92	115.14	120.38	100.00
	130.89	115.55	121.80	101.71
	131.08	116.56	121.86	104.50
	134.33	117.13	124.25	104.58
Oil Sardine	141.67	133.36	141.30	128.33
	143.33	134.25	141.36	130.00
	146.08	139.00	143.88	132.86
	146.44	139.29	143.89	132.90
	148.08	139.92	144.67	137.92
Pangasius	107.42	97.92	107.82	98.75
	107.67	100.14	107.86	99.00
	111.17	102.18	107.90	99.17
	111.22	102.38	108.50	100.29
	113.33	106.67	108.58	106.92
Rohu	140.86	127.92	148.30	128.00
	154.17	133.27	148.64	129.29
	158.25	133.63	154.75	130.17
	158.33	134.71	155.08	130.42
	158.44	144.44	157.60	135.00
Silver Pomfret	601.14	567.92	597.42	559.17
	604.33	577.29	599.10	544.17
	604.67	578.36	599.27	561.58
	616.33	580.13	601.13	565.30
	617.00	587.17	603.00	565.71
Tiger Shrimp	649.17	569.29	646.89	558.33
	653.33	572.50	658.50	567.50
	678.75	573.88	671.67	594.25
	681.67	581.09	672.50	601.00
	682.14	612.86	691.67	634.50
Tilapia	184.86	181.33	194.29	181.83
	181.70	183.18	194.40	183.67
	190.14	183.29	195.13	190.83
	194.00	185.25	195.44	194.42
	199.89	191.17	196.20	199.50

Lo=95 means lower confidence level with 95 percent accuracy

Hi=95 means higher confidence level with 95 percent accuracy

which provides further evidence to prove that the selected models would produce accurate real price forecasts. Price forecasts completed for the respective models for 52 weeks for selected fish types are given in Table 4.

Conclusion

The findings of the present study concluded that of the total species traded across different markets of Andhra Pradesh, anchovies, catla, king seer, Mrigal, oil sardine, *Pangasius,* rohu, silver pomfret, tilapia and tiger shrimp are the most traded compared to others available across the markets. The prices fluctuated due to the changes in supply, uncertainty of fish production, availability, affordability, accessibility and perishability. The high-value fish have better stable prices. The retail prices soar exorbitantly than landing centre prices. Fish prices show seasonal behaviour and tend to be high in mid-year. The increased affluence of the population, and factors such as freshness, availability and increased health perception about consuming fish and fish products are more important than price in determining the demand for fish and fishery products. Even though this information can be utilized by the different stakeholders involved in the fishing arena for better planning and execution of the different fishing and allied activities deeper analysis is warranted to determine the reasons for the seasonality and the behaviour of prices explained by the models and their consequences to the fishing industry.

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