ORIGINAL ARTICLE

# Trends in marine fish catches at Pattani Fishery Port (1999-2003)

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## Abstract

**Komontree, P., Tongkumchum, P. and Karntanut, W.**

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**This study aims to develop statistical models for forecasting the quantity of the various types of marine fish landed at Pattani Fishery Port, allowing for trend and seasonality, using official data during 1999-2003. The data comprise daily and monthly totals by weight for eight types of fish (mackerel, other food fish, squid, scads, trash fish, shrimp, lobster and crab). The statistical methods are one-way analysis of variance, multiple linear regression and time series forecasting using trend and seasonal models. It is found that mackerel, other food fish and squid catches tend to decrease, whereas the catches of scads tend to increase, and trash fish catches have no detectable trend up or down. Shrimp and lobster tend to decrease exponentially, and the trend of crab catch is constant. This study raises questions about the ecological and economic sustainability of the current fisheries policy in Thailand.**

**Key words :** forecasting, fish catches, sustainability, Pattani Fishery Port

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**แนวโน้มของปริมาณสัตว์น้ำที่ผ่านท่าเทียบเรือประมงปัตตานี จากข้อมูลระหว่างปี พ.ศ. 2542-2546**

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การวิจัยนี้มีวัตถุประสงค์เพื่อสร้างแบบจำลองสำหรับพยากรณ์ปริมาณสัตว์น้ำที่ผ่านท่าเทียบเรือประมงปัตตานี โดยคำนึงถึงแนวโน้มและอิทธิพลของฤดูกาล โดยใช้ข้อมูลรายวันของปริมาณสัตว์น้ำแยกตามชนิดระหว่างปี พ.ศ. 2542-2546 จากองค์การสะพานปลาปัตตานี ข้อมูลปริมาณสัตว์น้ำรายวันและรายเดือน แบ่งเป็น 8 ชนิด ได้แก่ ปลาทู ปลาเลย ปลาหมึก ปลาทูแขก ปลาเป็ด กุ้ง กั้ง และปู การวิเคราะห์ข้อมูลใช้การวิเคราะห์ความแปรปรวนแบบทางเดียว การวิเคราะห์การถดถอย และการพยากรณ์ จากการศึกษาพบว่า ปริมาณปลาทู ปลาเลย และปลาหมึกมีแนวโน้มลดลง ปลาทูแขกมีแนวโน้มเพิ่มขึ้น ปลาเป็ดมีแนวโน้มค่อนข้างคงที่ ในขณะที่กุ้งและกั้งมีแนวโน้มลดลงแบบเอ็กโพเนนเชียล ส่วนปูมีแนวโน้มคงที่ การวิจัยนี้ก่อให้เกิดคำถามเกี่ยวกับการสนับสนุนด้านนิเวศวิทยาและนโยบายเศรษฐกิจประมงปัจจุบันในประเทศไทย

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Trends in quantity of marine fish can be important indicators of the status of the sea fishing industry. This industry has been a major component of Thailand's economy for many years, and it is thus essential that sustainable practices are maintained. The Gulf of Thailand, the Andaman Sea and their extensions into surrounding seas provide a rich source of seafood, but sustainable fishing policies cannot be developed without scientific planning and relevant guidelines. Historical data provide the basic ingredients for developing reliable forecasts, which are in turn essential to planning. Pattani is one of the most important of the 22 provinces of Thailand involved in the sea fishing industry. Its main port is strategically located at the south-western extremity of the Gulf of Thailand.

The Department of Fisheries also records the quantity of marine fish data classified by eight types. Table 1 shows these annual data for Pattani Fishery Port for the five years from 1999 to 2003. Other food fish provide the largest production component by weight, with 40 percent of the total, followed by scads (27%), trash fish (23%) and mackerel (7%). (Department of Fisheries, 2003a) Various statistical models have been used to analyse

**Table 1. Total catch at Pattani Fishery Ports by type of fish**

| year | Quantity of marine fish (millions of tons) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mack-erel | Other food fish | Shrimp | Lobster | Squid | Crab | Scads | Trash fish |
| 1999 | 13.07 | 75.13 | 0.202 | 0.228 | 7.49 | 0.481 | 37.28 | 52.26 |
| 2000 | 14.44 | 89.89 | 0.071 | 0.094 | 6.03 | 0.231 | 48.11 | 41.19 |
| 2001 | 12.26 | 72.84 | 0.068 | 0.079 | 6.93 | 0.235 | 52.25 | 32.39 |
| 2002 | 11.83 | 70.46 | 0.049 | 0.043 | 6.34 | 0.303 | 59.49 | 42.22 |
| 2003 | 10.78 | 59.65 | 0.018 | 0.029 | 4.03 | 0.243 | 53.60 | 40.34 |
| Total | 62.38 | 367.97 | 0.408 | 0.473 | 30.81 | 1.493 | 250.73 | 208.40 |
| % | 6.76 | 39.88 | 0.044 | 0.051 | 3.34 | 0.162 | 27.17 | 22.59 |

fish catch data in previous studies. Stergiou and Christou (1996) applied multivariate statistical time series models to annual catches over a period of 25 years for 16 species in Hellenic marine waters. After applying forecasting methods separately to each marine species, their conclusion was that "not a single best approach was found." Wallace *et al*., (1998) used both annual and monthly time series analysis of catch per unit effort data for a lobster fishery, and concluded that modellers and managers of fisheries need to quantify the economic effects. Goni *et al.* (1999) applied generalized linear statistical models to analyse data from individual boats, and concluded that such modelling "is a sensible method for obtaining standardised abundance indices of exploited ground fish stocks." Sbrana *et al.* (2003) used generalized linear statistical models to investigate factors affecting the crustacean trawl fishery monthly catch rates, and concluded that boats differed in catching abilities.

Xiao (2004) also used a similar generalized linear modelling approach to analyse the catch and effort data on a specific species, the western king prawn *Penaeus latisulcatus* Kishinouye in the Gulf St. Vincent, Australia, over the period of July 1995 to June 1997. The conclusion from this study was that the current level of fishing effort could not sustain the exploitable biomass of the population at the level of December 1993.

This study aims to develop statistical models for forecasting the quantity of the various types of marine fish landed at Pattani Fishery Port, allowing for trend and seasonality.

## Materials and Methods

The data are daily and monthly totals catch (in kilograms) for the eight fish types from the Pattani Fishery Port published for the five years period from 1999 to 2003.

Statistical analyses on time series require data to be a sequence of observations observed over time, usually at regular intervals. The daily catches of marine fish of various species provide an example of time series. However, on some days no boats came in or no boats caught any fish of a particular species. This situation could be regarded as a zero catch if an attempt was made to fish but nothing was caught, or as a missing value if no boats landed. After preliminary analyses of the daily catches with zero catch days excluded, the monthly totals are used as a basis for forecasting future trends.

To satisfy statistical assumptions the daily and monthly catch weights are transformed using square roots, cube roots, or logarithms, depending on the period of aggregation and the type of fish. Daily data indicate that taking cube roots for squid and vertebrate catches (mackerel, other food fish, scads, trash fish), and taking logarithms for other invertebrate catches (shrimp, lobster and crab) provides distributions that are more symmetrically distributed, and thus more amenable to statistical analysis requiring the normality assumption. Monthly data are transformed using square roots for vertebrate and squid catches and logarithms for other invertebrate.

Preliminary data analysis involves one-way analysis of variance and multiple regressions. They are used to identify daily, monthly and yearly effects. We compare the marine fish catches with respect to the day of the week, the month of the year, and the year. We use multiple regressions to fit models to the transformed daily marine fish catches using the day of week, month of year, and year as joint categorical determinants.

Forecasting of monthly totals is carried out by fitting multiple regression models containing monthly seasonal patterns and linear trends separately for each of the eight fish types, and then back-transforming with appropriate adjustment to remove biases in catch weights due to the transformation. We fit the model of the form $y_t = a_t + bt$, where $y_t$ is the transformed marine fish catch $t$ months after December 1998 and $a_t$ is a monthly seasonal effect. Using statistical theory it can be shown that the forecasting formulas when the data are transformed is $f_t = y_t^2 + s^2$ (square root transformed), or $f_t = \exp(y_t + s^2/2)$ (natural logarithms transformed), where $s$ is the standard deviation of the residuals.

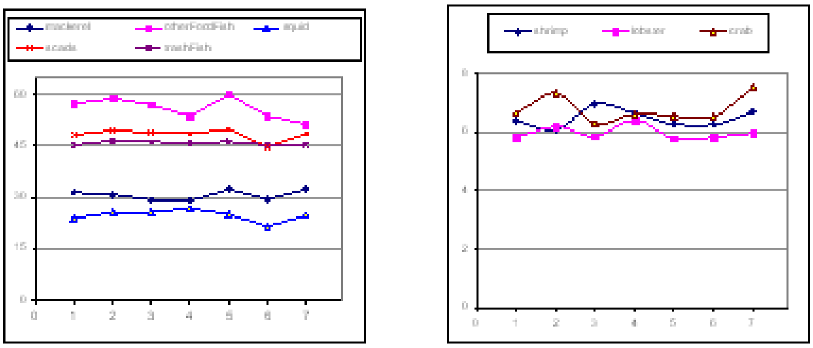
## Results

The data for our study cover the period of 1825 days or 60 months from January 1999 to December 2003.

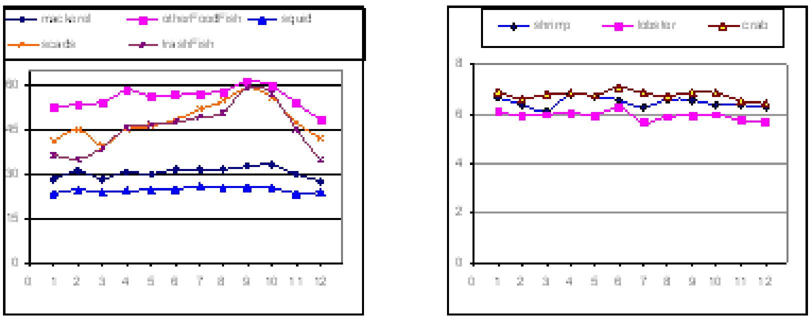
### 1. Preliminary analysis (daily catches)

We transformed using cube roots for vertebrate and squid catches and natural logarithm for other invertebrate catches. Figure 1 shows the day of week, month of year, and year effects for the transformed data. The catches are quite different between different days, months and years.

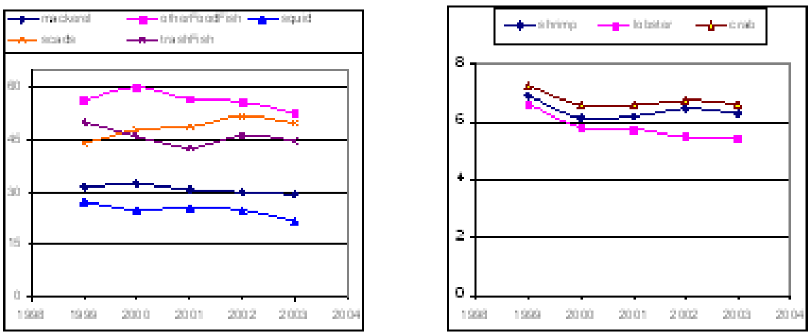
The results from the one-way analysis of variance suggested that there are seasonal patterns and trends in catches. Except for trash fish (p-value = 0.7), the day of week effects are statistically significant, with p-values below 0.001. The month of year effects are also highly statistically significant, for the vertebrates (p-values < 0.0005).




(a) Marine fish catches by days in a week




(b) Marine fish catches by month in a year




(c) Marine fish catches by year

**Figure 1. Marine fish catches by day of a week (Monday = 1, etc.), month of year (January = 1, etc.) and year**

In each case the catches are higher around September and October. For invertebrates, the monthly squid catches also show a similar pattern to the vertebrates (p-value = 0.025). However, there is no evidence of any season pattern for the other invertebrates. For all fish types, the year effects are statistically significant, with p-values below 0.0005.

**2. Regression analysis (monthly totals)**

We fit linear regression models of the form $y_t = a_t + bt$, where $y_t$ is the transformed marine fish catch $t$ months after December 1998 and $a_t$ is a monthly seasonal effect.

Tables 2 and 3 show coefficients from a fitted model, fitted to the square roots of the vertebrate and squid catches and natural logarithms

**Table 2.** ***Trend+ seasonal*** **model for transformations of vertebrates and squid catch**

| Determinant | mackerel | other food fish | squid | scads | trash fish |
|---|---|---|---|---|---|
| Constant | 940.02 | 2449.03 | 744.76 | 1391.46 | 1343.32 |
| Trend ($t$) | -1.57* | -6.85** | -3.37** | 7.86** | -4.35 |
| Month (baseline: Jan) | ** | ** | | ** | ** |
| February | -14.13 | -75.54 | 0.52 | 102.37 | -90.21 |
| March | 12.93 | 105.79 | 36.83 | -101.91 | 156.13 |
| April | 101.80 | 330.91 | 21.23 | 173.47 | 538.03 |
| May | 104.92 | 278.10 | 68.33 | 305.94 | 644.44 |
| June | 156.35 | 267.61 | 91.70 | 389.36 | 628.98 |
| July | 173.06 | 300.19 | 138.98 | 595.24 | 802.98 |
| August | 185.04 | 404.41 | 98.71 | 785.48 | 897.20 |
| September | 254.70 | 544.58 | 112.75 | 1027.86 | 1378.62 |
| October | 253.28 | 518.13 | 114.24 | 837.99 | 1267.31 |
| November | 96.67 | 133.39 | 53.16 | 287.85 | 577.32 |
| December | -28.93 | -212.24 | 37.37 | -43.76 | -36.05 |

*** p-value < 0.05, ** p-value < 0.01**

**Table 3.** ***Trend+seasonal*** **model for transformations of the invertebrates catch**

| Determinant | shrimp | lobster | crab |
|---|---|---|---|
| Constant | 10.07 | 10.07 | 10.12 |
| Trend ($t$) | -0.05 ** | -0.04 ** | -0.01 ** |
| Month (baseline:Jan) | | | |
| February | -0.30 | -0.28 | -0.16 |
| March | -0.57 | -0.48 | -0.15 |
| April | -0.57 | -0.45 | -0.09 |
| May | -0.23 | -0.07 | 0.25 |
| June | -0.03 | 0.20 | 0.47 |
| July | -0.79 | -0.56 | 0.18 |
| August | -0.29 | -0.19 | -0.08 |
| September | -0.53 | -0.26 | 0.28 |
| October | -0.82 | -0.05 | 0.31 |
| November | -0.42 | -0.09 | -0.06 |
| December | -0.17 | -0.12 | -0.06 |

**** p-value < 0.01**

of other invertebrates. For mackerel both the trend and the seasonal effect are statistically significant, with p-values below 0.05. The negative estimate for the trend indicates that the quantity of mackerel catches has a decreasing trend. The seasonal effect has a minimum during the four months from December to March, rising to a maximum in September and October. The interpretation is similar for other types of fish. For other invertebrates, the trends are statistically significant but the seasonal effects are not statistically significant. Again the negative estimate for the trend indicates that the quantity of other invertebrate catches have decreasing trends.

### 3. Forecasting the marine fish catches

We use the multiple regression models from Tables 2 and 3 to estimate the fitted values from January 1999 to December 2003 and to forecast the monthly catch quantities from January 2004 until December 2005.

Figure 2 shows monthly marine fish catches for 1999-2003 and forecasts for these years up to 24 months ahead. The mackerel and other food fish catches have decreasing trends and seasonal effects. The squid catch also has a decreasing trend but no seasonal effects. The trend of scads catch is increasing, and the season is a strong effect. The trash fish catches have no detectable trend up or down and the season is a strong effect. There are no seasonal effects for other invertebrates. The trend of the shrimp catch is decreasing exponentially. The trend of the lobster catch is also decreasing exponentially. The crab catch is constant.

## Discussion

In this study, using monthly data from the Pattani Fishery Port published for the five years from 1999 to 2003, we investigated the trends and seasonal patterns of marine fish catches, classified into the eight types of marine fish catch. We used graphical and statistical methods to investigate the patterns over the time period, and we used time series analysis to fit models used for short-term forecasting.

Our study found that monthly catch data has to be transformed using different transformation functions depending on fish type.

The marine fish catch varies between different types of fish. The maximum catches were for food fish (other than mackerel), followed by scads, trash fish, mackerel, squids, crab, shrimp and lobster. This result can be explained by the fact that the other food fish and the trash fish comprise more than ten types of fish (Department of Fisheries, 2000a). However, the high quantity of the scads may be due to the biology of the scads, which spawn all year (Department of Fisheries, 2000c).

The results from one way analysis of variance and multiple regression analysis using daily data showed differences in catches between days, months and years. However, these models gave a quite small value of r-squared compared to models of the monthly data, namely the *trend+ seasonal* models. The r-squared for all daily models are less than 26% except for the trash fish. The r-squared for all monthly models are greater than 56% except for the scads. Therefore, it is not necessary to use the daily data for forecasting.

The *trend+seasonal* model can be used to forecast the monthly catch for the eight types of marine fish. Since we now know the observations corresponding to monthly catches for the year 2004 (not used in fitting the model), we can compare the forecasts with these observed values. The results are shown in Figure 3. It can be seen from the graph that the forecasts and the observed values are quite similar in quantity and direction for mackerel, other food fish, trash fish, shrimp, lobster and crab. However, our models give overestimated forecast values for the squid and scads catches.

A decreasing trend occurred in five marine fish types (mackerel, other food fish, squid, shrimp and lobster), no detectable trend up or down in two types (trash fish and crab) and an increasing trend only in the scads. This decreasing trend could be related to lower amounts of marine fish in the sea, or a declining number of fishermen and fishery employees (Department of Fisheries, 2003b, 2003c). In our analysis we did not take

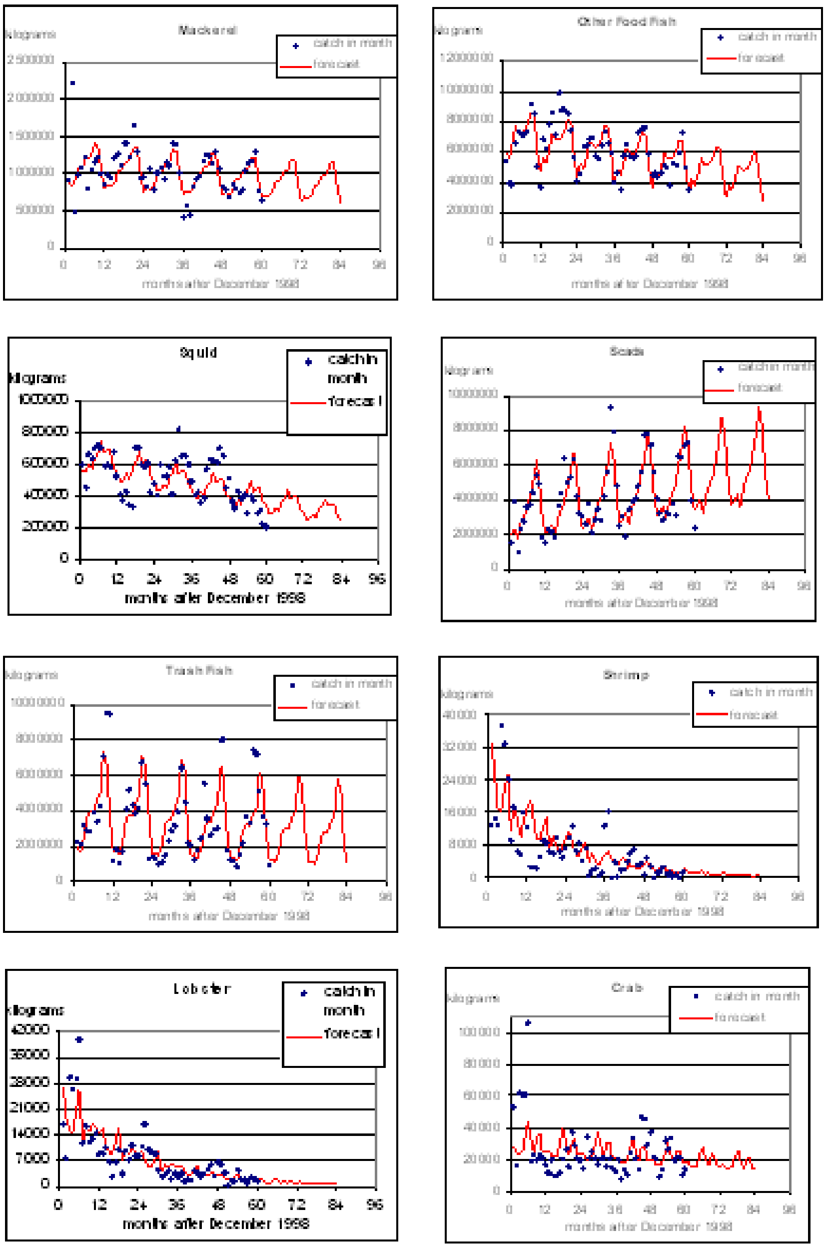



**Figure 2. Fitted model for forecasting the marine fish catches at Pattani Fishery Port**

these variables into account. This is a major limitation of our study. The increasing trend in scads is similar to those found at Songkhla Fishery Port (Department of Fisheries, 2003a). This result may be related to the biology of the scads.

Factors involved in seasonal variation in catch might be due to regional climate. During October to December it is the monsoon season in Pattani. It appears that during these months the catches decreased especially for mackerel, other food fish, scads and trash fish. Monthly effects in fish catches have been found in the previous

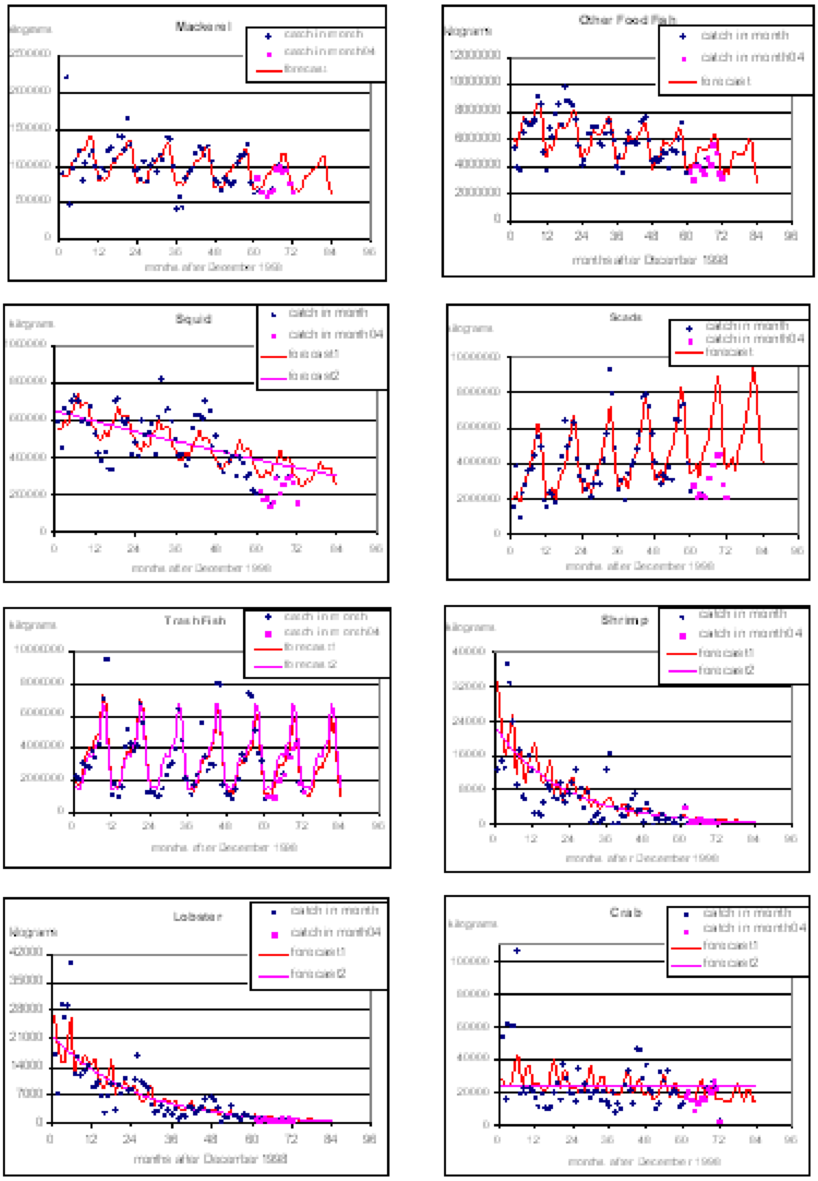



**Figure 3. Model checking for forecasting the marine fish at Pattani Fishery Port**

studies (Stergiou and Christou, 1996, Wallace *et al*., 1998, Goni *et al*., 1999, Sbrana *et al*., 2003). The monthly effects in these studies were due to winter and summer seasonal differences. In our study, for the invertebrates, the models show no significant differences between months. Another factor contributing to lower catches in March is the annual closure fishing area of the Gulf of Thailand from February 16 to May 15.

This study raises questions about the ecological and economic sustainability of the current fisheries policy in Thailand.

## Conclusion

After fitting the statistical model, we found that mackerel, other food fish and squid have decreasing catches, whereas the catches of scads are increasing, trash fish catches have no detectable trend up or down, shrimp and lobster catches are decreasing exponentially and the crab catch is constant.

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