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"Users' Guide for the Program 'LCAN'
(Length Cohort Analysis) and an Overview of
the Underlying Analysis"
by

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Preface

This document is a guide to the use of the program LCAN for length cohort analysis and its related sensitivity analyses. The program is the result of the analyses presented in the Technical Report No. 2 from the CRSP, entitled: "Effect of Variability on Estimates of Cohort Parameters Using Length-Cohort Analysis: with a guide to its use and mis-use". The program does a length cohort analysis, estimating the various parameters expected. In addition, the program will analyze, for the particular data the user enters, the effects upon the estimated parameters: of different choices of length intervals; 2) of mis-estimation of the growth parameters L_∞ and K that the user must provide; and 3) of mis-estimation of the mortality-values that the user must also provide.

It is probably true that in a fishery where length cohort analysis is being done instead of age cohort analysis, knowledge of the above parameters may be especially vague. Thus, it is important to know the consequences for the cohort analysis of mis-estimation. Further, the choice of the optimal length interval for analysis, which is always a question, can now be objectively appraised.

The program, one example, and a brief theoretical treatment to motivate the program, are included. To obtain the source code of this program, please send a $5\frac{1}{4}$ inch MS-DOS diskette to

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Introduction

The purpose of this document is to provide guidance and operational procedures for users of the PROGRAM LCAN. LCAN is an acronym for a program that does a series of analyses associated with a length cohort analysis (LCA). The program will estimate cohort parameters and investigate the sensitivity of the estimated parameters subject to: (1) changing the size of the length interval; (2) variation in the von Bertalanffy growth parameters L_∞ and K; and (3) variability in natural and terminal fish mortality. The model is derived and developed in the ms, "*Effect of Variability on Estimates of Cohort Parameters Using Length-Cohort Analysis: with a guide to its use and mis-use* ," by Han-Lin Lai and Vincent F. Gallucci. (1987, USAID Stock Assessment CRSP Technical Report No. 1 and also submitted to Journal du Conseil). Appendix I summarizes the major equations used in a length cohort analyses for the PROGRAM LCAN.

This program has been written in FORTRAN 77 to run as a batch job on the Cyber. The program will be converted to VAX, IBM-PC and Macintosh in later released versions. The program is organized into four major subroutines:

1) basic LCA analysis (SUBROUTINE BASIC),
2) effect of changing size of length interval (SUBROUTINE LINTV),
3) uncertainty in L_∞ and K (SUBROUTINE UNCRT), and
4) errors in mortality (SUBROUTINE CMORT).

Each subroutine can be called independently through the command statement, with the required input parameters, which are also stored in the Command File (called CMDF in our example). The numbers 1) - 4) above refer to code numbers in the command file that identify the subroutine desired. Another file that must be calle is the input Data File (called DATF in our example) in which the length frequency data to be analyzed is stored.

The source code for the program is presented as Appendix II. We will supply the program in ASCII code on either tape or a floppy diskette ($5\frac{1}{4}$" MS-DOS) if the appropriate blank is sent to Vincent F. Gallucci at Management Assistance for Artisanal Fisheries (MAAF), Center for Quantitative Science, HR-20, University of Washington, Seattle, WA98195. The program is not as efficientas one would like: it is a product of a long term effort and has evolved under substantial modification and revision.

Data File (Input length frequency data)

A data file that can be called by LCAN must be constructed. Table 1 shows the example of length frequency data file input to the program. The data in our example are essentially the same as those used in Lai and Gallucci (1987). The length data must be grouped into a histogram prior to being entered into the data file. The data are entered as two columns of numbers in **free format**. The first column is the lower bound of the length interval (XL) and the second column is the catch (CL) by that length interval. In our example the length intervals begin with 10mm and go to 59mm, in 1mm intervals.

The length frequency data will be preserved throughout the job. The number of length intervals is automatically counted in the trogram. If a length interval has zero catch, zero should be entered.

Command File and Output

A command file that can be called LCAN must be constructed. This file, which consists of a series of commands and parameter values, is required so the user can select from the four different tasks described in the Introduction. Each of the four tasks can be run as an independent job. The second, third and fourth tasks will, however, call the first task automatically. In any of the four tasks the first character is a fixed point number from 1 to 4 which identifies the task. A string of up to 80 characters describing the nature of the analysis follows. In our example the parameter values refer to bivalve (Protothaca) parameters. Each project will choose the title of the task for itself, subject to the 80 character limit. The parameters following the first record are the input parameter values for LCA and the associated sensitivity analysis. The parameters are different according to the task, and will be described in the sections hereafter using the length frequency data in Table 1 as the example.

A. Basic LCA analysis

Table 2 shows the command file input to the program for task 1 (or subroutine BASIC). The program reads all input values in free format, except the first record (line). We proceed by examining the input structure and then a resulting output. Part B,C, and D will refer to the other tasks and will have a similar organization.

FIRST RECORD:

ICK = 1, code number to call SUBROUTINE BASIC.

ITLT: the string to describe the analysis. Up to 80 characters.

FORMAT (I1, 10A8).

SECOND RECORD:

XLMIN: The lower bound of the first length group.

XLMAX: The upper bound of the terminal length group.

DL: The size of length interval ($\Delta\ell$).

THIRD RECORD:

XLINF: L_∞ of the Von Bertalanffy model.

XK: K of the Von Bertalanffy model.

XM is the variable related to natural mortality, it must be the same as of the following values:

XM= Natural mortality if XK≠0,

XM= Natural mortality divided by the Von Bertalanffy growth parameter, K, otherwise.

Remember that XL and C were defined in the Data file section. If XL(ℓ) + DL ≥ XLINF for any ℓ value, the program trucates the the list of length groups so that XL + DL < XLINF by calling SUBROUTINE TRUNK.

In our example, we give numerical values for K, M, and F(λ) which we presume we know.

FOURTH RECORD:

FL: The fishing mortality of the terminal length group

ZL: The total mortality of the terminal length group

EL = $^{FL}/_{ZL}$, the exploitation rate (Jones 1984)

Note that if XM≠0 and FL≠0, ZL is not needed (i.e., can be enterd as 0) since the program computes ZL = XM + FL. If either XM=0 or FL=0, then FL and ZL must be given, i.e., ZL cannot be entered as 0. If both FL=0 and ZL=0, then EL must be give; otherwise, the program will calculate EL automatically.

OUTPUT:

Table 3 shows the output of the analysis for the input data and parameters. The input values of L_∞, K, M, M/K, F(λ) and E(λ) are listed first. Note that these parameter names are from the analysis and not the computer code. The relationship is, however, easy to see. Next, the estimates for each length group are tabulated in columns.

<u>Column</u> <u>Description</u>

(i) lower and upper bounds of length interval

(ii) $\Delta t(\ell)=\frac{\ln(A(\ell))}{K} = (\frac{1}{K}) \ln (\frac{L_\infty-\ell}{L_\infty-(\ell+\Delta\ell)})$, is the time in years required to grow from the lower to upper bond of each length interval.

(iii) input number of catch, C, from Table 1.

(iv) $N(\ell)$, the number attaining the length ℓ.

(v) Mean Number. This is defined by Jones (1979, 1984) as the standing crop of individuals in the stock at any time for each length group ℓ.

(vi) $F\Delta t(\ell)$ is the fishing mortality of fish from length ℓ to $\ell+\Delta\ell$. (see Appendix I for computation)

(vii) $Z\Delta t(\ell)$ is the total fishing mortality of fish from length ℓ to $\ell+\Delta\ell$ (see Appendix I for computation)

(viii) $\frac{F(\ell)}{Z(\ell)} = E(\ell)$ is defined by Jones as the exploitation rate for length group ℓ.

(ix) $Z(\ell)$ is the annual total mortality rate for length group ℓ.

B. Effect of Changing the Size of the Length Interval

This task calls SUBROUTINE LINTV, which allows the user to evaluate the effects on parameter values when different length interval and used to construct a histogram of length frequency of occurence in the catch. Within this subroutine, the SUBROUTINE BASIC is called twice, one for the reference $\Delta\ell$, which is the original input histogam, and one for the revised $\Delta\ell'$, which is the new grouping you wish to try. For the revised $\Delta\ell'$, the SUBROUTINE REGRP is called to regroup length frequency histogram. See the note below for limitations on how to use the routine. Table 4 shows the command file required for this task if $\Delta\ell$ = 1mm, $\Delta\ell'$= 3mm. All input values are in free format, except the first record.

Note: Subroutine REGRP allows you to change the $\Delta\ell$ in the history in a prearranged way. Any $\Delta\ell$ may be chosen but you can get the $\Delta\ell$ in only a limited number of ways. For example, if $\Delta\ell$ = 1, $\Delta\ell'$= 2 follows from doubling $\Delta\ell$, a tripling of $\Delta\ell$ allows $\Delta\ell'$= 3,

a quadrupling gives $\Delta\ell = 4$, etc. You may nopt however get $\Delta\ell' = 4$ be going from $\Delta\ell = 3$ and adding one. You start over from $\Delta\ell = 1$ and choose $\Delta\ell' = 4$.

FIRST RECORD:

ICK = 2, code number to call subroutine LINTV.

ITLT: Description of the analysis (≤ 80 characters)

FORMAT (II, 10A8)

SECOND, THIRD, and FOURTH RECORDS:

Same as Basic LCA analysis. The records consist of the values of XLMIN, XLMAX, DL, XLINF, XK, XM, FL, ZL, and EL for the reference $\Delta\ell$

FIFTH RECORD:

DL: reference $\Delta\ell$

YDL: revised $\Delta\ell'$

SIXTH RECORD to EIGHTH RECORD:

Same as the Basic LCA analysis. Records consist of the values of XLMIN, XLMAX, DL, XLINF, XK, XM, FL, ZL, and EL for revised $\Delta\ell'$.

The output of this analysis has three parts. Table 5 shows only the second and third outputs, since the first part of the output is the same as Table 3 and has been omitted.

SECOND OUTPUT:

The results are based on the revised $\Delta\ell'$ (=3mm) and are tabulated in Table 5-1 in the same format as in Table 3. This output is also produced by SUBROUTINE BASIC, but the size of length interval has been changed to 3mm.

THIRD OUTPUT (see note below):

Table 5-2 shows the consequences of the change in $\Delta\ell$; in other words, the sensitivity of the estimates to changes in $\Delta\ell$. Parameters / values are estimated for each length group, $\Delta\ell'$ (in this case, 3mm). In addition the value for the original (or reference) $\Delta\ell$ that corresponds to the beginning of the revised interval is also given. For example: when $\Delta\ell'$ has values for 11-14 and 14-17 under the column "GROUP N", shows the same parameter's value for 11 and 14mm when computed under $\Delta\ell = 1$.

Column	Description
(i)	lower and upper bounds of revised length group,
(ii)	$N'(\ell)$: number of fish attaining length ℓ, using (revised) $\Delta\ell'$
(iii)	$N(\ell)$: number of fish attaining low bound of revised length interval using reference $\Delta\ell$.
(iv)	$\rho[N(\ell)]$: relative error ratio (see Appendix I for computation).
(v)	$F'(\ell)$: fishing mortality within length interval $(\ell, \ell+\Delta\ell')$
(vi)	$F(\ell)$: summation of fishing mortalities over intervals $(\ell, \ell+\Delta\ell)$, $(\ell+\Delta\ell, \ell+2\Delta\ell)$, and $(\ell+2\Delta\ell, \ell+3\Delta\ell)$.
(vii)	$\rho[F\Delta t'(\ell)]$: relative error ratio (see Appendix I for computation).

Note: The table of output is computed from bottom to top, in a LCA, starting from the biggest length and moving to low lengths by $\Delta\ell$ and $\Delta\ell'$. Therefore, the first line or lowest length may not be of a size that corresponds to the size interval under analysis.

C. Uncertainty in L_∞ and K

For this analysis, the variance and covariance of L_∞ and K are required. Table 6 shows the contents of the command file to call SUBROUTINE UNCRT.

FIRST RECORD:

ICK = 3, code number to call SUBROUTINE UNCRT.

ITLT: description of the analysis (≤ 80 characters)

FORMAT (II, 10A8)

SECOND AND THIRD RECORDS:

Consist values of XLMIN, XLMAX, DL, XLINF, XK, and XM. See Section A for detail description. Free format input.

FOURTH RECORD:

VL: Variance of L_∞

VK: Variance of K

VLK: Covariance of L_∞ and K

Free format input.

FIFTH RECORD:

Consist values of FL, ZL, and EL. Free format input. See Section A for a detailed description of these parameters.

The output of this subroutine includes three tables. The first part, which is produced by SUBROUTINE BASIC, is the same as Table 3. The other two tables are shown in Table 7.

FIRST OUTPUT:

The results of basic LCA analysis, same as Table 3. Thus, omitted from Table 7.

SECOND OUTPUT:

List stock size and fishing mortality and their variance and coefficient of variation (c.v.) for each length group. (Table 7-1)

Column	Description
(i)	lower and upper bounds of length interval,
(ii)	$C(\ell)$: catch at length group ℓ. (input from data file)
(iii)	$N(\ell)$: stock size at length group ℓ. (predicted)
(iv)	$V[N(\ell)]$: variance of stock size (see Appendix I for computation)
(v)	$CV[N(\ell)]$: coefficient of variation (C.V.) of stock size (see Appendix I for computation)
(vi)	$F(\ell) \cdot \Delta t(\ell)$: fishing mortality at length group ℓ.
(vii)	$V[F(\ell)\ \Delta t(\ell)]$: variance of fishing mortality (see Appendix I for computation)
(viii)	$CV[F(\ell)\Delta t(\ell)]$: coefficient of variation (C.V.) of fishing mortality (see Appendix I for computation)

THIRD OUTPUT:

List the values of $\frac{\partial N(\ell)}{\partial L\infty}$, $\frac{\partial N(\ell)}{\partial K}$, and $\frac{\partial^2 N(\ell)}{\partial L\infty \partial K}$ (see Appendix I for computation) for each length group. (Table 7-2).

D. Errors in Mortalities

In this analysis, we assume that true natural mortality M and F(λ) are 0.1 and 0.01 respectively as shown in Table 2. We give two examples: Example (1) natural mortality is wrongly guessed as 0.2, and Example (2) F(λ) is wrongly guessed as 0.2. In fact, these two examples can be run as two independent jobs, but here we illustrate how to construct a command file to carry out a multiple-task batch job. Table 8 shows the structure of the multiple-task command file.

FIRST RECORD:

ICK = 4, code number to call SUBROUTINE CMORT

ITLT: description of the analusis (up to 80 characters)

FORMAT (I1, 10I8)

SECOND, THIRD, and FOURTH RECORDS:

Consists of values of XLMIN, XLMAX, DL, XLINF, XF, XM, FL, ZL, and EL for true natural mortality (XM). See Section A for a detailed description.

FIFTH RECORD:

Same as the SECOND RECORD.

SIXTH RECORD:

Same as the THIRD RECORD, except for wrongly guessed XM.

SEVENTH RECORD:

Same as the FOURTH RECORD. The previous records are the command and input parameter values for our example 1. For example 2, we need:

EIGHTH RECORD (begins Example 2):

Same as FIRST RECORD.

NINTH, TENTH, and ELEVENTH RECORD

Same as SECOND to FOURTH RECORDS, but this time for true $F(\lambda)$.

TWELVETH RECORD:

Same as the SECOND RECORD.

THIRTEENTH RECORD:

Same as the THIRD RECORD.

FOURTEENTH RECORD:

Same as the FOURTH RECORD, except for wrongly guessd $F(\lambda)$.

OUTPUT:

The outputs of the two examples are in the same format. Each example's output has three parts. The first part of each example is produced by SUBROUTINE BASIC and is exactly the same as Table 3. Therefore, this output is omitted in our listing. For the first example, using a wrongly guessed natural mortality, the output is listed in Table 9.

FIRST OUTPUT:

Same as Table 3. List the results for true natural mortality.

SECOND OUTPUT:

Table 9-1 Shows the results of a wrongly guessed natural mortality in the same format as Table 3.

THIRD OUTPUT:

Table 9-2 shows the main results for using true vs. wrongly guessed natural mortality. For each length group, the following are tabulated.

(i) lower and upper bounds of length interval,

(ii) $N'(\ell)$: stock size estimated from wrongly guessed natural mortality

(iii) $N(\ell)$: stock size extimated from true natural mortality

(iv) $\rho[N(\ell)]$: relative error ratio (see Appendix I for computation)

(v) $F'(\ell)\Delta t(\ell)$: fishing mortality estimated from wrongly guessed natural mortality

(vi) $F(\ell)\Delta t(\ell)$: fishing mortality estimated from true natural mortality

(vii) $\rho[F(\ell)\Delta t(\ell)]$: relative error ratio (see Appendix I for computation)

For Example 2, using wrongly guessed F(λ), the outputs have the same format as in Example 1. Table 10 shows the tables of output. Again, we omit the FOURTH OUTPUT because it is produced by SUBROUTINE BASIC for true F(λ) and is exactly the same as Table 3.

FIFTH OUTPUT:

Shows the results for a wrongly guessed F(λ) in the same format as Table 3 (Table 9-3).

SIX OUTPUT:

Table 9-4 is the output for a wrongly guessed F(λ). This table is similar to Table 9-2.

A NOTE TO VAX USERS

The following are required to ran LCAN on VAX system.

(1) Delete all control statements listed in Appendix II.

(2) Delete the line contains program name.

(3) To run the program, enter the command lines:

$FORTRAN LCAN	compile and produce LCAN.OBJ
$LINK LCAN	link LCAN.OBJ and produce LCAN.EXE
$ASSIGN CMDF.DAT FORØØ1	direct program to get input from CMDF.DAT throng logic unit 1
$ASSIGN DATF.DAT FOR002	direct rogram to get input from CMDF.DAT through logic unit 2
$ASSIGN outname.DAT FOROO6	direct program to output result into file outname.DAT using logic unit 6.
$RUN LCAN	
$PRINT outname.DAT	print the result.(no program listing)

If you need a program listing with compilation diagnosis, enter

$FORTRAN/LIST/CHECK LCAN

After finishing the job, do not forget to enter

$DEASSIGN FOR001

$DEASSIGN FOR002

$DEASSIGN FOR006

Otherwise, you will mess up all sessions after this job.

Appendix I
Overiview of a LCA Analysis

The canonical formula for LCA is

$$N(\ell) = N(\ell+\Delta\ell)\, A(\ell)^{M/K} + C(\ell)\, A(\ell)^{M/2K}$$

where ℓ is the lower bound of the length interval,

$\Delta\ell$ is the size of the length interval,

$N(\ell)$ is the number of individuals attaining length ℓ,

$C(\ell)$ is the size of the catch assumed to be taken in the middle of the length interval $(\ell, \ell+\Delta\ell)$,

M is the natural mortality and assumed known

$$A(\ell) = \frac{L_\infty - \ell}{L_\infty - (\ell+\Delta\ell)}$$

L_∞ and K are the parameters of von Bertalauffy growth model.

LCA is a stepwise backward calculation starting at the terminal length group (λ). $N(\lambda)$ is calculated by

$$N(\lambda) = C(\lambda)/E(\lambda)$$

where $E(\lambda) = F(\lambda)/Z(\lambda)$. The total mortality in length ℓ to $\ell+\Delta\ell$ is calculated by

$$Z(\ell)\Delta t(\ell) = -\ln\left(\frac{N(\ell)}{N(\ell+\Delta\ell)}\right)$$

and the fishing mortality

$$F(\ell)\,\Delta t(\ell) = Z(\ell)\Delta t(\ell) - M$$

To compute relative error ratios for $N(\ell)$ and $F(\ell)\Delta t(\ell)$ for the effect of changing size of length interval the following equations are used.

$$\rho[N(\ell)] = \Delta N(\ell)/ N(\ell)$$

$$= \rho[N(\ell+n\Delta\ell)] \prod_{i=0}^{n-1} A(\ell+i\Delta\ell) - \frac{F(\ell+i\Delta\ell)}{K}$$

$$+ \frac{1}{N(\ell)} \sum_{i=0}^{n-1} C(\ell+i\Delta\ell) \left\{ \alpha(\ell)^{M/2K} - \beta(\ell+i\Delta\ell)^{M/2K} \right\}$$

$$\rho[F\Delta t'(\ell)] = \frac{\ln\left(\frac{1+\rho[N(\ell+\Delta\ell)]}{1+\rho[N(\ell)]}\right)}{\sum_{i=0}^{n-1} F(\ell+i\Delta\ell)\Delta t(\ell+i\Delta\ell)}$$

where, $\alpha(\ell) = \prod_{i=0}^{n-1} A(\ell+i\Delta\ell)$,

$$\beta(\ell+i\Delta\ell) = \frac{(L_\infty-\ell)^2}{\{L_\infty-(\ell+i\Delta\ell)\}\{L_\infty-[\ell+(i+1)\Delta\ell]\}}$$

Using the following equation to compute variance of $N(\ell)$ and $F(\ell)\Delta t(\ell)$:

$$V[N(\ell)] = \{N(\ell)\emptyset_{L_\infty} + \sum_{i=0}^{n-1} C(\ell+i\Delta\ell)\theta_{L_\infty}\}^2 V(L_\infty)$$

$$+ \{N(\ell)\emptyset_K + \sum_{i=0}^{n-1} C(\ell+i\Delta\ell)\theta_K\}^2 V(K)$$

$$+ 2\{N(\ell)\emptyset_{L_\infty K} + \sum_{i=0}^{n-1} C(\ell+i\Delta\ell)\theta_{L_\infty K}\} COV(L_\infty,K)$$

and

$$V[F(\ell)\Delta t(\ell)] = V[\ln N(\ell)] + V[\ln N(\ell+\Delta\ell)] + \left(\frac{\partial H(\ell)}{\partial L_\infty}\Big|_{L_\infty}\right)^2 V(L_\infty)$$

$$+\left(\frac{\partial H(\ell)}{\partial K}\Big|_K\right)^2 V(K) + 2\left(\frac{\partial^2 H(\ell)}{\partial L_\infty \partial K}\Big|_{L_\infty K}\right) COV(L_\infty,K)$$

where $H(\ell) = \frac{M}{K}\ln A(\ell)$

Using the following equations to compute the relative error ratios for $N(\ell)$ and $F(\ell)$ $\Delta t(\ell)$ for the wrongly guessed $F(\lambda)$ and M.

$$\rho[N(\lambda)] = \frac{1+\rho[Z(\lambda)]}{1+\rho[F(\lambda)]} - 1$$

$$\rho[N(i)] = \rho[N(\lambda)]\ \alpha(\ell)^{\Delta M/K} \prod_{i=1}^{n} [a] + \sum_{j=0}^{i} [b][c][d]$$

where, $n = (\lambda - \ell)/\Delta\ell$

$$[a] = A(\ell + i\Delta\ell)^{-F(\ell+i\Delta\ell)/K}$$

$$[b] = A(\ell + i\Delta\ell)^{\Delta M/2K} - 1$$

$$[c] = 1 + A(\ell + (i-1)\Delta\ell)^{(-2F(\ell+(i-1)\Delta\ell)+\Delta M)/2K}$$

$$[d] = \prod_{j=0}^{i} A(\ell + j\Delta\ell)^{(-F(\ell+j\Delta\ell)+\Delta M)/K}$$

and

$$\rho[F(\ell)\Delta t(\ell)] = \frac{1}{F(\ell)\Delta t(\ell)} \ln\left(\frac{1+\rho[N(\ell+\Delta\ell)]}{1+\rho[N(\ell)]}\right) - \frac{\Delta M}{F(\ell)}$$

```
/JOB
LCA.
/ACCOUNT
FTN5,L=0.
MAP=OFF.
GET,NORTH.
GET,CMD4.
LGO,CMD4,NORTH.
/EOR
      PROGRAM MAIN (TAPE1,TAPE2,OUTPUT,TAPE6=OUTPUT)
      CHARACTER*8 ITLT
      DIMENSION XL(100),C(100)
      DIMENSION ITLT(10)
      DIMENSION XN(100),F(100),Z(100)
      DIMENSION DT(100)
      DATA XL/100*0./,C/100*0./
      I=0
100   I=I+1
      READ(2,*,END=101)XL(I),C(I)
      GO TO 100
101   NL=I-1
200   READ(1,1,END=999)ICK,(ITLT(K),K=1,10)
1     FORMAT(I1,10A8)
      IF(ICK.LE.0 .OR. ICK.GE.5)GO TO 1000
      GO TO (201,202,203,204)ICK
1000  WRITE(6,2)
      GO TO 999
201   CALL BASIC(XLMIN,XLMAX,DL,DT,XLINF,XK,VL,VK,VLK,XM,
     >           FL,ZL,EL,XL,C,NL,ITLT,XN,F,Z,ICK)
      GO TO 200
202   CALL LINTV(XL,C,NL,ICK,ITLT)
      GO TO 200
203   CALL UNCRT(XL,C,NL,ICK,ITLT)
      NCALL=7
      GO TO 200
204   CALL CMORT(XL,C,NL,ICK,ITLT)
      NCALL=NCALL+1
      GO TO 200
999   IF(ICK.EQ.1)STOP
2     FORMAT(//'***NO SUCH OPTION***'/' LIST OF OPTIONS'/
     >         ' 1: BASIC ANALYSIS'/
     >         ' 2: EFFECT OF CHANGING LENGTH INTERVAL'/
     >         ' 3: UNCERTAINTY OF LINF AND K'/
     >         ' 4: ERRORS IN MORTALITIES')
      END

      SUBROUTINE BASIC(XLMIN,XLMAX,DL,DT,XLINF,XK,VL,VK,VLK,XM,
     >           FL,ZL,EL,XL,C,NL,ITLT,XN,F,Z,ICK)
```

```
      CHARACTER*8 ITLT
      DIMENSION E(100),F(100),Z(100),ZT(100),DT(100)
      DIMENSION XN(100)
      DIMENSION XL(100), C(100)
      DIMENSION ITLT(10)

C...........INPUT XLMIN, XLMAX, DL......................
      READ(1,*)XLMIN,XLMAX,DL
      IF(XLMIN.GT.XL(1)) XLMIN=XL(1)
      IF(XLMAX.LT.XL(NL)) XLMAX=XL(NL)
      IF(ICK.NE.999) XL(NL+1)=XL(NL)+DL

C...........INPUT XLINF, XK, XM, AND VARIANCE OF L-INF AND K IF REQUIRED......
      READ(1,*)XLINF,XK,XM
      IF(XK .EQ. 0.)XMK=XM
      IF(XK .NE. 0.)XMK=XM/XK
      IF(ICK.EQ.3)READ(1,*)VL,VK,VLK

C...........INPUT TERMINATE F, Z........................
      READ(1,*)FL,ZL,EL
      IF(FL.EQ.0.  .OR.  XM.EQ.0.)GO TO 125
      ZL=XM+FL

125   IF(XL(NL).GT.XLINF)CALL TRUNK(XLINF,XLMAX,DL,XL,C,NL)
      F(NL)=FL
      Z(NL)=ZL
      EL=FL/ZL
      E(NL)=EL


      CALL CHTL(XLMIN,XLMAX,DL,XLINF,XK,XM,XMK,E,XN,F,Z,DT,ZT,
     >          SUMN,XL,C,NL)
      WRITE(6,1)(ITLT(K),K=1,10)
1     FORMAT('1',2X,10A8//)
      WRITE(6,*)' LINF = ',XLINF,' K   = ',XK
      WRITE(6,*)' M    = ',XM,'   M/K = ',XMK
      WRITE(6,*)' FT   = ',FL,'   F/Z = ',EL
      WRITE(6,2)
2     FORMAT(/4X,' LENGTH ',6X,'DT',2X,'CATCH',1X,'STOCK SIZE',
     >        3X,'NO(DL/2)',4X,'F(L)',4X,'Z(L)',5X,'F/Z',
     >        7X,'Z'/96('='))
      YL1=XLMIN
      SUM=0.
      DO 50 I=1,NL
      IF(I.EQ.NL)GO TO 51
      XNM=(XN(I)-XN(I+1))/ZT(I)
      SUM=SUM+XNM
51    WRITE(6,3)XL(I),XL(I+1),DT(I),C(I),XN(I),XNM,F(I),Z(I),
```

```
     >          E(I),ZT(I)
3     FORMAT(F6.1,'-',F5.1,F8.4,F7.0,2F11.2,4F8.5)
50    CONTINUE
      WRITE(6,4)SUMN,SUM
4     FORMAT(96('=')/'  SUM',27X,2F16.2)
      RETURN
      END

      SUBROUTINE CHTL(XLMIN,XLMAX,DL,XLINF,XK,XM,XMK,E,XN,F,Z,DT,ZT,
     >                SUMN,XL,C,NL)
      DIMENSION XL(100),C(100)
      DIMENSION F(100),Z(100),E(100),XN(100),ZT(100),DT(100)
C
C...........CALCULATE N(NL)......................................
      XN(NL)=C(NL)/E(NL)
      SUMN=XN(NL)
C
C...........BACKWARD PROCESS OF LCA..............................
      KK=NL-1
      DO 50 L=1,KK
      I=KK-L+1
      AL=(XLINF-XL(I))/(XLINF-XL(I+1))
      XMOR=AL**(0.5*XMK)
      XN(I)=(XN(I+1)*XMOR+C(I))*XMOR
      SUMN=SUMN+XN(I)
      K=I+1
      SURV=XN(K)/XN(I)
      Z(I)=-ALOG(SURV)
      DN=XN(I)-XN(K)
      E(I)=C(I)/DN
      F(I)=E(I)*Z(I)
      IF(XK.EQ.0.)GO TO 50
      DT(I)=ALOG(AL)/XK
      ZT(I)=Z(I)/DT(I)
50    CONTINUE
      RETURN
      END

      SUBROUTINE TRUNK(XLINF,XLMAX,DL,XL,C,NL)
      DIMENSION XL(100),C(100)
      DO 10 I=1,NL
      J=NL-I+1
      XXL=XL(J)+DL
      IF(XXL .LT. XLINF)GO TO 11
      J1=J-1
      C(J1)=C(J1)+C(J)
10    CONTINUE
11    NL=J1
```

```
      XLMAX=XL(NL)
      RETURN
      END

      SUBROUTINE UNCRT(XL,C,NL,ICK,ITLT)
      CHARACTER*8 ITLT
      DIMENSION VN(100),VNR(100),VF(100),VFR(100)
      DIMENSION XL(100),C(100)
      DIMENSION ITLT(10)
      DIMENSION DT(100)
      DIMENSION XN(100),F(100),Z(100)
      DIMENSION PHL(100),PHK(100),PHLK(100)
      DIMENSION RAML(100),RAMK(100),RAMLK(100)
      DIMENSION SUML(100),SUMK(100),SUMLK(100)
      DIMENSION DNL(100),DNK(100),DNLK(100)
      DATA VN/100*0./,VF/100*0./
      DATA VNR/100*0./,VFR/100*0./
      CALL BASIC(XLMIN,XLMAX,DL,DT,XLINF,XK,VL,VK,VLK,XM,
     >           FL,ZL,EL,XL,C,NL,ITLT,XN,F,Z,ICK)
      XMK=XM/XK
      HMK=0.5*XMK
      XB=XLINF-XL(NL+1)
      KK=NL-1
      DO 50 I=1,KK
      J=KK-I+1
      XA=XLINF-XL(J)
      SUML(J)=0.
      SUMK(J)=0.
      SUMLK(J)=0.
      ALP=XA/XB
      ALPMK=ALP**XMK
      PHL(J)=XMK*ALPMK*(1./XA-1./XB)
      PHK(J)=(-XMK/XK)*ALPMK*ALOG(ALP)
      PHLK(J)=PHL(J)*(PHK(J)/ALPMK-1./XK)
      XC=XLINF-XL(J+1)
      CON=1./XA-1./XC
      RAML(J)=XMK*CON
      RAMK(J)=(-XMK/XK)*ALOG(XA/XC)
      RAMLK(J)=-RAML(J)/XK
      DO 51 K=J,NL
      XD=XLINF-XL(K)
      XE=XLINF-XL(K+1)
      BETA=(XA*XA)/(XD*XE)
      BETAMK=BETA**HMK
      XY=(2.*XD+DL)/(XD*XE)
      THL=HMK*BETAMK*(1./XA-XY)
      THK=(-HMK/XK)*BETAMK*ALOG(BETA)
      THLK=THL*(THK/BETAMK-1./XK)
```

```
      SUML(J)=SUML(J)+C(K)*THL
      SUMK(J)=SUMK(J)+C(K)*THK
      SUMLK(J)=SUMLK(J)+C(K)*THLK
51    CONTINUE
      DNL(J)=XN(NL)*PHL(J)+SUML(J)
      DNK(J)=XN(NL)*PHK(J)+SUMK(J)
      DNLK(J)=XN(NL)*PHLK(J)+SUMLK(J)
      VNL=DNL(J)*DNL(J)*VL
      VNK=DNK(J)*DNK(J)*VK
      VNLK=2.*DNLK(J)*VLK
      VN(J)=VNL+VNK+VNLK
      VNR(J)=VN(J)/XN(J)
      Z1=VNR(J)/XN(J)
      Z2=VNR(J+1)/XN(J+1)
      Z3=RAML(J)*RAML(J)*VL
      Z4=RAMK(J)*RAMK(J)*VK
      Z5=2.0*RAMLK(J)*VLK/XK
      VF(J)=Z1+Z2+Z3+Z4+Z5
      VFR(J)=VF(J)/F(J)
50    CONTINUE

C

      WRITE(6,1)(ITLT(I),I=1,10),XLINF,XK,VL,VK,VLK
1     FORMAT('1',2X,10A8/
     >        20X,'LINF',9X,'K',5X,'COVAR'/
     >        'XPARAMETER:',3X,2F10.4/
     >        'XVARIANCE :',3X,3F10.4/
     >       4X,'LENGTH',11X,'CATCH',9X,'NUMBER',9X,'VAR(N)',
     >       7X,'CV[N(L)]',14X,'F',9X,'VAR(F)',7X,'CV[F(I)]'/
     >       116('='))

      DO 52 I=1,NL
      CVN=SQRT(VN(I))/XN(I)
      CVF=SQRT(VF(I))/F(I)
      WRITE(6,2)XL(I),XL(I+1),C(I),XN(I),VN(I),CVN,
     >          F(I),VF(I),CVF
2     FORMAT(F5.1,'-',F5.1,7(1X,E14.5))
52    CONTINUE
      WRITE(6,3)
3     FORMAT(116('=')//5X,'C.V. NOT IN %')

C

      WRITE(6,5)
5     FORMAT(1H1,' DERIVATIVES OF N(L) RESPECT TO L-INF AND K'/
     >       4X,'LENGTH',12X,'DN/DL',
     >       12X,'DN/DK',
```

```
     >       11X,'DN/DLDK')
      WRITE(6,6)
6     FORMAT(62('='))

      DO 53 I=1,NL
      WRITE(6,4)XL(I),XL(I+1),DNL(I),DNK(I),DNLK(I)
53    CONTINUE

4     FORMAT(F5.1,'-',F5.1,3(5X,E12.5))
      WRITE(6,6)
      RETURN
      END

      SUBROUTINE LINTV (XL,C,NL,ICK,ITLT)
      CHARACTER*8 ITLT
      DIMENSION RHON(100),RHOF(100)
      DIMENSION YL(100),YC(100),XN(100),F(100),YN(100),YF(100)
      DIMENSION XL(100),C(100)
      DIMENSION ITLT(10)
      DIMENSION DT(100),YDT(100),Z(100),YZ(100)
      DIMENSION SF(100),XYN(100)

      CALL BASIC(XLMIN,XLMAX,DL,DT,XLINF,XK,VL,VK,VLK,XM,
     >           FL,ZL,EL,XL,C,NL,ITLT,XN,F,Z,ICK)
      CALL REGRP(XL,C,NL,YL,YC,NG,DL,YDL,XLMIN,XLMAX)
      ICK1=999
      CALL BASIC(YLMIN,YLMAX,YDL,YDT,XLINF,XK,VL,VK,VLK,XM,
     >           YFL,YZL,YEL,YL,YC,NG,ITLT,YN,YF,YZ,ICK1)

      XMK=XM/XK
      HMK=XMK/2.
      NP=YDL/DL
      RHON(NG)=(YN(NG)-XN(NL))/XN(NL)
      XYN(NG)=XN(FL)
      SF(NG)=YFL
      KP=NL
      KK=NG-1

      DO 100 I=1,KK
      J=KK-I+1
      XA=XLINF-YL(J)
      XB=XLINF-YL(J+1)
      ALP=XA/XB
      ALPMK=ALP**(HMK)

      SF(J)=0.
      ZZ=0.
      SUM=0.
```

```
      DO 101 K=1,NP
      KP=KP-1
      IF(KP.GT.0)GO TO 120
      KP=1
      GO TO 103
120   SF(J)=SF(J)+F(KP)
      XC=XLINF-XL(KP)
      XD=XLINF-XL(KP+1)
      BETA=(XA*XA)/(XC*XD)
      BLMK=BETA**(HMK)
      DIF=ALPMK-BLMK
      SUM=SUM+C(KP)*DIF
101   CONTINUE

103   XYN(J)=XN(KP)
      AFK=EXP(-SF(J))
      A=RHON(J+1)*AFK
      B=SUM/XYN(J)
      RHON(J)=A+B
      RHOF(J)=ALOG((1.+RHON(J))/(1.+RHON(J+1)))
      RHOF(J)=RHOF(J)/SF(J)
100   CONTINUE

      WRITE(6,1)(ITLT(I),I=1,10)
      DO 102 I=1,NG
123   WRITE(6,2)YL(I),YL(I+1),YN(I),XYN(I),RHON(I),YF(I),SF(I),RHOF(I)
2     FORMAT(F5.1,'-',F5.1,2F15.3,4F10.5)
102   CONTINUE
1     FORMAT('1',2X, 10A8//3X,' LENGTH ',8X,'GROUP N',
     >       7X,'ORIGINAL',2X,'EST-RHON',
     >       3X,'GROUP-F',2X,'ORIGINAL',1X,'EST-RHOF'
     >       /81('='))
      WRITE(6,3)
3     FORMAT(81('='))
      RETURN
      END

      SUBROUTINE REGRP(XL,C,NL,YL,YC,NG,DL,NGR,XLMIN,XLMAX)
      DIMENSION XL(100),C(100)
      DIMENSION YL(100),YC(100)
      DIMENSION YYL(100),YYC(100)

      DO 100 I=1,100
      YYC(I)=0.
      YC(I)=0.
100   CONTINUE
      READ(1,*)DL,YDL
      IF(YDL.GT.DL)GO TO 110
```

```
      WRITE(6,1)YDL,DL
1     FORMAT(' YDL IS SMALLER THAN DL')
      STOP
110   NG=1
      SUM=0.
      KK=NL-1
      DO 10 I=1,KK
      J=KK-I+1
      SUM=SUM+DL
      YYC(NG)=YYC(NG)+C(J)
      IF(SUM.EQ.YDL)GO TO 11
      IF(SUM.LT.YDL .AND. J.EQ.1)GO TO 11
      GO TO 10
11    SUM=0.
      YYL(NG)=XL(J)
      IF(J.GT.1)NG=NG+1
10    CONTINUE
      DO 12 I=1,NG
      J=NG-I+1
      YL(J)=YYL(I)
      YC(J)=YYC(I)
12    CONTINUE
      NG=NG+1
      YL(NG)=XL(NL)
      YL(NG+1)=XL(NL+1)
      YC(NG)=C(NL)
      XLMIN=YL(1)
      RETURN
      END

      SUBROUTINE CMORT(XL,C,NL,ICK,ITLT)
      CHARACTER*8 ITLT
      DIMENSION XL(100),C(100)
      DIMENSION ITLT(10)
      DIMENSION XN(100),F(100),Z(100)
      DIMENSION WN(100),WF(100),WZ(100)
      DIMENSION DT(100)
      DIMENSION RHON(100),RHOF(100),DN(100)

      CALL BASIC(XLMIN,XLMAX,DL,DT,XLINF,XK,VL,VK,VLK,XM,
     >           FL,ZL,EL,XL,C,NL,ITLT,XN,F,Z,ICK)
      CALL BASIC(XLMIN,XLMAX,DL,DT,XLINF,XK,VL,VK,VLK,WM,
     >           WFL,WZ,WE,XL,C,NL,ITLT,WN,WF,WZ,ICK)
      RHOF(NL)=(WFL-FL)/FL
      RHOZ=(WFL+WM-FL-XM)/(FL+XM)
      RHON(NL)=(1.+RHOZ)/(1.+RHOF(NL))-1.
      DM=WM-XM
      DMK=DM/XK
```

```
      XMK=XM/XK
      KK=NL-1
      DO 220 I=1,KK
      J=KK-I+1
      J1=J+1
      AL=(XLINF-XL(J))/(XLINF-XL(J1))
      AFK=EXP(-F(J))
      ADMK=AL**(DMK)
      AMK=AL**(XMK/2.)
      ADMK2=AL**(DMK/2.)
      RHON(J)=RHON(J1)*AFK*(1.+DM*DT(J))+(1.+AFK)*(DM*DT(J)/2.)
      RHOF(J)=(ALOG((1.+RHON(J))/(1.+RHON(J1)))-DM*DT(J))/F(J)
220   CONTINUE
      WRITE(6,22)(ITLT(I),I=1,10),XLINF,XK,XM,WM,FL,WFL
22    FORMAT('1',2X,10A8/5X,'LINF = ',F10.3,3X,'K = ',F7.3/
     >       5X,'TRUE M = ',F10.3,'  VS ERROR M = ',F10.3/
     >       5X,'TRUE FT= ',F10.3,'  VS ERROR FT= ',F10.3/
     >       3X,' LENGTH ',5X,'ERR N',4X,'REAL N',
     >       1X,'APRX-RHON',5X,'ERR F',4X,'REAL F',
     >       6X,'RHOF'/71('='))
      DO 230 I=1,NL
      WRITE(6,23)XL(I),XL(I+1),WN(I),XN(I),RHON(I),
     >           WF(I),F(I),RHOF(I)
23    FORMAT(F5.1,'-',F5.1,2F10.1,4F10.4)
230   CONTINUE
      WRITE(6,25)
25    FORMAT(71('='))
      RETURN
      END
```

Table 1. Length frequency data of Protothaca staminea in file DATF.

10	7.
11	2.
12	0.
13	1.
14	0.
15	1.
16	1.
17	1.
18	1.
19	2.
20	1.
21	3.
22	5.
23	2.
24	6.
25	9.
26	10.
27	9.
28	6.
29	3.
30	15.
31	7.
32	2.
33	9.
34	7.
35	14.
36	11.
37	14.
38	12.
39	17.
40	22.
41	19.
42	37.
43	36.
44	36.
45	50.
46	62.
47	55.
48	47.
49	43.
50	26.
51	26.
52	12.
53	10.
54	15.
55	6.
56	5.
57	4.
58	3.
59	1.

Table 2. Commands and parameter values input into program for the basic LCA analysis.

```
1 LENGTH COHORT ANALYSIS FOR PROTOTHACA, NORTH 1975
10, 60, 1.0
61.0, 0.346,0.47
0.1, 0.570, 0.
```

Table 3. Output of basic LCA analysis. See text for detailed explanation.

1 LENGTH COHORT ANALYSIS FOR PROTOTHACA, NORTH 1975

LINF = 61. K = .346
M = .47 M/K = 1.35838150289
FT = .1 F/Z = .1754385964912

LENGTH	DT	CATCH	STOCK SIZE	NO(DL/2)	F(L)	Z(L)	F/Z	Z
10.0- 11.0	.0572	7.	4641.64	261.91	.00153	.02843	.05380	.49673
11.0- 12.0	.0584	2.	4511.54	259.79	.00045	.02789	.01612	.47770
12.0- 13.0	.0596	0.	4387.44	257.83	.00000	.02801	.00000	.47000
13.0- 14.0	.0608	1.	4266.25	255.89	.00024	.02884	.00825	.47391
14.0- 15.0	.0622	0.	4144.99	253.91	.00000	.02921	.00000	.47000
15.0- 16.0	.0635	1.	4025.65	251.91	.00025	.03011	.00838	.47397
16.0- 17.0	.0650	1.	3906.25	249.85	.00026	.03079	.00844	.47400
17.0- 18.0	.0664	1.	3787.82	247.75	.00027	.03150	.00851	.47404
18.0- 19.0	.0680	1.	3670.38	245.63	.00028	.03224	.00859	.47407
19.0- 20.0	.0696	2.	3553.93	243.44	.00057	.03331	.01718	.47822
20.0- 21.0	.0714	1.	3437.52	241.22	.00030	.03384	.00874	.47415
21.0- 22.0	.0732	3.	3323.14	238.92	.00092	.03531	.02602	.48256
22.0- 23.0	.0751	5.	3207.85	236.44	.00159	.03687	.04306	.49115
23.0- 24.0	.0771	2.	3091.72	233.96	.00066	.03688	.01786	.47855
24.0- 25.0	.0792	6.	2979.76	231.39	.00205	.03927	.05229	.49593
25.0- 26.0	.0814	9.	2865.01	228.49	.00321	.04147	.07732	.50939
26.0- 27.0	.0838	10.	2748.62	225.39	.00372	.04309	.08626	.51437
27.0- 28.0	.0863	9.	2632.69	222.22	.00349	.04405	.07933	.51050
28.0- 29.0	.0889	6.	2519.24	219.17	.00243	.04423	.05504	.49738
29.0- 30.0	.0918	3.	2410.23	216.32	.00127	.04440	.02866	.48387
30.0- 31.0	.0948	15.	2305.56	212.99	.00667	.05122	.13031	.54043
31.0- 32.0	.0980	7.	2190.45	209.42	.00328	.04933	.06640	.50343
32.0- 33.0	.1014	2.	2085.03	206.40	.00098	.04865	.02020	.47969
33.0- 34.0	.1051	9.	1986.02	203.21	.00466	.05406	.08612	.51430
34.0- 35.0	.1091	7.	1881.51	199.68	.00382	.05509	.06941	.50506
35.0- 36.0	.1134	14.	1780.66	195.78	.00811	.06138	.13205	.54152
36.0- 37.0	.1180	11.	1674.64	191.56	.00678	.06223	.10887	.52743
37.0- 38.0	.1230	14.	1573.61	187.22	.00920	.06701	.13726	.54479
38.0- 39.0	.1285	12.	1471.61	182.70	.00844	.06882	.12261	.53569
39.0- 40.0	.1345	17.	1373.74	177.85	.01285	.07605	.16899	.56561
40.0- 41.0	.1410	22.	1273.15	172.17	.01802	.08430	.21375	.59782
41.0- 42.0	.1482	19.	1170.22	166.18	.01695	.08663	.19565	.58437
42.0- 43.0	.1563	37.	1073.11	158.80	.03641	.10987	.33138	.70309
43.0- 44.0	.1652	36.	961.46	149.87	.03968	.11735	.33817	.71034
44.0- 45.0	.1752	36.	855.00	140.67	.04484	.12722	.35247	.72607
45.0- 46.0	.1865	50.	752.86	129.80	.07185	.15956	.45026	.85554
46.0- 47.0	.1994	62.	641.82	115.97	.10661	.20045	.53183	1.00527
47.0- 48.0	.2142	55.	525.24	101.11	.11651	.21734	.53606	1.01471
48.0- 49.0	.2313	47.	422.64	87.19	.12470	.23363	.53375	1.00993
49.0- 50.0	.2515	43.	334.58	73.92	.14628	.26477	.55248	1.05287
50.0- 51.0	.2755	26.	256.75	62.76	.11411	.24380	.46805	.88505
51.0- 52.0	.3045	26.	201.20	53.12	.14905	.29256	.50946	.96075
52.0- 53.0	.3404	12.	150.17	45.22	.09034	.25054	.36058	.73598
53.0- 54.0	.3859	10.	116.89	39.35	.09808	.27974	.35059	.72486
54.0- 55.0	.4455	15.	88.36	32.17	.20772	.41825	.49664	.93879
55.0- 56.0	.5269	6.	58.16	25.59	.12353	.37182	.33222	.70562
56.0- 57.0	.6449	5.	40.10	20.73	.15555	.45987	.33824	.71307
57.0- 58.0	.8315	4.	25.32	15.80	.21048	.60408	.34844	.72653
58.0- 59.0	1.1719	3.	13.84	10.75	.32696	.88698	.36863	.75689
59.0- 60.0	-I	1.	5.70	10.75	.10000	.57000	.17544	-I
SUM				97401.08		8389.41		

Table 4. Commands and parameter values input into program for evaluating the effects of changing the size of the length interval.

```
2 CHANGE SIZE OF LENGTH INTERVAL FROM 1MM TO 3MM
10, 60, 1.0
61.0, 0.346,0.47
0.1, 0.570, 0.
1,3
10, 60, 3.0
61.0, 0.346,0.47
0.1, 0.570, 0.
```

Table 5-1. The second output from the Subroutine LINTV. This output is in the same format as Table 3 except that the size of length interval has been changed to 3mm.

1 CHANGE SIZE OF LENGTH INTERVAL FROM 1MM TO 3MM

LINF = 61. K = .346
M = .47 M/K = 1.35838150289
FT = .1 F/Z = .1754385964912

LENGTH	DT	CATCH	STOCK SIZE	NO(DL/2)	F(L)	Z(L)	F/Z	Z
10.0- 11.0	.0572	7.	4726.02	266.68	.00150	.02840	.05289	.49625
11.0- 14.0	.1788	3.	4593.68	787.65	.00068	.08473	.00804	.47381
14.0- 17.0	.1906	2.	4220.48	769.37	.00050	.09009	.00550	.47260
17.0- 20.0	.2041	4.	3856.87	750.20	.00109	.09701	.01122	.47533
20.0- 23.0	.2196	9.	3500.28	729.39	.00271	.10593	.02558	.48234
23.0- 26.0	.2377	17.	3148.46	706.06	.00572	.11744	.04873	.49409
26.0- 29.0	.2590	25.	2799.60	679.51	.00953	.13126	.07259	.50682
29.0- 32.0	.2845	25.	2455.22	650.35	.01094	.14467	.07560	.50847
32.0- 35.0	.3156	18.	2124.53	620.37	.00916	.15750	.05814	.49904
35.0- 38.0	.3543	39.	1814.93	585.66	.02360	.19017	.12408	.53669
38.0- 41.0	.4039	51.	1500.62	542.03	.03801	.22794	.16674	.56429
41.0- 44.0	.4697	92.	1194.75	482.38	.08958	.31068	.28835	.66142
44.0- 47.0	.5611	148.	875.70	390.63	.21260	.47796	.44481	.85176
47.0- 50.0	.6970	145.	542.97	271.53	.37220	.70531	.52772	1.01192
50.0- 53.0	.9204	64.	268.20	171.11	.34425	.78390	.43915	.85171
53.0- 56.0	1.3584	31.	122.47	102.29	.41168	1.06664	.38596	.78523
56.0- 59.0	2.6482	12.	42.15	48.24	.65870	2.00073	.32923	.75550
59.0- 60.0	-I	1.	5.70	48.24	.10000	.57000	.17544	.51050
SUM				37792.62		8553.47		

Table 5-2. The third output from the Subroutine LINTV. This table shows the relative error ratio due to the changing $\Delta\mathcal{L}$.

1 CHANGE SIZE OF LENGTH INTERVAL FROM 1MM TO 3MM

LENGTH	GROUP N	ORIGINAL	EST-RHON	GROUP-F	ORIGINAL	EST-RHOF
10.0- 11.0	4726.016	4641.636	.01823	.00150	.00153	-.01792
11.0- 14.0	4593.677	4511.536	.01826	.00068	.00069	-.00878
14.0- 17.0	4220.481	4144.988	.01827	.00050	.00051	-.03213
17.0- 20.0	3856.875	3787.824	.01828	.00109	.00112	-.02567
20.0- 23.0	3500.280	3437.515	.01831	.00271	.00280	-.03264
23.0- 26.0	3148.462	3091.723	.01840	.00572	.00592	-.03276
26.0- 29.0	2799.602	2748.618	.01860	.00953	.00965	-.01161
29.0- 32.0	2455.215	2410.234	.01872	.01094	.01122	-.02471
32.0- 35.0	2124.527	2085.027	.01900	.00916	.00946	-.03137
35.0- 38.0	1814.932	1780.661	.01930	.02360	.02408	-.01882
38.0- 41.0	1500.616	1471.615	.01976	.03801	.03931	-.03138
41.0- 44.0	1194.753	1170.221	.02102	.08958	.09304	-.03410
44.0- 47.0	875.695	855.001	.02427	.21260	.22330	-.04164
47.0- 50.0	542.972	525.237	.03384	.37220	.38749	-.02694
50.0- 53.0	268.204	256.751	.04468	.34425	.35350	-.00845
53.0- 56.0	122.467	116.887	.04781	.41168	.42932	-.00724
56.0- 59.0	42.149	40.101	.05107	.65870	.69299	.07187
59.0- 60.0	5.700	.000	.00000	.10000	.10000	-I

Table 6. Commands and parameter values input into program for evaluating the effects of the uncertainty in L_∞ and K.

```
3 UNCERTAINTY OF GROWTH PARAMETERS
10, 60, 1.0
61.0,0.346,0.47
7.053,0.0002,0.0
0.1,0.570, 0.
```

Table 7-1. The second output from the Subroutine UNCRT. This table lists stock size, fishing mortality and their variance and coefficient of variation.

I UNCERTAINTY OF GROWTH PARAMETERS

	LINF	K	COVAR
XPARAMETER:	61.0000	.3460	
XVARIANCE :	7.0530	.0002	.0000

LENGTH	CATCH	NUMBER	VAR(N)	CV[N(L)]	F	VAR(F)	CV[F(I)]
10.0- 11.0	.70000E+01	.46416E+04	.44097E+08	.14306E+01	.15296E-02	.40964E+01	.13232E+04
11.0- 12.0	.20000E+01	.45115E+04	.41717E+08	.14316E+01	.44952E-03	.40976E+01	.45032E+04
12.0- 13.0	.00000E+00	.43874E+04	.39423E+08	.14311E+01	.00000E+00	.40925E+01	R
13.0- 14.0	.10000E+01	.42663E+04	.37212E+08	.14299E+01	.23779E-03	.40863E+01	.85009E+04
14.0- 15.0	.00000E+00	.41450E+04	.35080E+08	.14289E+01	.00000E+00	.40798E+01	R
15.0- 16.0	.10000E+01	.40256E+04	.33027E+08	.14276E+01	.25217E-03	.40730E+01	.80034E+04
16.0- 17.0	.10000E+01	.39063E+04	.31052E+08	.14265E+01	.25936E-03	.40670E+01	.77576E+04
17.0- 18.0	.10000E+01	.37878E+04	.29154E+08	.14255E+01	.26818E-03	.40607E+01	.75139E+04
18.0- 19.0	.10000E+01	.36704E+04	.27330E+08	.14243E+01	.27687E-03	.40541E+01	.72723E+04
19.0- 20.0	.20000E+01	.35539E+04	.25581E+08	.14231E+01	.57218E-03	.40482E+01	.35164E+04
20.0- 21.0	.10000E+01	.34375E+04	.23904E+08	.14223E+01	.29586E-03	.40421E+01	.67955E+04
21.0- 22.0	.30000E+01	.33231E+04	.22298E+08	.14210E+01	.91879E-03	.40368E+01	.21868E+04
22.0- 23.0	.50000E+01	.32078E+04	.20762E+08	.14204E+01	.15876E-02	.40360E+01	.12654E+04
23.0- 24.0	.20000E+01	.30917E+04	.19294E+08	.14207E+01	.65889E-03	.40338E+01	.30482E+04
24.0- 25.0	.60000E+01	.29798E+04	.17894E+08	.14196E+01	.20534E-02	.40327E+01	.97797E+03
25.0- 26.0	.90000E+01	.28650E+04	.16559E+08	.14203E+01	.32069E-02	.40409E+01	.62683E+03
26.0- 27.0	.10000E+02	.27486E+04	.15288E+08	.14225E+01	.37171E-02	.40549E+01	.54173E+03
27.0- 28.0	.90000E+01	.26327E+04	.14079E+08	.14253E+01	.34944E-02	.40693E+01	.57728E+03
28.0- 29.0	.60000E+01	.25192E+04	.12934E+08	.14276E+01	.24347E-02	.40779E+01	.82941E+03
29.0- 30.0	.30000E+01	.24102E+04	.11851E+08	.14283E+01	.12725E-02	.40769E+01	.15867E+04
30.0- 31.0	.15000E+02	.23056E+04	.10828E+08	.14272E+01	.66740E-02	.40915E+01	.30308E+03
31.0- 32.0	.70000E+01	.21905E+04	.98580E+07	.14334E+01	.32752E-02	.41129E+01	.61922E+03
32.0- 33.0	.20000E+01	.20850E+04	.89483E+07	.14347E+01	.98274E-03	.41108E+01	.20631E+04
33.0- 34.0	.90000E+01	.19860E+04	.80954E+07	.14326E+01	.46553E-02	.41127E+01	.43563E+03
34.0- 35.0	.70000E+01	.18815E+04	.72934E+07	.14353E+01	.38238E-02	.41242E+01	.53109E+03
35.0- 36.0	.14000E+02	.17807E+04	.65443E+07	.14366E+01	.81060E-02	.41476E+01	.25124E+03
36.0- 37.0	.11000E+02	.16746E+04	.58434E+07	.14435E+01	.67751E-02	.41809E+01	.30180E+03
37.0- 38.0	.14000E+02	.15736E+04	.51932E+07	.14482E+01	.91982E-02	.42166E+01	.22324E+03
38.0- 39.0	.12000E+02	.14716E+04	.45897E+07	.14558E+01	.84381E-02	.42566E+01	.24450E+03
39.0- 40.0	.17000E+02	.13737E+04	.40334E+07	.14619E+01	.12851E-01	.43091E+01	.16152E+03
40.0- 41.0	.22000E+02	.12731E+04	.35202E+07	.14737E+01	.18019E-01	.43982E+01	.11639E+03
41.0- 42.0	.19000E+02	.11702E+04	.30488E+07	.14921E+01	.16950E-01	.45022E+01	.12518E+03
42.0- 43.0	.37000E+02	.10731E+04	.26206E+07	.15085E+01	.36408E-01	.46851E+01	.59452E+02
43.0- 44.0	.36000E+02	.96146E+03	.22272E+07	.15522E+01	.39683E-01	.49728E+01	.56195E+02
44.0- 45.0	.36000E+02	.85500E+03	.18739E+07	.16010E+01	.44840E-01	.53130E+01	.51405E+02
45.0- 46.0	.50000E+02	.75286E+03	.15584E+07	.16582E+01	.71853E-01	.58455E+01	.33648E+02
46.0- 47.0	.62000E+02	.64182E+03	.12752E+07	.17595E+01	.10661E+00	.68079E+01	.24475E+02
47.0- 48.0	.55000E+02	.52524E+03	.10240E+07	.19266E+01	.11651E+00	.82398E+01	.24638E+02
48.0- 49.0	.47000E+02	.42264E+03	.80871E+06	.21278E+01	.12470E+00	.10126E+02	.25518E+02
49.0- 50.0	.43000E+02	.33459E+03	.62672E+06	.23661E+01	.14628E+00	.12792E+02	.24450E+02
50.0- 51.0	.26000E+02	.25675E+03	.47417E+06	.26820E+01	.11411E+00	.15873E+02	.34915E+02
51.0- 52.0	.26000E+02	.20120E+03	.35136E+06	.29461E+01	.14905E+00	.19810E+02	.29862E+02
52.0- 53.0	.12000E+02	.15017E+03	.25095E+06	.33360E+01	.90339E-01	.23842E+02	.54050E+02
53.0- 54.0	.10000E+02	.11689E+03	.17366E+06	.35652E+01	.98076E-01	.27289E+02	.53264E+02
54.0- 55.0	.15000E+02	.88364E+02	.11380E+06	.38176E+01	.20772E+00	.34730E+02	.28371E+02
55.0- 56.0	.60000E+01	.58161E+02	.68155E+05	.44887E+01	.12353E+00	.43463E+02	.53370E+02
56.0- 57.0	.50000E+01	.40101E+02	.37468E+05	.48270E+01	.15555E+00	.50569E+02	.45718E+02
57.0- 58.0	.40000E+01	.25318E+02	.17459E+05	.52188E+01	.21048E+00	.58919E+02	.36468E+02
58.0- 59.0	.30000E+01	.13838E+02	.60499E+04	.56207E+01	.32696E+00	.31954E+02	.17289E+02
59.0- 60.0	.10000E+01	.57000E+01	.00000E+00	.00000E+00	.10000E+00	.00000E+00	.00000E+00

C.V. NOT IN %

Table 7-2. The third output from the Subroutine UNCRT. This table lists the values of $\frac{\partial N(\ell)}{\partial L_\infty}$, $\frac{\partial N(\ell)}{\partial K}$, and $\frac{\partial^2 N(\ell)}{\partial L_\infty \partial K}$.

1 DERIVATIVES OF N(L) RESPECT TO L-INF AND K

LENGTH	DN/DL	DN/DK	DN/DLDK
10.0- 11.0	-.24888E+04	-.45224E+05	.40302E+05
11.0- 12.0	-.24209E+04	-.43608E+05	.39023E+05
12.0- 13.0	-.23536E+04	-.42015E+05	.37758E+05
13.0- 14.0	-.22868E+04	-.40445E+05	.36508E+05
14.0- 15.0	-.22205E+04	-.38899E+05	.35273E+05
15.0- 16.0	-.21548E+04	-.37376E+05	.34054E+05
16.0- 17.0	-.20895E+04	-.35878E+05	.32850E+05
17.0- 18.0	-.20248E+04	-.34403E+05	.31661E+05
18.0- 19.0	-.19607E+04	-.32953E+05	.30488E+05
19.0- 20.0	-.18970E+04	-.31527E+05	.29331E+05
20.0- 21.0	-.18340E+04	-.30126E+05	.28190E+05
21.0- 22.0	-.17715E+04	-.28751E+05	.27065E+05
22.0- 23.0	-.17095E+04	-.27400E+05	.25957E+05
23.0- 24.0	-.16481E+04	-.26076E+05	.24866E+05
24.0- 25.0	-.15873E+04	-.24779E+05	.23791E+05
25.0- 26.0	-.15271E+04	-.23508E+05	.22734E+05
26.0- 27.0	-.14675E+04	-.22264E+05	.21694E+05
27.0- 28.0	-.14084E+04	-.21048E+05	.20671E+05
28.0- 29.0	-.13501E+04	-.19860E+05	.19667E+05
29.0- 30.0	-.12924E+04	-.18701E+05	.18681E+05
30.0- 31.0	-.12355E+04	-.17569E+05	.17713E+05
31.0- 32.0	-.11790E+04	-.16467E+05	.16764E+05
32.0- 33.0	-.11234E+04	-.15395E+05	.15835E+05
33.0- 34.0	-.10686E+04	-.14353E+05	.14925E+05
34.0- 35.0	-.10144E+04	-.13340E+05	.14035E+05
35.0- 36.0	-.96101E+03	-.12358E+05	.13165E+05
36.0- 37.0	-.90819E+03	-.11408E+05	.12315E+05
37.0- 38.0	-.85626E+03	-.10491E+05	.11487E+05
38.0- 39.0	-.80506E+03	-.96058E+04	.10680E+05
39.0- 40.0	-.75478E+03	-.87545E+04	.98950E+04
40.0- 41.0	-.70521E+03	-.79375E+04	.91321E+04
41.0- 42.0	-.65637E+03	-.71564E+04	.83918E+04
42.0- 43.0	-.60860E+03	-.64117E+04	.76755E+04
43.0- 44.0	-.56112E+03	-.57056E+04	.69816E+04
44.0- 45.0	-.51475E+03	-.50405E+04	.63130E+04
45.0- 46.0	-.46948E+03	-.44165E+04	.56704E+04
46.0- 47.0	-.42472E+03	-.38360E+04	.50526E+04
47.0- 48.0	-.38063E+03	-.33025E+04	.44611E+04
48.0- 49.0	-.33829E+03	-.28168E+04	.38997E+04
49.0- 50.0	-.29782E+03	-.23767E+04	.33694E+04
50.0- 51.0	-.25907E+03	-.19808E+04	.28705E+04
51.0- 52.0	-.22303E+03	-.16254E+04	.24066E+04
52.0- 53.0	-.18850E+03	-.13079E+04	.19751E+04
53.0- 54.0	-.15682E+03	-.10260E+04	.15810E+04
54.0- 55.0	-.12696E+03	-.77683E+03	.12225E+04
55.0- 56.0	-.98256E+02	-.56248E+03	.89967E+03
56.0- 57.0	-.72858E+02	-.38235E+03	.62072E+03
57.0- 58.0	-.49737E+02	-.23469E+03	.38506E+03
58.0- 59.0	-.29281E+02	-.12068E+03	.19749E+03
59.0- 60.0	-I	-I	-I

Table 8. Commands and parameter values input into program for evaluating the effects of wrongly guessed natural and terminal fishing mortality.

```
4 CHANGE M = 0.47 TO M = 0.2,  FINAL F CONSTANT
10, 60, 1.0
61.0, 0.346,0.47
0.1, 0.570, 0.
10, 60, 1.0
61.0, 0.346,0.2
0.1, 0.570, 0.
4 CHANGE F(L) = 0.1 TO F(L)= 0.2, M CONSTANT
10, 60, 1.0
61.0, 0.346,0.47
0.1, 0.570,0.
10, 60, 1.0
61.0, 0.346, 0.47
0.2, 0.67,0.
```

Table 9-1. The second output from the Subroutine CMORT. This table lists the estiamted parameter values based on a wrongly guessed natural mortality.

1 CHANGE M = 0.47 TO M = 0.2, FINAL F CONSTANT

LINF = 61. K = .346
M = .2 M/K = .5780346820809
FT = .1 F/Z = .3333333333333

LENGTH	DT	CATCH	STOCK SIZE	NO(DL/2)	F(L)	Z(L)	F/Z	Z
10.0- 11.0	.0572	7.	1418.64	80.53	.00497	.01642	.30295	.28692
11.0- 12.0	.0584	2.	1395.54	80.95	.00144	.01312	.10995	.22471
12.0- 13.0	.0596	0.	1377.35	81.59	.00000	.01192	.00000	.20000
13.0- 14.0	.0608	1.	1361.03	82.28	.00074	.01291	.05728	.21215
14.0- 15.0	.0622	0.	1343.57	82.99	.00000	.01243	.00000	.20000
15.0- 16.0	.0635	1.	1326.97	83.73	.00076	.01346	.05635	.21194
16.0- 17.0	.0650	1.	1309.23	84.45	.00077	.01376	.05590	.21184
17.0- 18.0	.0664	1.	1291.34	85.20	.00078	.01407	.05543	.21174
18.0- 19.0	.0680	1.	1273.30	85.97	.00079	.01439	.05496	.21163
19.0- 20.0	.0696	2.	1255.10	86.74	.00161	.01554	.10337	.22306
20.0- 21.0	.0714	1.	1235.75	87.53	.00082	.01509	.05404	.21142
21.0- 22.0	.0732	3.	1217.25	88.31	.00249	.01712	.14519	.23397
22.0- 23.0	.0751	5.	1196.59	88.97	.00422	.01923	.21935	.25620
23.0- 24.0	.0771	2.	1173.79	89.70	.00172	.01713	.10030	.22230
24.0- 25.0	.0792	6.	1153.85	90.41	.00526	.02109	.24914	.26636
25.0- 26.0	.0814	9.	1129.77	90.87	.00806	.02435	.33119	.29904
26.0- 27.0	.0838	10.	1102.59	91.19	.00919	.02594	.35414	.30967
27.0- 28.0	.0863	9.	1074.36	91.51	.00849	.02574	.32964	.29835
28.0- 29.0	.0889	6.	1047.05	92.03	.00580	.02359	.24584	.26520
29.0- 30.0	.0918	3.	1022.65	92.84	.00296	.02132	.13909	.23231
30.0- 31.0	.0948	15.	1001.08	93.27	.01524	.03420	.44571	.36084
31.0- 32.0	.0980	7.	967.42	93.52	.00733	.02693	.27232	.27485
32.0- 33.0	.1014	2.	941.72	94.45	.00215	.02243	.09574	.22118
33.0- 34.0	.1051	9.	920.83	95.30	.00993	.03095	.32073	.29444
34.0- 35.0	.1091	7.	892.77	95.94	.00796	.02977	.26729	.27296
35.0- 36.0	.1134	14.	866.58	96.33	.01647	.03915	.42083	.34534
36.0- 37.0	.1180	11.	833.31	96.52	.01345	.03704	.36299	.31397
37.0- 38.0	.1230	14.	803.01	96.71	.01781	.04241	.41988	.34477
38.0- 39.0	.1285	12.	769.67	96.85	.01592	.04161	.38252	.32391
39.0- 40.0	.1345	17.	738.29	96.80	.02361	.05050	.46753	.37564
40.0- 41.0	.1410	22.	701.93	96.05	.03230	.06051	.53383	.42908
41.0- 42.0	.1482	19.	660.72	95.10	.02962	.05927	.49970	.39980
42.0- 43.0	.1563	37.	622.70	92.89	.06224	.09351	.66563	.59838
43.0- 44.0	.1652	36.	567.11	89.16	.06670	.09975	.66863	.60384
44.0- 45.0	.1752	36.	513.27	85.20	.07403	.10910	.67861	.62264
45.0- 46.0	.1865	50.	460.22	79.54	.11726	.15461	.75840	.82891
46.0- 47.0	.1994	62.	394.29	70.75	.17473	.21472	.81374	1.07684
47.0- 48.0	.2142	55.	318.10	60.65	.19422	.23720	.81878	1.10747
48.0- 49.0	.2313	47.	250.93	51.14	.21261	.25907	.82067	1.11990
49.0- 50.0	.2515	43.	193.66	41.90	.25807	.30867	.83607	1.22743
50.0- 51.0	.2755	26.	142.23	34.45	.20792	.26324	.78986	.95563
51.0- 52.0	.3045	26.	109.31	28.19	.28087	.34222	.82074	1.12384
52.0- 53.0	.3404	12.	77.63	23.47	.17407	.24235	.71823	.71194
53.0- 54.0	.3859	10.	60.92	20.66	.18678	.26424	.70687	.68468
54.0- 55.0	.4455	15.	46.78	16.42	.40704	.49751	.81815	1.11668
55.0- 56.0	.5269	6.	28.44	12.60	.25084	.35689	.70283	.67729
56.0- 57.0	.6449	5.	19.90	10.38	.31062	.44086	.70458	.68359
57.0- 58.0	.8315	4.	12.81	8.08	.41172	.58085	.70883	.69860
58.0- 59.0	1.1719	3.	7.17	5.61	.62706	.87064	.72023	.74295
59.0- 60.0	-I	1.	3.00	5.61	.10000	.30000	.33333	-I

Table 9-2. The third output from the Subroutine CMORT. This table lists the estimated parameter values and relative error ratio for using true vs. wrongly guessed natural mortality.

1 CHANGE M = 0.47 TO M = 0.2, FINAL F CONSTANT
LINF = 61.000 K = .346
TRUE M = .470 VS ERROR M = .200
TRUE FT= .100 VS ERROR FT= .100

LENGTH	ERR N	REAL N	APRX-RHON	ERR F	REAL F	RHOF
10.0- 11.0	1418.6	4641.6	-.7010	.0050	.0015	2.2452
11.0- 12.0	1395.5	4511.5	-.6973	.0014	.0004	2.0003
12.0- 13.0	1377.3	4387.4	-.6928	.0000	.0000	-R
13.0- 14.0	1361.0	4266.3	-.6878	.0007	.0002	1.6036
14.0- 15.0	1343.6	4145.0	-.6827	.0000	.0000	-R
15.0- 16.0	1327.0	4025.6	-.6773	.0008	.0003	1.4833
16.0- 17.0	1309.2	3906.3	-.6719	.0008	.0003	1.4231
17.0- 18.0	1291.3	3787.8	-.6662	.0008	.0003	1.3623
18.0- 19.0	1273.3	3670.4	-.6603	.0008	.0003	1.3008
19.0- 20.0	1255.1	3553.9	-.6541	.0016	.0006	1.5524
20.0- 21.0	1235.8	3437.5	-.6478	.0008	.0003	1.1774
21.0- 22.0	1217.2	3323.1	-.6411	.0025	.0009	1.5458
22.0- 23.0	1196.6	3207.8	-.6345	.0042	.0016	1.5805
23.0- 24.0	1173.8	3091.7	-.6279	.0017	.0007	1.3278
24.0- 25.0	1153.9	2979.8	-.6204	.0053	.0021	1.4978
25.0- 26.0	1129.8	2865.0	-.6134	.0081	.0032	1.4883
26.0- 27.0	1102.6	2748.6	-.6067	.0092	.0037	1.4511
27.0- 28.0	1074.4	2632.7	-.5999	.0085	.0035	1.3976
28.0- 29.0	1047.1	2519.2	-.5924	.0058	.0024	1.3080
29.0- 30.0	1022.6	2410.2	-.5839	.0030	.0013	1.1301
30.0- 31.0	1001.1	2305.6	-.5740	.0152	.0067	1.2779
31.0- 32.0	967.4	2190.5	-.5667	.0073	.0033	1.1734
32.0- 33.0	941.7	2085.0	-.5568	.0021	.0010	.8381
33.0- 34.0	920.8	1986.0	-.5449	.0099	.0047	1.0837
34.0- 35.0	892.8	1881.5	-.5341	.0080	.0038	1.0037
35.0- 36.0	866.6	1780.7	-.5220	.0165	.0081	1.0101
36.0- 37.0	833.3	1674.6	-.5112	.0134	.0068	.9437
37.0- 38.0	803.0	1573.6	-.4986	.0178	.0092	.9087
38.0- 39.0	769.7	1471.6	-.4860	.0159	.0084	.8461
39.0- 40.0	738.3	1373.7	-.4716	.0236	.0129	.8160
40.0- 41.0	701.9	1273.1	-.4578	.0323	.0180	.7814
41.0- 42.0	660.7	1170.2	-.4446	.0296	.0169	.7276
42.0- 43.0	622.7	1073.1	-.4290	.0622	.0364	.7123
43.0- 44.0	567.1	961.5	-.4197	.0667	.0397	.6826
44.0- 45.0	513.3	855.0	-.4094	.0740	.0448	.6525
45.0- 46.0	460.2	752.9	-.3987	.1173	.0719	.6411
46.0- 47.0	394.3	641.8	-.3961	.1747	.1066	.6542
47.0- 48.0	318.1	525.2	-.4056	.1942	.1165	.6850
48.0- 49.0	250.9	422.6	-.4185	.2126	.1247	.7264
49.0- 50.0	193.7	334.6	-.4347	.2581	.1463	.7928
50.0- 51.0	142.2	256.8	-.4612	.2079	.1141	.8504
51.0- 52.0	109.3	201.2	-.4733	.2809	.1490	.9248
52.0- 53.0	77.6	150.2	-.5018	.1741	.0903	.9515
53.0- 54.0	60.9	116.9	-.4988	.1868	.0981	.9227
54.0- 55.0	46.8	88.4	-.4919	.4070	.2077	1.0132
55.0- 56.0	28.4	58.2	-.5357	.2508	.1235	1.0511
56.0- 57.0	19.9	40.1	-.5299	.3106	.1555	.9990
57.0- 58.0	12.8	25.3	-.5210	.4117	.2105	.9182
58.0- 59.0	7.2	13.8	-.5058	.6271	.3270	.7752
59.0- 60.0	3.0	5.7	-.4737	.1000	.1000	.0000

Table 9-3. The fifth output from the Subroutine CMORT. This table lists the estiamted parameter values based on a wrongly guessed terminal fishing mortality.

1 CHANGE F(L) = 0.1 TO F(L)= 0.2, M CONSTANT

LINF = 61. K = .346
M = .47 M/K = 1.35838150289
FT = .2 F/Z = .2985074626866

LENGTH	DT	CATCH	STOCK SIZE	NO(DL/2)	F(L)	Z(L)	F/Z	Z
10.0- 11.0	.0572	7.	4450.35	251.11	.00160	.02850	.05599	.49788
11.0- 12.0	.0584	2.	4325.33	249.06	.00047	.02791	.01680	.47803
12.0- 13.0	.0596	0.	4206.27	247.19	.00000	.02801	.00000	.47000
13.0- 14.0	.0608	1.	4090.09	245.32	.00025	.02885	.00860	.47408
14.0- 15.0	.0622	0.	3973.79	243.42	.00000	.02921	.00000	.47000
15.0- 16.0	.0635	1.	3859.38	241.50	.00026	.03012	.00873	.47414
16.0- 17.0	.0650	1.	3744.87	239.52	.00027	.03080	.00880	.47418
17.0- 18.0	.0664	1.	3631.30	237.52	.00028	.03151	.00888	.47421
18.0- 19.0	.0680	1.	3518.66	235.48	.00029	.03225	.00895	.47425
19.0- 20.0	.0696	2.	3406.99	233.37	.00060	.03333	.01791	.47857
20.0- 21.0	.0714	1.	3295.31	231.24	.00031	.03385	.00912	.47432
21.0- 22.0	.0732	3.	3185.62	229.03	.00096	.03535	.02711	.48310
22.0- 23.0	.0751	5.	3074.98	226.64	.00166	.03694	.04483	.49206
23.0- 24.0	.0771	2.	2963.46	224.25	.00069	.03691	.01862	.47892
24.0- 25.0	.0792	6.	2856.06	221.77	.00214	.03936	.05443	.49706
25.0- 26.0	.0814	9.	2745.83	218.97	.00335	.04161	.08042	.51110
26.0- 27.0	.0838	10.	2633.91	215.96	.00388	.04326	.08968	.51631
27.0- 28.0	.0863	9.	2522.41	212.89	.00365	.04420	.08252	.51228
28.0- 29.0	.0889	6.	2413.35	209.94	.00254	.04434	.05732	.49858
29.0- 30.0	.0918	3.	2308.67	207.20	.00133	.04446	.02988	.48448
30.0- 31.0	.0946	15.	2208.29	203.98	.00697	.05151	.13529	.54355
31.0- 32.0	.0980	7.	2097.42	200.51	.00342	.04947	.06914	.50492
32.0- 33.0	.1014	2.	1996.18	197.60	.00103	.04869	.02108	.48012
33.0- 34.0	.1051	9.	1901.31	194.52	.00486	.05426	.08962	.51627
34.0- 35.0	.1091	7.	1800[illegible]	191.10	.00400	.05526	.07230	.50663
35.0- 36.0	.1134	14.	1704[illegible]	187.32	.00847	.06175	.13720	.54475
36.0- 37.0	.1180	11.	1602.[illegible]	183.22	.00708	.06254	.11327	.53005
37.0- 38.0	.1230	14.	1504.90	179.01	.00962	.06743	.14266	.54822
38.0- 39.0	.1285	12.	1406.77	174.62	.00883	.06921	.12756	.53873
39.0- 40.0	.1345	17.	1312.69	169.90	.01345	.07665	.17552	.57008
40.0- 41.0	.1410	22.	1215.84	164.35	.01888	.08516	.22166	.60390
41.0- 42.0	.1482	19.	1116.59	158.50	.01777	.08745	.20321	.58991
42.0- 43.0	.1563	37.	1023.09	151.27	.03822	.11168	.34224	.71471
43.0- 44.0	.1652	36.	914.97	142.48	.04174	.11941	.34957	.72281
44.0- 45.0	.1752	36.	811.99	133.44	.04727	.12965	.36460	.73996
45.0- 46.0	.1865	50.	713.25	122.72	.07600	.16373	.46416	.87779
46.0- 47.0	.1994	62.	605.53	109.05	.11336	.20723	.54706	1.03924
47.0- 48.0	.2142	55.	492.20	94.37	.12483	.22568	.55312	1.05366
48.0- 49.0	.2313	47.	392.76	80.63	.13485	.24381	.55309	1.05389
49.0- 50.0	.2515	43.	307.78	67.55	.16007	.27861	.57453	1.10791
50.0- 51.0	.2755	26.	232.94	56.60	.12653	.25626	.49375	.93028
51.0- 52.0	.3045	26.	180.28	47.17	.16784	.31144	.53891	1.02275
52.0- 53.0	.3404	12.	132.04	39.51	.10339	.26364	.39216	.77446
53.0- 54.0	.3859	10.	101.44	33.89	.11387	.29561	.38520	.76597
54.0- 55.0	.4455	15.	75.48	26.97	.24779	.45871	.54018	1.02961
55.0- 56.0	.5269	6.	47.71	20.71	.15267	.40121	.38053	.76139
56.0- 57.0	.6449	5.	31.94	16.18	.19930	.50419	.39528	.78170
57.0- 58.0	.8315	4.	19.29	11.63	.28591	.68123	.41970	.81933
58.0- 59.0	1.1719	3.	9.76	7.03	.50041	1.06954	.46787	.91268
59.0- 60.0	-I	1.	3.35	7.03	.20000	.67000	.29851	-I

Table 9-4. The sixh output from the Subroutine CMORT. This table lists the estimated parameter values and relative error ratio for using true vs. wrongly guessed terminal fishing mortality.

1 CHANGE F(L) = 0.1 TO F(L)= 0.2, M CONSTANT
LINF = 61.000 K = .346
TRUE M = .470 VS ERROR M = .470
TRUE FT= .100 VS ERROR FT= .200

LENGTH	ERR N	REAL N	APRX-RHON	ERR F	REAL F	RHOF
10.0- 11.0	4450.3	4641.6	-.0419	.0016	.0015	.0438
11.0- 12.0	4325.3	4511.5	-.0420	.0005	.0004	.0438
12.0- 13.0	4206.3	4387.4	-.0420	.0000	.0000	I
13.0- 14.0	4090.1	4266.3	-.0420	.0002	.0002	.0439
14.0- 15.0	3973.8	4145.0	-.0420	.0000	.0000	I
15.0- 16.0	3859.4	4025.6	-.0420	.0003	.0003	.0439
16.0- 17.0	3744.9	3906.3	-.0420	.0003	.0003	.0439
17.0- 18.0	3631.3	3787.6	-.0420	.0003	.0003	.0439
18.0- 19.0	3518.7	3670.4	-.0420	.0003	.0003	.0439
19.0- 20.0	3407.0	3553.9	-.0421	.0006	.0006	.0439
20.0- 21.0	3295.3	3437.5	-.0421	.0003	.0003	.0439
21.0- 22.0	3185.6	3323.1	-.0421	.0010	.0009	.0440
22.0- 23.0	3075.0	3207.8	-.0421	.0017	.0016	.0440
23.0- 24.0	2963.5	3091.7	-.0422	.0007	.0007	.0441
24.0- 25.0	2856.1	2979.8	-.0422	.0021	.0021	.0441
25.0- 26.0	2745.8	2865.0	-.0423	.0033	.0032	.0443
26.0- 27.0	2633.9	2748.6	-.0425	.0039	.0037	.0444
27.0- 28.0	2522.4	2632.7	-.0426	.0036	.0035	.0446
28.0- 29.0	2413.3	2519.2	-.0428	.0025	.0024	.0447
29.0- 30.0	2308.7	2410.2	-.0429	.0013	.0013	.0448
30.0- 31.0	2208.3	2305.6	-.0429	.0070	.0067	.0450
31.0- 32.0	2097.4	2190.5	-.0432	.0034	.0033	.0452
32.0- 33.0	1996.2	2085.0	-.0433	.0010	.0010	.0453
33.0- 34.0	1901.3	1986.0	-.0434	.0049	.0047	.0455
34.0- 35.0	1800.9	1881.5	-.0436	.0040	.0038	.0457
35.0- 36.0	1704.1	1780.7	-.0438	.0085	.0081	.0460
36.0- 37.0	1602.0	1674.6	-.0441	.0071	.0068	.0463
37.0- 38.0	1504.9	1573.6	-.0444	.0096	.0092	.0467
38.0- 39.0	1406.8	1471.6	-.0448	.0088	.0084	.0471
39.0- 40.0	1312.7	1373.7	-.0452	.0135	.0129	.0477
40.0- 41.0	1215.8	1273.1	-.0458	.0189	.0180	.0484
41.0- 42.0	1116.6	1170.2	-.0466	.0178	.0169	.0493
42.0- 43.0	1023.1	1073.1	-.0474	.0382	.0364	.0507
43.0- 44.0	915.0	961.5	-.0492	.0417	.0397	.0528
44.0- 45.0	812.0	855.0	-.0512	.0473	.0448	.0552
45.0- 46.0	713.3	752.9	-.0535	.0760	.0719	.0587
46.0- 47.0	605.5	641.8	-.0575	.1134	.1066	.0646
47.0- 48.0	492.2	525.2	-.0640	.1248	.1165	.0728
48.0- 49.0	392.8	422.6	-.0719	.1348	.1247	.0829
49.0- 50.0	307.8	334.6	-.0814	.1601	.1463	.0961
50.0- 51.0	232.9	256.8	-.0942	.1265	.1141	.1109
51.0- 52.0	180.3	201.2	-.1056	.1678	.1490	.1286
52.0- 53.0	132.0	150.2	-.1226	.1034	.0903	.1472
53.0- 54.0	101.4	116.9	-.1342	.1139	.0981	.1642
54.0- 55.0	75.5	88.4	-.1480	.2478	.2077	.1971
55.0- 56.0	47.7	58.2	-.1822	.1527	.1235	.2407
56.0- 57.0	31.9	40.1	-.2062	.1993	.1555	.2873
57.0- 58.0	19.3	25.3	-.2409	.2859	.2105	.3670
58.0- 59.0	9.8	13.8	-.2973	.5004	.3270	.5465
59.0- 60.0	3.4	5.7	-.4123	.2000	.1000	1.0000