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Vol. 9, No. 4, Desember 2018 ISSN 0216 0544 e-ISSN 2301 6914 169 THE IMPLEMENTATION OF GREY FORECASTING MODEL FOR FORECAST OF CAPTURED FISHERIES PRODUCTION aMuhammad Shodiq, bBudi Warsito,cRachmat Gernowo a Magister of Information System, Diponegoro University, Semarang, Indonesia. bDepartment of Statistics, Diponegoro University, Semarang, Indonesia. cDepartment of Physics, Diponegoro University, Semarang, Indonesia. E-mail: aShodiqmuhammad13@gmail.com, bbudiwrst2@gmail.com, cgernowo@yahoo.com Abstract The increasing need for fish causes problems related to production in the fisheries sector.

In fisheries production all information related to fishing ground is well known, but on the other hand it is not easy to predict the amount of production due to unclear information. This is also related to the number of ships that make trips, the length (time) of the trip, the type of fishing gear, weather conditions, the quality of human resources, natural environmental factors, and others. The purpose of this study is to apply Grey forecasting model GM (1,1) to predict fisheries production. Grey forecasting models are used to build forecast models with limited amounts of data with short-term forecasts that will produce accurate forecasts.

This study employs the data of captured fish from 2010 to 2018 to analyze calculations using the GM model (1,1). The results showed that the Grey Forecasting Model GM (1,1) produced accurate forecasts with an ARPE error value of 9.60% or the accuracy of the forecast model reached 90.40%. Key words: Fisheries Production, Forecasting, GM (1,1), Grey Forecasting.. 170 Jurnal Ilmiah KURSOR Vol. 9, No. 4, Desember 2018, hlm. 169 - 176 INTRODUCTION The Developments in the fisheries sector, especially captured fisheries are currently related to the problem of overfishing [1].

This activity will create a significant reduction in fisheries resources along with filling production needs and the rapid pace of the economy wheel. The Increasing number of life needs related to fisheries resources requires planning and decision making for evaluation of fisheries management policies in order to obtain optimal results [2]. Fishery products have an important contribution to the other production activities and food security and also provide jobs opportunities; there for a policy is needed to manage socio-economic sustainability of the fisheries sector [3].

By understanding the upcoming fish production, it is possible to take advantage from it and use it as reference for planning and making decision optimally. Obtaining optimal results in forecasting unclear information obtained. One of the information related to the catch area is well- production. The difficulties are related to the number of ships sailing, sailing time, types of fishing gear used, weather conditions, natural environmental factors, engine strength used and the capacity of the vessels used [4].

Grey system is a system with partially known and partially unknown information. The theory of grey systems can be used in various fields to solve problems [5]. One of the grey system models is GM (1,1). The GM (1,1) model can be used for forecast with limited data samples. Compared to the time series analysis model the advantage of GM (1,1) model is it can be applied to limited data with short-term forecast that produce accurate forecast, besides this model also does not consider the statistical distribution of processed data [6].

Forecasting fish production can be applied as a first step to find the coming fisheries results, the implementation of grey forecasting will provide benefit if linked to the forecasting system. Using grey forecasting it is possible to develop an appropriate tool for forecasting systems that have important functions in planning and policy making [7]. In addition, grey forecasting has been used in forecasting accurate forecast [8]. Forecasting of agricultural products using GM (1,1) show accurate forecast results [9], the forecast of the syphilis incidence in China using GM (1,1) shows that GM (1,1) produces accurate forecast [10], and the forecast of China's electricity consumption by comparing grey forecasting and ARIMA shows that grey forecasting has the smaller MAPE than ARIMA [11]. In previous researches, grey forecasting was widely used in cases to electricity forecasting, disease incidence, and agricultural products.

In this research, grey forecasting was applied to the fisheries sector in the case of fisheries production. This research aims to find or help grey forecasting in fisheries production can produce high forecast accuracy, as in previous researches using grey forecasting. Based on these problems, a fisheries production forecasting system is

needed, so it can be used to find the information of fish production amount, one of the models used is GM (1,1).

In this research, the implementation of GM (1,1) produced an information on fisheries production forecasts that could be used strategies of the following period. FORECAST There are several definitions of forecasts, one of them in the Great Dictionary of Indonesian Language (KBBI), which states that forecasting is estimating an event based on the results of rational calculations. While other definitions of forecasting, are: a. Forecasting is a knowledge to predict future events carried out in a continuous sequence of studies [12]. b.

Forecasting is an important tool for companies in planning and determining policies in their operational activities [13]. c. Forecasting is a tool that handles important problems in various fields including, economics, physics, and engineering [14]. Based on these definitions, forecasting is a tool that is used to make decisions on future events by involving historical data and projecting it into the future with a mathematical model. The obtained results could help on various fields in determining policy. GREY SYSTEM THEORY Grey system theory was introduced by Professor Deng Julong in 1982. Grey system theory is a system that has some known parameters or systems with less information.

M. Shodiq, Budi W, Rachmat G., The Implementation of Grey ... 171 The purpose of this theory and its application is to link the gap between natural science and social science. Therefore, grey system theory can be utilized in various fields to solve problems [5]. The name grey system was taken based on the color of the subject under study. In control theory, the level of color depth is used to explain the level of information clarity. One of well-known type of it is called black box.

This concept is usually used if internal characteristics or mathematical equations that describe dynamics are completely unknown [15]. The word black describes unknown information, white for information that is completely clear or identified and grey shows information that is partly clear and partly unclear. Therefore, systems with completely unknown information are called black systems, systems that have clear information are called white systems, and systems with incomplete information are called grey systems [16].

GM type (1,1) is a type of grey system theory that is widely used in various fields because of its efficiency in terms of calculations rather than other grey system theories. The GM type (1,1) is usually known as Grey Model First Order One Variable which making predictions by using time series data [10]. GREY FORECASTING Grey Forecasting

Model or abbreviated as GM (1,1) is a method used for forecasting a limited and short-term amount of data that produces an accurate forecasting model with no need to consider statistical distribution of data processed [6]. This forecast can be used for line forecasting, natural disaster forecasts, interval forecasts, season forecasts and capital market forecast [5].

This general forecasting model is GM (n,m) where n is the order of differential equations and m is the number of variables in equation [15]. In the estimation stage of the grey model parameter, a technique is needed to change random raw data into regular data to form a grey model or known as grey generating. There are two grey generating techniques, namely: a. AGO (Accumulated Generating Operation) is a generator function to accumulate historical data sequences to obtain a new line of historical data in differential equations. b.

IAGO (Inverse Accumulated Generating Operation) is used to obtain predictive values from original data that previously changed to AGO. Grey forecasting is defined in the form of differential equations, in the model there are parameter values a and b that must be searched before by applying the grey generating technique for the original data. Grey forecasting or GM (1,1) procedure can be done with the following steps [9]: 1. Compile original data series based on time sequence (1) 2.

By taking the first order of accumulation to produce an operation (1-earlier) at , we can obtain a new data series of 1-AGO (Accumulated Generating Operation), namely:  $z_1(1) = (z_1(1)(1), z_1(1)(2), \dots, z_1(1)(n))$ ,  $z_1(1) = 4(2)$  with  $z_1(1)(n) = z_1(1)(n-1) + z_1(1)(1)$ ,  $z_1(1) = 2, 3, \dots, z_1(1)(n)$ . Calculate the background value of  $z_1(1)$  built with the generation method based on the average value of two data  $z_1(1)(n)$  which contiguous.  $z_1(1)(n) = 0.5(z_1(1)(n-1) + z_1(1)(n))$ , (3)  $z_1(1) = 2, 3, \dots, z_1(1)(n)$ . Next for each pair of values of  $z_1(0)(n)$  dan  $z_1(1)(n)$  is formed to apply the differential grey equation in GM (1,1).

But before forming GM (1,1) it is necessary to know the definition of the first grey order differential equation is  $z_1(1)(n) + z_1(1)(n) = z_1(1)$ . If integrated  $z_1(1)(n) + z_1(1)(n) +$  at the interval 172 [Jurnal Ilmiah KURSOR Vol. 9, No. 4, Desember 2018](#), hlm. 169 - 176  $z_1(1)(n) + z_1(1)(n) - 1 + z_1(1)(n) + z_1(1)(n) = z_1(1)$ ,  $z_1(1)(n) - 1$  Then obtained  $z_1(1)(n) - z_1(1)(n-1) + z_1(1)(n) + z_1(1)(n) = z_1(1)$ ,  $z_1(1)(n) - 1$  Namely:  $z_1(0)(n) + z_1(1)(n) + z_1(1)(n) = z_1(1)$  dan and the difference equation shown as shadow equation:  $z_1(0)(n) + z_1(1)(n) = z_1(1)$ , (4) With  $z_1(1)(n) = z_1(1)(n) + z_1(1)(n)$ ,  $z_1(1) = 2, 3, \dots, z_1(1)(n)$ .  $z_1(1)(n) - 1$  With a is the developer coefficient, and b is the grey input variable. 5.

To get the parameter values  $a$  and  $b$ , use the least square estimate  $\hat{\theta} = [ \hat{a} \hat{b} ]^T$ .  $\hat{\theta} = (X^T X)^{-1} X^T Y$  (5) With  $X = [ (0) (2) (3) (0) (??) ]$  (6) 6. Under the initial conditions such as the solution of the grey differential equation GM (1,1): (7) 7. Use (IAGO) Inverse Accumulated Generating Operation to get the forecast value (8) ACCURACY MODEL FORECASTING In forecasting, it is necessary to measure how accurate the method that used.

To find out the accuracy of the forecast used method, the measurement is done by using RPE (Relative Percentage Error) to determine the estimated error value by using the original value of both positive and negative errors. Then then using ARPE (Average Relative Percentage Error) to show the accuracy of the forecast method can be seen from the magnitude of the average percentage value of absolute error [15].  $x(k) = x(0) + kx^{(0)}(k)$  (9)  $RPE(k) = \frac{|x(k) - \hat{x}(k)|}{x(k)} \times 100\%$  (10)  $ARPE = \frac{1}{n-1} \sum_{k=2}^n |x(k) - \hat{x}(k)| \times 100\%$  (11) Accuracy = 100 – ARPE (12) Annotation:  $x(0)(k)$  = original data value  $\hat{x}(k)$  = forecast value  $|x(k) - \hat{x}(k)|$  = absolute remnant value. Table 1. Standard measure of the accuracy of forecast model [17].

RPE(k) and ARPE (%) Forecast Potency <10% Very accurate 10-20% Accurate 20-50% Quite accurate >50% Innacurate RESULT AND DISCUSSION This research was conducted at Brondong Nusantara Fisheries Port, Lamongan using annual production data from 2010 to 2018 and this forecast system fisheries production is build using PHP and MySQL. Table 2. Annual production data Year Production Data 2010 46569 2011 60769 2012 52249 2013 57198 2014 46432 2015 49278 2016 57763 M. Shodiq, Budi W, Rachmat G., The Implementation of Grey ... 173 2017 58145 2018 71626 Based on table 2 production data, a grey forecasting model will be calculated. The first step in this calculation starts from: 1. Form the initial data series (equation 1). Table 2.

Initial Data (production) k Year Production Data 1 2010 46569 2 2011 60769 3 2012 52249 4 2013 57198 5 2014 46432 6 2015 49278 7 2016 57763 8 2017 58145 9 2018 71626  $\hat{x}(0) = (46569, 60769, 52249, 57198, 46432, 49278, 57763, 58145, 71626)$  Picture 1. Production data chart 2. Set AGO sequence (Equation 2) Table 3. Post-AGO Production data k AGO 1 46569 2 107338 3 159587 4 216785 5 263217 6 312495 7 370258 8 428403 9 500029  $\hat{x}(1) = (46569, 107338, 159587, 216785, 263217, 312495, 370258, 428403, 500029)$ . Picture 2. Post-AGO Data chart Based on picture 2 the original data graph, it appears that the data pattern is not monotonous, while in picture 3 the post-AGO graph shows that the data pattern is monotonically go up. 3.

Determine the background value of two data  $\hat{x}(1)(??)$  that are contiguous, the results of the average will be used to calculate the matrix formation parameters  $a$  and  $b$  (Equation 3). Table 4. Rows of background values k Background Values 1 46569 2 76954

3 133463 4 188186 5 240001 6 287856 7 341377 8 399331 9 464216  $?? (1) = (46569, 76954, 133463, 188186, 240001, 287856, 341377, 399331, 464216)$  4. Calculating least square estimate to find out the parameter values a and b, done by specifying the matrix B and Y (Equation 6).

$?? = [$ , After B and Y matrix are formed, then calculate the multiplication of the B transpose matrix with matrix B (BTB), the result of multiplying the B matrix transpose with B will be converted to inverse matrix  $(BTB)^{-1}$ , then  $0 \ 20 \ 000 \ 40 \ 000 \ 60 \ 000 \ 80 \ 000$  Production Values Periode **Produ ctio n**  $0 \ 20 \ 000 \ 40 \ 000 \ 60 \ 000 \ 80 \ 000$  AGO Values Periode **Produ ctio n** 174 **Jurnal Ilmiah KURSOR Vol. 9, No. 4, Desember** 2018, hlm. 169 - 176 calculates the B transpose matrix with the Y matrix Y (BTY). a. Calculate multiplication of matrix  $BT \ B \ ?? \ ?? \ ?? = [ \ 691108865040 \ - \ 2131382 \ - \ 2131382 \ 8 ]$  b. Calculates inverse multiplication of matrix  $[BTB]^{-1} [ \ ?? \ ?? \ ?? ] - 1 = 1$  c. Calculate multiplication of matrix  $BT \ Y$  5.

Calculate parameters a and b, parameters a and b can be known after doing calculations with matrix multiplication  $([BT \ B]^{-1} * BT \ Y)$  (Equation 5).  $?? ^ \wedge = [ \ 8$ . Since = dan 6. Apply GM differential grey equation (1,1) Based on the equation of GM model (1,1) with the known parameters are Equation 4:  $???? (1) (??) \ ????? + - 0.02529693 \ ?? (1) (??) =$  And the response function at and first-order original data is (Equation 7): From the operation above, the obtained forecast value is a few steps ahead: 7.

Apply (IAGO) **Inverse Accumulated Generating Operation** to get the forecast value (Equation 8). From the results of IAGO, the value of the original data obtained is obtained,  $????$  ) dan  $?? ^ (??) (????)$  is the result of forecasts for the next 2 years. After forecast value is obtained, the next step is to measure forecast errors. This step is used to measure the accuracy of the model that used (equations 9, 10, 11, and 12). **The difference between the** original value and the forecast value is as Table 5 and Picture 3. Table 5.

Grey forecasting calculation results Year Production Forecast Error RP E 2010 46569 46569 0 0 2011 60769 51773 8996 15 2012 52249 53099 -850 2 2013 57198 54460 2738 5 2014 46432 55855 -9423 20 2015 49278 57286 -8008 16 2016 57763 58754 -991 2 2017 58145 60259 -2114 4 2018 71626 61803 9823 14 2019 63386 2010 65010 **M.** **Shodiq, Budi W, Rachmat G., The Implementation of Grey** ... 175 Picture 3. Forecast chart. From the table 5 grey forecasting calculation results obtained ARPE value of 9.60% with accurate forecasting power, as well as the **accuracy of the forecast model** reaches 90.40%. After the results of forecast are obtained, the next step is to test the accuracy of the GM (1,1) model. Testing is done by comparing the GM (1.1) model with traditional time series models is single moving average (SMA) and single exponential smoothing



(SES). Tests are done using ARPE error calculations, as in Table 6. Table 6. Comparison of accuracy results GM (1,1) SMA SES ARPE (%) 9.60 14 12 Accuracy (%) 90.40 86 88 Based on Table 6, the GM model (1.1) is more optimal than the traditional time series model. In addition, based on research using GM (1,1) in fisheries production, obtained the value of accuracy at 90.40%, whereas in previous research, GM (1,1) was applied in several cases including forecast of electric power prices resulting 92% value of accuracy [8], forecast of agricultural products have an accuracy of 90% [9], forecast of the incidence of syphilis in China have an accuracy of 88.5% [10], and forecast of electricity consumption by comparing GM (1,1) and ARIMA produce GM (1.1) 96.25% accuracy value and ARIMA at 95.38% [11], it can be said that the GM (1.1) model can be applied in case of fish production forecast and has optimal performance because taccuracisn'tf dierentfom previous research.

CONCLUSION In this research, grey forecasting model GM (1.1) applied in case of electricity forecasting, disease incidence, and agricultural products, but this research applied the GM (1.1) model in the case of fisheries production. According to results of the research on the implementation of grey forecasting models in the fisheries production forecasting system, it can be concluded that grey forecasting model has high accuracy in fisheries production reached 90.40%, it can be said that the GM (1.1) model can be applied in case of fish production forecast and has optimal performance because taccuracisn'tf dierentfom previous research.

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