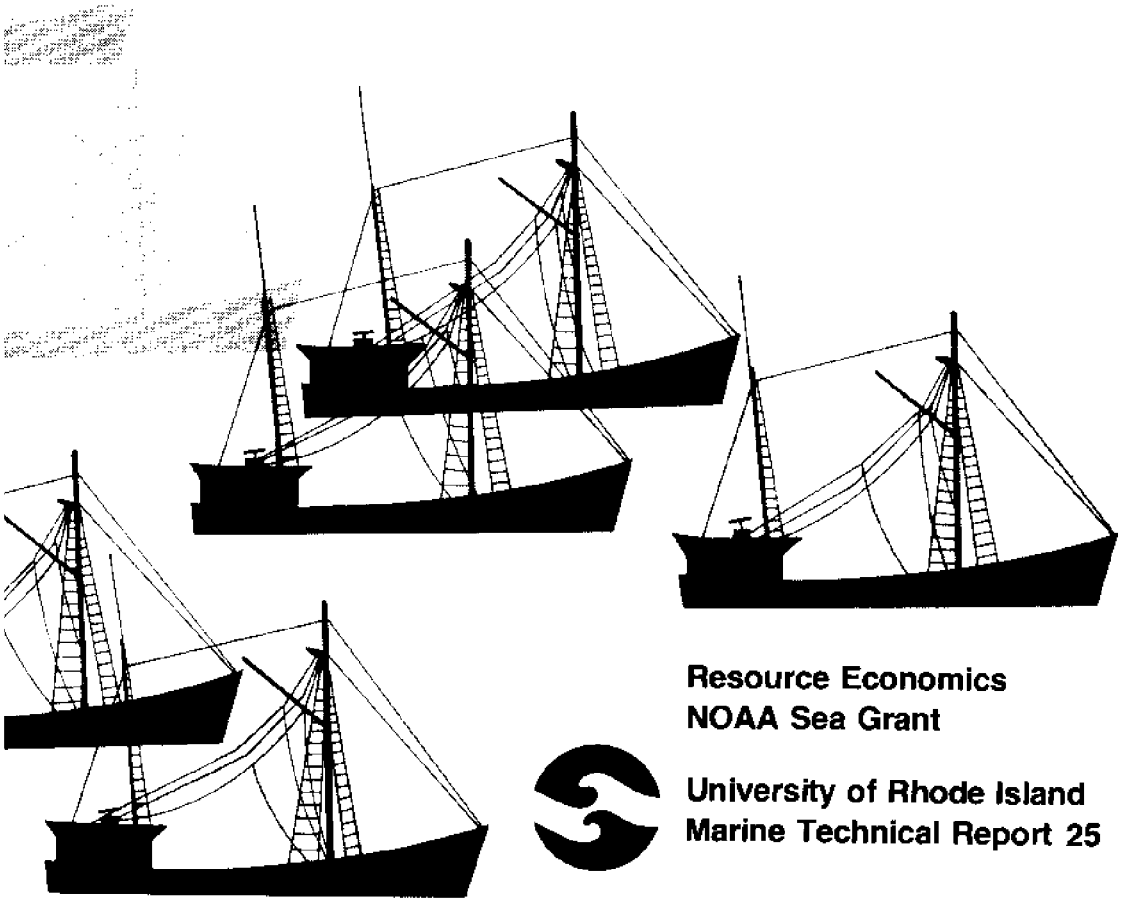
User Manual for RECON 4:

a Bio-Economic Simulator of a Fishery

J. M. Gates



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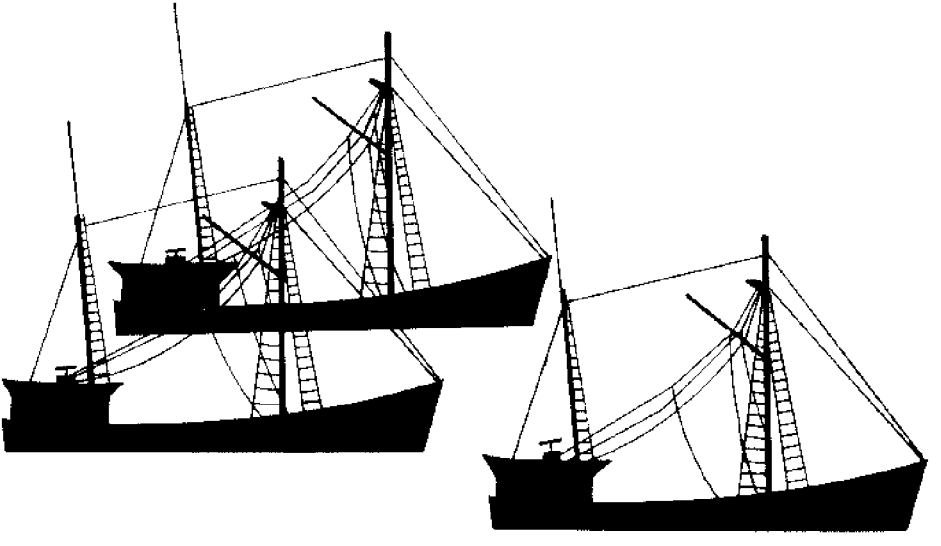

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1. Introduction

Fisheries management involves a synthesis of many factors biological, economic and sociological. The biological and economic components can be integrated to obtain a bio-economic model of a fishery (Gates and Norton, 1973, 1974). Typically, such a model is mathematical, consisting of a set of equations which describes relevant biological and economic relationships and a set of behavioral and institutional assumptions. Included in the latter, for example, are the assumptions that in an unregulated fishery, fishing effort continues to increase as long as any profit exists, and that certain institutional controls exist or do not exist and affect entry.

A mathematical model is most useful if it can efficiently indicate ordinal directions of change and/or cardinal estimates of the magnitude of changes associated with pertubations of parameters. In simple systems this may be done by the comparative statics method using differential calculus. An alternative and more flexible approach is simulation using the digital computer. RECON 4 is a computer program developed to analyze and evaluate bio-economic aspects of a fishery; it is an updated version of program COST used by Gates and Norton (1973). Like COST, this program is a steady-state simulator of variables of biologic and economic interest. The primary difference between the two is that subroutine PPLOT has been added to COST which permits plotting any variables of interest. Up to nine variables may be plotted against a base variable in a given chart, and any number of charts may be requested by reading additional plot cards.

2. Objectives of RECON 4

The objectives of RECON 4 are:

1. To calculate physical yields, prices, revenues, costs and profits, fish size, product yield and imports in a fishery for any desired range of fishing effort and/or mesh size regulation.

2. To identify four positions of interest: (a) aggregate domestic profits are a maximum; (b) price and marginal cost are equal, the Pareto efficient or socially optimum position, which is also referred to as one of maximum economic efficiency, or simply MEE; (c) sustainable (physical) yield is at a maximum (MSY), and (d) price and average cost are equal (the free entry position).

By appropriate variation of biological and economic parameters it is possible to explore the sensitivity of results and conclusions to policy changes, estimation errors or secular trends of interest, such as secular demand shifts or policy induced changes in the foreign/domestic shares ratio.

3. Subroutines Involved

RECON 4 comprises a MAIN program and four subroutines, BLK DATA, FUNC, MINMAX and PPLOT. MAIN program calculates 300 values for each of 23 variables such as domestic landings, price, fish size, profits, etc. Each of the 300 values for each variable is associated with a different level of fishing effort which may be varied over any desired range by appropriate specification of NO and DELTA (see list of variables, parameters and symbols in part 4 of this description).

MAIN draws upon subroutine FUNC to evaluate a Beverton and Hold (1957) yield function at alternate levels of fishing mortality associated with varying fishing effort.

MAIN also uses subroutine MINMAX to identify the four positions of interest described in part 2. These four positions correspond with the following conditions: (a) PRNREV is a maximum (maximum profits); (b) absolute value of (V-MC) is a minimum (price equals marginal cost); (c) YD is a maximum (maximum sustainable domestic yield), and (d) absolute value of (V-AC) is a minimum (price equals average cost).

Subroutine BLK DATA contains alphanumeric labels which may be called from COMMON by either MAIN or subroutine PPLOT.

Data plots can be produced by setting IPLOT equal to the number of plot cards to be read. If IPLOT is positive, subroutine PPLOT is used and a sequence of plot cards is read which describes the locations of variables to be plotted.

4. Variables and Parameters

FORTRAN Name	Text Symbol*	Description
WINF	W_∞	maximum fish size
ZK	K	catabolic coefficient x 3
LAMBDA	λ	fishable life
TO	t_o	age at zero weight
TRO	t_ρ	age at entry
TRHOP	$t_{\rho'}$	age at exploitation
R	R	recruitment at age t_ρ
NAMOR	M	natural mortality coefficient

*Gates and Norton (1974).

FORTRAN Name	Text Symbol	Description
N	N	number of domestic vessels
NO	-	minimum number of vessels of interest
LMAX(J)	ℓ_j^{max}	maximum catch capability of a vessel of class j
MC	MC	marginal cost
K(J)	k_j	annual fixed cost of a vessel of class j
LOLIM	-	lower bound on F used to find fishing mortality (FO) with one vessel by an iterative algorithm
UPLIM	-	upper bound complement of LOLIM
NRUN	-	number of models to be run
IPUNCH	-	parameter controlling punching or printing of output
IAL	-	parameter controlling the calculation of actual catch by vessel class
IMNMAX	-	parameter controlling the partial suppression of printing
ALABEL	-	an alphanumeric label card; used to describe a model
DELTA	c	integer variation used to increment domestic fleet size (N)
THETA	θ	proportion of time devoted to fishing the species in question
G	G	ratio of foreign/domestic catch
GG	GG	proportion of foreign catch imported
D(J)	d_j	days fished by vessel class
B(J)	b_j	proportion of fleet of the j^{th} vessel class

FORTRAN Name	Text Symbol	Description
C(J)	c_j	variable costs per day fished
FP(J)	FP_j	relative fishing power
CONS1	α	demand intercept
PNE	-	human population in the market demand region
PJQ1	β_2	price-quantity flexibility coefficient
PMS	β_3	price-processing yield flexibility coefficient
ERROR	-	tolerance limit in iterative algorithm mentioned in connection with UPLIM, LOLIM
FO	-	fishing mortality coefficient with a fleet of one vessel
FUNC		the steady state yield equation (Equation 2.D.4, Appendix 2 in Gates and Norton, 1974)
YT	Y_w	total catch in pounds, domestic plus foreign catch
P(J)	q_j	percent annual fishing mortality, j^{th} vessel class
FM	F	total instantaneous fishing mortality coefficient
FC	-	weighted average of fixed costs of vessels for the domestic fleet
YC	-	weighted average of annual variable costs for the domestic fleet
CT	TC	total costs of the domestic fleet

FORTRAN Name	Text Symbol	Description
YXN	Y_n	total catch in numbers of fish
YDN		number of fish caught by the domestic fleet
WB	$WB^{t\lambda}_{t_p}$	biomass of the exploited phase
YD	Yd	domestic catch
AL	-	actual or realized catch per vessel by vessel class
YMP	-	imports
YCONS	-	domestic catch and imports in pounds of product equivalents (fillets)
WGT	Y_w/Y_n	mean weight per fish
YCN	-	domestic consumption in numbers of fish
YLD	-	processing yield in pounds of fillets per fish processed
YPROD		domestic consumption in pounds of product equivalents
V	P	ex-vessel price
AC	AC	average harvest cost per pound captured, for the domestic fleet
PRNREV	-	total profits, domestic fleet
PNREVV	-	profits per vessel, domestic fleet
DELYD	ΔY_d	yield increment associated with a variation, ε, in number of vessels

FORTRAN Name	Text Symbol	Description
DELC	ΔTC	cost increment associated with a variation, ε, in number of vessels
VARS	-	a vector of alphanumeric labels used to identify variables printed and plotted by subroutine PPLOT
N1 N2	-	MAIN generates 300 values for each of 23 variables. Each variable is stored as a 300 element vector of the form X(i); i=1, 2, ..., 300. To plot a relevant range of data N1 and N2 are read and the data are plotted over the interval N1≤i≤N2
MASK		an M element vector of integers defining the locations of the variables to be plotted by the current plot card. 2≤M≤10.
IOUT		option control for listing, punching of data being plotted (i.e., a subset of the complete set of data generated by MAIN) IOUT=0; no data printed or punched IOUT=1; data printed IOUT=2; data punched and printed
NI) N)		domestic fleet size
TLAMDA	t_λ	maximum fishable age

5. Output Options Available

Output may be either printed (if IPUNCH = 0) or punched and printed (if IPUNCH = 1). Output may consist solely of a summary of the four positions of interest (if IMNMAX = 0) or it may also include (if IMNMAX = 1) all values of all variables over the range in fleet size from the beginning number of vessels (NO) to the terminal number of vessels (NO - 1 + 300 x DELTA). Since N is an integer variable, it would be a coincidence for profits to ever be exactly zero since profits at N vessels may be "slightly positive" and with N + ε vessels profits may be "slightly negative."*

Output may also be plotted. IPLOT specifies the number of charts desired (i.e., plot cards to be read), each of which may possess up to nine cross variables plotted against a base variable (see subsequent instructions regarding plot cards). It should be noted that MC(I) is discontinuous in the neighborhood of MSY landings. Hence, for plotting purposes the following rule is used to confine the plotting scale: if marginal cost does not lie in the interval 0<MC(I)<0.40, then the value plotted will be 0.40. Thus a plot containing marginal cost will usually include several data points along a 0.40 line. These points should be ignored since they may be fictitious.

6. Description of Input Data Deck

A typical job input must include cards in the order shown below:

Cards 1 - 3 System Control Cards (job control language)

Card 4 FORMAT (4I3) Output options

card columns	Parameter	Values	Interpretation
1-3	NRUN	001	only one model submitted
4-6	IPUNCH	{000, 001}	{printed output; punched and printed output
7-9	IAL	{000, 001}	{fleet average catches listed; listing of catch by vessel class
10-12	IMNMAX	{000, 001}	{summary solution, four positions only; listing of all values

*The sequence of fleet size NO, NO + DELTA, ..., NO + 299 DELTA are stored in the vector NI(I).

Card 5 FORMAT (40A2)

Label card to describe model; any alphanumeric information

Card 6 FORMAT (2F10.0, E10.0, 3F10.0, E10.0)

card columns	Parameter	Interpretation
1-10	NO	Initial fleet size
11-20	DELTA	Increment in fleet size
21-30	R	Recruitment at age t_ρ
31-40	THETA	Proportion time fishing species under analysis
41-50	G	Foreign/domestic shares ratio
51-60	GG	Proportion of foreign catch imported
61-70	LMAX(J)	Maximum catch capacity of a vessel of the j^{th} class

Card 7 FORMAT (6F.10.0) Days fished by vessel class

card columns	Parameter
1-10	D(1)
11-20	D(2)
21-30	D(3)
31-40	D(4)
41-50	D(5)
51-60	D(6)

Card 8 FORMAT (6F10.0) Proportion of vessels by vessel class

card columns	Parameter
1-10	B(1)
11-20	B(2)
21-30	B(3)
31-40	B(4)

41-50	B(5)
51-60	B(6)

Card 9 FORMAT (6F10.0) Variable costs per day fished by vessel class

card columns	Parameter
1-10	C(1)
11-20	C(2)
21-30	C(3)
31-40	C(4)
41-50	C(5)
51-60	C(6)

Card 10 FORMAT (6F10.0) Fixed costs per year by vessel class

card columns	Parameter
1-10	K(1)
11-20	K(2)
21-30	K(3)
31-40	K(4)
41-50	K(5)
51-60	K(6)

Card 11 FORMAT (6F10.0) Relative fishing power by vessel class

card columns	Parameter
1-10	FP(1)
11-20	FP(2)
21-30	FP(3)
31-40	FP(4)
41-50	FP(5)
51-60	FP(6)

Card 12 FORMAT (7F10.0) Biological parameters

card columns	Parameter	Interpretation
1-10	WINF	maximum weight per fish of the species in question
11-20	ZK	catabolic coefficient x 3
21-30	TLAMDA	maximum fishable age
31-40	NAMOR	natural mortality coefficient
41-50	TO	fish age at zero weight
51-60	TRHOP	fish age at exploitation
61-70	TRO	fish age at recruitment

Card 13 FORMAT (4F10.0) Demand parameters

card columns	Parameter	Interpretation
1-10	CONS1	demand price intercept
11-20	P121	price-quantity flexibility
21-30	PNE	human population in market area
31-40	PMS	price-processing percentage flexibility

Card 14 FORMAT (3E10.0) Range on initial fishing mortality coefficient FO and admissible error

card columns	Parameter
1-10	UPLIM
11-20	LOLIM
21-30	ERROR

Card 15 FORMAT (I3, I2) Number of charts desired

card columns	Parameter	Interpretation
1-3	NMAX	maximum number of data points
4-5	IPLOT	number of charts desired is IPLOT

Card 16 - 16 + m - 1: FORMAT (213, 11I2) Plot cards. Locations of base variable and cross variables to be plotted*

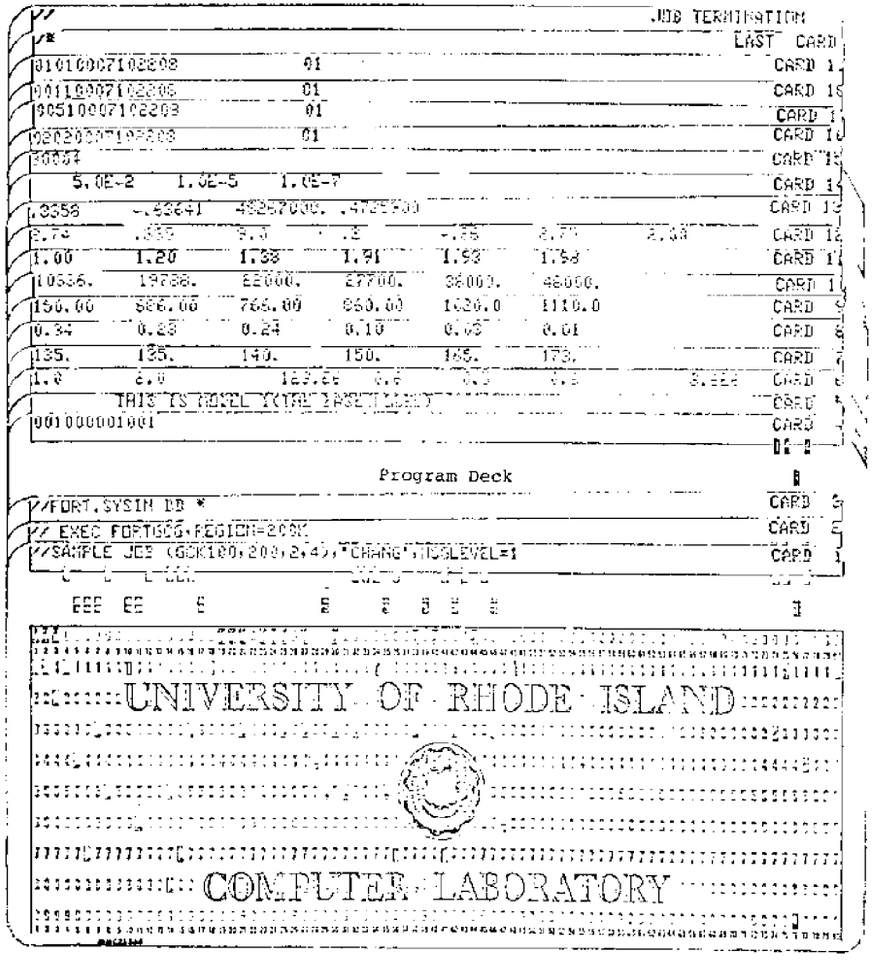
card columns	Parameter	Values	Results
1-3	N1		lowest number of vessels of interest is NI(N1)=NO-1+N1xDELTA
4-6	N2		highest number of vessels of interest is NI(N2)=NO-1+N2xDELTA
7-8	MASK(1)	1-23	the location of the base variable is MASK(1)
9-10	MASK(2)	00-23	the location of the first cross variable to be plotted is MASK(2)
11-12	.	.	.
.	.	.	.
.	.	.	.
.	MASK(9)	00-23	the location of the eighth cross variable to be plotted is MASK(9)
25-26	MASK(10)	00-23	the location of the ninth cross variable to be plotted is MASK(10)
27-28	IOUT	00 01 02	no plot data matrix plot data matrix printed plot data matrix printed and punched

Last card Job termination card**

*For a list of variables available in PPLOT and their locations, see Table 1.

**If more data plots are desired (IPLOT>1) then additional plot cards would be read before the termination card. If more models are to be run (NRUN>1) then a new label card (card 5) would be read before the termination card.

7. Sample Problem for RECON 4



Input Deck for Sample Problem

```
C      RECON 4
C      CALCULATES ECOLOGICAL AND ECONOMIC VARIABLES FOR A STEADY STATE ECOSYS
C      DATA FOR MODEL  1
001000C01001
          THIS IS MODEL 1(THE BASE MODEL)
1.0       2.0       123.E6    0.0       0.5       3.0       3.0E6
135.      135.      140.      150.      165.      175.
0.34      0.28      0.24      0.10      0.03      0.01
150.00    686.00    760.00    860.00    1020.0    1110.0
10336.    19788.    22000.    27700.    38000.    48000.
1.00      1.20      1.38      1.91      1.93      1.98
2.74      .335      9.0       .2        .26       2.75      2.00
.3358     -.63641   48267000. .4725900
5.0E-2    1.0E-5    1.0E-7
30004
020200C7102208          01
00510CC7102206          01
001100C7102208          01
010100C7102208          01
/*
```

Table 1. Locations of variables for plotting purposes, variable to be plotted.

FORTRAN NAME	Description*	Location of Variable (i.e. value of MASK(J) which will result in plotting of variable indicated.)
FM	Fishing mortality coefficient	01
YT	Total catch	02
FC	Fixed costs, domestic fleet	03
YC	Domestic consumption of fillets	04
CT	Total costs, domestic fleet	05
WB	Biomass of the exploited phase	06
YD	Domestic catch	07
AC	Average cost, domestic fleet	08
YDN	Number of fish caught, domestic fleet	09
V	Ex-vessel price	10
PRNREV	Industry profits, domestic fleet	11
WGT	Mean fish size, pounds per fish	12
AL(1)	Landings per vessel size class 1	13
AL(2)	" " " " " 2	14
AL(3)	" " " " " 3	15
AL(4)	" " " " " 4	16
AL(5)	" " " " " 5	17
AL(6)	" " " " " 6	18
YMP	Imports	19
YPROD	Product yield	20
PNREVV	Profit per vessel	21
MC	Marginal cost	22
NI	Domestic fleet size	23

*See part 4; also Gates and Norton (1974).

8. Program Listing for RECON 4

```
MAIN
C**********************************************************************
C
CRECON4 CALCULATES  BIOLOGICAL AND ECONOMIC VARIABLES FOR A STEADY STATE FISHERY
C
C**********************************************************************
C  IPUNC=CONTROL OPTION ON OUTPUT
C  IPUNC=0 IMPLIES PRINT OUTPUT ONLY
C  IPUNC=1 IMPLIES PRINT AND PUNCH
C  IAL=CONTROL OPTION ON ACTUAL CATCH BY VESSEL CLASS
C  IAL=0 IMPLIES AL(I,J)IS NOT PRINTED
C  IAL=1 IMPLIES AL(I,J) IS PRINTED
C  IMXMAX=CONTROL OPTION ON COMPLETE LISTING/PARTIAL  LISTING OF OUTPUT
C  IMXMAX=0 IMPLIES PRINT VARIABLES ONLY AT POSITIONS OF MAXIMUM PROFIT,PARETO
C  EFFICIENT POSITION,MSY AND ZERO RENT
C  IMXMAX=1 IMPLIES COMPLETE LISTING FOR FLEET SIZE RANGING FROM NO TO NMAX<=300
C  ALABEL=ANY ALPHAMERIC LABEL DESIRED TO DESCRIBE THE CURRENT MODEL
C  NO=MINIMUM # OF VESSELS OF INTEREST
C  DELTA=INCREMENTAL CHANGE IN # OF VESSELS
C  R=RECRUITMENT (NUMBER OF FISH)
C  THETA=PROPORTION OF TOTAL DAYS FISHED DEVOTED TO CAPTURE OF SPECIES IN QUESTIO
C  G=RATIO OF FOREIGN/DOMESTIC SHARES
C  GG=PROPORTION OF FOREIGN CATCH IMPORTED BY U.S.
C  LMAX(I)=MAXIMUM CATCH CAPACITY OF A VESSEL OF CLASS I
C  D(J)=TOTAL DAYS FISHED BY A VESSEL OF THE J'TH CLASS
C  A(J)=RATIO OF NUMBER OF VESSELS IN THE J'TH CLASS TO TOTAL NUMBER OF VESSELS
C  IN THE DOMESTIC FLEET
C  OC(J)=ANNUAL OPPORTUNITY COSTS OF A VESSEL OF THE J'TH CLASS
C  C(J)=VARIABLE COSTS PER DAY FISHED FOR A VESSEL OF THE J'TH CLASS
C  WINF=MAXIMUM WEIGHT OF A REPRESENTATIVE FISH
C  ZK=3 * THE CATABOLIC COEFFICIENT
C  LAMDA=FISHABLE LIFE
C  XNAUR=NATURAL MORTALITY COEFFICIENT
C  TW=AGE AT ZERO WEIGHT
C  TNOUGH=AGE AT EXPLOITATION
C  TKOUGH=AGE AT ENTRY TO FISHING GROUNDS
C  CONST=DEMAND INTERCEPT
C  PICI=PRICE-QUANTITY FLEXIBILITY COEFFICIENT
C  PNL=HUMAN POPULATION IN THE MARKET DEMAND REGION
C  PMS=PRICE-PROCESSING YIELD FLEXIBILITY COEFFICIENT
C  UPLIM=UPPER LIMIT ON FO; USED IN ITERATIVE ALGORITHM TO ESTIMATE FISHING
C  MORTALITY ASSOCIATED WITH ONE VESSEL OPERATING ALONE IN THE FISHERY
C  LOLIM=LOWER LIMIT ON FO; UPPER BOUND ANALOGUE OF UPLIM
C  ERRUR=PERMISSABLE ERROR IN ESTIMATING FO
C  YT=TOTAL YIELD IN WEIGHT
C  NMAX=MAXIMUM # OF VESSELS OF INTEREST;
C  NMAX=NUMBER OF INCREMENTAL INCREASES IN FLEET SIZE
C  YC=ANNUAL VARIABLE COSTS OF THE DOMESTIC FLEET
C  FC=ANNUAL FIXED COSTS OF THE DOMESTIC FLEET
C  NI=DOMESTIC FLEET SIZE
C  CT=TOTAL ANNUAL COSTS OF THE DOMESTIC FLEET
C  YXN=TOTAL YIELD IN NUMBERS
C  YDN=DOMESTIC YIELD IN NUMBERS
C  WB=BIOMASS OF THE EXPLOITED PHASE
C  YD=DOMESTIC YIELD IN WEIGHT
C  AL(J)=ACTUAL CATCH OF A REPRESENTATIVE VESSEL OF THE J'TH CLASS
C  YMP= DOMESTIC IMPORTS IN ROUND WEIGHT EQUIVALENTS
C  YCONS=CONSUMPTION IN ROUND WEIGHT EQUIVALENTS
C  WGT=MEAN WEIGHT PER FISH
C  YLD=PROCESSING YIELD; LBS. PRODUCT EQUIVALENTS PER FISH PROCESSED
C  YCN=DOMESTIC CONSUMPTION IN NUMBERS OF FISH
C  YPROD=DOMESTIC CONSUMPTION IN PRODUCT EQUIVALENTS
C  V=EX-VESSEL PRICE
C  AC=DOMESTIC AVERAGE ANNUAL COST PER LB OF FISH, ROUND WEIGHT
C  PNREV=TOTAL DOMESTIC PROFITS (OR RENT)
C  PNREVV=DOMESTIC PROFITS (OR RENT) PER VESSEL
C  MC=MARGINAL COST
C  ARUN=# OF MODELS TO BE RUN
C  POSITION OF MAXIMUM PROFITS = POSITION AT WHICH PNREV IS A MAXIMUM
C  PARETO EFFICIENT POSITION = POSITION AT WHICH PRICE (V) AND MARGINAL COST
C  (MC) ARE (APPROXIMATELY) EQUAL
C  POSITION OF MAXIMUM SUSTAINABLE YIELD = POSITION AT WHICH YT IS A MAXIMUM
C  POSITION OF ZERO PROFITS = POSITION AT WHICH PNREV IS (APPROXIMTELY) ZERO
      DIMENSION OMEGA(4),P(6),R(6),D(6),C( 6),FM(300),YT(300),YCONS(300)
     1,WB(300),MC(300),YNI(300),YMP(300)
     2,OFM(300),FC(300),YC(300),WGT(300),YDN(300),FP(6),                080973
     3C(300),OFCYD(300),AC(300),NI(300),SLOPV(300),AL(300,6),ALABEL(300
     4),MASK(10),CC(6),A(500),                                          080373
```

```
      SPAREV(300),PAREVV(300),SNREV(300),YXN(300),V(300),YPROD(300)
     &,YLD(300),DELY(300),DELC(300)                                    080873
      COMMON WINF,ZK,LAMDA,NAMOR,TC,TRHCP,RZLABELS/ VARS,MASK          080973
      REAL NAMOR,LAMDA,MULT,N,NU,LMAX,MC,LCLIM,LMAX(6), VARS*8(23)     080873
      INTEGER OUT
      IN=5
      OUT=6
      READ(IN,100) NMUN,IPUNCH,IAL,IMAMAX
      DO 999 II=1,NMUN
      READ(IN,98)(ALABEL(I),I=1,40)
   98 FORMAT(40A2)
      WRITE(OUT,235) II,NMUN
      READ(IN,115)NC,DELTA,R,THETA,G,GG,LMAX(1)
      WRITE(OUT,240)THETA,G,R,GG,LMAX(1)
      READ(IN,120) (U(J),J=1,6)
      WRITE(OUT,250) (U(J),J=1,6)
      READ(IN,120) (B(J),J=1,6)
      WRITE(OUT,260) (B(J),J=1,6)
      READ(IN,120) (C(J),J=1,6)
      WRITE(OUT,280) (C(J),J=1,6)
      READ(IN,120) (CC(J),J=1,6)
      WRITE(OUT,290) (CC(J),J=1,6)
      READ(IN,120) (FP(J),J=1,6)
      WRITE(OUT,310) (FP(J),J=1,6)
      READ(IN,140) WINF,ZK,LAMDA,NAMOR,TC,TRHCP,TRC
      WRITE(OUT,200) WINF,ZK,LAMDA,NAMOR,TC,TRHCP,TRC
      READ(IN,120)CONS1,P1(1),FMC,FMS
      WRITE(OUT,320)CONS1,FMC,FMS,P101
      WRITE(OUT,99)(ALABEL(I),I=1,40)
   99 FORMAT(1X,40A2)
      READ(IN,299) UPLIM,LCLIM,ERROR
  299 FORMAT(3E10.1)
      READ(IN,301)NMAX,IPLOT
      IF(NMAX.LT.10)NMAX=10
      IF(NMAX.GT.300)NMAX=300
      WRITE(OUT,302)NMAX,IPLOT
  301 FORMAT(I3,I2)
  302 FORMAT(1OX,'NMAX=',I3,';NUMBER OF PLOT CARDS TO BE READ=',I2)
      IF(100-NMAX)303,305,305                                          080373
  303 WRITE(OUT,306)
  304 FORMAT(10X,'ERROR DETECTED;NMAX EXCEEDS 300')
  305 CONTINUE
      WRITE(OUT,300)UPLIM,LCLIM,ERROR
  300 FORMAT('1','UPPER LIMIT ON FO...',E15.7,5X,'LOWER LIMIT ON FO...',
     1E15.7,5X,'PERMISSABLE ERROR...',E15.7///)
      LMAX(1)=THETA*(1.0+G)*LMAX(1)
      WRITE(OUT,6010)LMAX(1)
 6010 FORMAT(E16.5)
      YT(1)=LMAX(1)/R
      WRITE(OUT,6010)YT(1)
      FO=UPLIM
      WRITE(OUT,6010)FO
      Y1(2)=FUNC(FO)
      WRITE(OUT,6010)YT(2)
      YT(2)=YT(2)/R
      WRITE(OUT,6010)YT(2)
      IF(YT(1),LT.YT(2))GO TO 316
      WRITE(OUT,311)
  311 FORMAT(1X,'UPPER LIMIT TOO LOW')
      STOP
  316 FO=LCLIM
      YT(2)=FUNC(FO)/R
      IF(YT(1).GT.YT(2)) GO TO 324
      WRITE(OUT,321)
  321 FORMAT(1X,'LOWER LIMIT TOO HIGH')
      STOP
  324 I=0
  325 FO=(UPLIM+LCLIM)/2
      I=I+1
      YT(2)=FUNC(FO)/R
      IF(YT(2).GT.YT(1)) UPLIM=FO
      IF(YT(2).LT.YT(1)) LCLIM=FO
      DYT=ABS(YT(2)-YT(1))
      P(1)=1.0-EXP(-FO)
      IF(DYT.GT.ERROR) GO TO 325
      WRITE(OUT,330)I,DYT,FO,P(1)
  330 FORMAT (' ITERATION #                    YIELD PER RECRUIT-LMAX(1)
     1/R              FO                        P(1)'//3X,I5,12X,3(10X
```



```
     2,E20.7)//)
  335 NMAD=DELTA
      SUMBJ=0.0
      SUMBFP=0.0
      DO 40 J=1,6
      SUMBJ=SUMBJ+B(J)
      SUMBFP=SUMBFP+B(J)*FP(J)
      IF(B(J).GE.0.0.AND.B(J).LE.1.0) GO TO 20
      WRITE(OUT,15)B(J)
   15 FORMAT(10X,'B(J) DOES NOT LIE BETWEEN ZERO & UNITY ;B(J)=',F10.5)
   20 CONTINUE
   40 LMAX(J)=LMAX(1)*FP(J)
      IF(ABS(SUMBJ-1.0).LE.0.00001) GO TO 25
      WRITE(OUT,21)SUMBJ
   21 FORMAT(10X,'SUM OF THE B(J)'S DOES NOT EQUAL UNITY;SUMBJ=',F10.4)
   25 CONTINUE
      DO 4 J=1,6
    4 P(J)=P(1)*FP(J)
      WRITE(OUT,589)(P(J),J=1,6)
  589 FORMAT(///' THE P(J)S ARE...'//6E13.6)
      WRITE(OUT,99)(ALABEL(I),I=1,40)
      DO 600 J=1,6
      IF(P(J).LT.1..AND.P(J).GT.0.0) GO TO 600
      WRITE(OUT,590)LMAX(1),FO,(P(J),J=1,6)
  590 FORMAT(' CHECK P(J) LIES BETWEEN ZERO & UNITY;LMAX(1)=',E10.3,5X,
     1'FZERO=',F6.0///'THE P(J)S ARE...'//6E13.6)
      STOP
  600 CONTINUE
 6000 CONTINUE
      DO 2 I=1,NMAX
      YC(I)=0.0
      EC(I)=0.0
      N=N+DELTA
      N1(I)=N
      IF(N1(I).GT.0)  GO TO 605
      WRITE(OUT,601)N1(I)
  601 FORMAT(10X,'NUMBER OF BOATS IS NON-POSITIVE;N1(I)=',F5.0)
      STOP
  605 CONTINUE
      OFM(I)=0.0
      DO 3 J=1,6
      YC(I)=YC(I)+E(J)*B(J)*C(J)
      EC(I)=EC(I)+C(J)*B(J)
    3 OFM(I)=OFM(I)+N*B(J)*ALOG(1.0-P(J))
      IF(OFM(I).LT.0.) GO TO 8
      WRITE(OUT,10)N1(I),OFM(I)
   10 FORMAT(4X,'OFM(',F5.0,')=',E10.4,'PROGRAM TERMINATES')
      STOP
    8 CONTINUE
      FM(I)=-OFM(I)
      RHO=TRHCP-TRC
      IF(RHO.GE.0.) GO TO 7
    5 WRITE(OUT,6) RHO
    6 FORMAT(10X,'TRHCP EXCEEDS TRC;RHO=',E10.3)
      STOP
    7 CONTINUE
      RP=R*EXP(-NAMOR*RHO)
      EC(I)=N*DELTA*EC(I)
      YC(I)=N*DELTA*YC(I)
      C(I)=EC(I)+YC(I)
      F=FM(I)
      YXN(I)=FM(I)*RP*(1.-EXP(-(FM(I)+NAMOR)*LAMDA))/(FM(I)+NAMOR)
      YDN(I)=YXN(I)/(1.+G)
      YT(I)=FUNC(F)
      IF(YT(I).GT.0..AND.YXN(I).GT.0.)GO TO 12
   11 FORMAT(' NUMBER OF VESSELS=',I4,10X,'YT(I)=',E20.8,10X,'YXN(I)=',
     1E20.8)
   12 CONTINUE
      WB(I)=YT(I)/(1.0-EXP(-FM(I)))
      YJ(I)=YT(I)/(1.0+G)
      DO 9 J=1,6
    9 AL(I,J)=(YD(I)/N)*(FP(J)/SUMBFP)
      YMP(I)=GG*G*YD(I)
      YCONS(I)=YC(I)+YMP(I)
      WT(I)=YT(I)/YXN(I)
      YLD(I)=-0.14*C.99*WT(I)
      YCA=YCONS(I)/WT(I)
      YPROD(I)=YCA*YLD(I)
```

```
      SLOG(I)=ALOG(CONS(I)+PIG*ALOG(YCONS(I)/PNE)+PMS*ALOG(YLDE(I))
      VE(I)=EXP(SLOG(I))
      AG(I)=C(I)/YE(I)
      PRNREV(I)=YO(I)*(V(I)-AG(I))
      PNREVV(I)=PRNREV(I)/N(I)
      IF(I.EQ.1) GO TO 2
      DELY(I-1)=Y(I)-Y(I-1)
      DELC(I-1)=C(I)-C(I-1)
      DELYO(I-1)=YO(I)-YO(I-1)
      EP=1.0E-07
      ELP=-EP
      MC(I-1)=DELC(I-1)/DELY(I-1)
  610 SNREV(I-1)=V(I-1)-MC(I-1)
    2 CONTINUE
   57   IF(IMAX.EQ.0.)GO TO 900
      LL=NMAX
      WRITE(IOUT,210) (N(J),P(J),Y(J),PC(J),YC(J),C(J),
     1,V(J),J=1,LL)
      WRITE(IOUT,95)(ALABEL(I),I=1,40)
      WRITE(IOUT,230)(N(J),YO(J),AG(J),YDN(J),V(J),PRNREV(J),WGT(J),
     1J=1,LL)
      WRITE(IOUT,99)(ALABEL(I),I=1,40)
      LLL=LL-1
      WRITE(IOUT,220)(N(J),YMF(J),DELYO(J),YPRCC(J),MC(J),PNREVV(J),
     1SNREV(J)),J=1,LLL)
      WRITE(IOUT,99)(ALABEL(I),I=1,40)
      IF(IAL.EQ.0) GO TO 630
      WRITE(IOUT,625)(N(I),(AL(J,J),J=1,6),I=1,LL)
  620 FORMAT('1',40X,'ACTUAL CATCH PER VESSEL BY VESSEL CLASS'//
     *' BOATS',4X,'CLASS#1',13X,'CLASS#2',13X,'CLASS#3',13X,'CLASS#4',
     *13X,'CLASS#5',13X,'CLASS#6'///35(I4,6E20.8/))
      WRITE(IOUT,99)(ALABEL(I),I=1,40)
  630   IF(IPRINC.EQ.0)GO TO 105
      WRITE(7,640)(N(J),P(J),Y(J),PC(J),YC(J),C(J),V(J)
     1,YO(J),AG(J),DELY(J-1),DELYO(J-1),DELC(J-1),MC(J-1),J=2,LL)
  100 FORMAT(1X)
  105 CONTINUE
  115   FORMAT(2F10.0,F10.0,3F10.0,E10.0)
  120   FORMAT(6F10.0)
  140   FORMAT(7F10.0)
  200   FORMAT(1X,'MGT. AT IN...',F10.4,' CATABOLIC COEF...',F10.4
     1,' LAMDA...',F10.4,' NATURAL MORT...',F10.4,' TO...',F10.4
     2,/1X,' THRUP...',F10.4,' THRL...',F10.4///
  210   FORMAT('1',' BOATS',1X,'FISHMPTCOEF',7X,'TOTAL YIELD',6X
     1,'FIXED COST',9X,'VARIABLE COST',7X,'TOTAL COST',8X,'BIOMASS'
     2/15(I4,F10.8,5E20.8/))
  220 FORMAT('1',' BOATS',4X,'  IMPORTS   ',7X,'DY(I)-DY(I-1)',7X,'PRODUC
     1T WEIGHT',6X,'MARGINAL COST',6X,'RENT/VESSEL',8X,'PRICE-MARGINAL
     2COST'/14(I4,6E20.8/))
  230 FORMAT('1',' BOATS',4X,'DOMESTIC WEIGHT',6X,'AVERAGE COST',6X,'DOM
     1ESTIC #',10X,'EX-VESSEL PRICE',9X,'TOTAL RENT ',8X,'MEAN WEIGHT/FI
     2SH',/35(I4,6E20.8/))
  235 FORMAT('1',56X,'THIS IS RUN #',I3,' OF ',I3,' RUNS'//)
  240 FORMAT(1X,'% TIME FLEUNDER FISHED...',F10.4,4X,'FOREIGN/DOMESTIC CA
     1TCH...',F10.4,1X,'RECRUITS...',E10.4,//' & FOREIGN CATCH IMPORTED...
     2',F10.4,10X,'LMAX(I)...',F10.0)
  250   FORMAT(//1X,'D(J)...DAYS FISHED PER VESSEL PER YEAR;BY
     1VESSEL CLASS'/10X,6(F10.4,2X))                                    080373
  260   FORMAT(//1X,'N(J)...DISTRIBUTION OF VESSELS BY VESSEL CLASS'
     1/10X,6(F10.4,2X))                                                 080373
  280   FORMAT (//1X,'C(J)...VARIABLE COSTS PER VESSEL PER DAYFISHED,
     1BY VESSEL CLASS'/10X,6(F10.4,2X))                                 080373
  290   FORMAT(//1X,'K(J)....OPPORTUNITY COSTS PER VESSEL PER YEAR;
     1BY VESSEL CLASS'/10X,6(F10.4,2X))                                 080373
  310 FORMAT(//1X,'EP(J)....RELATIVE FISHING POWER BY VESSEL CLASS....'
     1//10X,6(F10.5,2X)//)                                              080373
  320 FORMAT(4X,'RECRUITMENT INTERCEPT...',F12.5,4X,'POPULATION OF THE NORTHE080373
     1AST..',E12.5,5X,'PROCESSING YIELD COEFFICIENT..',F10.5//          080373
     24X,'PRICE FLEXIBILITY COEFFICIENT...',F10.5//)                    080373
  400   FORMAT(8E10.4/5E10.4)
  900 CONTINUE
      I=NMAX
      CALL MINMAX(PRNREV,I-1,2,L4,L1)
      CALL MINMAX(SNREV,I-1,1,L2,LCC2)
      CALL MINMAX(YC,I-1,3,LCC1,L3)
      DO 550 K=1,4
      IF(K.NE.1)GO TO 510
      L=L1
```



```
      WRITE(IOUT,905)NC,DELTA                                           080373
  905 FORMAT('1',25X,'POSITION OF MAXIMUM PROFITS :NO=',F10.0,10X,'DELTA=080373
     1',F10.0//)                                                        080373
      GO TO 940
  910 CONTINUE
      IF(K.NE.2)GO TO 920
      L=L2
      WRITE(IOUT,915)NC,DELTA                                           080373
  915 FORMAT('1',25X,'PARETO EFFICIENT POSITION:NO=',F10.0,10X,'DELTA=',080373
     1F10.0//)                                                          080373
      GO TO 940
  920 CONTINUE
      IF(K.NE.3)GO TO 930
      WRITE(IOUT,925)NC,DELTA                                           080373
  925 FORMAT('1',25X,'POSITION OF MAXIMUM SUSTAINABLE YIELD:NO=',F10.0, 080373
     110X,'DELTA=',F10.0//)                                             080373
      L=L3
      GO TO 940
  930 CONTINUE
      IF(K.NE.4)GO TO 950
      WRITE(IOUT,935)NC,DELTA                                           080373
  935 FORMAT('1',25X,'POSITION OF ZERO PROFITS:NO=',F10.0,10X,'DELTA=',080373
     1F10.0//)                                                          080373
      L=L4
      GO TO 940
  940 WRITE(IOUT,945)   N(L),P(L),Y(L),PC(L),YC(L),C(L),VE(L),N(L),
     *YO(L),AG(L),YDN(L),V(L),PRNREV(L),WGT(L),N(L),YMF(L),DELYO(L)
     *,YPRCC(L),MC(L),PNREVV(L),SNREV(L),N(L),(AL(L,J),J=1,6)
  945 FORMAT(' BOATS',1X,'FISHMORTCOEF',7X,'TOTAL YIELD',6X,'FIXED COST'
     *,9X,'VARIABLE COST',7X,'TOTAL COST',8X,'BIOMASS'//I4,E14.8,5E20.8/
     */' BOATS',4X,'DOMESTIC WEIGHT',6X,'AVERAGE COST',6X,'DOMESTIC #',1
     *0X,'EX-VESSEL PRICE',9X,'TOTAL RENT',8X,'MEAN WEIGHT/FISH'//
     *I4,6E20.8/' BOATS',4X,'IMPORTS',6X,'YIELD INCREMENT',6X,'PRODUCT
     * WEIGHT',6X,'MARGINAL COST',6X,'PROFIT/BOAT',8X,'PRICE-MARGINAL
     * COST'//I4,6E20.8/' BOATS',40X,'ACTUAL CATCH PER VESSEL BY VESSEL
     * CLASS'//I4,6E20.8)
      WRITE(IOT,946)
  946 FORMAT(///)
      WRITE(IOUT,99)(ALABEL(I),I=1,40)
  950 CONTINUE
      IF(IPL01)955,955,3000
 3000 NPLOTC=0
 3005 NPLOTC=NPLOTC+1
 3010 IF(IQUITE-IPLOT)3015,3015,955
 3015 READ(IN,3020)NAME,N2,(MASK(LM),LM=1,10),IOUT
 3020 FORMAT(2I1,11I2)
      IF(N1.LT.1)N1=1
      IF(N2.GT.NMAX)N2=NMAX
      IF(N2.LT.N1)N2=NMAX
      N3=N2-N1
      ZN1=FLOAT(N3+1)
      ZN2=1.0*ZN1/50.
      IZE=IDINT(ZN2)
      ZN3=FLOAT(IZE)
      ZN4=ZN1/ZN3                                                       080373
      N7=IDINT(ZN4+1.0)
      DO 3035 LM=1,10
      IF(MASK(LM))3025,3025,3030
 3025 MLM=L
      GO TO 3040
 3030 M=LM
 3035 CONTINUE
 3040 DO 3042 J=1,M
      IF(MASK(J).LT.23) GO TO 3042
      WRITE(IOUT,3041)J,MASK(J)
 3041 FORMAT(//,'ERROR DETECTED;MASK(',I2,')=',I2,'GT.23')
 3042 CONTINUE                                                          080373
      N4=N3+1
      N10=N1-1
      DO 4060 J=1,M
      K=J
      JJ=0
      DO 4060 I=1,N4,IZI
      JJ=JJ+1
      IC=MASK(J)
      GOTO(3045,3050,3055,3060,3065,3070,3075,3080,3085,3090,3095,
     14000,4005,4010,4015,4020,4025,4030,4035,4040,4045,4050,4055),IC
 3045 A(K-1)*N7+JJ)=P*(N10+I)                                           080373
```

```
      GOTO4060
3050  A((K-1)*N7+JJ)=YT(N10+1)                                          080373
      GOTO4060
3055  A((K-1)*N7+JJ)=FC(N10+1)                                          080373
      GOTO4060
3060  A((K-1)*N7+JJ)=YC(N10+1)                                          080373
      GOTO4060
3065  A((K-1)*N7+JJ)=CT(N10+1)                                          080373
      GOTO4060
3070  A((K-1)*N7+JJ)=WB(N10+1)                                          080373
      GOTO4060
3075  A((K-1)*N7+JJ)=YO(N10+1)                                          080373
      GOTO4060
3080  A((K-1)*N7+JJ)=AC(N10+1)                                          080373
      GOTO4060
3085  A((K-1)*N7+JJ)=YDN(N10+1)                                         080373
      GOTO4060
3090  A((K-1)*N7+JJ)=V(N10+1)                                           080373
      GOTO4060
3095  A((K-1)*N7+JJ)=PRNREV(N10+1)                                      080373
      GOTO4060
4000  A((K-1)*N7+JJ)=WGT(N10+1)                                         080373
      GOTO4060
4005  A((K-1)*N7+JJ)=AL(N10+1,1)                                        080373
      GOTO4060
4010  A((K-1)*N7+JJ)=AL(N10+1,2)                                        080373
      GOTO4060
4015  A((K-1)*N7+JJ)=AL(N10+1,3)                                        080373
      GOTO4060
4020  A((K-1)*N7+JJ)=AL(N10+1,4)                                        080373
      GOTO4060
4025  A((K-1)*N7+JJ)=AL(N10+1,5)                                        080373
      GOTO4060
4030  A((K-1)*N7+JJ)=AL(N10+1,6)                                        080373
      GO TO 4060
4035  A((K-1)*N7+JJ)= YP(N10+1)                                         080373
      GOTO4060
4040  A((K-1)*N7+JJ)=YPROD(N10+1)                                       080373
      GOTO4060
4045  A((K-1)*N7+JJ)=PRNEVV(N10+1)                                      080373
      GOTO4060
4050  A((K-1)*N7+JJ)=MC(N10+1)                                          080373
      IF(A((K-1)*N7+JJ).LE.0.0.OR.A((K-1)*N7+JJ).GE.0.40)A((K-1)*N7+JJ) 080373
     1=0.40
      GOTO4060
4055  A((K-1)*N7+JJ)=FLOAT(NI(N10+1))                                   080373
      GOTO4060
4060  CONTINUE
      WRITE(6,4075)APLOTC,IPLOT
4075  FORMAT('1',10X,'PLOT CARD # ',I2,' OF ',I2)
      WRITE(IOUT,4072)N1,N2,IOUT,IZ1,N7,M
4072  FORMAT(' ',10X,'N1=',I3,3X,'N2=',I3,3X,'IOUT=',I1,3X,'IZ1=',I2,3X,
     1'N7=',I2,3X,'M=',I2)
      WRITE(IOUT,4070)( VARS(MASK(LM)),LM=1,M)                          080373
4070  FORMAT('0',10X,'THE BASE VARIABLE:',A6/' ',10X,'THE CROSS VARIABLE
     1S:',9(A6,2X))
      CALL PPLOT(APLOTC,A,N7,M,0,L,IOUT)
      GO TO 3005
 555  CONTINUE
      DEBUG SUBCHK
 556  STOP
      END



      BLOCK DATA
      COMMON /LABELS/ VARS,MASK
      DIMENSION MASK(10)
      REAL*8  VARS(23)                                                  080373
      DATA  VARS/'F','YT','FC','YC','CT','WB','YO','AC','YDN','V',     080373
     1'PRNREV','WGT','AL(1)','AL(2)','AL(3)','AL(4)','AL(5)','AL(6)',  080373
     2'YMP','YPROD','PRNEVV','MC','N'/                                  080373
      END



      FUNCTION FUNC(FM)
      DIMENSION OMEGA(4),CEXP(4),G(4)
      DATA OMEGA/1.,-3.,3.,-1./
```



```
      COMMON WINF,ZK,LAMDA,NAMDR,TC,TMC,TRHOP,R
      REAL NAMDR,LAMDA,MULT
      DO 30 K=1,4
      ZN=FLOAT(K)-1.0
      QEXP(K)=NAMDR*ZN*ZK
   30 G(K)=OMEGA(K)/EXP(ZN*ZK*(TRHOP-TO))
      MULT=FM*R*WINF*EXP(-(NAMDR*(TRHOP-TRO)))
      FIRST=0.0
      DO 35 L=1,4
      QEXX=FM*QEXP(L)
      QEXXL=LAMDA*QEXX
      A=EXP(-QEXXL)
   35 FIRST=FIRST+G(L)*(1.0-A)/QEXX
      FUNC=MULT*FIRST
      RETURN
      DEBUG SUBCHK
      END



      SUBROUTINE MINMAX(X,M,N,LOC1,LOC2)
      DIMENSION X(M)
      REAL MAX
      MM=M-1
      GO TO (1,1,2),N
    1 MAX=ABS(X(1))
      LOC1=1
      DO 3 I=1,MM
      IF(MAX.LT.ABS(X(I+1)))GO TO 3
      LOC1=I+1
      MAX=ABS(X(I+1))
    3 CONTINUE
      IF(N.EQ.1)RETURN
    2 MAX=X(1)
      LOC2=1
      DO 4 I=1,MM
      IF(MAX.GT.X(I+1))GO TO 4
      LOC2=I+1
      MAX=X(I+1)
    4 CONTINUE
      RETURN
      END
```

```
      MAIN                                                              PPLOT001
C*****************************************************************     PPLOT002
C                                                                       PPLOT003
C     SUBROUTINE PPLOT                                                  PPLOT004
C                                                                       PPLOT005
C     PURPOSE                                                           PPLOT006
C        PLOT SEVERAL CROSS-VARIABLES VERSUS A BASE VARIABLE            PPLOT007
C                                                                       PPLOT008
C     USAGE                                                             PPLOT009
C        CALL PPLOT(NO,A,N,M,NL,NS,IOUT)                                PPLOT010
C                                                                       PPLOT011
C     DESCRIPTION OF PARAMETERS                                         PPLOT012
C        NO - CHART NUMBER (3 DIGITS MAXIMUM)                           PPLOT013
C        A  - MATRIX OF DATA TO BE PLOTTED. FIRST COLUMN REPRESENTS     PPLOT014
C             BASE VARIABLE AND SUCCESSIVE COLUMNS ARE THE CROSS-       PPLOT015
C             VARIABLES (MAXIMUM CROSS VARIABLES ALLOWED IS 9)          PPLOT016
C        N  - NUMBER OF ROWS IN MATRIX A                                PPLOT017
C        M  - NUMBER OF COLUMNS IN MATRIX A (EQUAL TO THE TOTAL         PPLOT018
C             NUMBER OF VARIABLES). MAXIMUM IS 10.                      PPLOT019
C        NL - NUMBER OF LINES IN THE PLOT. IF 0 IS SPECIFIED, 50        PPLOT020
C             LINES ARE USED.                                           PPLOT021
C        NS - CODE FOR SORTING THE BASE VARIABLE DATA IN ASCENDING      PPLOT022
C             ORDER                                                     PPLOT023
C               0  SORTING IS NOT NECESSARY (ALREADY IN ASCENDING       PPLOT024
C                  ORDER).                                              PPLOT025
C               1  SORTING IS NECESSARY.                                PPLOT026
C        IOUT - CODE FOR OUTPUT OF DATA TO BE PLOTTED                   PPLOT027
C                  0  NO DATA LIST REQUESTED                           PPLOT028
C                  1  PRINT DATA TO BE PLOTTED IN ASCENDING ORDER OF   PPLOT029
C                     BASE VARIABLE                                     PPLOT030
C                  2  PRINT AND PUNCH DATA TO BE PLOTTED IN ASCENDING  PPLOT031
C                     ORDER OF BASE VARIABLE                            PPLOT032
C                                                                       PPLOT033
```

```
C     REMARKS                                                          PPLOT034
C        NPTS = INDICATES NUMBER OF BASE VARIABLE ELEMENTS WHOSE       PPLOT035
C               VALUE FALLS WITHIN 1 SCALE UNIT(1 LINE OF PRINT)       PPLOT036
C                                                                      PPLOT037
C     SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED                    PPLOT038
C        NONE                                                          PPLOT039
C                                                                      PPLOT040
C***********************************************************************PPLOT041
C                                                                      PPLOT042
      SUBROUTINE PPLOT(INC,A,N,M,NL,NS,ICUT)                           PPLOT043
      DIMENSION CUT(132),YPR(11),DIGITS(9),A(1),MASK(10)
      REAL*8  VARS(23)
      COMMON /LABELS/ VARS,MASK
      DATA BLANK/' '/,DIGITS/'1','2','3','4','5','6','7','8','9'/     PPLOT045
                                                                       PPLOT046


      PPLOT
    1 FORMAT('1',60X,'CHART ',I3)                                      PPLOT047
    2 FORMAT(' ',E10.4,1X,I2,1X,'I',101A1)                             PPLOT048
    3 FORMAT(' ',E10.4,1X,I2,1X,'I')                                   PPLOT049
    4 FORMAT('0',30X,'CROSS VARIABLE(S)I',9(A6,1X))
    5 FORMAT(' BASE I',A6,4X,'.         .         .         .         .
     1         .         .         .         .*/'**',15
     2X,'
     3_____'I')
    6 FORMAT(' ',11X,11(E8.2,2X))                                      PPLOT055
    7 FORMAT(' ',10X,'*** ERROR: NPTS= ',I2,' (TOO LOW)')              PPLOT056
    8 FORMAT(' ',10X,'PLOT DATA'/6X,10(A6,7X))
    9 FORMAT(' ',10(1X,E12.4))                                         PPLOT058
   10 FORMAT(2(5E16.5/))                                               PPLOT059
                                                                       PPLOT060
C***********************************************************************PPLOT061
C                                                                      PPLOT062
      NLL=NL                                                           PPLOT063
C                                                                      PPLOT064
      IF(NS) 17,17,11                                                  PPLOT065
C                                                                      PPLOT066
C          SORT BASE VARIABLE DATA IN ASCENDING ORDER                  PPLOT067
C                                                                      PPLOT068
   11 DO 16 I=1,N                                                      PPLOT069
      DO 15 J=I,N                                                      PPLOT070
      IF(A(I)-A(J)) 15,12,12                                           PPLOT071
   12 L=I-N                                                            PPLOT072
      LL=J-N                                                           PPLOT073
      DO 13 K=1,M                                                      PPLOT074
      L=L+N                                                            PPLOT075
      LL=LL+N                                                          PPLOT076
      F=A(L)                                                           PPLOT077
      A(L)=A(LL)                                                       PPLOT078
   13 A(LL)=F                                                          PPLOT079
   15 CONTINUE                                                         PPLOT080
   16 CONTINUE                                                         PPLOT081
                                                                       PPLOT082
C          PRINT(AND PUNCH) DATA TO BE PLOTTED                         PPLOT083
C                                                                      PPLOT084
   17 IF(ICUT-1) 20,18,19                                              PPLOT085
   18 WRITE(6,8)    ( VARS(MASK(LM)),LM=1,M)                          PPLOT087
      DO 20   I=1,N                                                    PPLOT088
      IF(ICUT-1)20,21,19                                               PPLOT089
   21 WRITE(6,9)    (A(J-1)*N+I),J=1,M)                               PPLOT090
      GO TO 20                                                         PPLOT091
   19 WRITE(7,10)   (A(J-1)*N+I),J=1,M)                               PPLOT092
      WRITE(6,9)    (A(J-1)*N+I),J=1,M)                               PPLOT093
   20 CONTINUE                                                         PPLOT094
C                                                                      PPLOT095
C          TEST NLL                                                    PPLOT096
C                                                                      PPLOT097
      IF(NLL) 23,22,23                                                 PPLOT098
   22 NLL=50                                                           PPLOT099
C                                                                      PPLOT100
C          PRINT TITLE                                                 PPLOT101
C                                                                      PPLOT102
   23 WRITE(6,1)INC                                                    PPLOT103
C                                                                      PPLOT104
C          FIND SCALE FOR BASE VARIABLE                                PPLOT105
C                                                                      PPLOT106
      XSCAL=(A(N)-A(1))/FLOAT(NLL-1)
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C                                                                      PPLOT107
C          FIND SCALE FOR CROSS-VARIABLE                               PPLOT108
C                                                                      PPLOT109
      M1=N+1                                                           PPLOT110
      YMIN=A(M1)                                                       PPLOT111
      YMAX=YMIN                                                        PPLOT112
      M2=M*N                                                           PPLOT113
      DO 40 J=M1,M2                                                    PPLOT114
      IF(A(J)-YMIN) 28,26,26                                           PPLOT115
   26 IF(A(J)-YMAX)40,40,30                                            PPLOT116
   28 YMIN=A(J)                                                        PPLOT117
      GO TO 40                                                         PPLOT118
   30 YMAX=A(J)                                                        PPLOT119
   40 CONTINUE                                                         PPLOT120
      YSCAL=(YMAX-YMIN)/100.0                                          PPLOT121
C                                                                      PPLOT122
C          GENERATE AND PRINT CROSS-VARIABLE-AXIS LABELS               PPLOT123
C                                                                      PPLOT124
      WRITE(6,4)( VARS(MASK(LM)),LM=2,M)                               PPLOT126
      YPR(1)=YMIN                                                      PPLOT127
      DO 65 KK=1,9                                                     PPLOT128
   65 YPR(KK+1)=YPR(KK)+YSCAL*10.0                                     PPLOT129
      YPR(11)=YMAX                                                     PPLOT130
      WRITE(6,5)(YPR(IF),IF=1,11)
      WRITE(6,6)   VARS(MASK(01))                                      PPLOT132
C                                                                      PPLOT133
C                                                                      PPLOT134
C                                                                      PPLOT135
      L=1                                                              PPLOT136
      MM=M-1                                                           PPLOT137
      XPR=A(1)                                                         PPLOT138
      DO 70 MM=1,MM                                                    PPLOT139
      NPTS=0                                                           PPLOT140
      KM=N+1-L                                                         PPLOT141
      DO 80 IM=1,KM                                                    PPLOT142
C                                                                      PPLOT143
C          DISTRIBUTE BASE VARIABLE ELEMENTS                           PPLOT144
C                                                                      PPLOT145
      IF(A(L-1+IM).GE.XPR).AND.(A(L-1+IM).LT.(XPR+XSCAL)) GO TO 82     PPLOT146
      IF(NPTS) 140,120,130                                             PPLOT147
   82 NPTS=NPTS+1                                                      PPLOT148
      IF(NPTS-11) 140,90,91                                            PPLOT149
C                                                                      PPLOT150
C          FIND CROSS-VARIABLES                                        PPLOT151
C                                                                      PPLOT152
   90 DO 100 IX=1,101                                                  PPLOT153
  100 CUT(IX)=BLANK                                                    PPLOT154
   91 DO 110 J=1,MM                                                    PPLOT155
      LL=L+J*N                                                         PPLOT156
      JP=((A(L-1+IM)-YMIN)/YSCAL)+1.0                                  PPLOT157
      CUT(JP)=DIGITS(J)                                                PPLOT158
  110 CONTINUE                                                         PPLOT159
C                                                                      PPLOT160
   80 CONTINUE                                                         PPLOT161
C                                                                      PPLOT162
C          PRINT LINE WITH CROSS-VARIABLES                             PPLOT163
C                                                                      PPLOT164
  130 WRITE(6,2)XPR,    NPTS,(CUT(IZ),IZ=1,101)                        PPLOT165
C                                                                      PPLOT166
      L=L-1+IM                                                         PPLOT167
      GO TO 71                                                         PPLOT168
C                                                                      PPLOT169
C          PRINT LINE WITHOUT CROSS-VARIABLES                          PPLOT170
C                                                                      PPLOT171
  120 WRITE(6,3)XPR,    NPTS                                           PPLOT172
C                                                                      PPLOT173
   71 XPR=XPR+XSCAL                                                    PPLOT174
   70 CONTINUE                                                         PPLOT175
      GO TO 150                                                        PPLOT176
C                                                                      PPLOT177
  140 WRITE(6,7)NPTS                                                   PPLOT178
C                                                                      PPLOT179
  150 CONTINUE                                                         PPLOT180
      RETURN                                                           PPLOT181
      END
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9. References Cited

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