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Economic Assessment of the Mariculture Functional Zones Using System Dynamics

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Abstract: The economic activity and assessment methods of the Mariculture Functional Zones (MFZ) in Qingdao are investigated. A System Dynamic (SD) model of the prediction and the utilization Effectiveness for Qingdao MFZ is established to provide decision-making for managers. A fishery impact assessment for the MFz is set up to estimate the total incomes and outcomes and thus the cause and effect feedback chart is obtained. Data are processed by statistical method and World Wind Java. The causal loop diagram is presented to express the feedbacks. Simulations are conducted to verify the validation of the model proposed based on Vensim.

Key words: System dynamic, assessment, expert system, marine fisheries

INTRODUCTION

Recently, Marine fishery has been an essential part of marine economy, There are potential conflicts exist between human activities and nature restoration objectives. With the world's attention focused on sustainable fishery, numerous studies have been conducted to investigate the theoretical disciplines and polices (Hilborn, 2012; Stelzenmuller *et al*., 2010; Fork, 2008). For example, a prey–predator type fishery model with prey dispersal in a two-patch environment is presented (Kunal and Kar, 2012) in India. Punt and Hilborn (1997) provided Bayesian approach to determine the probabilities of alternative hypotheses using information for the stock in question and from inferences for other stocks species. An economic impact assessment of recreational fisheries has been provided to explore that how anglers' expenditures affect economic activity (Steinback, 1999). However, the policy maker is often interested not only in the predictions arising from an economic model but also in the path taken by policy variables as they move. Chinese economy is dependent on the health of the ocean. the marine economy has been on a path of rapid development and continuous growth in the past decade. Since, 1992, China's marine fishing industry has been ranking first in the world, the seafood production reach 9.34 million tons, of which the aquaculture output is 2.42 million tons; In 2005 marine capture production has reached 28.38 million tons and the aquaculture output is13.85 million tons, marine capture production increased 3 times, aquaculture production increased by 5.7 times; aquaculture production of national marine catch the proportion has increased from 26-49%. In 2001, the total output value of China's marine industry was less than RMB 1 trillion Yuan; in 2011, the number reached 4.56 trillion Yuan, an average annual growth of 16.7%, significantly higher than the growth of the GDP. Currently, China's total marine output value accounts for 9.7% of the GDP, making it a new growth engine for the national economy. Marine functional zoning is applied only in China's territorial sea, i.e., within 12 nm of its shore. Marine functional zoning refers to dividing sea areas (inclusive of islands) into different functional "zones" in which a functional zone is a designated sea area for human activities based on its geographical and ecological features, natural resources, current usage and socioeconomic development needs. The development of MFZ is an important part of Chinese marine economy (Luan, 2002).

Qingdao has abundant marine resources and a good industrial base. In 2004, Qingdao designated nine categories total 191 Marine functional zones, of which there is 33 fisheries resource utilization zones and conservation zones (including fishing areas and fishing facilities, fishing bases, breeding areas, the proliferation area and fishing area), the total area is 385.1585 km^2 and is

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29.2% of whole MFZs of Qingdao. Qingdao Fishery output value accounted for 22.3% of the marine economy and marine aquaculture production accounts for 73% of the total output of aquatic products in 2009. However, with the booming of marine economy and tourism, the rapid development of port and shipping services, the aquaculture area is shirking (Luan, 2002). It is an incontrovertible need for us to move forward in implementing the harvesting marine ecosystems polices. Therefore, in order to promote sustainability of marine fisheries resources and associated habitats, it is important to monitor, predict and assess the utilization Effectiveness of the existed MFZ in China, Qingdao. We needs to revamp its traditional economic model.

SD is a computer-aided approach to policy analysis and design. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems-literally any dynamic systems characterized by interdependence, mutual interaction, information feedback and circular causality (Smith and van Ackere, 2002). It deals with internal feedback loops and time delays that affect the behavior of the entire system. SD was created during the mid-1950s (Forrester, 1994) by Professor Jay Forrester of the Massachusetts Institute of Technology. SD models solve the problem of simultaneity (mutual causation) by updating all variables in small time increments with positive and negative feedbacks and time delays structuring the interactions and control (Saleh *et al.*, 2010). SD models have been set up for different problems (Min Kang and Jae, 2005; Saleh *et al.*, 2010; Chen *et al.*, 2012; Ford, 2011).

The study aims at integrating SD into decision-making that affects the contribution of marine fisheries to Chinese economies, as well as the state of marine ecosystems. Recognizing that we cannot afford to delay decisions until we have a perfect understanding of the relationship between fisheries and marine capture fisheries, we provides a SD model that allows factoring of scientific information into the impact assessments as more knowledge is gained. The impact assessment system is constructed in order to obtain the cause and effect feedback chart of the MFZ based on the data from year 2000 to year 2011. Data are processed by statistical method and World Wind Java geographic information system. A feedback SD model and the main control loops for the utilization effects evaluation are presented based on the results above. Simulations are conducted to verify the model proposed.

REQUIREMENTS AND ACCESSMENT SYSTEM FRAMEWORK ANALYSIS

Aquatic products price is the most important factor in the amount of breeding. In addition, the price of aquatic products production is also affected by aquiculture, catching costs, social economic conditions, per capital annual expenditure on consumption and consumption habits. However, the factors above will affect the fishery price in one or two years (depending on the growth cycle of aquiculture products).

Even among the same Aquatic products, the price of edible fish in the low category is far less affected by the economic situation than that of the delicious seafood. Many marine economic function zones (such as mariculture zones, tourism zones, etc.) are also affected by the regional marine environment, marine weather conditions and other major environmental.. Ports and sailing areas of wastewater and pollution can affect nearby breeding area and breeding areas, the sediment and water power also affect the tourist zones.

In summarize, the system state variables are selected as follows: urban population, aquatic products price, energy cost, production materials cost, feed cost, human resource cost, consumption desire, marine capture production, whipping throughout, tourism income, marine aquaculture area, marine aquaculture production.

The system decision variables are: urban population growth rate, the first industry growth rate, the second industry growth rate, the third industry growth rate, growth rate of agricultural products price, growth rate of aquaculture cost, growth rate of Consumption per capita, growth rate of consumption expected, growth rate of marine capture, growth rate of freshwater aquaculture, growth rate of freshwater capture. Figure 1 shows the main feedback loop of the marine fisheries economic system.

From Fig. 1 one can observes that the relationship loop of the price of aquatic products, aquatic products, aquatic products per capita, per capita aquatic consumption, Gap between desired and actual consumption is shown in Fig. 2.

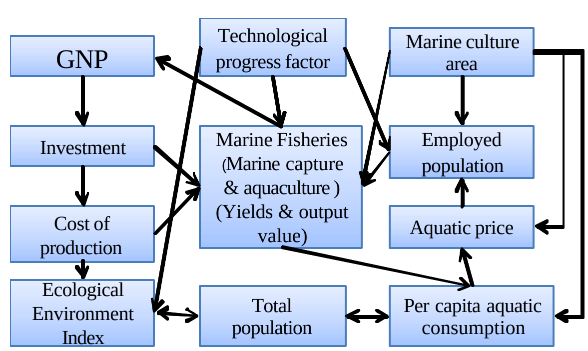

Fig. 1: Main feedback loop of the marine fisheries economic system

Generally aquatic prices lead to a reduction in per capita consumption and it is also often lead to an increased cultivation (1-2 year lag).

With the increase of the aquaculture products, limited to the total population and consumption habits, the aquatic prices fall again which leads to the decrease in breeding enthusiasm and also results in reduction of the aquaculture products, thus a negative feedback loop is set up; the loop can adjust the system automatically. In order to reduce this oscillation, a SD model is presented as the follows.

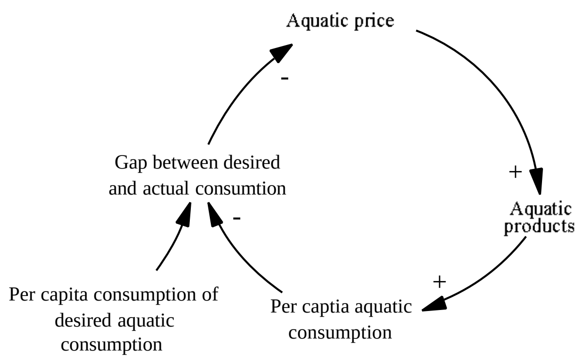

Fig. 2: Feedback loop of aquatic product prices

SD MODEL FOR THE MARINE FISHERIES MANAGEMENT

The causal loop diagram can express the feedbacks in the system better than causal relation model. The price of aquatic products is divided into the six categories and each category is refined. Each system branch description is analyzed based on according category. The causal loop diagrams are then obtained by using Vensim. The branches of SD modeling of Qingdao MFZs are shown as Fig. 3.

We cannot use all those variables in this model; hence some important factors were selected to build the model which is shown in Fig. 3. The causal loop diagram in Fig 3 can express the feedbacks in the system better than causal relation model.

From Fig. 3 one can know that the impact of marine fisheries (sea fishing, aquaculture) have strong interactions, it is very difficult to analysis any single impact of the factors.

In order to validate the simulation model the historical data (from year 2000-2011) is used. Five subsystems are setup to simulate 3 main state variables (human resource costs, production costs and energy costs). In addition,

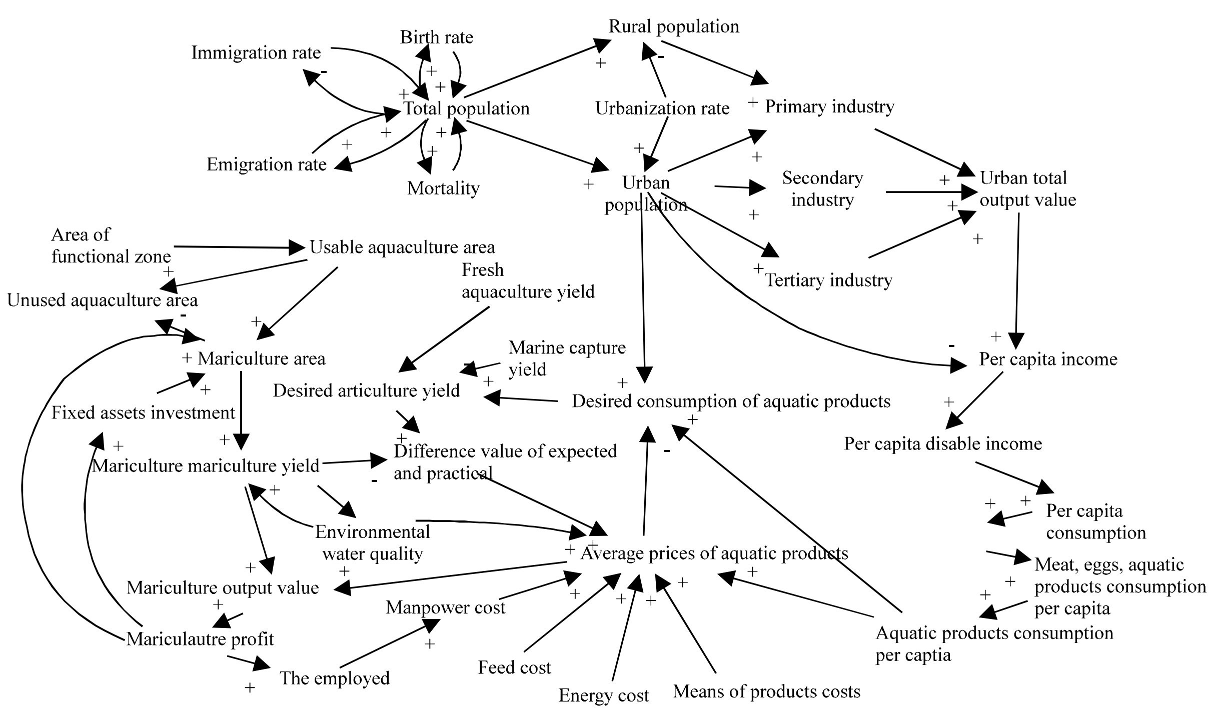

Fig. 3: Feedback structure for the utilization effeteness of Qingdao MFZs

Table 1: Simulation errors of the SD model of Qingdao MFZs between marine aquaculture area and production

	Marine aquaculture area (H)			Marine aquaculture production (T)		
Year	Actual value	Simulation value	Error (%)	Actual value	Simulation value	Error (%)
2006	45602	49586.66	6.83	800482	893560.0	6.83
2007	41416	44197.38	1.93	755466	763008.0	1.93
2008	35954	36324.74	6.80	755843	804455.8	6.80
2009	37098	41319.45	7.75	794168	809608.1	7.75
2010	44789	47494.39	5.75	821744	854998.5	5.75
2011	45368	50757.68	7.26	806198	851189.2	7.26

urban population, aquatic products price, marine aquaculture production and per capital consumption costs are verified. The verified data refer to Table 1 which describes the errors between Marine Aquaculture Area and Marine Aquaculture production from 2000-2011.

CONCLUSION

From the analysis above we can draw conclusion that impact factors of aquatic products is more than scientific-technological progress and prices. Scientific and technological progress is a long process, price of aquatic products and the level of consumption is a process of continuous volatility. Under the influence of aquatic growth cycle, information delay, the aquatic price wave 4-5 years period^{-1}. In summary, the detail conclusions are obtained as follows:

- Qingdao marine aquatic area reduced by 33% in past 10 years and aquaculture production would not change much
- By the affection of the aquatic products price and other factors, there is aquaculture fluctuation period of 5-6 years
- The aquatic production and output value of Qingdao has been increasing recently which is not a real performance boost affected by the increasing energy price, production materials, feed and human resource cost. With the economic development of Qingdao and the extension of the city, aquaculture will be further marginalized. Therefore, factory aquaculture will be very important work for future development of aquaculture

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