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USER'S GUIDE TO PROGRAM CASA A CATCH-AT-SIZE ANALYSIS

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User's Guide to Program

C A S A

A Catch-At-Size Analysis

Release 1.0

July 1990

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ABSTRACT

The present document provides guidance for the use of the program "Catch-At-Size Analysis" [CASA]. The program uses an optimization algorithm as a part of a nonlinear least square approach to estimate relative abundance, recruitment, fishing mortality and the LVB parameters. The sample problem provided is drawn from a simulation program which demonstrates how close the input data and the output estimates can be. The present version 1.0 of CASA does not offer the option of including auxliary information, such as hydroacoustics, trawl data and fishing effort, but this option will be a part of later versions. Such information constrains the program to consistently provide biologically more meaningful values and more accurate estimates.

INTRODUCTION

CASA is a Catch-At-Size Analysis program that estimates both population and fishery stock assessment parameters from length frequency distributions drawn from a time series of catch data. In particular, CASA estimates the following:

- The abundance of fish potentially available to the gear, depending upon gear selectivity as a function of size.
- The parameters of a selection function expressed in terms of length.
- Recruitment to the population.
- Fishing mortality of fully recruited length classes as a function of time.
- The growth parameters of a von Bertalanffy model.

The estimated selectivity, fishing mortality and abundance can be applied to the Baranov catch equation to estimate the catch-at-length and time.

This users' guide is based on the paper "A Catch-At-Length Analysis that Incorporates a Stochastic Model of Growth" by Sullivan, Lai and Gallucci (1990). CASA is written in ANSI standard FORTRAN 77 for a VAX computer. Release 1.0 of CASA is designed to run in a batch mode so the user must prepare a self-explanatory input file for the program. The program output is stored in a user named file which can later be sent to the printer for a hard copy of the results. The purpose of this document is to provide

guidance to the user as to the detailed operational procedures of CASA.

CASA estimates up to 100 parameters via a nonlinear least squares procedure that minimizes the sum of squares of the difference between the predicted and observed catch. The program uses the modified Levenberg-Marquardt technique to solve this optimization problem. As in any non-linear optimization routine, it is possible that there is more than one minimum in the domain of the sum of squares. That is, a solution may be neither unique nor global.

Another characteristic of non-linear optimization algorithms is that the user must provide initial values of the parameters being estimated. These serve as the starting points in the iteration process of the algorithm. There is no need to be accurate in the selection of these values. However, close initial points to the real values of the parameters may guarantee convergence to the optimum in relatively fewer iterations.

Aside from the question whether a solution is optimal or not, a danger in applying global methods of non-linear optimization is that estimates without biological meaning may result. That is, the set of the estimated parameters cannot adequately describe the biological and fishing processes. A safe-guard against such problems is the collection of other information on the population and their use as "auxiliary data", thus, constraining the parameter space to an appropriately smaller domain. The present

release (version 1.0) of CASA does not allow the use of these types of data. However, future releases will accept auxiliary information, e.g., population size from hydroacoustics estimation, fishing effort, etc.

PREPARATION OF THE INPUT FILE

Upon program execution, the user is prompted to respond with input and output file names. Since the program is designed to run in a batch mode, the input file must be prepared before execution using a text editor. An example of a self-explanatory input file is shown in appendix I. The layout of this data can be divided into nine (9) sections separated by titles and spacers. Each section deals with one type of fishery parameter. The basic data for CASA is commercial catch-at-length. This is entered in a form of a matrix where the rows represent the catch-at-length and the columns represent the time steps. CASA is programmed to allow a maximum of 12 time steps per matrix and can accept an arbitrary number of matrices. The 13th time step will define a new matrix, so would the 25th time step. The variable NOD specifies the number of matrices. For 12 time steps, NOD = 1, for 14 time steps, NOD = 2, for 27 time steps, NOD = 3, and so on. The variable TMAX specifies the actual number of time steps, e.g., 0, 19, 31.

Therefore, the input file must contain the following sections:

SECTION 1: Title of the job or analysis being done, FORMAT (A80)

SECTION 2: Basic information about catch-at-length

Record 1: A blank space, serves as the section divider

Record 2: Variables names of the data used in this section:

LINC:	The size of length interval used to group catch-at-length data
VBLMIN:	Lower bound of the first length class
VBLMAX:	Lower bound of the last length class
M:	Natural mortality rate
NOD:	Number of catch-at-length data matrices
TMAX:	Number of time steps of catch-at-length data
MAXR:	Largest length class where recruitment can occur

Record 3: Enter a dashed line

Record 4: Data corresponding to the variables in record 2, free format input

SECTION 3: Recruitment (R(t), t = 2 to TMAX)

Record 1: A blank space, serves as the section divider

Record 2: Variable names used in this section

Record 3: Enter a dashed line

Record 4: Initial values for R(t)

Record 5: Specify whether each parameter in R(t) is to be estimated

1: to be estimated
0: known value

SECTION 4: Parameters of the selectivity curve

Record 1: A blank space, serves as the section divider

Record 2: Variable names used in this section

IND = 1, logistic curve (two parameters)
(IND is always equal to 1 in release 1.0)

Record 3: Enter a dashed line

Record 4: Enter data for the variables

Record 5: Same as in section 3

SECTION 5: Fishing mortality rate for all time steps

Record 1: A blank space, serves as the section divider

Record 2: Variable names used in this section

Record 3: Enter a dashed line

Record 4: Initial values for F(t)

Record 5: Same as in section 3

SECTION 6: Growth parameters

Record 1: A blank space, serves as the section divider

Record 2: Variable names used in this section

VBLINF = L_∞
VBK = k
BETA = scale parameter of a gamma distribution

Record 3: Enter a dashed line

Record 4: Initial values for all the three parameters

Record 5: Same as in section 3

SECTION 7: Distribution of recruitment (a gamma distribution)

Record 1: A blank space, serves as the section divider

Record 2: Variable names used in this section

ALPHA = shape parameter of gamma distribution
BETA = scale parameter of gamma distribution

Record 3: Enter a dashed line

Record 4: Initial values for the two parameters

Record 5: Same as in section 3

SECTION 8: Initial population size (NZERO)

Record 1: A blank space, serves as the section divider

Record 2: Variable names used in this section

Record 3: Enter a dashed line

Record 4: Initial values for NZERO

Record 5: Same as in section 3

SECTION 9: Observed catch-at-length data (COBS(l,t), l = 1 to LMAX, t = 1 to TMAX)

Record 1: A blank space, serves as the section divider

Record 2: Variable names used in this section

Record 3: Enter a dashed line

DATA MATRIX 1:

Record 1: Blank

Record 2: Description of catch-at-length data for the first matrix

Record 3: Enter a dashed line

Record 4: Number of time steps in this panel

Records 5, 6, 7, etc: Observed catch-at-length

DATA MATRIX 2: If present, is catch-at-length for the next set of times up until 2*NOD

DATA MATRIX 3: If present, etc.

Precaution:

The user is reminded that large optimization problems often respond to certain combinations of initial values with estimates that are inconsistent. We suggest that the estimates should be generated by successive applications of the program so that trends in estimates become apparent. An inconsistent estimate would clearly show up in this context and should simply be ignored.

THEORY AND COMPUTATION

The theory of CASA is described in the paper by Sullivan, Lai and Gallucci (1990). This section provides some basic concepts that will assist the user in running CASA efficiently and in interpreting its results.

Catch Equation:

Based on the Baranov catch equation, the catch is assumed to be taken at discrete times. The catch of a certain length class l at time t is calculated as

$$C(l, t) = N(l, t) \frac{F(l, t) \left[1 - \exp(-Z(l, t))\right]}{Z(l, t)} \qquad [1]$$

where

$Z(l,t) = F(l,t) + M$

$F(l,t)$ = instantaneous fishing mortality rate for length l and time t

M = natural mortality rate assumed to be a known constant over time and length

$C(l,t)$ = predicted catch-at-length l and time t

$N(l,t)$ = population size at length l and time t

The mortality rates are based on the time unit between two consecutive sample collections (e.g., week, 3 months, year, etc.) In version 1.0 of CASA, a constant time step between two sample collections is required.

- **Computation of N(l,1):**

The population size-at-length l at time t = 1, N(l,1), can be calculated as

$$N(l, 1) = NZERO * P(l) \qquad [2]$$

where

NZERO = ΣN(l,t)

and

$$P(l) = \frac{N(l, 1)}{NZERO} = \frac{\dfrac{C(l, 1)\, Z(l, 1)}{F(l, 1)\left[1 - \exp(-Z(l, 1))\right]}}{\sum \left\{ \dfrac{C(l, 1)\, Z(l, 1)}{F(l, 1)\left[1 - \exp(-Z(l, 1))\right]} \right\}} \qquad [3]$$

Dividing the numerator and denominator of P(l) by ΣC(l,1), we obtain

$$P(l) = \frac{N(l, 1)}{NZERO} = \frac{\dfrac{C(l, 1)\, Z(l, 1)}{\left(\sum C(l, 1)\right) F(l, 1)\left[1 - \exp(-Z(l, 1))\right]}}{\sum \left\{ \dfrac{C(l, 1)\, Z(l, 1)}{\left(\sum C(l, 1)\right) F(l, 1)\left[1 - \exp(-Z(l, 1))\right]} \right\}} \qquad [4]$$

Letting $Q(l,1) = C(l,1)/\Sigma C(l,1)$ and substituting into [4] yields

$$N(l,1) = NZERO \frac{\dfrac{Q(l,1)\,Z(l,1)}{F(l,1)\left[1 - \exp(-Z(l,1))\right]}}{\sum \left\{ \dfrac{Q(l,1)\,Z(l,1)}{F(l,1)\left[1 - \exp(-Z(l,1))\right]} \right\}} \qquad [5]$$

where $Q(l,1)$ is the proportion of the length frequency distribution and can be calculated based on the observed catch $C_{obs}(l,1)$. With this formulation, we reduce LMAX parameters to one parameter NZERO.

- Fishing Mortality and Selectivity:

We use Doubleday's separable model for fishing mortality, i.e., the fishing mortality for length class l at time t, $F(l,t)$, can be expressed as the product of the selectivity of length class l, $S(l)$, and full-recruitment fishing mortality $F(t)$ at time t:

$$F(l,t) = S(l) * F(t) \qquad [6]$$

Here, $F(.,.)$ is a two dimensional function and $F(.)$ is a univariate function and may look quite different from each other.

If necessary, one could further express the time dependent fishing mortality F(t) as the product of the catchability and fishing effort as a function of time E(t). Many functions may be assumed for selectivity. One of the most versatille is the logistic function. In release 1.0, only the logistic function is used. Later releases of CASA will offer other functions to allow more flexibility.

The logistic function is given by:

$$S(l) = \frac{1}{1 + a_2 \exp(-a_1 l')} \qquad [7]$$

where l' is the mid-length class l. The logistic function is frequently used to represent a situation where fish are thought to recruit into the fishery gradually, beginning at a small size, and slowly increasing with length, and finally becoming fully vulnerable to the gear at a certain length. The logistic function is rather general in its ability to express a wide range of fully vulnerable sizes. However, this function has always an inflection point at S(l) = 0.5 which forces a symmetry that may not be present in the data. This is one disadvantage of the use the logistic function for selectivity.

- **Recruitment:**

Knife-edge recruitment as described by Ricker (1975) is not assumed in the present application. We adopt a partial

recruitment concept in CASA such that fish can enter the fishery over several length classes which may extend over several ages according to the stochasticity of growth. The probability distribution of length when recruitment occurs is described by a gamma probability density

$$g(x) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}} x^{\alpha-1} e^{-x/\beta} = \frac{1}{\Gamma(\alpha)\beta} \left[\frac{x}{\beta}\right]^{\alpha-1} e^{-x/\beta} \qquad [8]$$

where x is the variable representing length at recruitment of individual fish, α is the shape parameter and β is the scale parameter of the gamma distribution (Hoag and Craig, 1970.) In the program, we use polynomial approximation to compute $\Gamma(\alpha)$. The cumulative probability function up to length l is then computed as

$$G(x) = \frac{1}{\Gamma(\alpha)} \int_0^l \frac{1}{\beta} \left[\frac{x}{\beta}\right]^{\alpha-1} e^{-x/\beta} dx \qquad [9]$$

The cumulative probability function is easier to handle via the transformation of x to x/β. If we let $\mu = x/\beta$, the cumulative probability function can be written as

$$G(\mu) = \frac{1}{\Gamma(\alpha)} \int_0^{\frac{l}{\beta}} \mu^{\alpha-1} e^{-\mu} d\mu \qquad [10]$$

From now on, we assign the subscript 'r' to the parameters α and β to refer to recruitment. The probability of recruitment into the lth length class, with length range of [l,l'], is $p(l) = G(\mu') - G(\mu)$, where $\mu = l/\beta$ and $\mu' = l'/\beta$.

The number of fish recruited into the lth length class at time t is

$$R(l,t) = R(t) * P(l) \qquad [11]$$

where $R(t) = \Sigma R(l,t)$ is the total number of fish recruited at time t with limits l = 1 to l = LMAX.

There is no need to specify the maximum length of recruitment in order to make recruitment well defined, especially to separate the recruited individuals from the fully recruited segment of the population. Using the recruitment model described above , we can reduce the number of parameters to be estimated from MAXR * TMAX to TMAX + 2 (TMAX and the shape and scale parameters of the gamma distribution.) Since the mean of the gamma distribution is $\alpha_r\beta_r$ and the variance is $\alpha_r\beta_r^2$, we can easily obtain an initial estimates of α_r and β_r by analyzing the first mode of the length frequency distributions and computing the mean length and the variance of recruitment.

- Growth:

One difference between the CASA model and age-structured models is that the age of fish is not directly expressed. The terminology of age in CASA is treated as the time interval between two time steps when two consecutive

length frequency distributions are sampled, i.e., Δt. Therefore, the formal von Bertalanffy growth equation

$$l_t = L_\infty \left[1 - e^{-k(t-t_o)}\right] \qquad [12]$$

cannot apply is CASA. To accommodate this difference, we use the growth increment of a fish starting from length l during time interval Δt as

$$\Delta l = l_{t+\Delta t} - l_t = (L_\infty - l)(1 - e^{-k\Delta t}) \qquad [13]$$

When we set Δt = 1 unit of time (e.g., 1 week, 1 month, etc.), the equation becomes

$$\Delta l = (L_\infty - l)(1 - e^{-k}) \qquad [14]$$

where the units of k are expressed in terms of a per unit time interval. The growth is then described independently of age over the designated time unit and independently of t_o.

Applying this formula to a discrete length frequency histogram and taking into account variation in growth represented by stochasticity, we denote l' as the mid-length of class l where the fish starts to grow and Δl_i as the

length increment of the ith fish in the length class l. The probability distribution of the length increment Δl is assumed to be gamma distributed with mean growth of $\Delta l = \alpha_g \beta_g$ and variance $\sigma^2 = \alpha_g \beta_g^2$. Since $\alpha g = \Delta l / \beta_g$ and Δl is calculated from L_∞ and k, so only β_g needs to be estimated. Therefore, there are three parameters to be estimated in the growth model. The proportion, FRACT(l,l'), of fish growing from length class l to any other length class l' is found by the difference of the two cumulative gamma probabilities [9],

$$\mathrm{FRACT}(l, l') = G\left[\frac{l'}{\beta_g}\right] - G\left[\frac{l}{\beta_g}\right] \qquad [15]$$

Since L_∞ is a parameter in a stochastic growth equation, it may be smaller than the largest fish found in the sample. This will cause the problem of $\Delta l \leq 0$ in the length classes l's where $l \geq L_\infty$. To avoid this problem, we use the equation

$$\Delta l_j = (1 - e^{-k})\, \Delta l_{j-1} \qquad [16]$$

where j indexes the length class $l \geq L_\infty$.

- **Computation of N(l,t) from t = 2 to TMAX:**

Applying the models described in the previous sections, the population size-at-length can be calculated as

$$N(l', t+1) = \sum_{l=1}^{lmax} FRAC(l, l') \, N(l, t) \exp(-Z(l, t)) + R(l', t+1) \qquad [17]$$

where l' now refers to the next length interval.

- **Optimization:**

After N(l,t) is computed, C(l,t) can be calculated from the Baranov catch equation. These predicted catches are different from the observed catches. It is assumed that this difference is additive random error with mean zero and a constant variance. Thus, non-linear least squares can be applied to

$$\text{Minimize} \sum_{l=1}^{lmax} \sum_{t=1}^{tmax} \left[C_{obs}(l, t) - C(l, t)\right]^2 \qquad [18]$$

The modified Levenberg-Marquardt technique is used to find the least squares estimates of the model parameters.

INTERPRETATION OF THE OUTPUT

As mentioned earlier, CASA will prompt the user for an input and an output file names. The detailed description of the input file has been presented previously. This section describes the contents of the CASA output file. This can be divided into nine (9) sections:

SECTION 1: List of input values:

When CASA starts execution, all the input values will be echoed in the first section of the output file. From this list, the user can check of there is any input error, otherwise, this section must look exactly the same as the input file.

SECTION 2: List of observed and estimated catch-at-length:

This table lists the observed and estimated catch-at-length data at each time step. The user can compare the difference between these two items, especially where the peaks of catch occur, to make qualitative evaluation of whether the estimates are acceptable or not. A residual plot can be generated from this data. The trend of the deviations between observed and estimated catch can be examined. If a trend exists, it is an indication that the assumptions of constant growth, selectivity, and recruitment distributions

over time may not be valid. Some modification to the model is thus required.

SECTION 3: List of estimated initial population size, recruitment, and population size-at-length.

SECTION 4: List of estimated parameters of gamma distribution and recruitment proportion for each length class.

SECTION 5: List of estimated parameters of the selectivity curve and selectivity by length.

SECTION 6: List of estimated instantaneous fishing mortality rates.

SECTION 7: List of the estimated parameters of the von Bertalanffy growth equation.

SECTION 8: List of the growth pattern of fish in each age class.

SECTION 9: Summary of the estimates.

EXAMPLE

In this section we provide a simulation example of how to use CASA. This example simulates the Pacific cod population in the Eastern Bering sea. Ten years of catch-at-length data were simulated based upon the population length distribution in 1977. The length frequency distribution of catch were grouped into 2 cm intervals. The input and output of the program are displayed in Appendix I and II respectively. The true value of the parameters are

displayed in Appendix III. As can be observed from this table, the estimates are very close to the true value of the parameters.

We also used the same simulation program to examine CASA's output sensitivity to various input parameters. The data were grouped into 1 cm intervals. The first analysis consisted of testing the sensitivity of the estimates to different patterns and selctivity of gear. When the selectivity was equal to 1 for all length classes, the estimated parameters and catch-at-length were satisfactory. However, when the selectivity was set equal to .1, the estimates were very different from the true value of the parameters. When the selectivity was set to 0 for the first length class and then increased to 1 for various length classes,i.e., to the 15th, 30th, 50th, and 90th classes, the magnitude of deviation of the estimates from the true values increased as the fully vulnerable length class increased. Finally, the selectivity was set to 0.5 for the first length class and increased to 1 for the 15th, 30th, 50th, and 90th length classes. The magnitude of deviation of the estimates from the true values of the parameters in this case was substantially reduced compared to the previous results. This pattern indicates that CASA does not perform well when the fishing mortality rate in each length class is too low. The evidence agrees with that of catch-at-age analysis (e.g., cohort analysis, virtual population analysis,

etc.),i.e., that fishing mortality should be a major fraction of total mortality.

When one applies CASA to a real dat set, the challenges are different. In our simulation example, giving different initial values for NZERO can cause different interpretations of recruitment, fishing mortality and growth of the population. Therefore, auxiliary information about the estimates is very helpful. If this is not available, we suggest equation [1] to compute N(1,1) using the best guessed mortality rates.

Changes in the starting values of L_∞ and k affected greatly the estimates. These two parameters govern the progress of a length mode representing a cohort. They influence the estimation of other parameters. The larger the β_k, the wider and more "skewed" the gamma distribution. This indicates that the growth of fish from one length class, especially the smallest ones, to other length classes might extend and cover few modes that would not be real in the population. The problem then becomes that a major part of the fish are growing faster than expected with a larger k estimate and thus a smaller L_∞ (Gallucci and Quinn, 1978). These problems are illustrated by the catch-at-length data of the pelagic scad Decapterus russelli in the Java sea (W' 'odo, 1988).

Sullivan et al. (1990) applied CASA to the catch-at-length data of demersal Nemipterus japonicus for the period May-December in Karimun, Java. The results obtained from

CASA reflect the cohort progress and catch intensity very well. This shows that the "quality" of the data as an important factor and efforts must be extended to produce the best data set possible. CASA rewards the management agency with a complete array of stock assessment parameters. One must be seriously concerned with the pooling of the data sets across fishing grounds and over time. The pooled data set may give good estimates of growth but will distort the history of the fisheries. Also, the more modes of length groups that can be descerne and followed diagonally across the page, the more likely that CASA will give "good" estimates. This, of course, is a classic problem in stock assessment and fishery management. A third example dealing with the fishery on the demersal Long Neck Croake (Pseudololithus typus) off the coast of Cameroon is contained in the paper by Sullivan et al. (1990) and is not repeated here.

ERROR MESSAGES

This section summarizes some error messages that frequently occur in CASA and the actions that should be taken:

1. Input conversion errors:

You may have a format error in the input file. Check the input file and correct the errors.

2. Output conversion errors:

We tried to make the output file general for all data sets, but there could be exceptions. CHange the corresponding FORMAT in SUBROUTINE OUTPUT.

3. Underflows and overflows:

This error occurs most often when calculating the proportion of recruitment into length classes. This may happen when α_r and β_r are out of range, especially $\mu = \alpha_r\beta_r$ > MAXR. It might also occur in other subroutines such as growth if the initial value of k is chosen to be very small. In these cases, the initial value of the parameters must be changed.

4. XERROR

This indicates that the convergence test in the optimization procedure is not based on the check of tolerance (current SSQ/previous SSQ ≤ TOL.) Check the results and decide whether they are acceptable. If not, use different initial values and re-submit the job.

We have reduced the possibility of these errors in CASA, but they may occur in some special cases. The user is encouraged to report to Dr. V.F. Gallucci any new problem that may improve the present release of CASA. This contribution will be acknowledged in future revised Releases as CASA evolves.

Reference

SULLIVAN, P.J., H.-L. LAI AND V.F. GALLUCCI. 1990. A catch-at-length analysis that incorporates a stochastic model of growth. Can. J. Fish. Aquat. Sci. 47:184-198

APPENDIX I. CASA INPUT FILE

```
CATCH AT LENGTH DATA, SIM3.F

LINC     VBLMIN    VBLMAX      M     NOA  NOY    T
----     ------    ------    ----    ---  ---    -
   2.      0.     90. 0.3000   1  10  32

R(T)  T=2,TMAX
--------------
 .57500E+09  .93000E+08  .18100E+09  .10600E+09  .63000E+08
 .11500E+09  .15000E+09  .90000E+08  .10600E+09
  1   1   1   1   1   1   1   1   1

A1, A2 FOR THE SELECTIVITY CURVE
--------------------------------
  0.3000  20.0000  1 90 90
  1   1

F(T), T=1,TMAX
--------------
 .3  .6  .3  .65 .25 .6  .7  .3  .6  .3
  1   1   1   1   1   1   1   1   1   1

VBLINF     VBK     BETA
------     ---     ----
   95.000     0.300     1.400
  1   1   1

ALPHA and BETA of RECRUITMENT
-----------------------------
   25.000     0.700
  1   1
```

APPENDIX I. CASA INPUT FILE (Continued)

```
NZERO
-----------------------------
    1000000000
 1

COBS(L,T)  T=1,TMAX
-----------------------------

CATCH AT LENGTH DATA IN YEAR  0
-----------------------------
 10
        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
       44.        0.        0.        0.        0.        0.        0.        0.        0.        0.
     1023.        2.        1.        1.        0.        0.        1.        0.        0.        0.
    15249.      714.      223.      245.      148.      158.      273.      185.      188.      153.
   147082.    34790.    10853.    11917.     7222.     7716.    13277.     9002.     9173.     7464.
   918816.   438807.   136871.   150254.    91069.    97287.   167448.   113502.   115737.    94152.
  3718929.  2141383.   667780.   732923.   444268.   474554.   817008.   553651.   564962.   459474.
  9753797.  5153265.  1606576.  1762385.  1068490.  1141113.  1965094.  1331415.  1359628.  1105486.
 16575645.  7192393.  2243812.  2453294.  1488810.  1588475.  2735048.  1854844.  1894161.  1540545.
 18255256.  6623529.  2092064.  2227938.  1362092.  1442636.  2473740.  1696009.  1719574.  1405829.
 13085590.  4891942.  1684810.  1516573.   974935.   982358.  1630969.  1210292.  1159901.   985963.
  6369441.  4679313.  1992860.  1083506.   840427.   702670.  1002718.  1033245.   792932.   790592.
  2933109.  7547359.  3532603.  1266418.  1198620.   820808.   920505.  1460478.   869738.  1053178.
  2962936. 12999805.  5946434.  1906662.  1901011.  1225157.  1234011.  2306218.  1268369.  1638482.
  4645130. 18548084.  8270665.  2644117.  2568086.  1652368.  1610668.  3093483.  1703647.  2204196.
  6271422. 21280592.  9862601.  3292274.  2897366.  1915651.  1806368.  3423378.  1972918.  2474570.
  6634985. 20124494. 11109676.  4023887.  2891464.  2038696.  1799793.  3256509.  2094000.  2436727.
  5488430. 16461832. 12969672.  5151347.  2792060.  2174502.  1728116.  2853624.  2220075.  2284196.
  3607040. 12560291. 15719003.  6737171.  2832861.  2406630.  1715299.  2487270.  2431558.  2198526.
  1985388.  9734994. 18356812.  8530848.  3105217.  2664130.  1777382.  2250190.  2642511.  2218942.
  1063392.  7906561. 19407970. 10289296.  3617866.  2825593.  1867415.  2094029.  2705363.  2291395.
   712149.  6401014. 18218340. 11969208.  4375284.  2859849.  1951510.  1959280.  2560512.  2365870.
   639087.  4831603. 15356501. 13485174.  5357306.  2852155.  2020478.  1835034.  2268294.  2415539.
   649890.  3299036. 11929089. 14434769.  6480402.  2930856.  2062504.  1735716.  1932648.  2404847.
```

669041.	2068415.	8751887.	14285486.	7608558.	3190659.	2064479.	1667254.	1627196.	2291223.
678775.	1263872.	6122928.	12849771.	8551493.	3656569.	2042238.	1619751.	1380441.	2063722.
677167.	826066.	4061754.	10474451.	9042833.	4275908.	2050673.	1576768.	1194193.	1760248.
664675.	620380.	2538331.	7782122.	8818601.	4919120.	2153866.	1530628.	1059361.	1443043.
642550.	530234.	1511325.	5308208.	7801991.	5386734.	2377955.	1496614.	962436.	1163447.
612593.	485652.	894949.	3341787.	6205009.	5456019.	2675727.	1510413.	891824.	945377.
576217.	453707.	565893.	1954759.	4423079.	4992315.	2920672.	1598205.	846376.	789071.
534044.	421978.	404457.	1082628.	2828508.	4057013.	2949566.	1734076.	836002.	684757.
486635.	386754.	324423.	593990.	1631016.	2897380.	2656443.	1822292.	863146.	625202.
438074.	347664.	276836.	347192.	861163.	1809799.	2079487.	1742033.	895291.	604603.
383014.	305186.	239011.	229108.	432564.	991095.	1391847.	1442355.	865417.	599995.
332017.	260458.	202442.	168444.	221814.	483570.	790311.	1000903.	724058.	562360.
284306.	216563.	165547.	129149.	124946.	219300.	382136.	571037.	497116.	452314.
240416.	175650.	129894.	97250.	77673.	99395.	161173.	266404.	271200.	290172.
199950.	138678.	97535.	69593.	49733.	47799.	62451.	102978.	116003.	142073.
162369.	105930.	69818.	46659.	30559.	23988.	23651.	34216.	39187.	52133.
127613.	77704.	47436.	29184.	17398.	11739.	8940.	10273.	10768.	14446.
96253.	54530.	30672.	17204.	9230.	5425.	3320.	2915.	2532.	3141.
69174.	36399.	18855.	9639.	4650.	2398.	1218.	821.	551.	579.
47107.	24083.	12063.	5925.	2722.	1315.	600.	332.	166.	130.
30276.	15363.	7629.	3708.	1681.	797.	352.	180.	77.	47.

APPENDIX II. CASA OUTPUT FILE

```
CATCH AT LENGTH DATA, SIM3.F

LINC      VBLMIN     VBLMAX      M      NOA  NOY    T
----      ------     ------    ----    ---  ---    -
 2.000000      0.0000000E+00   90.00000      0.3000000              1
       10          32

R(T)  T=2,TMAX
--------------
5.7500000E+08  9.3000000E+07  1.8100000E+08  1.0600000E+08  6.3000000E+07
1.1500000E+08  1.5000000E+08  9.0000000E+07  1.0600000E+08
        1           1           1           1           1           1
        1           1           1

A1, A2 FOR THE SELECTIVITY CURVE
--------------------------------
0.3000000       20.00000              90          90
        1           1

F(T), T=1,TMAX
--------------
0.3000000      0.6000000      0.3000000      0.6500000      0.2500000
0.6000000      0.7000000      0.3000000      0.6000000      0.3000000
        1           1           1           1           1           1
        1           1           1           1

VBLINF     VBK     BETA
------     ---     ----
 95.00000      0.3000000      1.400000
        1           1           1

ALPHA and BETA of RECRUITMENT
-----------------------------
 25.00000      0.7000000
        1           1
```

APPENDIX II. CASA OUTPUT FILE (Continued)

```
NZERO
-----------------------------
1.0000000E+09
        1

COBS(L,T)  T=1,TMAX
-----------------------------

CATCH AT LENGTH DATA IN YEAR  0
-----------------------------
```

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1023.	2.	1.	1.	0.	0.	1.	0.	0.	0.
15249.	714.	223.	245.	148.	158.	273.	185.	188.	153.
147082.	34790.	10853.	11917.	7222.	7716.	13277.	9002.	9173.	7464.
918816.	438807.	136871.	150254.	91069.	97287.	167448.	113502.	115737.	94152.
3718929.	2141383.	667780.	732923.	444268.	474534.	817008.	553651.	564962.	459474.
9753797.	5153265.	1606576.	1752385.	1068490.	1141113.	1965094.	1331415.	1359628.	1105486.
16575645.	7192393.	2243812.	2453294.	1488810.	1588475.	2735048.	1854844.	1894161.	1540545.
18255256.	6623529.	2092064.	2227938.	1362092.	1442636.	2473740.	1696009.	1719574.	1405829.
13085590.	4891942.	1684810.	1516573.	974935.	982358.	1630969.	1210292.	1159901.	985963.
6369441.	4679313.	1992860.	1083506.	840427.	702670.	1002718.	1033245.	792932.	790592.
2933109.	7547859.	3532603.	1266418.	1198620.	820808.	920505.	1460478.	869738.	1053178.
2962936.	12999805.	5946434.	1906662.	1901011.	1225157.	1234011.	2306218.	1268369.	1638482.
4645130.	18548084.	8270665.	2644117.	2568086.	1652368.	1610668.	3093483.	1703647.	2204196.
6271422.	21280592.	9862601.	3292274.	2897366.	1915651.	1806368.	3423378.	1972918.	2474570.
6634985.	20124494.	11109676.	4023887.	2691464.	2038696.	1799793.	3256509.	2094000.	2436727.
5488430.	16461832.	12969672.	5151347.	2792060.	2174502.	1728116.	2853624.	2220075.	2284196.
3607040.	12560291.	15719003.	6737171.	2832861.	2406630.	1715299.	2487270.	2431558.	2198526.
1985388.	9734994.	18356812.	8530848.	3105217.	2664130.	1777382.	2250190.	2642511.	2218942.
1063392.	7906561.	19407970.	10289296.	3617866.	2825593.	1867415.	2094029.	2705363.	2291395.
712149.	6401014.	18218340.	11969208.	4375284.	2859849.	1951510.	1959280.	2560512.	2365870.
639087.	4831603.	15356501.	13485174.	5357306.	2852155.	2020478.	1835034.	2268294.	2415539.
649890.	3299036.	11929089.	14434769.	6480402.	2930856.	2062504.	1735716.	1932648.	2404847.
669041.	2068415.	8751887.	14285486.	7608558.	3190659.	2064479.	1667254.	1627196.	2291223.

APPENDIX II. CASA OUTPUT FILE (Continued)

678775.	1263872.	6122928.	12849771.	8551493.	3656569.	2042238.	1619751.	1380441.	2063722.
677167.	826066.	4061754.	10474451.	9042833.	4275908.	2050673.	1576768.	1194193.	1760248.
664675.	620380.	2538331.	7782122.	8818601.	4919120.	2153866.	1530628.	1059361.	1443043.
642550.	530234.	1511325.	5308208.	7801991.	5386734.	2377955.	1496614.	962436.	1163447.
612593.	485652.	894949.	3341787.	6205009.	5456019.	2675727.	1510413.	891824.	945377.
576217.	453707.	565893.	1954759.	4423079.	4992315.	2920672.	1598205.	846376.	789071.
534044.	421978.	404457.	1082628.	2828508.	4057013.	2949566.	1734076.	836002.	684757.
486635.	386754.	324423.	593990.	1631016.	2897380.	2656443.	1822292.	863146.	625202.
438074.	347664.	276836.	347192.	861163.	1809799.	2079487.	1742033.	895291.	604603.
383014.	305186.	239011.	229108.	432564.	991095.	1391847.	1442355.	865417.	599995.
332017.	260458.	202442.	168444.	221814.	483570.	790311.	1000903.	724058.	562360.
284306.	216563.	165547.	129149.	124946.	219300.	382136.	571037.	497116.	452314.
240416.	175650.	129894.	97250.	77673.	99395.	161173.	266404.	271200.	290172.
199950.	138678.	97535.	69593.	49733.	47799.	62451.	102978.	116003.	142073.
162369.	105930.	69818.	46659.	30559.	23988.	23651.	34216.	39187.	52133.
127613.	77704.	47436.	29184.	17398.	11739.	8940.	10273.	10768.	14446.
96253.	54530.	30672.	17204.	9230.	5425.	3320.	2915.	2532.	3141.
69174.	36399.	18855.	9639.	4650.	2398.	1218.	821.	551.	579.
47107.	24083.	12063.	5925.	2722.	1315.	600.	332.	166.	130.
30276.	15363.	7629.	3708.	1681.	797.	352.	180.	77.	47.

1

APPENDIX II. CASA OUTPUT FILE (Continued)

REPORT OF CATCH AT SIZE ANALYSIS
FINAL MODIFIED SUM OF SQUARES = .9120082E+06

FINAL MODIFIED SUMS OF SQUARES = .9120082E+06
1 TABLE 1. OBSERVED AND ESTIMATED CATCH-AT-LENGTH

	TIME									
	1	2	3	4	5	6	7	8	9	10
COBS(1,T)=	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CEST(1,T)=	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COBS(2,T)=	44.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CEST(2,T)=	44.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COBS(3,T)=	1023.	2.	1.	1.	0.	0.	1.	0.	0.	0.
CEST(3,T)=	1023.	2.	1.	1.	0.	0.	1.	0.	0.	0.
COBS(4,T)=	15249.	714.	223.	245.	148.	158.	273.	185.	188.	153.
CEST(4,T)=	15249.	714.	223.	245.	148.	158.	273.	185.	188.	153.
COBS(5,T)=	147082.	34790.	10853.	11917.	7222.	7716.	13277.	9002.	9173.	7464.
CEST(5,T)=	147082.	34792.	10854.	11917.	7222.	7716.	13278.	9002.	9174.	7465.
COBS(6,T)=	918816.	438807.	136871.	150254.	91069.	97287.	167448.	113502.	115737.	94152.
CEST(6,T)=	918816.	438817.	136874.	150257.	91071.	97289.	167451.	113504.	115740.	94154.

APPENDIX II. CASA OUTPUT FILE (Continued)

COBS(7,T)=	3718929.	2141383.	667780.	732923.	444268.	474554.	817008.	553651.	564962.	459474.
CEST(7,T)=	3718929.	2141413.	667789.	732932.	444274.	474560.	817020.	553659.	564969.	459481.
COBS(8,T)=	9753797.	5153265.	1606576.	1762385.	1068490.	1141113.	1965094.	1331415.	1359628.	1105486.
CEST(8,T)=	9753797.	5153262.	1606575.	1762381.	1068489.	1141111.	1965093.	1331414.	1359626.	1105485.
COBS(9,T)=	16575645.	7192393.	2243812.	2453294.	1488810.	1588475.	2735048.	1854844.	1894161.	1540545.
CEST(9,T)=	16575645.	7192126.	2243728.	2453199.	1488754.	1588412.	2734945.	1854776.	1894090.	1540488.
COBS(10,T)=	18255256.	6623529.	2092064.	2227938.	1362092.	1442636.	2473740.	1696009.	1719574.	1405829.
CEST(10,T)=	18255256.	6623622.	2092093.	2227967.	1362112.	1442654.	2473776.	1696034.	1719599.	1405850.
COBS(11,T)=	13085590.	4891942.	1684810.	1516573.	974935.	982358.	1630969.	1210292.	1159901.	985963.
CEST(11,T)=	13085589.	4892036.	1684843.	1516606.	974956.	982379.	1631008.	1210318.	1159928.	985986.
COBS(12,T)=	6369441.	4679313.	1992860.	1083506.	840427.	702670.	1002718.	1033245.	792932.	790592.
CEST(12,T)=	6369441.	4679363.	1992878.	1083527.	840439.	702683.	1002741.	1033260.	792948.	790604.
COBS(13,T)=	2933109.	7547859.	3532603.	1266418.	1198620.	820808.	920505.	1460478.	869738.	1053178.
CEST(13,T)=	2933109.	7547857.	3532590.	1266421.	1198618.	820809.	920511.	1460475.	869741.	1053177.
COBS(14,T)=	2962936.	12999805.	5946434.	1906662.	1901011.	1225157.	1234011.	2306218.	1268369.	1638482.
CEST(14,T)=	2962936.	12999789.	5946401.	1906656.	1901000.	1225153.	1234007.	2306204.	1268364.	1638473.
COBS(15,T)=	4645130.	18548084.	8270665.	2644117.	2568086.	1652368.	1610668.	3093483.	1703647.	2204196.
CEST(15,T)=	4645130.	18548160.	8270679.	2644123.	2568089.	1652372.	1610669.	3093485.	1703649.	2204198.
COBS(16,T)=	6271422.	21280592.	9862601.	3292274.	2897366.	1915651.	1806368.	3423378.	1972918.	2474570.
CEST(16,T)=	6271422.	21280450.	9862534.	3292254.	2897344.	1915638.	1806351.	3423350.	1972903.	2474550.
COBS(17,T)=	6634985.	20124494.	11109676.	4023887.	2891464.	2038696.	1799793.	3256509.	2094000.	2436727.
CEST(17,T)=	6634985.	20124552.	11109714.	4023896.	2891477.	2038703.	1799799.	3256523.	2094006.	2436737.
COBS(18,T)=	5488430.	16461832.	12969672.	5151347.	2792060.	2174502.	1728116.	2853624.	2220075.	2284196.
CEST(18,T)=	5488430.	16461791.	12969660.	5151331.	2792061.	2174499.	1728115.	2853626.	2220071.	2284196.

COBS(19,T)=	3607040.	12560291.	15719003.	6737171.	2832861.	2406630.	1715299.	2487270.	2431558.	2198526.
CEST(19,T)=	3607040.	12560342.	15719042.	6737173.	2832875.	2406635.	1715306.	2487286.	2431563.	2198536.
COBS(20,T)=	1985388.	9734994.	18356812.	8530848.	3105217.	2664130.	1777382.	2250190.	2642511.	2218942.
CEST(20,T)=	1985388.	9735017.	18356782.	8530820.	3105218.	2664125.	1777382.	2250195.	2642504.	2218942.
COBS(21,T)=	1063392.	7906561.	19407970.	10289296.	3617866.	2825593.	1867415.	2094029.	2705363.	2291395.
CEST(21,T)=	1063392.	7906581.	19408028.	10289313.	3617873.	2825600.	1867419.	2094036.	2705369.	2291400.
COBS(22,T)=	712149.	6401014.	18218340.	11969208.	4375284.	2859849.	1951510.	1959280.	2560512.	2365870.
CEST(22,T)=	712149.	6400996.	18218278.	11969170.	4375270.	2859841.	1951504.	1959275.	2560505.	2365862.
COBS(23,T)=	639087.	4831603.	15356501.	13485174.	5357306.	2852155.	2020478.	1835034.	2268294.	2415539.
CEST(23,T)=	639087.	4831610.	15356542.	13485187.	5357304.	2852161.	2020480.	1835036.	2268301.	2415541.
COBS(24,T)=	649890.	3299036.	11929089.	14434769.	6480402.	2930856.	2062504.	1735716.	1932648.	2404847.
CEST(24,T)=	649890.	3299024.	11929069.	14434729.	6480375.	2930850.	2062497.	1735711.	1932646.	2404838.
COBS(25,T)=	669041.	2068415.	8751887.	14285486.	7608558.	3190659.	2064479.	1667254.	1627196.	2291223.
CEST(25,T)=	669041.	2068423.	8751927.	14285518.	7608563.	3190664.	2064482.	1667257.	1627203.	2291228.
COBS(26,T)=	678775.	1263872.	6122928.	12849771.	8551493.	3656569.	2042238.	1619751.	1380441.	2063722.
CEST(26,T)=	678775.	1263873.	6122935.	12849768.	8551480.	3656563.	2042237.	1619749.	1380442.	2063722.
COBS(27,T)=	677167.	826066.	4061754.	10474451.	9042833.	4275908.	2050673.	1576768.	1194193.	1760248.
CEST(27,T)=	677167.	826067.	4061770.	10474489.	9042845.	4275908.	2050676.	1576770.	1194196.	1760254.
COBS(28,T)=	664675.	620380.	2538331.	7782122.	8818601.	4919120.	2153866.	1530628.	1059361.	1443043.
CEST(28,T)=	664675.	620379.	2538334.	7782132.	8818605.	4919116.	2153865.	1530626.	1059361.	1443046.
COBS(29,T)=	642550.	530234.	1511325.	5308208.	7801991.	5386734.	2377955.	1496614.	962436.	1163447.
CEST(29,T)=	642550.	530231.	1511321.	5308204.	7801984.	5386722.	2377950.	1496611.	962434.	1163446.
COBS(30,T)=	612593.	485652.	894949.	3341787.	6205009.	5456019.	2675727.	1510413.	891824.	945377.
CEST(30,T)=	612593.	485652.	894952.	3341796.	6205022.	5456022.	2675726.	1510413.	891825.	945379.

COBS(31,T)=	576217.	453707.	565893.	1954759.	4423079.	4992315.	2920672.	1598205.	846376.	789071.
CEST(31,T)=	576217.	453706.	565892.	1954758.	4423082.	4992316.	2920670.	1598204.	846376.	789072.
COBS(32,T)=	534044.	421978.	404457.	1082628.	2828508.	4057013.	2949566.	1734076.	836002.	684757.
CEST(32,T)=	534044.	421978.	404458.	1082635.	2828520.	4057021.	2949569.	1734076.	836003.	684759.
COBS(33,T)=	486635.	386754.	324423.	593990.	1631016.	2897380.	2656443.	1822292.	863146.	625202.
CEST(33,T)=	486635.	386754.	324423.	593992.	1631021.	2897386.	2656446.	1822292.	863147.	625204.
COBS(34,T)=	438074.	347664.	276836.	347192.	861163.	1809799.	2079487.	1742033.	895291.	604603.
CEST(34,T)=	438074.	347664.	276836.	347192.	861164.	1809802.	2079489.	1742033.	895292.	604604.
COBS(35,T)=	383014.	305186.	239011.	229108.	432564.	991095.	1391847.	1442355.	865417.	599995.
CEST(35,T)=	383014.	305185.	239011.	229108.	432563.	991093.	1391847.	1442355.	865418.	599997.
COBS(36,T)=	332017.	260458.	202442.	168444.	221814.	483570.	790311.	1000903.	724058.	562360.
CEST(36,T)=	332017.	260458.	202442.	168445.	221815.	483571.	790312.	1000904.	724059.	562362.
COBS(37,T)=	284306.	216563.	165547.	129149.	124946.	219300.	382136.	571037.	497116.	452314.
CEST(37,T)=	284306.	216564.	165548.	129150.	124947.	219303.	382139.	571040.	497118.	452317.
COBS(38,T)=	240416.	175650.	129894.	97250.	77673.	99395.	161173.	266404.	271200.	290172.
CEST(38,T)=	240416.	175649.	129894.	97250.	77672.	99393.	161170.	266402.	271199.	290172.
COBS(39,T)=	199950.	138678.	97535.	69593.	49733.	47799.	62451.	102978.	116003.	142073.
CEST(39,T)=	199950.	138678.	97535.	69594.	49733.	47800.	62452.	102978.	116003.	142073.
COBS(40,T)=	162369.	105930.	69818.	46659.	30559.	23988.	23651.	34216.	39187.	52133.
CEST(40,T)=	162369.	105930.	69818.	46660.	30560.	23988.	23652.	34217.	39188.	52133.
COBS(41,T)=	127613.	77704.	47436.	29184.	17398.	11739.	8940.	10273.	10768.	14446.
CEST(41,T)=	127613.	77703.	47435.	29184.	17398.	11739.	8938.	10270.	10765.	14444.

COBS(42,T)=	96253.	54530.	30672.	17204.	9230.	5425.	3320.	2915.	2532.	3141.
CEST(42,T)=	96253.	54530.	30671.	17203.	9229.	5424.	3319.	2912.	2529.	3138.
COBS(43,T)=	69174.	36399.	18855.	9639.	4650.	2398.	1218.	821.	551.	579.
CEST(43,T)=	69174.	35988.	18443.	9335.	4463.	2286.	1157.	783.	532.	565.
COBS(44,T)=	47107.	24083.	12063.	5925.	2722.	1315.	600.	332.	166.	130.
CEST(44,T)=	47107.	24132.	12115.	5966.	2748.	1332.	610.	339.	170.	135.
COBS(45,T)=	30276.	15363.	7629.	3708.	1681.	797.	352.	180.	77.	47.
CEST(45,T)=	30276.	15730.	7996.	3977.	1845.	895.	404.	212.	92.	58.

1 TABLE 2. ESTIMATED N(L,T); L=1, 45 T= 1,10
INITIAL POPULATION SIZE = .13629E+10

	T I M E									
	1	2	3	4	5	6	7	8	9	10
RECRUITMENT	------	.44200E+09	.13200E+09	.13900E+09	.86000E+08	.90000E+08	.16500E+09	.10500E+09	.12800E+09	.97001E+08
N (1,T)=	.00000E+00	.26038E-10	.77759E-11	.81883E-11	.50661E-11	.53018E-11	.97199E-11	.61854E-11	.75403E-11	.57142E-11
N (2,T)=	.25840E+04	.52100E-02	.15559E-02	.16384E-02	.10137E-02	.10608E-02	.19449E-02	.12377E-02	.15088E-02	.11434E-02
N (3,T)=	.49802E+05	.82363E+02	.24597E+02	.25901E+02	.16025E+02	.16771E+02	.30746E+02	.19566E+02	.23852E+02	.18075E+02
N (4,T)=	.61694E+06	.27599E+05	.82422E+04	.86793E+04	.53699E+04	.56197E+04	.10303E+05	.65564E+04	.79925E+04	.60569E+04
N (5,T)=	.49602E+07	.11209E+07	.33474E+06	.35249E+06	.21809E+06	.22823E+06	.41843E+06	.26627E+06	.32460E+06	.24599E+06
N (6,T)=	.25921E+08	.11828E+08	.35323E+07	.37196E+07	.23013E+07	.24084E+07	.44153E+07	.28098E+07	.34252E+07	.25957E+07
N (7,T)=	.88131E+08	.48495E+08	.14482E+08	.15249E+08	.94348E+07	.98735E+07	.18101E+08	.11519E+08	.14042E+08	.10642E+08
N (8,T)=	.19511E+09	.98527E+08	.29420E+08	.30970E+08	.19163E+08	.20052E+08	.36761E+08	.23397E+08	.28519E+08	.21613E+08
N (9,T)=	.28142E+09	.11674E+09	.34891E+08	.36617E+08	.22676E+08	.23709E+08	.43441E+08	.27685E+08	.33713E+08	.25567E+08
N (10,T)=	.26473E+09	.91858E+08	.27804E+08	.28428E+08	.17734E+08	.18408E+08	.33576E+08	.21641E+08	.26136E+08	.19932E+08
N (11,T)=	.16324E+09	.58379E+08	.19273E+08	.16662E+08	.10927E+08	.10793E+08	.19052E+08	.13297E+08	.15161E+08	.12027E+08
N (12,T)=	.68888E+08	.48430E+08	.19778E+08	.10331E+08	.81736E+07	.66999E+07	.10160E+08	.98519E+07	.89824E+07	.83624E+07
N (13,T)=	.27739E+08	.68334E+08	.30679E+08	.10570E+08	.10203E+08	.68511E+07	.81603E+07	.12190E+08	.86119E+07	.97426E+07
N (14,T)=	.24728E+08	.10390E+09	.45609E+08	.14061E+08	.14294E+08	.90348E+07	.96594E+07	.17007E+08	.11078E+08	.13378E+08

APPENDIX II. CASA OUTPUT FILE (Continued)

N (15,T)=	.34541E+08	.13214E+09	.56569E+08	.17395E+08	.17223E+08	.10871E+08	.11240E+08	.20352E+08	.13253E+08	.16039E+08
N (16,T)=	.41965E+08	.13649E+09	.60755E+08	.19516E+08	.17505E+08	.11356E+08	.11351E+08	.20293E+08	.13805E+08	.16207E+08
N (17,T)=	.40356E+08	.11737E+09	.62262E+08	.21710E+08	.15896E+08	.10999E+08	.10287E+08	.17570E+08	.13312E+08	.14509E+08
N (18,T)=	.30646E+08	.88182E+08	.66787E+08	.25549E+08	.14107E+08	.10785E+08	.90740E+07	.14153E+08	.12951E+08	.12489E+08
N (19,T)=	.18670E+08	.62395E+08	.75097E+08	.31013E+08	.13282E+08	.11078E+08	.83542E+07	.11450E+08	.13143E+08	.11145E+08
N (20,T)=	.96138E+07	.45261E+08	.82111E+08	.36782E+08	.13634E+08	.11487E+08	.81035E+07	.97022E+07	.13357E+08	.10526E+08
N (21,T)=	.48590E+07	.34701E+08	.81982E+08	.41911E+08	.15004E+08	.11509E+08	.80386E+07	.85295E+07	.12899E+08	.10259E+08
N (22,T)=	.30950E+07	.26729E+08	.73246E+08	.46419E+08	.17273E+08	.11091E+08	.79941E+07	.75984E+07	.11608E+08	.10076E+08
N (23,T)=	.26607E+07	.19334E+08	.59182E+08	.50146E+08	.20276E+08	.10606E+08	.79324E+07	.68239E+07	.98476E+07	.98566E+07
N (24,T)=	.26085E+07	.12731E+08	.44347E+08	.51794E+08	.23663E+08	.10516E+08	.78099E+07	.62280E+07	.80868E+07	.94619E+07
N (25,T)=	.26035E+07	.77405E+07	.31560E+08	.49733E+08	.26952E+08	.11108E+08	.75820E+07	.58043E+07	.65996E+07	.87413E+07
N (26,T)=	.25735E+07	.46090E+07	.21521E+08	.43612E+08	.29529E+08	.12410E+08	.73098E+07	.54975E+07	.54536E+07	.76717E+07
N (27,T)=	.25119E+07	.29479E+07	.13973E+08	.34802E+08	.30566E+08	.14207E+08	.71835E+07	.52389E+07	.46150E+07	.64028E+07
N (28,T)=	.24210E+07	.21743E+07	.85773E+07	.25401E+08	.29281E+08	.16056E+08	.74104E+07	.49961E+07	.40193E+07	.51545E+07
N (29,T)=	.23052E+07	.18306E+07	.50314E+07	.17072E+08	.25524E+08	.17325E+08	.80598E+07	.48135E+07	.35961E+07	.40935E+07
N (30,T)=	.21702E+07	.16559E+07	.29428E+07	.10617E+08	.20051E+08	.17334E+08	.89571E+07	.47987E+07	.32902E+07	.32848E+07
N (31,T)=	.20202E+07	.15311E+07	.18418E+07	.61477E+07	.14148E+08	.15701E+08	.96770E+07	.50264E+07	.30898E+07	.27134E+07
N (32,T)=	.18563E+07	.14119E+07	.13053E+07	.33765E+07	.89717E+07	.12653E+08	.96901E+07	.54082E+07	.30255E+07	.23346E+07
N (33,T)=	.16795E+07	.12849E+07	.10397E+07	.18398E+07	.51376E+07	.89741E+07	.86662E+07	.56442E+07	.31014E+07	.21165E+07
N (34,T)=	.15031E+07	.11484E+07	.88215E+06	.10693E+07	.26972E+07	.55737E+07	.67449E+07	.53650E+07	.31979E+07	.20349E+07
N (35,T)=	.13078E+07	.10033E+07	.75802E+06	.70230E+06	.13484E+07	.30381E+07	.44931E+07	.44213E+07	.30762E+07	.20097E+07
N (36,T)=	.11292E+07	.85289E+06	.63955E+06	.51436E+06	.68879E+06	.14766E+07	.25413E+07	.30563E+07	.25635E+07	.18762E+07
N (37,T)=	.96380E+06	.70687E+06	.52133E+06	.39313E+06	.38676E+06	.66755E+06	.12249E+07	.17382E+07	.17542E+07	.15042E+07
N (38,T)=	.81283E+06	.57181E+06	.40798E+06	.29526E+06	.23980E+06	.30176E+06	.51524E+06	.80881E+06	.95442E+06	.96242E+06
N (39,T)=	.67454E+06	.45047E+06	.30569E+06	.21084E+06	.15322E+06	.14481E+06	.19922E+06	.31198E+06	.40734E+06	.47019E+06
N (40,T)=	.54677E+06	.34348E+06	.21843E+06	.14111E+06	.93981E+05	.72547E+05	.75315E+05	.10348E+06	.13736E+06	.17223E+06
N (41,T)=	.42910E+06	.25159E+06	.14819E+06	.88134E+05	.53427E+05	.35450E+05	.28421E+05	.31016E+05	.37677E+05	.47646E+05
N (42,T)=	.32326E+06	.17634E+06	.95704E+05	.51893E+05	.28308E+05	.16360E+05	.10540E+05	.87846E+04	.88421E+04	.10338E+05
N (43,T)=	.23209E+06	.11627E+06	.57493E+05	.28131E+05	.13677E+05	.68879E+04	.36694E+04	.23607E+04	.18578E+04	.18613E+04
N (44,T)=	.15792E+06	.77903E+05	.37737E+05	.17964E+05	.84138E+04	.40103E+04	.19330E+04	.10197E+04	.59312E+03	.44249E+03
N (45,T)=	.10143E+06	.50746E+05	.24889E+05	.11968E+05	.56451E+04	.26936E+04	.12796E+04	.63732E+03	.32129E+03	.18925E+03

APPENDIX II. CASA OUTPUT FILE (Continued)

```
1 TABLE 3.  ESTIMATED DISTRIBUTION OF RECRUITMENT
-----------------------------------------------------------------------------------------------------------
 COEFFICIENTS OF RECRUITMENT DISTRIBUTION :
 ALPHA = .3289970E+02  BETA = .5230054E+00
        PROPORTION
 P( 1) =  0.0000000
 P( 2) =  0.0000000
 P( 3) =  0.0000002
 P( 4) =  0.0000624
 P( 5) =  0.0025359
 P( 6) =  0.0267594
 P( 7) =  0.1097045
 P( 8) =  0.2227748
 P( 9) =  0.2630760
 P(10) =  0.2021061
 P(11) =  0.1095566
 P(12) =  0.0445296
 P(13) =  0.0142167
 P(14) =  0.0036968
 P(15) =  0.0008057
 P(16) =  0.0001507
 P(17) =  0.0000246
1 TABLE 4.  ESTIMATED SE'ECTIVITY


 A1 =      0.10000 A2 =     30.00010
-----------------------------------------------------------------------------------------------------------
 SELECTIVITY AT LENGTH
-----------------------
     S( 1)=   0.0392654
     S( 2)=   0.0475471
     S( 3)=   0.0574714
     S( 4)=   0.0693170
     S( 5)=   0.0833889
```

```
S( 6)=   0.1000118
S( 7)=   0.1195181
S( 8)=   0.1422300
S( 9)=   0.1684357
S(10)=   0.1983581
S(11)=   0.2321188
S(12)=   0.2697014
S(13)=   0.3109169
S(14)=   0.3553815
S(15)=   0.4025103
S(16)=   0.4515363
S(17)=   0.5015520
S(18)=   0.5515735
S(19)=   0.6006168
S(20)=   0.6477733
S(21)=   0.6922733
S(22)=   0.7335303
S(23)=   0.7711577
S(24)=   0.8049644
S(25)=   0.8349319
S(26)=   0.8611808
S(27)=   0.8839328
S(28)=   0.9034755
S(29)=   0.9201307
S(30)=   0.9342312
S(31)=   0.9461015
S(32)=   0.9560470
S(33)=   0.9643468
S(34)=   0.9712500
S(35)=   0.9769760
S(36)=   0.9817144
S(37)=   0.9856285
S(38)=   0.9888561
S(39)=   0.9915147
S(40)=   0.9937019
```

```
S(41)=   0.9954998
S(42)=   0.9969766
S(43)=   0.9981891
S(44)=   0.9991841
S(45)=   1.0000000

1 TABLE 5. ESTIMATED FISHING MORTALITY
-----------------------------------------------------------------------------------------------------------------------
F( 1)=  .41845E+00
F( 2)=  .43838E+00
F( 3)=  .45830E+00
F( 4)=  .47823E+00
F( 5)=  .46827E+00
F( 6)=  .47823E+00
F( 7)=  .44834E+00
F( 8)=  .47823E+00
F( 9)=  .39852E+00
F(10)=  .42841E+00
1 TABLE 6.  ESTIMATED GROWTH PARAMETERS
-----------------------------------------------------------------------------------------------------------------------
MINIMUM SIZE OF CATCH   =    0.00
MAXIMUM SIZE OF CATCH   =   90.00
L-INFINITE              =   85.00
VON BERTALANFFY  K      =  0.2400
BETA.                   =  1.0000
```

APPENDIX II. CASA OUTPUT FILE (Continued)

FOLLOWING PAGES LIST GROWTH PROPORTION
ACROSS IS START LENGTH AND DOWN IS DISTRIBUTED CLASS
1 LENGTH = 1 TO 10

1	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
2	0.0000004	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
3	0.0000789	0.0000007	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
4	0.0019696	0.0001272	0.0000014	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
5	0.0152212	0.0028126	0.0002032	0.0000026	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
6	0.0553474	0.0197394	0.0039765	0.0003212	0.0000049	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
7	0.1192149	0.0662660	0.0253386	0.0055645	0.0005027	0.0000089	0.0000000	0.0000000	0.0000000	0.0000000
8	0.1750143	0.1333371	0.0785193	0.0321869	0.0077050	0.0007783	0.0000162	0.0000000	0.0000000	0.0000000
9	0.1918908	0.1844930	0.1475746	0.0920512	0.0404477	0.0105540	0.0011921	0.0000291	0.0000000	0.0000000
10	0.1672924	0.1919761	0.1924378	0.1615813	0.1067398	0.0502682	0.0142964	0.0018056	0.0000516	0.0000000
11	0.1212699	0.1597184	0.1900289	0.1985557	0.1749675	0.1223852	0.0617650	0.0191449	0.0027035	0.0000905
12	0.0755411	0.1109871	0.1508681	0.1860578	0.2025959	0.1873176	0.1387075	0.0750051	0.0253366	0.0040003
13	0.0414546	0.0665206	0.1004932	0.1409541	0.1801370	0.2043573	0.1982004	0.1553389	0.0899864	0.0331243
14	0.0204312	0.0352339	0.0579517	0.0899965	0.1302156	0.1724070	0.2037147	0.2072013	0.1718364	0.1066185
15	0.0091826	0.0168058	0.0296264	0.0499332	0.0796913	0.1189102	0.1630601	0.2006183	0.2139307	0.1876850
16	0.0038096	0.0073267	0.0136757	0.0246381	0.0425400	0.0697512	0.1073020	0.1523471	0.1951092	0.2180599
17	0.0014736	0.0029544	0.0057833	0.0110063	0.0202584	0.0358223	0.0603265	0.0956467	0.1405571	0.1873168
18	0.0005358	0.0011128	0.0022666	0.0045147	0.0087580	0.0164645	0.0298069	0.0515378	0.0841863	0.1280044
19	0.0001844	0.0003945	0.0008312	0.0017198	0.0034846	0.0068881	0.0132217	0.0244979	0.0434752	0.0731403
20	0.0000604	0.0001326	0.0002874	0.0006140	0.0012901	0.0026583	0.0053529	0.0104875	0.0198807	0.0361981
21	0.0000190	0.0000425	0.0000943	0.0002071	0.0004485	0.0009566	0.0020038	0.0041087	0.0082136	0.0159237
22	0.0000057	0.0000130	0.0000296	0.0000663	0.0001475	0.0003238	0.0007008	0.0014918	0.0031139	0.0063491
23	0.0000016	0.0000039	0.0000089	0.0000203	0.0000461	0.0001038	0.0002310	0.0005071	0.0010966	0.0023292
24	0.0000005	0.0000011	0.0000026	0.0000060	0.0000138	0.0000317	0.0000722	0.0001627	0.0003623	0.0007956
25	0.0000001	0.0000003	0.0000007	0.0000017	0.0000040	0.0000093	0.0000216	0.0000497	0.0001131	0.0002555
26	0.0000001	0.0000001	0.0000002	0.0000005	0.0000011	0.0000026	0.0000061	0.0000144	0.0000337	0.0000777
27	0.0000000	0.0000000	0.0000001	0.0000001	0.0000003	0.0000007	0.0000017	0.0000041	0.0000095	0.0000225
28	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000002	0.0000004	0.0000011	0.0000026	0.0000063
29	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000002	0.0000007	0.0000017

30	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000002	0.0000005
31	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001
32	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001
33	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
34	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
35	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
36	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
37	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
38	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
39	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
40	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
41	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
42	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
43	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
44	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
45	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

1 LENGTH = 11 TO 20

11	0.0000001	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
12	0.0001568	0.0000002	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
13	0.0058476	0.0002682	0.0000005	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
14	0.0427643	0.0084411	0.0004530	0.0000010	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
15	0.1247048	0.0544953	0.0120275	0.0007552	0.0000022	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
16	0.2023227	0.1439229	0.0685149	0.0169089	0.0012419	0.0000048	0.0000000	0.0000000	0.0000000	0.0000000
17	0.2193394	0.2151619	0.1638214	0.0849464	0.0234426	0.0020139	0.0000102	0.0000000	0.0000000	0.0000000
18	0.1774490	0.2176246	0.2256216	0.1838168	0.1038021	0.0320347	0.0032138	0.0000215	0.0000000	0.0000000
19	0.1150212	0.1657965	0.2128833	0.2331704	0.2032054	0.1249456	0.0434230	0.0050681	0.0000443	0.0000000
20	0.0626946	0.1019325	0.1527126	0.2052035	0.2373575	0.2211913	0.1460530	0.0571478	0.0078569	0.0000900
21	0.0297354	0.0529984	0.0890467	0.1385970	0.1948084	0.2378555	0.2369206	0.1725860	0.0745061	0.0119856
22	0.0125834	0.0240885	0.0441623	0.0766431	0.1238701	0.1820307	0.2344902	0.2495436	0.1977699	0.0954902
23	0.0048418	0.0098060	0.0192348	0.0362551	0.0649588	0.1089586	0.1673122	0.2272690	0.2582676	0.2226056
24	0.0017188	0.0036411	0.0075320	0.0151315	0.0293077	0.0541821	0.0942659	0.1511613	0.2163853	0.2624354
25	0.0005695	0.0012507	0.0026990	0.0056996	0.0117207	0.0233145	0.0444476	0.0801588	0.1341471	0.2022271
26	0.0001777	0.0004019	0.0008971	0.0019708	0.0042466	0.0089341	0.0182402	0.0358358	0.0669452	0.1168333
27	0.0000526	0.0001219	0.0002795	0.0006338	0.0014170	0.0031135	0.0066971	0.0140244	0.0283747	0.0548666

28	0.0000149	0.0000352	0.0000824	0.0001916	0.0004410	0.0010025	0.0022449	0.0049337	0.0105894	0.0220464
29	0.0000040	0.0000097	0.0000231	0.0000548	0.0001293	0.0003018	0.0006974	0.0015906	0.0035691	0.0078458
30	0.0000011	0.0000026	0.0000062	0.0000150	0.0000360	0.0000858	0.0002033	0.0004769	0.0011067	0.0025335
31	0.0000003	0.0000007	0.0000016	0.0000039	0.0000096	0.0000232	0.0000560	0.0001344	0.0003201	0.0007555
32	0.0000001	0.0000002	0.0000004	0.0000010	0.0000024	0.0000060	0.0000147	0.0000359	0.0000873	0.0002109
33	0.0000000	0.0000001	0.0000001	0.0000002	0.0000006	0.0000015	0.0000037	0.0000092	0.0000226	0.0000556
34	0.0000000	0.0000000	0.0000001	0.0000001	0.0000001	0.0000004	0.0000009	0.0000022	0.0000057	0.0000140
35	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000002	0.0000005	0.0000013	0.0000034
36	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000004	0.0000008
37	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000002
38	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001
39	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
40	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
41	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
42	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
43	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
44	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
45	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

1 LENGTH = 21 TO 30

21	0.0001798	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
22	0.0179794	0.0003525	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
23	0.1202087	0.0265023	0.0006784	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
24	0.2458937	0.1484989	0.0383558	0.0012803	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
25	0.2615839	0.2663020	0.1796348	0.0544525	0.0023676	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
26	0.1853467	0.2555128	0.2824532	0.2132482	0.0757516	0.0042859	0.0000000	0.0000000	0.0000000	0.0000000
27	0.0997761	0.1664308	0.2443198	0.2930528	0.2472852	0.1031407	0.0075868	0.0000000	0.0000000	0.0000000
28	0.0440885	0.0834692	0.1462564	0.2284136	0.2970266	0.2800107	0.1372562	0.0131182	0.0000000	0.0000000
29	0.0167938	0.0347012	0.0683270	0.1256335	0.2085089	0.2936559	0.3090958	0.1782339	0.0221286	0.0000000
30	0.0056987	0.0125296	0.0267237	0.0546676	0.1053483	0.1855708	0.2827118	0.3319917	0.2254091	0.0363678
31	0.0017630	0.0040540	0.0091459	0.0201120	0.0426874	0.0861033	0.1607455	0.2645242	0.3461938	0.2770018
32	0.0005057	0.0012015	0.0028215	0.0065238	0.0147721	0.0324879	0.0684773	0.1352617	0.2400155	0.3495866
33	0.0001362	0.0003315	0.0008011	0.0019189	0.0045413	0.0105731	0.0240545	0.0528894	0.1103160	0.2106392
34	0.0000348	0.0000861	0.0002126	0.0005218	0.0012734	0.0030804	0.0073620	0.0172930	0.0395840	0.0869803
35	0.0000085	0.0000213	0.0000533	0.0001332	0.0003318	0.0008234	0.0020325	0.0049772	0.0120462	0.0286323

36	0.0000020	0.0000050	0.0000127	0.0000322	0.0000814	0.0002055	0.0005180	0.0013021	0.0032599	0.0081093
37	0.0000005	0.0000012	0.0000029	0.0000075	0.0000190	0.0000485	0.0001238	0.0003163	0.0008080	0.0020630
38	0.0000001	0.0000002	0.0000007	0.0000016	0.0000043	0.0000109	0.0000281	0.0000724	0.0001872	0.0004845
39	0.0000000	0.0000001	0.0000001	0.0000004	0.0000009	0.0000024	0.0000061	0.0000158	0.0000410	0.0001070
40	0.0000000	0.0000000	0.0000001	0.0000001	0.0000002	0.0000005	0.0000013	0.0000033	0.0000086	0.0000225
41	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000002	0.0000007	0.0000017	0.0000045
42	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000004	0.0000009
43	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001	0.0000001	0.0000001
44	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000001
45	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

1 LENGTH = 31 TO 40

31	0.0581469	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
32	0.3298548	0.0902997	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
33	0.3408161	0.3793395	0.1359688	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
34	0.1782570	0.3196265	0.4195517	0.1981349	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
35	0.0660970	0.1449386	0.2870894	0.4439242	0.2788493	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
36	0.0199583	0.0482348	0.1127300	0.2456277	0.4463328	0.3782105	0.0000000	0.0000000	0.0000000	0.0000000
37	0.0052587	0.0133550	0.0336555	0.0834166	0.1988026	0.4226108	0.4932930	0.0000000	0.0000000	0.0000000
38	0.0012578	0.0032761	0.0085424	0.0223289	0.0583208	0.1508397	0.3722188	0.6174216	0.0000000	0.0000000
39	0.0002799	0.0007361	0.0019491	0.0051949	0.0139917	0.0381784	0.1059694	0.2995430	0.7403118	0.0000000
40	0.0000589	0.0001552	0.0004117	0.0011035	0.0029827	0.0082040	0.0231134	0.0677087	0.2141390	0.8495759
41	0.0000119	0.0000311	0.0000822	0.0002188	0.0005866	0.0016036	0.0044466	0.0127116	0.0382560	0.1293224
42	0.0000023	0.0000060	0.0000157	0.0000414	0.0001098	0.0002909	0.0007963	0.0021888	0.0061749	0.0181783
43	0.0000004	0.0000011	0.0000029	0.0000075	0.0000197	0.0000515	0.0001358	0.0003575	0.0009507	0.0025203
44	0.0000001	0.0000002	0.0000005	0.0000013	0.0000034	0.0000088	0.0000224	0.0000584	0.0001435	0.0003465
45	0.0000000	0.0000001	0.0000001	0.0000003	0.0000007	0.0000017	0.0000043	0.0000104	0.0000241	0.0000566

1 LENGTH = 41 TO 50

41	0.9337117	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
42	0.0589188	0.9859065	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
43	0.0064888	0.0128614	0.9859065	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
44	0.0007716	0.0011041	0.0128614	0.9859065	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
45	0.0001091	0.0001280	0.0012321	0.0140935	1.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000

APPENDIX II. CASA OUTPUT FILE (Continued)

SUMMARY OF THE ESTIMATES

Modified Sum of Squares:	912008.2
Initial Population Size:	1.3628765E+09
Alpha-Recruitment:	32.89970
Beta-Recruitment:	0.5230054
Alpha Selectivity:	0.1000003
Beta-Selectivity:	30.00010
L-Infinity:	84.99994
Brody Growth Coefficient:	0.2400004
Beta-Growth:	1.000001
Natural Mortality:	0.3000000

TIME	FISHING MORTALITY	RECRUITMENT	POPULATION SIZE
1	0.4184504	0.0000000E+00	1.3628765E+09
2	0.4383759	4.4200080E+08	1.3539096E+09
3	0.4583019	1.3200031E+08	9.8004013E+08
4	0.4782282	1.3900010E+08	7.0532998E+08
5	0.4682650	8.6000168E+07	4.7886966E+08
6	0.4782278	9.0000088E+07	3.5547101E+08
7	0.4483381	1.6500058E+08	3.6431651E+08
8	0.4782263	1.0500062E+08	3.2544685E+08
9	0.3985212	1.2800093E+08	3.2119430E+08
10	0.4284092	9.7000968E+07	2.9628365E+08

SELECTIVITY:

3.9265394E-02
4.7547061E-02
5.7471368E-02
6.9316961E-02
8.3388932E-02
0.1000118
0.1195181
0.1422300

0.1684357
0.1983581
0.2321188
0.2697014
0.3109169
0.3553815
0.4025103
0.4515363
0.5015520
0.5515735
0.6006168
0.6477733
0.6922733
0.7335303
0.7711577
0.8049644
0.8349319
0.8611808
0.8839328
0.9034755
0.9201307
0.9342312
0.9461015
0.9560470
0.9643468
0.9712500
0.9769760
0.9817144
0.9856285
0.9888561
0.9915147
0.9937019
0.9954998
0.9969766
0.9981891
0.9991841
1.000000

APPENDIX III. TRUE VALUE OF THE PARAMETERS

Parameters	value
Initial population size	1.36000E+09
Alpha-recruitment	37.000
Beta-recruitment	0.500
Alpha-selectivity	0.100
Beta-selectivity	30.000
L-Infinity (L)	83.000
Brody growth coefficient, k	0.240
Beta-growth	1.000
Fishing mortalities:	
T = 1	0.42
T = 2	0.44
T = 3	0.46
T = 4	0.48
T = 5	0.47
T = 6	0.48
T = 7	0.45
T = 8	0.48
T = 9	0.40
T = 10	0.43