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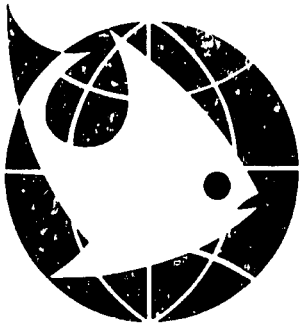
FISHERIES STOCK ASSESSMENT

TITLE XII

Collaborative Research Support Program



Fisheries Stock Assessment CRSP Management Office
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The University of Rhode Island—International Center for Marine Resource Development
The University of Washington—Center for Quantitative Sciences
The University of Costa Rica—Centro de Investigación en Ciencias del Mar y Limnología
The University of the Philippines—Marine Science Institute (Diliman)—College of Fisheries (Visayas)

In collaboration with The University of Delaware; The University of Maryland—College of Business and Management; The University of Miami; and The International Center for Living Aquatic Resources Management (ICLARM).

WORKING PAPER SERIES

Working Paper No. 42
"User's Manual for SIMULPOP,
a Program to Simulate Series of
Length Frequency Distributions of
an Exploited Fish Stock"
by
Margarida Castro
University of Rhode Island

May, 1988

Fisheries Stock Assessment
Title XII
Collaborative Research Support Program

The Fisheries Stock Assessment CRSP (sponsored in part by USAID Grant No. DAN-4146-G-SS-5071-00) is intended to support collaborative research between the U.S. and developing countries' universities and research institutions on fisheries stock assessment and management strategies.

This Working Paper was produced by the University of Rhode Island research component in collaboration with the University of the Philippines and in association with the International Center for Living Aquatic Resources Managment. Additional copies are available from the CRSP Management Office and from:

International Center for Marine Resource Development
The University of Rhode Island
126 Woodward Hall
Kingston, Rhode Island 02881

TABLE OF CONTENTS

NOTE: The author would appreciate feedback from any user of SIMULPOP. Disk copies of the program can be obtained from:

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Narragansett, RI 02882
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1 - INTRODUCTION

"SIMULPOP" was written to simulate series of length distributions, in order to test length frequency analysis techniques (CASTRO and ERZINI, 1987). It was written in MS DOS BASICA. It's structure is shown in Figure 1.

The objective of the program is to obtain a series of monthly length-frequency distributions representing the catch of a population with known parameters (life history and fishing activity related parameters). Consequently, it is possible to verify the ability of different length frequency techniques to retrieve the parameters used in the simulations. The length distributions simulated for each month represent the extrapolation to the total monthly catch of the length and age structure verified at the middle of the month considered (day 15).

The first part of the program (steps 10000 to 15720) deals with the input of parameters needed for the simulation and with the calculation of values for arrays containing recruitment numbers for each year, the probability of retention by the net for each length class and the mortality rates. Random access files that will store the results of the simulation are created. The number of years to obtain simulated data (S), the oldest class present in the population (M) and the largest length class considered (P) are used to determine the dimensions of the arrays.
The subscripts are:

i for the age,	i=0,1,2,...,M
j for the year,	j=0,1,2,...,N
l for the length class,	l=0,1,2,...,P.

Another subscript, t, is used to identify the month:

t=0,1,2,...,12=Q.

t=0 refers to the total of the year, when the array considered requires calculation of a value for the total of the year. For example CATCH(j=2,t=0) is the total catch for year 2, CATCH(j=2,t=3) is the total catch for the month of March of year 2.

The oldest class present in the population (M) and the number of years to obtain simulated data (S) are used to determine how many years the simulations have to run (N). For example, to obtain length frequency distributions for 2 years, for a population where M=4, we need to generate and follow cohorts for 6 years (Figure 2). Only years

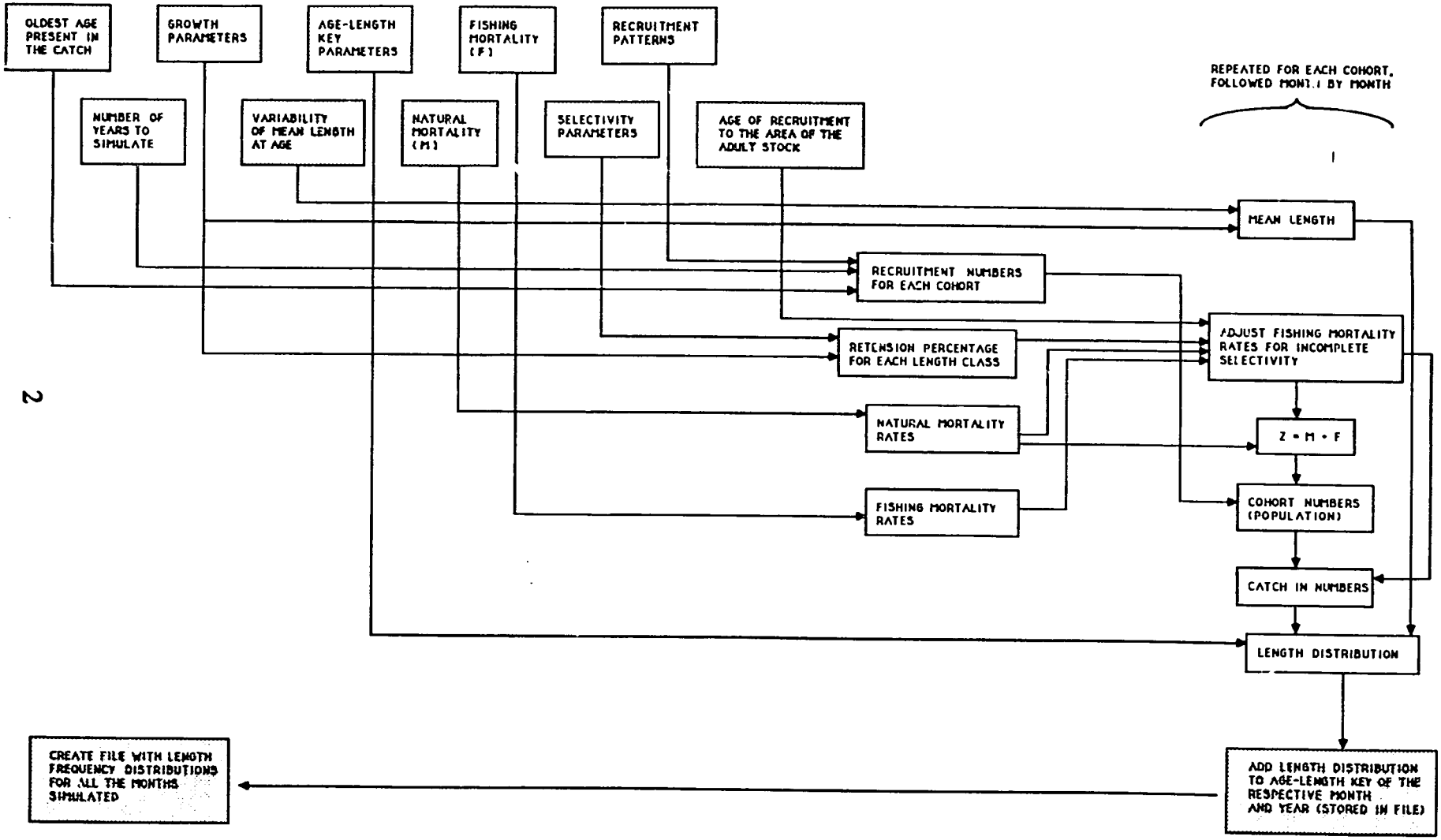

Figure 1 - Structure of SIMULPOP. Inputs and final output in shaded boxes.

4 and 5 will have data for all ages, and will be useful for obtaining data on the age and length structure of the population.

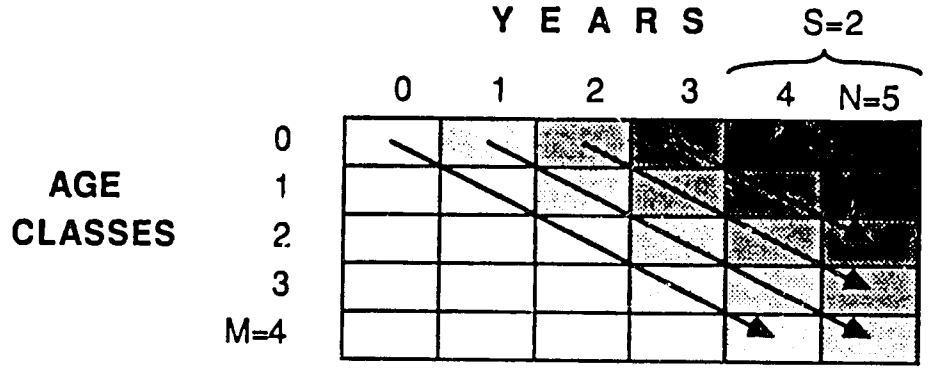

Figure 2 - Number of years to run the simulation (N) to obtain data for the last two years including information about all ages. The oldest class present in the catch is age class 4 (M). Each arrow describes the progress of a cohort.

In the second part of the program (steps 15730-17780) the cohorts are followed in time, one by one, and for years of complete data, length frequency distributions of the catch are generated, and added to the age-length-key of the corresponding month.

In the third part of the program (steps 17790-18970) a file with only the length distributions (no age information) is created, containing the data used to test the length frequency analysis techniques.

2 - DEFINITION OF TERMS

Cohort - will refer to a group of individuals that hatched in the same month.

Age class - will refer to a group of individuals that hatched in the same calendar year. The theoretical birthday is considered to be January 1st, so this is the date a fish will change from one age class to the next.

3 - INPUTS FOR THE PROGRAM

The following parameters will be requested in the order presented here. After the description of each input, in parenthesis are examples of the inputs for the program, used to produce the example shown later in this manual.

Title for the simulation - Title to be printed on top of the printed output. (SMALL SPARIDAE SPECIES TWO RECRUITMENT PEAKS PER YEAR)

Age of oldest class present in the catch in years (6).

Number of years to obtain simulated data (2).

Parameters of the von Bertalanffy growth curve, L_∞, K and t_0 (L_∞=35 cm, K=0.2 and t_0=0).

Age-length-key parameters - Two series of standard deviation values.

The first set of values (STDLENGTH(i)), refers to the standard deviation associated with the variability of mean length (not length at age) for each age class. If it is desired that the mean length of a given age is the same from year to year input zeros for the standard deviation (STDLENGTH(i)=0 for all i).

The second group of values (STDAGE(i)), represents the variation for length-at-age. These have to be greater than zero (STDAGE(0)=1.0, STDAGE(1)=1.2, STDAGE(2)=1.5 and STDAGE(3 to 6)=2.0).

All these parameters have to be input in the same units as L_∞

More precise information about these parameters is presented in the step by step description of the program referring to steps 11970-12500.

Natural mortality values - mean and standard deviation for the distribution of M, annual instantaneous natural mortality rate (mean=0.2 and standard deviation=0.01).

Fishing mortality values - mean and standard deviation for the distribution of F, annual instantaneous fishing mortality rate (mean=0.8 and standard deviation=0.02).

Selectivity curve parameters - Parameters refer to the selectivity of a trawling net - Mesh size, $l_{25\%}$ (length for which the probability of retention by the gear is 0.25) and $l_{75\%}$ (length for which the probability of retention by the gear is 0.75). All these parameters have to be input in the same units as L_∞ (mesh=3.5 cm, $l_{25\%}$=11.25 cm and $l_{75\%}$=16.75 cm).

Recruitment pattern - choice of months when recruitment occurs. This values are input in the form of probability of recruitment occurring in a given month of the year considered, so the values for each year should add up to 1 (recruitment probabilities for months March and September of all years=0.5 for all years, all other months=0).

Age of recruits when they join the area of the fishing activity - in months (6).

Name of the file to store length distributions for all months. This in the only file created by the program that is named by the user (TESTCASE).

4 - OUTPUT FROM THE PROGRAM

Printed output:

An extensive printout is produced by the program, containing information about all the inputs, and all the intermediate steps of the simulation (mortality values, numbers of individuals for each cohort, retention percentages for each length class considered and information about the age and length structure of the cohorts), as well as description of the contents of the random access files. Age-length-keys for each month of the simulation (also stored in random access files) are printed.

Random access files:

Three types of files are produced.

One of the files is named "ALLDATA" and contains the length distributions for each cohort, month by month. These data will be useful if it is desired to understand in detail the contribution of each cohort to the population.

The second group of files (named according to the year and month they refer to) contain the age-length-keys for each one of the months simulated. In the example represented in figure 2 we would get 24 of these files, named "Y4M1", "Y4M2", ... , "Y4M11", "Y4M12", "Y5M1", "Y5M2", ... , "Y5M11" and "Y5M12".

The third type of file is the file containing the length distributions for all the months of the simulation, the name of which is chosen by the user.

5 - STEP BY STEP DESCRIPTION OF THE PROGRAM

STEPS 10000-11440
Documentation and definition of constants and arrays used in the program.

STEPS 11450-11500
Initiation steps.

STEPS 11510-11580
Input and print title for the simulation (TITLE$).

STEPS 11590-11760
Input age of oldest class present in the population (M) and number of years to obtain simulated data (S).
Calculate number of years to simulate (N).
Print information about parameters.

STEPS 11770-11960
Input and print parameters for the von Bertalanffy growth curve (LINF, KEI and TZERO).

STEPS 11970-12500
Input Age-length-key parameters.

Two types of standard deviations will be requested. The first set of standard deviation values refers to the variability of the average length for a given age over time (STDLENGTH(i)). If this value is greater than zero, the mean length for age i will not be constant from year to year. It will have a random normal distribution with mean given by the von Bertalanffy growth equation and standard deviation equal to STDLENGTH(i). STDLENGTH(i)

can be equal to zero if it is desired that the mean length for age i is constant over time.
The second set of standard deviation values refers to the length distribution for a given age (STDAGE(i)). The length distribution for age i is considered to be normal, with mean defined according to the description given in the previous paragraph and standard deviation equal to STDAGE(i). STDAGE(i) has to be greater than zero for all ages.

Define largest length class to be considered (P).
Print information about age-length-key parameters.

STEPS 12510-12570
Dimension arrays with M (older class present in the population, N and P.

STEPS 12580-13510
Input parameters for calculation of instantaneous natural mortality rates (MEANM and STDM) and instantaneous fishing mortality rates (MEANF and STDF) .
Calculate values for the fractions of monthly natural and fishing mortality rates for year j and month t respectively MORT(j,t) and F(j,t).

Both instantaneous annual mortality rates (natural and fishing) are considered to be random normal, with means MEANM and MEANF, and standard deviation STDM and STDF (the standard deviation values can be equal to zero if it is desired to keep the mortality rates constant).
The program uses monthly fractions of the mortality rates. These values are also assumed to have random normal distributions. If the annual mortality rate has mean $\mu(y)$ and standard deviation $\sigma(y)$, and the monthly mortality rate has mean $\mu(m)$ and standard deviation $\sigma(m)$, then:

$\mu(y) = 12 \cdot \mu(m)$ and $\sigma(y)^2 = 12\ \sigma(m)^2$ (approximately)

then $\mu(m) = \mu(m) / 12$ and $\sigma(m) = \sqrt{\sigma(y)^2 / 12}$

It is assumed that all the population at a given point in time will be subjected to the same values of natural and fishing mortality rates (not considering correction of F for incomplete selection by the gear, discussed later).

STEPS 13520-13870
Input parameters of selectivity curve.

The selectivity curve considered was a logistic curve (PALOHEIMO and CADIMA, 1964):

$$r_l = \frac{1}{1 + e^{-(a + b\,l)}}$$

where

r_l = probability of fish of length class k retained by the net.

l = length class (mid point)

a and b = parameters of the selectivity curve.

Some other relationships of interest are:

$$l_{50\%} = -a / b$$

where $l_{50\%}$ = length at which the retention percentage is 50%

$$l_{25\%} = l_{50\%} - (1/b)\ \ln(3)$$

where $l_{25\%}$ = length at which the retention percentage is 25%

$$l_{75\%} = l_{50\%} + (1/b)\ \ln(3)$$

where $l_{75\%}$ = length at which the retention percentage is 75%

$$l_{75\%} - l_{25\%} = (2/b)\ \ln(3)$$

where $l_{75\%} - l_{25\%}$ = selection range

$$l_{50\%} = s \,.\, m$$

where s = selection factor
m = mesh size.

For simplification the selection factor is considered constant for a given net type. Then

$$-a / b = s \cdot m$$

and

$$a = -b \cdot s \cdot m$$

In this program

r_l = RETENSION = RP(l)
l = LENGTH
$l_{25\%}$ = L25
$l_{50\%}$ = L50
$l_{75\%}$ = L75
$l_{75\%}-l_{25\%}$ = DELTA
a = ALFA
b = BETA
m = MESH
s = SELFAC

STEPS 13880-14010
Calculation of recruitment numbers for year j (POP(0,j,0)).
Print recruitment numbers.

Recruitment numbers are calculated using the random number generator (random numbers between 0 and 1 multiplied by one million).

STEPS 14020-14390
Distribution of recruitment along the year (RECRUIT(j,t)).
Input age of recruitment to the area of the fishery (RECAGE).
Calculate length of recruitment to the area of the fishery (RECLENGTH).

If a given month has a recruitment probability greater than zero, then recruitment is considered to happen at the beginning of the month considered (day 1).

STEPS 14680-14890
Print information about recruitment patterns.

STEPS 14680-14890
Calculate and print (for each age class) average age (AGE), average length(LENGTH), average retention percentage (RETENSION), average fishing mortality adjusted for incomplete selectivity by the gear (NEWF2). These values are only used to print information , and are not involved in further calculations.

The correction of fishing mortality rates for incomplete selectivity by the gear was done the following way:
The basic equation considered is the equation for cohort analysis (RICKER, 1975). For a given time interval we have:

(1) $$C_t = N_t \cdot F_t/Z_t \cdot (1 - e^{-(F_t+M_t)})$$

where

C_t = Catch in numbers for the cohort considered during time interval t

N_t = Population numbers at the beginning of t

F_t = Instantaneous fishing mortality rate over t

M_t = Instantaneous natural mortality rate over t.

Z_t = Instantaneous total mortality rate over t ($Z_t = M_t+F_t$).

If we define a situation 1 in which all individuals are recruited to the gear, we have the equation:

(2) $$C1_t = N_t \cdot F1_t / Z1_t \cdot (1- e^{-(F1_t+M_t)})$$

If F is reduced because not all individuals are recruited to the gear. The new catch will be reduced by a value r corresponding to the average retention percentage for the age of the cohort considered at time t (situation 2). Then:

$$C2_t = r_t \cdot C1_t$$

(3) $$C2_t = N_t \cdot F2_t/Z2_t \cdot (1- e^{-(F2_t+M_t)}) = r_t \cdot C1_t$$

(4) $$C1_t = N_t / r_t \cdot F2_t/Z2_t \cdot (1- e^{-(F2_t+M_t)})$$

Combining equations (2) and (4) and simplifying we get

$$(5) \qquad F2_t/Z2_t . (1 - e^{-(F2_t+M_t)}) = r_t . F1_t/Z1_t . (1 - e^{-(F1_t+M_t)})$$

In this simulation we have $F1_t$, M_t and r_t for each age class and we want to find the value of $F2_t$ that satisfies equation (5). The value of $F2_t$ is determined through an iterative loop. In the subroutine that adjusts F for incomplete selectivity by the gear (steps 19600-19750) $F1_t$=F1, $F2_t$=F2, M_t=NM and r_t=RETENTION.

STEPS 14900-15260
Count number of cohorts to be generated (C).
The subscript 'a' is used to identify the order number of the cohorts, lower values of a correspond to older cohorts.
a = 1,2,...,C.
Print information related with cohort generation.
Create arrays with identification number (COHORID(a)), year of recruitment (RYEAR(a)) and month of recruitment (RMONTH(a)) for each cohort.

STEPS 15270-15540
Create files to store age-length-keys for each month of simulated data (TOTCATCH(i,t)). These files are named "Y?M?" according to the corresponding year and month. For example, a file to store information for February of simulation year 6 would be named "Y6M2".

STEPS 15550-15600
Create a file "ALLDATA" that will contain all the detailed information for the simulated data (length distributions of the catch for each cohort month by month).

STEPS 15610-15730
Print information about the files created previously.
Input name of the file to contain final length frequency distributions for all months simulated (FILENAME$).

STEPS 15740-15770
Initiation of loop for calculations that are made cohort by cohort. This loop will end at step 17760.

STEPS 15780-15860
Dimension of arrays relative to the cohort considered and definition of constants identifying the cohort and used in loop dimensioning.

STEPS 15870-16140
For the cohort considered, calculate for each month, mean age (MEANAGE(i,t)), mean length (MEANLENGTH(i,t), fishing mortality rates (F(j,t)) and total mortality rates (Z(i,j,t)).

STEPS 16150-16420
Calculation of population numbers for every month of the cohort considered (COHORTN(i,j,t)).

It is assumed that for a given cohort and time period t (BEVERTON and HOLT, 1957)

$$N_t = N_{t-1} \cdot e^{-Z_{t-1}}$$

where

N_t = population numbers at the beginning of t
N_{t-1} = population numbers at the beginning of t-1
Z_{t-1} = instantaneous total mortality rate over t-1.

STEPS 16430-16520
Calculation of the catch in numbers for each month of the cohort considered (COHORTC(i,j,t))

It is assumed that for a given time period t (RICKER, 1975)

$$C_t = N_t \cdot F_t/Z_t \cdot (1 - e^{-Z_t})$$

Where

C_t = catch in numbers over t
F_t = instantaneous fishing mortality rate over t
Z_t = instantaneous total mortality rate over t.

STEPS 16820-17680
Simulation of the age-length-key for each month of the cohort considered.

STEPS 16990-17010
Calculation of the mean and standard deviation of the length distribution (assumed to be normal).

STEPS 17030-17080
Calculation of the probability (area under the normal curve) associated with each length class for the individuals that enter the net.

STEPS 17110-17270
Calculation of the probability associated with each length class in the catch, the same length distribution for the individuals that are retained by the net.
Calculation of length frequency distributions for the catch.

Taking age class i, the probability $p_{i,l}$ of an individual of age i belonging to a given length class l is equal to the area under the normal curve (describing the length distribution for age i) between the values corresponding to the limits of the length class l (Fig 3).

The probability of an individual belonging to length class l being retained by the gear is equal to the retention probability $r_{i,l}$. This probability is defined by the selectivity curve.

$$0 \leq r_{i,l} \leq 1$$

The length distribution of age i in the catch will be skewed if the retention probabilities for all or some of the length classes is not equal to 1.
The probability of an individual of age class i belonging to length class l in the catch is $c_{i,l}$

$$c_{i,l} = \frac{p_{i,l} \cdot r_{i,l}}{\Sigma\ p_{i,l} \cdot r_{i,l}}$$

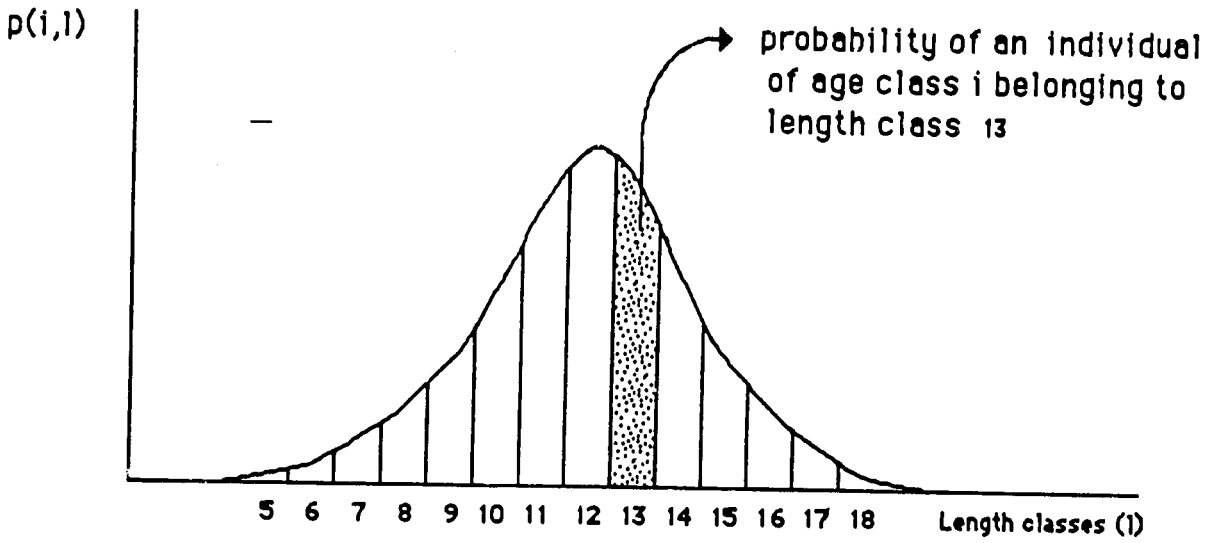

Figure 3 - Area under the normal curve representing to the length distribution for age class i. The area of the different slices correspond to the probability of a given individual of age class i belonging to length class l.($p_{i,l}$)

The number of individuals in the catch belonging to age class i and length class l is

$C_{i,l} = C_i \cdot c_{i,l}$ where C_i is the total catch for age i.

In this program

$p_{i,l}$ = PROB(l+1)-PROB(l)
$c_{i,l}$ = ALKEY (i,l)
$r_{i,l}$ = RP(l)
$\Sigma\ p_{i,l} \cdot r_{i,l}$ = TOTAGE(i)
$C_{i,l}$ = COHCATCH(i,l)
C_i = COHORTC(i,j,t).

STEPS 17280- 17410
Write length distributions in file "ALLDATA".

STEPS 17420-17650
Add length distribution for the cohort and month considered to the age-length-key of the corresponding month.

STEP 17710
Erase arrays dimensioned at the beginning of the loop.

STEPS 17740-17780
End of loop initiated in step 15750.

STEPS 17790-17950
Create file to contain final length frequency distributions.

STEPS 17960-18810
Sum length distributions of all cohorts for a given month to obtain total length distributions (TOTLENGTHS(1)).
Print age-length-keys for each month.

STEPS 18220-18970
The end !!!

6 - REFERENCES

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International; Center For Marine Resource Development
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ICNAF, serial number 1394, document number 98

RICKER, W.E., 1975 - Computation and Interpretation of Biological Statistics of Fish Populations
Bull. Fish. Res. Board of Can.,n.191

```
10000 GOTO 11450
10010 '*************************************************************************
10020 '            Name: SIMULPOP
10030 '
10040 '            Author: Margarida Castro
10050 '                    Graduate School of Oceanography
10060 '                    Narragansett Bay Campus
10070 '                    Narragansett, RI 02882 , U.S.A.
10080 '                    Tel: (401)792-6144
10090 '
10100 '            Date: March 1988
10110 '*************************************************************************
10120 '
10130 '               DEFINITION OF CONSTANTS
10140 '
10150 '  ----  Constants used to dimension arrays ----
10160 '
10170 '  C        a = 1, ... ,c  (order number for each cohort)
10180 '  M        i = 0, ... ,m  (number of age classes)
10190 '  N        j = 0, ... ,n  (number of years)
10200 '  P        l = 0, ... ,p  (last size class to be considered)
10210 '  Q        t = 0, ... ,12  (0 for the total of the year,
10220 '                            1 to 12 for each one of the months)
10230 '
10240 ' ----  Other constants ----
10250 '
10260 '  AGE            Input for the subroutine that calculates length at age
10270 '  ALFA           a, parameter of the logistic curve, used to determine
10280 '                 retension percentages by the gear (interception)
10290 '  B1 to B5       Constants used in the subroutine that calculates
10300 '                 area under the normal curve
10310 '  BETA           b, parameter of the logistic curve, used to determine
10320 '                 retension percentages by the gear ("slope" of the curve)
10330 '  COHORTID       Order number for each cohort
10340 '  CONSTANT       Used in the subroutine that corrects fishing
10350 '                 mortality for incomplete gear retension
10360 '  COUNT          Used to count how many cohorts will be generated, and
10370 '                 to create ID numbers for each one of them
10375 '  DELTA          Selectivity parameter, selection range, equal
10376 '                 to the differenco between length at which the
10377 '                 retension by the net is 75% and length at which
10378 '                 the retension by the net is 25%
10380 '  DIF            Difference between F1 and F2, used in the subroutine
10390 '                 that corrects fishing mortality for incomplete
10400 '                 retension by the gear
10402 '  ERL            Line where an error occured
10405 '  ERR            Error type
```

```
10410  '  F1            Fishing mortality (F) , input for the subroutine that
10420  '                corrects for incomplete retension by the gear
10430  '  F2            Fishing mortality , used in the subroutine that
10440  '                corrects for incomplete retension by the gear
10450  '  FILENAME$     Name of the file to store final length distributions
10460  '                for each month
10470  '  FIRSTYEAR     First year to create age-length keys for the cohort
10480  '                considered
10490  '  H             Constant used in the subroutine that calculates
10500  '                area under the normal curve
10510  '  KEI           K , parameter of the von Bertalanffy growth curve
10520  '  LASTYEAR      Last year to create age-length keys for the cohort
10530  '                considered
10540  '  LENGTH        Output for the subroutine that calculates length at age
10550  '                and input for the subroutine that calculates retension
10560  '                percentages for each length
10562  '  L25           Selectivity parameter, length at which the percentage
10563  '                retained by the net is 25%
10564  '  L50           Selectivity parameter, length at which the percentage
10565  '                retained by the net is 50%
10566  '  L75           Selectivity parameter, length at which the percentage
10567  '                retained by the net is 75%
10570  '  LINF          L oo , parameter of the von Bertalanffy growth curve
10580  '  MEAN          Mean of a normal distribution, input for the
10590  '                randomization subroutine, and for the subroutine that
10600  '                calculates areas under the normal curve
10610  '  MEANF         Mean value of F (fishing mortality)
10620  '  MEANM         Mean value of M (natural mortality)
10630  '  MESH          Standard measurement of the mesh size
10640  '                (in the same units as Loo and the length classes)
10650  '  NEWF2         Fishing mortality (F) , output of the subroutine that
10660  '                corrects for incomplete retension by the gear
10670  '  NM            Natural mortality (M) , input for the subroutine that
10680  '                corrects for incomplete retension by the gear
10690  '  R             Dimension of loop used in the randomization subroutine
10700  '  RECAGE        Mean age of recruits to the adult population in months
10710  '  RECLENGTH     Mean length of recruits to the adult population in cm
10720  '  RETENSION     Output of the subroutine that determines retension
10730  '                percentage for each length and input for the subroutine
10740  '                that adjusts F for incomplete retension by the gear
10750  '  RMONTH        Month of recruitment to the adult population for a cohort
10760  '  RYEAR         Year of recruitment to the adult population for a cohort
10770  '  S             Number of years to obtain simulated data
10780  '  SELFAC        f, selection factor, parameter that relates the mesh
10790  '                size and  length of 50% retension
10800  '  STD           Standard deviation of a normal distribution, input for
10810  '                the randomization subroutine, and for the subroutine that
10820  '                calculates areas under the normal curve
10830  '  STDM          Standard deviation of M (natural mortality)
10840  '  STDF          Standard deviation of F (fishing mortality)
10850  '  SUM           Sum of random numbers, used in the randomization
10860  '                subroutine
10870  '  TITLE$        Title for the simulation to be printed at the top
```

```
10880 '                 of hardcopy and data files and file 'ALLDATA'
10890 '  TZERO          to , parameter of the von Bertalanffy growth curve
10930 '  X              Output of randomization subroutine
10940 '
10950 '
10960 '                 DIMENTION AND DEFINITION OF ARRAYS
10970 '
10980 '
10990 '   ALKEY(M,P)                Age-length key (in %) for year=j and month=t
11000 '   COHCATCH(M,P)             Catch in numbers for a specific cohort for
11010 '                             age=i and length=l  (age-length key in
11020 '                             numbers for year=j and month=t)
11030 '   COHORTC(M,N,Q)            Catch in numbers for a given cohort
11040 '   COHORTID(C)               Order number for the cohort considered
11050 '   COHORTN(M,N,Q)            Population numbers for a given cohort
11060 '   F(N, Q)                   Instantaneous fishing mortality rates
11070 '   FILECODE$(N, Q)           Array to store names for data files
11080 '   MEANAGE(M,Q)              Real age (mean value) of individuals for
11090 '                             age=i and month=t  (for a cohort)
11100 '   MEANLENGTH(M,Q)           Mean length for age=i and month=t
11110 '   MORT(N, Q)                Instantaneous natural mortality rates
11120 '   POP(M, N, Q)              Population numbers at the beginning
11130 '                             of each time interval
11140 '   PROB(P + 1)               Variable used in the subroutine that
11150 '                             calculates area under the normal curve
11160 '   RECRUITM(N, Q)            Recruitment probability for year=j
11170 '                             and month=t
11180 '   RMONTH(C)                 Recruitment month for the cohort considered
11190 '   RP(P)                     Retension percentage for length=l
11200 '   RYEAR(C)                  Year of recruitment for the cohort considered
11210 '   STDAGE(M)                 Standard deviation for the length
11220 '                             distribution of age=i
11230 '   STDLENGTH(M)              Standard deviation for the distribution
11240 '                             of the average length of each age class
11250 '                             (RELATIVE TO THE POSITIONNING OF THE MEAN
11260 '                             LENGTH OF AGE=I, NOT TO THE DISTRIBUTION
11270 '                             OF LENGTHS FOR AGE=I)
11280 '   T(P + 1)                  Variable used in the subroutine that
11290 '                             calculates area under the normal curve
11300 '   TOTAGE(M)                 Auxiliary array used in the correction of the
11310 '                             age-length key for gear selectivity
11320 '   TOTCATCH(M, P)            Catch in numbers for all the cohorts
11330 '                             summed for age=i, year=j, month=t and
11340 '                             length=l (age-length key in numbers for
11350 '                             year=j and month=t)
11360 '   TOTLENGTHS(P)             Total numbers for each length class
11370 '                             (all ages summed) for a given age-length key
11380 '   Y(P + 1)                  Variable used in the subroutine that
11390 '                             calculates area under the normal curve
11400 '   Z(M, N, Q)                Instantaneous total mortality rates
11410 '   ZNORMAL(P + 1)            Variable used in the subroutine that
11420 '                             calculates area under the normal curve
11430 '
```

```
11440   '*************************************************************************
11450   CLS
11460   ON ERROR GOTO 19760
11470   KEY OFF
11475   WIDTH "LPT1:", 80
11480   DEFSNG A-Z
11490   RANDOMIZE VAL(RIGHT$(TIME$, 2))
11500   '
11510   PRINT : PRINT
11520   PRINT "TITLE FOR THIS SIMULATION (max. 80 characters)     ";
11530   INPUT TITLE$
11540   '
11550   LPRINT "*************************************************************************"
11560   LPRINT : LPRINT TITLE$: LPRINT
11570   LPRINT "*************************************************************************"
11580   '
11590   PRINT : PRINT "AGE OF OLDEST CLASS PRESENT IN THE CATCH (in years) ";
11600   INPUT M
11610   M = CINT(M)
11620   '
11630   PRINT : PRINT "NUMBER OF YEARS TO OBTAIN SIMULATED DATA  ";
11640   INPUT S
11650   S = CINT(S)
11660   N = M + S - 1
11670   '
11680   Q = 12
11690   '
11700   LPRINT : LPRINT "PARAMETERS USED IN THE LENGTH FREQUENCY SIMULATION:"
11710   LPRINT : LPRINT
11720   LPRINT "AGE OF OLDER CLASS PRESENT IN THE CATCH (in years) ="; M
11730   LPRINT
11740   LPRINT "NUMBER OF YEARS TO OBTAIN SIMULATED DATA ="; S
11750   LPRINT
11760   '*************************************************************************
11770   '
11780   ' ----  Growth curve (von Bertalanffy)  ----
11790   '
11800   CLS
11810   PRINT : PRINT
11820   LPRINT "PARAMETERS FOR THE GROWTH CURVE (von BERTALANFFY):"
11830   PRINT "INPUT PARAMETERS FOR THE von BERTALANFFY GROWTH CURVE "
11840   '
11850   PRINT : PRINT "L infinity (in cm)";
11860   INPUT LINF
11870   PRINT "K ";
11880   INPUT KEI
11890   PRINT "To ";
11900   INPUT TZERO
11910   '
11920   LPRINT "L-inf ="; LINF
11930   LPRINT "K ="; KEI
11940   LPRINT "To ="; TZERO
11950   '
```

```
11960  '*************************************************************************
11970  '
11980  ' ---- Age - length key parameters  ----
11990  '
12000  CLS
12010  DIM STDLENGTH(M), STDAGE(M)
12020  PRINT "AGE-LENGTH KEY PARAMETERS "
12030  PRINT
12040  PRINT "The mean length for each age is considered to be          "
12050  PRINT "normally distributed with:                                "
12060  PRINT "      mean = MEANLENGTH(i,1)  -  given by the             "
12070  PRINT "                 von Bertalanffy equation                 "
12080  PRINT "       std = STDLENGTH(i)                                 "
12090  PRINT
12100  PRINT "The mean length for each age class, in a particular year  "
12110  PRINT "and month, is obtained randomly using the parameters      "
12120  PRINT "defined before.                                           "
12130  PRINT
12140  PRINT "The length distribution for each age class is considered  "
12150  PRINT "to be normally distributed with:                          "
12160  PRINT "      mean = value produced randomly                      "
12170  PRINT "       std = STDAGE(i)                                    "
12180  PRINT : PRINT "NOTE: STDLENGTH(i) can be zero, if you want to keep the"
12190  PRINT "       mean lengths for a given age class constant along time,  "
12200  PRINT "       but STDAGE(i) has to have some value greater than 0. "
12210  PRINT : PRINT "ALL VALUES MUST BE IN THE SAME UNITS AS Loo       "
12220  PRINT
12230  '
12240  FOR I = 0 TO M
12250     PRINT "STDLENGTH("; I; ")";
12260     INPUT STDLENGTH(I)
12270  NEXT I
12280  '
12290  FOR I = 0 TO M
12300     PRINT "STDAGE("; I; ")";
12310     INPUT STDAGE(I)
12320     IF STDAGE(I) = 0 THEN PRINT "ERROR ! STDAGE(i) CAN NOT BE ZERO. ENTER NEW VALUE"
12330     IF STDAGE(I) = 0 THEN GOTO 12300
12340  NEXT I
12350  '
12360  P = INT(LINF + (2 * STDAGE(M)))
12370  '
12380  LPRINT : LPRINT "AGE-LENGTH KEY PARAMETERS"
12390  LPRINT "Standard deviation for the mean length of each age:"
12400  '
12410  FOR I = 0 TO M
12420     LPRINT "std. for mean length ("; I; ") ="; : LPRINT USING "##.###"; STDLENGTH(I)
12430  NEXT I
12440  '
12450  LPRINT "Standard deviation for the length distribution of each age:"
12460  '
12470  FOR I = 0 TO M
12480     LPRINT "std ("; I; ") ="; : LPRINT USING "##.###"; STDAGE(I)
```

```
12490   NEXT I
12500   '
12510   '*************************************************************************
12520   '
12530   DIM F(N, Q), FILECODE$(N, Q), MORT(N, Q)
12540   DIM POP(M, N, Q), PROB(P + 1), RECRUITM(N, Q), RP(P), T(P + 1)
12550   DIM TOTCATCH(M, P), TOTLENGTHS(P), Y(P + 1), ZNORMAL(P + 1)
12560   '
12570   '*************************************************************************
12580   '
12590   '          ---- INSTANTANEOUS MORTALITY RATES ----
12600   '
12610   ' ---- Mortality may vary with time but for a given point
12620   ' ---- in time all ages will be affected equally by natural
12630   ' ---- mortality or fishing mortality. An exception is made when
12640   ' ---- a given age class is not fully recruited to the gear.
12650   ' ---- In this case fishing mortality rates will be adjusted.
12660   '
12670   '                M DISTRIBUTED NORMALY WITH MEAN = MEANM
12680   '                AND STD = STDM
12690   '
12700   '
12710   LPRINT : LPRINT "NATURAL MORTALITY VALUES "
12720   PRINT : PRINT
12730   PRINT "MEAN VALUE FOR INSTANTANEOUS ANNUAL NATURAL MORTALITY RATE (M)";
12740   INPUT MEANM
12750   '
12760   PRINT : PRINT "STANDARD DEVIATION FOR THE DISTRIBUTION OF M"
12770           PRINT "     (If you want M constant choose standard"
12780           PRINT "     deviation = 0 )                        ";
12790   INPUT STDM
12800   '
12810   MEAN = MEANM / 12
12820   STD = SQR((STDM  2) / 12)
12830   '
12840   LPRINT "Mean value for M = "; MEANM
12850   LPRINT "Standard deviation for M = "; STDM
12860   PRINT : PRINT "Calculating M values."
12870   '
12880   FOR J = 0 TO N
12890      FOR T = 1 TO Q
12900         GOSUB 18970
12910         MORT(J, T) = X
12920         MORT(J, 0) = MORT(J, 0) + MORT(J, T)
12930      NEXT T
12940   NEXT J
12950   '
12960   LPRINT
12970   LPRINT "NATURAL MORTALITY VALUES (INSTANTANEOUS RATES)"
12980   LPRINT "TOTAL=M. Monthly fraction of M follow"
12990   LPRINT : LPRINT " Y TOTAL    JAN    FEB    MAR    APR    MAY    JUN    JUL    AUG    SEP    OCT    NOV    DEC";
13000   FOR J = 0 TO N
13010      LPRINT USING "##"; J;
```

```
13020       FOR T = 0 TO Q
13030          LPRINT USING "##.###"; MORT(J, T);
13040       NEXT T
13060    NEXT J
13070    '
13080    '                  F DISTRIBUTED NORMALY WITH MEAN = MEANF
13090    '                  AND STD = STDF
13100    '
13110    '
13120    LPRINT : LPRINT "FISHING MORTALITY VALUES "
13130    PRINT : PRINT : PRINT
13140    PRINT "MEAN VALUE FOR INSTANTANEOUS ANNUAL FISHING MORTALITY RATE (F)";
13150    INPUT MEANF
13160    '
13170    PRINT : PRINT "STANDARD DEVIATION FOR THE DISTRIBUTION OF F"
13180            PRINT "     (If you want F constant choose standard"
13190            PRINT "    deviation = 0 )                          ";
13200    INPUT STDF
13210    '
13220    LPRINT "Mean value for F ="; MEANF
13230    LPRINT "Standard deviation for F ="; STDF: LPRINT
13240    PRINT : PRINT "Calculating F values. "
13250    '
13260    MEAN = MEANF / 12
13270    STD = SQR((STDF  2) / 12)
13280    '
13290    FOR J = 0 TO N
13300       FOR T = 1 TO Q
13310          GOSUB 18970
13320          F(J, T) = X
13330          F(J, 0) = F(J, 0) + F(J, T)
13340       NEXT T
13350    NEXT J
13360    '
13380    LPRINT "FISHING MORTALITY VALUES (INSTANTANEOUS RATES)"
13385    LPRINT "TOTAL=F. Monthly fraction of F follow"
13390    LPRINT : LPRINT " Y TOTAL   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC";
13400    FOR J = 0 TO N
13410       LPRINT USING "##"; J;
13420       FOR T = 0 TO Q
13430          LPRINT USING "##.###"; F(J, T);
13440       NEXT T
13460    NEXT J
13470    '
13480    LPRINT : LPRINT "NOTE: This fishing mortality rates will be corrected"
13490    LPRINT "       for age classes not fully recruited to the gear."
13500    '
13510    '*************************************************************************
13520    CLS
13530    LPRINT : LPRINT "PARAMETERS FOR GEAR SELECTIVITY"
13540    LPRINT "SELECTIVITY CURVE CONSIDERED = LOGISTIC CURVE"
13550    '
13560    '  ---- Reference for selectivity curve and parameter definition:
```

```
13570   '       PALOHEIMO, J.E. and CADIMA, E.L.,1964
13580   '       "On statistics of mesh selection"
13590   '       ICNAF, serial number 1394, document number 98
13600   '
13610   PRINT : PRINT
13620   PRINT "INPUT PARAMETERS FOR LOGISTIC SELECTIVITY CURVE"
13630   '
13640   PRINT : PRINT "MESH SIZE (standard size measured in diagonal) - in the SAME UNITS as Loo ";
13660   INPUT MESH
13670   PRINT : PRINT "L 25% (length at which the retension is 25%) - in the SAME UNITS as Loo ";
13680   INPUT L25
13690   PRINT : PRINT "L 75% (length at which the retension is 75%) - in the SAME UNITS as Loo ";
13700   INPUT L75
13710   '
13712   DELTA = L75 - L25:                      'DELTA = selection range
13714   L50 = L25 + (DELTA / 2):                'L50 = length of 50% retension
13715   SELFAC = L50 / MESH:                    'SELFAC = selection factor
13716   BETA = LOG(3) * (2 / DELTA):            'BETA = b (logistic parameter)
13720   ALFA = -BETA * SELFAC * MESH:           'ALFA = a (logistic parameter)
13730   '
13740   LPRINT "Mesh size ="; MESH
13742   LPRINT "L(25%) ="; L25
13744   LPRINT "L(50%) ="; L50
13746   LPRINT "L(75%) ="; L75
13748   LPRINT "Selection range ="; DELTA
13750   LPRINT "a (position of the logistic curve) ="; ALFA
13760   LPRINT "b (slope of the logistic curve) ="; BETA
13770   LPRINT "f (selection factor) ="; SELFAC: LPRINT
13780   '
13790   LPRINT " Length class (mid point) and corresponding retension %"
13800   FOR L = 0 TO P
13810      LENGTH = L + .5
13820      GOSUB 19500
13830      RP(L) = RETENSION
13840      LPRINT "    "; L; "       "; RP(L)
13850   NEXT L
13860   '
13870   '*************************************************************************
13880   '
13890   ' ----  Recruitment numbers and recruitment patterns  ----
13900   '
13910   '
13920   LPRINT
13930   LPRINT "TOTAL NUMBER OF RECRUITS TO AGE 0 FOR EACH SIMULATED YEAR"
13940   LPRINT "(THE NUMBERS ARE GENERATED RANDOMLY)"
13950   '
13960   FOR J = 0 TO N
13970      POP(0, J, 0) = INT(RND(1) * 1000000!)
13980      LPRINT "POP(0,"; J; ",0) = "; POP(0, J, 0)
13990   NEXT J
14000   LPRINT
14010   '
14020   LPRINT "DISTRIBUTION OF RECRUITMENT ALONG THE YEAR"
```

```
14030   LPRINT "( # OF REC. FOR THE MONTH / # OF REC. FOR THE TOTAL OF THE YEAR)"
14040   '
14050   CLS
14060   PRINT : PRINT
14070   PRINT "CHOICE OF MONTHS TO DISTRIBUTE RECRUITMENT "
14080   PRINT
14090   PRINT "RECRUITMENT TO WILL BE CONSIDERED TO HAPPEN AT THE BEGINNING"
14100   PRINT "OF THE MONTHS CHOSEN"
14110   PRINT
14120   PRINT "THE DATA ARE INPUT IN THE FORM OF PROBABILITY OF RECRUITS FOR THE"
14130   PRINT "MONTH CONSIDERED IN RELATION TO THE TOTAL OF THE YEAR"
14140   PRINT "( # OF REC. FOR THE MONTH / # OF REC. FOR THE TOTAL OF THE YEAR)"
14150   PRINT
14160   PRINT "THE TOTAL OF THE VALUES ENTERED FOR EACH YEAR SHOULD SUM TO 1"
14170   PRINT
14180   PRINT "ENTER VALUES FOR "; N + 1; "YEARS,(YEARS 0 to "; N; ") TO SIMULATE "; S; "YEAR(S)"
14190   PRINT : PRINT
14200   '
14210   FOR J = 0 TO N
14220      FOR T = 1 TO Q
14230         PRINT "YEAR ="; J; "  MONTH ="; T;
14240         INPUT RECRUITM(J, T)
14250      NEXT T
14260   NEXT J
14270   '
14280   PRINT : PRINT
14290   PRINT "AGE OF RECRUITS WHEN THEY JOIN THE AREA OF THE FISHING ACTIVITY (in months) ";
14320   INPUT RECAGE
14330   RECAGE = CINT(RECAGE)
14340   AGE = RECAGE / 12
14350   GOSUB 19410
14360   RECLENGTH = CINT(LENGTH * 10) / 10
14370   GOSUB 19500
14380   PRINT
14390   '
14400   ' ----- Printing information about recruitment patterns -----
14410   '
14420   FOR J = 0 TO N
14430      FOR T = 1 TO Q
14440      IF RECRUITM(J, T) = 0 THEN GOTO 14570
14450      IF T = 1 THEN LPRINT "Recruitment for JAN year "; J; "="; RECRUITM(J, T)
14460      IF T = 2 THEN LPRINT "Recruitment for FEB year "; J; "="; RECRUITM(J, T)
14470      IF T = 3 THEN LPRINT "Recruitment for MAR year "; J; "="; RECRUITM(J, T)
14480      IF T = 4 THEN LPRINT "Recruitment for APR year "; J; "="; RECRUITM(J, T)
14490      IF T = 5 THEN LPRINT "Recruitment for MAY year "; J; "="; RECRUITM(J, T)
14500      IF T = 6 THEN LPRINT "Recruitment for JUN year "; J; "="; RECRUITM(J, T)
14510      IF T = 7 THEN LPRINT "Recruitment for JUL year "; J; "="; RECRUITM(J, T)
14520      IF T = 8 THEN LPRINT "Recruitment for AUG year "; J; "="; RECRUITM(J, T)
14530      IF T = 9 THEN LPRINT "Recruitment for SEP year "; J; "="; RECRUITM(J, T)
14540      IF T = 10 THEN LPRINT "Recruitment for OCT year "; J; "="; RECRUITM(J, T)
14550      IF T = 11 THEN LPRINT "Recruitment for NOV year "; J; "="; RECRUITM(J, T)
14560      IF T = 12 THEN LPRINT "Recruitment for DEC year "; J; "="; RECRUITM(J, T)
14570      NEXT T
```

```
14580   NEXT J
14590   '
14600   LPRINT "NO RECRUITMENT IN OTHER MONTHS": LPRINT
14610   PRINT
14620   LPRINT "AVERAGE AGE OF RECRUITMENT TO THE FISHERY (IN MONTHS) ="; RECAGE
14630   LPRINT "AVERAGE RETENSION PERCENTAGE FOR RECRUITS TO THE FISHERY ="; RETENSION
14640   LPRINT "AVERAGE LENGTH OF RECRUITMENT TO THE FISHERY (IN CM)="; RECLENGTH
14650   LPRINT
14660   '
14670   '*************************************************************************
14680   '
14690   ' ---- Adjusting F for imcomplete retension of younger age classes ---
14700   ' ---- (average values for each age class ) -------------------------
14710   '
14720   LPRINT "AGE, LENGTH AND RETENSION FOR EACH AGE CLASS (AVERAGE VALUES):"
14730   '
14740   FOR I = 0 TO M
14750      AGE = (6 + (I * 12)) / 12
14760      GOSUB 19410
14770      GOSUB 19500
14780      LPRINT "Average age for age class "; I; "="; CINT(AGE * 10) / 10
14790      LPRINT "Average length for age class "; I; "="; CINT(LENGTH * 10) / 10
14800      LPRINT "Average retension percentage for age class "; I; "="; RETENSION
14810      F1 = MEANF
14820      NM = MEANM
14830      GOSUB 19660
14840      LPRINT "Average F (adjusted) for age class "; I; "=";
14850      LPRINT USING "##.###"; NEWF2
14860   NEXT I
14870   '
14880   '
14890   '*************************************************************************
14900   CLS
14910   PRINT : PRINT
14920   PRINT "COUNTING THE COHORTS"
14930   PRINT "COHORTS ARE GENERATED AND FOLLOWED ONE AT A TIME"
14940   '
14950   ' ----- Counting the cohorts   -----
14960   '
14970   FOR J = 0 TO N
14980      FOR T = 1 TO Q
14990      IF RECRUITM(J, T) > 0 THEN C = C + 1
15000      NEXT T
15010   NEXT J
15020   '
15030   DIM RMONTH(C), RYEAR(C), COHORTID(C)
15040   '
15050   LPRINT
15060   LPRINT "A TOTAL OF "; C; " COHORTS WILL BE GENERATED ALONG YEARS 0 TO "; N; "."
15070   LPRINT "ONLY THE LAST "; S; " YEAR(S) WILL HAVE DATA FOR ALL AGES,"
15080   LPRINT "AND WILL BE IMPORTANT FOR FUTURE USE OF THE SIMULATED DATA"
15090   LPRINT
15100   PRINT : PRINT "TOTAL NUMBER OF COHORTS ="; C
```

```
15110   '
15120   ' -----  Establishing correspondence between the cohort ID  -----
15130   ' ----- and the time of recruitment to the adult population -----
15140   '
15150   FOR J = 0 TO N
15160      FOR T = 1 TO Q
15170         IF RECRUITM(J, T) = 0 THEN GOTO 15220
15180         COUNT = COUNT + 1
15190         COHORTID(COUNT) = COUNT
15200         RMONTH(COUNT) = T
15210         RYEAR(COUNT) = J
15220      NEXT T
15230   NEXT J
15240   '
15250   '
15260   '*************************************************************************
15270   '
15280   PRINT : PRINT
15290   PRINT "CREATING PERMANENT FILES (ONE FOR EACH MONTH) TO CONTAIN"
15300   PRINT "AGE-LENGTH KEYS FOR EACH MONTH OF SIMULATION "
15310   PRINT : PRINT
15320   '
15330   LPRINT "DISK FILES CONTAINING THE AGE-LENGTH KEYS FOR EACH MONTH ARE:"
15340   FOR J = M TO N
15350      FOR T = 1 TO Q
15360         IF T <= 9 AND J <= 9 THEN FILECODE$(J, T) = "Y" + RIGHT$(STR$(J), 1) + "M" + RIGHT$(STR$(T), 1)
15370         IF T >= 10 AND J <= 9 THEN FILECODE$(J, T) = "Y" + RIGHT$(STR$(J), 1) + "M" + RIGHT$(STR$(T), 2)
15380         IF T <= 9 AND J >= 10 THEN FILECODE$(J, T) = "Y" + RIGHT$(STR$(J), 2) + "M" + RIGHT$(STR$(T), 1)
15390         IF T >= 10 AND J >= 10 THEN FILECODE$(J, T) = "Y" + RIGHT$(STR$(J), 2) + "M" + RIGHT$(STR$(T), 2)
15400         '
15410         OPEN FILECODE$(J, T) FOR OUTPUT AS #1
15420         FOR I = 0 TO M
15430            FOR L = 0 TO P - 1
15440               PRINT #1, TOTCATCH(I, L); ",";
15450            NEXT L
15460            PRINT #1, TOTCATCH(I, P)
15470         NEXT I
15480         CLOSE #1
15490         '
15500         LPRINT FILECODE$(J, T); " has the information for year"; J; " and month"; T
15510      NEXT T
15520   NEXT J
15530   LPRINT
15540   '
15550   OPEN "ALLDATA" FOR OUTPUT AS #1
15560      PRINT #1, TITLE$
15570      PRINT #1, "INFORMATION FOR EACH INDIVIDUAL COHORT"
15580      PRINT #1, "  "
15590   CLOSE #1
15600   '
15610   CLS
15620   PRINT : PRINT
15630   PRINT "NAME OF THE FILE TO STORE LENGTH DISTRIBUTIONS FOR ALL MONTHS"
```

```
15640   PRINT "(maximum 8 characters, no spaces)     ";
15650   INPUT FILENAME$
15660   '
15670   LPRINT "DISK FILE CONTAINING THE DATA FOR EACH INDIVIDUAL COHORT IS:";
15680   LPRINT "ALLDATA": LPRINT
15690   LPRINT "DISK FILE CONTAINING THE LENGTH DISTRIBUTIONS FOR ALL MONTHS IS:";
15700   LPRINT FILENAME$
15710   '
15720   '
15730   '*************************************************************************
15740   '
15750   FOR A = 1 TO C
15760   '
15770   '*************************************************************************
15780   '
15790   '
15800   DIM COHORTN(M, N, Q), COHORTC(M, N, Q), MEANAGE(M, Q), MEANLENGTH(M, Q)
15810   DIM ALKEY(M, P), TOTAGE(M), COHCATCH(M, P), Z(M, N, Q)
15820   '
15830   RYEAR = RYEAR(A)
15840   RMONTH = RMONTH(A)
15850   COHORTID = COHORTID(A)
15860   '
15870   PRINT : PRINT
15880   PRINT "CALCULATING MEAN AGE AND MEAN LENGTH FOR EACH MONTH"
15890   PRINT "AND ADJUSTING F FOR INCOMPLETE SELECTIVITY FOR COHORT # "; A
15900   '
15910   '
15920   FOR I = 0 TO M
15930      IF I + RYEAR > N THEN GOTO 16140
15940      FOR T = 1 TO Q
15950         IF I = 0 AND T < RMONTH THEN GOTO 16120
15960         IF I = 0 THEN MEANAGE(I, T) = (T - RMONTH + .5) / 12
15970         IF I > 0 THEN MEANAGE(I, T) = ((12 - RMONTH + 1) + ((I - 1) * 12) + (T - .5)) / 12
15980         AGE = MEANAGE(I, T)
15990         GOSUB 19410
16000         MEAN = LENGTH
16010         STD = STDLENGTH(I)
16020         GOSUB 18970
16030         MEANLENGTH(I, T) = X: LENGTH = X
16040         GOSUB 19500
16050         IF MEANAGE(I, T) * 12 < RECAGE THEN NEWF2 = 0: GOTO 16100
16070         F1 = F(RYEAR + I, T)
16080         NM = MORT(RYEAR + I, T)
16090         GOSUB 19660
16100         Z(I, RYEAR + I, T) = MORT(RYEAR + I, T) + NEWF2
16110         Z(I, RYEAR + I, 0) = Z(I, RYEAR + I, 0) + Z(I, RYEAR + I, T)
16120      NEXT T
16130   NEXT I
16140   '
16150   PRINT : PRINT
16160   PRINT "GENERATING NUMBERS FOR COHORT #"; COHORTID
16170   PRINT "RECRUITED IN YEAR"; RYEAR; " AND MONTH"; RMONTH; "."
```

```
16180   '
16190   ' -----  Initial number for the cohort -----
16200   '
16210   COHORTN(0, RYEAR, RMONTH) = POP(0, RYEAR, 0) * RECRUITM(RYEAR, RMONTH)
16220   '
16230   ' ----- Numbers for class i=0 (from recruitment time to end of the year)
16240   '
16250   IF RMONTH = 12 GOTO 16340
16260   '
16270   FOR T = RMONTH + 1 TO Q
16280      COHORTN(0, RYEAR, T) = COHORTN(0, RYEAR, T - 1) * EXP(-Z(0, RYEAR, T - 1))
16290   NEXT T
16300   '
16310   ' -----  Numbers for classes i=1 on   -----
16320   '
16330   '
16340   FOR I = 1 TO M
16350      IF I + RYEAR > N THEN GOTO 16420
16360      COHORTN(I, RYEAR + I, 0) = COHORTN(I - 1, RYEAR + I - 1, 12) * EXP(-Z(I - 1, RYEAR + I - 1, 12))
16370      COHORTN(I, RYEAR + I, 1) = COHORTN(I, RYEAR + I, 0)
16380      FOR T = 2 TO Q
16390         COHORTN(I, RYEAR + I, T) = COHORTN(I, RYEAR + I, T - 1) * EXP(-Z(I, RYEAR + I, T - 1))
16400      NEXT T
16410   NEXT I
16420   '
16430   ' ---- calculating catch in numbers for each month ----
16440   '
16450   FOR I = 0 TO M
16460      IF RYEAR + I > N THEN GOTO 16520
16470      FOR T = 1 TO Q
16480         IF I = 0 AND T < RMONTH THEN GOTO 16500
16490         COHORTC(I, RYEAR + I, T) = COHORTN(I, RYEAR + I, T) * (Z(I, RYEAR + I, T) - MORT(RYEAR + I, T))
                                         / Z(I, RYEAR + I, T) * (1 - EXP(-Z(I, RYEAR + I, T)))
16495         COHORTC(I, RYEAR + I, T) = CINT(COHORTC(I, RYEAR + I, T))
16500      NEXT T
16510   NEXT I
16520   '
16530   LPRINT
16540   LPRINT "TOTAL MORTALITY(Z-month), COHORT NUMBERS AND CATCH FOR COHORT #"; A
16550   LPRINT "AGE CLASS    YEAR    MONTH    AGE IN MONTHS       Z       N       C"
16560   FOR I = 0 TO M
16570      IF I + RYEAR > N THEN GOTO 16710
16580      FOR T = 1 TO Q
16590         IF I = 0 AND T < RMONTH THEN GOTO 16690
16600         IF I = 0 THEN AGE = T - RMONTH + .5
16610         IF I > 0 THEN AGE = (12 - RMONTH + 1) + ((I - 1) * 12) + (T - .5)
16620         LPRINT USING "#########"; I;
16630         LPRINT USING "########"; RYEAR + I;
16640         LPRINT USING "########"; T;
16650         LPRINT USING "##############.#"; AGE;
16660         LPRINT USING "###.###"; Z(I, RYEAR + I, T);
16670         LPRINT USING "#######"; COHORTN(I, RYEAR + I, T);
16680         LPRINT USING "#######"; COHORTC(I, RYEAR + I, T)
```

```
16690       NEXT T
16700    NEXT I
16710    '
16720    LPRINT
16730    LPRINT "TOTAL MORTALITY(Z-year) FOR COHORT #"; A
16740    LPRINT "AGE CLASS     YEAR         Z"
16750    FOR I = 0 TO H
16760       IF I + RYEAR > N THEN GOTO 16810
16770       LPRINT USING "#########"; I;
16780       LPRINT USING "########"; RYEAR + I;
16790       LPRINT USING "#####.###"; Z(I, RYEAR + I, 0)
16800    NEXT I
16810    '
16820    '*************************************************************************
16830    '
16840    PRINT : PRINT
16850    PRINT "SIMULATION OF AGE-LENGTH  KEYS FOR EACH YEAR AND MONTH"
16860    PRINT "FOR THE COHORT RECRUITED IN YEAR"; RYEAR; " AND MONTH"; RMONTH
16870    '
16880    '
16890    IF RYEAR >= M THEN FIRSTYEAR = RYEAR
16900    IF M > RYEAR THEN FIRSTYEAR = M
16910    IF RYEAR + M <= N THEN LASTYEAR = RYEAR + M
16920    IF RYEAR + M > N THEN LASTYEAR = N
16930    '
16940    '
16950    FOR J = FIRSTYEAR TO LASTYEAR
16960       FOR T = 1 TO Q
16970          IF J = RYEAR AND T < RMONTH THEN GOTO 17670
16980          I = J - RYEAR
16990          MEAN = MEANLENGTH(I, T)
17000          STD = STDAGE(I)
17010          GOSUB 19160
17020          '
17030          '  ---- Accumulated probabilities for unit length intervals ----
17040          '
17050          FOR L = 0 TO P
17060             ALKEY(I, L) = PROB(L + 1) - PROB(L)
17070          NEXT L
17080          '
17090          ' ---- Correction of the age-length keys for gear selectivity ----
17100          '
17110          TOTAGE(I) = 0
17120          '
17130          FOR L = 0 TO P
17140             ALKEY(I, L) = ALKEY(I, L) * RP(L)
17150             TOTAGE(I) = TOTAGE(I) + ALKEY(I, L)
17160          NEXT L
17170          '
17180          FOR L = 0 TO P
17190             ALKEY(I, L) = ALKEY(I, L) / TOTAGE(I)
17200          NEXT L
17210          '
```

```
17220         ' ---- Transforming the age-length key from % into numbers -------
17230         '
17240         FOR L = 0 TO P
17250            COHCATCH(I, L) = COHORTC(I, J, T) * ALKEY(I, L)
17260         NEXT L
17270         '
17280         ' ---- Writing catch numbers for all cohorts in a file
17290         '
17300         OPEN "ALLDATA" FOR APPEND AS #1
17310         PRINT #1, "COHORTID = "; COHORTID; ","; "RECRUITMENT YEAR = ";
17320         PRINT #1, RYEAR; ","; "RECRUITMENT MONTH = "; RMONTH
17330         PRINT #1, "CATCH FOR YEAR = "; J; " AND MONTH = "; T
17340         PRINT #1, "AGE"; ","; I
17350         PRINT #1, "LENGTH CLASSES FROM 0 TO "; P
17360         FOR L = 0 TO P - 1
17370             PRINT #1, CINT(COHCATCH(I, L)); ",";
17380         NEXT L
17390         PRINT #1, CINT(COHCATCH(I, P))
17400         CLOSE #1
17410         '
17420         ' ---- Adding the numbers for this cohort to previous ones ----
17430         '
17440         OPEN FILECODE$(J, T) FOR INPUT AS #1
17450         '
17460         FOR I = 0 TO M
17470            FOR L = 0 TO P
17480               INPUT #1, TOTCATCH(I, L)
17490            NEXT L
17500         NEXT I
17510         CLOSE #1
17520         '
17530         FOR L = 0 TO P
17540            TOTCATCH(J - RYEAR, L) = TOTCATCH(J - RYEAR, L) + COHCATCH(J - RYEAR, L)
17550         NEXT L
17560         '
17570         OPEN FILECODE$(J, T) FOR OUTPUT AS #1
17580         FOR I = 0 TO M
17590            FOR L = 0 TO P - 1
17600               PRINT #1, CINT(TOTCATCH(I, L)); ",";
17610               COHCATCH(I, L) = 0
17620            NEXT L
17630            PRINT #1, CINT(TOTCATCH(I, P))
17640         NEXT I
17650         CLOSE #1
17660         '
17670      NEXT T
17680   NEXT J
17690   '
17700   '
17710   ERASE COHORTN, COHORTC, MEANAGE, MEANLENGTH, ALKEY, TOTAGE, COHCATCH, Z
17720   '
17730   '
17740   '*************************************************************************
```

```
17750   '
17760   NEXT A
17770   '
17780   '*************************************************************************
17790   '
17800   CLS
17810   PRINT : PRINT
17820   PRINT "CREATING '"; FILENAME$; "' WITH LENGTH DISTRIBUTIONS FOR EACH MONTH"
17830   '
17840   ' ---- Saving information about the simulation in final file ----
17850   '
17860   OPEN FILENAME$ FOR OUTPUT AS #1
17870   '
17880   PRINT #1, "TITLE IS "; ","; TITLE$
17890   PRINT #1, "NUMBER OF SAMPLES SIMULATED IS "; ","; S * 12
17900   PRINT #1, "LARGEST LENGTH CONSIDERED IN THE SIMULATIONS IS "; ","; P
17910   PRINT #1, "FOR EACH SAMPLE THE SEQUENCE WILL BE:"
17920   PRINT #1, "YEAR - MONTH - LENGTH CLASS FROM 0 TO "; P
17930   PRINT #1, "-------------------------------------------------------"
17940   '
17950   CLOSE #1
17960   '
17970   '
17980   ' ---- Adding all the numbers for the same length class and   ----
17990   ' ---- different ages for each age-length key                 ----
18000   '
18010   ' ---- Printing age-length keys                               ----
18020   '
18030   LPRINT
18040   LPRINT "AGE-LENGTH KEYS FOR EACH MONTH"
18050   LPRINT "(cohorts from the same year totaled in each age class)"
18060   LPRINT "Ages in columns and length classes in rows": LPRINT
18070   '
18080   FOR J = M TO N
18090      FOR T = 1 TO Q
18100         '
18110         FOR L = 0 TO P
18120            TOTLENGTHS(L) = 0
18130         NEXT L
18140         '
18150         OPEN FILECODE$(J, T) FOR INPUT AS #1
18160         '
18170         FOR I = 0 TO M
18180            FOR L = 0 TO P
18190               INPUT #1, TOTCATCH(I, L)
18200            NEXT L
18210         NEXT I
18220         '
18230         CLOSE #1
18240         '
18250         FOR L = 0 TO P
18260            FOR I = 0 TO M
18270               TOTLENGTHS(L) = TOTLENGTHS(L) + TOTCATCH(I, L)
```

```
18280           NEXT I
18290        NEXT L
18300        '
18310        OPEN FILECODE$(J, T) FOR OUTPUT AS #1
18320        '
18330        PRINT #1, "YEAR IS "; ","; J
18340        PRINT #1, "MONTH IS "; ","; T
18350        PRINT #1, "LENGTH CLASSES ARE 0 TO "; ","; P
18360        PRINT #1, "AGE CLASSES ARE 0 TO "; ","; M
18370        FOR I = 0 TO M
18380           FOR L = 0 TO P - 1
18390              PRINT #1, TOTCATCH(I, L); ",";
18400           NEXT L
18410           PRINT #1, TOTCATCH(I, P)
18420        NEXT I
18430        '
18440        PRINT #1, " TOTAL "
18450        '
18460        FOR L = 0 TO P - 1
18470           PRINT #1, TOTLENGTHS(L); ",";
18480        NEXT L
18490        PRINT #1, TOTLENGTHS(P)
18500        CLOSE #1
18510        '
18520        LPRINT : LPRINT FILECODE$(J, T)
18530        LPRINT "      LC";
18540        FOR I = 0 TO M
18545           LPRINT " AGE=";
18550           LPRINT USING "##"; I;
18560        NEXT I
18570        LPRINT "  TOTAL"
18580        FOR L = 0 TO P
18590        LPRINT USING " ######"; L;
18600        FOR I = 0 TO M
18610           LPRINT USING " ######"; TOTCATCH(I, L);
18620        NEXT I
18630        LPRINT USING " ######"; TOTLENGTHS(L)
18640        NEXT L
18650        '
18660        OPEN FILENAME$ FOR APPEND AS #1
18670        '
18680        PRINT #1, J
18690        PRINT #1, T
18700        '
18710        FOR L = 0 TO P - 1
18720           PRINT #1, TOTLENGTHS(L); ",";
18730        NEXT L
18740        PRINT #1, TOTLENGTHS(P)
18750        PRINT #1, "----------------------"
18760        '
18770        CLOSE #1
18780        '
18790     NEXT T
```

```
18800      LPRINT : LPRINT
18810    NEXT J
18820    '
18830    LPRINT : LPRINT : LPRINT
18840    LPRINT "*********************************"
18850    LPRINT "    SIMULATION FINISHED !!!"
18860    LPRINT "*********************************"
18870    CLS
18880    PRINT : PRINT
18890    PRINT "*********************************"
18900    PRINT "    SIMULATION FINISHED !!!"
18910    PRINT "*********************************"
18920    '
18930    '*************************************************************************
18940    '
18950    END
18960    '
18970    '*************************************************************************
18980    '
18990    ' ----- Randomization subroutine
19000    '
19010    ' ----- Reference for this subroutine:
19020    ' ----- HASTINGS, N.A.J. and J.B. PEACOCK, 1975,
19030    ' -----             "Statistical Distributions"
19040    ' -----             John Wiley and Sons
19050    '
19060    '
19070    SUM = 0
19080    FOR R = 1 TO 12
19090       SUM = SUM + RND
19100    NEXT R
19110    SUM = SUM - 6!
19120    X = (SUM * STD) + MEAN
19130    IF X < 0 THEN X = 0
19140    '
19150    RETURN
19160    '*************************************************************************
19170    '
19180    ' ----- Subroutine to calculate areas under the normal curve
19190    '
19200    ' ----- The approximation to determine area under the normal curve
19210    ' ----- is from: HASTINGS, C., 1955,
19220    ' -----             "Approximations for digital computers"
19230    ' -----             Princeton University Press, Princeton, NJ
19240    '
19250    H = .2316419
19260    B1 = .31938153#
19270    B2 = -.356563782#
19280    B3 = 1.781477937#
19290    B4 = -1.821255978#
19300    B5 = 1.330274429#
19310    '
19320    FOR L = 0 TO P + 1
```

```
19330      Y(L) = (L - MEAN) / STD
19340      ZNORMAL(L) = (1 / ((2 * 3.1415926#)  (1 / 2))) * EXP(-((Y(L)  2) / 2))
19350      T(L) = 1 / (1 + (H * ABS(Y(L))))
19360      PROB(L) = 1 - (ZNORMAL(L) * ((B1 * T(L)) + (B2 * (T(L)  2)) + (B3 * (T(L)  3)) + (B4 * (T(L)  4))
                  + (B5 * (T(K)  5))))
19370      IF Y(L) < 0 THEN PROB(L) = 1 - PROB(L)
19380   NEXT L
19390   '
19400   RETURN
19410   '*************************************************************************
19420   '
19430   '  -----  Subroutine to calculate length at age  ------
19440   '  -----  the von Bertalanffy growth curve is used -----
19450   '
19460   LENGTH = LINF * (1 - EXP(-KEI * (AGE - TZERO)))
19470   IF LENGTH < 0 THEN LENGTH = 0
19480   '
19490   RETURN
19500   '*************************************************************************
19510   '
19520   '     -----  Subroutine to calculate retension %     -----
19530   '     -----  due to selectivity of the trawling net -----
19540   '     -----  The logistic equation was used         -----
19550   '
19560   RETENSION = 1 / (1 + EXP(-ALFA - BETA * LENGTH))
19570   RETENSION = CINT(RETENSION * 100) / 100
19580   '
19590   RETURN
19600   '*************************************************************************
19610   '
19620   '    -----  Subroutine to approximately adjust fishing mortality -----
19630   '    -----  for age classes not fully recruited to the gear.     -----
19640   '
19650   '
19660   CONSTANT = 9999991
19670   '
19680   FOR F2 = 0 TO F1 STEP .01
19690      DIF = F2 / (F2 + NM) * (1 - EXP(-F2 - NM))
19695      DIF = DIF - (RETENSION * F1 / (F1 + NM) * (1 - EXP(-F1 - NM)))
19700      DIF = ABS(DIF)
19710      IF DIF < CONSTANT THEN NEWF2 = F2
19720      IF DIF < CONSTANT THEN CONSTANT = DIF
19730   NEXT F2
19740   '
19750   RETURN
19760   '*************************************************************************
19770   '
19780   '    ----- Error detection subroutine -----
19790   '
19820   PRINT "ERROR TYPE NO.    ="; ERR
19830   PRINT "AT LINE NUMBER    ="; ERL
```

8 - EXAMPLE OF PRINTED OUTPUT

The output shown here was obtained running SIMULPOP with the parameters referred in part 3 of this manual (inputs for the program) and removing the 'RANDOMIZE' step from the beginning of the program.

```
**********************************************************************

SMALL SPARIDAE TWO RECRUITMENT PEAKS PER YEAR

**********************************************************************

PARAMETERS USED IN THE LENGTH FREQUENCY SIMULATION:


AGE OF OLDER CLASS PRESENT IN THE CATCH (in years) = 6

NUMBER OF YEARS TO OBTAIN SIMULATED DATA = 2

PARAMETERS FOR THE GROWTH CURVE (von BERTALANFFY):
L-inf = 35
K = .2
To = 0

AGE-LENGTH KEY PARAMETERS
Standard deviation for the mean length of each age:
std. for mean length ( 0 ) = 0.000
std. for mean length ( 1 ) = 0.000
std. for mean length ( 2 ) = 0.000
std. for mean length ( 3 ) = 0.000
std. for mean length ( 4 ) = 0.000
std. for mean length ( 5 ) = 0.000
std. for mean length ( 6 ) = 0.000
Standard deviation for the length distribution of each age:
std ( 0 ) = 1.000
std ( 1 ) = 1.200
std ( 2 ) = 1.500
std ( 3 ) = 2.000
std ( 4 ) = 2.000
std ( 5 ) = 2.000
std ( 6 ) = 2.000
```

NATURAL MORTALITY VALUES
Mean value for M = .2
Standard deviation for M = .01

NATURAL MORTALITY VALUES (INSTANTANEOUS RATES)
TOTAL=M. Monthly fraction of M follow

Y	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DE
0	0.188	0.018	0.015	0.013	0.015	0.018	0.017	0.018	0.012	0.011	0.017	0.016	0.01
1	0.192	0.018	0.009	0.017	0.014	0.022	0.018	0.017	0.018	0.019	0.013	0.011	0.01
2	0.208	0.017	0.021	0.014	0.022	0.013	0.017	0.018	0.016	0.020	0.017	0.021	0.01
3	0.184	0.013	0.018	0.012	0.017	0.012	0.012	0.018	0.014	0.017	0.014	0.016	0.01
4	0.192	0.012	0.014	0.017	0.018	0.015	0.019	0.014	0.023	0.017	0.017	0.012	0.01
5	0.193	0.015	0.016	0.014	0.019	0.018	0.014	0.014	0.016	0.019	0.020	0.015	0.01
6	0.208	0.020	0.020	0.022	0.015	0.014	0.009	0.021	0.017	0.014	0.014	0.020	0.02
7	0.180	0.012	0.017	0.016	0.014	0.010	0.013	0.015	0.015	0.017	0.018	0.016	0.01

FISHING MORTALITY VALUES
Mean value for F = .8
Standard deviation for F = .02

FISHING MORTALITY VALUES (INSTANTANEOUS RATES)
TOTAL=F. Monthly fraction of F follow

Y	TOTAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DE
0	0.813	0.055	0.073	0.070	0.064	0.067	0.071	0.062	0.065	0.075	0.079	0.069	0.06
1	0.792	0.066	0.070	0.068	0.051	0.064	0.068	0.068	0.061	0.073	0.063	0.071	0.07
2	0.798	0.070	0.060	0.069	0.067	0.060	0.057	0.068	0.072	0.073	0.057	0.073	0.07
3	0.807	0.065	0.071	0.067	0.070	0.074	0.073	0.055	0.072	0.067	0.062	0.065	0.06
4	0.833	0.063	0.064	0.062	0.069	0.078	0.084	0.064	0.071	0.073	0.078	0.063	0.06
5	0.790	0.062	0.081	0.071	0.061	0.059	0.060	0.058	0.067	0.072	0.066	0.072	0.06
6	0.771	0.063	0.069	0.063	0.074	0.070	0.060	0.068	0.058	0.059	0.067	0.062	0.05
7	0.795	0.063	0.065	0.068	0.071	0.061	0.069	0.068	0.071	0.067	0.071	0.062	0.06

NOTE: This fishing mortality rates will be corrected
for age classes not fully recruited to the gear.

PARAMETERS FOR GEAR SELECTIVITY
SELECTIVITY CURVE CONSIDERED = LOGISTIC CURVE
Mesh size = 3.5
L(25%) = 11.25
L(50%) = 14
L(75%) = 16.75
Selection range = 5.5
a (position of the logistic curve) =-5.592936
b (slope of the logistic curve) = .3994954
f (selection factor) = 4

```
Length class (mid point) and corresponding retension %
    0         0
    1         .01
    2         .01
    3         .01
    4         .02
    5         .03
    6         .05
    7         .07
    8         .1
    9         .14
    10         .2
    11         .27
    12         .35
    13         .45
    14         .55
    15         .65
    16         .73
    17         .8
    18         .86
    19         .9
    20         .93
    21         .95
    22         .97
    23         .98
    24         .99
    25         .99
    26         .99
    27         1
    28         1
    29         1
    30         1
    31         1
    32         1
    33         1
    34         1
    35         1
    36         1
    37         1
    38         1
    39         1

TOTAL NUMBER OF RECRUITS TO AGE 0 FOR EACH SIMULATED YEAR
(THE NUMBERS ARE GENERATED RANDOMLY)
POP(0, 0 ,0) =  14949
POP(0, 1 ,0) =  843561
POP(0, 2 ,0) =  996579
POP(0, 3 ,0) =  808461
POP(0, 4 ,0) =  997508
POP(0, 5 ,0) =  243783
POP(0, 6 ,0) =  2211
POP(0, 7 ,0) =  422667
```

```
DISTRIBUTION OF RECRUITMENT ALONG THE YEAR
( # OF REC. FOR THE MONTH / # OF REC. FOR THE TOTAL OF THE YEAR)
Recruitment for MAR year  0 = .5
Recrutiment for SEP year  0 = .5
Recruitment for MAR year  1 = .5
Recrutiment for SEP year  1 = .5
Recruitment for MAR year  2 = .5
Recrutiment for SEP year  2 = .5
Recruitment for MAR year  3 = .5
Recrutiment for SEP year  3 = .5
Recruitment for MAR year  4 = .5
Recrutiment for SEP year  4 = .5
Recruitment for MAR year  5 = .5
Recrutiment for SEP year  5 = .5
Recruitment for MAR year  6 = .5
Recrutiment for SEP year  6 = .5
Recruitment for MAR year  7 = .5
Recrutiment for SEP year  7 = .5
NO RECRUITMENT IN OTHER MONTHS

AVERAGE AGE OF RECRUITMENT TO THE FISHERY (IN MONTHS) = 6
AVERAGE RETENSION PERCENTAGE FOR RECRUITS TO THE FISHERY = .01
AVERAGE LENGTH OF RECRUITMENT TO THE FISHERY (IN CM)= 3.3

AGE, LENGTH AND RETENSION FOR EACH AGE CLASS (AVERAGE VALUES):
Average age for age class  0 = .5
Average length for age class  0 = 3.3
Average retension percentage for age class  0 = .01
Average F (adjusted) for age class  0 = 0.010
Average age for age class  1 = 1.5
Average length for age class  1 = 9.1
Average retension percentage for age class  1 = .12
Average F (adjusted) for age class  1 = 0.070
Average age for age class  2 = 2.5
Average length for age class  2 = 13.8
Average retension percentage for age class  2 = .48
Average F (adjusted) for age class  2 = 0.310
Average age for age class  3 = 3.5
Average length for age class  3 = 17.6
Average retension percentage for age class  3 = .81
Average F (adjusted) for age class  3 = 0.590
Average age for age class  4 = 4.5
Average length for age class  4 = 20.8
Average retension percentage for age class  4 = .94
Average F (adjusted) for age class  4 = 0.730
Average age for age class  5 = 5.5
Average length for age class  5 = 23.3
Average retension percentage for age class  5 = .98
Average F (adjusted) for age class  5 = 0.780
Average age for age class  6 = 6.5
Average length for age class  6 = 25.5
Average retension percentage for age class  6 = .99
Average F (adjusted) for age class  6 = 0.790

A TOTAL OF  16  COHORTS WILL BE GENERATED ALONG YEARS 0 TO  7 .
ONLY THE LAST  2  YEAR(S) WILL HAVE DATA FOR ALL AGES,
AND WILL BE IMPORTANT FOR FUTURE USE OF THE SIMULATED DATA
```

DISK FILES CONTAINING THE AGE-LENGTH KEYS FOR EACH MONTH ARE:
Y6M1 has the information for year 6 and month 1
Y6M2 has the information for year 6 and month 2
Y6M3 has the information for year 6 and month 3
Y6M4 has the information for year 6 and month 4
Y6M5 has the information for year 6 and month 5
Y6M6 has the information for year 6 and month 6
Y6M7 has the information for year 6 and month 7
Y6M8 has the information for year 6 and month 8
Y6M9 has the information for year 6 and month 9
Y6M10 has the information for year 6 and month 10
Y6M11 has the information for year 6 and month 11
Y6M12 has the information for year 6 and month 12
Y7M1 has the information for year 7 and month 1
Y7M2 has the information for year 7 and month 2
Y7M3 has the information for year 7 and month 3
Y7M4 has the information for year 7 and month 4
Y7M5 has the information for year 7 and month 5
Y7M6 has the information for year 7 and month 6
Y7M7 has the information for year 7 and month 7
Y7M8 has the information for year 7 and month 8
Y7M9 has the information for year 7 and month 9
Y7M10 has the information for year 7 and month 10
Y7M11 has the information for year 7 and month 11
Y7M12 has the information for year 7 and month 12

DISK FILE CONTAINING THE DATA FOR EACH INDIVIDUAL COHORT IS:ALLDATA

DISK FILE CONTAINING THE LENGTH DISTRIBUTIONS FOR ALL MONTHS IS:TESTCASE

TOTAL MORTALITY(Z-month), COHORT NUMBERS AND CATCH FOR COHORT # 1

AGE CLASS	YEAR	MONTH	AGE IN MONTHS	Z	N	C
0	0	3	0.5	0.013	7475	0
0	0	4	1.5	0.015	7376	0
0	0	5	2.5	0.018	7267	0
0	0	6	3.5	0.017	7137	0
0	0	7	4.5	0.018	7018	0
0	0	8	5.5	0.012	6891	0
0	0	9	6.5	0.011	6809	0
0	0	10	7.5	0.017	6735	0
0	0	11	8.5	0.016	6622	0
0	0	12	9.5	0.018	6519	0
1	1	1	10.5	018	6400	0
1	1	2	11.5	0.009	6289	0
1	1	3	12.5	0.017	6233	0
1	1	4	13.5	0.014	6126	0
1	1	5	14.5	0.022	6039	0
1	1	6	15.5	0.028	5909	58
1	1	7	16.5	0.027	5749	57
1	1	8	17.5	0.028	5597	55
1	1	9	18.5	0.029	5445	54
1	1	10	19.5	0.023	5288	52
1	1	11	20.5	0.021	5166	51
1	1	12	21.5	0.027	5059	50

2	2	1	22.5	0.037	4923	97
2	2	2	23.5	0.041	4746	93
2	2	3	24.5	0.034	4555	90
2	2	4	25.5	0.042	4402	86
2	2	5	26.5	0.033	4220	83
2	2	6	27.5	0.037	4085	80
2	2	7	28.5	0.048	3937	115
2	2	8	29.5	0.046	3753	110
2	2	9	30.5	0.060	3586	139
2	2	10	31.5	0.047	3377	99
2	2	11	32.5	0.061	3222	125
2	2	12	33.5	0.053	3032	118
3	3	1	34.5	0.053	2875	112
3	3	2	35.5	0.068	2726	132
3	3	3	36.5	0.062	2547	123
3	3	4	37.5	0.067	2393	116
3	3	5	38.5	0.062	2238	108
3	3	6	39.5	0.072	2103	122
3	3	7	40.5	0.058	1956	76
3	3	8	41.5	0.074	1847	107
3	3	9	42.5	0.067	1715	83
3	3	10	43.5	0.064	1604	78
3	3	11	44.5	0.066	1504	73
3	3	12	45.5	0.079	1407	81
4	4	1	46.5	0.072	1300	75
4	4	2	47.5	0.074	1210	70
4	4	3	48.5	0.077	1124	65
4	4	4	49.5	0.078	1041	60
4	4	5	50.5	0.085	962	65
4	4	6	51.5	0.099	884	67
4	4	7	52.5	0.074	801	46
4	4	8	53.5	0.093	744	50
4	4	9	54.5	0.087	678	45
4	4	10	55.5	0.087	621	42
4	4	11	56.5	0.072	569	33
4	4	12	57.5	0.075	530	31
5	5	1	58.5	0.075	492	28
5	5	2	59.5	0.096	456	35
5	5	3	60.5	0.084	415	28
5	5	4	61.5	0.079	381	22
5	5	5	62.5	0.068	352	17
5	5	6	63.5	0.064	329	16
5	5	7	64.5	0.064	309	15
5	5	8	65.5	0.076	290	17
5	5	9	66.5	0.089	269	18
5	5	10	67.5	0.080	246	14
5	5	11	68.5	0.085	227	15
5	5	12	69.5	0.075	209	12

6	6	1	70.5	0.080	193	11
6	6	2	71.5	0.080	179	10
6	6	3	72.5	0.082	165	9
6	6	4	73.5	0.085	152	10
6	6	5	74.5	0.074	139	8
6	6	6	75.5	0.069	129	8
6	6	7	76.5	0.081	121	7
6	6	8	77.5	0.067	111	5
6	6	9	78.5	0.064	104	5
6	6	10	79.5	0.074	98	6
6	6	11	80.5	0.080	91	5
6	6	12	81.5	0.071	84	4

TOTAL MORTALITY(Z-year) FOR COHORT # 1

AGE CLASS	YEAR	Z
0	0	0.155
1	1	0.262
2	2	0.538
3	3	0.794
4	4	0.972
5	5	0.933
6	6	0.908

(the same for cohorts 2 to 15

TOTAL MORTALITY(Z-month), COHORT NUMBERS AND CATCH FOR COHORT # 16

AGE CLASS	YEAR	MONTH	AGE IN MONTHS	Z	N	C
0	7	9	0.5	0.017	211334	0
0	7	10	1.5	0.018	207844	0
0	7	11	2.5	0.016	204211	0
0	7	12	3.5	0.018	201060	0

TOTAL MORTALITY(Z-year) FOR COHORT # 16

AGE CLASS	YEAR	Z
0	7	0.068

AGE-LENGTH KEYS FOR EACH MONTH
(cohorts from the same year totaled in each age class)
Ages in columns and length classes in rows

Y6M1

LC	AGE= 0	AGE= 1	AGE= 2	AGE= 3	AGE= 4	AGE= 5	AGE= 6	TOTAL
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	1	0	0	0	0	1
4	0	0	7	0	0	0	0	7
5	0	0	44	0	0	0	0	44
6	0	0	209	1	0	0	0	210
7	0	0	548	4	0	0	0	552
8	0	0	1000	19	0	0	0	1019
9	0	0	1295	78	0	0	0	1373
10	0	0	1376	253	1	0	0	1630
11	0	0	1193	628	9	0	0	1830
12	0	0	811	1209	44	0	0	2064
13	0	0	401	1888	161	1	0	2451
14	0	0	129	2321	450	4	0	2904
15	0	0	26	2300	971	22	0	3319
16	0	0	3	1805	1601	73	0	3482
17	0	0	0	1143	2087	195	0	3425
18	0	0	0	581	2172	399	0	3152
19	0	0	0	232	1797	639	1	2669
20	0	0	0	73	1199	807	2	2081
21	0	0	0	18	643	810	4	1475
22	0	0	0	3	279	654	5	941
23	0	0	0	1	96	421	6	524
24	0	0	0	0	26	218	5	249
25	0	0	0	0	5	90	4	99
26	0	0	0	0	1	29	2	32
27	0	0	0	0	0	8	1	9
28	0	0	0	0	0	1	0	1
29	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0

⋮

THE SAME FOR Y6M2 to Y7M11

Y7M12

LC	AGE= 0	AGE= 1	AGE= 2	AGE= 3	AGE= 4	AGE= 5	AGE= 6	TOTAL
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	1	0	0	0	0	1
9	0	1	11	0	0	0	0	12
10	0	2	54	3	0	0	0	59
11	0	2	174	16	0	0	0	192
12	0	1	377	67	0	0	0	445
13	0	0	605	231	1	0	0	837
14	0	0	729	597	6	0	0	1332
15	0	0	665	1195	26	0	0	1886
16	0	0	426	1827	84	1	0	2338
17	0	0	186	2209	208	7	0	2610
18	0	0	54	2135	406	23	0	2618
19	0	0	10	1642	615	66	2	2335
20	0	0	1	1020	736	144	7	1908
21	0	0	0	510	701	248	20	1479
22	0	0	0	207	538	338	45	1128
23	0	0	0	67	329	364	78	838
24	0	0	0	18	162	312	111	603
25	0	0	0	3	64	212	122	401
26	0	0	0	1	20	115	106	242
27	0	0	0	0	5	50	74	129
28	0	0	0	0	1	17	41	59
29	0	0	0	0	0	5	18	23
30	0	0	0	0	0	1	6	7
31	0	0	0	0	0	0	1	1
32	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0

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SIMULATION FINISHED !!!
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