

Fol. 416
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International Council for
the Exploration of the Sea

C.M. 1982/G:7
Demersal Fish Committee
Ref.:
Pelagic Fish Committee

*Fiskeridirektoratet
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A program for estimation of number and survival of a population, given a series of tag release/recapture data.

by

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ABSTRACT

A computer program for convenient storage of tag release/recapture data is given. The program provides a facility to combine yearclasses if releases/recaptures are split into yearclasses. One estimate of number and three different estimates of survival are printed as output. Tables of release/recaptures of tags in different years and absolute and relative tagging densities together with a table of catch statistics are also given. The program is interactive and presupposes no knowledge of programming.

1. Introduction

The program is written in NORD-FORTRAN (Anon., 1979) and is implemented on a ND-100 computer.

The user must create his own datafiles in the prescribed manner. Once this is done the program is selfexplaining, and the results will be printed on the lineprinter.

The routines used are basically taken from Seber, 1973. One routine to estimate survival is from Hamre, 1978.

2. The data files

2.1 File of release/recapture history

This data file consist of the following record types: A,B,C,D, E,F and *. One of these characters must be the first character in a record.

A-type:

This record type occurs only once in the data file as the first record. It is convenient to have an alpha-numeric stock description here. Upto 39 characters are allowed.

B-type:

This record preceedes all data concerning the actual yearclass or group. If the given year for a "yearclass" is negative it is not possible to combine with other groups but is taken as a stand-alone-group.

C-type:

These records are the release history of the actual yearclass.

D-type:

The D-records gives the recapture history of the actual yearclass.

E-type:

These records contains the number screened and the number totally caught of the yearclass in each year. The last E-record of the actual yearclass will either be succeeded by a new B-record, F-record or by the *-record.

F-type:

This record is the last record of the file and it is only one F-record in the file. It contains only the character F.

*-type:

If an asteriks is in the first column in any record it is ignored. This recordtype is convenient for spacing and comments in the datafile. A maximum of 40 characters are allowed.

2.2 Data_file_of_weight_at_age

This file tells us the weight of an individual at different ages in grams.

3. Warnings when creating the data files

Give the yearclasses in increasing order (1969, 1970 etc.). It is always supposed by the program that the first year tags were released into the population, tags were also released into the oldest age group. If, by accident, this age group was not present the first year, you must create a C-record for this yearclass in that year with zero tags released. When a yearclass is recorded one year it must always be recorded by some figure (might be zero) the following years that recaptures are done. In the present versions of the program the maximum number of years that releases or recaptures can be done is 30 years which should be sufficient for most cases. It is easy to increase this number.

4. What the program does

The program prints out three tables.

- the table of recaptures. This simply lists the number of tags released in each year together with a record of when and how many tags from each release that were recaptured. The sums of lines and columns in the array are printed out.

- the table of tagging densities. This table has the same layout as the above table, but the elements in the array of tag recaptures is divided by the number of individuals screened the actual year and multiplied by 10^6 .
- the table of relative tagging densities. The elements in this table are computed from the table of tagging densities by taking the mean in each line and divide each number in the line by this mean value.
- the table of catch statistics, gives the number screened, the total number caught and the ratio between these two figures for each year of recapture.
- the table of estimates of weight, number and survival, lists for each year estimates of weight, number, standard error of number and three different estimates of survival. Two estimates of survival are given with an estimate of their standard error.
- A chisquared test statistic is produced for the third of the three survival estimates. See chapter 5.3.

5. Theory of the computations

5.1 Computations of number with standard error

The estimates of these figures are computed according to the formulae on page 218 in Seber.

With the great numbers involved in fisheries work, it is easily seen that the estimate of, N_i , the number of fish in the group, degenerates to:

$$\hat{N}_i = \frac{R_i \cdot \sum_{j=i}^t ns_j}{\sum_{j=i}^t m_{ij}} \quad (1)$$

where:

R_i = number of marked individuals released in year i
 $i = 1, 2, \dots, s$

ns_j = number of individuals screened for tags in year j

m_{ij} = number of tags released in year i recaptured in year j
 $j \geq i$

t = the number of years that tags are recaptured

This is the same formula as given in chapter 3.7 in Seber, 1973.

When the first year of recaptures are excluded due to incomplete mixing, m_{ii} and $ns_{j=i}$ are excluded from (1).

NOTE: The figures for R_i are adjusted in the program by the tagging survival at release given interactively by the user for each year. The figures for ns_j must be the number effectively screened for tags.

The estimate of standard error of \hat{N}_i should be considered as an approximate estimate. In general it will be too small because the R_i 's are random variables, the ns_j 's are random variables, the age/length keys used to split tags and catch into different yearclasses are random variables and there could be incomplete mixing and unknown immigration/emigration into/out of the population.

5.2 The estimate of weight in tonnes

This is simply the estimated number N_i multiplied by the weight at age of the yearclass in year i . It is only possible to use one weight at age key in the program so differences in growth patterns between yearclasses are not taken into account.

5.3 The estimates of survival, ϕ_i

The first estimate of survival is given in (2):

$$\phi_i = \frac{R_{i+1} \cdot \sum_{j=i+1}^t m_{i,j}}{R_i \cdot \sum_{j=i+1}^t m_{i+1,j}} \quad (2)$$

This is the estimate used by Hamre, 1978. It is simply the ratio between N_{i+1} and N_i where the first year of recapture is excluded for N_i using (1). Standard error of this estimate is not given.

The second estimate of survival with standard error is the method given on page 218 in Seber. The third estimate of survival, with standard error is the method given in chapter 5.4.1 in Seber.

6. Relative tagging densities

Relative tagging densities is a convenient tool if you want to check if there is some trends in the recapture data. The relative tagging density is taken as the tagging density divided by the mean tagging density for all years of recapture for the actual release. If the assumptions of the underlying statistical model for the Petersen method is true, these figures should vary randomly around the value 1 for each

release. If their values shows a decreasing or increasing trend over the years of recapture, you have one or more of these reasons:

- Different mortality for tagged and untagged individuals
- Relaxed recruitment to the fishery of tagged individuals
- A trend in effectivity over years when screening catch for tags
- Immigration into the population
- Incomplete mixing phenomenas

7. Delayed recruitment to the fishery

If some measure is provided by a method to say whether a young tagged individual of age K is recruited later to the fishery than an untagged of the same age, then the ratio between their recruitment rates is fed into the program. The program adjusts the number screened at each age with these ratios.

8. Combination of yearclasses

The combination of yearclasses is done by summing their adjusted R_i 's, adjusted ns_j 's and m_{ij} 's. The methods given above are then used on these arrays.

The estimates of weight in tons is different than above. Each year gets a weighted mean of the weights of the yearclasses included that year:

$$w_i = \frac{\sum_{y=\ell}^m \hat{N}_i(y) \cdot wa(k)}{\sum_{y=\ell}^m \hat{N}_i(y)} \quad (3)$$

w_i = weight of an individual in year i

$N_i(y)$ = estimated number of yearclass y in year i

$wa(k)$ = weight of an individual with age k , $k=i-y$

y = $\ell, \ell+1, \ell+2, \dots, m$ = yearclasses to be included in the calculation

If for some reason an estimate of number of a yearclass does not exist one year, even if the yearclass is present in the population the w_i will be biased.

References

- ANON. 1979. NORD-10 Fortran system reference manual. Norsk Data A/S. Lindeberg gård. Norway.
- HAMRE, J. 1978. Biology, exploitation and management of the north-east atlantic mackerel. In ICES Symposium on the Biological Basis of Pelagic Fish Stock Management, No. 32, pp 1-74, 15 tab., 18 figs.
- SEBER, G.A.F. 1973. The estimation of animal abundance and related parameters. Griffin. 506 pp.

Appendix 2. Sample user Communication

WHAT RECAPTURE DATA DO YOU WANT?(FILENAME)

→ RELEASE-RECAPTUR:SYMB "CR"

DO YOU WANT FIRST YEAR OF RECAPTURES TO BE INCLUDED?(YES/NO)

→ YES "CR"

DOES TAGGED FISH RECRUIT LATER TO THE FISHERY THAN
UNTAGGED FROM THE SAME YEARCLASS?(YES/NO)

→ NO "CR"

IS THE SURVIVAL OF TAGGED FISH THE SAME EACH YEAR?(YES/NO)

→ YES "CR"

TYPE THE FIRST AND LAST YEAR THAT YOU KNOW THE
TAGGING SURVIVAL ON RELEASE(E.G.: 1968,1982)

→ 1970,1972 "CR"

GIVE TAGGING SURVIVAL ON RELEASE :

→ 0.7 "CR"

DO YOU WANT TO COMBINE YEARCLASSES?(YES/NO)

→ YES "CR"

WHAT YEARCLASSES DO YOU WANT TO COMBINE?(E.G.: YOUR ANSWER :
1969,1971 RESULT: THE YEARCLASSES 1969,1970,1971 WILL BE COMBINED)

→ 1969,1970 "CR"

DO YOU WANT ESTIMATES OF WEIGHT?(YES/NO)

→ YES "CR"

GIVE NAME OF FILE WHERE WEIGHT AT AGE DATA IS :

→ WEIGHT-AT-AGE:SYMB "CR"

STOP OUTPUT SENT TO LINEPRINTER. GOODBYE !

→ user's answer

Appendix 3. Sample output

TAG-ESTIMATES

INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY

RECAPTURES OF
HYPOFISH IN HYPOSEA

NOTE: WHEN A VARIABLE IS -9., IT IS NOT POSSIBLE TO COMPUTE!!

YEARCLASS : 1969

** TABLE OF RECAPTURES **

| YEAR RECAPTURED : | 1970 | 1971 | 1972 | | |
|-------------------|------|------|------|----|--|
| NR.REL.:YEAR REL: | | | | | |
| 4000 1970 | 20 | 18 | 16 | 54 | |
| 4300 1971 | | 19 | 21 | 40 | |
| 4150 1972 | | | 24 | 24 | |
| SUM: | 20 | 37 | 61 | | |

** TABLE OF (TAGGING DENSITIES)*1.0E+06 **

| YEAR RECAPTURED : | 1970 | 1971 | 1972 | | |
|-------------------|------|------|------|--|--|
| NR.REL.:YEAR REL: | | | | | |
| 4000 1970 | 0.49 | 0.46 | 0.38 | | |
| 4300 1971 | | 0.49 | 0.50 | | |
| 4150 1972 | | | 0.57 | | |

** TABLE OF RELATIVE TAGGING DENSITIES **

| YEAR RECAPTURED : | 1970 | 1971 | 1972 | | |
|-------------------|------|------|------|--|--|
| NR.REL.:YEAR REL: | | | | | |
| 4000 1970 | 1.10 | 1.04 | 0.86 | | |
| 4300 1971 | | 0.99 | 1.01 | | |
| 4150 1972 | | | 1.00 | | |

** TABLE OF CATCH STATISTICS **

| YEAR : | 1970 | 1971 | 1972 | | |
|------------------|----------|----------|----------|--|--|
| CATCH SCREENED : | 4.10E+07 | 3.90E+07 | 4.20E+07 | | |
| TOTAL CATCH : | 8.05E+07 | 7.50E+07 | 8.60E+07 | | |
| TOTAL/SCREENED : | 1.96 | 1.92 | 2.05 | | |

** TABLE OF ESTIMATES OF NUMBER, WEIGHT AND SURVIVAL **

| YEAR: | 1970 | 1971 | 1972 |
|-----------------------------|----------|----------|----------|
| WEIGHT, TON: | 1.91E+06 | 2.45E+06 | 2.56E+06 |
| NUMBER: | 6.37E+09 | 6.13E+09 | 5.13E+09 |
| ST. ERROR, N: | 8.53E+08 | 9.57E+08 | 1.03E+09 |
| SURVIVAL 1: | 0.91 | 0.84 | |
| SURVIVAL 2: | 0.97 | 0.84 | |
| ST. ERROR 2: | 0.20 | 0.23 | |
| SURVIVAL 3: | 0.91 | 0.80 | |
| ST. ERROR 3: | 0.21 | 0.23 | |
| CHISQUARED TEST STATISTIC : | | 0.218 | |
| DEGREES OF FREEDOM : | | 1 | |

YEARCLASS : 1970

** TABLE OF RECAPTURES **

| YEAR RECAPTURED : | 1971 | 1972 | | |
|----------------------|------|------|----|--|
| NR. REL. : YEAR REL: | | | | |
| 4006 1971 | 17 | 19 | 36 | |
| 3804 1972 | | 21 | 21 | |
| SUM: | 17 | 40 | | |

** TABLE OF (TAGGING DENSITIES)*1.0E+06 **

| YEAR RECAPTURED : | 1971 | 1972 | | |
|----------------------|------|------|--|--|
| NR. REL. : YEAR REL: | | | | |
| 4006 1971 | 0.44 | 0.48 | | |
| 3804 1972 | | 0.53 | | |

** TABLE OF RELATIVE TAGGING DENSITIES **

| YEAR RECAPTURED : | 1971 | 1972 | | |
|----------------------|------|------|--|--|
| NR. REL. : YEAR REL: | | | | |
| 4006 1971 | 0.96 | 1.04 | | |
| 3804 1972 | | 1.00 | | |

** TABLE OF CATCH STATISTICS **

| YEAR : | 1971 | 1972 | | |
|------------------|----------|----------|--|--|
| CATCH SCREENED : | 3.86E+07 | 3.98E+07 | | |
| TOTAL CATCH : | 9.04E+07 | 8.23E+07 | | |
| TOTAL/SCREENED : | 2.34 | 2.07 | | |

** TABLE OF ESTIMATES OF NUMBER, WEIGHT AND SURVIVAL **

| | | |
|-----------------------------|----------|----------|
| YEAR: | 1971 | 1972 |
| WEIGHT, TON: | 1.84E+06 | 2.03E+06 |
| NUMBER: | 6.15E+09 | 5.09E+09 |
| ST. ERROR, N: | 1.01E+09 | 1.10E+09 |
| SURVIVAL 1: | 0.86 | |
| SURVIVAL 2: | 0.83 | |
| ST. ERROR 2: | 0.25 | |
| SURVIVAL 3: | 0.86 | |
| ST. ERROR 3: | 0.27 | |
| CHISQUARED TEST STATISTIC : | | 0.000 |
| DEGREES OF FREEDOM : | | 0 |

YEARCLASSES 1969 TO 1970 COMBINED

** TABLE OF RECAPTURES **

| | | | |
|---------------------|------|------|-------|
| YEAR RECAPTURED : | 1970 | 1971 | 1972 |
| NR. REL.: YEAR REL: | | | |
| 2799 1970 | 20 | 18 | 16 54 |
| 5814 1971 | | 36 | 40 76 |
| 5567 1972 | | | 45 45 |
| SUM: | 20 | 54 | 101 |

** TABLE OF (TAGGING DENSITIES)*1.0E+06 **

| | | | |
|---------------------|------|------|------|
| YEAR RECAPTURED : | 1970 | 1971 | 1972 |
| NR. REL.: YEAR REL: | | | |
| 2799 1970 | 0.49 | 0.23 | 0.20 |
| 5814 1971 | | 0.46 | 0.49 |
| 5567 1972 | | | 0.55 |

** TABLE OF RELATIVE TAGGING DENSITIES **

| | | | |
|---------------------|------|------|------|
| YEAR RECAPTURED : | 1970 | 1971 | 1972 |
| NR. REL.: YEAR REL: | | | |
| 2799 1970 | 1.60 | 0.76 | 0.64 |
| 5814 1971 | | 0.97 | 1.03 |
| 5567 1972 | | | 1.00 |

** TABLE OF CATCH STATISTICS **

| | | | |
|------------------|----------|----------|----------|
| YEAR : | 1970 | 1971 | 1972 |
| CATCH SCREENED : | 4.10E+07 | 7.76E+07 | 8.18E+07 |
| TOTAL CATCH : | 8.05E+07 | 1.65E+08 | 1.68E+08 |
| TOTAL/SCREENED : | 1.96 | 2.13 | 2.06 |

** TABLE OF ESTIMATES OF NUMBER, WEIGHT AND SURVIVAL **

| YEAR: | 1970 | 1971 | 1972 |
|-----------------------------|-----------|----------|----------|
| WEIGHT, TON: | -9.00E+00 | 3.68E+06 | 4.08E+06 |
| NUMBER: | 1.04E+10 | 1.23E+10 | 1.02E+10 |
| ST.ERROR, N: | 1.40E+09 | 1.39E+09 | 1.50E+09 |
| SURVIVAL 1: | 0.93 | 0.85 | |
| SURVIVAL 2: | 1.18 | 0.84 | |
| ST.ERROR 2: | 0.19 | 0.17 | |
| SURVIVAL 3: | 0.93 | 0.82 | |
| ST.ERROR 3: | 0.19 | 0.17 | |
| CHISQUARED TEST STATISTIC : | | 0.292 | |
| DEGREES OF FREEDOM : | | 1 | |

DATA SUPPLIED BY THE "CUSTOMER" :

FIRST YEAR OF RECARTURES INCLUDED ?YES

THE RATIO BETWEEN TAGGED AND UNTAGGED INDIVIDUALS RECRUITMENT TO THE FISHERY AT DIFFERENT AGES :

| | | | | | | | | | | |
|--------|------|------|------|------|------|------|------|------|------|------|
| AGE: | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| RATIO: | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| AGE: | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| RATIO: | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| AGE: | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| RATIO: | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

TAGGING SURVIVAL ON RELEASE IN DIFFERENT YEARS :

1970 0.70
 1971 0.70
 1972 0.70

Note. The sample output is somewhat edited to save space.

Appendix 4. List of program

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1* C ** TAG-ESTIMATES **
2* C
3* C ****
4* C
5* C A PROGRAM FOR ESTIMATION OF NUMBER AND SURVIVAL OF A
6* C POPULATION SPLIT INTO YEARCLASSES, BASED ON RELEASES AND
7* C RECAPTURES OF TAGGED INDIVIDUALS.
8* C
9* C TROND WESTGARD, INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY
10* C MARCH, 1982
11* C ****
12* C
13* C PARAMETER MAX = 35, MAXRF = MAX + 1
14* C DIMENSION FIH(MAX), FIS(MAX), VFIS(MAX), SEFIS(MAX), FIC(MAX)
15* C DIMENSION RF(0:MAX), TSR(MAX,2), NS(MAX), LR(MAX), M(MAX,MAX), N(MAX)
16* C DIMENSION SEFIC(MAX), SEN(MAX), MT(MAX), KK(MAX), YEARIN(MAX)
17* C DIMENSION WATAGE(0:MAX), W(MAX), TC(MAX), R(MAX), VFIC(MAX), VN(MAX)
18* C DIMENSION TCDNS(MAX), TD(MAX,MAX), TDM(MAX), YEARUT(MAX), TDR(MAX,MAX)
19* C DIMENSION MC(MAX,MAX), NSC(MAX), RC(MAX), TCC(MAX)
20* C DIMENSION WC(MAX), WC1(MAX), WC2(MAX)
21* C CHARACTER FIL1*16, FIL2*16, ANSW1*3, ANSW2*3, ANSW3*3, ANSW4*3, ANSW5*3
22* C CHARACTER DATA*40, TYPE*1
23* C INTEGER YEAR1, YEAR2, YEAR3, YEAR4, SYEARD, SYEAR, YEARCL, DEL
24* C REAL NDD, N, NS, NSS, M, MT, LR, NSC, MC
25* C EQUIVALENCE (TDR(1,1), TD(1,1))
26* C DATA WC1, WC2, WC, W, WATAGE/MAX*0., MAX*0., MAX*0., MAX*0., MAXRF*0./
27* C DATA RC, NSC, TCC, RF/MAX*0., MAX*0., MAX*0., MAXRF*1.0/
28* C DATA INDB, INDA, YEAR3, YEAR4, INDS, INDE/0,0,0,0,0/
29* C
30* C EXPLANATION OF VARIABLES USED:
31* C
32* C ANSWI = CUSTOMERS ANSWER TO QUESTIONS(YES OR NO)(I=1,2,...)
33* C FIX(I) = ESTIMATE OF SURVIVAL IN YEAR I (X = H, S OR C)
34* C IS = NR. OF YEARS TAGS ARE RELEASED
35* C IT = NR. OF YEARS TAGS ARE RECAPTURED
36* C INDI = INDICATOR TO TELL IF A THING IS DONE OR NOT.(I=A,B,...)
37* C K = AGE OF THE FISH
38* C LR(I) = NR. OF TAGS RECAPTURED OF TAGS RELEASED IN YEAR I
39* C M(I,J) = NR. OF TAGS RECAPTURED IN YEAR J, RELEASED IN YEAR I
40* C MC(I,J) = COMBINATION OF M(I,J)'S FOR DIFFERENT YEARCLASSES.
41* C MT(J) = NR. OF TAGS RECAPTURED IN YEAR J
42* C MAX = MAXIMUM VALUE OF IS AND IT
43* C N(I) = ESTIMATED NR. OF INDIVIDUALS IN YEAR I
44* C NS(J) = NR. EFFECTIVELY SCREENED FOR TAGS IN YEAR J
45* C NSC(J) = COMBINATION OF NS(J)'S FOR DIFFERENT YEARCLASSES
46* C R(I) = NR. OF TAGS RELEASED IN YEAR I
47* C RC(J) = COMBINATION OF R(I)'S FOR DIFFERENT YEARCLASSES
48* C RF(K) = RATIO BETWEEN TAGGED AND UNTAGGED INDIVIDUALS RECRUITMENT
49* C TO THE FISHERY, WHEN THE INDIVIDUALS ARE K YEARS OLD
50* C SYEAR = THE YEAR WHEN RELEASES STARTED
51* C SYEARD = FIRST YEAR THAT ONE KNOWS THE TAGGING SURVIVAL ON RELEASE
52* C TC(J) = TOTAL CATCH OF THE YEARCLASS IN NUMBER IN YEAR J
53* C TCC(J) = TOTAL CATCH IN NUMBER OF COMBINED YEARCLASSES
54* C TCDNS(J)= RATIO BETWEEN TC(J) AND NS(J)
55* C TD(I,J) = TAGGING DENSITY OF TAGS RELEASED IN YEAR I, CAPTURED IN J
56* C TDM(I) = MEAN OF TD(I,J) TAKEN OVER ALL J'S
57* C TDR(I,J)= TD(I,J)/TDM(I) I.E. RELATIVE TAGGING DENSITY
58* C W(I) = ESTIMATE OF TOTAL WEIGHT IN YEAR I
59* C WATAGE(K)= WEIGHT OF AN INDIVIDUAL AT AGE K
60* C WC(I) = WEIGHT OF COMBINED YEARCLASSES IN YEAR I.
61* C YEARCL = THE YEAR WHEN THE ACTUAL YEARCLASS WAS BORN

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62* C
63* C NOTE: 'SE' BEFORE A VARIABLENAME MEANS STANDARD ERROR AND
64* C 'V' BEFORE A VARIABLENAME MEANS VARIANCE OF THE VARIABLE
65* C
66* C
67* C OVERFLOW ON OUTPUT IS MARKED WITH BLANK INSTEAD OF STAR
68* C CALL OVEFL(32)
69* C CERTAINS OVERFLOW IN THE CORRECT POSITIONS IN OUTPUT-TABLES
70* C DO FOR I = 1,MAX
71* C DO FOR J = 1,MAX
72* C IF(J .GE. I) THEN
73* C MC(I,J) = 0.
74* C M(I,J) = 0.
75* C TD(I,J) = 0.
76* C ELSE
77* C MC(I,J) = -20000.
78* C M(I,J) = -20000.
79* C TD(I,J) = -1000.
80* C ENDIF
81* C ENDDO
82* C ENDDO
83* C
84* C ***** START CUSTOMER PART *****
85* C
86* C CUSTOMER GIVES NAME OF ACTUAL DATAFILE:
87* C WRITE(1,100)
88* C 100 FORMAT(' WHAT RECAPTURE DATA DO YOU WANT?(FILENAME)'/)
89* C READ(1,*) FIL1
90* C OPEN(10,FILE=FIL1,ACCESS='R',STATUS='OLD',ERR=18)
91* C OPEN(6,FILE='L-P-1',ACCESS='W')
92* C DECIDES WHETHER OR NOT FIRST YEAR OF RECAPTURES SHOULD BE IN-
93* C CLUDED.
94* C WRITE(1,102)
95* C 102 FORMAT(' DO YOU WANT FIRST YEAR OF RECAPTURE TO BE INCLUDED?(YES/N
96* C FO)'/)
97* C READ(1,*) ANSW1
98* C MERKET FISKES REKRUTTERING TIL FISKBAR BESTAND
99* C WRITE(1,103)
100* C 103 FORMAT(' DOES TAGGED FISH RECRUIT LATER TO THE FISHERY THAN '/
101* C F' UNTAGGED FROM THE SAME YEARCLASS?(YES/NO)'/)
102* C READ(1,*) ANSW2
103* C IF(ANSW2 .EQ. 'YES') THEN
104* C WRITE(1,104)
105* C 104 FORMAT(' HOW OLD IS THE FISH BEFORE THE EFFECT CEASES?'/)
106* C READ(1,*) I
107* C IF(I .GT. MAX) GOTO 20
108* C DO FOR K = 0,I
109* C WRITE(1,105) K,K
110* C 105 FORMAT(' GIVE THE RATIO:(TAGGED IND. OF 'I3' YEARS OLD IN THE FISHE
111* C RY IN % / UNTAGGED IND. OF 'I3' YEARS OLD IN THE FISHERY IN %):'/)
112* C READ(1,*) RF(K)
113* C ENDDO
114* C ENDIF
115* C TAGGING SURVIVAL IN DIFFERENT YEARS:
116* C WRITE(1,106)
117* C 106 FORMAT(' IS THE SURVIVAL OF TAGGED FISH ON RELEASE THE SAME EACH'/
118* C F' YEAR?(YES/NO)'/)
119* C READ(1,*) ANSW3
120* C WRITE(1,107)
121* C 107 FORMAT(' TYPE THE FIRST AND LAST YEAR THAT YOU KNOW THE TAGGING'/
122* C F' SURVIVAL ON RELEASE(E.G.:1968,1982)'/)
123* C READ(1,*) YEAR1,YEAR2
124* C IF((YEAR2-YEAR1+1) .GT. MAX) GOTO 20

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125*      IF(ANSW3 .EQ. 'NO') THEN
126*          DO FOR I = YEAR1, YEAR2
127*              WRITE(1,108) I
128*      108 FORMAT(' TAGGING SURVIVAL IN 'I6' ?'/)
129*              I1 = I - YEAR1 + 1
130*              READ(1,*) TSR(I1,2)
131*              TSR(I1,1) = I
132*          ENDDO
133*      ELSE
134*          WRITE(1,109)
135*      109 FORMAT(' GIVE TAGGING SURVIVAL ON RELEASE:'/)
136*          READ(1,*) MDD
137*          DO FOR I = YEAR1, YEAR2
138*              I1 = I - YEAR1 + 1
139*              TSR(I1,1) = I
140*              TSR(I1,2) = MDD
141*          ENDDO
142*      ENDIF
143*      NMD = YEAR2 - YEAR1 + 1
144*  C. COMBINATION OF YEARCLASSES ?
145*      WRITE(1,110)
146*      110 FORMAT(' DO YOU WANT TO COMBINE YEARCLASSES?(YES/NO)'/)
147*      READ(1,*) ANSW5
148*      IF( ANSW5 .EQ. 'YES') THEN
149*          WRITE(1,111)
150*      111 FORMAT(' WHAT YEARCLASSES DO YOU WANT TO COMBINE?'/
151*          F' (EX.:YOUR ANSWER: 1969,1971 RESULT: THE YEARCLASSES'/
152*          F' 1969,1970 AND 1971 WILL BE COMBINED.)'/)
153*          READ(1,*) YEAR3, YEAR4
154*      ENDIF
155*  C WANTS WEIGHT OF POPULATION ?
156*      WRITE(1,112)
157*      112 FORMAT(' DO YOU WANT ESTIMATES OF WEIGHT?(YES/NO)'/)
158*      READ(1,*) ANSW4
159*      IF(ANSW4 .EQ. 'YES') THEN
160*          WRITE(1,113)
161*      113 FORMAT(' GIVE NAME OF FILE WHERE WEIGHT AT AGE DATA IS:'/)
162*          READ(1,*) FIL2
163*          OPEN(11, FILE=FIL2, ACCESS = 'R', STATUS='OLD', ERR = 18)
164*          DO FOR I = 1, MAX
165*              READ(11,114, END=1) K, WATA
166*              WATAGE(K) = WATA
167*      114 FORMAT(I3, F7.3)
168*          ENDDO
169*      ENDIF
170*  C
171*  C***** STOP CUSTOMER PART *****
172*  C
173*  C***** START DATA READING PART *****
174*  C
175*      1 READ(10,*) DATA
176*          WRITE(6,115) DATA(3:40)
177*      115 FORMAT(1H1,////,54X,'TAG-ESTIMATES',////,40X,
178*          F' INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY',////,54X,
179*          F' RECAPTURES OF',//,50X,A,////,23X,
180*          F' NOTE: WHEN A VARIABLE IS -9., IT IS NOT POSSIBLE TO COMPUTE!!')
181*      2 READ(10,*) DATA
182*          IF(DATA(1:1) .EQ. '*') GOTO 2
183*          READ(DATA,117) TYPE, X1, X2, X3, X4, X5
184*      117 FORMAT(A1,3F5.0,2E9.0)
185*          ITYPE = ICHAR(TYPE) - 65
186*          GOTO(3,4,5,6,7), ITYPE
187*      3 IF(INDB .EQ. 0) THEN

```

```

188*      YEARCL = X1
189*      WRITE(6,118) YEARCL
190* 118 FORMAT(1H1,' YEARCLASS :',I6, '/')
191*      INDB = 1
192*      GOTO 2
193*      ELSE
194*      GOTO 7
195*      ENDIF
196* 4 IF(INDC .EQ. 0) THEN
197*      INDC = 1
198*      SYEAR = X1
199*      IS = 0
200*      ENDIF
201*      IS = IS + 1
202*      R(IS) = X2
203*      GOTO 2
204* 5 I = X1 - SYEAR + 1
205*      J = X2 - SYEAR + 1
206*      IF(J .GT. IT) IT = J
207*      M(I,J) = X3
208*      GOTO 2
209* 6 J = X1 - SYEAR + 1
210*      NS(J) = X4
211*      TC(J) = X5
212*      GOTO 2
213* C
214* C***** STOP DATA READING PART *****
215* C
216* C***** START TABLE PART *****
217* C
218* 7 IF(IS .GT. MAX .OR. IS .GT. MAX) GOTO 20
219*      IF(IS .GT. IT) IS = IT
220*      DO FOR I = 1,IS
221*          YEARUT(I) = SYEAR + I - 1
222*          LR(I) = 0.
223*          DO FOR J = 1,IT
224*              LR(I) = LR(I) + M(I,J)
225*          ENDDO
226*      ENDDO
227*      DO FOR J = 1,IT
228*          MT(J) = 0.
229*          YEARIN(J) = SYEAR + J - 1
230*          IF(J .GE. IS) THEN
231*              J1 = IS
232*          ELSE
233*              J1 = J
234*          ENDIF
235*          DO FOR I = 1,J1
236*              MT(J) = MT(J) + M(I,J)
237*          ENDDO
238*      ENDDO
239*      WRITE(6,119)
240* 119 FORMAT(' ** TABLE OF RECAPTURES **')
241*      IF(IT .GT. 15) THEN
242*          K1 = 2
243*      ELSE
244*          K1 = 1
245*      ENDIF
246*      DO FOR K = 1,K1
247*          IF(K .EQ. 2) THEN
248*              K2 = 16
249*              K3 = IT

```

```

250*      ELSEIF(IT .GT. 15) THEN
251*          K2 = 1
252*          K3 = 15
253*      ELSE
254*          K2 = 1
255*          K3 = IT
256*      ENDIF
257*      WRITE(6,120)(YEARIN(J),J = K2,K3)
258* 120 FORMAT(' YEAR RECAPTURED :',20I6)
259*      WRITE(6,121)
260* 121 FORMAT(' NR.REL.:YEAR REL:')
261*      DO FOR I = 1,IS
262*          IF(IT .GT. 15 .AND. K .EQ. 1) THEN
263*              WRITE(6,122) R(I),YEARUT(I),(M(I,J),J=K2,K3)
264*          ELSE
265*              WRITE(6,122) R(I),YEARUT(I),(M(I,J),J = 1,IT),LR(I)
266* 122 FORMAT(I8,I7,2X,20(1X,I5))
267*          ENDIF
268*      ENDDO
269*      WRITE(6,123)(MT(J),J= K2,K3)
270* 123 FORMAT('/' SUM:',1X,20I6)
271*      ENDDO
272* C COMPUTATION OF TAG DENSITIES TD(I,J):
273*      DO FOR I = 1,IS
274*          DO FOR J = I,IT
275*              IF(NS(J) .EQ. 0.) THEN
276*                  TD(I,J) = 0.
277*              ELSE
278*                  TD(I,J) = (M(I,J)/NS(J))*1.0E+06
279*              ENDIF
280*          ENDDO
281*      ENDDO
282*      WRITE(6,124)
283* 124 FORMAT('/' '** TABLE OF (TAGGING DENSITIES)*1.0E+06 **'//)
284*      8 DO FOR K = 1,K1
285*          IF(K .EQ. 2) THEN
286*              K2 = 16
287*              K3 = IT
288*          ELSEIF(IT .GT. 15) THEN
289*              K2 = 1
290*              K3 = 15
291*          ELSE
292*              K2 = 1
293*              K3 = IT
294*          ENDIF
295*          WRITE(6,120)(YEARIN(J),J = K2,K3)
296*          WRITE(6,121)
297*          DO FOR I = 1,IS
298*              WRITE(6,125) R(I),YEARUT(I),(TD(I,J),J=K2,K3)
299* 125 FORMAT(I8,I7,3X,20F6.2)
300*          ENDDO
301*      ENDDO
302* C COMPUTES RELATIVE TAG DENSITIES,TDR(I,J)(USES SAME STORAGE
303* C LOCATIONS AS TD(I,J) OCCUPIES)
304*      IF(INDA .EQ. 1) GOTO 9
305*      DO FOR I = 1,IS
306*          TDM(I) = 0.
307*          DO FOR J = I,IT
308*              TDM(I) = TDM(I) + TD(I,J)
309*          ENDDO
310*          TDM(I) = TDM(I)/(IT -I +1)
311*      ENDDO
312*      DO FOR I = 1,IS

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313*      DO FOR J = I,IT
314*          IF(TDM(I) .EQ. 0.) TDM(I) = 1.
315*          TDR(I,J) = TD(I,J)/TDM(I)
316*      ENDDO
317*      ENDDO
318*      WRITE(6,126)
319*      126 FORMAT(1H1, '//, ' ** TABLE OF RELATIVE TAGGING DENSITIES **'//)
320*      INDA = 1
321*      GOTO 8
322*      9 INDA = 0
323*      C COMPUTES THE RATIO BETWEEN SCREENED AND TOTAL CATCH
324*      DO FOR J = 1,IT
325*          IF(NS(J) .EQ. 0. .OR. TC(J) .EQ. 0.)THEN
326*              TCDNS(J) = -9.
327*          ELSE
328*              TCDNS(J) = TC(J)/NS(J)
329*          ENDIF
330*      ENDDO
331*      WRITE(6,151)
332*      151 FORMAT('//, ' ** TABLE OF CATCH STATISTICS **' )
333*      IF(IT .GT. 11) THEN
334*          K1 = 2
335*      ELSE
336*          K1 = 1
337*      ENDIF
338*      DO FOR K = 1,K1
339*          IF(K .EQ. 2) THEN
340*              K2 = 12
341*              K3 = IT
342*          ELSEIF(IT .GT. 11) THEN
343*              K2 = 1
344*              K3 = 11
345*          ELSE
346*              K2 = 1
347*              K3 = IT
348*          ENDIF
349*          WRITE(6,127) (YEARIN(J),J = K2,K3)
350*      127 FORMAT('// ' YEAR :',20I9)
351*          WRITE(6,128)(NS(J),J = K2,K3)
352*      128 FORMAT(/, ' CATCH SCREENED :',3X,20E9.2)
353*          WRITE(6,129)(TC(J),J = K2,K3)
354*      129 FORMAT(/, ' TOTAL CATCH :',3X,20E9.2)
355*          WRITE(6,130)(TCDNS(J),J = K2,K3)
356*      130 FORMAT(/, ' TOTAL/SCREENED :',3X,20F9.2)
357*      ENDDO
358*      C COMPUTES ESTIMATES OF NUMBER AND SURVIVAL
359*      C CORRECTS FOR BIASED RECRUITMENT TO THE FISHERY
360*      IF(INDE .EQ. 1) GOTO 10
361*      IF(YEARCL .LT. 0.) GOTO 21
362*      DO FOR J = 1,IT
363*          K = SYEAR - YEARCL + (J - 1)
364*          NS(J) = RF(K)*NS(J)
365*      ENDDO
366*      C CORRECTS FOR TAGGING MORTALITY IN NUMBER RELEASED
367*      21 SYEARD = TSR(1,1)
368*      IF(SYEARD .GT. SYEAR) GOTO 17
369*      DEL = SYEAR - SYEARD
370*      DO FOR I = 1,IS
371*          R(I) = TSR(I+DEL,2)*R(I)
372*      ENDDO
373*      C ESTIMATE OF NUMBER

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374*      10 CALL NUM(N,SEN,IS,IT,M,LR,R,NS,ANSW1,MAX)
375* C ESTIMATE OF SURVIVAL "THE HAMRE WAY" :
376*      CALL SURH(FIH,M,LR,IS,R,MAX)
377* C ESTIMATE OF SURVIVAL "THE SIMPLE SEBER WAY" :
378*      CALL SURS(FIS,SEFIS,N,LR,NS,IS)
379* C ESTIMATE OF SURVIVAL "THE COMPLICATED SEBER WAY" :
380*      CALL SURC(FIC,SEFIC,M,LR,IS,IT,R,MT,MAX)
381* C CHISQUARED TEST OF THE MODEL UNDERLYING SURC( ) :
382*      CALL CHISQR(M,IS,IT,R,MT,LR,TEST,NY,MAX,FIC)
383* C ESTIMATE OF WEIGHT :
384*      IF(ANSW4 .EQ. 'NO' .OR. YEARCL .LT. 0) GOTO 11
385*      DO FOR I = 1,IS
386*          K = SYEAR - YEARCL + I-1
387*          IF(N(I) .LT. 0 .OR. WATAGE(K) .EQ. 0.) THEN
388*              W(I) = -9.
389*          ELSE
390*              W(I) = N(I)*WATAGE(K)*0.001
391*          ENDIF
392*      ENDDO
393*      11 WRITE(6,131)
394*      131 FORMAT(1H1, //' ** TABLE OF ESTIMATES OF NUMBER, WEIGHT AND SURVIVA
395*      FL **' /)
396*      IF(IS .GT. 11) THEN
397*          K1 = 2
398*      ELSE
399*          K1 = 1
400*      ENDIF
401*      DO FOR K = 1,K1
402*          IF(K .EQ. 2) THEN
403*              K2 = 12
404*              K3 = IS
405*          ELSEIF(IS .GT. 11) THEN
406*              K2 = 1
407*              K3 = 11
408*          ELSE
409*              K2 = 1
410*              K3 = IS
411*          ENDIF
412*          WRITE(6,132)(YEARUT(I),I = K2,K3)
413*      132 FORMAT(/,7X,'YEAR:' ,20I10,///)
414*          IF(ANSW4 .EQ. 'YES' .AND. YEARCL .GT. 0) THEN
415*              WRITE(6,133)(W(I),I = K2,K3)
416*      133 FORMAT(/' WEIGHT,TON:' ,20E10.2)
417*          ENDIF
418*          WRITE(6,134)(N(I),I = K2,K3)
419*      134 FORMAT(/,5X,'NUMBER:' ,20E10.2)
420*          WRITE(6,135)(SEN(I),I = K2,K3)
421*      135 FORMAT(/,' ST.ERROR,N:' ,20E10.2)
422*          IF(.NOT.(K1 .EQ. 2 .AND. K .EQ. 1)) K3 = K3 - 1
423*          WRITE(6,136)(FIH(I),I = K2,K3)
424*      136 FORMAT(/' SURVIVAL 1:' ,20F10.2)
425*          WRITE(6,137)(FIS(I),I = K2,K3)
426*      137 FORMAT(/' SURVIVAL 2:' ,20F10.2)
427*          WRITE(6,138)(SEFIS(I),I = K2,K3)
428*      138 FORMAT(/' ST.ERROR 2:' ,20F10.2)
429*          WRITE(6,139)(FIC(I),I = K2,K3)
430*      139 FORMAT(/' SURVIVAL 3:' ,20F10.2)
431*          WRITE(6,140)(SEFIC(I),I = K2,K3)
432*      140 FORMAT(/' ST.ERROR 3:' ,20F10.2)
433*      ENDDO
434*      WRITE(6,150) TEST,NY
435*      150 FORMAT(/,' CHISQUARED TEST STATISTIC :' ,F10.3,/)

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436*      >          4 DEGREES OF FREEDOM          :',I10)
437*      C
438*      C***** STOP TABLE PART *****
439*      C
440*      C***** START COMBINATION PART *****
441*      C
442*      IF(ANSW5 .EQ. 'NO') GOTO 14
443*      IF(YEARCL .LT. YEAR3 .OR. YEARCL .GT. YEAR4) GOTO 14
444*      IF(INDS .EQ. 1) GOTO 12
445*      INDS = 1
446*      IYEAR = YEARUT(1)
447*      DO FOR I = 1, IS
448*          RC(I) = R(I)
449*          IF(N(I) .GT. 0.) THEN
450*              K = IYEAR - YEARCL + I - 1
451*              WC1(I) = N(I)*WATAGE(K)
452*              WC2(I) = N(I)
453*          ENDIF
454*          DO FOR J = I, IT
455*              MC(I,J) = M(I,J)
456*          ENDDO
457*      ENDDO
458*      DO FOR J = 1, IT
459*          TCC(J) = TC(J)
460*          NSC(J) = NS(J)
461*      ENDDO
462*      ISMAX = IS
463*      ITMAX = IT
464*      GOTO 14
465*      12 IF(INDE .EQ. 1) GOTO 16
466*          IF((YEARUT(1)+IT) .GT. (IYEAR+ITMAX)) ITMAX=YEARUT(1)-IYEAR+IT
467*          IF((YEARUT(1)+IS) .GT. (IYEAR+ISMAX)) ISMAX=YEARUT(1)-IYEAR+IS
468*          IDIFF = YEARUT(1) - IYEAR + 1
469*          DO FOR I = IDIFF, ISMAX
470*              I1 = I - IDIFF + 1
471*              RC(I) = RC(I) + R(I1)
472*              IF(ANSW4 .EQ. 'NO') GOTO 13
473*              IF(N(I1) .GT. 0.) THEN
474*                  K = YEARUT(1) - YEARCL + I1 - 1
475*                  WC1(I) = WC1(I) + N(I1)*WATAGE(K)
476*                  WC2(I) = WC2(I) + N(I)
477*              ENDIF
478*          DO FOR J = I, ITMAX
479*              J1 = J - IDIFF + 1
480*              MC(I,J) = MC(I,J) + M(I1,J1)
481*          ENDDO
482*      ENDDO
483*      DO FOR J = IDIFF, ITMAX
484*          J1 = J - IDIFF + 1
485*          NSC(J) = NSC(J) + NS(J1)
486*          TCC(J) = TCC(J) + TC(J1)
487*      ENDDO
488*      14 INDC = 0
489*      IT = 0
490*      IF(TYPE .EQ. 'F') GOTO 15
491*      YEARCL = X1
492*      IF(INDB .EQ. 1) WRITE(6,118) YEARCL
493*      DO FOR I = 1, MAX
494*          NS(I) = R(I) = TC(I) = MT(I) = LR(I) = 0.
495*          DO FOR J = 1, MAX
496*              IF( J .GE. I) M(I,J) = 0.
497*          ENDDO

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498*      ENDDO
499*      GOTO 2
500*      15 IF(ANSW5 .EQ. 'NO' .OR. INDE .EQ. 1) GOTO 16
501*      INDE = 1
502*      WRITE(6,141) YEAR3, YEAR4
503*      141 FORMAT(1H1, ' YEARCLASSES ' IS ' TO ' IS ' COMBINED' //)
504*      IS = ISMAX
505*      IT = ITMAX
506*      DO FOR I = 1, IS
507*          R(I) = RC(I)
508*          IF(WC2(I) .EQ. 0.) THEN
509*              WC(I) = -9.
510*          ELSE
511*              WC(I) = WC1(I)/WC2(I)
512*          ENDIF
513*      DO FOR J = 1, IT
514*          M(I, J) = MC(I, J)
515*      ENDDO
516*      ENDDO
517*      DO FOR J = 1, IT
518*          NS(J) = NSC(J)
519*          TC(J) = TCC(J)
520*      ENDDO
521*      SYEAR = IYEAR
522*      GOTO 7
523*      C
524*      C***** STOP COMBINATION PART *****
525*      C
526*      C
527*      C***** LIST OF DATA SUPPLIED BY CUSTOMER *****
528*      C
529*          16 WRITE(6,142)
530*          142 FORMAT(1H1, ' DATA SUPPLIED BY THE "CUSTOMER" : ' //)
531*          WRITE(6,143) ANSW1
532*          143 FORMAT(' FIRST YEAR OF RECAPTURES INCLUDED ? ' , A, /)
533*          DO FOR K = 1, MAX
534*              KK(K) = K - 1
535*          ENDDO
536*          WRITE(6,144)
537*          144 FORMAT(' THE RATIO BETWEEN TAGGED AND UNTAGGED INDIVIDUALS RECRUIT
538*          >MENT TO THE FISHERY AT DIFFERENT AGES : ' //)
539*          WRITE(6,145)(KK(K), K=1, 15), (RF(K), K=0, 14),
540*          > (KK(K), K=16, 30), (RF(K), K=15, 29)
541*          145 FORMAT(2(' AGE: ', 15I5, /, ' RATIO: ', 15F5.2, //))
542*          WRITE(6,147)
543*          147 FORMAT(' TAGGING SURVIVAL ON RELEASE IN DIFFERENT YEARS : ' //)
544*          WRITE(6,148)((TSR(I, J), J = 1, 2), I = 1, NMD)
545*          148 FORMAT(I6, F5.2)
546*          GOTO 19
547*      C
548*      C***** POSSIBLE ERROR CONDITIONS *****
549*      C
550*          17 WRITE(1,149) SYEAR, SYEARD
551*          149 FORMAT(' THE RELEASES STARTED IN ' I6 ' THEREFORE THE TAGGING ' /
552*          F ' SURVIVAL MUST BE SPECIFIED FOR THE YEARS BEFORE ' I6, /)
553*          STOP ' SORRY, TRY AGAIN!'
554*          18 STOP ' SORRY, NONE EXISISTING FILE NAME!'
555*          19 STOP ' OUTPUT SENT TO LINE-PRINTER. GOODBYE!'
556*          20 STOP ' SORRY, YOUR SPAN IN YEARS IS TOO BIG. INCREASE MAX!'
557*          END

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```

1* C ** NUM **
2* C
3* C SUBROUTINE TO ESTIMATE A NUMBER OF A POPULATION FROM TAG RECAPTURES
4* C
5* C TROND WESTGÅRD, INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY
6* C
7* C SUBROUTINE NUM(N,SEN,IS,IT,M,LR,R,NS,ANSW1,MAX)
8* C CHARACTER ANSW1*3
9* C DIMENSION N(1),SEN(1),M(MAX,1),LR(1),R(1),NS(1)
10* C REAL N,M,LR,NS,NSS
11* C
12* C EXPLANATION OF VARIABLES USED:
13* C
14* C N(I) = ESTIMATE OF NR. IN POPULATION IN YEAR I
15* C SEN(I) = STANDARD ERROR OF N(I)
16* C IS = NR. OF YEARS TAGS ARE RELEASED
17* C IT = NR. OF YEARS TAGS ARE RECAPTURED
18* C M(I,J) = NR. OF TAGS RELEASED IN I TAKEN IN J
19* C LR(I) = NR. OF TAGS RECAPTURED FROM THE RELEASE IN I
20* C R(I) = NR. OF TAGS EFFECTIVELY RELEASED IN I
21* C NS(I) = NR. OF INDIVIDUALS SCREENED IN YEAR I
22* C ANSW1 = 'YES' FIRST YEAR OF RECAPTURES INCLUDED
23* C MAX = MAXIMUM VALUE IS AND IT CAN HAVE
24* C
25* C DO FOR I = 1, IS
26* C NSS = 0.
27* C DO FOR J = I, IT
28* C NSS = NSS + NS(J)
29* C ENDDO
30* C IF(ANSW1.EQ. 'NO') THEN
31* C NSS = NSS - NS(I)
32* C LR(I) = LR(I) - M(I,I)
33* C ENDIF
34* C IF(LR(I) .EQ. 0. .OR. NSS .EQ. 0.) THEN
35* C N(I) = -9.
36* C ELSE
37* C N(I) = (R(I)*NSS)/LR(I) + NS(I)
38* C ENDIF
39* C IF(ANSW1 .EQ. 'NO') THEN
40* C NSS = NSS + NS(I)
41* C LR(I) = LR(I) + M(I,I)
42* C ENDIF
43* C ENDDO
44* C DO FOR I = 1, IS
45* C IF(N(I) .LT. 0. .OR. LR(I) .EQ. 0. .OR. N(1) .LT. 0.) THEN
46* C SEN(I) = -9.
47* C ELSE
48* C VM = (N(I)-NS(I))*(N(I)-NS(I)+R(I))*
49* C F (1/LR(I) - 1/R(I)) + N(I) - (N(I)**2.)/N(1)
50* C SEN(I) = SQRT(VN)
51* C ENDIF
52* C ENDDO
53* C RETURN
54* C END

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```

1* C ** SURH **
2* C
3* C SUBROUTINE TO CALCULATE SURVIVAL(HAMRE,1978)
4* C
5* C TROND WESTGÅRD, INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY
6* C
7* C SUBROUTINE SURH(FIH,M,LR,IS,R,MAX)
8* C DIMENSION FIH(1),M(MAX,1),LR(1),R(1)
9* C REAL M,LR
10* C
11* C FIH(I) = ESTIMATE OF SURVIVAL IN YEAR I
12* C M(I,J) = NR. OF TAGS RECAPTURED IN J FROM THE RELEASES IN I
13* C LR(I) = NR. OF TAGS RECAPTURED FROM THE RELEASE IN I
14* C IS = NR. OF YEARS TAGS ARE RELEASED
15* C MAX = MAXIMUM VALUE IS CAN HAVE
16* C
17* C DO FOR I = 1,IS - 1
18* C IF((LR(I)-M(I,I)) .EQ. 0. .OR. LR(I+1) .EQ. 0.) THEN
19* C FIH(I) = -9.
20* C ELSE
21* C FIH(I) = (R(I+1)*(LR(I)-M(I,I)))/(R(I)*LR(I+1))
22* C ENDIF
23* C ENDDO
24* C RETURN
25* C END

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1* C ** SURS **
2* C
3* C SUBROUTINE TO CALCULATE SURVIVAL( SEBER,CH. 5.1.3)
4* C
5* C TROND WESTGÅRD, INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY
6* C
7* C SUBROUTINE SURS(FIS,SEFIS,N,LR,NS,IS)
8* C DIMENSION FIS(1),SEFIS(1),N(1),LR(1),NS(1)
9* C REAL NS,LR,N
10* C
11* C FIS(I) = ESTIMATE OF SURVIVAL IN YEAR I
12* C SEFIS(I) = ESTIMATE OF STANDARD ERROR IN FIS(I)
13* C VFIS(I) = ESTIMATE OF VARIANCE IN FIS(I)
14* C N(I) = ESTIMATE OF NR. IN POPULATION IN YEAR I
15* C LR(I) = NR. OF TAGS RECAPTURED FROM THE RELEASE IN I
16* C NS(I) = NR. OF INDIVIDUALS SCREENED IN YEAR I
17* C IS = NR. OF YEARS TAGS ARE RELEASED
18* C MAX = MAXIMUM VALUE IS CAN HAVE
19* C
20* C DO FOR I = 1,IS - 1
21* C IF(N(I) .LE. 0. .OR. N(I+1) .LE. 0.) THEN
22* C FIS(I) = -9.
23* C ELSE
24* C FIS(I) = N(I+1)/(N(I)-NS(I))
25* C ENDIF
26* C ENDDO
27* C DO FOR I = 1,IS - 1
28* C IF(FIS(I).LT.0..OR.N(I).LT.0..OR.N(I+1).LT.0..OR.LR(I).EQ.0.
29* C > .OR. LR(I+1) .EQ. 0.) THEN
30* C SEFIS(I) = -9.
31* C ELSE
32* C VFIS = (FIS(I)**2.)*(((N(I+1) - NS(I+1))**2.)/
33* C > N(I+1)**2.)*(1/LR(I+1)) + (N(I)-NS(I))/(N(I)*LR(I))
34* C SEFIS(I) = SQRT(VFIS)
35* C ENDIF
36* C ENDDO
37* C RETURN
38* C END

```

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1* C ** SURC **
2* C
3* C SUBROUTINE TO ESTIMATE SURVIVAL(SEBER CH. 5.4.1)
4* C
5* C TROND WESTGARD, INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY
6* C
7* C SUBROUTINE SURC(FIC,SEFIC,M,LR,IS,IT,R,MT,MAX)
8* C DIMENSION FIC(1),SEFIC(1),M(MAX,1),LR(1),Z(100),T(100)
9* C DIMENSION R(1),MT(1)
10* C REAL M,LR,MT
11* C COMMON /LAB/ T
12* C
13* C FIC(I) = ESTIMATE OF SURVIVAL IN YEAR I
14* C SEFIC(I) = ESTIMATE OF STANDARD ERROR IN FIC(I)
15* C M(I,J) = NR. OF TAGS RECAPTURED IN J RELEASED IN I
16* C MT(J) = NR. OF TAGS RECAPTURED IN YEAR J
17* C LR(I) = NR. OF TAG RECAPTURED FROM THE RELEASE IN YEAR I
18* C IS = NR. OF YEARS TAGS ARE RELEASED
19* C IT = NR. OF YEARS TAGS ARE RECAPTURED
20* C MAX = MAXIMUM VALUE IS AND IT CAN HAVE
21* C
22* C DO FOR I1 = 1, IS
23* C Z(I1) = 0.
24* C DO FOR I = 1, I1-1
25* C DO FOR J = I1, IT
26* C Z(I1) = Z(I1) + M(I, J)
27* C ENDDO
28* C ENDDO
29* C ENDDO
30* C Z(1) = 0.
31* C DO FOR I = 1, IS
32* C T(I) = Z(I) + LR(I)
33* C ENDDO
34* C DO FOR I = 1, IS - 1
35* C IF( LR(I+1) .EQ. 0. .OR. R(I) .EQ. 0. .OR. T(I) .EQ. 0.) THEN
36* C FIC(I) = -9.
37* C ELSE
38* C FIC(I) = ((T(I) - MT(I))/T(I))*(LR(I)/LR(I+1))*(R(I+1)/R(I))
39* C ENDF
40* C ENDDO
41* C DO FOR I = 1, IS - 1
42* C IF(FIC(I).LT.0..OR.Z(I+1).EQ.0..OR.LR(I).EQ.0..OR.
43* C > LR(I+1) .EQ. 0.) THEN
44* C SEFIC(I) = -9.
45* C ELSE
46* C VFIC = (FIC(I)**2.)*( 1/LR(I) + 1/LR(I+1) + 1/Z(I+1)
47* C > - 1/R(I) - 1/R(I+1) - 1/(LR(I) + Z(I)))
48* C SEFIC(I) = SQRT(VFIC)
49* C ENDF
50* C ENDDO
51* C RETURN
52* C END

```

```

1* C ** CHISQR **
2* C
3* C ROUTINE TO COMPUTE A CHI-SQUARED TEST STATISTIC( P.243 IN SEBER)
4* C
5* C TROND WESTGARD, INSTITUTE OF MARINE RESEARCH, BERGEN, NORWAY
6* C
7*     SUBROUTINE CHISQR(M,IS,IT,R,MT,LR,TEST,NY,MAX,FIC)
8*     DIMENSION M(MAX,1),MT(1),R(1),FIC(1),LR(1),Z(100),T(100)
9*     REAL M,LR,MT
10*    COMMON /LAB/ T
11* C
12* C NOTE : SURC( ) MUST BE CALLED BEFORE CHISQR( ).
13* C
14* C FOR EXPLANATION OF VARIABLES SEE ALSO SURC( )
15* C
16* C TEST = VALUE OF THE STATISTIC WITH CHISQUARE DISTRIBUTION
17* C NY   = THE NUMBER OF DEGREES OF FREEDOM
18* C
19*     TEST = 0.
20*     NY = (IS-1)*(IT-1) - IS*(IS-1)/2.
21*     DO FOR I = 1,IS
22*         DO FOR J = 1,IT
23*             IF(J .EQ. I) THEN
24*                 EIJ = (LR(I)*MT(I))/T(I)
25*                 GOTO 1
26*             ELSEIF(J .LE. IS) THEN
27*                 EIJ = R(I)*LR(J)*MT(J)/(R(J)*T(J))
28*                 I1 = I
29*                 J2 = J
30*                 DO FOR J1 = I1,J2-1
31*                     IF(FIC(J1) .EQ. -9.) GOTO 2.
32*                     EIJ = FIC(J1)*EIJ
33*                 ENDDO
34*                 GOTO 1
35*             ELSE
36*                 GOTO 2
37*             ENDF
38*     1     TEST = TEST + ((M(I,J)-EIJ)**2)/EIJ
39*     ENDDO
40*     ENDDO
41*     GOTO 3
42*     2 TEST = -9.
43*     3 RETURN
44*     END

```

