Monitoring Change of Marine Fish Landing Amount in Chonburi with CUSUM Control Chart

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Abstract — The main objective of this research was to monitor the change of marine fish landing amount in Chonburi, Thailand by cumulative sum or CUSUM control chart. The marine fish landing was investigated during 2001 to 2010. The research results indicated the marine fishery catches was maximum in rainy season particularly in July and August. Furthermore, the CUSUM control chart illustrated to ascertain abnormality abruptly with the lower CUSUM or it could state gave a clear alarm signal that the amount of marine fish landing in Chonburi was decreasing since 2006 and continually lessened until 2010.

Keywords — Marine Fish Landing, CUSUM Control Chart.

I. INTRODUCTION

Marine fisheries are not only providing the large important sources of food but also making the huge income for the coastal communities worldwide. Because of the rapid demand of marine fishery resources, 30% of marine fish stocks were completely overfished and 57% were close to being overfished [1]. Like many seashore provinces in other countries, Chonburi has confronted with the subsequent decline of many marine fisheries by reason of over-fishing, the use of destructive fishing practices and the lack of adequate management. Our research objective was then to find the simple way as an alternative tool for investigating the change of marine fish landing amount in Chonburi. Many techniques were often applied to build the various forecasting models; for example, regression model [2-3], general linear model or GLM [4], conceptual model [5] or even descriptive statistics [6]. The cumulative sum or CUSUM control chart is one of popularly efficient tools for monitoring the change of quality characteristics relative to time series rather than any models. Nevertheless, it was often used for only an empirical process. An example of CUSUM capability in detection persistent changes of the North Sea cod stock in the FISBOAT project was demonstrated [7]. This research then presented how efficient CUSUM control chart detecting the change of marine fish landing amount in Chonburi.

II. Materials and Methods

Data of marine fish landing was provided in the unit of metric tons from the 3 districts of Chonburi; Mueang Chonburi, Si Racha and Sattahip, by the Fishery Statistics Analysis and Research Group, Information Technology Center, Department of Fisheries, Thailand. The 15 types of marine fish; Indo-Pacific mackerel, Indian mackerel, King mackerel, Tuna, Scads, Hardtail scad, Trevallies, Sardinellae, Anchovies, Threadfin breams, Lizard fishes, Redsnappers, Big-eyes, Other foodfish and Trash fish, were then monthly recorded during 2001 to 2010. Assessing amount of marine fish landing was firstly conducted with descriptive statistics to determine the pattern of marine fish landing amount in Chonburi. Monitoring amount of marine fish landing was then performed with CUSUM control chart to investigate the change of marine fish landing amount.

Suppose a sequence of marine fish landing amount xi collected at time i; i = 2001, 2002, …, 2010. The procedure for detecting the change of marine fish landing stock abundance was as follows.

1. Estimating the in-control mean (μ0) and standard deviation (σ0) of marine fish landing amount with  and s, respectively.

2. Computing the two statistic values plotted in CUSUM control chart. The positive deviations or the one-sided upper CUSUM firstly defined as

\[ S_i^+ = \max \left[ 0, S_{i-1}^+ + z_i - k \right] \]

The negative deviations or the one-sided lower CUSUM secondly defined as

\[ S_i^- = \min \left[ 0, S_{i-1}^- + z_i + k \right] \]

where \( z_i = \frac{x_i - \bar{x}}{s} \) be the standardization of marine fish landing amount and k be parameter denoted reference value of CUSUM control chart.

3. Plotting both of \( S_i^+ \) and \( S_i^- \) against i into the CUSUM control chart containing the control limit equal to the decision limit h called the decision interval. If any \( S_i^+ \) exceeds the upper control limit (UCL. or h) or any \( S_i^- \) lies below the lower control limit (LCL. or -h), the process is indicated the out-of-control status.
III. Results

To assess the amount of marine fish landing, the descriptive statistics was shown in Figure 1.

![The Amount of Marine Fish Landing in Chonburi](image)

Fig. 1 The Amount of Marine Fish Landing in Chonburi

The average of marine fish landing was 2,149 metric tons. During 2001 to 2004, the amount of marine fish landing was above the average and then it was mostly decreasing and below the average after 2005. In addition, the marine fish landing was maximum amount in rainy season particularly in July and August.

Since the marine fish of the first phase (2001-2004) was caught in a higher amount than the later phase (2005-2010) also the amount of marine fish landing was continually decreasing after 2005, the reference period (2001-2005) was then specified for estimating the in-control mean and standard deviation. The results of procedure for detecting the change of marine fish landing stock profusion were below.

1. The estimated in-control mean and standard deviation were respectively 34,545.6 and 7,904.038512 metric tons.

2. Based on the recommendation of [7], the two parameters of CUSUM control chart were set the allowance $k = 1.3$ and the decision interval equalled $-1 < h < 1$. The values of $S_i^+$ and $S_i^-$ were then computed in following Table 1.

3. Once both of $S_i^+$ and $S_i^-$ plotted in the CUSUM control chart as of Figure 2, all $S_i^+$ were kept along the center line but the five values of $S_i^-$ were pointed below the LCL since 2006.

Table 1: The $S_i^+$ and $S_i^-$ of CUSUM control chart at time $i$

<table>
<thead>
<tr>
<th>$i$</th>
<th>$x_i$</th>
<th>$z_i$</th>
<th>$S_i^+$</th>
<th>$S_i^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>30,678</td>
<td>-0.4893</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>39,347</td>
<td>0.60746</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2003</td>
<td>43,191</td>
<td>1.0938</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>36,511</td>
<td>0.24866</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

2.3951
2.1911
2.2776
1.9953
1.4606

Fig. 2 The CUSUM of Marine Fish Landing Amount in Chonburi

IV. Conclusion and Discussion

The CUSUM control chart could be applied as the magnificent tool in monitoring the change of marine fish landing in Chonburi. The resulting CUSUM control chart signally illustrated the amount of marine fish landing lessened since 2006 to 2010 which was in agreement of the deduced descriptive statistics. The finding of this study may help to warn the one who power for planning, managing and controlling the marine fish landing in Chonburi back into the stability of marine ecosystem.

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REFERENCE
