

# SEAFDEC Training Department

Southeast Asian Fisheries Development Center

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AN ANALYSIS OF CATCH CURVE USING LENGTH COMPOSITION DATA  
WITH APPLICATIONS TO THE LIZARD FISH (*Saurida elongata*)  
IN THE GULF OF THAILAND

by

Prichar Sommani



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INTRODUCTION

Since the beginning of this century a catch curve, which represents the relationship between the size or age of the fish and the logarithms of the frequency of the occurrence of the fish in catches, has long been recognized as a convenient method of representing the catches graphically and as a useful method of estimating the mortality rate Ricker (1958). At that time, the method was mostly applied to estimate the mortality rate under the constant mortality with age condition. Not until the middle of the 1960's was the method developed independently, to make it possible to estimate the mortality rate by iterative method when the fishing mortality varies with age, by Murphy (1965, 1966) for the North Pacific fish and by Gulland (1965, see also his manual published in 1980) for the North Atlantic fish. The common features of these methods are that they require the catches in numbers of various age groups, the natural mortality usually assumed to be constant and the fishing mortality of the older age group. The method has not been widely used, however, because it is tedious and time consuming especially when worked by hand. Pope (1972) developed an ingenious technique which approximates Gulland's method and this has been proved to be a very useful tool in the assessment of exploited fish stocks when the fishing and natural mortality rates are less than 1.2 and 0.3 respectively.

The technique, however, relies to a large extent on age information for the catches. This makes it difficult or even impossible to apply to tropical fishes for whom age determination is not as easy as for temperate species and the results of age determination are often unreliable. However recently, Jones (1981) made some modifications to Pope's (1972) technique so that it could be used to estimate the mortality rate based on the length composition data of the catches. This modification has proved to be very useful in working with tropical fishes. But there still exist some weak points which underly Pope's (1972) approximation *i.e.*, the fishing mortality and natural mortality rates must be lower than 1.2 and 0.3 respectively.

I have attempted to modify the Gulland-Murphy technique and combine it with the method of estimating the fishing mortality rate from the exploitation and natural mortality rates by iterative method described by Sommani (1972), so that it can be used to estimate the mortality rate from the length composition of the catches. Although the technique is tedious and time consuming, it is my view that at the present time, it is not impossible to carry on the iteration by using a small personal computer or even a small electronic calculator with an algebraic memory mode.

#### BASIC EQUATIONS AND CONDITIONS

Let the life span of the fish be divided into intervals which need not be of equal length, and let the  $i^{\text{th}}$  period begin at age  $t_i$  of the fish and end at age  $t_i + \Delta t_i$ , i.e., the length of the time period is  $\Delta t_i$ . Further, let the mortality rate during this period be constant. Under these conditions, it can be shown that, the number of the fish at the end of the  $i^{\text{th}}$  period ( $N_{i+1}$ ) is :

$$N_{i+1} = N_i e^{-Z_i \Delta t_i} \quad (1)$$

and the catch in number during the period ( $C_i$ ) is represented by :

$$C_i = \frac{F_i}{Z_i} (1 - e^{-Z_i \Delta t_i}) N_i \quad (2)$$

where

- $N_i$  = the number of fish of age  $t_i$  at the beginning of the  $i^{\text{th}}$  period,
- $F_i$  = the instantaneous fishing mortality coefficient of the fish of age  $t_i$  during the  $i^{\text{th}}$  period,
- $Z_i$  = the instantaneous total mortality coefficient
- =  $F_i + M$
- $M$  = the instantaneous natural mortality coefficient which is assumed to be constant with age.

If the growth of the fish is described by BERTALANFFY's (1938) equation, i.e.,

$$l_i = L_{\infty} (1 - e^{-K(t_i - t_0)}) \quad (3)$$

where

$l_i$  = the length of the fish at age  $t_i$

$L_{\infty}$  = the ultimate length of the fish assumed to be constant

$K$  = the rate at which the length is approaching the ultimate length assumed to be constant

$t_0$  = the intercept on the age axis corresponding to the zero length.

This equation can be rearranged to give an expression of age as a function of the length of the fish,  $t_i$ , as :

$$t_i = t_0 - \frac{1}{K} \ln \frac{L_{\infty} - l_i}{L_{\infty}} \quad (4)$$

This equation can be used to determine the time ( $\Delta t_i$ ) required to grow from the length at the beginning of the period ( $l_i$ ) to reach the length at the end of the period ( $l_{i+1}$ ). And it can be shown that this is equal to :

$$\Delta t_i = - \frac{1}{K} \ln \frac{L_{\infty} - l_{i+1}}{L_{\infty} - l_i} \quad (5)$$

and if we let

$$X_i = \frac{L_{\infty} - l_{i+1}}{L_{\infty} - l_i} \quad (6)$$

then

$$\Delta t_i = - \frac{1}{K} \ln X_i \quad (7)$$

By substituting  $\Delta t_i$  from (7) in (1) and (2), we have

$$N_{i+1} = N_i X_i^{Z_i/K} \quad (8)$$

and

$$C_i = \frac{F_i}{Z_i} (1 - X_i^{Z_i/K}) N_i \quad (9)$$

respectively.



The expression  $X_i^{Z_i/K}$  is the survival rate of the fish of age  $t_i$  during the  $i^{th}$  period ( $s_i$ ). Thus, the number of the fish of age  $t_i$  at the end of the  $i^{th}$  period and the catch during this period are now expressed as the functions of the length of the fish. Equation (9) may be rewritten in a shorter form as :

$$C_i = E_i N_i \quad (10)$$

where

$$E_i = \frac{F_i}{Z_i} (1 - X_i^{Z_i/K}) \quad (11)$$

which is the expression of the exploitation rate of the fish of age  $t_i$  during the  $i^{th}$  period.

If we let  $C_{i+1}$  be catch in number of the fish of age  $t_i + \Delta t_i$  taken during the  $(i+1)^{th}$  period, it can be expressed in terms of the number of the fish of age  $t_i$  available at the beginning of the previous period, the survival rate during the  $i^{th}$  period and the exploitation rate during the  $(i+1)^{th}$  period, i.e.,

$$C_{i+1} = E_{i+1} N_i X_i^{Z_i/K} \quad (12)$$

#### SOLUTION OF THE CATCH CURVE

Let us first consider the catches from two successive periods of the cohort of fish, and let us consider only the fully recruited fish. The catch taken from one period is represented by equation (10) and the catch in the following period is represented by equation (12). Dividing equation (12) by equation (10) yields the catch ratio ( $C_{i+1}/C_i = P_i$ ) :

$$P_i = \frac{E_{i+1} X_i^{Z_i/K}}{E_i} \quad (13)$$

The basic concepts behind equation (13) follow those of Murphy (1965 and 1966). Given  $C_i$  and  $C_{i+1}$ ,  $P_i$  can be calculated. If the instantaneous natural mortality coefficient,  $M$ , is known, either  $F_{i+1}$  can be estimated when  $F_i$  or  $E_i$  is available, or  $F_i$  can be calculated when  $F_{i+1}$  or  $E_{i+1}$  is available, by iterative method.



For the first case, equation (13) may be rearranged following Sommani (1972), to yield, in our notations:

$$E_{i+1} = P_i E_i X_i^{-Z_i/K} \quad (14)$$

Once  $F_i$  is known, the right hand side can be readily calculated, and  $F_{i+1}$  can be estimated by iterative method since the left hand side may be expressed in terms of  $F_{i+1}$ ,  $M$  and  $X_{i+1}$  as :

$$E(E_{i+1}) = \frac{F_{i+1}}{F_{i+1} + M} (1 - X_{i+1}^{(F_{i+1} + M)/K}) \quad (15)$$

However, if  $E_i$  is known but  $F_i$  is unknown, the iteration must be operated first for  $E(E_i)$  in order to estimate  $F_i$  as described by Sommani (1972). The expression for  $E(E_i)$  is similar to equation (15), except that the subscripts must be  $i$  instead of  $i+1$ . Once  $F_i$  is obtained the survival rate ( $s_i$ ) can be estimated by applying the following formula:

$$s_i = X_i^{(F_i + M)/K} \quad (16)$$

For the second case, where  $E_{i+1}$  is given, equation (13) may be rearranged following Sommani (1972), to give, in our notations the ratio of  $E_{i+1}$  to  $P_i$  as :

$$E_i X_i^{-Z_i/K} = \frac{E_{i+1}}{P_i} \quad (17)$$

This expression is the  $C_i$  to  $N_{i+1}$  ratio as derived by Gulland (1965). By letting this equal  $H_i$ , the expected value of the left hand side of equation (17),  $E(H_i)$ , may be rewritten in terms of  $F_i$ ,  $M$  and  $X_i$  as :

$$E(H_i) = \frac{F_i}{F_i + M} (X_i^{-(F_i + M)/K} - 1) \quad (18)$$

The expressions for  $E(E_{i+1})$  and  $E(H_i)$  are simple ones. The first contains  $F_{i+1}$ ,  $M$  and  $X_{i+1}$ , the second contains  $F_i$ ,  $M$  and  $X_i$ . Given  $X_{i+1}$  and  $M$  or  $X_i$  and  $M$ , the values of  $E(E_{i+1})$  or  $E(H_i)$  can be calculated and tabulated as the functions of  $F$ . Since the catch ratio is known, the corresponding value of  $F_{i+1}$  or  $F_i$  can be read off from the table. The iterative process, is of course, more laborious than in the case where the age of the fish is known and the time interval is constant and equal to unity. However, the values of  $X$ 's are on a given limit, i.e., between 0 to 1. For a given species, the functions of  $F$  can be calculated and tabulated by using a small personal computer or even a small electronic calculator.

By ignoring the subscript  $i$  and by letting  $(j)$  be the subscript standing for the  $j^{\text{th}}$  step of the iteration, the method of iteration may be described as follows: Starting with a trial solution,  $F_{(j)}$ , the factor which may be called  $\Delta F_{(j)}$  is needed in order to add it to  $F_{(j)}$  to get a new trial solution,  $F_{(j+1)}$ , where

$$\Delta F_{(j)} = \frac{E_{(j)} - E(E_{(j)})}{E'(E_{(j)})} \quad (19)$$

for the first case, and

$$\Delta F_{(j)} = \frac{H_{(j)} - E(H_{(j)})}{E'(H_{(j)})} \quad (20)$$

for the second case, where  $E'(E_{(j)})$  and  $E'(H_{(j)})$  are the first derivatives of  $E(E_{(j)})$  and  $E(H_{(j)})$  evaluated at  $F = F_{(j)}$  respectively.

As the iteration is carried on, the values of  $\Delta F_{(j)}$  will decrease continuously. When  $\Delta F_{(j)}$  is approximately equal to zero, the estimate of  $F$  is obtained. Usually, only a few steps of iteration are required to obtain this estimate.

#### MATERIALS AND INPUT DATA

The length frequency data of the catch sample and Bertalanffy's growth parameters for lizard fish (*Saurida elongata*) in the Gulf of Thailand used in this study were taken from Boonwanich and Amornchairojkul (1982). The details of the methods of sampling, length frequency analysis and the estimation of the growth parameters may be consulted from such report. Their study area is reproduced for reference here in Figure 1. Their estimates of the growth parameters which will be employed in this study are as follows:  $L_{\infty} = 37.07$  centimetres and  $K = 0.1179$  per month for the male fish; and  $L_{\infty} = 43.86$  centimetres and  $K = 0.1071$  per month for the female fish.

The computation of the population parameters was made by a pocket size programmable electronic calculator. Working backwards, from the large size to the small size groups, the calculation is conducted in this study. Thus, the mortality parameters required for the inputs are the natural mortality, which is assumed to be constant for all size groups, and the fishing mortality of the fish in the largest size group.

An estimate of the natural mortality of this fish is not available. But for this species, as well as other tropical fishes, the average life span in the natural unfished population is likely to be short, probably a year or slightly less than a year. As the first approximation, it is assumed that the coefficient of natural mortality is equal to the growth coefficient or the M-K ratio is unity; i.e., the coefficients of natural mortality are 0.1179 per month for the male and 0.1071 per month for the female fish. This would imply that the average life span of this fish is approximately 8 to 9 months.



The lizard fish family in this area has been heavily exploited for a long time Sommani (1983). This species is not an exception. The exploitation ratio ( $F/Z$ ) of the fish in the largest size group would be high and probably very slightly less than unity. Reasonable figures should be around 0.7 to 0.9, therefore, it is expected that the coefficient of fishing mortality be relatively high when compared with that of natural mortality. The figure of 0.5 per month is assumed for the first approximation of the fish in the largest size group and this would imply that the exploitation ratios of these fish are 0.8092 and 0.8236 for the male and female fish, respectively, in the largest size groups.

## RESULTS AND DISCUSSION

The results of the analyses of the catch curves of the male and female lizard fish are shown in Table 1 and Table 2 respectively. In general, the estimated parameters are given up to four decimal points. The figures for the population sizes are rounded off to the integers. Only six decimal points are given for the values of  $E_{i+1}/P_i$  although in the actual calculation up to eight decimal points of the  $E_{i+1}/P_i$  and their expected values are computed and compared. It should be noted that the fishing and total mortality coefficients are expressed as the figures per month unit; while the survival and exploitation rates are expressed as the rates of the whole time interval required for the fish to grow from the lower limit to the upper limit of the given length class.

Since the lengths are grouped at equal intervals, the time required for the fish to grow from the lower limit to the upper limit of the length class increases as the size increases. This is due to the nature of the growth curve employed, in which the fish grow slowly when older. The increases in the time intervals will affect the changes or variations of the survival and exploitation rates. These effects will be discussed later.

The coefficients of fishing mortality tend to increase as the sizes increase, but at a decreasing rate. This results in the increase with size of the instantaneous total mortality rates. In order to compare the results of this estimation with the estimates reported by Boonwanich and Amornchairojkul (1982) who used Jones and Zalinge's (1981) method, the average coefficients of total mortality of the large fish, 16 centimetres in total length and larger, are calculated. The average estimates are 0.5536 ( $\pm 0.0639$ ) per month for the male fish and 0.5774 ( $\pm 0.0494$ ) per month for the female fish. The results are close to the values given by the authors previously mentioned who reported the figures of 0.5563 and 0.5525 per month for the male and the female fish respectively. It might be stated that the results are agreeable although the technique of Jones and Zalinge (1981) assumes constant mortality while the method described here does not, rather it allows the fishing mortality to be varied.

As mentioned earlier, the coefficients of fishing mortality increase as the size of the fish increases. The relationships between the fishing mortality coefficients (F) and the mid-points of the length class (l) are shown in Figure 2. The model representing such a relationship is as follows:

$$F = \alpha e^{-\beta/(l-l_0)} \quad (21)$$

where  $\alpha$  and  $\beta$  are the constants and  $l_0$  is the length at which fishing mortality is zero. The details of the model derivation and of the curve fitting will be reported elsewhere. For the lizard fish in the Gulf of Thailand, the correlation analyses between  $\ln F$  and the reciprocal of  $(l-l_0)$  yield highly significant relationships ( $r = -0.996$ ,  $n = 10$  for the male fish and  $r = -0.984$ ,  $n = 11$  for the female fish). The estimated  $l_0$  is 9.5 centimetres. The estimated relationships are as follows:

$$F = 0.6527e^{-4.8132/(l-9.5)}$$

for the male fish and

$$F = 0.6826e^{-5.0334/(l-9.5)}$$

for the female fish.

According to this model, the highest possible fishing mortality is reached when the fish has attained its maximum length ( $L_\infty$ ). In the lizard fish in the Gulf of Thailand, these ultimate fishing mortality coefficients are estimated to be 0.5480 and 0.5896 per month for the male and female fish respectively. This means that if the assumption of constant natural mortality is true for all sizes of fish, on the average, the highest possible total mortality coefficients of these fish should be 0.6659 per month for the male fish and 0.6967 per month for the female fish.

The survival rates tend to decrease as the sizes of the fish increase while the rates of exploitation increase as the fish grow up. These phenomena are not unexpected, at least, for two reasons. It should be recalled that these two parameters are expressed for the whole time period the fish require to grow from the lower limit to the upper limit of the given length class; and the time intervals increase and the sizes increase. The larger time intervals are closer to the ultimate length of the sizes. The total mortality rates also increase with the sizes as mentioned earlier. Both will result in a decline in the survival rates and an increase in the rates of exploitation with the sizes of the fish. It should be noted that even though the lengths are rearranged so that the time intervals are constant, the declines in the survival rates and the increases of the exploitation rates still occur because of the increases with the sizes of the fishing mortality rates.

For the estimated population sizes, these are not the absolute figures since the catch sample is not total catch. However, if the catches of the length groups are proportional to those of the total



catch they will be proportional to the true population sizes. Thus, they could be used as the indices for the population sizes.

Although Jones' (1981) method and the method described in this paper have some common features, which need not be mentioned here, the steps of computation are different and should be pointed out. With the common data and parameters required for the input, in Jones' technique, the first parameter to be estimated is the population sizes of the successive lower limits of the length intervals. The following steps are to estimate the survival rate and/or the coefficient of total mortality or the exploitation rate and the fishing mortality coefficient. In this method, the coefficient of fishing mortality is to be computed first by iteration, however the other mortality parameters are also obtained at the same time. The population size is estimated in the last step. Thus, in Jones' method the validity of the other estimated parameters relies upon the estimates of the population sizes, especially the first one. According to the derived method, however, the validity of other parameters relies upon the estimated fishing mortality.

In order to explore the effects of the input fishing mortality on the estimated fishing mortality coefficients, various values of input  $F$  are employed in a calculation for the male lizard fish. In addition to the figure  $F = 0.5$  ( $F/Z = 0.8092$ ), the following values of  $F$  are used as input;  $F = 1.0$  ( $F/Z = 0.8945$ ),  $F = 0.7$  ( $F/Z = 0.8559$ ) and  $F = 0.18$  ( $F/Z = 0.6042$ ). The results are shown in Figure 3. Note that although the range of the input values of  $F$  is quite high, the figures of  $F/Z$  are still within the reasonable figures, 0.7 to 0.9, except for the lowest value of  $F$  (0.18) with the exploitation ratio of 0.6042. For all values of input  $F$ , the tendency is for the subsequent estimated values of fishing mortality to converge at the 20-22 length class. But in the case of high values of input, 0.5 to 1.0, this convergence is more rapid and occurs at the 24-26 length class. The differences of the estimates for the large size groups are small. For example, the estimated fishing mortality coefficients of the 28-30 length class fish, which was the first size group to have its parameters computed for the input values of 0.5, 0.7 and 1.0 which are 0.4659, 0.4825 and 0.4958 per month respectively, the largest difference is 0.0299 for the input values of 0.5 and 1.0. In all cases, the differences occur at the second decimal point. Thus, it might be stated that, within the range of input values mentioned, the difference in the inputs does not have much effect on the subsequently estimated fishing mortality. This suggests that for the heavily exploited fish stock, if the fishing mortality or the exploitation ratio of the largest size group is not known or cannot be guessed, it is possible to start with any value of input and examine the results. The result will suggest the next input value of fishing mortality to be tried; and finally the reasonable input figure or range of input figures can be obtained.

It is worthwhile to examine the effects of the input natural mortality. In general, it is obvious that a high input for natural mortality will result in lower estimates for fishing mortality, although this does not have much effect on the estimated total mortality coefficient. The lower estimates for fishing mortality will result in an underestimate of the exploitation rate and hence an overestimate of

the population sizes. This occurrence of bias is similar to those described by Jones (1981). Thus, the difficulty is not the choice of the input fishing mortality but the reliability of the natural mortality coefficient to be employed as the input. In my opinion it is worthwhile to start with the unity M-K ratio for the tropical fish stocks in the Gulf of Thailand, and then try the vicinity values. It is also worthwhile to state here that the length frequency data or the mean length of the fish before the fishery started or for the early state of the fishery are important and necessary data that should be compiled. This simple information would provide a preliminary estimate of the natural mortality.

#### CONCLUSION

The method of catch curve analysis using the length frequency data by iterative technique is derived. This method is applied to the lizard fish (*Saurida elongata*) in the Gulf of Thailand. The natural mortality is assumed to be constant and equal to the growth coefficient; the natural mortality coefficients are 0.1179 per month for the male fish and 0.1071 per month for the female fish. The reasonable figure for the fishing mortality coefficient of the largest size groups used as the input is assumed to be 0.5 or the exploitation ratios of 0.8092 for the male and 0.8236 for the female.

The fishing mortality increases as the sizes of the fish increase. The relationships between the fishing mortality coefficients (F) and the size (l), expressed as the mid-point of the length class are highly significant and such functions are as follows:

$$F = 0.6527e^{-4.8132/(l-9.5)}$$

for the male fish and

$$F = 0.6826e^{-5.0334/(l-9.5)}$$

for the female fish;

where 9.5 is the length at which the fishing mortality is zero.

The highest possible fishing mortality is reached when the fish has attained its ultimate length. These ultimate coefficients of fishing mortality are estimated to be 0.5480 and 0.5896 for the male and female fish respectively. The corresponding total mortality coefficients are 0.6659 per month for the male and 0.6967 for the female fish. The average coefficients of the total mortality of the large fish, 16 centimetres in total length and longer, are estimated to be 0.5536 ( $\pm 0.0639$ ) for the male fish and 0.5774 ( $\pm 0.0494$ ) for the female fish.



In general, the survival rates decrease while the rates of exploitation increase as the sizes of the fish increase. These are caused by the increase with size of the fishing mortality and the time required for the fish to grow from the lower limit to the upper limit of the length class. But the effect of the former is more prominent.

The variations of the input fishing mortality do not have much effect on the subsequent estimates of fishing mortality. For various values of the inputs, the subsequent estimates of fishing mortality tend to converge at the lower size group. The convergence is more rapid when the inputs are high, say, 0.5 to 1.0.

A high input for natural mortality will result in lower estimates for the fishing mortality coefficients although this does not have much effect on the total mortality estimated. This, in turn, will cause underestimates of the rates of exploitation and hence overestimates of the population sizes.

Thus, it might be concluded that the difficulty in this derived method is not the choice of the input fishing mortality, but rather the selection of the reasonable input for natural mortality.

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REFERENCES

- BERTALANFFY, L. VON (1938). A quantitative theory of organic growth. *Human Biology*, 10(2):81-213.
- BOONWANICH, T. and S. AMORNCHAIROJKUL (1982). Length, Growth and Mortality of *Saurida elongata* in the Gulf of Thailand, 1979-1980. *Dept. of Fish., Demersal Fish. Publication* 12/1982, 13 p.
- GULLAND, J.A. (1965). Estimation of mortality rates. Annex to Arctic Fisheries Working Group Report (meeting in Hamburg, January 1965), ICES, C.M. 1965. Doc. No.3 (mimeograph).
- \_\_\_\_\_, (1980). Fish stock assessment. FAO/Wiley series on food and agriculture Vol. 1. A Wiley-Interscience publication. John Wiley and Sons. 224 p.
- JONES, R. (1981). The use of length composition data in fish stock assessments (with notes on VPA and cohort analysis). *FAO Fisheries Circular*, No. 734, 55 p.
- JONES, R. and N.P. van ZALINGE (1981). Estimates of mortality rate and population size for shrimp in Kuwait waters. *Kuwait Bulletin of Marine Science*, 2:273-288.
- MURPHY, G.I. (1965). A solution of the catch equation. *J. Fish. Res. Bd. Canada*, 22(1):191-202.
- \_\_\_\_\_, (1966). Population biology of the Pacific sardine (*Sardinops caerulea*) *Proc. California Acad. Sci. Ser. 4*, 34(1):1-84.
- POPE, J.G. (1972). An investigation of the accuracy of virtual population analysis using cohort analysis. *ICNAF Res. Bull.*, 9:65-74.
- RICKER, W.E. (1958). Handbook of computations for biological statistics of fish populations. *Fish. Res. Bd. Canada, Bull.*, 119, 300 p.
- SOMMANI, P. (1972). A study on the population dynamics of striped bass (*Morone saxatilis* Walbaum) in the San Francisco Bay estuary. Ph. D. thesis, University of Washington, 133 p.
- \_\_\_\_\_, (1983). An Assessment of the Multispecies Demersal Fisheries and Fish Stocks in the Southern Part of the Gulf of Thailand. *SEAFDEC Joint Research Paper (Thailand)*, No. 4, 30 p.



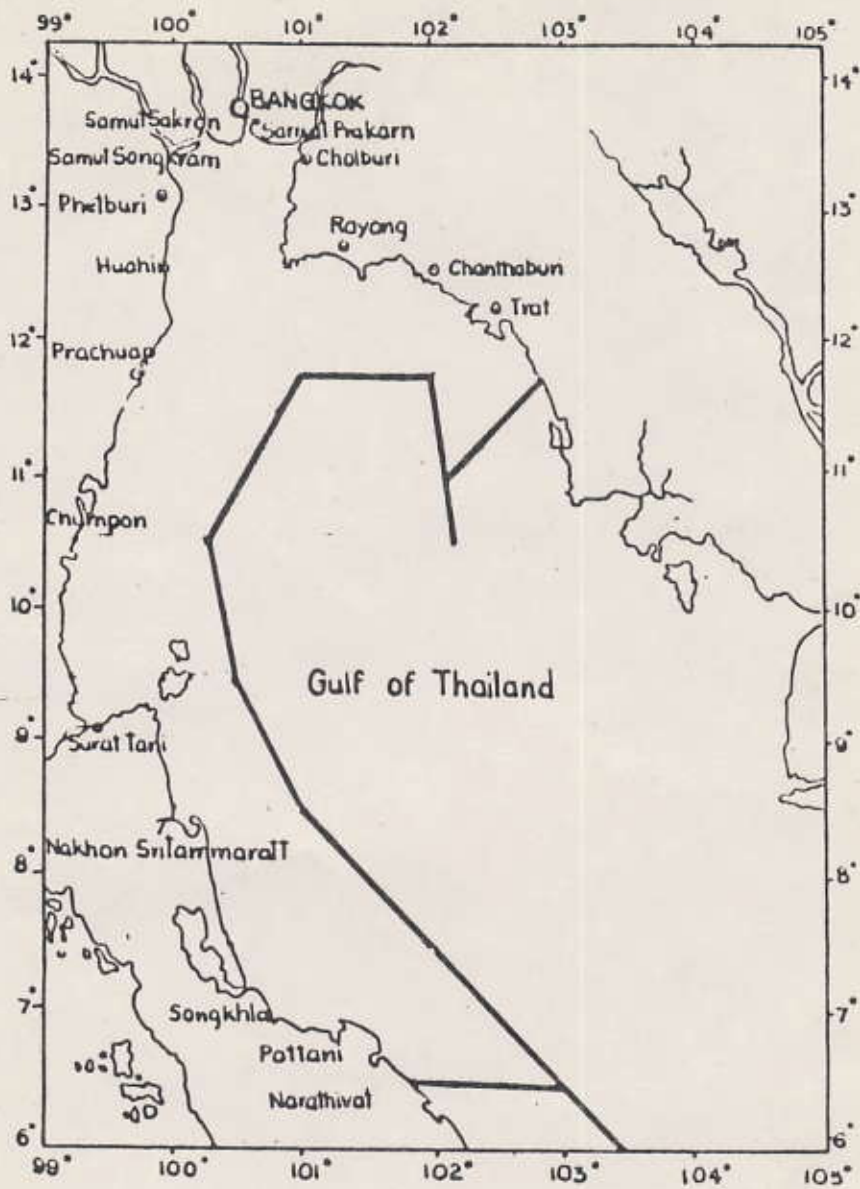


Figure 1. The Gulf of Thailand showing the study area

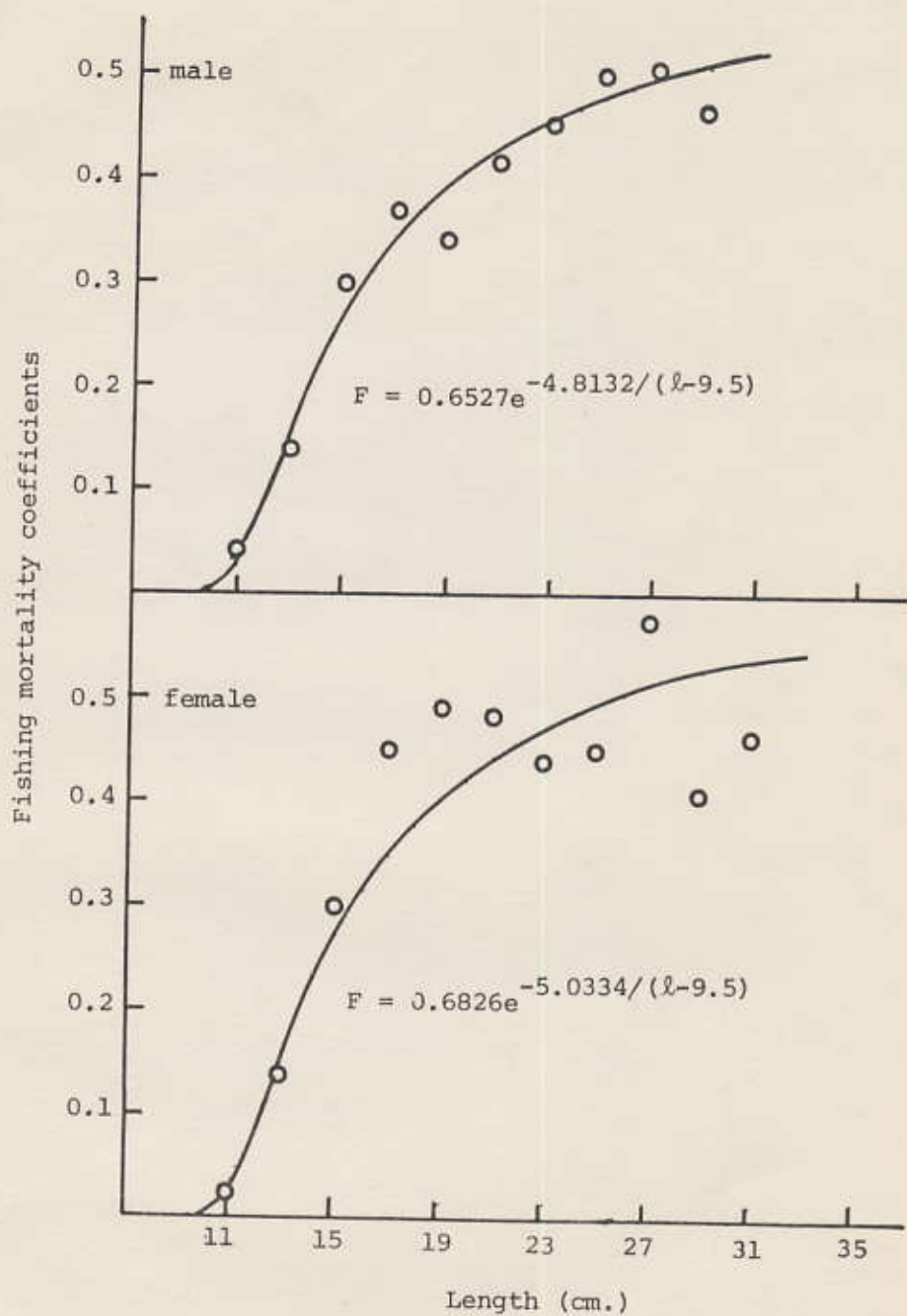


Figure 2. Relationships between the fishing mortality coefficients and the lengths of the lizard fish in the Gulf of Thailand

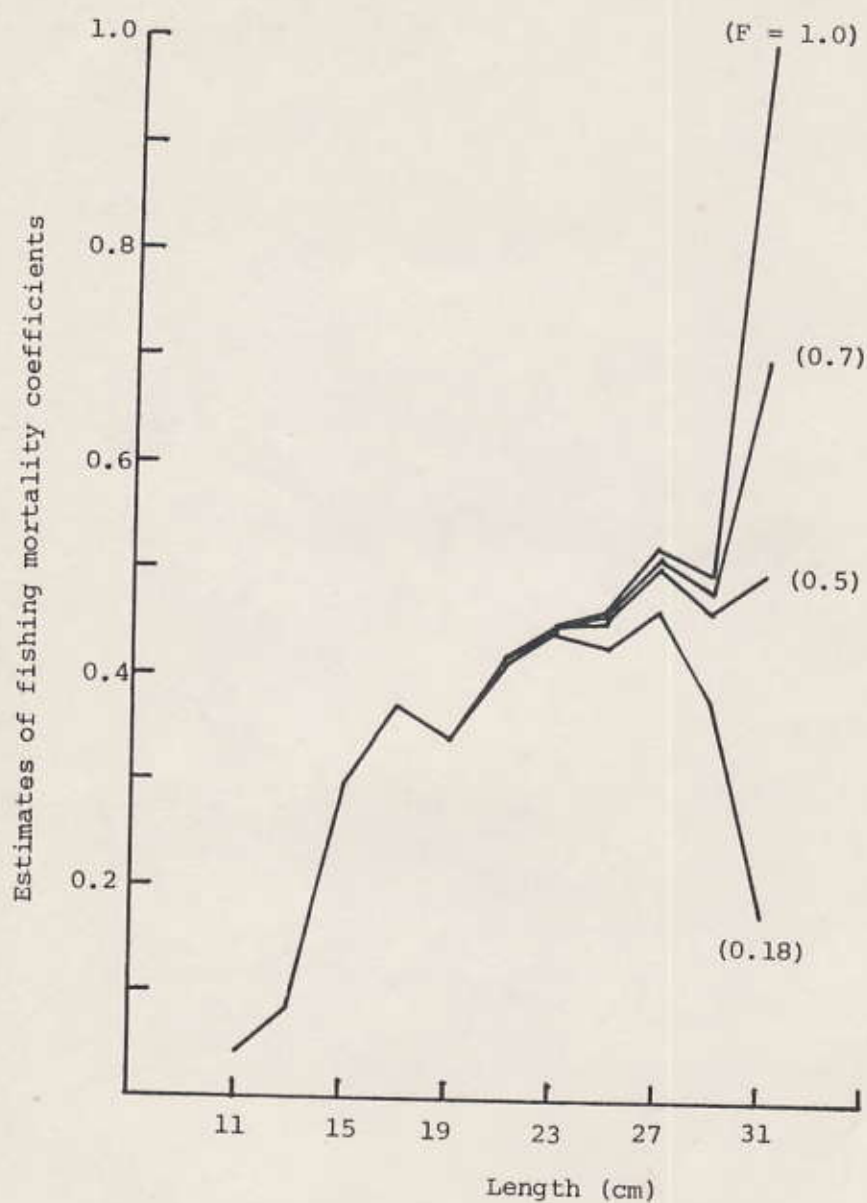


Figure 3. Effects of the input fishing mortality coefficients on the estimated fishing mortality coefficients. (The figures given within parenthesis are the input values.)

Table 1. Results of an analysis of the catch curve for male lizard fish (*Saurida elongata*) in the Gulf of Thailand, 1980. ( $L_{\infty} = 37.07$  cm,  $K = 0.1179/\text{month}$ ,  $M = K = 0.1179/\text{month}$ )

Length	Catch $C_i$	$X_i = \frac{L_{\infty} - L_{i+1}}{L_{\infty} - L_i}$	$\Delta t_i = -\frac{1}{K} \ln X_i$	$E_{i+1}/P_i$	$F_i^*$	$Z_i$	$S_i = e^{-Z_i \Delta t_i}$	$E_i = \frac{F_i}{Z_i} (1 - S_i)$	$N_i = C_i/E_i$
10-12	237	0.9261	0.6510	0.029403	0.0428	0.1607	0.9006	0.0265	8950
12-14	955	0.9202	0.7052	0.146872	0.1867	0.3042	0.8067	0.1185	8060
14-16	1247	0.9133	0.7692	0.269713	0.2976	0.4155	0.7265	0.1959	6502
16-18	1208	0.9051	0.8459	0.386019	0.3688	0.4867	0.6625	0.2557	4724
18-20	813	0.8951	0.9397	0.399577	0.3402	0.4581	0.6502	0.2598	3129
20-22	682	0.8828	1.0570	0.588557	0.4147	0.5326	0.5695	0.3352	2035
22-24	457	0.8673	1.2077	0.784590	0.4517	0.5696	0.5027	0.3944	1159
24-26	274	0.8470	1.4087	1.123510	0.5001	0.6180	0.4187	0.4704	583
26-28	129	0.8193	1.6901	1.520114	0.5067	0.6246	0.3480	0.5290	244
28-30	48	0.7795	2.1129	1.942062	0.4659	0.5838	0.2913	0.5656	85
30+	20	-	-	-	(0.5000)	(0.6179)	-	(0.8092)**	25

\* The figure within parenthesis is the input value

\*\*  $E = F/Z$