# USER MANUAL FOR RECON:

# A GENERAL FISH-STOCK RECONSTRUCTION MODEL AT OREGON STATE UNIVERSITY

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## PREFACE

This guide documents the model RECON, a specific application of the SIMCON software package. Although not imperative, it is advisable that users of RECON have some familiarity with SIMCON or at least have access to the SIMCON User's Guide (see References).

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## INTRODUCTION

RECON is a computer simulation model for reconstructing a fish stock with age-class structure to find optimal exploitation strategies given fairly standard stock assessment data for a fishery. The chief purpose of the model is to account for effects of variation in recruitment to the stock in yield estimation. It is suitable for application to any fish species with up to 20 age classes in the fishery. The number of age-classes can be increased. RECON assumes the simplification that the pre-conditions of the Baranov catch equation hold, and that the simulated fishery will not interfere with the annual number of recruits. We propose this simplification because of difficulty of demonstrating stock-recruitment relationships, not to foster the notion that recruitment overfishing is unusual.

## SPECIFIC USES OF RECON

1. To calculate yield isopleth diagrams of the dynamic pool model under the simplification that mean annual recruitment is representative. Weight-at-age data and an estimate of the annual instantaneous natural mortality rate (M) are required.
2. To estimate next year's yields under a range of instantaneous fishing mortality rates (F), given an estimate of present recruitment to the fishery, plus recent historic recruitment, as well as the data in 1 above.
3. To reconstruct a stock's history given recruitment estimates for a period of time, weight-at-age data, an estimate of M, or a range of likely M values. The user may select a series of F values that produces a simulated annual catch that may be validated against actual historic catch.

4. To reconstruct the stock, and experiment with alternative quota and effort regimes to learn how to cope with the pecularities of the stock on the assumption that the recent past recruitment is an indication of how the stock will behave in the near future. For example, what quota range would one expect if one managed at F = M?
5. To reconstruct the stock as it would have been had there been no fishery. This is accomplished by setting historic F to zero.

## LINKAGE WITH SIMCON

To simplify re-parameterization of the model between runs, and gain flexibility in output, the model is run with the model handling program, SIMCON, developed at the University of British Columbia (Beals, 1981). SIMCON, supported by O.S.U. Sea Grant, is available as a public program on the O.S.U. Cyber computer, in either FORTRAN IV or FORTRAN V versions. RECON is written as a series of subroutines with no specific I/O code. Running the model with SIMCON allows re-parameterization between runs without re-editing and re-compiling the code. Specific instructions for use with SIMCON are given here. The model can be used without SIMCON if the user cares to attach her/his own FORTRAN I/O code. Further information on using SIMCON is to be found in Beals 1981.

## RUNNING THE MODEL

Modeling Case I.--Use of historic Dover sole data of the Oregon Department of Fish and Wildlife.

The model is provided with data from females of the Dover sole stock of the Pacific continental shelf off the Columbia River (INPFC Statistical Area 3A). These data are shown in Appendix 1 (Hayman, Tyler, Demory 1980).

In the example here we calculate the annual total allowable catch (TAC) as it might have been for the period 1948 to 1962. This is a period for which we have cohort analyses that give annual numbers of age-6 fish entering the fishery.

STEP 1. Linking with SIMCON.

Enter (via keyboard): GET, PRECON/UN= AAVQ7M

Enter: PRECON

Enter: SIMC

Enter: SIMCON

After each entry, wait for a response from the computer before making the next entry. A question mark will be the response after typing SIMCON.

STEP 2. Finding the data provided with the model.

Enter: DISPLAY NMORT(6)

The value of M will appear for age-6 fish. All ages 6-20 have the same value.

Enter: DISPLAY WT (6...10)

The mean weight-at-age for ages 6 through 10 appears.

Enter: DISPLAY FRY (1...5)

Gives the recruitment record as thousands of age-6 females for years 1949 to 1953.

Enter: DISPLAY FRY (6...10)

Gives age-6 female recruits (thousands) for years 1954 to 1958.

Enter: DISPLAY FRY (11...14)

Gives age-6 female recruits (thousands) for years 1959 to 1962.

Enter: DISPLAY FRY (15)

Gives age-6 female recruits (thousands) for 1948.

Step 3. Choosing a value of F and simulating the fishery.

Enter: SET F = .2

Causes the stock to be fished at F = 0.20

Enter: SIMULATE 30

Initializes the model

Enter: SIMULATE 1948 to 1962

Calculates the values for model variables for the time period specified. This is the simulation run.

Enter: PRINT BIOM YIELD

Prints a table giving fishable stock biomass and the annual total allowable catch or TAC (= YIELD) for management at F = 0.20.

Enter: VIEW YIELD MAX = 1000

Produces a year-by-year plot of the TAC.

If you are using a Techtronics scope terminal (CRT), use the following command for a continuous graph.

Enter: GRAPH YIELD MAX = 1000

Modeling Case 2. Development of a yield curve from the dynamic pool model.

The dynamic pool model of Beverton and Holt requires an estimate of M, size-at-age data, and a mean annual recruitment.

All of these statistics are available in RECON, as is the basic mathematics of the dynamic pool model. One can use RECON to make the calculations in simulation mode rather than as the large formula originally presented (See logic given in Tyler and Gallucci, 1980). In a series of runs with selected F values, RECON will calculate mean yields for the period described above. The user then plots the yield against the value of F used in the run.

Size-at-entry into the fishery is set-up with a utilization curve developed by TenEyck and Demory, 1975.

Step 1. Linking with SIMCON

Same as Step 1 above

Step 2. Calculating yield with a series of F values.

Enter: SET F = 0.2

Enter: SIMULATE 30

Initializes the model

Enter: SIMULATE 30

This is the usable simulation run.

Enter: STATS YIELD

Mean yield will be displayed along with the standard deviation and standard error.

Step 3. Repeat Step 2 with F incremented by 0.20 until you have reached a high value of F, say F = 4.0. This will provide an interesting range of F for your plot.

When you have all your data, plot the yield curve by hand on graph paper.

Modeling Case 3.--Substitution of a new data set into RECON.

Suppose one has a new series of recruitment estimates for a 25-year period, an estimate of M, and weight-at-age data.

Step 1. Call the computer's editor (e.g. XEDIT on the O.S.U. Cyber).

Replace FRY(15) with FRY(25) in all COMMON statements of the file RECON.

Step 2. Edit the file RECONB.

This is the data storage file for the model. The series of variables POP(5) to POP(20) gives an approximate age-class structure as number

of age-0 through age-20 fish. The value of the variable POP(5) is the number of 5-year olds at the end of the year, which is the same as the number of 6-year olds at the beginning of the following year. Because the program is coded to graduate all numbers to the next age at the beginning of the year, the number of age-6 fish must be entered here by the user as the number of age-5 fish at year's end.

Step 3. If there are a significant number of fish caught at ages younger than age-6, and older than age 20, edit the file RECON as follows:

a. In all subroutines change all dimensions of 20 in the COMMON statement to a number equal to the oldest age caught in the stock.

b. Subroutine statements to change

```
SUBROUTINE UMODEL

   DO 1  I = 6,20
   DO 2  I = 6,20

SUBROUTINE FTAKE

   DO 100  I = 6,20

SUBROUTINE FSURV

DO 100  I = 6,20
```

Change 6 to the youngest age-caught in the DO statement.

Change 20 to the oldest age caught.

Step 4. Edit weight-at-age into RECONB with computer editing system. The variable WT (I) is age-specific weight. In RECONB the statement: S WT (1...5) = .004 .021 .054 .104 .169 allows SIMCON to use female Dover sole weights in kilograms, where weight at age 1 is 0.004 kg, weight at age 2 is 0.021 kg,

etc. To edit, replace the old (WT (1) = .004 with the new mean weight at age 1. Similarly replace all other weights with appropriate new weights.

Step 5. Replace the initial stock biomass, BIOM = 3968 (tonnes) with the new initial stock biomass in RECONB, calculated as $\Sigma$ [POP (I)* WT (I)], where the sum is made over all ages recruited to the fishery.

Step 6. Replace the old instantaneous natural mortality rate (M) with the new one in RECONB. The variable to change is called NMORT (I). The mortality rate is age specific. At present, however, the rate for all ages is 0.20. The SIMCON statement S NMORT (ALL) = 0.2 sets the rate for all ages to 0.2. Suppose one replaces the old age-specific values with the following statements:

S NMORT (6...10) = 0.25 0.25 0.23 0.23 0.20

S NMORT (11...20) = 0.18

These statements will set the rate at age 6 = 0.25, at age 7 = 0.25, at age 8 = 0.23, at age 9 = 0.23, at age 10 = 0.20, and for all older fish the rate will be 0.18.

Step 7. Setting-up a new catch ogive.

To set an empirical catch ogive into RECON, divide the ogive into four equal weight classes, such that fish smaller than class 1 are essentially unexploited, and fish larger than class 4 are fully exploited. F is the instantaneous fishing mortality rate applied to fully recruited weight classes set

by the user. Variables SEL1, SEL2, SEL3, SEL4 are the proportions of F that apply to the four partially recruited weight classes. If the fish of the smallest weight class are 20% recruited on the average, smallest then SEL1 equals .20. These values should then be substituted into the RECONB file in place of the values given.

Weight categories for the ogive must also be set in the program. The smallest weight (kg) of fish that is 100% recruited to the fishery is the variable WMIN. The new WMIN weight must be substituted into the RECONB file.

With the Dover sole data, only two partially recruited weight classes are used. The weight classes are set-up in Subroutines FTAKE and FSURV in FORTRAN statements number 11, 11 + 1, 11 + 2. Fully recruited fish have a weight greater or equal to 0.4 kg (WMIN = .4). Fish that are 50% recruited are in the class with the smallest fish equal to (WMIN - .1) and the largest less than WMIN, in other words 0.3 to 0.399 kg, inclusive. Fish that are 20% recruited are 0.2 to 0.299 kg. Smaller fish are considered not recruited. Thus variable SEL1 and SEL2 are not used in the Dover sole data set, but are available for new data sets.

Step 8. Knife-edge recruitment

If an ogive is not available, or if the user wishes to compare yields with knife edge recruitment versus ogive recruitment, ogive recruitment can be by-passed by assigning a positive value to the variable KNIFE. When KNIFE is set to the fish

weight (kg) that is 50% recruited in the data, then all calculations are made with fish of weight greater or equal to KNIFE caught with the full value of F. Both KNIFE and F are set to zero in RECONB.

These variables should be reset without editing the file by using the power of SIMCON, as follows:

Enter: SET F = .2

Enter: SET KNIFE = .3

Enter: SIMULATE 30 (to initialize the model)

Enter: SIMULATE 30 (the usable simulation run)

Enter: STATS YIELD

This set of commands is given after the model is linked to SIMCON refer to p 3). For the next simulation run, and all runs until F is changed, or until the user logs onto SIMCON a second time, F will equal 0.2 instead of the default value (which equals = 0.0). Similarly KNIFE will now equal 0.3. If the user wishes to change F again after the DISPLAY command, and carry out a new run, carry on as follows:

Enter: TIME 0 (zero)

Enter: SET F = .4

Enter: SIMULATE 30

Enter: SIMULATE 30

Enter: STATS YIELD

For this run F = 0.4, KNIFE remains at 0.30. The TIME command recaptures the initial conditions.

VARIABLE DEFINITIONS

The variables defined here may be useful for retrieving information from the model, depending on the user's needs.

| | | |
|---|---|---|
| 1. | BIOM | the biomass of the total stock in tonnes (metric tons) |
| 2. | CATCH (I) | number of fish caught |
| 3. | EBIOM | biomass of the total stock in (English) pounds |
| 4. | EYIELD | pounds of fish caught all ages |
| 5. | F | instantaneous fishing mortality rate set by user as an alternative to setting QUOTA |
| 6. | FPOP | number of fish in total stock |
| 7. | FRY (I) | this is the driving variable - the numbers of age 6 fish recruited to the fishery each year. See p. 3. |
| 8. | KNIFE | the weight-at-age to be set by the user for knife-edge recruitment as an alternative to ogive recruitment. Fish sizes greater or equal to KNIFE will be fully recruited to the fishery. See p. 8 for further explanation. |
| 9. | LBS (I) | age-specific pounds of biomass |
| 10. | NMORT (I) | age-specific instantaneous natural mortality rate |
| 11. | POP (I) | number of fish in each age class |
| 12. | QUOTA | tonnes to be set by user as an alternative to setting F |
| 13. | SEL1, SEL2, SEL3, SEL4 | portion of F applied to small fish in generating the catch ogive. See p. 7 for further explanation |
| 14. | TONS (I) | tonnes biomass in each age-class after fishery exploitation |
| 15. | WMIN | minimum weight for 100% recruitment under ogive selection |
| 16. | WT (I) | mean weight at age |
| 17. | YIELD | tonnes of fish caught from total stock |
| 18. | YLBS (I) | pounds of fish caught by age class |
| 19. | YTONS (I) | tonnes of fish caught by age class |

NOTE: Not all variables listed in the COMMON statements are functional. Some were used in earlier versions of the model and are no longer operative in the code.

## References

Beals, E. 1981. SIMCON. A simulation control language at Oregon State University. MS. 45 pp.

Hayman, R.A., A.V. Tyler and R.L. Demory. 1980. A comparison of cohort analysis and catch per unit effort for Dover sole and English sole. Trans. Am. Fish. Soc. 109:35-53.

TenEyck, N. and R.L. Demory. 1975. Utilization of flatfish caught by Oregon trawlers in 1974. Presented at the 16th Annual Meeting of the Technical Subcommittee. International North Pacific Fisheries Commission. Oregon Department of Fish and Wildlife. International Report 75-3. 11 pp.

Tyler, V. and V.F. Gallucci. 1980. "Dynamics of Fished Stocks". pp. 111-147 in R.T. Lackey and L.A. Nielsen (ed.). Fisheries Management. John Wiley and Sons.

# APPENDIX 1

Numbers at age in the first year

```
-- INITIAL POPULATION VECTOR FOR 1948 (HAYMAN,TYLER,1980)
S POP(5)       = 3001000
S POP(6...10)  = 2162000 1630000 1275000  924000  695000
S POP(11...15) =  504000  300000  222000  165000  122000
S POP(16...20) =   90400   66900   49600   36700   27200
```

Weight at age (kg). Constant in model.

```
S WT(1...5)    =  .004  .021  .054  .104  .169
S WT(6...10)   =  .247  .333  .426  .522  .619
S WT(11...15)  =  .716  .811  .902  .989 1.071
S WT(16...20)  = 1.150 1.222 1.290 1.351 1.410
--
```

Number of age-6 recruits in thousands, 1949 to 1962. The last figure (3001 thousand or 3.001 million) is for 1948. This ordering is necessary for the SIMCON algorithm.

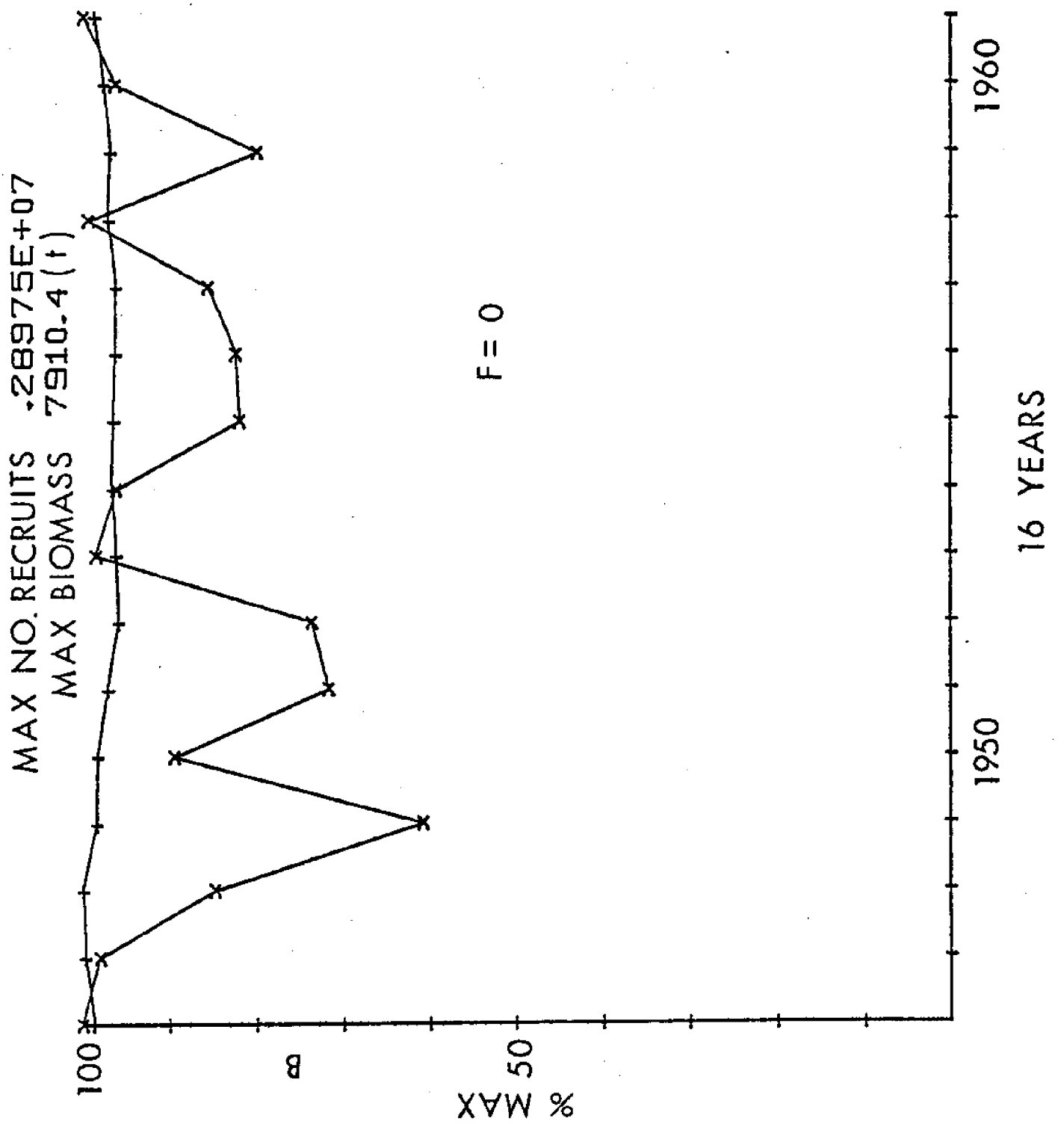
```
S FRY(1...5)   = 2154 3170 2543 2611 3487
S FRY(6...10)  = 3407 2906 2921 3035 3521
S FRY(11...15) = 2835 3411 3539 3469 3001
--
```

Other variables

```
S BIOM = 3968
S WMIN = .4
S NMORT(ALL) = .2
S F=0.0
S SEL1=.001
S SEL2=.0165
S SEL3=.2
S SEL4=.5
S QUOTA=0.0
S IYEAR=0
S KNIFE = 0
--
```

Figure 1. Reconstruction of the Dover sole stock off the Columbia River for years 1946 to 1961, based on recruitment data in Hayman, Tyler and Demory, 1980. Upper line (+ symbols) is total stock biomass (tonnes) as it would have fluctuated had there been no fishing. The strongly fluctuating line (x symbols) shows the numbers of age-6 recruits. All fluctuation in the biomass trajectory is due to recruitment variation. The vertical axis is percentage of the maximum value for recruits and biomass. The maxima are given at the top of the graph.

Figure 1.


MAX NO. RECRUITS .28975E+07
MAX BIOMASS 7910.4 (t)
F = 0
100
B
50
% MAX
1950
1960
16 YEARS

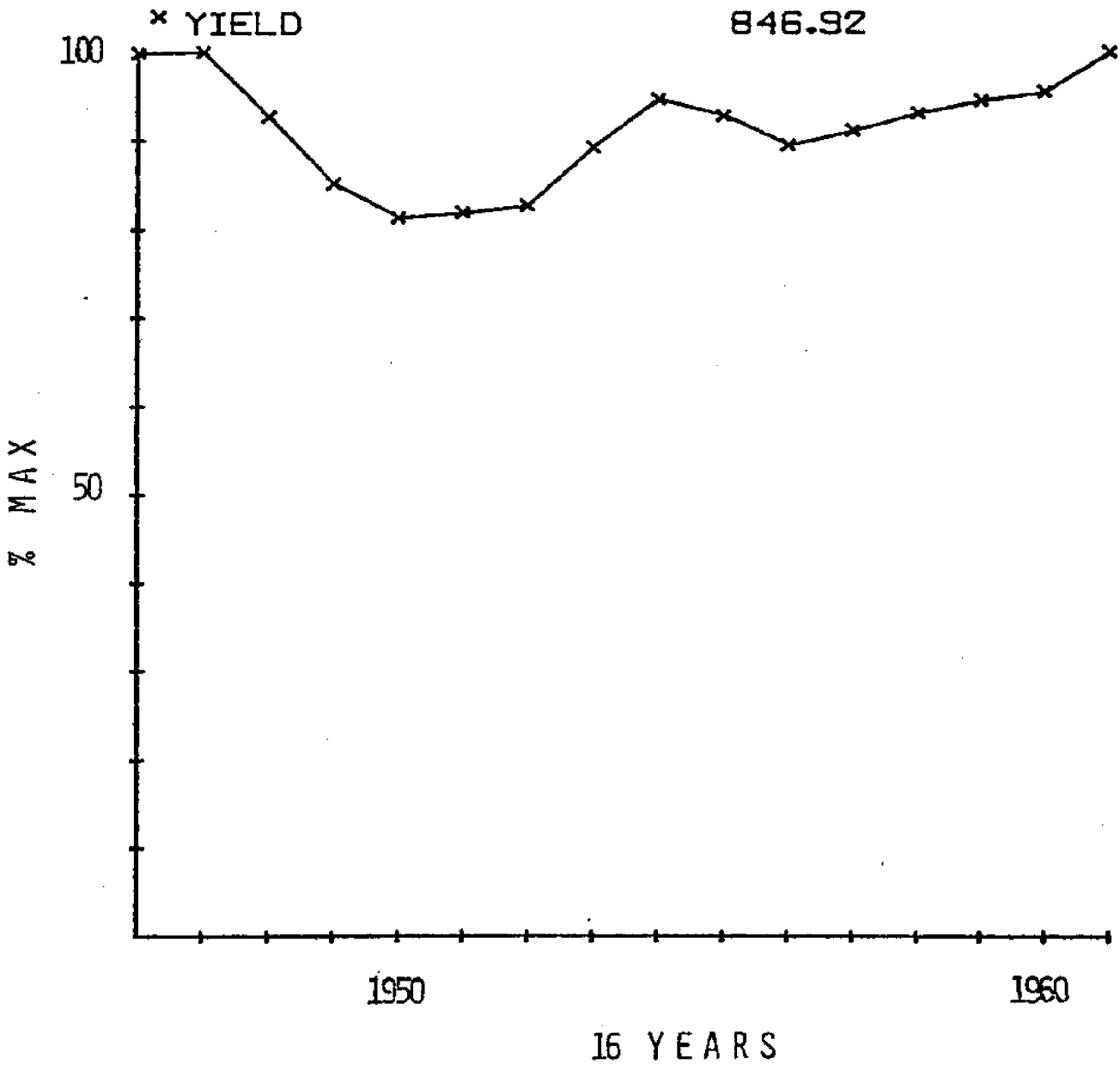



Figure 2. Reconstruction of total allowable catch (TAC) for the Dover sole stock that would have maximized yield for the period 1946 to 1961. The smallest TAC is about 20% of the largest (846.9 tonnes). The annual change in TAC is necessary because of change in recruitment. Graph axes are the same as in Fig. 1.

The procedure file used to run RECON.

```
      PRECON
.PROC,PRECON. PROCEDURE FOR MODEL RECON OCT 82
SETTL,200B.
GET,RECON,COMMON=RECONC,BATCH=RECONB/UN=AAVQ7M.
ATTACH,FTN4/UN=LIBRARY.
RETURN,BMODL.
FTN4,I=RECON,L=0,B=BMODL,OPT=2.
GET,SIMC/UN=AAVI7M.
 EOI ENCOUNTERED.
/
```

The COMMON block file used with RECON. This file is necessary for SIMCON, and is automatically linked by running PRECON. See p. 3.

RECONC

```
REAL NMORT,LBS
COMMON POP(20),CATCH(20),TONS(20),YTONS(20),LBS(20),YLBS(20)
COMMON WT(20),BIOM,EBIOM
COMMON YIELD,EYIELD,FPOP,FLAG,NMORT(20)
COMMON FMORT,F,SEL1,SEL2,SEL3,SEL4,WMIN,IYEAR
COMMON WT3,QUOTA,FRY(15),KNIFE
```

```
C MODEL RECON - WITH A RECONSTRUCTION OF THE ASTORIA DOVER SOLE STOCK
C            PROGRAM AND MODEL BY A.V. TYLER.
C               INCLUDING YEAR-CLASS STRENGTH AS A DRIVING
C               VARIABLE FROM THE COHORT ANALYSIS BY HAYMAN,TYLER,DEMORY 1980
      SUBROUTINE UMODEL (IT)
      REAL MMORT,LBS
      COMMON POP(20),CATCH(20),TONS(20),YTONS(20),LBS(20),YLBS(20)
      COMMON WT(20),BIOM,EBIOM
      COMMON YIELD,EYIELD,FPOP,FLAG,MMORT(20)
      COMMON FMORT,F,SEL1,SEL2,SEL3,SEL4,WMIN,IYEAR
      COMMON WT3,QUOTA,FRY(15),KNIFE
      DO 1 I=6,20
      TONS(I)=0.
      YTONS(I)=0.
      LBS(I)=0.
    1 YLBS(I)=0.
      YIELD=EYIELD=EBIOM=FLAG=FPOP=0.
C******AGING OF POPULATION
      DO 2 I=6,20
      L=26-I
      M=L-1
    2 POP(L)=POP(M)
C*****RECRUITMENT
C     FRY TIMES 1000 IS THE NO. OF FEMALES,AGE 5
      IF(IYEAR.EQ.15)IYEAR=0
      IYEAR=IYEAR+1
      POP(5)=FRY(IYEAR)*1000.
      CALL FTAKE
      CALL FSURV
C234567 *** COLUMN NOS.
      RETURN
      END
C
```

```
C
      SUBROUTINE FTAKE
      REAL NMORT,LBS
      COMMON POP(20),CATCH(20),TONS(20),YTONS(20),LBS(20),YLBS(20)
      COMMON WT(20),BIOM,EBIOM
      COMMON YIELD,EYIELD,FPOP,FLAG,NMORT(20)
      COMMON FMORT,F,SEL1,SEL2,SEL3,SEL4,WMIN,IYEAR
      COMMON WT3,QUOTA,FRY(16),KNIFE
    1 YIELD=EYIELD=0.
      DO 100 I=6,20
      IF (KNIFE .EQ. 0) GOTO 11
C  KNIFE EDGE SELECTION AT AGE <KNIFE>
      IF (I .GE. KNIFE) GOTO 9
      FMORT = 0.
      GOTO 10
C  OGIVE SELECTION (FULL RECRUITMENT AT AGE 8)
 11   IF(WT(I).GE.WMIN)GO TO 9
      IF(WT(I).GE.WMIN-.1) GO TO 8
      IF(WT(I).GE.WMIN-.2)GO TO 7
      GO TO 10
    5 FMORT=SEL1*F
      GO TO 10
    6 FMORT=SEL2*F
      GO TO 10
    7 FMORT=SEL3*F
      GO TO 10
    8 FMORT=SEL4*F
      GO TO 10
    9 FMORT=F
   10 CONTINUE
      CATCH(I)=POP(I)*FMORT/(FMORT+NMORT(I))*(1-EXP(-FMORT-NMORT(I)))
C2345678 **** THESE ARE COL. NOS.
      YTONS(I)=CATCH(I)*WT(I)/1000.
      YLBS(I)=YTONS(I)*2204.6
      YIELD=YIELD+YTONS(I)
      EYIELD=EYIELD+YLBS(I)
  100 CONTINUE
      IF(YIELD.GE.QUOTA)GO TO 200
C  WHEN QUOTA SET, ITERATIVELY FIND THE F THAT GIVES IT...
      IF(F.GE.5.0)GO TO 200
C  NOTE THAT F=5. MEANS A  99% ANNUAL MORTALITY
      F=F+.01
      GO TO 1
  200 CONTINUE
      RETURN
      END
```

```
C
      SUBROUTINE FSURV
      REAL NMORT,LBS
      COMMON POP(20),CATCH(20),TONS(20),YTONS(20),LBS(20),YLBS(20)
      COMMON WT(20),BIOM,EBIOM
      COMMON YIELD,EYIELD,FPOP,FLAG,NMORT(20)
      COMMON FMORT,F,SEL1,SEL2,SEL3,SEL4,WMIN,IYEAR
      COMMON WT3,QUOTA,FRY(16),KNIFE
    1 BIOM=0.
      DO 100 I=6,20
C  KNIFE EDGE SELECTION AT AGE <KNIFE>
      IF (KNIFE .EQ. 0) GOTO 11
      IF (I .GE. KNIFE) GOTO 9
      FMORT = 0.
      GOTO 10
C  OGIVE SELECTION (FULL RECRUITMENT AT AGE 8)
 11   IF(WT(I).GE.WMIN)GO TO 9
      IF(WT(I).GE.WMIN-.1) GO TO 8
      IF(WT(I).GE.WMIN-.2)GO TO 7
      FMORT=0.
      GO TO 10
    5 FMORT=SEL1*F
      GO TO 10
    6 FMORT=SEL2*F
      GO TO 10
    7 FMORT=SEL3*F
      GO TO 10
    8 FMORT=SEL4*F
      GO TO 10
    9 FMORT=F
   10 CONTINUE
      POP(I)=POP(I)*EXP(-FMORT-NMORT(I))
C2345678 **** THESE ARE COL. NOS.
      IF(POP(I).LT.1.) POP(I)=0.
      FPOP=FPOP+POP(I)
      TONS(I)=POP(I)*WT(I)/1000.
      LBS(I)=TONS(I)*2204.6
      BIOM=BIOM+TONS(I)
      EBIOM=EBIOM+LBS(I)
  100 CONTINUE
      RETURN
      END
```

This subroutine is used by SIMCON to speed processing, and is optional.

```
SUBROUTINE CCOM
REAL NMORT,LBS
COMMON POP(20),CATCH(20),TONS(20),YTONS(20),LBS(20),YLBS(20)
COMMON WT(20),BIOM,EBIOM
COMMON YIELD,EYIELD,FPOP,FLAG,NMORT(20)
COMMON FMORT,F,SEL1,SEL2,SEL3,SEL4,WMIN,IYEAR
COMMON WT3,QUOTA,FRY(16),KNIFE
RETURN
END
```