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ECOPATH: A USER'S MANUAL AND PROGRAM LISTINGS

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INTRODUCTION

Recent trends in ecosystem modeling have produced complex simulation models which are very data intensive (Andersen and Ursin 1977; Laevastu and Larkins 1981). However, in many situations the construction of a biomass budget for a box model of an ecosystem is relatively simple and can provide important information about the ecosystem standing stock and energy flow (Walsh 1981; Pauly 1982; Polovina in press).

The ECOPATH model is an analytical procedure to estimate a biomass budget for a box model of an ecosystem given inputs which specify the components of the ecosystem, together with their mortality, diet, and energetics value. A computer program for ECOPATH has been written in BASIC-80, version 5.21, by Microsoft[1] (CP/M version) and a listing is provided in Appendix I.

The ECOPATH model produces estimates of mean annual biomass, annual biomass production, and annual biomass consumption for each of the user specified species groups. The species groups represent aggregations of species with similar diet and life history characteristics and which have a common physical habitat. The ECOPATH model is not a simulation model with a time component as are some more complex ecosystem models. It estimates a biomass budget for the marine ecosystem in a static situation under the assumption that the ecosystem is at equilibrium conditions.

Equilibrium conditions are defined to exist when the mean annual biomass for each species group does not change from year to year. This condition results in a system of biomass budget equations which, for species group i, can be expressed as:

(1) Production of biomass for species i - all predation on species i - nonpredatory biomass mortality for species i - fishery catch for species i = 0 for all i.

The ECOPATH model expresses each term in the budget equation as a linear function of the unknown mean annual biomasses (B_i's) so the resulting biomass budget equations become a system of simultaneous equations linear in the B_i's. The mean annual biomass estimates are obtained by solving the system of simultaneous linear equations.

The formulation of each term of the biomass budget equation will now be presented in detail.

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[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

THE MODEL

Biomass Production

Production (P) for a cohort of animals over 1 year is defined as:

$$P = \int_0^1 N_t \frac{d}{dt} (w_t) \, dt$$

and mean annual biomass (B) for the cohort is defined as:

$$B = \int_0^1 N_t \, w_t \, dt$$

where N_t is the number of animals and w_t the mean individual weight at time t.

Allen (1971) has investigated the production to biomass (P/B) ratio for a cohort over a range of mortality and growth functions. For a number of growth and mortality functions, including negative exponential mortality and von Bertalanffy growth, the ratio of annual production to mean biomass for a cohort is the annual instantaneous total mortality (Z_i). For a species group which consists of n cohorts or species, with instantaneous annual total mortality (Z_i) for cohort or species i, where mortality is determined by a negative exponential function and growth by a von Bertalanffy growth function, the total species group production (P) is the sum of the cohort production (P_i) and can be expressed as:

(2)
$$P = \sum_{i=1}^{n} P_i = \sum_{i=1}^{n} Z_i \, B_i$$

Under the assumption that the Z_i's are all equal to say Z, then total species group production can be expressed as:

$$P = Z \, B$$

where B is the mean annual species group biomass.

Allen (1971) has also shown that when growth in weight is linear, the P/B ratio is equal to the reciprocal of the mean age for a range of mortality functions. For a number of other growth and mortality functions the ratio of cohort P/B can be the reciprocal of the mean lifespan. Thus, for a range of growth and mortality functions, total species group production can be expressed as:

$$P = C \cdot B$$

where B is the mean annual species group biomass, and C is a parameter. In an application of ECOPATH to an ecosystem of French Frigate Shoals where there was very little fishing mortality, the P/B ratio for fishes and crustaceans was taken as the annual instantaneous natural mortality (M); whereas, for primary and secondary producers whose growth is more likely to be linear than the von Bertalanffy, the P/B ratio was estimated as the reciprocal of the mean age (Polovina in press).

Predation Mortality

The predation mortality is the fraction of the biomass of a species group which is consumed by all predators. Two types of information are needed. First the food web or predator-prey relationships must be defined. A diet composition matrix DC_{ij} must be specified where an entry DC_{ij} from this matrix refers to the proportion (by weight) of prey j in the diet of predator i. The primary source of this information is the analysis of stomach contents (Macdonald and Green 1983). The second type of information needed to ascertain predation mortality is the food requirements of the predator. The ECOPATH model requires the user to specify FR_i, the ratio of annual consumption to mean annual biomass. The annual food required by the predator is the product of FR_i and B_i.

Some values of daily food required as a fraction of body weight range from 0.005 to 0.02 (Laevastu and Larkins 1981). Based on these daily estimates a range of annual food required as a fraction of mean biomass (FR_i) is 1.8 to 7.3.

Nonpredation Mortality

All mortality attributable to causes other than predation and fishing is termed nonpredator mortality. The ECOPATH model defines ecotrophic efficiency e_i as the fraction of total production which is removed by fishing and predation mortality. This was 0.95 in the French Frigate Shoals model. The nonpredator mortality rate is $(1-e_i) \cdot Z_i$, and the amount of production which goes to nonpredation mortality is

$$(1-e_i)\ P_i = (1-e_i)\ C_i\ B_i \quad .$$

For n species groups the biomass budget equation (1) becomes a system of n simultaneous equations as follows:

$$C_1 B_1 - \sum_{k=1}^{n} (FR_k) B_k DC_{k1} - (1-e_1) C_1 B_1 = catch_1 \quad ,$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$C_i B_i - \sum_{k=1}^{n} (FR_k) B_k DC_{ki} - (1-e_i) C_i B_i = catch_i \quad ,$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$C_n B_n - \sum_{k=1}^{n} (FR_k) B_k DC_{kn} - (1-e_n) C_n B_n = catch_n \quad .$$

With input estimates for parameters C_i, FR_i, DC_{ij}, and e_i for all i and j, and catches ($catch_i$) if there is fishing, this system of equations is a system of n simultaneous equations linear in the unknown B_i's. This system of equations can be expressed in matrix form as AB = C, where A is an n x n matrix of coefficient, B is an n-dimensional vector of mean annual species group biomass, and C is the vector of fishery catch where the i^{th} element is the total catch for the i^{th} species group.

If the matrix A is of full rank and if there are some fishery catches for some species so the vector C is not null, then there typically exists a unique nontrivial solution vector of biomass B. If there are no fishery catches then it is necessary to provide an estimate of at least one of the mean species group biomass B_i before there exists a unique nontrivial biomass vector B which solves the budget equation. In the application of ECOPATH to an ecosystem at French Frigate Shoals where there was no fishing mortality, the biomasses of three apex predators were estimated from field censuses and treated as known inputs. In this application the i^{th} element of C vector was the annual predation by the three apex predators on the i^{th} species group.

THE COMPUTER PROGRAM

The ECOPATH model has been implemented via two BASIC language programs. The "dialect" of the language used is BASIC-80, version 5.21, by Microsoft (CP/M version). These programs are designed to be used interactively on a terminal or a hard copy printer. The first program is the input parameter program which accepts the input parameters and formats them into a BASIC sequential file. The second program is the ECOPATH model itself. This program uses the file created by the input program and allows parameter changes. The intent is to allow modification to the parameters of the ecosystem and show their immediate impact on prior runs. This change-and-run process may be done successively until the desired parameters are realized, with the option of saving them after each trial run.

The input program requests the following information in the order presented. The variable names used in both programs are given in parentheses.

1. (FLNAME$). The name of the file to be created. This name should follow the file naming conventions of the system used.

   NOTE: The program does not check for files already existing with this name and will write over an existing file. Character variable.

2. (N). The number of species groups. Numeric variable with no decimal point.

3. (SPECIE$(N)). N-species group names. Character variable (first 15 characters used).

4. (NFLAG(N)). Indication of a fixed biomass estimate provided by entering a "1" or a "0" for each species group. A "1" indicates that an estimate of species group biomass will be provided, a "0" allows ECOPATH to estimate it.

5. (B(N)). The biomass estimates for the species indicated by a "1" in response to 4. Numeric with a decimal point as needed.

6. (CFLAG%(N)). Indicator of catch data to be provided by entering a "1" or a "0" for each species group.

7. (CATCH(N)). The catch data for each species group indicated by a "1" in response to 6.

8. (Z(N)). Annual production/biomass ratios for the N-species groups. Numeric with a decimal point as needed.

9. (EE(N)). Ecotrophic efficiencies for the N-species groups. Ecotrophic efficiency is the fraction of total mortality due to fishing and predation. Numeric with a decimal point as needed.

10. (HABAR(N)). Habitat areas for the N-species groups. Numeric with a decimal point as needed.

11. (FR(N)). Annual food required as the ratio of annual consumption to mean annual biomass for the N-species groups. Numeric with a decimal point as needed.

12. (DC(N,N)). N x N diet composition parameters. The first row would make up the diet composition for the first species group and so on. NOTE: The sum of the diet composition vector (row) for each species group must be equal to 1 or 0. The diet composition matrix must sum to 1 for all species, except for primary producers which can sum to 0. Numeric with a decimal point.

If a mistake is made during input, simply continue as it is correctable via the main program (except for the value of N and the species group names).

The input parameter program works in the following manner: First the file name is requested. Next, the number of species groups (N) is requested. The response should be a numeric value without a decimal point such as "15." The next requests are for the N-species group names. These may include blanks, numbers, letters, etc., but only the first 15 characters are used as identification within the ECOPATH main program. Notice that a number is assigned to each species group name. This corresponds to the order in which they are entered. It is a good idea to note the number of each group, as all the following input parameters will be requested in the order that the names were entered. We have found it works well to enter top level predators first and proceed successively down the food chain.

The input parameters will be requested in the order outlined earlier. For further information about the input parameters, please refer to the program listing.

Input errors: All input may be changed via the main program except for the value of N and the species group names.

Stopping the input program: Interrupting the program at any point before the message: ****> CREATING FILE ... will prevent the creation of an undesired file.

File creation: The input parameters are stored in variables (in memory). This means that a file is not being created as input is entered. The file is created after verification that the file name entered is really the one desired. If it is discovered that the file name initially entered is incorrect, simply finish entering the input parameters and enter the letter "N" in response to:

ARE YOU SURE YOU WANT TO USE THE FILENAME ...(Y/N)?

Then enter the desired file name, after the message:

****> CREATING FILE ...

the file is created and all of the input information will be placed into it. The format of the file is outlined in the input program listing along with further usage notes. Please refer to Appendix II for an example of the input program usage.

The main program performs calculations, provides output, and allows input parameters to be changed. After the creation of an input file, one may interactively adjust the parameters and view their impact upon the model. All of the input parameters may be modified except for the number of species groups (N), and the species group names. After each run, it is possible to save the parameters used in that run in a file. For example, one may save the latest parameters under the same file name as the initial input file, hence defining a new set of baseline parameters, or save it under a new name, thus having two files, the original and the modified parameters.

The main program operates in the following manner. First, the name of the file to be used is requested. This file contains the baseline or original input parameter values. Next, the option of the output size may be modified. "S" indicates a screen or 80-column output to be produced. "P" indicates that a printer or hard copy is to be made. It is important to note that if the "P" option is used, the width of the printer output must be specified to the BASIC system before running the program. For MBASIC users, the command is: WIDTH 132.

Modification of the input values (parameters) may be made at this point. Simply reply "Y" to the request "CHANGES?". If changes are to be made, then a menu associating a single digit to the seven sets of parameters is displayed. Upon choosing the desired parameter set to modify, a menu of the species groups and their corresponding number is displayed.

If no changes are desired, the program will display the input parameters and the results. When this is completed, the option to make changes is presented again. If no changes are desired at this point, the option to save the parameters is given.

EXAMPLES

Appendix III shows an actual run of the ECOPATH program. This example is provided as an installation aid. Note that each species group is equated with a number. This number corresponds with the order in which they were entered (see the input program description). The species group name and number are used interchangeably throughout the program.

There are two places where changes to the parameters are offered. The first is shown in Appendix IV. The second is at the end of a run (see the end of Appendix III). The changes made do not alter the file itself (in these two examples, "JEFF"). If it is desired to save the changes, they can either be saved as a new data set or stored in the original data set to replace the previous values (i.e., saving the input parameters under the name of "JEFF" would replace the existing ones).

The use of the input parameter program is shown in Appendix II. The biomass estimate and catch data require a "1" or "0" to indicate that values will be entered. If a mistake is made such as entering a "2," a warning message is displayed along with the prompt. The diet composition is structured such that all N parameters for a particular species group are entered at one time. The first number of "DC(1,2)" indicates the predator, and the second number indicates the prey. Thus the i^{th} row of the DC(N,N) matrix represents the proportion of various prey in the diet of predator i. Note that the sum of a predators diet consumption must be 1.0 or 0.0. (A sum of 0.0 occurs for primary producers.) If a mistake is made such that 0.33 and 0.77 are entered so 0.33 + 0.77 = 1.1, then a warning message is displayed along with the prompts. At the end of the program there is a prompt to ensure that the parameters entered will be stored in a file without ruining a previously created file. Once the message "CREATING FILE" is displayed, the file is physically created. Because the program doesn't check for existing file names, it is possible to run over an existing file by entering the same name. For example, if there was a file already called "DATA," then it would be replaced by this current set of parameters.

Appendices V and VI show other warning messages which may be displayed. Appendix V shows that after the habitat area input parameters are displayed, the diagonal elements of the AA matrix (AA*B=C) are checked to see that they all are greater than 0. If any are not greater than 0, then they are displayed along with the AA matrix. The program then allows changes to be made. When a diagonal element of the AA matrix is less than or equal to 0, this means mortality exceeds production for that species group and either the P/B ratio should be increased or some of the mortality components reduced until the diagonal element becomes positive. Appendix V shows that after the ecotrophic efficiency input parameters are displayed, the diet consumption rows are checked to see that they sum to 1 (as in the input program, see Appendix II). If a predator's diet consumption doesn't sum to 1 or 0, the name of the species group is displayed and changes are allowed. Thus, the sums of the rows in the diet composition matrix are checked in both the input program and the ECOPATH program.

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Appendix I.--The ECOPATH input parameter and main programs.

```
10 REM ****************************************************************************
20 REM *                              E  C  O  P  A  T  H                           *
30 REM *                           INPUT PARAMETER PROGRAM                          *
40 REM *===========================================================================*
50 REM * BY JEFFREY J. POLOVINA                                                     *
60 REM *    MARK D. OW                                                              *
70 REM *---------------------------------------------------------------------------*
80 REM *  THIS PROGRAM CREATES A SEQUENTIAL FILE OF INPUT PARAMETERS FOR  THE *
90 REM * ECOPATH PROGRAM.  THE FILE IS CREATED IN THE FOLLOWING FASHION:          *
100 REM *                                                                          *
110 REM *        CARD NUMBER                    INFORMATION                        *
120 REM *        ===========                    ===========                        *
130 REM *             1                          N = THE NUMBER OF SPECIES GROUPS  *
140 REM *                                        IN THIS SET OF DATA.              *
150 REM *                                                                          *
160 REM *             2                          SPECIE$(1):= THE FIRST SPECIES    *
170 REM *                                        GROUP NAME.                       *
180 REM *                                                                          *
190 REM *             3                         >NFLAG(1) = 1 IF BIOMASS ESTIMATE  *
200 REM *                                        ENTERED, 0 IF NONE.               *
210 REM *                                       >CFLAG%(1) = 1 IF CATCH DATA ENTER-*
220 REM *                                        ED, 0 IF NONE.                    *
230 REM *                                       >CATCH(1):= THE CATCH DATA AS ENT- *
240 REM *                                        ERED OR SET TO 0.                 *
250 REM *                                       >B(1):= THE BIOMASS ESTIMATE AS    *
260 REM *                                        ENTERED OR SET TO 0.              *
270 REM *                                       >Z(1):= THE PRODUCTION/BIOMASS     *
280 REM *                                        RATIO.                            *
290 REM *                                       >EE(1):= THE ECOTROPHIC EFFICIENCY.*
300 REM *                                       >HABAR(1):= THE HABITAT AREA.      *
310 REM *                                       >FR(1):= THE FOOD REQUIRED.        *
320 REM *                                                                          *
330 REM *            4                           SPECIE$(2) THE SECOND SPECIES     *
340 REM *                                        GROUP NAME.                       *
350 REM *                                                                          *
360 REM *            5                          >NFLAG(2)    ETC.......            *
370 REM *                                                                          *
380 REM *            ETC.                                                          *
390 REM *                                                                          *
400 REM *            2N + 2                      DC(1,1):= THE FIRST DIET COMPOS-  *
410 REM *                                        ITION FOR SPECIES GROUP 1.        *
420 REM *                                                                          *
430 REM *            2N + 3                      DC(1,2):= THE SECOND DIET COMP-   *
440 REM *                                        OSITION FOR SPECIES GROUP 1.      *
450 REM *            ETC.                                                          *
460 REM *                                                                          *
470 REM *--------------------------------------------------------------------------*
480 REM * USAGE NOTES:                                                             *
490 REM *          1) THE DIET COMPOSITION MAY BE REFORMATTED FOR SMALL N OR       *
500 REM *             OTHER BASICS TO REDUCE THE SIZE OF THE INPUT PARAMETER       *
510 REM *             FILE. (REMEMBER TO ALSO CHANGE THE MAIN PROGRAM IF DONE.) *
520 REM *                                                                          *
```

Appendix I.--Continued.

```
530 REM *           2) THE SUM OF EACH DIET COMPOSITION ROW IS CHECKED TO BE      *
540 REM *              1 OR 0.  THE TOLERANCE TO THE NUMBER 1 MAY BE CHECKED TO   *
550 REM *              THE DESIRED DECIMAL PLACE (SEE VARIABLE SUM).              *
560 REM *                                                                         *
570 REM *           3) THE PROGRAM DOES NOT VERIFY THAT THE FILE NAME TO BE       *
580 REM *              CREATED DOES NOT EXIST, AND WILL WRITE OVER AN EXISTING    *
590 REM *              FILE IF IN EXISTENCE. (THIS PROTECTION IS POSSIBLE BY      *
600 REM *              CHECKING THE RETURN CODE OF THE "OPEN" INSTRUCTION.)       *
610 REM *                                                                         *
620 REM *           4) ERRORS ARE CORRECTABLE USING THE PARAMETER CHANGE          *
630 REM *              OPTION IN THE MAIN PROGRAM. (MOST ERRORS EXCEPT FOR THE    *
640 REM *              VALUE OF N AND THE SPECIES GROUP NAMES).                   *
650 REM *                                                                         *
660 REM *           5) FOR FURTHER INFORMATION, PLEASE REFER TO THE MAIN PROGRAM *
670 REM *              AS WELL AS THE ECOPATH USER MANUAL.                        *
680 REM *                                                                         *
690 REM ***************************************************************************
700 REM
710 REM
720 DEFINT I-N
730 DEFDBL A-H,M-Z
740 OPTION BASE 1
750 REM DECLARE THE MINIMUM VALUE OF ARRAY SUBSCRIPTS.
760 REM -----------------------------------------------
770 REM
780 PRINT:PRINT:PRINT:PRINT
790 PRINT "**************  ECOPATH INPUT PARAMETER FILE PROGRAM ***********"
800 PRINT " "
810 INPUT "ENTER THE NAME OF THE FILE FOR THESE INPUT PARAMETERS ";FLNAME$
820 PRINT "THE NAME OF THE FILE TO BE CREATED IS ";FLNAME$
;", IS THIS CORRECT (Y/N) ";
830 INPUT " ";CORRECT$
840 IF (CORRECT$ = "N") GOTO 800
850 IF (CORRECT$ <> "Y") GOTO 800
860 REM
870 REM
880 PRINT " ":PRINT " "
890 INPUT "PLEASE ENTER THE NUMBER OF SPECIES GROUPS";N
900 IF (N < 1) THEN PRINT " ":PRINT "SORRY, THAT'S TOO SMALL.":GOTO 880
910 PRINT "THE NUMBER OF SPECIES GROUPS IS";N;", IS THIS CORRECT (Y/N)";
920 INPUT " ";CORRECT$
930 IF (CORRECT$ = "N") GOTO 880
940 IF (CORRECT$ <> "Y") GOTO 880
950 REM
960 REM ===========================================================================
970 REM                            VARIABLE  DECLARATIONS
980 REM ---------------------------------------------------------------------------
990 DIM B(N)
1000 DIM CATCH(N),CFLAG%(N)
1010 DIM DC(N,N)
1020 DIM EE(N)
1030 DIM FR(N)
```

Appendix I.--Continued.

```
1040 DIM HABAR(N)
1050 DIM NFLAG(N)
1060 DIM SPECIE$(N),SUM(N)
1070 DIM Z(N)
1080 REM -----------------------------------------------------------------------
1090 REM
1100 PRINT " ":PRINT " "
1110 FOR I = 1 TO N
1120      PRINT "ENTER THE NAME OF SPECIES GROUP";I;
1130      LINE INPUT " ";SPECIE$(I)
1140 NEXT I
1150 PRINT:PRINT
1160 FOR I = 1 TO N
1170      PRINT "ENTER '1' IF FIXED BIOMASS ESTIMATE, '0' IF NONE FOR "
;SPECIE$(I);
1180      INPUT " ";NFLAG(I)
1182      IF (NFLAG(I) <> 1 AND NFLAG(I) <> 0) THEN PRINT " "
:PRINT "1 OR 0 PLEASE":GOTO 1170
1190 NEXT I
1200 PRINT:PRINT
1210 FOR I = 1 TO N
1220      IF (NFLAG(I) = 0) THEN B(I) = 0#:GOTO 1250
1230      PRINT "ENTER THE KNOWN BIOMASS/HABITAT AREA FOR ";SPECIE$(I);
1240      INPUT " ";B(I)
1250 NEXT I
1260 PRINT:PRINT
1270 FOR I = 1 TO N
1280      PRINT "ENTER '1' IF CATCH DATA AVAILABLE, '0' IF NONE FOR ";SPECIE$(I);
1290      INPUT " ";CFLAG%(I)
1295      IF (CFLAG%(I) <> 0 AND CFLAG%(I) <> 1) THEN PRINT " ":PRINT
"1 OR 0 PLEASE":GOTO 1280
1300 NEXT I
1310 PRINT:PRINT
1320 FOR I = 1 TO N
1330     IF (CFLAG%(I) = 0) THEN CATCH(I) = 0#:GOTO 1360
1340      PRINT "ENTER THE CATCH DATA FOR ";SPECIE$(I);
1350      INPUT " ";CATCH(I)
1360 NEXT I
1370 PRINT:PRINT
1380 FOR I = 1 TO N
1390      PRINT "ENTER THE PRODUCTION/BIOMASS RATIO FOR ";SPECIE$(I);
1400      INPUT " ";Z(I)
1410 NEXT I
1420 PRINT:PRINT
1430 FOR I = 1 TO N
1440      PRINT "ENTER THE ECOTROPHIC EFFICIENCY FOR ";SPECIE$(I);
1450      INPUT  " ";EE(I)
1460 NEXT I
1470 PRINT:PRINT
1480 FOR I = 1 TO N
1490      PRINT "ENTER THE HABITAT AREA FOR ";SPECIE$(I);
1500      INPUT " ";HABAR(I)
```

Appendix I.--Continued.

```
1510 NEXT I
1520 PRINT:PRINT
1530 FOR I = 1 TO N
1540     PRINT "ENTER THE FOOD REQUIRED FOR ";SPECIE$(I);
1550     INPUT " ";FR(I)
1560 NEXT I
1570 PRINT:PRINT
1580 FOR I = 1 TO N
1590     PRINT " "
1600     SUM! = 0!
1610     PRINT "ENTER THE";N;" DIET COMPOSITION PARAMETERS FOR ";SPECIE$(I)
1620     FOR J = 1 TO N
1630         PRINT "ENTER DC(";I;",";J;")  ";
1640         INPUT " ";DC(I,J)
1650         SUM! = SUM! + DC(I,J)
1660     NEXT J
1670     IF (SUM! = 0) GOTO 1790
1680     SM! = ABS(SUM! - 1#)
1690     IF ((SM!) < .0001) GOTO 1790
1700 REM
1710 REM MODIFY THE ABOVE INEQUALITY TO VARY THE APPROXIMATION TO 1 BY THE SUM!.
1720 REM -----------------------------------------------------------------------
1730 REM
1740     PRINT " ":PRINT " "
1750     PRINT "*** WARNING: THE DIET COMPOSITION FOR ";SPECIE$(I);
1760     PRINT " DOES NOT SUM TO 1 OR 0, PLEASE REENTER."
1770     PRINT " "
1780     GOTO 1590
1790     PRINT
1800 NEXT I
1810 PRINT " ":PRINT " "
1820 PRINT "ARE YOU SURE YOU WANT TO USE THE FILE NAME ";FLNAME$;" (Y/N)";
1830 INPUT " ";CORRECT$
1840 IF (CORRECT$ = "Y") GOTO 1890
1850 IF (CORRECT$ <> "N") GOTO 1810
1860 PRINT " "
1870 INPUT "ENTER THE DESIRED FILE NAME ";FLNAME$
1880 GOTO 1810
1890 PRINT " "
1900 PRINT " ****> CREATING FILE ";FLNAME$
1910 OPEN "O",#1,FLNAME$
1920 REM
1930 REM ENTER THE RETURN CODE CHECK HERE PER FILE PROTECTION CAPABILITY
1940 REM -------------------------------------------------------------
1950 REM
1960 PRINT#1,N
1970 FOR I = 1 TO N
1980    PRINT#1,SPECIE$(I)
1990    PRINT#1,NFLAG(I);CFLAG%(I);CATCH(I);B(I);Z(I);EE(I);HABAR(I);FR(I)
2000 NEXT I
2010 FOR I = 1 TO N
2020    FOR J = 1 TO N
```

Appendix I.--Continued.

```
2030        PRINT#1,DC(I,J)
2040    NEXT J
2050 NEXT I
2060 CLOSE
2070 PRINT "FILE ";FLNAME$;" HAS BEEN CREATED."
2080 PRINT:PRINT:PRINT "**************** END OF INPUT PROGRAM *******************"
2090 END
```

Appendix I.--Continued.

```
10 REM ***************************************************************************
20 REM *                        E  C  O  P  A  T  H                              *
30 REM *-------------------------------------------------------------------------*
40 REM *  BY JEFFREY J. POLOVINA                                                 *
50 REM *     MARK D. OW                                                          *
60 REM *                                                                         *
70 REM *=========================================================================*
80 REM *  THIS PROGRAM IS WRITTEN IN MICROSOFT (TM) BASIC - 80  REV. 5.21       *
90 REM * CP/M VERSION.  THE PROGRAMMING CONSTRUCTS WHICH WILL DIFFER FROM       *
100 REM * OTHER BASICS ARE THE "WHILE/WEND" CONSTRUCT AND THE OUTPUT FORMATS.  *
110 REM * THE WHILE CONSTRUCTS MAY BE IMPLEMENTED VIA A "FOR/NEXT" CONSTRUCT   *
120 REM * WITH AN "IF" CONTROL STATEMENT.                                       *
122 REM *                                                                       *
124 REM * NOTE:THE COMMENTS INCLUDED THROUGHOUT THIS PROGRAM MAY CAUSE MEMORY  *
126 REM *      ALLOCATION PROBLEMS ON SMALLER SYSTEMS.                          *
130 REM *=======================================================================*
140 REM *                      DICTIONARY OF VARIABLES                          *
150 REM *                      ======================                           *
160 REM *                                                                       *
170 REM *   AA(N,N)              COEFFICIENT MATRIX PER  AA*B = C               *
180 REM *                                                                       *
190 REM *   AASV(N,N)            SAME AS ABOVE, USED IN ACTUAL COMPUTAIONS      *
200 REM *                                                                       *
210 REM *   ANPROD(N)            ANNUAL PRODUCTION OUTPUT VECTOR                *
220 REM *                                                                       *
230 REM *   ARRAYA(N*N)          COLUMN-WISE VECTOR OF THE AA(N,N) MATRIX       *
240 REM *                        WHERE ARRAYA(3) = AA(1,3)                      *
250 REM *                                                                       *
260 REM *   B(N)                 INITALLY A VECTOR OF THE MEAN ANNUAL SPECIES   *
270 REM *                        GROUP BIOMASS, AFTER COMPUTATION OF A*B = C,   *
280 REM *                        THE NONTRIVIAL SOLUTION VECTOR                 *
290 REM *                                                                       *
300 REM *   BEATEN(N,N)          CONSUMPTION OUTPUT MATRIX                      *
310 REM *                                                                       *
320 REM *   BSTPHA(N)            BIOMASS PER UNIT OF HABITAT AREA OUPUT VECTOR  *
330 REM *                                                                       *
340 REM *   C(N)                 VECTOR OF FISHERIES CATCH PER A*B = C          *
350 REM *                                                                       *
360 REM *   CATCH(N)             CATCH INPUT VECTOR                             *
370 REM *                                                                       *
380 REM *   CFLAG%(N)            INDICATES THE PRESENCE OF NON-ZERO CATCH INPUT *
390 REM *                        1 = PRESENT,0 = NOT PRESENT                    *
400 REM *                                                                       *
410 REM *   D(N)                 VECTOR OF (1 - EE(I)) * Z(I)                   *
420 REM *                                                                       *
430 REM *   DC(N,N)              DIET COMPOSITION INPUT MATRIX                  *
440 REM *                                                                       *
450 REM *   DISPLAY$             "S" = SCREEN OUTPUT, "P" = PRINTER OUTPUT      *
460 REM *                        LIMITS OF 80 AND 132 COLUMNS RESPECTIVELY      *
470 REM *                        USAGE NOTE: IF A PRINTER IS SLAVED, THEN THE   *
480 REM *                        PRINTER MODE MAY BE USED IF THE SCREEN OUTPUT  *
490 REM *                        WIDTH IS DEFINED AS 132 (I.E. ENTER 'WIDTH 132')*
```

Appendix I.--Continued.

```
500 REM *                                                                      *
510 REM *   ECFF(N)            ECOLOGICAL EFFICIENCY (PRODUCTION/CONSUMTION)   *
520 REM *                      OUTPUT VECTOR                                   *
530 REM *                                                                      *
540 REM *   EE(N)              ECOTROPHIC EFFICIENCY INPUT VECTOR              *
550 REM *                                                                      *
560 REM *   FCATCH(N)          FISHERY CATCH OUTPUT VECTOR                     *
570 REM *                                                                      *
580 REM *   FLNAME$            SEQUENTIAL FILE OF INPUT PARAMETERS CREATED BY  *
590 REM *                      THE ECOPATH INPUT PROGRAM OR THIS PROGRAM       *
600 REM *                                                                      *
610 REM *   FR(N)              FOOD REQUIRED INPUT VECTOR                      *
620 REM *                                                                      *
630 REM *   HABAR(N)           HABITAT AREA INPUT VECTOR                       *
640 REM *                                                                      *
650 REM *   INCREMENT          THE NUMBER OF OUTPUT ITEMS THAT WILL FIT ON ONE *
660 REM *                      SCREEN PAGE (IF DISPLAY$ = "S") OR PRINTER PAGE *
670 REM *                                                                      *
680 REM *   NEGFLAG(N)         INDICATES THE PRESENCE OF AA MATRIX DIAGONAL    *
690 REM *                      ELEMENTS WHICH ARE LESS THAN OR EQUAL TO 0      *
700 REM *                      1 = DIAGONAL <= 0, 0 = DIAGONAL > 0             *
710 REM *                                                                      *
720 REM *   NFLAG(N)           INDICATES THE PRESENCE OF FIXED INPUT BIOMASS   *
730 REM *                      ESTIMATES. 1 = PRESENT ,0 = NOT PRESENT  AND    *
740 REM *                      THE CORRESPONDING B INPUT ELEMENT SET TO 0.0    *
750 REM *                                                                      *
760 REM *   OLDB(N)            STORAGE VECTOR OF B VALUES BEFORE SOLUTION      *
770 REM *                                                                      *
780 REM *   OLDCATCH(N)        STORAGE VECTOR OF CATCH VALUES BEFORE USE IN    *
790 REM *                      COMPUTATION                                     *
800 REM *                                                                      *
810 REM *   SPECIE$(N)         SPECIES GROUP NAMES (ONLY FIRST 15 CHARACTERS   *
820 REM *                      USED PER OUTPUT)                                *
830 REM *                                                                      *
840 REM *   SUM!(N)            THE SUM OF THE ITH ROW OF DC(I,J). IF NOT EQUAL *
850 REM *                      TO 1 OR 0, THEN ERROR IS FLAGGED                *
860 REM *   TOTAL(N)           THE SUM OF THE JTH COLUMN OF BEATEN(I,J)        *
870 REM *                                                                      *
880 REM *   Z(N)               PRODUCTION/BIOMASS RATIO WHERE Z = M + F INPUT  *
890 REM *                      VECTOR                                          *
900 REM *                                                                      *
910 REM *----------------------------------------------------------------------*
920 REM *   DEFINT             DEFINES ALL VARIABLES STARTING WITH THE LETTERS *
930 REM *                      I THRU N TO BE INTEGERS                         *
940 REM *   DEFDBL             DEFINES ALL VARIABLES STARTING WITH THE LETTERS *
950 REM *                      A THRU H AND M THRU Z TO BE DOUBLE PRECISION    *
960 REM *                                                                      *
970 REM * NOTE: VARIABLES ENDING WITH THE FOLLOWING CHARACTERS DO NOT FOLLOW   *
980 REM *       THE ABOVE DEFINITIONS:                                         *
990 REM *                                                                      *
1000 REM*                      %       INTEGER NUMBERS OR VARIABLES            *
1010 REM*                      !       SINGLE PRECISION NUMBERS OR VARIABLES   *
```

Appendix I.--Continued.

```
1020 REM*                      #      DOUBLE PRECISION NUMBERS OR VARIABLES    *
1030 REM*                      $      STRING VARIABLES                         *
1040 REM************************************************************************
1050 REM
1060 REM
1070 DEFINT I-N
1080 DEFDBL A-H,M-Z
1090 OPTION BASE 1
1100 REM DECLARE THE MINIMUM VALUE OF ARRAY SUBSCRIPTS.
1110 REM -------------------------------------------
1120 PRINT " ":PRINT "           **********   E C O P A T H   **********"
1130 PRINT " ":PRINT " "
1140 INPUT "PLEASE ENTER THE NAME OF THE FILE TO BE USED ";FLNAME$
1150 PRINT "THE FILE TO BE USED IS ";FLNAME$;", IS THIS CORRECT (Y/N) ";
1160 INPUT " ";CORRECT$
1170 IF (CORRECT$ = "N") GOTO 1130
1180 IF (CORRECT$ <> "Y") GOTO 1130
1190 OPEN "I",#1,FLNAME$
1200 INPUT #1,N
1210 REM INPUT THE NUMBER OF SPECIES GROUPS
1220 REM ---------------------------------
1230 DIM AA(N,N),AASV(N,N),ANPROD(N),ARRAYA(N*N)
1240 DIM B(N),BEATEN(N,N),BSTPHA(N)
1250 DIM C(N),CATCH(N),CFLAG%(N)
1260 DIM D(N),DC(N,N)
1270 DIM ECFF(N),EE(N)
1280 DIM FCATCH(N),FR(N)
1290 DIM HABAR(N),NEGFLAG(N),NFLAG(N),OLDB(N),OLDCATCH(N)
1300 DIM SPECIE$(N),SUM!(N)
1310 DIM TOTAL(N),Z(N)
1320 PRINT "  "
1330 INPUT "ARE YOU USING A SCREEN OR A PRINTER (S/P) ";DISPLAY$
1340 IF (DISPLAY$ <> "S" AND DISPLAY$ <> "P") GOTO 1320
1350 PRINT " "
1360 PRINT " "
1370 REM ======================================================================
1380 REM                          INPUT SECTION
1390 REM ----------------------------------------------------------------------
1400 FOR I = 1 TO N
1410    LINE INPUT#1,SPECIE$(I)
1420    INPUT#1,NFLAG(I),CFLAG%(I),CATCH(I),B(I),Z(I),EE(I),HABAR(I),FR(I)
1430 NEXT I
1440 FOR I = 1 TO N
1450    FOR J = 1 TO N
1460       INPUT#1,DC(I,J)
1470    NEXT J
1480 NEXT I
1490 REM ======================================================================
1500 REM
1510 INPUT "WOULD YOU LIKE TO MAKE ANY CHANGES TO THE INPUT VALUES NOW (Y/N)";NOW$
1520 IF (NOW$ =  "Y") GOTO 7110
1530 IF (NOW$ <> "N") GOTO 1510
```

Appendix I.--Continued.

```
1540 REM =======================================================================
1550 REM                       INPUT DISPLAY AND PROCESSING
1560 REM -----------------------------------------------------------------------
1570 REM
1580 PRINT " ":PRINT " ":PRINT " "
1590 PRINT "      SPECIES GROUPS"
1600 PRINT " "
1610 FOR I = 1 TO N
1620     PRINT USING "        ##";I;
1630     PRINT " = ";SPECIE$(I)
1640 NEXT I
1650 PRINT " "
1660 PRINT " "
1670 PRINT " "
1680 PRINT " "
1690 PRINT "           KNOWN BIOMASS/(WEIGHT/UNIT AREA OVER HABITAT AREA)   (B)"
1700 PRINT " "
1710 IF (DISPLAY$ = "S") THEN INCREMENT = 5 ELSE INCREMENT = 8
1720 K = 1
1730 J = 1
1740 WHILE (J <= N)
1750    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
1760    FOR I = 1 TO INCREMENT
1770        PRINT USING "             ##";J;
1780        J = J + 1
1790    NEXT I
1800    PRINT " "
1810    PRINT " "
1820    FOR I = 1 TO INCREMENT
1830        PRINT USING "##########.###";B(K);
1840        K = K + 1
1850    NEXT I
1860    PRINT " "
1870    PRINT " "
1880 WEND
1890 PRINT " "
1900 PRINT " "
1910 PRINT " "
1920 PRINT " "
1930 PRINT " "
1940 PRINT " "
1950 PRINT " "
1960 PRINT " "
1970 PRINT "           TOTAL CATCH/(WEIGHT/UNIT AREA OVER HABITAT AREA)
  (CATCH)"
1980 PRINT " "
1990 IF (DISPLAY$ = "S") THEN INCREMENT = 5 ELSE INCREMENT = 8
2000 K = 1
2010 J = 1
2020 WHILE (J <= N)
2030    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
2040    FOR I = 1 TO INCREMENT
```

Appendix I.--Continued.

```
2050         PRINT USING "                ##";J;
2060         J = J + 1
2070     NEXT I
2080     PRINT " "
2090     PRINT " "
2100     FOR I = 1 TO INCREMENT
2110         PRINT USING "###########.###";CATCH(K);
2120         K = K + 1
2130     NEXT I
2140     PRINT " "
2150     PRINT " "
2160 WEND
2170 PRINT " "
2180 PRINT " "
2190 PRINT " "
2200 PRINT " "
2210 PRINT "           ECOTROPHIC EFFICIENCY (FRACTION OF PRODUCTION
 CONSUMED BY PREDATORS)  (EE)"
2220 IF (DISPLAY$ = "S") THEN INCREMENT = 8   ELSE INCREMENT = 14
2230 K = 1
2240 J = 1
2250 WHILE (J <= N)
2260     IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
2270     FOR I = 1 TO INCREMENT
2280         PRINT USING "       ##";J;
2290         J = J + 1
2300     NEXT I
2310    PRINT " "
2320    PRINT " "
2330    FOR I = 1 TO INCREMENT
2340        PRINT USING "   ##.###";EE(K);
2350        K = K + 1
2360    NEXT I
2370    PRINT " "
2380    PRINT " "
2390 WEND
2400 FOR I = 1 TO N
2410     SUM!(I) = 0!
2420     FOR J = 1 TO N
2430         SUM!(I) = CSNG(DC(I,J)) + SUM!(I)
2440     NEXT J
2450 NEXT I
2460 REM
2470 REM CHECK THAT THE DIET COMPOSITION FOR A SPECIES GROUP SUMS TO 1 OR 0 BY
2480 REM A TOLERANCE OF SM! . IF THE SUM! IF OFF, THEN ALLOW THE USER TO
2490 REM ENTER CHANGES.
2500 REM ---------------------------------------------------------------------
2510 REM
2520 FOR I = 1 TO N
2530     IF (SUM!(I) = 0!) GOTO 2630
2540     SM! = ABS(SUM!(I) - 1#)
2550     IF (SM! < .0001) GOTO 2630
```

Appendix I.--Continued.

```
2560      PRINT " ":PRINT " "
2570      PRINT "*** WARNING: THE DIET COMPOSITION FOR THE FOLLOW SPECIES"
2580      PRINT "             DOES NOT SUM TO 1 OR 0, PLEASE VERIFY DC INPUT"
2590      PRINT " "
2600      PRINT "             ";SPECIE$(I)
2610      PRINT " "
2620      BADDC$ = "Y"
2630 NEXT I
2640 IF (BADDC$ = "Y") GOTO 6980
2650 REM
2660 IF (DISPLAY$ = "S") THEN INCREMENT = 6  ELSE INCREMENT = 12
2670 PRINT " "
2680 PRINT " "
2690 PRINT " "
2700 PRINT " "
2710 PRINT " "
2720 PRINT "           DIET COMPOSITION BY SPECIES GROUPS   (DC)"
2730 PRINT "           (ROWS REPRESENT PREDATORS AND COLUMNS ARE PREY)"
2740 PRINT " "
2750 K = 1
2760 J = 1
2770 WHILE (J <= N)
2780    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
2790    PRINT "                ";
2800    FOR I = 1 TO INCREMENT
2810        PRINT USING "      ##";J;
2820        J = J + 1
2830    NEXT I
2840    IF ((J-1) = N) THEN PRINT "    SUM"  ELSE PRINT " "
2850    FOR  L = 1 TO N
2860        K = (J - INCREMENT)
2870        PRINT USING "●              ●";SPECIE$(L);
2880        PRINT USING " ##";L;
2890        FOR I = 1 TO INCREMENT
2900            PRINT USING "  ##.###";DC(L,K);
2910            K = K + 1
2920        NEXT I
2930        IF ((K-1) = N) THEN PRINT USING "  ##.##";SUM!(L)  ELSE PRINT " "
2940    NEXT L
2950    PRINT " "
2960    PRINT " "
2970 WEND
2980 PRINT " "
2990 PRINT " "
3000 PRINT " "
3010 PRINT " "
3020 PRINT " "
3030 PRINT " "
3040 PRINT " "
3050 PRINT "           PRODUCTION/BIOMASS RATIO (Z = M + F)"
3060 PRINT " "
3070 IF (DISPLAY$ = "S") THEN INCREMENT = 5 ELSE INCREMENT = 8
```

Appendix I.--Continued.

```
3080 K = 1
3090 J = 1
3100 WHILE (J <= N)
3110    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
3120    FOR I = 1 TO INCREMENT
3130        PRINT USING "            ##";J;
3140        J = J + 1
3150    NEXT I
3160    PRINT " "
3170    PRINT " "
3180        FOR I = 1 TO INCREMENT
3190            PRINT USING "##########.###";Z(K);
3200            K = K + 1
3210        NEXT I
3220    PRINT " "
3230    PRINT " "
3240 WEND
3250 PRINT " "
3260 PRINT " "
3270 FOR I = 1 TO N
3280    D(I) = (1# - EE(I))*Z(I)
3290 NEXT I
3300 PRINT " "
3310 PRINT " "
3320 PRINT "           ANNUAL FOOD REQUIRED AS A FRACTION OF THE
 MEAN ANNUAL BIOMASS (FR)"
3330 PRINT " "
3340 IF (DISPLAY$ = "S") THEN INCREMENT = 5 ELSE INCREMENT = 8
3350 PRINT " "
3360 K = 1
3370 J = 1
3380 WHILE (J <= N)
3390    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
3400    FOR I = 1 TO INCREMENT
3410        PRINT USING "            ##";J;
3420        J = J + 1
3430    NEXT I
3440    PRINT " "
3450    PRINT " "
3460        FOR I = 1 TO INCREMENT
3470            PRINT USING "##########.###";FR(K);
3480            K = K + 1
3490        NEXT I
3500    PRINT " "
3510    PRINT " "
3520 WEND
3530 PRINT " "
3540 PRINT " "
3550 PRINT " "
3560 PRINT " "
3570 PRINT " "
3580 PRINT "           HABITAT AREA  (HABAR)"
```

Appendix I.--Continued.

```
3590 PRINT " "
3600 PRINT " "
3610 IF (DISPLAY$ = "S") THEN INCREMENT = 5 ELSE INCREMENT = 8
3620 K = 1
3630 J = 1
3640 WHILE (J <= N)
3650    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
3660    FOR I = 1 TO INCREMENT
3670        PRINT USING "              ##";J;
3680        J = J + 1
3690    NEXT I
3700    PRINT " "
3710    PRINT " "
3720        FOR I = 1 TO INCREMENT
3730            PRINT USING "###########.###";HABAR(K);
3740            K = K + 1
3750        NEXT I
3760    PRINT " "
3770    PRINT " "
3780 WEND
3790 PRINT " "
3800 PRINT " "
3810 PRINT " "
3820 PRINT " "
3830 PRINT " "
3840 REM
3850 REM STORE THE CURRENT VALUES OF B(N) PER LATER REFERENCE IN OLDB(N)
3860 REM
3870 FOR I = 1 TO N
3880    OLDB(I) = B(I)
3890    IF (NFLAG(I) = 1) THEN  B(I) = B(I)*HABAR(I)
3900 NEXT I
3910 REM
3920 REM INITIALIZE THE MATRICES FOR SOLUTION OF THE EQUALIBRIUM MATRIX PER
3930 REM  AA*B = C.
3940 REM -----------------------------------------------------------------
3950 REM
3960 FOR J = 1 TO N
3970    C(J) = 0#
3980    IF (NFLAG(J) = 1)  GOTO 4020
3990    FOR I = 1 TO N
4000       IF (NFLAG(I) = 1) THEN C(J) = B(I)*FR(I)*DC(I,J) + C(J)
4010    NEXT I
4020 NEXT J
4030 REM
4040 REM FOR THE SPECIES GROUPS WHICH CONTAIN BIOMASS ESTIMATES (FROM INPUT)
4050 REM SET THE DIAGONAL OF THE AA MATRIX TO 1.
4060 REM -----------------------------------------------------------------
4070 REM
4080 FOR I = 1 TO N
4090    IF (NFLAG(I) = 0)  GOTO 4150
4100    C(I) = B(I)
```

Appendix I.--Continued.

```
4110     FOR J = 1 TO N
4120        AA(I,J) = 0#
4130        IF (I = J) THEN AA(I,J) = 1#
4140     NEXT J
4150 NEXT I
4160 FOR I = 1 TO N
4170     OLDCATCH(I) = CATCH(I)
4180     FCATCH(I) = CATCH(I)
4190     CATCH(I) = CATCH(I)*HABAR(I)
4200     IF (CFLAG%(I) = 1) THEN C(I) = C(I) + CATCH(I)
4210 NEXT I
4220 FOR I = 1 TO N
4230     FOR J = 1 TO N
4240         IF (NFLAG(I) = 1  OR  NFLAG(J) = 1)  GOTO 4260
4250         IF (J = I)  THEN AA(I,J) = Z(I)-D(I)-FR(J)*DC(J,I)
                         ELSE AA(I,J) = -FR(J)*DC(J,I)
4260     NEXT J
4270 NEXT I
4280 FOR I = 1 TO N
4290     FOR J = 1 TO N
4300        AASV(I,J) = AA(I,J)
4310     NEXT J
4320 NEXT I
4330 REM ****************************************************************
4340 NEGATIVE = 0
4350 FOR I = 1 TO N
4360     NEGFLAG(I) = 0
4370 NEXT I
4380 REM
4390 REM IF A DIAGONAL ELEMENT OF THE AA MATRIX IS LESS THAN OR EQUAL TO 0,
4400 REM OUTPUT THE AA MATRIX AND ALLOW THE USER TO MAKE CHANGES.
4410 REM ----------------------------------------------------------------
4420 REM
4430 FOR I = 1 TO N
4440     IF (AASV(I,I) <= 0#) THEN NEGFLAG(I) = 1:NEGATIVE = 1
4450 NEXT I
4460 IF (NEGATIVE = 0) GOTO 5210
4470 PRINT " "
4480 PRINT " "
4490 PRINT " "
4500 PRINT " "
4510 PRINT " "
4520 PRINT " "
4530 PRINT " "
4540 PRINT " "
4550 PRINT "          ** WARNING :THE DIAGONAL ENTRIES IN THE AA MATRIX ARE NOT"
4560 PRINT "                     POSITIVE FOR THE FOLLOWING SPECIES GROUPS:"
4570 PRINT " "
4580 PRINT " "
4590 PRINT "                SPECIES GROUP      LOCATION        VALUE"
4600 PRINT "                _____________      ________        _________"
4610 FOR I = 1 TO N
```

Appendix I.--Continued.

```
4620      IF (NEGFLAG(I) <> 1) GOTO 4710
4630      PRINT "                    ";
4640      PRINT USING "•              •";SPECIE$(I);
4650      PRINT "   AA(";
4660      PRINT USING "##";I;
4670      PRINT ",";
4680      PRINT USING "##";I;
4690      PRINT ")";
4700      PRINT USING "      ####.###";AASV(I,I)
4710 NEXT I
4720 PRINT " "
4730 PRINT " "
4740 PRINT " "
4750 PRINT " "
4760 PRINT " "
4770 PRINT "        ***> NOTE: THE ABOVE INDICATES THAT PREDATION PLUS
FISHING (AS APPLICABLE)"
4780 PRINT "                   IS EXCEEDING PRODUCTION.  THE EQUALIBRI
UM BIOMASS ESTIMATES"
4790 PRINT "                   AS A RESULT, ARE NEGATIVE.  THEREFORE,
THE"
4800 PRINT "                   EQUALIBRIUM BIOMASS OUTPUT HAS BEEN SUP
PRESSED."
4810 PRINT " "
4820 PRINT " "
4830 PRINT "                   PLEASE CHECK THE INPUT VALUES OF: DIET
COMPOSITION,"
4840 PRINT "                   PRODUCTION/BIOMASS, AND FOOD REQUIREME
NTS FOR THE"
4850 PRINT "                   SPECIES GROUPS LISTED ABOVE AND RERUN
THE PROGRAM."
4860 PRINT " "
4870 PRINT " "
4880 PRINT " "
4890 PRINT " "
4900 PRINT " "
4910 PRINT " "
4920 PRINT "          THE AA MATRIX"
4930 PRINT " "
4940 PRINT " "
4950 PRINT " "
4960 IF (DISPLAY$ = "S") THEN INCREMENT = 4 ELSE INCREMENT = 8
4970 K = 1
4980 J = 1
4990 WHILE (J <= N)
5000    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
5010    PRINT "                    ";
5020    FOR I = 1 TO INCREMENT
5030       PRINT USING "          ##";J;
5040       J = J + 1
5050    NEXT I
5060    PRINT " "
```

Appendix I.--Continued.

```
5070     PRINT " "
5080     FOR  L = 1 TO N
5090         K = (J - INCREMENT)
5100         PRINT USING "•              •";SPECIE$(L);
5110         PRINT USING " ##";L;
5120         FOR I = 1 TO INCREMENT
5130             PRINT USING " ######.###";AASV(L,K);
5140             K = K + 1
5150         NEXT I
5160         PRINT " "
5170     NEXT L
5180     PRINT " "
5190 WEND
5200 GOTO 6980
5210 PRINT " "
5220 PRINT " "
5230 PRINT " "
5240 PRINT " "
5250 PRINT " "
5260 FOR I = 1 TO N
5270     B(I) = C(I)
5280 NEXT I
5290 REM ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
5300 REM SUBROUTINE CALL TO OBTAIN A SOLUTION TO LINEAR EQUATION AA*B = C
5310 REM FOR EQUALIBRIUM, C VECTOR REPLACES B VECTOR, CALCULATE THE BIOMASSES
5320 REM USING THE VALUES IN C WITH THE SOLUTION REPLACING THE VALUES IN B.
5330 REM ----------------------------------------------------------------------
5340 GOSUB 8610
5350 REM ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
5360 REM
5370 PRINT " "
5380 PRINT " "
5390 PRINT " "
5400 PRINT " "
5410 PRINT " "
5420 PRINT " "
5430 PRINT " "
5440 PRINT " "
5450 PRINT "                               INITIAL EQUALIBRIUM"
5460 PRINT " "
5470 PRINT " "
5480 FOR I = 1 TO N
5490     BSTPHA(I) = B(I)/HABAR(I)
5500     ANPROD(I) = (Z(I)*B(I))/HABAR(I)
5510     IF (ABS(FR(I)) >= .001#  AND  ABS(B(I)) >= .001#)
         THEN ECFF(I) = ANPROD(I) /(FR(I)*BSTPHA(I))
5520 NEXT I
5530 PRINT " "
5540 PRINT " "
5550 PRINT "             BIOMASS RECALCULATED PER HABITAT AREA FOR OUTPUT"
5560 PRINT " "
5570 PRINT " "
```

Appendix I.--Continued.

```
5580 PRINT " "
5590 PRINT "                    BIOMASS     ANNUAL        FISHERY     HABITAT
    ECOLOGICAL"
5600 PRINT "                    PER UNIT    PRODUCTION    CATCH PER   AREA
      EFFICIENCY"
5610 PRINT "                    OF HABITAT  PER UNIT      UNIT OF
             (PRODUCTION/"
5620 PRINT "                    AREA        HABITAT       HABITAT
             CONSUMPTION)"
5630 PRINT "                                AREA          AREA"
5640 PRINT " "
5650 FOR I = 1 TO N
5660    PRINT USING "•             •";SPECIE$(I);
5670    PRINT USING " ## ";I;
5680    PRINT USING "##########";BSTPHA(I);
5690    PRINT USING "  ##########";ANPROD(I);
5700    PRINT USING "  ##########";FCATCH(I);
5710    PRINT USING " #########";HABAR(I);
5720    PRINT USING "   #######.####";ECFF(I)
5730 NEXT I
5740 PRINT " "
5750 PRINT " "
5760 PRINT " "
5770 PRINT " "
5780 PRINT " "
5790 PRINT " "
5800 FOR I = 1 TO N
5810    TOTAL(I) = 0#
5820    FOR J = 1 TO N
5830       BEATEN(I,J) = (B(I)/HABAR(I))*FR(I)*DC(I,J)
5840       TOTAL(I) = TOTAL(I) + BEATEN(I,J)
5850    NEXT J
5860 NEXT I
5870 IF (DISPLAY$ = "S") THEN INCREMENT = 3  ELSE INCREMENT = 6
5880 PRINT "          CONSUMPTION VECTOR (BIOMASS/HABITAT AREA)"
5890 PRINT "          (COLUMNS REPRESENT PERDATOR, ROWS REPRESENT PREY)"
5900 PRINT " "
5910 K = 1
5920 J = 1
5930 WHILE (J <= N)
5940    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
5950    PRINT "                    ";
5960    FOR I = 1 TO INCREMENT
5970        PRINT USING "            ##";J;
5980        J = J + 1
5990    NEXT I
6000    PRINT " "
6010    PRINT " "
6020    FOR  L = 1 TO N
6030        K = (J - INCREMENT)
6040        PRINT USING "•             •";SPECIE$(L);
6050        PRINT USING " ##";L;
```

Appendix I.--Continued.

```
6060          FOR I = 1 TO INCREMENT
6070              PRINT USING " ###########,.##";BEATEN(K,L);
6080              K = K + 1
6090          NEXT I
6100          PRINT " "
6110      NEXT L
6120      PRINT " "
6130      PRINT "TOTAL                   ";
6140      K = (J - INCREMENT)
6150      FOR I = 1 TO INCREMENT
6160          PRINT USING " ###########,.##";TOTAL(K);
6170          K = K + 1
6180      NEXT I
6190      PRINT " "
6200      PRINT " "
6210 WEND
6220 PRINT " "
6230 PRINT " "
6240 PRINT " "
6250 PRINT " "
6260 PRINT " "
6270 PRINT " "
6280 PRINT " "
6290 PRINT " "
6300 PRINT " "
6310 PRINT "           C VECTOR"
6320 PRINT " "
6330 PRINT " "
6340 IF (DISPLAY$ = "S") THEN INCREMENT = 5  ELSE INCREMENT = 8
6350 K = 1
6360 J = 1
6370 WHILE (J <= N)
6380      IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
6390      FOR I = 1 TO INCREMENT
6400          PRINT USING "            ##";J;
6410          J = J + 1
6420      NEXT I
6430      PRINT " "
6440      PRINT " "
6450          FOR I = 1 TO INCREMENT
6460              PRINT USING "##########.###";C(K);
6470              K = K + 1
6480          NEXT I
6490      PRINT " "
6500      PRINT " "
6510 WEND
6520 PRINT " "
6530 PRINT " "
6540 PRINT " "
6550 PRINT " "
6560 PRINT " "
6570 PRINT " "
```

Appendix I.--Continued.

```
6580 PRINT " "
6590 PRINT "            AA MATRIX"
6600 PRINT " "
6610 PRINT " "
6620 IF (DISPLAY$ = "S") THEN INCREMENT = 4 ELSE INCREMENT = 8
6630 K = 1
6640 J = 1
6650 WHILE (J <= N)
6660    IF ((N - K + 1) < INCREMENT)  THEN INCREMENT = (N - K + 1)
6670    PRINT "                  ";
6680    FOR I = 1 TO INCREMENT
6690        PRINT USING "         ##";J;
6700        J = J + 1
6710    NEXT I
6720    PRINT " "
6730    PRINT " "
6740    FOR  L = 1 TO N
6750        K = (J - INCREMENT)
6760        PRINT USING "•              •";SPECIE$(L);
6770        PRINT USING " ##";L;
6780        FOR I = 1 TO INCREMENT
6790            PRINT USING " ######.###";AASV(L,K);
6800            K = K + 1
6810        NEXT I
6820        PRINT " "
6830    NEXT L
6840    PRINT " "
6850 WEND
6860 REM
6870 REM ==================================================================
6880 REM                        PARAMETER CHANGE SECTION
6890 REM ------------------------------------------------------------------
6900 REM
6910 REM ALLOW THE USER TO MODIFY THE CURRENT PARAMETERS AND MAKE ANOTHER RUN,
6920 REM AND/OR ALLOW THE USER TO SAVE THE CURRENT PARAMETERS IN A SEQUENTIAL
6930 REM FILE.  NOTE: PROGRAM DOES NOT VERIFY  IF THE NAME OF THE FILE TO
6940 REM              BE CREATED ALREADY EXIST.  IF IT DOES, THEN THE CONTENTS
6950 REM              WILL BE WRITTEN OVER.
6960 REM ------------------------------------------------------------------
6970 REM
6980 PRINT " "
6990 PRINT " "
7000 INPUT "WOULD YOU LIKE TO CHANGE ANY INPUT PARAMETERS (Y/N)";CHANGE$
7010 IF (CHANGE$ = "N") GOTO 8310
7020 IF (CHANGE$ <> "Y") GOTO 7000
7030 REM
7040 REM RESTORE THE CURRENT B AND CATCH PARAMETERS
7050 REM -----------------------------------------
7060 REM
7070 FOR I = 1 TO N
7080    B(I) = OLDB(I)
7090    CATCH(I) = OLDCATCH(I)
```

Appendix I.--Continued.

```
7100 NEXT I
7110 PRINT " ":PRINT " ":PRINT " ":PRINT " "
7120 PRINT "    1 = KNOWN BIOMASS/HABITAT AREA  (B)"
7130 PRINT "    2 = TOTAL CATCH/HABITAT AREA (CATCH)"
7140 PRINT "    3 = ECOTROPHIC EFFICIENCY (EE)"
7150 PRINT "    4 = DIET COMPOSITION (DC)"
7160 PRINT "    5 = PRODUCTION/BIOMASS RATIO (Z = M + F)"
7170 PRINT "    6 = FOOD REQUIRED (FRACTION OF MEAN ANNUAL BIOMASS)  (FR)"
7180 PRINT "    7 = HABITAT AREA (HABAR)"
7190 PRINT "    8 = NO MORE CHANGES TO BE MADE  (MAKE ANOTHER PASS)"
7200 PRINT " "
7210 INPUT "ENTER THE NUMBER OF YOUR CHOICE (1-8)";CHOICE%
7220 IF (CHOICE% < 1 OR CHOICE% > 8) GOTO 7210
7230 PRINT " ":PRINT " ":PRINT " "
7240 IF (CHOICE% = 8) THEN PRINT "     ********************  NEW RUN
  **********************" : GOTO 1540
7250 INCREMENT = 4
7260 K = 1
7270 J = 1
7280 WHILE (J <= N)
7290    IF ((N - K + 1) < INCREMENT) THEN INCREMENT = (N - K + 1)
7300    FOR I = 1 TO INCREMENT
7310        PRINT USING "##                ";J;
7320        J = J + 1
7330    NEXT I
7340    PRINT " "
7350    PRINT " "
7360    FOR I = 1 TO INCREMENT
7370        PRINT USING "•                •_ ";SPECIE$(K);
7380        K = K + 1
7390    NEXT I
7400    PRINT " "
7410    PRINT " "
7420 WEND
7430 PRINT " ":PRINT " "
7440 IF (CHOICE% <> 1) GOTO 7550
7450     PRINT "ENTER THE NUMBER OF THE BIOMASS/HABITAT PARAMETER TO"
7460     PRINT "CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)";
7470     INPUT " ";CHANGE%
7480     IF (CHANGE% = 0) GOTO 7110
7490     IF (CHANGE% < 1 OR CHANGE% > N) GOTO 7450
7500     PRINT "THE VALUE IS CURRENTLY ";B(CHANGE%)
7510     INPUT "ENTER THE NEW VALUE ";B(CHANGE%)
7520     IF (B(CHANGE%) = 0# OR B(CHANGE%) = 0! OR B(CHANGE%) = 0)
         THEN NFLAG(CHANGE%) = 0   ELSE NFLAG(CHANGE%) = 1
7530     PRINT " "
7540     GOTO 7450
7550 IF (CHOICE% <> 2)  GOTO 7660
7560     PRINT "ENTER THE NUMBER OF THE CATCH/HABITAT PARAMETER TO"
7570     PRINT "CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)";
7580     INPUT " ";CHANGE%
7590     IF (CHANGE% = 0) GOTO 7110
```

Appendix I.--Continued.

```
7600      IF (CHANGE% < 1 OR CHANGE% > N) GOTO 7560
7610      PRINT "THE VALUE IS CURRENTLY ";CATCH(CHANGE%)
7620      INPUT "ENTER THE NEW VALUE ";CATCH(CHANGE%)
7630      IF (CATCH(CHANGE%) = 0# OR CATCH(CHANGE%) = 0! OR
 CATCH(CHANGE%) = 0) THEN CFLAG%(CHANGE%) = 0  ELSE CFLAG%(CHANGE%) = 1
7640      PRINT " "
7650      GOTO 7560
7660 IF (CHOICE% <> 3)  GOTO 7760
7670      PRINT "ENTER THE NUMBER OF THE ECOTROPHIC EFFICIENCY PARAMETER"
7680      PRINT "TO CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)";
7690      INPUT " ";CHANGE%
7700      IF (CHANGE% = 0) GOTO 7110
7710      IF (CHANGE% < 1 OR CHANGE% > N) GOTO 7670
7720      PRINT "THE VALUE IS CURRENTLY ";EE(CHANGE%)
7730      INPUT "ENTER THE NEW VALUE ";EE(CHANGE%)
7740      PRINT " "
7750      GOTO 7670
7760 IF (CHOICE% <> 3)  GOTO 7860
7770      PRINT "ENTER THE NUMBER OF THE ECOTROPHIC EFFICIENCY PARAMETER"
7780      PRINT "TO CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)";
7790      INPUT " ";CHANGE%
7800      IF (CHANGE% = 0) GOTO 7110
7810      IF (CHANGE% < 1 OR CHANGE% > N) GOTO 7770
7820      PRINT "THE VALUE IS CURRENTLY ";EE(CHANGE%)
7830      INPUT "ENTER THE NEW VALUE ";EE(CHANGE%)
7840      PRINT " "
7850      GOTO 7770
7860 IF (CHOICE% <> 4) GOTO 8000
7870      PRINT "ENTER THE NUMBERS FOR THE DIET COMPOSITION PARAMETER TO"
7880      PRINT "CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)"
7890      INPUT "ENTER THE ROW NUMBER (THE ITH ROW IN DC(I,J)";IPARM%
7900      IF (IPARM% = 0) GOTO 7110
7910      IF (IPARM% < 1 OR IPARM% > N) GOTO 7890
7920      INPUT "ENTER THE COLUMN NUMBER (THE JTH COLUMN IN DC(I,J)";JPARM%
7930      IF (JPARM% < 1 OR JPARM% > N) GOTO 7920
7940      PRINT " "
7950      PRINT "THE CURRENT VALUE FOR DC(";IPARM%;",";JPARM%") IS "
;DC(IPARM%,JPARM%)
7960      INPUT "ENTER THE NEW VALUE";DC(IPARM%,JPARM%)
7970      PRINT " "
7980      PRINT " "
7990      GOTO 7870
8000 IF (CHOICE% <> 5) GOTO 8100
8010      PRINT "ENTER THE NUMBER FOR THE PRODUCTION/BIOMASS PARAMETER TO"
8020      PRINT "CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)";
8030      INPUT " ";CHANGE%
8040      IF (CHANGE% = 0) GOTO 7110
8050      IF (CHANGE% < 1 OR CHANGE% > N) GOTO 8010
8060      PRINT "THE VALUE IS CURRENTLY ";Z(CHANGE%)
8070      INPUT "ENTER THE NEW VALUE";Z(CHANGE%)
8080      PRINT " "
8090      GOTO 8010
```

Appendix I.--Continued.

```
8100 IF (CHOICE% <> 6) GOTO 8200
8110      PRINT "ENTER THE NUMBER FOR THE FOOD REQUIRED PARAMETER TO"
8120      PRINT "CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)";
8130      INPUT " ";CHANGE%
8140      IF (CHANGE% = 0) GOTO 7110
8150      IF (CHANGE% < 1 OR CHANGE% > N) GOTO 8110
8160      PRINT "THE VALUE IS CURRENTLY ";FR(CHANGE%)
8170      INPUT "ENTER THE NEW VALUE";FR(CHANGE%)
8180      PRINT " "
8190      GOTO 8110
8200 IF (CHOICE% <> 7) GOTO 8300
8210      PRINT "ENTER THE NUMBER FOR THE HABITAT AREA PARAMETER TO"
8220      PRINT "CHANGE 0 -";N;" (ENTER 0 IF NO MORE TO BE CHANGED)";
8230      INPUT " ";CHANGE%
8240      IF (CHANGE% = 0) GOTO 7110
8250      IF (CHANGE% < 1 OR CHANGE% > N) GOTO 8110
8260      PRINT "THE VALUE IS CURRENTLY ";HABAR(CHANGE%)
8270      INPUT "ENTER THE NEW VALUE";HABAR(CHANGE%)
8280      PRINT " "
8290      GOTO 8210
8300 IF (CHOICE% <> 8) GOTO 7210
8310 PRINT " "
8320 PRINT " "
8330 INPUT "WOULD YOU LIKE TO SAVE THE INPUT PARAMETERS FROM THIS RUN (Y/N)"
;SAVEIT$
8340 IF (SAVEIT$ = "N") GOTO 8550
8350 IF (SAVEIT$ <> "Y") GOTO 8320
8360 INPUT "ENTER THE FILE NAME UNDER WHICH THIS RUN WILL BE SAVED ";FLNAME$
8370 PRINT "THE FILE NAME IS ";FLNAME$;", IS THIS CORRECT (Y/N) ";
8380 INPUT " ";CORRECT$
8390 IF (CORRECT$ = "N") GOTO 8320
8400 IF (CORRECT$ <> "Y") GOTO 8320
8410 OPEN "O",#2,FLNAME$
8420 PRINT#2,N
8430 FOR I = 1 TO N
8440      B(I) = OLDB(I)
8450      CATCH(I) = OLDCATCH(I)
8460      PRINT#2,SPECIE$(I)
8470      PRINT#2,NFLAG(I),CFLAG%(I),CATCH(I),B(I),Z(I),EE(I),HABAR(I),FR(I)
8480 NEXT I
8490 FOR I = 1 TO N
8500     FOR J = 1 TO N
8510         PRINT#2,DC(I,J)
8520     NEXT J
8530 NEXT I
8540 PRINT "FILE ";FLNAME$;" HAS NOW BEEN SAVED"
8550 PRINT " "
8560 PRINT " "
8570 CLOSE
8580 PRINT "              **************** END OF PROGRAM ECOPATH ****************"
8590 END
8600 REM
```

Appendix I.--Continued.

```
8610 REM ***********************************************************************
8620 REM                         LOGICAL END OF PROGRAM
8630 REM ***********************************************************************
8640 REM
8650 REM =======================================================================
8660 REM SOLUTION TO A LINEAR EQUATIONS SUBROUTINE.
8670 REM
8680 REM METHOD USED:
8690 REM   THE METHOD OF SOLUTION IS BY ELIMINATION USING THE LARGEST PIVOTAL
8700 REM   DIVISOR.  EACH ITERATION INTERCHANGES THE ROWS REQUIRED TO AVOID
8710 REM   DIVISION BY 0 OR VERY SMALL ELEMENTS.  SUCCESSIVE SUBSTITUTION
8720 REM   YEILDS THE SOLUTION IN THE B VECTOR.  A CHECK IS MADE TO VERIFY
8730 REM   THAT THE MATIX IS NOT SINGULAR.
8740 REM -----------------------------------------------------------------------
8750 REM
8760 K = 1
8770 FOR I = 1 TO N
8780    FOR J = 1 TO N
8790        ARRAYA(K) = AA(J,I)
8800        K = K + 1
8810    NEXT J
8820 NEXT I
8830 TOL = 0!
8840 JJ = -N
8850 FOR J = 1 TO N
8860    JY = J + 1
8870    JJ = JJ + N +1
8880    BIGA = 0#
8890    IT = JJ - J
8900    FOR I = J TO N
8910 REM
8920 REM SEARCH FOR THE MAXIMUM COEFFICEINT IN THE COLUMN
8930 REM ------------------------------------------------
8940        IJ = IT + I
8950        IF ((ABS(BIGA) - ABS(ARRAYA(IJ))) >= 0#) GOTO 8980
8960        BIGA = ARRAYA(IJ)
8970        IMAX = I
8980    NEXT I
8990 REM
9000 REM TEST IF THE PIVOT IS LESS THAN THE TOLERANCE. CHECK FOR A SINGULAR
9010 REM MATRIX.  IF THE MATRIX IS SINGULAR, THE SOLUTION MAY NOT BE ACCURATE.
9020 REM --------------------------------------------------------------------
9030 REM
9040    IF ((ABS(BIGA) - TOL) > 0#)  GOTO 9130
9050    PRINT " "
9060    PRINT " "
9070    PRINT "****> WARNING: THE MATRIX IS SINGULAR"
9080    PRINT " "
9090    RETURN
9100 REM
9110 REM INTERCHANGE ROWS AS NEEDED
9120 REM -------------------------
```

Appendix I.--Continued.

```
9130     IONE = J + N*(J - 2)
9140     IT = IMAX - J
9150     FOR K = J TO N
9160        IONE = IONE + N
9170        ITWO = IONE + IT
9180        SAVED = ARRAYA(IONE)
9190        ARRAYA(IONE) = ARRAYA(ITWO)
9200        ARRAYA(ITWO) = SAVED
9210 REM
9220 REM DIVIDE THE PIVOT ROW BY THE PIVOT COEFFICIENT
9230 REM -----------------------------------------------
9240        ARRAYA(IONE) = ARRAYA(IONE)/BIGA
9250     NEXT K
9260 REM
9270     SAVED = B(IMAX)
9280     B(IMAX) = B(J)
9290     B(J) = SAVED/BIGA
9300 REM
9310     IF ((J - N) = 0#) GOTO 9440
9320     IQS = N*(J - 1)
9330     FOR IX = JY TO N
9340        IXJ = IQS + IX
9350        IT = J - IX
9360        FOR JX = JY TO N
9370           IXJX = N*(JX - 1) + IX
9380           JJX = IXJX + IT
9390           ARRAYA(IXJX) = ARRAYA(IXJX) - (ARRAYA(IXJ)*ARRAYA(JJX))
9400        NEXT JX
9410        B(IX) = B(IX) - (B(J)*ARRAYA(IXJ))
9420     NEXT IX
9430 NEXT J
9440 NY = N - 1
9450 IT = N*N
9460 FOR J = 1 TO NY
9470     IA = IT - J
9480     IB = N - J
9490     IC = N
9500     FOR K = 1 TO J
9510        B(IB) = B(IB) - ARRAYA(IA)*B(IC)
9520        IA = IA - N
9530        IC = IC - 1
9540     NEXT K
9550 NEXT J
9560 RETURN
9570 REM ************************************************************************
```

Appendix II.--Sample run of the ECOPATH input program.

```
RUN


************** ECOPATH INPUT PARAMETER FILE PROGRAM ************

ENTER THE NAME OF THE FILE FOR THESE INPUT PARAMETERS ? DATA1
THE NAME OF THE FILE TO BE CREATED IS DATA1, IS THIS CORRECT (Y/N)  ? Y

PLEASE ENTER THE NUMBER OF SPECIES GROUPS? 0

SORRY, THAT'S TOO SMALL.

PLEASE ENTER THE NUMBER OF SPECIES GROUPS? 2
THE NUMBER OF SPECIES GROUPS IS 2 , IS THIS CORRECT (Y/N) ? Y

ENTER THE NAME OF SPECIES GROUP 1  GROUP ONE
ENTER THE NAME OF SPECIES GROUP 2  GROUP # 2

ENTER '1' IF FIXED BIOMASS ESTIMATE, '0' IF NONE FOR GROUP ONE ? 2

1 OR 0 PLEASE
ENTER '1' IF FIXED BIOMASS ESTIMATE, '0' IF NONE FOR GROUP ONE ? 1
ENTER '1' IF FIXED BIOMASS ESTIMATE, '0' IF NONE FOR GROUP # 2 ? 0

ENTER THE KNOWN BIOMASS/HABITAT AREA FOR GROUP ONE ? 54.0

ENTER '1' IF CATCH DATA AVAILABLE, '0' IF NONE FOR GROUP ONE ? 0
ENTER '1' IF CATCH DATA AVAILABLE, '0' IF NONE FOR GROUP # 2 ? 9

1 OR 0 PLEASE
ENTER '1' IF CATCH DATA AVAILABLE, '0' IF NONE FOR GROUP # 2 ? 0


ENTER THE PRODUCTION/BIOMASS RATIO FOR GROUP ONE ? 5.4
ENTER THE PRODUCTION/BIOMASS RATIO FOR GROUP # 2 ? 6.5

ENTER THE ECOTROPHIC EFFICIENCY FOR GROUP ONE ? 0.85
ENTER THE ECOTROPHIC EFFICIENCY FOR GROUP # 2 ? 0.75

ENTER THE HABITAT AREA FOR GROUP ONE ? 1200
ENTER THE HABITAT AREA FOR GROUP # 2 ? 1200

ENTER THE FOOD REQUIRED FOR GROUP ONE ? 24.0
ENTER THE FOOD REQUIRED FOR GROUP # 2 ? 35.0

ENTER THE 2  DIET COMPOSITION PARAMETERS FOR GROUP ONE
ENTER DC( 1 , 1 )    ? 0.9
ENTER DC( 1 , 2 )    ? 0.1

ENTER THE 2  DIET COMPOSITION PARAMETERS FOR GROUP # 2
```

Appendix II.--Continued.

```
ENTER DC( 2 , 1 )    ? .33
ENTER DC( 2 , 2 )    ? .77


*** WARNING: THE DIET COMPOSITION FOR GROUP # 2
 DOES NOT SUM TO 1 OR 0, PLEASE REENTER.


ENTER THE 2  DIET COMPOSITION PARAMETERS FOR GROUP # 2
ENTER DC( 2 , 1 )    ? .33
ENTER DC( 2 , 2 )    ? .67


ARE YOU SURE YOU WANT TO USE THE FILE NAME DATA1 (Y/N) ? N

ENTER THE DESIRED FILE NAME ? DATA

ARE YOU SURE YOU WANT TO USE THE FILE NAME DATA (Y/N) ? Y

 ****) CREATING FILE DATA
FILE DATA HAS BEEN CREATED.

**************** END OF INPUT PROGRAM ******************
Ok
```

Appendix III.--Sample run of the ECOPATH program using file "JEFF."

```
RUN

          **********   E C O P A T H   **********

PLEASE ENTER THE NAME OF THE FILE TO BE USED ? JEFF
THE FILE TO BE USED IS JEFF, IS THIS CORRECT (Y/N)  ? Y

ARE YOU USING A SCREEN OR A PRINTER (S/P) ? S

WOULD YOU LIKE TO MAKE ANY CHANGES TO THE INPUT VALUES NOW (Y/N)? N

     SPECIES GROUPS

        1 = BIRD
        2 = SEAL
        3 = TIGER SHARKS
        4 = REEF SHARKS
        5 = TURTLE
        6 = SMALL PELAGIC
        7 = JACK
        8 = REEF FISHES
        9 = LOBSTER & CRABS
       10 = BOTTOM FISH
       11 = TUNA
       12 = ZOOPLANKTON
       13 = PHYTOPLANKTON
       14 = HETEROTROPHIC BENTHOS
       15 = BENTHIC ALGAE


     KNOWN BIOMASS/(WEIGHT/UNIT AREA OVER HABITAT AREA)   (B)

          1              2              3              4              5
     15.000         63.000         42.000          0.000          0.000
          6              7              8              9             10
      0.000          0.000          0.000          0.000          0.000
         11             12             13             14             15
      0.000          0.000          0.000          0.000          0.000


     TOTAL CATCH/(WEIGHT/UNIT AREA OVER HABITAT AREA)   (CATCH)

          1              2              3              4              5
      0.000          0.000          0.000          0.000          0.000
          6              7              8              9             10
      0.000          0.000          0.000          0.000          0.000
         11             12             13             14             15
      0.000          0.000          0.000          0.000          0.000
```

Appendix III.--Continued.

ECOTROPHIC EFFICIENCY (FRACTION OF PRODUCTION CONSUMED BY PREDATORS) (EE)

1	2	3	4	5	6	7	8
0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950
9	10	11	12	13	14	15	
0.950	0.950	0.950	0.950	0.950	0.950	0.950	

DIET COMPOSITION BY SPECIES GROUPS (DC)
(ROWS REPRESENT PREDATORS AND COLUMNS ARE PREY)

		1	2	3	4	5	6
BIRD	1	0.000	0.000	0.000	0.000	0.000	0.680
SEAL	2	0.000	0.000	0.000	0.000	0.000	0.000
TIGER SHARKS	3	0.300	0.080	0.010	0.030	0.010	0.080
REEF SHARKS	4	0.000	0.000	0.000	0.000	0.000	0.050
TURTLE	5	0.000	0.000	0.000	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	0.000	0.000	0.000	0.000	0.060
JACK	7	0.000	0.000	0.000	0.000	0.000	0.080
REEF FISHES	8	0.000	0.000	0.000	0.000	0.000	0.000
LOBSTER & CRABS	9	0.000	0.000	0.000	0.000	0.000	0.000
BOTTOM FISH	10	0.000	0.000	0.000	0.000	0.000	0.125
TUNA	11	0.000	0.000	0.000	0.000	0.000	0.480
ZOOPLANKTON	12	0.000	0.000	0.000	0.000	0.000	0.000
PHYTOPLANKTON	13	0.000	0.000	0.000	0.000	0.000	0.000
HETEROTROPHIC B	14	0.000	0.000	0.000	0.000	0.000	0.000
BENTHIC ALGAE	15	0.000	0.000	0.000	0.000	0.000	0.000

		7	8	9	10	11	12
BIRD	1	0.100	0.150	0.000	0.000	0.020	0.050
SEAL	2	0.000	0.850	0.150	0.000	0.000	0.000
TIGER SHARKS	3	0.050	0.280	0.140	0.000	0.020	0.000
REEF SHARKS	4	0.000	0.900	0.050	0.000	0.000	0.000
TURTLE	5	0.000	0.000	0.000	0.000	0.000	0.100
SMALL PELAGIC	6	0.000	0.000	0.000	0.000	0.000	0.940
JACK	7	0.000	0.800	0.120	0.000	0.000	0.000
REEF FISHES	8	0.000	0.123	0.000	0.000	0.000	0.170
LOBSTER & CRABS	9	0.000	0.000	0.000	0.000	0.000	0.021
BOTTOM FISH	10	0.000	0.469	0.018	0.026	0.000	0.104
TUNA	11	0.000	0.080	0.000	0.080	0.000	0.360
ZOOPLANKTON	12	0.000	0.000	0.000	0.000	0.000	0.000
PHYTOPLANKTON	13	0.000	0.000	0.000	0.000	0.000	0.000
HETEROTROPHIC B	14	0.000	0.000	0.000	0.000	0.000	0.000
BENTHIC ALGAE	15	0.000	0.000	0.000	0.000	0.000	0.000

		13	14	15	SUM
BIRD	1	0.000	0.000	0.000	1.00
SEAL	2	0.000	0.000	0.000	1.00
TIGER SHARKS	3	0.000	0.000	0.000	1.00
REEF SHARKS	4	0.000	0.000	0.000	1.00
TURTLE	5	0.000	0.000	0.900	1.00
SMALL PELAGIC	6	0.000	0.000	0.000	1.00
JACK	7	0.000	0.000	0.000	1.00
REEF FISHES	8	0.000	0.459	0.248	1.00
LOBSTER & CRABS	9	0.000	0.979	0.000	1.00
BOTTOM FISH	10	0.000	0.258	0.000	1.00
TUNA	11	0.000	0.000	0.000	1.00
ZOOPLANKTON	12	0.910	0.000	0.090	1.00
PHYTOPLANKTON	13	0.000	0.000	0.000	0.00
HETEROTROPHIC B	14	0.000	0.150	0.850	1.00
BENTHIC ALGAE	15	0.000	0.000	0.000	0.00

Appendix III.--Continued.

PRODUCTION/BIOMASS RATIO (Z = M + F)

1	2	3	4	5
5.400	3.000	0.500	0.175	0.150
6	7	8	9	10
1.100	0.350	1.500	0.520	0.320
11	12	13	14	15
0.660	40.000	70.000	3.000	12.500

ANNUAL FOOD REQUIRED AS A FRACTION OF THE MEAN ANNUAL BIOMASS (FR)

1	2	3	4	5
80.000	40.000	4.500	3.800	3.500
6	7	8	9	10
7.500	3.800	9.500	8.200	3.600
11	12	13	14	15
5.300	280.000	0.000	12.500	0.000

HABITAT AREA (HABAR)

1	2	3	4	5
1200.000	1200.000	1200.000	1200.000	1200.000
6	7	8	9	10
1200.000	1200.000	700.000	700.000	300.000
11	12	13	14	15
900.000	1200.000	1200.000	700.000	700.000

Appendix III.--Continued.

INITIAL EQUALIBRIUM

BIOMASS RECALCULATED PER HABITAT AREA FOR OUTPUT

		BIOMASS PER UNIT OF HABITAT AREA	ANNUAL PRODUCTION PER UNIT HABITAT AREA	FISHERY CATCH PER UNIT OF HABITAT AREA	HABITAT AREA	ECOLOGICAL EFFICIENCY (PRODUCTION/ CONSUMPTION)
BIRD	1	15	81	0	1200	0.0675
SEAL	2	63	189	0	1200	0.0750
TIGER SHARKS	3	42	21	0	1200	0.1111
REEF SHARKS	4	34	6	0	1200	0.0461
TURTLE	5	13	2	0	1200	0.0429
SMALL PELAGIC	6	1864	2050	0	1200	0.1467
JACK	7	389	136	0	1200	0.0921
REEF FISHES	8	25695	38543	0	700	0.1579
LOBSTER & CRABS	9	2062	1072	0	700	0.0634
BOTTOM FISH	10	357	114	0	300	0.0889
TUNA	11	59	39	0	900	0.1245
ZOOPLANKTON	12	993	39721	0	1200	0.1429
PHYTOPLANKTON	13	3805	266342	0	1200	0.0000
HETEROTROPHIC B	14	132042	396126	0	700	0.2400
BENTHIC ALGAE	15	126859	1585741	0	700	0.0000

CONSUMPTION VECTOR (BIOMASS/HABITAT AREA)
(COLUMNS REPRESENT PERDATOR, ROWS REPRESENT PREY)

		1	2	3
BIRD	1	0.00	0.00	56.70
SEAL	2	0.00	0.00	15.12
TIGER SHARKS	3	0.00	0.00	1.89
REEF SHARKS	4	0.00	0.00	5.67
TURTLE	5	0.00	0.00	1.89
SMALL PELAGIC	6	816.00	0.00	15.12
JACK	7	120.00	0.00	9.45
REEF FISHES	8	180.00	2,142.00	52.92
LOBSTER & CRABS	9	0.00	378.00	26.46
BOTTOM FISH	10	0.00	0.00	0.00
TUNA	11	24.00	0.00	3.78
ZOOPLANKTON	12	60.00	0.00	0.00
PHYTOPLANKTON	13	0.00	0.00	0.00
HETEROTROPHIC B	14	0.00	0.00	0.00
BENTHIC ALGAE	15	0.00	0.00	0.00
TOTAL		1,200.00	2,520.00	189.00

Appendix III.--Continued.

		4	5	6
BIRD	1	0.00	0.00	0.00
SEAL	2	0.00	0.00	0.00
TIGER SHARKS	3	0.00	0.00	0.00
REEF SHARKS	4	0.00	0.00	0.00
TURTLE	5	0.00	0.00	0.00
SMALL PELAGIC	6	6.48	0.00	838.62
JACK	7	0.00	0.00	0.00
REEF FISHES	8	116.64	0.00	0.00
LOBSTER & CRABS	9	6.48	0.00	0.00
BOTTOM FISH	10	0.00	0.00	0.00
TUNA	11	0.00	0.00	0.00
ZOOPLANKTON	12	0.00	4.64	13,138.45
PHYTOPLANKTON	13	0.00	0.00	0.00
HETEROTROPHIC B	14	0.00	0.00	0.00
BENTHIC ALGAE	15	0.00	41.78	0.00
TOTAL		129.60	46.42	13,977.08

		7	8	9
BIRD	1	0.00	0.00	0.00
SEAL	2	0.00	0.00	0.00
TIGER SHARKS	3	0.00	0.00	0.00
REEF SHARKS	4	0.00	0.00	0.00
TURTLE	5	0.00	0.00	0.00
SMALL PELAGIC	6	118.35	0.00	0.00
JACK	7	0.00	0.00	0.00
REEF FISHES	8	1,183.54	30,024.81	0.00
LOBSTER & CRABS	9	177.53	0.00	0.00
BOTTOM FISH	10	0.00	0.00	0.00
TUNA	11	0.00	0.00	0.00
ZOOPLANKTON	12	0.00	41,497.70	355.11
PHYTOPLANKTON	13	0.00	0.00	0.00
HETEROTROPHIC B	14	0.00	112,043.79	16,554.93
BENTHIC ALGAE	15	0.00	60,537.82	0.00
TOTAL		1,479.43	244,104.11	16,910.04

		10	11	12
BIRD	1	0.00	0.00	0.00
SEAL	2	0.00	0.00	0.00
TIGER SHARKS	3	0.00	0.00	0.00
REEF SHARKS	4	0.00	0.00	0.00
TURTLE	5	0.00	0.00	0.00
SMALL PELAGIC	6	160.72	150.29	0.00
JACK	7	0.00	0.00	0.00
REEF FISHES	8	603.00	25.05	0.00
LOBSTER & CRABS	9	23.14	0.00	0.00
BOTTOM FISH	10	33.43	25.05	0.00
TUNA	11	0.00	0.00	0.00
ZOOPLANKTON	12	133.72	112.72	0.00
PHYTOPLANKTON	13	0.00	0.00	253,024.44
HETEROTROPHIC B	14	331.72	0.00	0.00
BENTHIC ALGAE	15	0.00	0.00	25,024.39
TOTAL		1,285.72	313.10	278,048.83

Appendix III.--Continued.

		13	14	15
BIRD	1	0.00	0.00	0.00
SEAL	2	0.00	0.00	0.00
TIGER SHARKS	3	0.00	0.00	0.00
REEF SHARKS	4	0.00	0.00	0.00
TURTLE	5	0.00	0.00	0.00
SMALL PELAGIC	6	0.00	0.00	0.00
JACK	7	0.00	0.00	0.00
REEF FISHES	8	0.00	0.00	0.00
LOBSTER & CRABS	9	0.00	0.00	0.00
BOTTOM FISH	10	0.00	0.00	0.00
TUNA	11	0.00	0.00	0.00
ZOOPLANKTON	12	0.00	0.00	0.00
PHYTOPLANKTON	13	0.00	0.00	0.00
HETEROTROPHIC B	14	0.00	247,578.61	0.00
BENTHIC ALGAE	15	0.00	1,402,945.43	0.00
TOTAL		0.00	1,650,524.04	0.00

C VECTOR

1	2	3	4	5
18000.000	75600.000	50400.000	6804.000	2268.000
6	7	8	9	10
997344.000	155340.000	2849904.000	485352.000	0.000
11	12	13	14	15
33336.000	72000.000	0.000	0.000	0.000

AA MATRIX

		1	2	3	4
BIRD	1	1.000	0.000	0.000	0.000
SEAL	2	0.000	1.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	1.000	0.000
REEF SHARKS	4	0.000	0.000	0.000	0.166
TURTLE	5	0.000	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	0.000	0.000	-0.190
JACK	7	0.000	0.000	0.000	0.000
REEF FISHES	8	0.000	0.000	0.000	-3.420
LOBSTER & CRABS	9	0.000	0.000	0.000	-0.190
BOTTOM FISH	10	0.000	0.000	0.000	0.000
TUNA	11	0.000	0.000	0.000	0.000
ZOOPLANKTON	12	0.000	0.000	0.000	0.000
PHYTOPLANKTON	13	0.000	0.000	0.000	0.000
HETEROTROPHIC B	14	0.000	0.000	0.000	0.000
BENTHIC ALGAE	15	0.000	0.000	0.000	0.000

Appendix III.--Continued.

		5	6	7	8
BIRD	1	0.000	0.000	0.000	0.000
SEAL	2	0.000	0.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	0.000	0.000
REEF SHARKS	4	0.000	0.000	0.000	0.000
TURTLE	5	0.143	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	0.595	-0.304	0.000
JACK	7	0.000	0.000	0.333	0.000
REEF FISHES	8	0.000	0.000	-3.040	0.256
LOBSTER & CRABS	9	0.000	0.000	-0.456	0.000
BOTTOM FISH	10	0.000	0.000	0.000	0.000
TUNA	11	0.000	0.000	0.000	0.000
ZOOPLANKTON	12	-0.350	-7.050	0.000	-1.615
PHYTOPLANKTON	13	0.000	0.000	0.000	0.000
HETEROTROPHIC B	14	0.000	0.000	0.000	-4.361
BENTHIC ALGAE	15	-3.150	0.000	0.000	-2.356

		9	10	11	12
BIRD	1	0.000	0.000	0.000	0.000
SEAL	2	0.000	0.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	0.000	0.000
REEF SHARKS	4	0.000	0.000	0.000	0.000
TURTLE	5	0.000	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	-0.450	-2.544	0.000
JACK	7	0.000	0.000	0.000	0.000
REEF FISHES	8	0.000	-1.688	-0.424	0.000
LOBSTER & CRABS	9	0.494	-0.065	0.000	0.000
BOTTOM FISH	10	0.000	0.210	-0.424	0.000
TUNA	11	0.000	0.000	0.627	0.000
ZOOPLANKTON	12	-0.172	-0.374	-1.908	38.000
PHYTOPLANKTON	13	0.000	0.000	0.000	-254.800
HETEROTROPHIC B	14	-8.028	-0.929	0.000	0.000
BENTHIC ALGAE	15	0.000	0.000	0.000	-25.200

		13	14	15
BIRD	1	0.000	0.000	0.000
SEAL	2	0.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	0.000
REEF SHARKS	4	0.000	0.000	0.000
TURTLE	5	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	0.000	0.000
JACK	7	0.000	0.000	0.000
REEF FISHES	8	0.000	0.000	0.000
LOBSTER & CRABS	9	0.000	0.000	0.000
BOTTOM FISH	10	0.000	0.000	0.000
TUNA	11	0.000	0.000	0.000
ZOOPLANKTON	12	0.000	0.000	0.000
PHYTOPLANKTON	13	66.500	0.000	0.000
HETEROTROPHIC B	14	0.000	0.975	0.000
BENTHIC ALGAE	15	0.000	-10.625	11.875

WOULD YOU LIKE TO CHANGE ANY INPUT PARAMETERS (Y/N)? N

WOULD YOU LIKE TO SAVE THE INPUT PARAMETERS FROM THIS RUN (Y/N)? N

***************** END OF PROGRAM ECOPATH ****************

OK

Appendix IV.--Changing an input parameter value.

```
RUN

          **********   E C O P A T H   **********

PLEASE ENTER THE NAME OF THE FILE TO BE USED ? JEFF
THE FILE TO BE USED IS JEFF, IS THIS CORRECT (Y/N)  ? Y

ARE YOU USING A SCREEN OR A PRINTER (S/P) ? S

WOULD YOU LIKE TO MAKE ANY CHANGES TO THE INPUT VALUES NOW (Y/N)? Y

     1 = KNOWN BIOMASS/HABITAT AREA  (B)
     2 = TOTAL CATCH/HABITAT AREA (CATCH)
     3 = ECOTROPHIC EFFICIENCY (EE)
     4 = DIET COMPOSITION (DC)
     5 = PRODUCTION/BIOMASS RATIO (Z = M + F)
     6 = FOOD REQUIRED (FRACTION OF MEAN ANNUAL BIOMASS)   (FR)
     7 = HABITAT AREA (HABAR)
     8 = NO MORE CHANGES TO BE MADE  (MAKE ANOTHER PASS)

ENTER THE NUMBER OF YOUR CHOICE (1-8)? 3

 1                  2                  3                  4
BIRD               SEAL               TIGER SHARKS       REEF SHARKS
 5                  6                  7                  8
TURTLE             SMALL PELAGIC      JACK               REEF FISHES
 9                 10                 11                 12
LOBSTER & CRABS    BOTTOM FISH        TUNA               ZOOPLANKTON
13                 14                 15
PHYTOPLANKTON      HETEROTROPHIC B    BENTHIC ALGAE

ENTER THE NUMBER OF THE ECOTROPHIC EFFICIENCY PARAMETER
TO CHANGE 0 - 15  (ENTER 0 IF NO MORE TO BE CHANGED) ? 3
THE VALUE IS CURRENTLY  .95
ENTER THE NEW VALUE ? .75

ENTER THE NUMBER OF THE ECOTROPHIC EFFICIENCY PARAMETER
TO CHANGE 0 - 15  (ENTER 0 IF NO MORE TO BE CHANGED) ? 0

     1 = KNOWN BIOMASS/HABITAT AREA  (B)
     2 = TOTAL CATCH/HABITAT AREA (CATCH)
     3 = ECOTROPHIC EFFICIENCY (EE)
     4 = DIET COMPOSITION (DC)
     5 = PRODUCTION/BIOMASS RATIO (Z = M + F)
     6 = FOOD REQUIRED (FRACTION OF MEAN ANNUAL BIOMASS)   (FR)
     7 = HABITAT AREA (HABAR)
     8 = NO MORE CHANGES TO BE MADE  (MAKE ANOTHER PASS)

ENTER THE NUMBER OF YOUR CHOICE (1-8)?
```

Appendix V.--AA matrix warning message.

HABITAT AREA (HABAR)

1	2	3	4	5
1200.000	1200.000	1200.000	1200.000	1200.000
6	7	8	9	10
1200.000	1200.000	700.000	700.000	300.000
11	12	13	14	15
900.000	1200.000	1200.000	700.000	700.000

** WARNING :THE DIAGONAL ENTRIES IN THE AA MATRIX ARE NOT POSITIVE FOR THE FOLLOWING SPECIES GROUPS:

SPECIES GROUP	LOCATION	VALUE
BOTTOM FISH	AA(10, 10)	-0.093

***) NOTE: THE ABOVE INDICATES THAT PREDATION PLUS FISHING (AS APPLICABLE) IS EXCEEDING PRODUCTION. THE EQUALIBRIUM BIOMASS ESTIMATES AS A RESULT, ARE NEGATIVE. THEREFORE, THE EQUALIBRIUM BIOMASS OUTPUT HAS BEEN SUPPRESSED.

PLEASE CHECK THE INPUT VALUES OF: DIET COMPOSITION, PRODUCTION/BIOMASS, AND FOOD REQUIREMENTS FOR THE SPECIES GROUPS LISTED ABOVE AND RERUN THE PROGRAM.

THE AA MATRIX

		1	2	3	4
BIRD	1	1.000	0.000	0.000	0.000
SEAL	2	0.000	1.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	1.000	0.000
REEF SHARKS	4	0.000	0.000	0.000	0.166
TURTLE	5	0.000	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	0.000	0.000	-0.190
JACK	7	0.000	0.000	0.000	0.000
REEF FISHES	8	0.000	0.000	0.000	-3.420
LOBSTER & CRABS	9	0.000	0.000	0.000	-0.190
BOTTOM FISH	10	0.000	0.000	0.000	0.000
TUNA	11	0.000	0.000	0.000	0.000
ZOOPLANKTON	12	0.000	0.000	0.000	0.000
PHYTOPLANKTON	13	0.000	0.000	0.000	0.000
HETEROTROPHIC B	14	0.000	0.000	0.000	0.000
BENTHIC ALGAE	15	0.000	0.000	0.000	0.000

Appendix V.--Continued.

		5	6	7	8
BIRD	1	0.000	0.000	0.000	0.000
SEAL	2	0.000	0.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	0.000	0.000
REEF SHARKS	4	0.000	0.000	0.000	0.000
TURTLE	5	0.143	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	0.595	-0.304	0.000
JACK	7	0.000	0.000	0.333	0.000
REEF FISHES	8	0.000	0.000	-3.040	0.256
LOBSTER & CRABS	9	0.000	0.000	-0.456	0.000
BOTTOM FISH	10	0.000	0.000	0.000	0.000
TUNA	11	0.000	0.000	0.000	0.000
ZOOPLANKTON	12	-0.350	-7.050	0.000	-1.615
PHYTOPLANKTON	13	0.000	0.000	0.000	0.000
HETEROTROPHIC B	14	0.000	0.000	0.000	-4.361
BENTHIC ALGAE	15	-3.150	0.000	0.000	-2.356

		9	10	11	12
BIRD	1	0.000	0.000	0.000	0.000
SEAL	2	0.000	0.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	0.000	0.000
REEF SHARKS	4	0.000	0.000	0.000	0.000
TURTLE	5	0.000	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	-0.450	-2.544	0.000
JACK	7	0.000	0.000	0.000	0.000
REEF FISHES	8	0.000	-1.688	-0.424	0.000
LOBSTER & CRABS	9	0.494	-0.065	0.000	0.000
BOTTOM FISH	10	0.000	-0.093	-0.424	0.000
TUNA	11	0.000	0.000	0.627	0.000
ZOOPLANKTON	12	-0.172	-0.374	-1.908	38.000
PHYTOPLANKTON	13	0.000	0.000	0.000	-254.800
HETEROTROPHIC B	14	-8.028	-0.929	0.000	0.000
BENTHIC ALGAE	15	0.000	0.000	0.000	-25.200

		13	14	15
BIRD	1	0.000	0.000	0.000
SEAL	2	0.000	0.000	0.000
TIGER SHARKS	3	0.000	0.000	0.000
REEF SHARKS	4	0.000	0.000	0.000
TURTLE	5	0.000	0.000	0.000
SMALL PELAGIC	6	0.000	0.000	0.000
JACK	7	0.000	0.000	0.000
REEF FISHES	8	0.000	0.000	0.000
LOBSTER & CRABS	9	0.000	0.000	0.000
BOTTOM FISH	10	0.000	0.000	0.000
TUNA	11	0.000	0.000	0.000
ZOOPLANKTON	12	0.000	0.000	0.000
PHYTOPLANKTON	13	66.500	0.000	0.000
HETEROTROPHIC B	14	0.000	0.975	0.000
BENTHIC ALGAE	15	0.000	-10.625	11.875

WOULD YOU LIKE TO CHANGE ANY INPUT PARAMETERS (Y/N)? N

WOULD YOU LIKE TO SAVE THE INPUT PARAMETERS FROM THIS RUN (Y/N)? N

***************** END OF PROGRAM ECOPATH ****************

Ok

Appendix VI.--Diet composition warning message.

ECOTROPHIC EFFICIENCY (FRACTION OF PRODUCTION CONSUMED BY PREDATORS) (EE)

1	2	3	4	5	6	7	8
0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950
9	10	11	12	13	14	15	
0.950	0.950	0.950	0.950	0.950	0.950	0.950	

```
*** WARNING: THE DIET COMPOSITION FOR THE FOLLOW SPECIES
             DOES NOT SUM TO 1 OR 0, PLEASE VERIFY DC INPUT

             REEF FISHES


WOULD YOU LIKE TO CHANGE ANY INPUT PARAMETERS (Y/N)? N

WOULD YOU LIKE TO SAVE THE INPUT PARAMETERS FROM THIS RUN (Y/N)? N

          ***************** END OF PROGRAM ECOPATH ****************
Ok
```