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System Simulation Model for the West Coast Trawl Fishery in Peninsular Malaysia: Sensitivity Analysis and Model Validation

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Abstract: The trawl fishing industry in the West Coast of Peninsular Malaysia is the dynamic and non-linear system and the system simulation model is used in order to analyze the impact of management policies for the objective of sustainability in fish resources and economically profitable fishing industry. The conceptual model is the combination of the three main modules of biological, economic and industry module. The system simulation model is developed based on the conceptual model. The model validation test is needed to carried out in order to get the confidence of the model developed. The behavior sensitivity test is carried out in which some parameters such as trend of substitute good (s1), trend of income (τ1), effort response parameter (Ω) and threshold income (β) showed the sensitivity effect on the behavior of the system. The modification of these parameter is used to simulate the behavior of the system which is similar with the historical behavior of the system. The analysis of model validation is carried out from 1987 to 2012 in order to compare the system behaviors. The statistical accuracy measures of MAPE (Mean Absolute Percent Error) and APEM (Absolute Percent Error Mean) is used in order to analyze the simulated data and historical data. The results indicated that the model showed the significant accuracy measures with the modified parameters and the system simulation model can be used for the policy implication analysis for the management of the trawl fishery in the West Coast of Peninsular Malaysia.

Key words: System simulation model · Model validation test · Trawl fishery

INTRODUCTION

Fisheries Resources are renewable resources and it can be associated with many problems on management. The important problem concerning with fisheries resources is 'open-access' problem it was discussed in fishery literature [1, 2]. Open access is the condition where access to the fishery (for the purpose of harvesting fish) is unrestricted; i.e., the right to catch fish is free and open to all [3]. Open access exploitation of common property fish resources cause severe stock depletion and also cause extinction of the fishery stock. This scenario was analyzed by many researchers since last decades [4], [5-7]. Wilen [8] explained the theoretical view of dynamics of open access or free entry behavior of fisheries. In the context of fisheries, the theory indicates that the entry of mobile variable factors such as fishermen and fishing fleets will occur beyond the sufficient numbers in line with the use of fish stock efficiently. The reason to happen this situation is that no one is able to exercise entrepreneurial control in an open access industry. Under this circumstance, the resources will be attracted to exploited until the potential rent of the resources have been exhausted. The industry was left in a sub-optimal bio-economic equilibrium [8]. Stock equilibrium may also be stable and positive with the fixed prices and technology and in the long run, the stock move to extinction with the changes of these variables [9].

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The fisheries with open-access nature lead to the over-capacity and causing the over-exploitation of the resources. The application of the operational research models for the management of fish resources is one of the reliable methodologies and there are various types of models used to consider the strategies in managing a fishery [10]. The models include biological population growth models which is based on differential equation and econometric models, optimization models, optimum control models and computer simulation models. System simulation is the useful tool which was developed for helping decision makers to design better policies using the improved understanding of how structure generates behavior [11]. System simulation technique focuses on problem especially on the complex interrelationships within the system components. The relationships between the system components through causal loops and feed backs loops (stock and flows) change over time and it can simulate using the numerical equations for each of the system components and variables. The system models can be used as the systems of differential equations with the use of numerical integration for the certain time period and simulate the outcomes and results. The above mentioned distinguished characteristics of can help us for the use of system dynamics in the solution of complex problems.

Model calibration or validation is the important step in the system dynamics simulation. Model validation can be regarded as the process of building confidence [12, 13]. Moreover, the model validation can lead the acceptance of the model in such a way that commitment and usage which can leads to decision implementation derived from the model [14]. There are two types of model validation: structure validity and behavior validity [13]. Quantitative or formal behavior tests that can provide some structural information is used in model validation as 'structurally-oriented behavior test'. Under this test the following 3 main types can be used for model validation [15]: A: Extreme Condition test: Assigning the extreme values to selected parameters and compare the model-generated behavior of the real system, under the same extreme condition. Extreme condition is that the condition that may never have been observed in the real world (for example: what happen in the GDP of a simulated economy if the energy supply is set as zero), B: Behavior Sensitivity test: Determining the parameters to which model behavior displays high sensitivity and ask if the real system world exhibit a similar high sensitivity, C: Modified-Behavior Prediction test: It is sometimes possible to find data about the behavior of some 'modified' version of the real system (which could be due to parameter modification, or structural modification). Then, test if the model is able to generate the same 'modified behavior', when simulated with similar modification.

Fisheries management is the complex and the integrated consideration of fish resources together with socio-economic impacts is inevitable needed. In Malaysia trawl fishery, the overfishing of the trawlers because of the overcapacity of trawl vessels in the west coast fishery is current problematic issue. The evaluation of the fishery performance with the current policy application is carried out with the integrated analysis of biological, economic and management sectors. The outcomes of the fishery by the alternative policy implications are evaluated and the proper policy used for the sustainability of trawl fishery is proposed in the west cost of Peninsular Malaysia. The dynamics of fish population, economic development of the industry by management policy regulations and the dynamic of fishing effort interact interdependently each other and form a system which is complex, dynamics and non-linear in characteristics. To analyze this complex system and its dynamics behavior, system simulation is appropriate tool in fisheries management [12]. Therefore, the building of the system simulation model for the west coast trawl fishery and the model validation and sensitivity analysis is carried out in this study in order to achieve the reliable and sustained system simulation model for the management of trawl fishery in Peninsular Malaysia.

MATERIALS AND METHODS

Conceptual Model: The classic model used to represent fisheries system is bio-economic model in which biological, economic and fishing components of the system are linked together in the system structure [16]. The conceptual model of the fleet dynamics in the West Coast trawl fishery is shown in Figure 1 and the model consists of three main modules: biological module, economic module and industry module. The interrelation of these three main modules with the exogenous effect by management policy implication provides the system of the industry and the performance of the industry is evaluated by the simulation over time. The interconnection between these three main modules occurs through the key variables. Biological module interacts with economic module through total catch and the ex-vessel prices of each species groups. The output from this interaction is vessel profit which serves as a key variable in the interaction of the economic module with management module and also with industry module through effort dynamics.

The biological module represents the total catch or total landings of the industry. The population dynamics of the multispecies tropical fisheries is different with the temperate single species fisheries and leading to the complex system in management of the fishery. In the biological module, the population dynamics of the three main targeted species groups of pelagic, demersal and crustacean groups are modeled using Surplus Production models. The analytical model used for the population dynamics of the fish species groups is the less data demanding method such as Surplus Production models uses only the time series data of catch per unit of effort available or most fisheries [17]. Surplus production model has been used over many decades in fisheries analysis and the traditional Surplus production model has the assumption that catch per unit effort is constant for a given stock size [18]. Moreover, surplus production models is the use of limited information and the results are also obviously flexible and adaptive approach in the actions of fishery management [19]. Models of Surplus production function using in this study include: (1) Schaefer's Model, (2) Fox Model, (3) Schnute Model and (4) Clark, Yoshimoto and Pooley (CY&P) Model in order to estimate the best fitted surplus production model for each species group. To estimate the parameters of intrinsic growth rate of species, r_i, the catchability coefficient of species with the effort, q_i and maximum population size of species group, K_i, the catch per unit of effort for each species group ($CPUE_i$) or relative abundance of species are used.

The total catch or total landings is the major output of biological module and it is the figure of summation of the catches of the three targeted species groups; pelagic, demersal and crustacean species groups. The total catch computed under biological module is determined by the fishing effort which is the output variable of industry module. The fishing effort used in the total catch function is the nominal fishing effort of trawl vessels in each zoning areas of zones B and C which is assumed that all the trawl vessels operating in each zone are homogenous of tonnage class such as less than 40 GRT in zone B and between 40 to 70 GRT in zone C.

The economic module represents the total revenue, total cost and profit of the industry which is the sub system like biological module. The total revenue of the industry is the summed figure of revenues of three targeted species groups and revenue from by-catch. The by-catch in this study includes the catches of trash fish, mixed fish and Mollusca species. The revenue is the product of catch of each species groups and its corresponding price and the price used in this study is ex-vessel price which is the price received by the fishermen right after their fishing operation The price is major factor in determining the dynamics of the fishery by effecting to revenues and profit which in turn effects to the effort dynamics in the industry. The main output variable of the economic variable is profit and which is affected by the cost of the industry. The total cost of the industry is the product of cost per vessel and total number of vessels in the industry. The major factors affecting to the cost of the industry is the policy variables which can render the incentives and disincentives on the fishing operation. The total cost of the industry is mainly affected by the financial policies such as subsidy policy and policy concerning with the expenses used for the landings at the port. The fuel price subsidy and imposing jetty charge for every vessels landing at the jetty are the issues currently applied in the trawl fishery of Peninsular Malaysia and used as the policy control variables in the economic module. The output of the economic module is the profit of the industry and dynamics of the fishing effort in industry module is determined by the amount of profit which is the interface variable among economic module and industry module.

The industry module represents the level of fishing effort exerted by the industry which is based on the amount of profit. With the positive profit, the fishing effort is increased and the effort is decreased with negative profit. The major determinant of dynamics of fishing effort is considered by the profit of the industry. However, the fishermen will increase the fishing effort unlimitedly as long as the profit is positive under open access condition. In the control of over capacity like the trawl fishery in this study area, the management policy regulations for the effort control is needed as input control variables. A variety of management policy regulatory measures is discussed in previous chapter and among those regulations limited entry licensing is the most appropriate tool for the fishery of multispecies tropical fishery. The major control variables of fishing

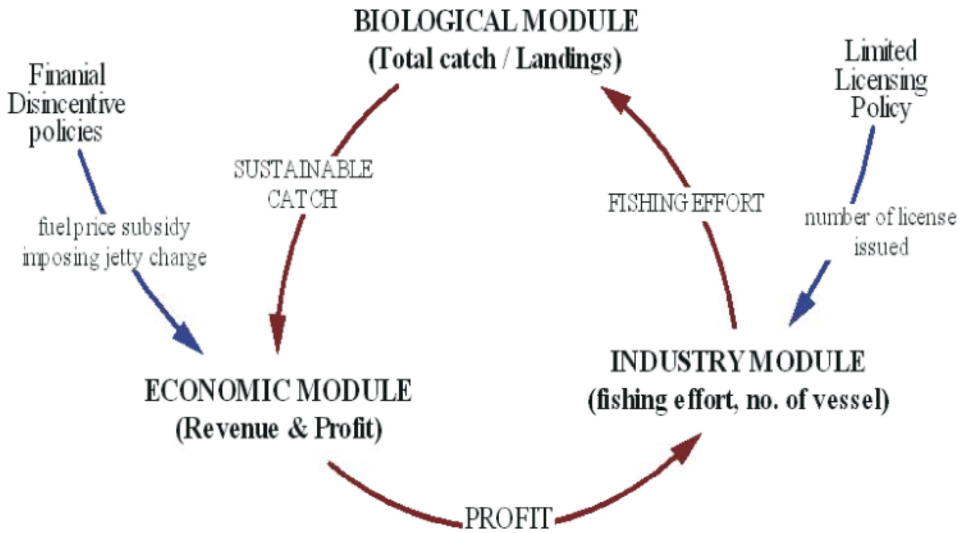

Fig. 1: Conceptual Frame work of the fleet dynamics model of the trawl Fishery in the West Coast of Peninsular Malaysia

effort is number of license issued for the vessels in each zone and the dynamics of fishing effort is mainly affected by this entry limitation policy. The behavioral responses of fishing fleet to the management regulations are evaluated in the context of controlling overcapacity.

The conceptual model used in this study is, in fact, the interconnection and feedback system between the modules in response to the management regulations are simulated for successful fishery management. Biological module interacts with economic module through total catch and the ex-vessel prices of each species groups. The output from this interaction is vessel profit which serves as a key variable in the interaction of the economic module with management module and also with industry module through effort dynamics. The model accounts for the trawl fleet and its interaction with the management regulations. The key variables are interconnected each other. The features of the model include; the model is a simulation model; model is input driven such as controlling license issued for the vessel and subsidy; models simulate the responses of key variables for the separate zoning area (Zone B and Zone C).

System Simulation Model: The system simulation analysis is used because of the complexity and dynamic behavior of trawl fishing industry. The interconnection of variables and parameters in three main modules: Biological module, Economic module and Industry module is analyzed for the changes of performance variables. The major performance variables used in this study include Catches of each species group, Total catch, Total Profit, Profit per vessel and finally the changes of efforts effecting on the changes of number of trawl vessels for fleet dynamic behavior of the industry. The system simulation models of West coast Zone B and Zone C trawl fishery are shown in Figure 2 and Figure 3. Moreover, the main input variables such as ex-vessel price function, the major policy control variables such as marketing cost and fuel cost function are also presented in Figure 4.

The system simulation model is developed for the policy assessment using system dynamics and multi-criteria analysis approach. The focus of the model is to examine the management policies using integrated system simulation model. The simulation model is essential tool in using the dynamic and complex system analysis because the complexity of our mental models vastly exceeds our capacity to understand the implication of the model. Without simulation, even the best conceptual models can only be tested and improved by relying on the learning feedbacks through real world. However, those feedbacks are very slow and often rendered ineffective by dynamic complexity, time delays, inadequate and ambiguous feedbacks, poor reasoning skills, defensive actions and the cost of experimentations [20].

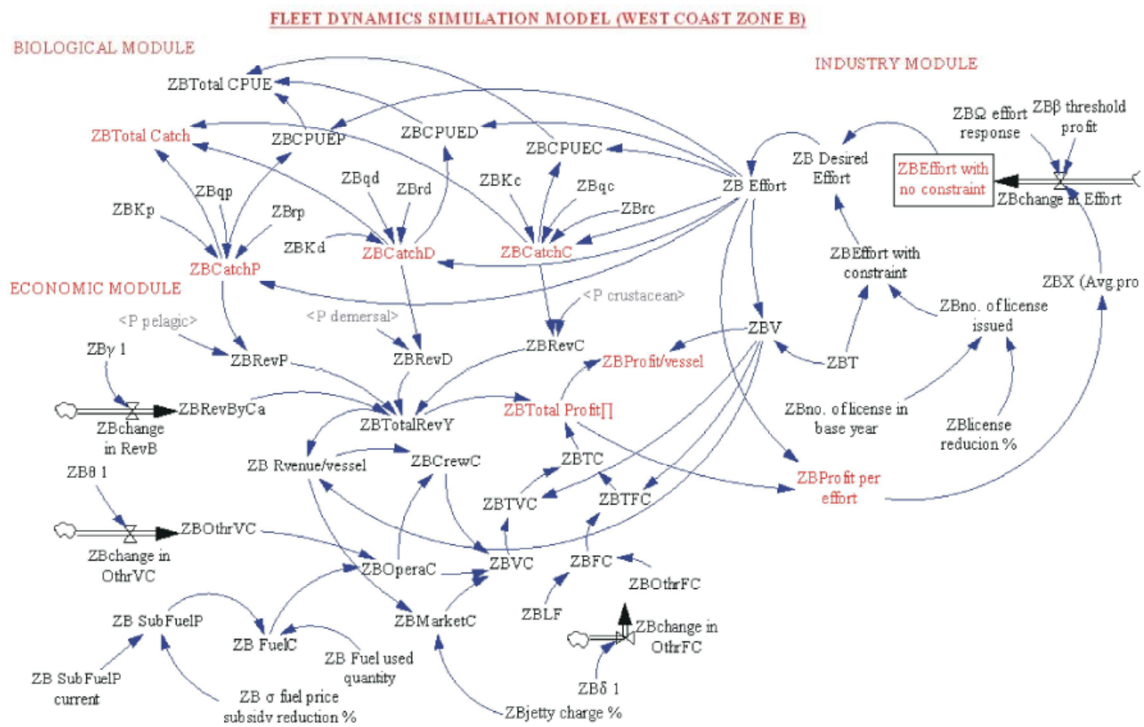

Fig. 2: System simulation model of West coast Zone B Trawl Fishery

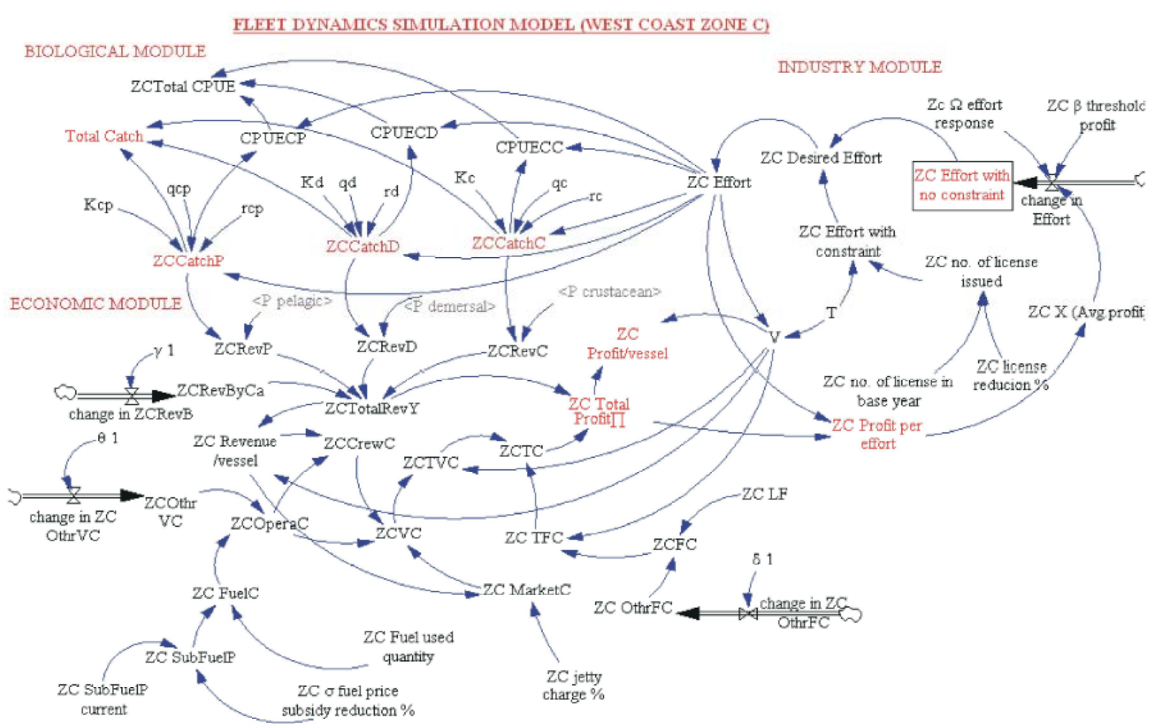

Fig. 3: System simulation of West coast Zone C Trawl Fishery

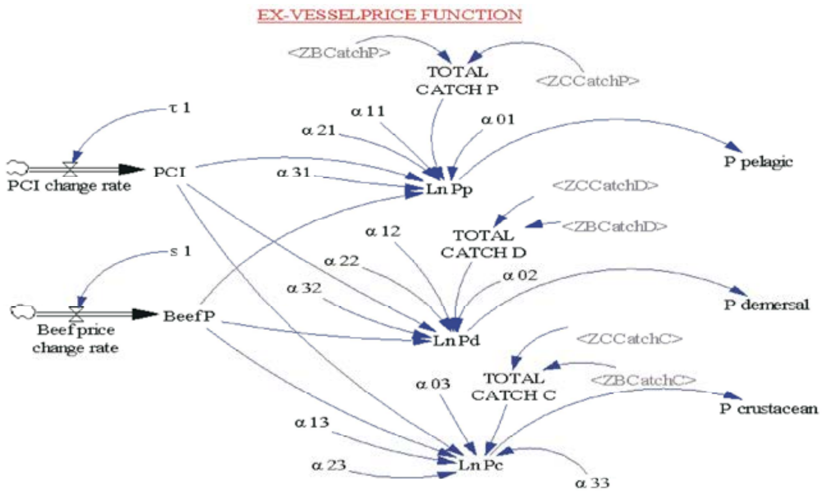

Fig. 4: Ex-vessel price of three species groups, fuel cost function and marketing cost function for West Coast Trawl Fishery.

Validation of Simulation Model: The state of the fishery system over time can be simulated using the computer simulation software (Vensim). In the initialization phase, the values of the paracmeters are assigned and time is initialized as zero. In the execution phase, time is updated as T=T+dT and state and rate varibles are computed for time T. Model validation and sensitivity tests should be conducted after the initial model is constructed. Model validation is necessary to check that the model correctness can closely mimic the real system. There are three major approaches for the model validation [21].

- By comparing the simulated results with the historical results of the real system under the same condition.
- By comparing the model behavior with the established theories. When we construct the model and variables used, it is based upon the theories and also for the detremination of the structural form of the equations and parameters values assigned.
- By validation with the expert opinion on the behavior of the real system.

In this study the approach of comparing the simulated data with historical observed data (1987-2012) will be used in order to validate the model correctness closely figure out the real sysetem. The main concern of the study is the changes in fishing effort and this is considered as central issue in decision making process. The simulation of the performance cirteria, fishing effort dysnamcis in terms of number of fishing days and number of trawl vessels with the different management interventions will be carried out in this study. Moreover, the major performance indicator of fisheries such as Catch per unit of Effort (CPUE) is also used for the model validation test.

The simulated behavior of the system is evaluated by using the estimated parameters and initial values as in the condition of the year 1987 for each zone. If the model behavior has deviated from the behavior of the real system, some of the parameters are modified until to achieve the behavior closely similar with the real system. The list of the modified parameters used in the model validation and the rate of modification are presented in Table 1. The comparison of two models: models with non-modified data and models with modified data are carried out and the accuracy measure and fitness of the model are evaluated. The confidence of the model can be built based on structure validity and behavior validity and the behavior validity test is to assess how model accurately reproduce the behavior pattern of the real system [15].

The quantitative examination of the fit of the predictive model was analysed using error measurement indices such Mean Absolute Percent Error (MAPE) and Absolute Percent Error Mean (APEM) are used for the accuracy measures of fittness of model. MAPE gives the measure of accurcy of the time series simulated data with historical data and expressed as percentage. The above mentioned accuracy measures are not very informative if those are considered by themselves, however, they become significant of accuracy measures in comparison among different models. All the accuracy measures indicate better fit with smaller values.

Table 1: List of parameters used in the sensitivity test for model validation.

Parameter	Definition	Estimated value		Modified value		Modification
		Zone B	Zone C	Zone B	Zone C	
s_1	Trend of beef price	472		127		-73 % of estimated value
∞_1	Trend of per capita income	1033		312		-70% of estimated value
Ω	Effort response parameter	18.06	3.84	15	2.5	-17% for zone B and -34 % for zone C
β	Threshold income	1,784	1,277	2,000	1,000	+12% for zone B and -22% for zone C

Table 2: Summary of accuracy measures models and equations

Name of Accuracy measures	Model	Unit
MAPE (Mean Absolute Percent Error)	$MAPE = \frac{\sum_{t=1}^{n} \left\| \frac{y_t - \hat{y}_t}{y_t} \right\|}{n} * 100$	%
APEM (Absolute Percent Error Mean)	$APEM = \left\| \frac{Mean\, y_t - Mean\, \hat{y}_t}{Mean\, y_t} \right\| * 100$	%

Note: y_t equals observed historical data at time t, $\hat{y}_t$ equals simulated data at time t

The quantitative examination of the fit of simulation model was made using error measurement indices commonly used in the evaluation of forcasting [22]. The summary of accuracy measures models is shown in Table 2.

Source of Data: The data used in this study include both primary and secondary data for the estimation of the parameters and constants of the mathematical equations. The annual catch and effort data of the three targeted species groups is used from the Annual Fishery Statistics of Department of Fishery, Malaysia.

RESULTS AND DISCUSSION

Model Validation Results for Zone B: The validation test results of zone B is shown in Figure 5, a to e. The statistical accuracy measures of the validation test of zone B simulation model are presented in Table 2.

The behavioral pattern of fishing effort from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 5,a (i). The results showed that the simulated behavior of fishing effort significantly deviated from the historical behavior. Therefore, the model is simulated again by using the modified parameters (parameters listed in Table 2) and the comparison is carried out among the historical behavior and the simulated behavior by using modified data and presented in Figure 5,a (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis among the fishing effort two data sets showed that the MAPE for historical vs. simulated is 5 % and that of historical vs. simulated with no modified data is 43 %, the APEM of fishing effort for historical vs. simulated is 1 % and that of for historical vs. simulated with no modified data is 31 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The validation of test was carried out by comparing the historical catch per unit of effort (CPUE) and model simulated CPUE for each target species groups and total CPUE. The fishery bioeconomic theory revealed that the additional unit of fishing effort gives the decreasing catch after the certain period of time and cause the decreasing CPUE under overexploited condition (Ola, 2010). The nature of diminishing returns was found in the zone B the catch was increasing with increasing effort from 1987 until 2007 and the diminishing return or decreasing trend of CPUE was found after 2007. This nature and behavior occurred in both historical and simulated CPUE. The similar trends were found in CPUE of three target species groups and also in total CPUE in the zone B (Figure 5, b, c, d, e).

The behavioral pattern of CPUE for pelagic species from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 5,b (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and

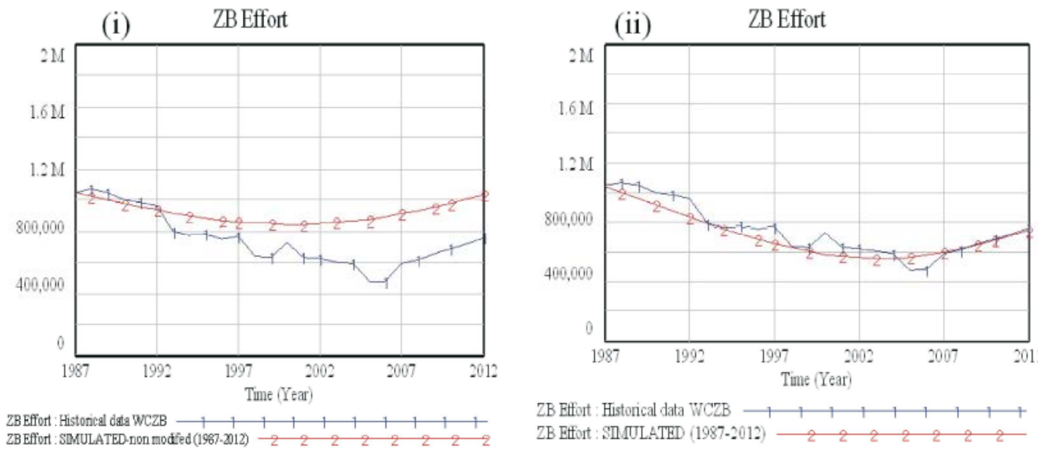

Fig. 5: (a) Validation Test using historical observed data and model simulated data of Fishing Effort in zone B

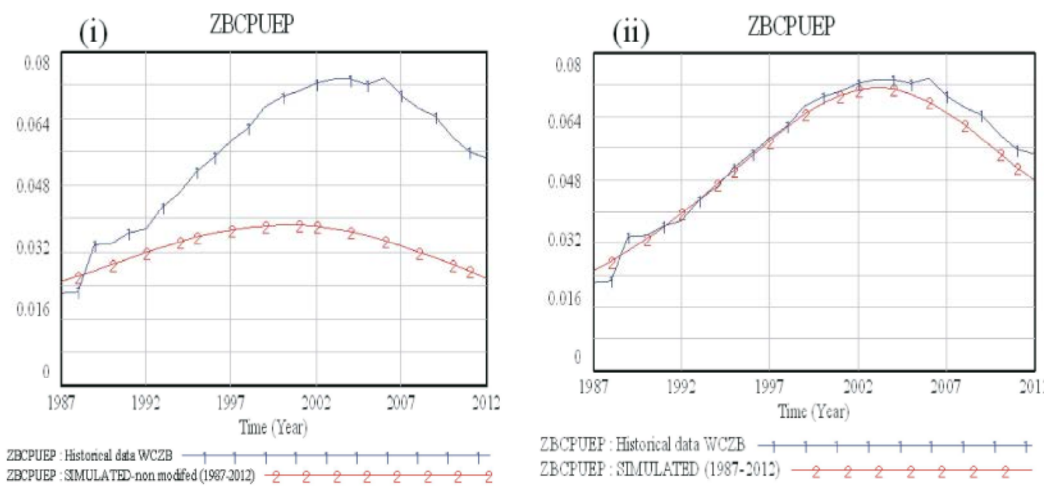

Fig. 5: (b) Validation Test using historical observed data and model simulated data of CPUE for pelagic species group in zone B

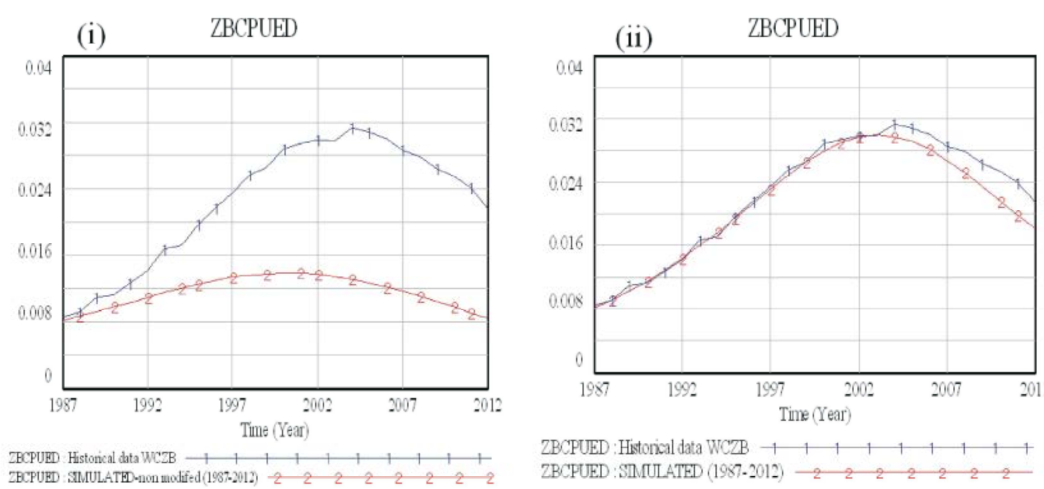

Fig. 5: (c) Validation Test using historical observed data and model simulated data of CPUE for demersal species group in zone B

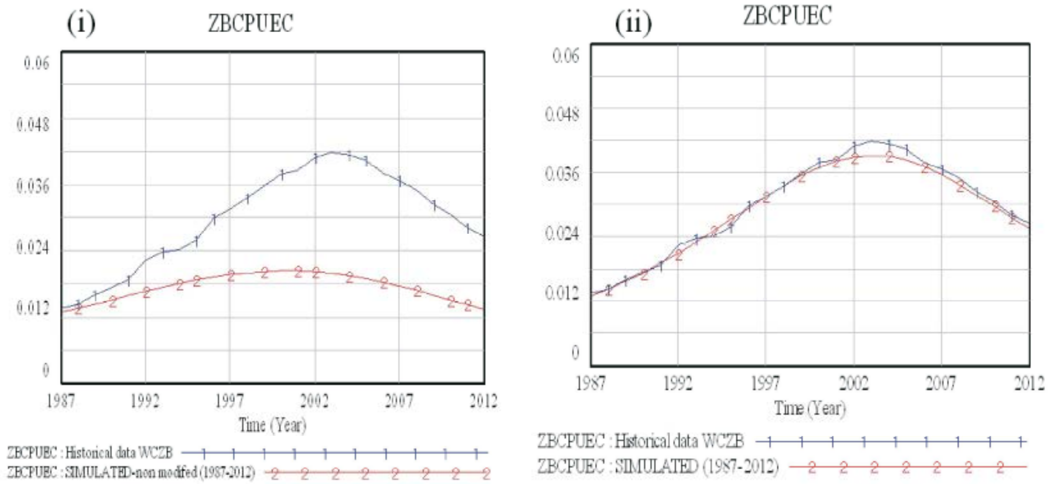

Fig. 5: (d) Validation Test using historical observed data and model simulated data of CPUE for crustacean species group in zone B

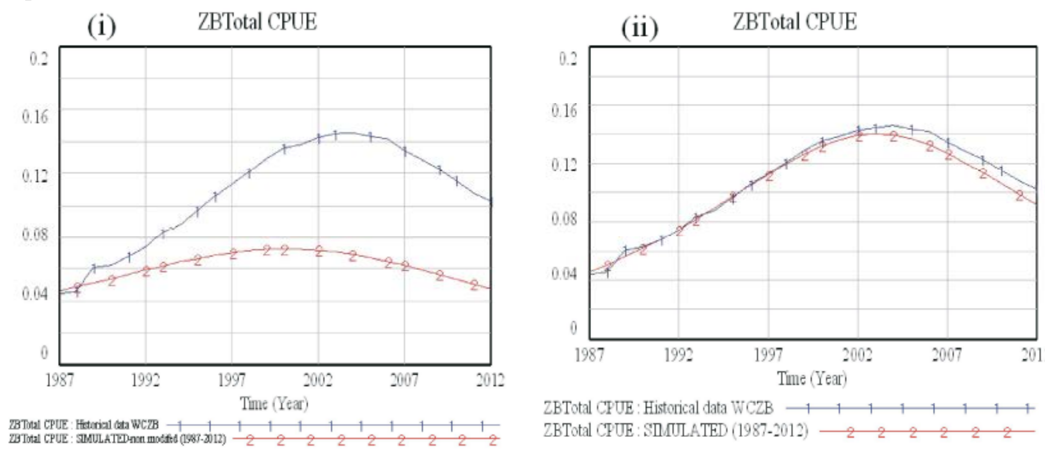

Fig. 5: (e) Validation Test using historical observed data and model simulated data of total CPUE. in zone B

presented in Figure 5,b (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of CPUE for pelagic species showed that the MAPE for historical vs. simulated is 5 % and that of historical vs. simulated with no modified data is 38 % and the APEM of CPUE for pelagic species for historical vs. simulated is 3 % and that of for historical vs. simulated with no modified data is 40 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The behavioral pattern of CPUE for demersal species from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 5,c (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and presented in Figure 5,c (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of CPUE for demersal species showed that the MAPE for historical vs. simulated is 5 % and that of historical vs. simulated with no modified data is 43 % and the APEM of CPUE for demersal species for historical vs. simulated is 5 % and that of for historical vs. simulated with no modified data is 48 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The behavioral pattern of CPUE for crustacean species from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 5,d (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and presented in Figure 5,d (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of CPUE for crustacean species showed that the MAPE for historical vs. simulated is 3 % and that of historical vs. simulated with no modified data is 37 % and the APEM of CPUE for crustacean species for historical vs. simulated is 2 % and that of for historical vs. simulated with no modified data is 42 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The behavioral pattern of total CPUE from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 5,e (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and presented in Figure 5,e (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of total CPUE showed that the MAPE for historical vs. simulated is 4 % and that of historical vs. simulated with no modified data is 38 % and the APEM of total CPUE for historical vs. simulated is 3 % and that of for historical vs. simulated with no modified data is 42 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The results of the accuracy measures showed that simulated model with modified data showed significantly smaller values of deviation and error percentage than the simulated model with non-modified data. Therefore, the model used in the simulation analysis should be used the modified data and this model showed the fitness for the system behavior of the zone B trawl fishery.

Model Validation Results for Zone C: The validation test results of zone C is shown in Figure 6, a to e. The statistical accuracy measures of the validation test of zone B simulation model are presented in Table 4.

The behavioral pattern of fishing effort from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 6,a (i). The results showed that the simulated behavior of fishing effort significantly deviated from the historical behavior. Therefore, the comparison of the historical behavior and the simulated behavior by using modified data is carried out and presented in Figure 6,a (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis among the fishing effort two data sets showed that the MAPE for historical vs. simulated is 4 % and that of historical vs. simulated with no modified data is 95 %, the APEM of fishing effort for historical vs. simulated is 0.37 % and that of for historical vs. simulated with no modified data is 108 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The behavioral pattern of CPUE for pelagic species from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 6,b (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and presented in Figure 6,b (ii).

Table 3: Accuracy measures of historical data and simulated data in West coast Zone B Trawl fishery

Statistical Measurements		Fishing Effort	CPUEP	CPUED	CPUECR	Total CPUE
MAPE	Actual data and Simulated-modified data	5	5	5	3	4
	Actual data and Simulated - no modified data	43	38	43	37	38
APEM	Actual data and Simulated-modified data	1	3	5	2	3
	Actual data and Simulated - no modified data	31	40	48	42	42

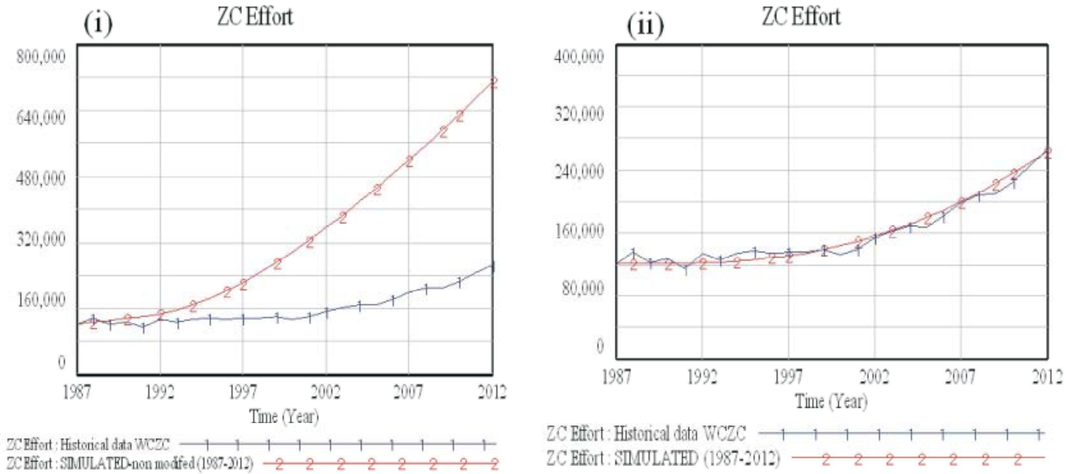

Fig. 6: (a) Validation Test using historical observed data and model simulated data of Fishing Effort in zone C.

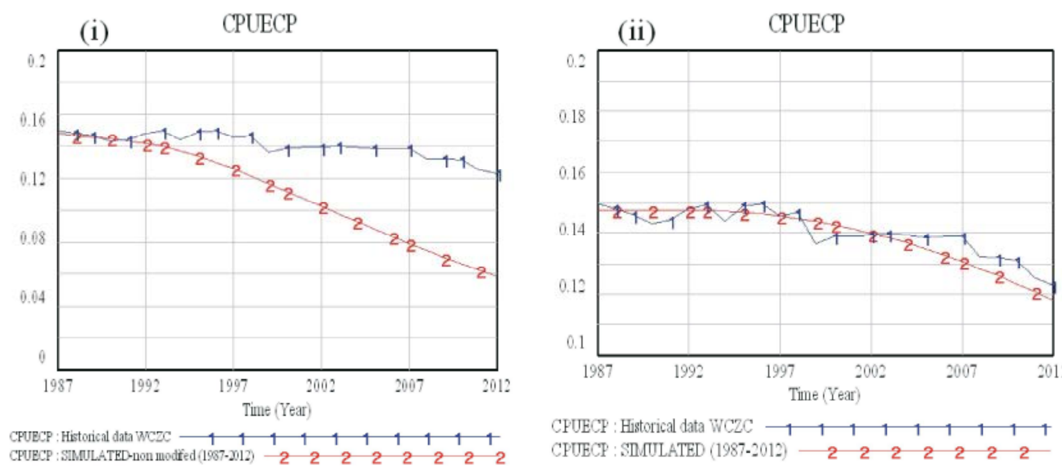

Fig. 6: (b) Validation Test using historical observed data and model simulated data of CPUE for pelagic species group in zone C.

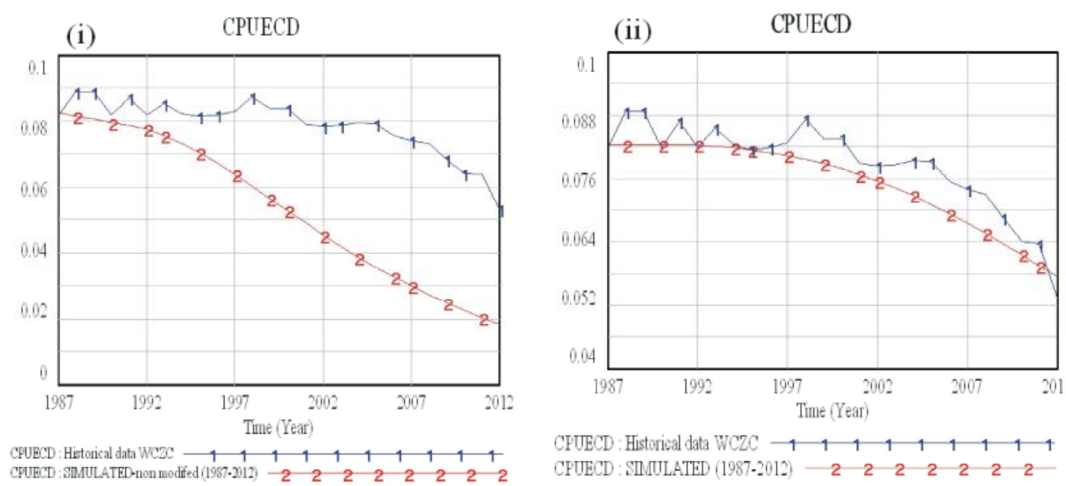

Fig. 6: (c) Validation Test using historical observed data and model simulated data of CPUE for demersal species group in zone C.

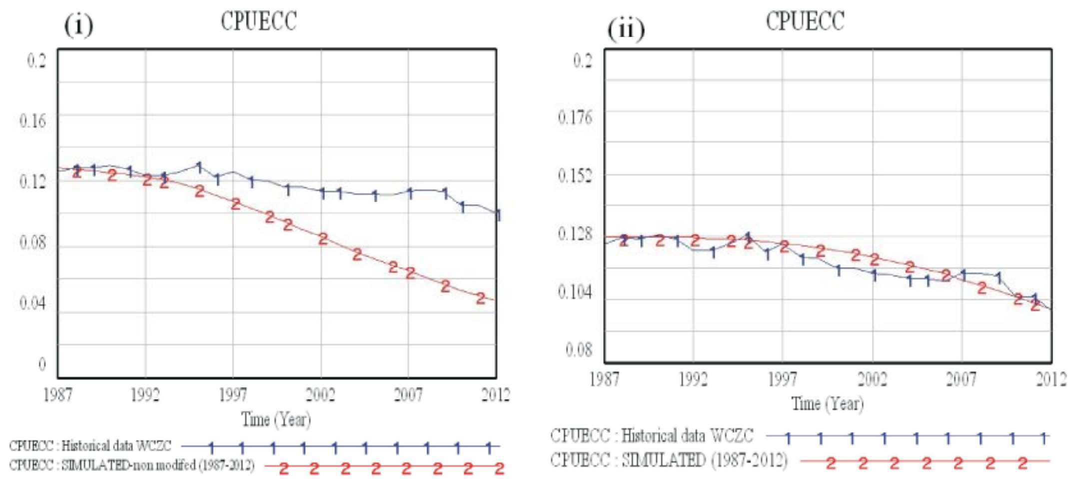

Fig. 6: (d) Validation Test using historical observed data and model simulated data of CPUE for crustacean species group in zone C.

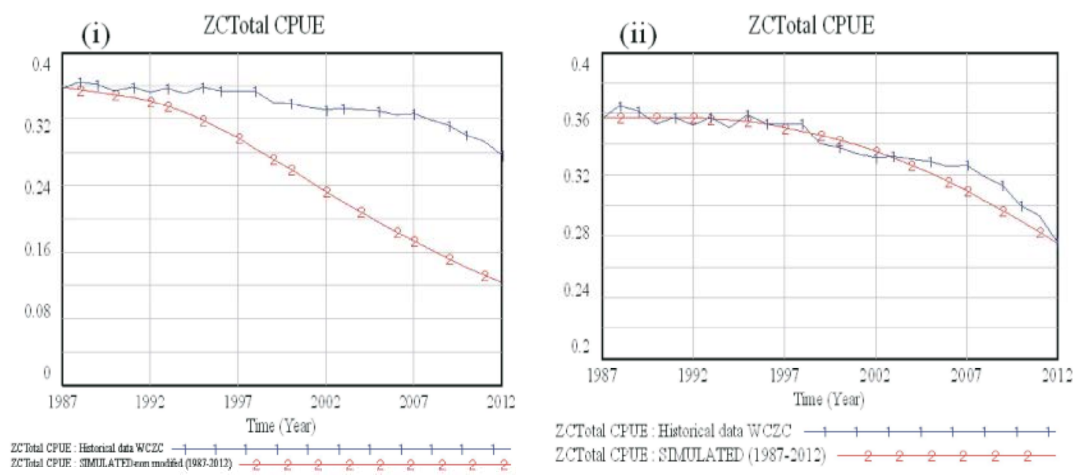

Fig. 6: (e) Validation Test using historical observed data and model simulated data of total CPUE in zone C.

The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of CPUE for pelagic species showed that the MAPE for historical vs. simulated is 2 % and that of historical vs. simulated with no modified data is 22 % and the APEM of CPUE for pelagic species for historical vs. simulated is 0.91 % and that of for historical vs. simulated with no modified data is 21 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The behavioral pattern of CPUE for demersal species from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 6,c (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and presented in Figure 6,c (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of CPUE for demersal species showed that the MAPE for historical vs. simulated is 5 % and that of historical vs. simulated with no modified data is 34 % and the APEM of CPUE for demersal species for historical vs. simulated is 4.5 % and that of for historical vs. simulated with no modified data is 32 %. The results indicated that the simulated model using modified parameter values

Table 4: Accuracy measures of historical data and simulated data in West coast Zone C Trawl fishery

Statistical Measurements		Fishing Effort	CPUEP	CPUED	CPUECR	Total CPUE
MAPE	Actual data and Simulated-modified data	4	2	5	3	2
	Actual data and Simulated - no modified data	95	22	34	22	25
APEM	Actual data and Simulated-modified data	0.37	0.91	4.50	1.48	0.91
	Actual data and Simulated - no modified data	108	21	32	21	24

showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The behavioral pattern of CPUE for crustacean species from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 6,d (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and presented in Figure 6,d (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of CPUE for crustacean species showed that the MAPE for historical vs. simulated is 3 % and that of historical vs. simulated with no modified data is 22 % and the APEM of CPUE for crustacean species for historical vs. simulated is 1.48 % and that of for historical vs. simulated with no modified data is 21 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The behavioral pattern of total CPUE from 1987 to 2012 is evaluated by comparing the historical behavior with the simulated behavior using estimated parameters and presented in Figure 6,e (i). The result showed that there is significant deviation occurred and the comparison of historical behavior and the simulated behavior using modified parameters is carried out and presented in Figure 6,e (ii). The accuracy measures are used in comparison between the historical vs simulated with non-modified parameters and historical vs. modified parameters are carried out. The statistical analysis of two data sets of total CPUE showed that the MAPE for historical vs. simulated is 2 % and that of historical vs. simulated with no modified data is 25 % and the APEM of total CPUE for historical vs. simulated is 0.91 % and that of for historical vs. simulated with no modified data is 24 %. The results indicated that the simulated model using modified parameter values showed the smaller value of MAPE and APEM and the model showed the statistical fitness and closely similar to the real system.

The results of the accuracy measures showed that simulated model with modified data showed significantly smaller values of deviation and error percentage than the simulated model with non-modified data. Therefore, the model used in the simulation analysis should be used the modified data and this model showed the fitness for the system behavior of the zone C trawl fishery.

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