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# BIOLIN: A BIOMASS LINEAR EQUATIONS ECOSYSTEM MODEL
## 1. Documentation, preliminary applications and results.

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By

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## INTRODUCTION

BIOLIN (Biomass Linear Equations), is a linear difference model based on E. Ursin's (1986) simulation of the North Sea ecosystem. Ursin based his model on Polovina's (1984) simulation of French Frigate Shoals (Hawaiian Islands). All three were patterned after the ecosimulation models of Laevastu.

BIOLIN estimates the biomass budget of an ecosystem at steady state by simultaneously solving a system of equations. Each term in the budget equation is a linear function of the B(i)'s; the unknown biomasses. Solving the equations estimates either mean annual biomasses or annual growth rates, depending on whether growth or biomass data are specified. Although the data may be collected over a period of one to several years, the model assumes that mean annual biomasses do not change from year to year. In addition, BIOLIN operates with constant fishing and natural mortality. Neither age structure nor spatial resolution are explicitly represented.

In Part I, the general equation,

Production of biomass (i) - Predation on (i) - Natural mortality of (i) - Fishing catch (i) = 0 (for all (i))

is mathematically expressed for species groups 1 to n, as

$$C(1)B(1) - \sum_j [b(j) + a(j)C(j)]\, B(j)\, DC(j,1) - d(1)B(1) - Y(1) = 0$$

$$\vdots$$

$$C(n)B(n) - \sum_j [b(k) + a(k)C(k)]\, B(k)\, DC(k,n) - d(n)B(n) - Y(n) = 0$$

where: C(i) is the ratio of production to biomass, or the biomass growth coefficient of Laevastu, here assumed equivalent to Z, B(i) is biomass of a species group

b(j) is the coefficient of food required for maintenance

a(j) is the coefficient of food required for growth

DC(j,i) is the diet compostions matrix of all species groups, or the amount predator j eats of species i

d(i) is the natural mortality of species i, and

Y(i) is the fishing yield (or catch).

The simulation computes the food available to predator j as

$$AVAIL(j) = 1 / (\sum_i DC(j,i)/B(i))$$

and the suitability of prey species i as food for predator j (predator j's preference matrix) as

$$PREF(j,i) = DC(j,i) * AVAIL(j)/B(i)$$

where $\sum_i PREF(j,i) = 1$.

In Part II, the simulation computes a new food composition table based on the preference matrix from Part I. This may then be used with a new data set in which the food composition table, normally derived from stomach content data, is unknown. Alternatively, Part II may be used to analyse the original data set with selected biomasses or Z values already prescribed. The simulation then solves for Z as in part I, and iterates to compute biomasses if they are left unspecified.

$$AVAIL(j) = \sum_i PREF(j,i) * B(i) \quad \text{and}$$

$$DC(j,i) = PREF(j,i) * B(j) / AVAIL(j)$$

If B(i) is not given for a particular species group, the iterative biomass solution is found using B(i) results from the first steady state as the starting values. B(i)'s for the next iteration are then

$$B(i) * Z(i) \{iteration\} / Z(i) \{data\}.$$

This procedure continues until

$$\sum_i (Z(i)\ \{iteration\} - Z(i)\ \{data\})^2 < epsilon\ \{1.0E-9\}$$

for values of i where B(i) {data} is equal to zero.

<u>Examples using the Benguela Current Ecosystem</u>

1. In this exercise, all data were specified as inputs except the biomass data, and the simulation was allowed to solve for annual mean biomasses at equilibrium. BIOLIN's solutions for the biomasses were lower than the corresponding empirical biomass estimates provided, except for juvenile hakes and midwater fish where the solved biomasses were 112% and 98% of the empirical data, respectively. Mammals, birds, adult hakes (the top predators) and pelagic plankton were the most underrepresented (Table 1).

2. Holding mammals' and birds' biomasses constant as specified in the empirical data (such that the simulation solved for Z(i) and not B(i) in Part I for those two groups) resulted in biomass solutions that were closer to the empirical data for most of the species groups. This time, however, predatory fish, juvenile hakes, and midwater fish were overestimated. The Z solution was close (66%) for birds but extremely low (1%) for mammals when compared with the empirical Z values (Table 2).

3. Specifying adult hakes' biomass from the data again underestimated mammals and birds and overestimated predatory fish, juvenile hakes and midwater fish. Plankton biomass solutions were closer to the empirical data, but the Z solution for adult hakes was only 16% of the original value (Table 3).

Although these results have illustrated some trends in species interactions, their statistical evaluation awaits identification of the types and sources of error associated with the data. This simulation should now be expanded and tested using data from other ecosystems and from other time periods within the Benguela ecosystem.

## Brief Descriptions

PROG/BIOLIN/BEN66 is parameterized to the Benguela current upwelling system using data provided by R. Crawford (University of Capetown). It evaluates the equilibrium conditions of 10 species groups (Table 4). Data to run the program are encoded on file DATA/POLONS/BEN5.

PROG/BIOLIN/NOSEA was parameterized to the North Sea ecosystem from data assembled by E.Ursin. It consists of 13 species groups, including a few split into age categories (Table 5). Data are on file DATA/POLONS/NOSEA.

## REFERENCES

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Table 1. Benguela Current ecosystem, example 1; all data specified except biomasses.

| # | SPP.GROUP | ORIGINAL BIOMASS DATA | INPUT BIOMASS | OUTPUT BIOMASS SOLUTION | % OF ORIGINAL |
|---|---|---|---|---|---|
| 1 | MAMMALS | 37 | 0 | 0.51897 | 1.40 |
| 2 | BIRDS | 3 | 0 | 0.03426 | 1.14 |
| 3 | PREDATORY FISH | 200 | 0 | 139.83905 | 69.92 |
| 4 | ADULT HAKES | 200 | 0 | 32.81272 | 16.41 |
| 5 | JUVENILE HAKES | 300 | 0 | 336.23358 | 112.08 |
| 6 | PELAGICS | 2000 | 0 | 890.25386 | 44.51 |
| 7 | MIDWATER FISH | 1000 | 0 | 981.50895 | 98.15 |
| 8 | PELAGIC PLANKTON | 33000 | 0 | 5474.8055 | 16.59 |
| 9 | SHARED PLANKTON | 33000 | 0 | 7651.65545 | 23.19 |
| 10 | MIDWATER PLANKTON | 33000 | 0 | 11438.00102 | 34.66 |

| # | SPP.GROUP | ORIGINAL GROWTH DATA | SOLUTION FOR Z |
|---|---|---|---|
| 1 | MAMMALS | 1.11 | - |
| 2 | BIRDS | 1.49 | - |
| 3 | PREDATORY FISH | 1.49 | - |
| 4 | ADULT HAKES | 1.34 | - |
| 5 | JUVENILE HAKES | 2.23 | - |
| 6 | PELAGICS | 1.45 | - |
| 7 | MIDWATER FISH | 1.62 | - |
| 8 | PELAGIC PLANKTON | 1.04 | - |
| 9 | SHARED PLANKTON | 0.81 | - |
| 10 | MIDWATER PLANKTON | 0.60 | - |

Table 2. Biomass and Z solutions with biomasses of mammals and birds specified.

| # | SPP.GROUP | ORIGINAL BIOMASS DATA | INPUT BIOMASS | OUTPUT BIOMASS SOLUTION | % OF ORIGINAL |
|---|---|---|---|---|---|
| 1 | MAMMALS | 37 | 37 | 37 | 100.00 |
| 2 | BIRDS | 3 | 3 | 3 | 100.00 |
| 3 | PREDATORY FISH | 200 | 0 | 269.54977 | 134.77 |
| 4 | ADULT HAKES | 200 | 0 | 65.28123 | 32.64 |
| 5 | JUVENILE HAKES | 300 | 0 | 604.58097 | 201.53 |
| 6 | PELAGICS | 2000 | 0 | 1563.49321 | 78.17 |
| 7 | MIDWATER FISH | 1000 | 0 | 1776.75394 | 177.68 |
| 8 | PELAGIC PLANKTON | 33000 | 0 | 9640.41008 | 29.21 |
| 9 | SHARED PLANKTON | 33000 | 0 | 13689.13144 | 41.48 |
| 10 | MIDWATER PLANKTON | 33000 | 0 | 20731.56358 | 62.82 |

| # | SPP. GROUP | ORIGINAL GROWTH DATA | SOLUTION FOR Z | % OF ORIGINAL |
|---|---|---|---|---|
| 1 | MAMMALS | 1.11 | 0.01567 | 1.41 |
| 2 | BIRDS | 1.49 | 0.98388 | 66.03 |
| 3 | PREDATORY FISH | 1.49 | - | |
| 4 | ADULT HAKES | 1.34 | - | |
| 5 | JUVENILE HAKES | 2.23 | - | |
| 6 | PELAGICS | 1.45 | - | |
| 7 | MIDWATER FISH | 1.62 | - | |
| 8 | PELAGIC PLANKTON | 1.04 | - | |
| 9 | SHARED PLANKTON | 0.81 | - | |
| 10 | MIDWATER PLANKTON | 0.60 | - | |

Table 3. Biomass and Z solutions to BIOLIN when adult hake biomass is specified.

| # | SPP.GROUP | ORIGINAL BIOMASS DATA | INPUT BIOMASS | OUTPUT BIOMASS SOLUTION | % OF ORIGINAL |
|---|---|---|---|---|---|
| 1 | MAMMALS | 37 | 0 | 0.51897 | 1.40 |
| 2 | BIRDS | 3 | 0 | 0.03426 | 1.14 |
| 3 | PREDATORY FISH | 200 | 0 | 318.54702 | 159.27 |
| 4 | ADULT HAKES | 200 | 200 | 200 | 100.00 |
| 5 | JUVENILE HAKES | 300 | 0 | 904.71509 | 301.57 |
| 6 | PELAGICS | 2000 | 0 | 1742.70695 | 87.14 |
| 7 | MIDWATER FISH | 1000 | 0 | 2487.6371 | 248.76 |
| 8 | PELAGIC PLANKTON | 33000 | 0 | 10763.06293 | 32.62 |
| 9 | SHARED PLANKTON | 33000 | 0 | 17488.39381 | 53.00 |
| 10 | MIDWATER PLANKTON | 33000 | 0 | 29088.69113 | 88.15 |

| # | SPP.GROUP | ORIGINAL GROWTH | SOLUTION FOR Z | % OF ORIGINAL |
|---|---|---|---|---|
| 1 | MAMMALS | 1.11 | - | |
| 2 | BIRDS | 1.49 | - | |
| 3 | PREDATORY FISH | 1.49 | - | |
| 4 | ADULT HAKES | 1.34 | 0.21993 | 16.41 |
| 5 | JUVENILE HAKES | 2.23 | - | |
| 6 | PELAGICS | 1.45 | - | |
| 7 | MIDWATER FISH | 1.62 | - | |
| 8 | PELAGIC PLANKTON | 1.04 | - | |
| 9 | SHARED PLANKTON | 0.81 | - | |
| 10 | MIDWATER PLANKTON | 0.60 | - | |

Table 4. Species groups in a Benguela Current upwelling ecosystem

| # | GROUP | REPRESENTATIVE SPECIES | |
|---|---|---|---|
| 1 | MAMMALS | Cape fur seal | (*Arctocephalus pusilis*) |
| 2 | BIRDS | Cape gannet | (*Morus capensis*) |
| 3 | PREDATORY FISH | Chub mackerel | (*Scomber japonicus*) |
| 4 | ADULT HAKES | Cape hakes | |
| 5 | JUVENILE HAKES | | |
| 6 | PELAGICS | Pilchard | (*Sardinops ocellatus*) |
| 7 | MIDWATER FISH | Horse mackerel | (*Trachurus capensis*) |
| 8 | PELAGIC PLANKTON | | |
| 9 | SHARED PLANKTON | | |
| 10 | MIDWATER PLANKTON | | |

Table 5. Species groups in a North Sea ecosystem.

| # | GROUP | SPECIES |
|---|---|---|
| 1 | COD 01 | (*Gadus morhua*) |
| 2 | COD 2+ | |
| 3 | WHITING 01 | (*Merlangus merlangus*) |
| 4 | WHITING 2+ | |
| 5 | SAITHE 3+ | (*Gadus virens*) |
| 6 | MACKEREL | (*Scomber scombrus*) |
| 7 | HADDOCK 01 | (*Melanogrammus aeglefinus*) |
| 8 | HADDOCK 2+ | |
| 9 | HERRING | (*Clupea harengus*) |
| 10 | SPRAT | (*Sprattus sprattus*) |
| 11 | NORWAY POUT | (*Trisopterus esmarki*) |
| 12 | SANDEELS | (*Ammodytes* sp.) |
| 13 | OTHER FOOD | |

WORKFILE: PROG/BIOLIN/BEN66 (02/25/87)

```
$RESET FREE
$SET AUTOBIND
$BIND= FROM *IMSL/= ON UTIL;
C
C
C
C      PROGRAM BIOLIN
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
FILE  6(TITLE="READ/ALLOF/ME2",KIND=DISK,FILETYPE=7,NEWFILE=.TRUE.,
     +MAXRECSIZE=22)
CFILE  6(MAXRECSIZE=22)
CFILE  6(MAXRECSIZE=22,KIND=PRINTER)
FILE  5(TITLE="DATA/POLONS/BEN5",KIND=DISK,FILETYPE=7)
C      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
       REAL M1,M2,MAT,K1
       INTEGER IA,IDGT,IER,INT,M,N
       DIMENSION A(10),B(10),BIO(10),Z(10),M1(10)
     +,Y(10),D(11,11),F(10)
     +,C(10),MAT(10,10),Q(10),M2(11,10)
     +,ZSO1(10),BPERM2(10),CDIVB(10),G(10,10)
     +,BIOSO1(10),CONS(11,11),TOTCON(10),PROD(10),K1(10),NAME(2,11)
     +,FEXP1(10),BIOEXP(10),YEXP1(10),DEXP1(11,11),CONSEX(11,10)
     +,ZEXP1(10),PHI(11),BBB(10),CDAT(10),BIOM(10),TITLE1(11)
     +,AU(10,10),BU(10,1),WKSU(10),TITLE2(14),TITLE3(14)
C
       INT=10       output integer for iteration procedure
       N=10         number of interacting species groups (row dimension of matrix)
       IA=10        parameter for IMSL subroutine (row dimensions of AU and BU)
       M=1          number of right-hand sides in IMSL subroutine
       AREA=1.      Area studied to compute grams/meter² of biomass
C
C
       READ(5,/)DUMMY
       READ(5,144)((NAME(K,I),K=1,2),I=1,N)    Species group names
       WRITE(6,145)((NAME(K,I),K=1,2),I=1,N)
  144  FORMAT(5(2A6))
  145  FORMAT(1X,2A6,4(2A6))
       READ(5,/)(A(I),I=1,N)     coefficient of annual food required for growth
       READ(5,/)(B(I),I=1,N)       "    "    "    "    "    " maintenance
       READ(5,/)(BIO(I),I=1,N)   Biomasses
       READ(5,/)(Z(I),I=1,N)     annual mortality (from growth)
       READ(5,/)(M1(I),I=1,N)    annual natural mortality
       READ(5,/)(Y(I),I=1,N)     yield (catch)
       READ(5,/)(CDAT(I),I=1,N)  consumption of each species group
       READ(5,154)(NAME(K,11),K=1,2)
       WRITE(6,155)(NAME(K,11),K=1,2)
  154  FORMAT(5(2A6))
  155  FORMAT(1X,2A6)
       READ(5,/)(BIOEXP(I),I=1,N)   Biomasses - second data set
       READ(5,/)(ZEXP1(I),I=1,N)    mortality -    "    "    "
       READ(5,/)(YEXP1(I),I=1,N)    yield (catch   "    "    "
       WRITE(6,/)(YEXP1(I),I=1,N)
       READ(5,/)((D(I,J),J=1,N),I=1,N)   Diet composition matrix; prey (i)
       WRITE(6,/)((D(I,J),J=1,N),I=1,N)                           predator (j)
C
C***COMPUTE Q(I), THE RATIO OF ANNUAL CONSUMPTION TO MEAN ANNUAL
C     BIOMASS . WRITE OUT ALONG WITH INPUT DATA.
C
```

```
          DO 10 I=1,N          Storage for solutions to 1st set of equations when solving
            BIOM(I)=0.                   for biomass.
            Q(I)=B(I)+A(I)*Z(I)   proportion of annual food required
            DO 10 J=1,N
  10      D(J,N+1)=D(J,N+1)+D(J,I)   Summing total % consumption   each species
          READ(5,166)(TITLE1(I),I=1,11)
  166     FORMAT(6A6)
          WRITE(6,51)(TITLE1(I),I=1,11)
          WRITE(6,55)(I,(NAME(K,I),K=1,2),A(I),B(I),BIO(I)
         +,Z(I),M1(I),Y(I),Q(I),CDAT(I),BIOEXP(I),ZEXP1(I),YEXP1(I),I=1,N)
          WRITE(6,59)'AREA=',AREA,' UNITS'
  2       FORMAT(1H0,5A6/1H ,17X,11I7)
  3       FORMAT(1H0,A6,A6,12X,A6,A6,A6/1H ,17X,10I7,A6,A6)
          WRITE(6,3)' D(J,I',')*100.','PREY (','COLUMN','S:  I) '
         +,(I,I=1,N),'   SUM'
          WRITE(6,63)(J,(NAME(K,J),K=1,2),(D(J,I),I=1,N+1),J=1,N)
  51      FORMAT(1H1,18X,2(A6,3X),3(2X,A6),4(3X,A6),2(4X,A6)/)
  55      FORMAT(1H ,I3,1X,A6,A6,11F9.3)
  59      FORMAT(1H0,A6,F7.0,A6)
  63      FORMAT(1H ,I2,3X,A6,A6,11F7.2/)
C
C****COMPUTE PREDATION MORTALITY MATRIX MAT(J,I)
C
          DO 200 I=1,N
            C(I)=Y(I)      annual yield (or catch) stored in C(I)
            DO 100 J=1,N
              D(J,I)=D(J,I)/100.        convert diet composition to proportions
              IF(BIO(J) .GT. 0)GO TO 4  ... if solving for Z
              MAT(J,I)=-Q(J)*D(J,I)   (food required) * (prop. of each spp. in diet)
              IF(I .EQ. J)MAT(J,I)=MAT(J,I)+Z(I)-M1(I)
              GO TO 100
  4             C(I)=C(I)+B(J)*D(J,I)*BIO(J) (food required for maintenance)*(diet)
                MAT(J,I)=-A(J)*D(J,I)*BIO(J) (food requ. for growth)* (prop. in diet)
                IF(I .EQ. J)MAT(J,I)=MAT(J,I)+BIO(I)
                IF(I .EQ. J)C(I)=C(I)+M1(I)*BIO(I)
  100       CONTINUE
  200     CONTINUE
C         WRITE(6,2)'SET OF EQUATIONS: ',(I,I=1,N)
C         WRITE(6,67)(I,(MAT(J,I),J=1,N),C(I),I=1,N)
  67      FORMAT(1H ,I2,11F9.3)
          DO 400 I=1,N
            BU(I,1)=C(I)       right-hand side of linear equations
            DO 300 J=1,N
              AU(J,I)=MAT(I,J)   left-hand side of linear equations
  300       CONTINUE
  400     CONTINUE
          IER=0    error term in subroutine. If IER ≥129, shuts down computations
C
C *** FIRST CALL TO SUBROUTINE FOR LINEAR ANALYSIS *** WRITE OUT
C       SOLUTION VECTOR (BIOMASS OR NEW Z) TO SET OF EQUATIONS
C
          CALL LEGT1F(AU,M,N,IA,BU,IDGT,WKSU,IER)         IMSL Subroutine
C                                                            solves equation set
C               A - INPUT N BY N MATRIX COEFF. OF AX=B
C               M - INPUT NO. OF RIGHT-HAND SIDES
C               N - ORDER OF A AND NO. OF ROWS IN B
C              IA - ROW DIMENSION OF A & B AS SPECIFIED
C                     IN CALLING PROGRAM
C               B - INPUT N BY M MATRIX : RIGHT-HAND SIDES OF
C                     AX=B. REPLACED BY X ON OUTPUT
```

```
C             IDGT - OPTION TO PERFORM/NOT ACCURACY TEST ON
C                    A AND B TO IDGT DEC. PLACES. IF 0 NO TEST.
C             WKAREA - WORKING ARRAY DIMENSION .GE. N
C             IER - TERMINAL OR WARNING ERROR PARAMETER.
C
        IF(IER .GT. 128)GO TO 5
          WRITE(6,/)'SOLUTION:'
          WRITE(6,1)(BU(I,1),I=1,N)
          WRITE(6,/)' IER=',IER
        GO TO 6
  5     WRITE(6,/)' SERIOUS ERRORS, IER=',IER
          GOTO 9999
  6     CONTINUE
  1     FORMAT(2X,2(5F12.5/))
C
C *** SOLUTION VECTOR BU(I) IS NOW BIOS01(I) OR IF
C      Z WAS COMPUTED, BU(I) IS ZS01(I).
C
        DO 800 I=1,N
          IF(BIO(I) .EQ. 0)GO TO 7
            BIOS01(I)=BIO(I)
            ZS01(I)=BU(I,1)
          GO TO 800
  7         BIOS01(I)=BU(I,1)
            ZS01(I)=Z(I)
 800    CONTINUE
C
C *** BIOMASS PER METER**2, NEW ESTIMATE OF FR (Q(I)),
C      TOTAL CONSUMPTION, PRODUCTION COMPUTED
C
        DO 900 I=1,N
          BPERM2(I)=BIOS01(I)/AREA    Compute density
          TEMP=B(I)+A(I)*ZS01(I)
          TOTCON(I)=TEMP*BIOS01(I)   Total food required  Ri = (bi + ai Zi) Bi
          PROD(I)=ZS01(I)*BIOS01(I)   Production      P=ZB
 900    IF(TOTCON(I) .NE. 0)K1(I)=PROD(I)/TOTCON(I)      Production/Consumption
C                                                               ratio for spp. i
C *** NEW PRED MORTALITY MATRIX, FISHING MORTALITY "F"
C      TOTAL PRED MORTALITY OF SPECIES I, CONS/BIOMASS.
C
        DO 1100 I=1,N
          DO 1000 J=1,N                         Total consumption of i by j
            CONS(J,I)=TOTCON(J)*D(J,I)               Rj DCji = (bj + aj C) Bj DCji
            CONS(N+1,I)=CONS(N+1,I)+CONS(J,I)  total cons. of i by all j
            CONS(J,N+1)=CONS(J,N+1)+CONS(J,I)  total predation by j of all spp. i
            M2(J,I)=CONS(J,I)/BIOS01(I)
 1000     CONTINUE                        Consumption/Biomass for each group
          IF(BIOS01(I) .EQ. 0)GOTO 1090
          F(I)=Y(I)/BIOS01(I)          fishing mortality
          M2(N+1,I)=CONS(N+1,I)/BIOS01(I)        Total consumption/Biomass
          CDIVB(I)=TOTCON(I)/BIOS01(I)
          BIOM(I)=BIOS01(I)       storing solutions to part 1
 1090     CONS(N+1,N+1)=CONS(N+1,N+1)+CONS(N+1,I)  total predation mortality
 1100 CONTINUE
        WRITE(6,2)'PREDAT','ION MO','RTALIT','Y MATR','IX:    '
        READ(5,177)(TITLE2(I),I=1,14)
 177    FORMAT(7A6)
        WRITE(6,71)(J,(NAME(K,J),K=1,2),(M2(J,I),I=1,N),J=1,N+1)
        WRITE(6,75)(TITLE2(I),I=1,14)
        WRITE(6,79)(I,(NAME(K,I),K=1,2),TOTCON(I),Z(I),PROD(I),K1(I)
```

```
      +, BIOSO1(I), Q(I), CDIVB(I), ZSO1(I), M1(I), M2(N+1, I), F(I)
      +, Z(I)-ZSO1(I), BIOSO1(I)-BIO(I), BPERM2(I), I=1, N)
 71    FORMAT(1H , I2, 1X, A6, A6, 10F7.2)
 75    FORMAT(1H1, 18X, A6, 2(2X, A6), A6, 2X, 6A6, 3X, A6, 1X, A6, A6, 2X, A6)
 79    FORMAT(1H , I3, 1X, 2A6, F8.0, F8.2, F8.0, F6.2, 1X, F7.0, 6F6.2
      +, 3F8.2)
C
C *** COMPUTE FOOD SUITABLE FOR PREDATOR G(J, I) FROM
C      FOOD AVAILABLE TO PREDATOR PHI(I).
C
       DO 1300 I=1, N
         DO 1200 J=1, N
           IF(BIOSO1(J) .EQ. 0)GOTO 1200
           G(J, I)=D(J, I)/BIOSO1(I)      fraction of (i) j consumes;  Σ_i (DCji / Bi)
 1200    CONTINUE
 1300 CONTINUE
       DO 1310 J=1, N
       DO 1310 I=1, N
 1310 PHI(J)=PHI(J)+G(J, I)   total amount of food j eats
       DO 1315 J=1, N
       IF(PHI(J) .NE. 0)PHI(J)=1/PHI(J)   reciprocal; AVAIL(j) = 1/ Σ_i DCji/Bi
       DO 1313 I=1, N
 1313 G(J, I)=G(J, I)*PHI(J)   fraction of "i" j consumes; preference matrix
 1315 CONTINUE                 PREF(j,i) = DC(j,i) * AVAIL(j) /Bi
C
C *** WRITE OUT THE SUITABILITY (PREFERENCE) MATRIX   where Σ PREF(ji) = 1
C      OF SPECIES J AS FOOD FOR PRED I (G(J, I))
C      AND FOOD AVAILABLE PHI(J)
C
       WRITE(6, 222)
 222   FORMAT(//)
       WRITE(6, /)'PREFERENCE MATRIX, G(J, I),
      +                PREY (COLUMNS: I)'
         WRITE(6, 13)(I, I=1, N), 'PHI(J)'
 13      FORMAT(1H , 17X, 10I7, 4X, A6, A6)
       WRITE(6, 83)(J, (NAME(K, J), K=1, 2), (G(J, I), I=1, N), PHI(J), J=1, N)
 83    FORMAT(1H , I2, 1X, A6, A6, 4X, 10F7.3, F8.0)
C
C ****SECOND STOCK COMPOSITION -- FOOD COMPOSTION NOT    PART II of program
C       KNOWN FROM STOMACH COMPOSITION DATA.
C       COMPUTE EITHER B(I) OR Z(I) AT A NEW
C       STEADY STATE CONDITION AFTER COMPUTING
C       FOOD COMPOSITION (J, I) = SUIT(J, I)*BIO(I)/AVAIL(J)
C       HERE SAME INPUT DATA ARE USED EXCEPT A NEW
C       Z IS COMPUTED USING ORIGINAL BIOMASS AS BIOEXP(I)
C *********************************************
C
C
       ICOUNT=0                 Counter for iterations in biomass solution
       DO 1320 I=1, N
         IF(BIOEXP(I) .GT. 0)BBB(I)=BIOEXP(I) } Biomasses for 2nd computation
         IF(BIOEXP(I) .LE. 0)BBB(I)=BIOSO1(I) } are either new data
 1320 CONTINUE                                  BIOEXP(i) or from solution
C                                               to part 1
C   RETURN HERE IF PERFORMING ITERATION
C   ZERO OUT ARRAYS
C
 1330 DO 1350 I=1, N+1
       PHI(I)=0
       DO 1350 J=1, N+1
```

```
            DEXP1(I,J)=0                                   } zero-out arrays
       1350 CONS(I,J)=0
            DO 1450 I=1,N
            F(I)=0
            DO 1400 J=1,N
            MAT(I,J)=0
            DEXP1(J,I)=G(J,I)*BBB(I)          DCji = Suitability(ji) * Biomass (i)
       1400 PHI(J)=PHI(J)+DEXP1(J,I)                 new diet compositions
       1450 CONTINUE
            DO 1470 I=1,N
            DO 1470 J=1,N+1
       1470 IF(PHI(J) .NE. 0)DEXP1(J,I)=DEXP1(J,I)/PHI(J) proportion of spp i in
                                                              total diet of j
            DO 1500 I=1,N
            C(I)=YEXP1(I)          yield
            Q(I)=B(I)+A(I)*ZEXP1(I)  Food Required Computation
            DO 1490 J=1,N
              C(I)=C(I)+B(J)*DEXP1(J,I)*BBB(J)    Σ bj DCji Bj   yield + predation loss
              MAT(J,I)=-A(J)*DEXP1(J,I)*BBB(J)    -aj DCji Bj   predation loss of i for
              IF(I .EQ. J)MAT(J,I)=MAT(J,I)+BBB(I)                 growth of j
              IF(I .EQ. J)C(I)=C(I)+M1(I)*BBB(I)
       1490 CONTINUE
       1500 CONTINUE
      C     WRITE(6,2)'SECOND SET OF EQUATIONS:',(I,I=1,N)
      C     WRITE(6,87)(I,(MAT(J,I),J=1,N),C(I),I=1,N)
       87   FORMAT(1H ,I2,10F10.3,F9.2)
            DO 1600 I=1,N
              BU(I,1)=C(I)     array for IMSL subroutine  (1/2 pred. loss + yield)
            DO 1600 J=1,N
              DEXP1(J,N+1)=DEXP1(J,N+1)+DEXP1(J,I)
       1600 AU(J,I)=MAT(I,J)             invert matrix; (other 1/2 predation loss)
            IER=0
      C
      C *** CALL LINEAR ANALYSIS SUBROUTINE (IMSL)
      C
      C     WRITE(6,/)' SECOND CALLING OF SUBROUTINE'
            CALL LEQT1F(AU,M,N,IA,BU,IDGT,WKSU,IER)
            IF(IER .GE. 128)GO TO 9999
      C     WRITE(6,/)' IER=',IER
      C
      C *** IF Z IS KNOWN AND BIOEXP(I) IS NOT, DO ITERATIVE
      C      SOLUTION TO FIND BIOEXP(I).
      C
            SUM=0
            DO 1700 I=1,N
            IF(BIOEXP(I) .EQ. 0 .AND. ZEXP1(I) .NE. 0) Compare squared sum of
           +SUM=SUM+(BU(I,1)-ZEXP1(I))**2        differences between old Z and
       1700 CONTINUE                              new Z values to some factor
            IF(MOD(ICOUNT,INT) .EQ. 0)              epsilon.
           +WRITE(6,/)'  SUM OF SQUARED Z-DIFFS =',SUM
            IF(SUM .LE. 1.E-9)GO TO 9     iterate until solution converges
            IF(ICOUNT .GE. 1000)GO TO 9
              ICOUNT=ICOUNT+1
              DO 1750 I=1,N
                IF(BIOEXP(I) .EQ. 0 .AND. ZEXP1(I) .NE. 0)
           +    BBB(I)=BBB(I)*BU(I,1)/ZEXP1(I)   Bi new = Bi last iteration *(Zi / Zi input)
       1750   CONTINUE
              GOTO 1330
       9    CONTINUE
      C
      C *** WRITE OUT SOLUTION VECTOR Z FOR SECOND STOCK
```

```
C         ITERATION ONLY WHEN SOME BIOMASS = 0
C          COMPUTE REST OF STOCK DESCRIPTORS
C
        WRITE(6,/)'SOLUTION FOR SECOND STOCK COMPOSITION (VALUES OF Z):'
        WRITE(6,1)(BU(I,1),I=1,N)
        WRITE(6,/)'SUM OF SQUARED DIFFERENCES',SUM
        WRITE(6,/)' NO OF ITERATIONS',ICOUNT
C
        DO 1800 I=1,N
        BIOSO1(I)=BBB(I)      place biomass solutions into BIOSO1 array
   1800 CONTINUE
        DO 1900 I=1,N
          TOTCON(I)=(B(I)+A(I)*BU(I,1))*BIOSO1(I)   total consumption by i
          PROD(I)=BU(I,1)*BIOSO1(I)                     P = ZB = (production)
   1900 IF(TOTCON(I) .NE. 0)K1(I)=PROD(I)/TOTCON(I)
C
        DO 2100 I=1,N
        DO 2000 J=1,N
        CONS(J,I)=TOTCON(J)*DEXP1(J,I)   Σ Rj DCji = (bj + aj Zj) Bj DCji
        CONS(N+1,I)=CONS(N+1,I)+CONS(J,I)   Total amt of i consumed
        M2(J,I)=CONS(J,I)/BIOSO1(I)       individual spp. C/B ratio
   2000 CONS(J,N+1)=CONS(J,N+1)+CONS(J,I)   Total amt. j consumes
        IF(BIOSO1(I) .EQ. 0)GOTO 2090
        F(I)=YEXP1(I)/BIOSO1(I)          yield/unit biomass (fishing mortality)
        M2(N+1,I)=CONS(N+1,I)/BIOSO1(I)  Total amt. i consumed
        CDIVB(I)=TOTCON(I)/BIOSO1(I)              C/B ratio for system
   2090 CONS(N+1,N+1)=CONS(N+1,N+1)+CONS(N+1,I)  Total predation in system
   2100 CONTINUE
C
C *** WRITE OUT RESULTS FOR SECOND STOCK AND COMPUTE
C       DIFFERENCES
C
        WRITE(6,/)
       +'PREDATION MORTALITY MATRIX FOR SECOND STOCK COMPOSITION:'
        WRITE(6,12)(I,I=1,N)
     12 FORMAT(1H ,17X,11I7)
        WRITE(6,91)(J,(NAME(K,J),K=1,2),(M2(J,I),I=1,N),J=1,N+1)
        WRITE(6,/)' SECOND FOOD COMPOSITION:'
        WRITE(6,199)((I,I=1,N),'    SUM','PHI(J)')
    199 FORMAT(1H ,21X,10I7,A6,5X,A6)                    Write out all
        WRITE(6,103)(J,(NAME(K,J),K=1,2),                  Results
       +(100*DEXP1(J,I),I=1,N+1),PHI(J),J=1,N)
        READ(5,188)(TITLE3(I),I=1,14)
    188 FORMAT(7A6)
        WRITE(6,107)(TITLE3(I),I=1,14)
        WRITE(6,111)(I,(NAME(K,I),K=1,2),TOTCON(I),PROD(I),K1(I)
       +,BIOSO1(I),CDIVB(I),BU(I,1),M2(N+1,I),F(I),ZEXP1(I)
       +,BU(I,1)-ZEXP1(I),BIOSO1(I)/AREA,Z(I)-ZEXP1(I)
       +,BIOM(I)-BIOEXP(I),I=1,N)
     91 FORMAT(1H ,I2,1X,A6,A6,4X,10F7.2)
    103 FORMAT(1H ,I2,1X,A6,A6,7X,11F7.2,F7.0)
    107 FORMAT(1H0,18X,2(1X,A6),8(1X,A6),2X,3(1X,A6))
    111 FORMAT(1H ,I3,1X,A6,A6,2F8.0,F6.2,F8.0,4F7.2,2F7.2
       +,F9.2,F7.2,F9.2)
        CLOSE(6,DISP=CRUNCH)
        CLOSE(8,DISP=CRUNCH)
   9999 CONTINUE
        END
```

```
 MAMMALS     BIRDS        PRED. FISH  ADULT HAKES JUVNIL. HAKE
PELAGICS    MIDWTR FISH PELAGIC PLNKSHARED PLANK
MIDWTR PLANK
 TOTAL M2
0.576, 0.0, 50.4, 43.2, 108.0, 324.0, 118.8, 0.0, 0.0, 0.0,
0.0, 1.0, 23.0, 15.0, 22.0, 16.0, 23.0, 0.0, 0.0, 0.0, 0.0, 0.0, 3.0, 0.0, 0.0, 81.0, 14.0, 2.0, 0.0, 0.0, 0.0, 0.0, 0/
    /.0, 0.0, 0.0,
58.0, 16.0, 9.0, 8.0, 9.0, 0.0, 0.0, 0.4, 0.0, 60.3, 0.0, 20.9, 0.0, 9.3, 9.3, 0.0, 0.0, 6.25, 0.0, 20.8, 0.2, 4=.6, 0/
    /.0, 9.1,
17.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 67.0, 33.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 33.0, 67.0, 0.0, 0.0,/
    / 0.0, 0.0,
0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,/
    / 0.0, 0.0,
1                        A        B    BIODAT     ZDAT       M1     YDAT    FRDAT     CDAT      BIO2       Z2        Y2

   1 MAMMALS         1.700    7.950    37.000    1.110    0.000    0.576    9.837    0.000    37.000    1.110    0 376
   2 BIRDS           1.700   12.810     3.000    1.490    0.000    0.000   15.343    0.000     3.000    1.490    0 000
   3 PRED. FISH      1.700    9.310     0.000    1.490    0.000   50.400   11.843    0.000   200.000    1.490   50 400
   4 ADULT HAKES     1.700    3.870   200.000    1.340    0.000   43.200    6.148    0.000   200.000    1.340   43 200
   5 JUVNIL. HAKE    1.700    3.630   300.000    2.230    0.000  108.000    7.421    0.000   300.000    2.230  108 000
   6 PELAGICS        1.700    6.830     0.000    1.450    0.000  324.000    9.295    0.000  2000.000    1.450  324 000
   7 MIDWTR FISH     1.700    6.780     0.000    1.620    0.000  118.800    9.534    0.000  1000.000    1.620  118 800
   8 PELAGIC PLNK    1.700    0.000     0.000    1.040    0.000    0.000    1.768    0.00033000.000       1.040    0 000
   9 SHARED PLANK    1.700    0.000     0.000    0.810    0.000    0.000    1.377    0.00033000.000       0.810    0.000
  10 MIDWTR PLANK    1.700    0.000     0.000    0.600    0.000    0.000    1.020    0.00033000.000       0.600    0.000
OAREA=      1. UNITS
O D(J,I)*100.              PREY (COLUMNS: I)
                           1       2       3       4       5       6       7       8     . 9      10  SUM
 1   MAMMALS            0.00    1.00   23.00   15.00   22.00   16.00   23.00    0.00    0.00    0.00 100.00

 2   BIRDS              0.00    0.00    3.00    0.00    0.00   81.00   14.00    2.00    0.00    0.00 100.00

 3   PRED. FISH         0.00    0.00    0.00    0.00    0.00   58.00   16.00    9.00    8.00    9.00 100.00

 4   ADULT HAKES        0.00    0.00    0.40    0.00   60.30    0.00   20.90    0.00    9.30    9.30 100.20

 5   JUVNIL. HAKE       0.00    0.00    6.25    0.00   20.80    0.20   46.60    0.00    9.10   17.00  99.95

 6   PELAGICS           0.00    0.00    0.00    0.00    0.00    0.00    0.00   67.00   33.00    0.00 100.00

 7   MIDWTR FISH        0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   33.00   67.00 100.00

 8   PELAGIC PLNK       0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   0.00

 9   SHARED PLANK       0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   0.00

10   MIDWTR PLANK       0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   0.00

SOLUTION:,
       0.01567      0.98388   233.88004      0.43745      4.92925
  1393.28795  1548.08896  8584.54120 12075.06762 18063.75663

 IER=, 0,
OPREDATION MORTALITY MATRIX:

  1 MAMMALS        0.00    0.98    0.29    0.22    0.22    0.03    0.04    0.00    0.00    0.00
  2 BIRDS          0.00    0.00    0.01    0.00    0.00    0.03    0.00    0.00    0.00    0.00
  3 PRED. FISH     0.00    0.00    0.00    0.00    0.00    1.15    0.29    0.03    0.02    0.01
```

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 ADULT HAKES | 0.00 | 0.00 | 0.02 | 0.00 | 1.85 | 0.00 | 0.12 | 0.00 | 0.01 | 0.00 |
| 5 JUVNIL. HAKE | 0.00 | 0.00 | 0.96 | 0.00 | 2.50 | 0.01 | 1.08 | 0.00 | 0.03 | 0.03 |
| 6 PELAGICS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.01 | 0.35 | 0.00 |
| 7 MIDWTR FISH | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.55 |
| 8 PELAGIC PLNK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 SHARED PLANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 MIDWTR PLANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 TOTAL M2 | 0.00 | 0.98 | 1.27 | 0.22 | 4.57 | 1.22 | 1.54 | 1.04 | 0.81 | 0.60 |

| 1 | CONS | ZDAT | PROD | K1 | BIOM | FR | C/B | Z | M1 | M2 | F | ZDIF | BIODIF | GBM-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 MAMMALS | 295. | 1.11 | 1. | 0.00 | 37. | 9.84 | 7.98 | 0.02 | 0.00 | 0.00 | 0.02 | 1.09 | 0.00 | 37.00 |
| 2 BIRDS | 43. | 1.49 | 3. | 0.07 | 3. | 15.34 | 14.48 | 0.98 | 0.00 | 0.98 | 0.00 | 0.51 | 0.00 | 3.00 |
| 3 PRED. FISH | 2770. | 1.49 | 348. | 0.13 | 234. | 11.84 | 11.84 | 1.49 | 0.00 | 1.27 | 0.22 | 0.00 | 233.88 | 233.88 |
| 4 ADULT HAKES | 923. | 1.34 | 87. | 0.09 | 200. | 6.15 | 4.61 | 0.44 | 0.00 | 0.22 | 0.22 | 0.90 | 0.00 | 200.00 |
| 5 JUVNIL. HAKE | 3603. | 2.23 | 1479. | 0.41 | 300. | 7.42 | 12.01 | 4.93 | 0.00 | 4.57 | 0.36 | -2.70 | 0.00 | 300.00 |
| 6 PELAGICS | 12951. | 1.45 | 2020. | 0.16 | 1393. | 9.30 | 9.30 | 1.45 | 0.00 | 1.22 | 0.23 | 0.00 | 1393.29 | 1393.29 |
| 7 MIDWTR FISH | 14759. | 1.62 | 2508. | 0.17 | 1548. | 9.53 | 9.53 | 1.62 | 0.00 | 1.54 | 0.08 | 0.00 | 1548.09 | 1548.09 |
| 8 PELAGIC PLNK | 15177. | 1.04 | 8928. | 0.59 | 8585. | 1.77 | 1.77 | 1.04 | 0.00 | 1.04 | 0.00 | 0.00 | 8584.54 | 8584.54 |
| 9 SHARED PLANK | 16627. | 0.81 | 9781. | 0.59 | 12075. | 1.38 | 1.38 | 0.81 | 0.00 | 0.81 | 0.00 | 0.00 | 12075.07 | 12075.07 |
| 10 MIDWTR PLANK | 18425. | 0.60 | 10838. | 0.59 | 18064. | 1.02 | 1.02 | 0.60 | 0.00 | 0.60 | 0.00 | 0.00 | 18063.76 | 18063.76 |

PREFERENCE MATRIX, G(J, I), PREY (COLUMNS: I),

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | PHI(J) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 MAMMALS | 0.000 | 0.550 | 0.162 | 0.124 | 0.121 | 0.019 | 0.025 | 0.000 | 0.000 | 0.000 | 165. |
| 2 BIRDS | 0.000 | 0.000 | 0.160 | 0.000 | 0.000 | 0.725 | 0.113 | 0.003 | 0.000 | 0.000 | 1246. |
| 3 PRED. FISH | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.768 | 0.191 | 0.019 | 0.012 | 0.009 | 1846. |
| 4 ADULT HAKES | 0.000 | 0.000 | 0.008 | 0.000 | 0.924 | 0.000 | 0.062 | 0.000 | 0.004 | 0.002 | 460. |
| 5 JUVNIL. HAKE | 0.000 | 0.000 | 0.209 | 0.000 | 0.542 | 0.001 | 0.235 | 0.000 | 0.006 | 0.007 | 781. |
| 6 PELAGICS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.741 | 0.259 | 0.000 | 9490. |
| 7 MIDWTR FISH | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.424 | 0.576 | 15523. |
| 8 PELAGIC PLNK | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0. |
| 9 SHARED PLANK | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0. |
| 10 MIDWTR PLANK | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0. |

SUM OF SQUARED Z-DIFFS =, 0.0,

SOLUTION FOR SECOND STOCK COMPOSITION (VALUES OF Z):,

0.01567 1.03032 1.33732 0.44790 4.16528

0.79967 1.27893 0.38237 0.28081 0.19424

SUM OF SQUARED DIFFERENCES, 0.0,

NO OF ITERATIONS, 0,

PREDATION MORTALITY MATRIX FOR SECOND STOCK COMPOSITION:,

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 MAMMALS | 0.00 | 1.03 | 0.30 | 0.23 | 0.23 | 0.04 | 0.05 | 0.00 | 0.00 | 0.00 |
| 2 BIRDS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 PRED. FISH | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.58 | 0.14 | 0.01 | 0.01 | 0.01 |
| 4 ADULT HAKES | 0.00 | 0.00 | 0.01 | 0.00 | 1.60 | 0.00 | 0.11 | 0.00 | 0.01 | 0.00 |
| 5 JUVNIL. HAKE | 0.00 | 0.00 | 0.76 | 0.00 | 1.98 | 0.00 | 0.86 | 0.00 | 0.02 | 0.03 |
| 6 PELAGICS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.13 | 0.00 |
| 7 MIDWTR FISH | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.16 |
| 8 PELAGIC PLNK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 SHARED PLANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 MIDWTR PLANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 TOTAL M2 | 0.00 | 1.03 | 1.09 | 0.23 | 3.81 | 0.64 | 1.16 | 0.38 | 0.28 | 0.19 |

SECOND FOOD COMPOSITION:,

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | SUM | PHI(J) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 MAMMALS | 0.00 | 1.05 | 20.60 | 15.71 | 23.04 | 24.05 | 15.56 | 0.00 | 0.00 | 0.00 | 100.00 | 157. |
| 2 BIRDS | 0.00 | 0.00 | 1.89 | 0.00 | 0.00 | 85.77 | 6.67 | 5.67 | 0.00 | 0.00 | 100.00 | 1690. |
| 3 PRED. FISH | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.01 | 6.21 | 20.78 | 13.13 | 9.88 | 100.00 | 3073. |
| 4 ADULT HAKES | 0.00 | 0.00 | 0.29 | 0.00 | 51.74 | 0.00 | 11.58 | 0.00 | 21.81 | 14.58 | 100.00 | 536. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11500 | 5 JUVNIL. HAKE | 0.00 | 0.00 | 4.75 | 0.00 | 18.50 | 0.26 | 26.77 | 0.00 | 22.11 | 27.62 | 100.00 | 879. |
| 11600 | 6 PELAGICS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 74.07 | 25.93 | 0.00 | 100.00 | 33000. |
| 11700 | 7 MIDWTR FISH | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 42.42 | 57 58 | 100.00 | 33000. |
| 11800 | 8 PELAGIC PLNK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0. |
| 11900 | 9 SHARED PLANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0. |
| 12000 | 10 MIDWTR PLANK | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0. |

| 12100 | 0 | CONS | PROD | K1 | BIOMS | C/B | Z-NEW | M2 | F | Z2 | Z-DIFF | GB/M*M | ZDAT-Z | BIODIF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12200 | | | | | | | | | | | | | | |
| 12300 | 1 MAMMALS | 295. | 1. | 0.00 | 37. | 7.98 | 0.02 | 0.00 | 0.02 | 1.11 | -1.09 | 37.00 | 0.00 | 0.00 |
| 12400 | 2 BIRDS | 44. | 3. | 0.07 | 3. | 14.56 | 1.03 | 1.03 | 0.00 | 1.49 | -0.46 | 3.00 | 0.00 | 0.00 |
| 12500 | 3 PRED. FISH | 2317. | 267. | 0.12 | 200. | 11.58 | 1.34 | 1.09 | 0.25 | 1.49 | -0.15 | 200.00 | 0.00 | 33.88 |
| 12600 | 4 ADULT HAKES | 926. | 90. | 0.10 | 200. | 4.63 | 0.45 | 0.23 | 0.22 | 1.34 | -0.89 | 200.00 | 0.00 | 0.00 |
| 12700 | 5 JUVNIL. HAKE | 3213. | 1250. | 0.39 | 300. | 10.71 | 4.17 | 3.81 | 0.36 | 2.23 | 1.94 | 300.00 | 0.00 | 0.00 |
| 12800 | 6 PELAGICS | 16379. | 1599. | 0.10 | 2000. | 8.19 | 0.80 | 0.64 | 0.16 | 1.45 | -0.65 | 2000.00 | 0.00 | -606.71 |
| 12900 | 7 MIDWTR FISH | 8954. | 1279. | 0.14 | 1000. | 8.95 | 1.28 | 1.16 | 0.12 | 1.62 | -0.34 | 1000.00 | 0.00 | 548.09 |
| 13000 | 8 PELAGIC PLNK | 21451. | 12618. | 0.59 | 33000. | 0.65 | 0.38 | 0.38 | 0.00 | 1.04 | -0.66 | 33000.00 | 0.00 | -24415.46 |
| 13100 | 9 SHARED PLANK | 15753. | 9267. | 0.59 | 33000. | 0.48 | 0.28 | 0.28 | 0.00 | 0.81 | -0.53 | 33000.00 | 0.00 | -20924.93 |
| 13200 | 10 MIDWTR PLANK | 10897. | 6410. | 0.59 | 33000. | 0.33 | 0.19 | 0.19 | 0.00 | 0.60 | -0.41 | 33000.00 | 0.00 | -14936.24 |