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A SIMULATION MODEL FOR LAKE TROUT STOCKING AND CATCH IN THE WISCONSIN WATERS OF LAKE MICHIGAN

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ABSTRACT

A computer program was written in Applesoft BASIC that simulates the hatchery lake trout population in the Wisconsin waters of Lake Michigan. The purpose of the model was to determine the effect of fishing mortality and stocking rates on parameters associated with lake trout reproduction. Four versions of the model were developed representing three lake trout management zones and the three zones combined. Input variables to the model are prompted by screen menus and are entered by the user from a keyboard. Inputs to the model include the numbers of lake trout to be annually stocked and the number of lake trout that may be caught by the small mesh gill net fishery, large mesh gill net fishery, trawl fishery, trap net fishery, pound net fishery, and sport fishery. Based on these inputs, the model predicts lake trout population parameters with respect to reproduction when management remains constant for twenty years. Output parameters include the number of fertilized eggs/reef acre, the number of mature lake trout/reef acre, the number of mature age classes, and fishing, natural, and total annual mortality by age class. Natural recruitment to the year classes was assumed not to occur.

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INTRODUCTION

The establishment of naturally reproducing stocks of lake trout in Lake Michigan is a major goal of fish management by the Wisconsin Department of Natural Resources (DNR). Rehabilitation efforts have concentrated on stocking of yearling lake trout in the nearshore waters and, more recently, stocking on offshore reef areas. Hatchery lake trout in Lake Michigan have gradually increased since the stocking program began in 1965; however, no naturally produced year classes have been detected in Wisconsin waters.

A computer simulation model of hatchery lake trout populations was developed in order to help formulate management plans related to lake trout rehabilitation. The model simulates the effects of stocking and catch on the development of hatchery lake trout populations in the Wisconsin waters of Lake Michigan. The model has been used to determine levels of stocking and catch required to develop a lake trout population that has optimum characteristics for natural reproduction (Krueger and Dehring 1986). This document describes the simulation model and its use. The model is available on a diskette from the authors at cost.

METHODS

The computer program was written in Applesoft (BASIC) language and compiled using a Microsoft Applesoft compiler (Appendixes 1-4). Both the compiled and noncompiled versions are contained on the same diskette. The program was written to operate on an Apple II+ or IIe computer with one disk drive, at least 48K RAM, and a monitor screen. The input is interactive with the computer keyboard. Output is made available on the monitor screen and from a printer. Hard copy output can be printed on the Epson FX-80 or similar printer interfaced to the computer via a Grappler + or similar card in slot #1. Switches in the printer should be set to "condensed mode" to allow more than 80 characters to be printed per line.

PROGRAM DESCRIPTION

The program simulates hatchery lake trout population dynamics within the geographic area of the Wisconsin waters of Lake Michigan south of the Baileys Harbor line (135° bearing from the mid-channel marker buoy of Baileys Harbor). Four versions of the model were developed which represent the three lake trout management zones: Clay Banks, Mid-Lake Reef, and Kenosha-Kewaunee and a composite of these management zones (Fig. 1). Versions differ from each other in terms of the amount of spawning reef area available and adult return rates to reefs.

The first operation performed by the program is to set internal variables (Fig. 2). These variables include natural mortality rates, fecundity values, and the distribution of catch by fishery for each age class. In this model, 20 age classes were chosen in order to include the most important reproductive age classes (VII-XV). The age classes were labeled using their corresponding Roman numerals.

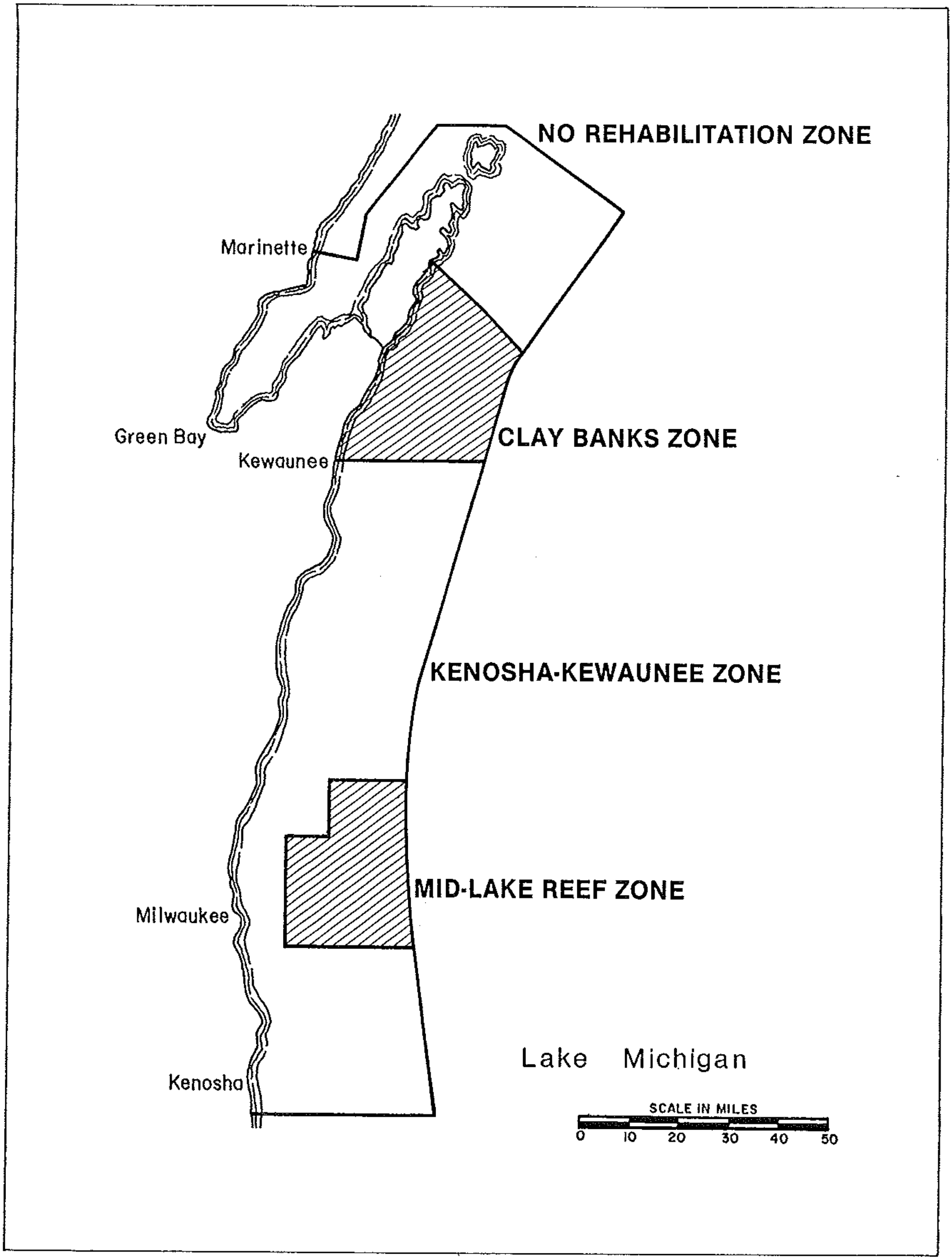

FIGURE 1. Lake trout management zones in the Wisconsin waters of Lake Michigan.

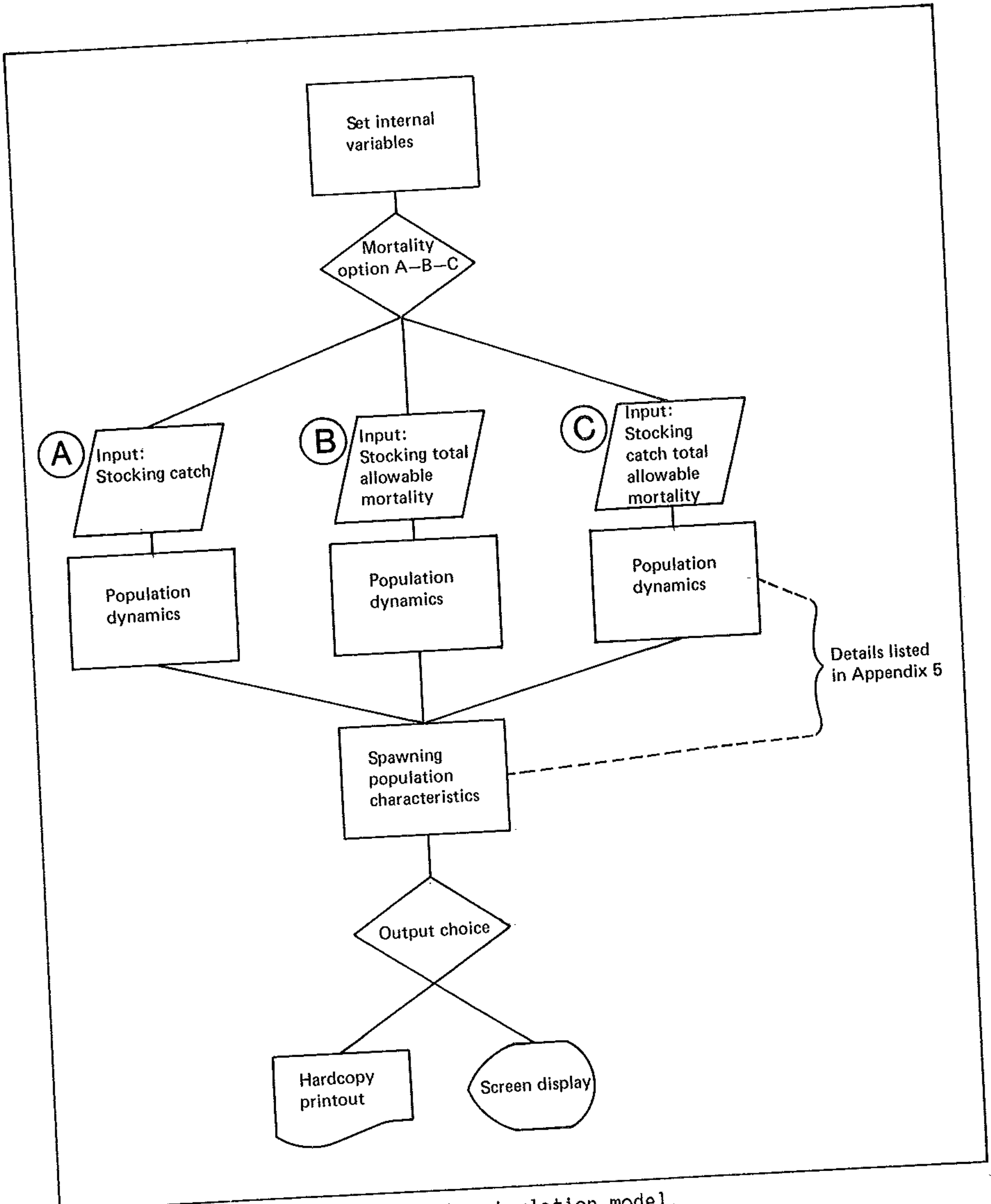

FIGURE 2. General structure of the simulation model.

The natural mortality rates for each age class were established as follows:

a) from age I (stocking) to age IV, the instantaneous natural mortality rate (M) was 0.46, and

b) from age V to age XX, the instantaneous natural mortality rate (M) was 0.29.

These values were reported by Rybicki and Keller (1978) for hatchery lake trout stocked in the Michigan waters of Lake Michigan.

The instantaneous natural mortality rate was converted to the conditional rate of mortality (n) for use in this model. This value was determined using the equation:

$$n = 1 - e^{-M}$$

where e = 2.7183 (Ricker 1975). The values of n used in the model were (Append. 3, lines 1060-1078):

ages I - IV	n = 0.37
ages V - XX	n = 0.25

Fecundity values (eggs/female trout) used in the program were based on data from Lake Superior lean lake trout that use Gull Island Shoal as a spawning reef (Bruce Swanson, pers. comm.). Egg production started at age VII and increased to age XIII. At age XV, Lake Superior female trout were suspected to spawn every other year. This characteristic was incorporated into the program by reducing the fecundity values by approximately one-half. The fecundity values used in the program were as follows (Append. 3, lines 1260-1450):

age I - VI	0
VII	3,942
VIII	4,887
IX	5,436
X	7,155
XI	8,349
XII	11,000
XIII	12,500
XIV	12,500
XV - XX	6,000

The catch distribution by age class was determined through the use of fishery specific catch curves. Catch curves were determined using data collected from monitored commercial catches (Toneys 1982, 1983; Toneys and Lychwick 1980) and from sport creel surveys. For the commercial fisheries, data were collected over a 3-year period, 1981-1983. The proportion of total catch by age class was determined for each year and a total average value for all years was computed. Data were only available to calculate catch proportions through age XII. For purposes of this model, a linear regression of the last several age classes was used to extrapolate the probable catch of fish to Age XIV. From these data, a catch-age distribution was developed for each fishery (Fig. 3; see Append. 3, lines 1460-2450).

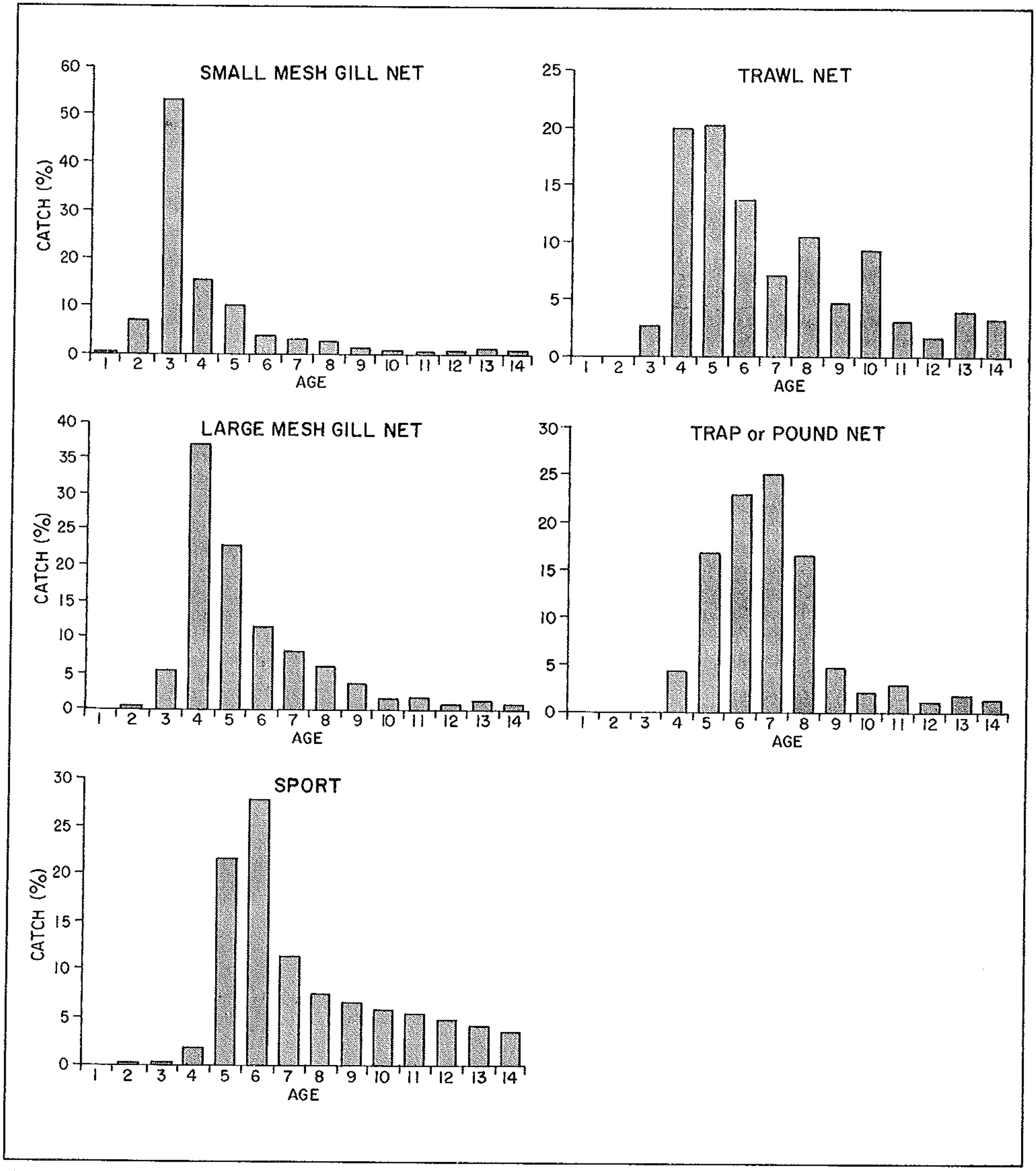

FIGURE 3. Catch frequency of lake trout in Lake Michigan by age for various fisheries.

After the internal variables are set, the program requests the user to choose one of the four program versions described above. After a version is chosen, the user has a choice of three mortality options: A, B, or C.

Mortality option A allows the user to select an annual stocking rate (numbers) and annual catch (numbers) for each fishery. The total annual mortality rate was allowed to fluctuate to a maximum of 100%. This option was used to determine the effect of stocking and catch levels on lake trout population dynamics.

Mortality option B allows the user to specify the stocking rate (numbers) and choose a total allowable annual mortality rate (between 0.30 and 0.60) which is not to be exceeded. This option assumes that the fishing mortality can be controlled. The output shows the number of fish/age class available to be harvested under the given parameters. This option can be helpful for determination of catch levels when mortality must not exceed a specific rate.

Mortality option C is a mixture of the above two options. This option allows the user to set annual stocking rate (numbers), allowable catches by fishery, and the maximum total allowable annual mortality rate. If the variables specified by the user cause the total annual mortality rate to exceed the maximum specified, then the catch values are reduced proportionately. This option assumes that control over the fishery by age class is possible, since only the "surplus" fish in each age class are allowed to be harvested. Both option A and option C produce nearly identical results when the maximum total allowable annual mortality rate is fixed at 1.00 in option C (see Append. 5).

After choosing a mortality option and inputting information specific to the mortality option chosen, the program calculates the hatchery lake trout population characteristics after 20 years of the same management. Mortality rates, mortality numbers, and the number of survivors are determined for each age class.

The total mortality rate calculated by the program was the total annual mortality (A) (Ricker 1975). This value was determined by the equation:

$$A = m + n - mn$$

where m is the conditional rate of exploitation and n is the conditional natural mortality rate. This equation emulates a Type II fisheries where fishing and natural mortality occur simultaneously, closely simulating a natural situation (Ricker 1975).

The user should note that this equation defines total mortality as a not strictly additive function between the conditional rates of exploitation and natural mortality. This equation takes into account that some trout caught in the fisheries would have naturally died.

The conditional rate of exploitation (m) was used as the fishing mortality rate in the program (Ricker 1975). This value was determined by distributing the specified catch for each fishery over the 14 age classes through the use of the fishery specific catch curves (Fig. 3). The catch by fishery by age class was summed to provide the total catch by age class. This value was then divided by the number of survivors in that age class to arrive at the conditional rate of exploitation for that age class. By using this method, fishing mortality was governed by both the amount and the type of fishing specified by the user.

When the total annual mortality rate (A) does not exceed the limit set by the operator, then natural and fishing mortality take place simultaneously. When the total annual mortality rate exceeds the limit set, then fish are removed on a basis determined by the mortality option selected.

After the computation of the population numbers, the program calculates the spawning population characteristics. These calculations include the number of mature adults, the number of mature age classes, the number of mature fish/acre of spawning reef, the total number of eggs deposited, and the number of eggs/acre of spawning reef.

The model assumed that all lake trout were mature at age VII. Studies elsewhere indicate that some lake trout mature before this age, but the data vary by lake and sex (Healey 1978). Thus, for simplicity of the model, we assumed that no fish were mature at age VI and that all fish were mature at age VII and thereafter. For purposes of this model, a 50:50 sex ratio was assumed from age VII through age XX or termination of the population.

In the equation used to compute egg deposition, the percentage of return of mature adults to a reef during spawning season was assumed to be less than 100% in order to account for a suspected inability to home or recognize suitable spawning areas (Brown et al. 1981, Krueger et. al. 1986). The value used for this rate was 0.6, except for the Mid-Lake Reef Zone where a rate of 0.8 was used. Trout in the Mid-Lake Reef Zone were suspected to have a decreased tendency to stray from reefs due to the surrounding deep water (Ross Horrall, pers. comm.).

The amount of reef area available for spawning was determined from maps of the historical lake trout spawning reefs in the Wisconsin waters of Lake Michigan (Coberly and Horrall 1980). The area of each spawning reef was determined using a polar planimeter. Four measurements of each reef were taken and the average value was used as the area in acres (Append. 6).

The lake trout spawning reef acres available in each management zone were determined by summing the areas of individual reefs found in each management zone (Fig. 1). These values were (see Append. 3, lines 3732-3735):

1)	Clay Banks Zone	14,451 acres
2)	Mid-Lake Reef Zone	140,486 acres
3)	Kewaunee - Kenosha	43,714 acres
4)	All of the above	198,651 acres

When the calculations are completed, the program displays a screen menu describing the outputs available. Examples of these output are given in Appendix 5. Options are also provided to return to the beginning of the program (to run another scenario) or to leave the program entirely.

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APPENDIX 1.

Program structure listing by line number and function.

line #	Description
1000-2710	Set internal variables/dimensions.
3010-3270	Menu - choose model.
3280-3360	Menu - choose mortality option.
3370-3510	Input parameters - option A and C, stocking, catch, mortality rate.
3511-3720	Population dynamics computation - option A and C.
3725-3800	Spawning population characteristics.
3900-3970	Zero unneeded printout values.
4000-4100	Input parameters - option B.
4110-4370	Population dynamics computation - option B.
4400-4450	Reallocate catch and natural mortality rates if total exceeds 1.00 - option A.
4500-4600	Reallocate catch and natural mortality rates if total exceeds 1.00 - option C.
4700-4950	Reallocate catch per age class if fishing mortality exceeds acceptable level.
5000-5500	Menu - choose output.
6000-6230	Output - list parameters used in run.
7000-7210	Output - Table 1.
7500-7690	Output - Table 2.
8000-8220	Output - Table 3.
9000-9150	Output - print out all available tables on printer.

APPENDIX 2.

Variables used in the simulation model.

A key to the variables used in this program is listed below. Variable identifiers are listed in order of use: prefix, suffix, and single unit variables. In each one of these groups, the variable identifiers are listed in alphabetical order. Prefix and suffix identifiers are combined to make variable names. For example, the variable that represents the allowable catch (suffix "T") of lake trout in the sport fishery (prefix "R") has the variable name of RT.

PREFIX

Total annual mortality	A-
Fishing mortality	F-
Large mesh gill net	L-
Natural mortality	M-
Trap/pound net	P-
Sport	R-
Small mesh gill net	S-
Trawl	T-

SUFFIX

Numbers	-N
Rates	-R
Allowable catches (quotas)	-T
Fishery catch at an age class	-Y
Fishery type sum	-Z

SINGLE UNIT VARIABLES

Eggs deposited	EG
Egg fecundity	EF
Egg fertilization rate	ER
Sum of allowable quotas	ET
Fishing mortality rates	FR or U
Mature age classes	MA
Mature trout	MT
Number stocked	NS
Spawning reef acres	SA
Total allowable mortality	TA mortality option B
rates	TM mortality option C

APPENDIX 3.

Program listing of the simulation model.

```
1000  REM  S.M.O.L.T.
1010  REM  SIMULATED MORTALITY OF
                        LAKE TROU
    T
1020  REM  SET DIMENSIONS FOR ARR
    AYS FOR            VARIABLES

1030  DIM N(20),A(20),AN(20),M(20
    ),MN(20),Z(20),EF(20),C$(20)

1040  DIM NF(20),FR(20),SN(20),SR
    (20)
1042  DIM LN(20),LR(20),TN(20),TR
    (20)
1044  DIM PN(20),PR(20),RN(20),RR
    (20)
1050  REM  FIX RATE VALUES IN ARR
    AYS FOR EACH AGE CLASS IT CO
    RRESPONDS TO
1060  FOR I = 1 TO 4
1065 M(I) = 0.37
1068  NEXT
1070  FOR I = 5 TO 20
1075 M(I) = 0.25
1078  NEXT
1260 EF(1) = 0: REM  'EF'=EGG FEC
    UNDITY
1270 EF(2) = 0
1280 EF(3) = 0
1290 EF(4) = 0
1300 EF(5) = 0
1310 EF(6) = 0
1320 EF(7) = 3942
1330 EF(8) = 4887
1340 EF(9) = 5436
1350 EF(10) = 7155
1360 EF(11) = 8349
1370 EF(12) = 11000
1380 EF(13) = 12500
1390 EF(14) = 12500
1400 EF(15) = 6000
1410 EF(16) = 6000
1420 EF(17) = 6000
1430 EF(18) = 6000
1440 EF(19) = 6000
1450 EF(20) = 6000
1460 SR(1) = .0029: REM  'SR'=SMA
    LL MESH CATCH DISTRIBUTION
1470 SR(2) = .0708
1480 SR(3) = .5333
1490 SR(4) = .1545
1500 SR(5) = .1002
1510 SR(6) = .0389
1520 SR(7) = .0302
1530 SR(8) = .0268
1540 SR(9) = .0131
1550 SR(10) = .0083
1560 SR(11) = .0029
1570 SR(12) = .0036
1580 SR(13) = 0.0086
1590 SR(14) = 0.0059
1600 SR(15) = 0
1610 SR(16) = 0
1620 SR(17) = 0.0000
1630 SR(18) = 0.0000
1640 SR(19) = 0.0000
1650 SR(20) = 0.0000
1660 LR(1) = 0.000: REM  'LR'=LG
    MSH RATE
1670 LR(2) = .0016
1680 LR(3) = .053
1690 LR(4) = .3701
1700 LR(5) = .2277
1710 LR(6) = .1151
1720 LR(7) = .0803
1730 LR(8) = .0604
1740 LR(9) = .0356
1750 LR(10) = .0149
1760 LR(11) = .0165
1770 LR(12) = .0066
1780 LR(13) = .0099
1790 LR(14) = .0083
1800 LR(15) = 0
1810 LR(16) = 0
1820 LR(17) = 0
1830 LR(18) = 0
1840 LR(19) = 0
1850 LR(20) = 0.0000
1860 TR(1) = 0.0000: REM 'TR'=TRA
    WL RATE
1870 TR(2) = 0
1880 TR(3) = .0256
1890 TR(4) = .2006
1900 TR(5) = .2016
1910 TR(6) = .1374
1920 TR(7) = .0721
1930 TR(8) = .1057
1940 TR(9) = .0464
1950 TR(10) = .0929
1960 TR(11) = .0307
1970 TR(12) = .0158
1980 TR(13) = .0395
1990 TR(14) = .0317
2000 TR(15) = 0
2010 TR(16) = 0
2020 TR(17) = 0
2030 TR(18) = 0.0000
2040 TR(19) = 0.0000
2050 TR(20) = 0.0000
2060 PR(1) = 0.0000: REM  'PR'=PD
    /TRP RATE
2070 PR(2) = 0.0000
2080 PR(3) = 0.0000
2090 PR(4) = .0432
```

```
2100 PR(5) = .1691
2110 PR(6) = .2302
2120 PR(7) = .2518
2130 PR(8) = .1655
2140 PR(9) = .0467
2150 PR(10) = .0215
2160 PR(11) = .0288
2170 PR(12) = .0108
2180 PR(13) = .0180
2190 PR(14) = .0144
2200 PR(15) = 0
2210 PR(16) = 0
2220 PR(17) = 0
2230 PR(18) = 0
2240 PR(19) = 0.0000
2250 PR(20) = 0.0000
2260 RR(1) = 0.0000: REM  'RR'=SP
     ORT RATE
2270 RR(2) = .0011
2280 RR(3) = .0033
2290 RR(4) = .0183
2300 RR(5) = .2154
2310 RR(6) = .2775
2320 RR(7) = .1126
2330 RR(8) = .0729
2340 RR(9) = .0654
2350 RR(10) = .0568
2360 RR(11) = .0536
2370 RR(12) = .0472
2380 RR(13) = .0407
2390 RR(14) = .0352
2400 RR(15) = 0
2410 RR(16) = 0
2420 RR(17) = 0
2430 RR(18) = 0
2440 RR(19) = 0
2450 RR(20) = 0.0000
2460 C$(1) = "    I"
2470 C$(2) = "   II"
2480 C$(3) = "  III"
2490 C$(4) = "   IV"
2500 C$(5) = "    V"
2510 C$(6) = "   VI"
2520 C$(7) = "  VII"
2530 C$(8) = " VIII"
2540 C$(9) = "   IX"
2550 C$(10) = "    X"
2560 C$(11) = "   XI"
2570 C$(12) = "  XII"
2580 C$(13) = " XIII"
2590 C$(14) = "  XIV"
2600 C$(15) = "   XV"
2610 C$(16) = "  XVI"
2620 C$(17) = " XVII"
2630 C$(18) = "XVIII"
2640 C$(19) = "  XIX"
2650 C$(20) = "   XX"
2660  REM  ZERO VARIABLES
2670 TA = 0:TM = 0
2680 NS = 0:ST = 0
2690 LT = 0:TT = 0
2700 PT = 0:RT = 0
2710 ET = 0
3010  PRINT : PRINT : PRINT : PRINT
3020  PRINT : PRINT
3070  HOME
3080  PRINT "THIS PROGRAM COMPUTE
     S THE NUMBER OF LAKETROUT SU
     RVIVING IN EACH AGE CLASS IN
      A  GIVEN AREA (SOUTH OF THE
      BAILEYS HARBOR LINE)."
3085  PRINT
3090  PRINT "DO YOU WISH TO RUN T
     HE MODEL FOR:"
3095  PRINT
3100  PRINT "  1) THE CLAY BANKS
     ZONE"
3110  PRINT "  2) THE MID-LAKE RE
     EF ZONE"
3120  PRINT "  3) KENOSHA-KEWAUNE
     E ZONE"
3130  PRINT "  4) ALL OF THE ABOV
     E"
3230  PRINT
3250  PRINT
3260  PRINT "KEY IN ONE CHOICE:"
3265  GET CI$
3270  IF CI$ <  > "1" AND CI$ <  >
     "2" AND CI$ <  > "3" AND CI$
      <  > "4" THEN  GOTO 3260
3280  HOME : REM  CLEAR THE SCREE
     N
3290  PRINT "CHOOSE ONE OF THE FO
     LLOWING:"
3300  PRINT
3310  PRINT "'A' : SET ALLOWABLE
     CATCH NUMBERS FOR          EA
     CH FISHERY"
3315  PRINT
3320  PRINT "'B' : SET TOTAL ALLO
     WABLE ANNUAL MORTAL-       IT
     Y RATE"
3322  PRINT
3325  PRINT "'C' : SET ALLOWABLE
     CATCH NUMBERS FOR          EA
     CH FISHERY WITH A MAXIMUM TO
     TAL       ANNUAL MORTALITY R
     ATE NOT TO BE          EXCEED
     ED"
3330  PRINT : PRINT : PRINT
3340  PRINT "ENTER YOUR CHOICE: "
3345  GET J$
```

```
3350  IF J$ <  > "A" AND J$ <  >
    "B" AND J$ <  > "C" THEN  GOTO
    3340
3360  IF J$ = "B" THEN  GOTO 4000

3370  REM  CONTINUE WITH CHOICE '
    A'
3380  HOME
3390  PRINT "YOU CHOSE TO SET ALL
    OWABLE CATCH NUMBERSFOR EACH
     FISHERY.  FILL IN THE DATA
    AS  IT IS ASKED FOR."
3395  PRINT
3400  INPUT "ENTER THE ANNUAL LAK
    E TROUT STOCKING          RAT
    E: ";NS
3410  IF NS <  = 100 THEN NS = 10
    00000
3420  PRINT : PRINT "ENTER THE AL
    LOWABLE CATCH (IN NUMBERS)
        FOR THE:"
3430  PRINT
3440  INPUT "SMALL MESH GILL NET
    FISHERY: ";ST
3450  INPUT "LARGE MESH GILL NET
    FISHERY: ";LT
3460  INPUT "TRAWL NET FISHERY: "
    ;TT
3470  INPUT "TRAP AND POUND NET F
    ISHERY: ";PT
3480  INPUT "SPORT FISHERY: ";RT
3490 ET = ST + LT + TT + PT + RT
3500  IF ET < NS THEN  GOTO 3502
3501  PRINT "THE TOTAL CATCH OF A
    LL THE FISHERIES    EXCEEDS
    THE STOCKING RATE.  PLEASE E
    NTERTHE CATCH VALUES AGAIN A
    ND DO BE A      LITTLE MORE
    CONSERVATIVE.": PRINT : GOTO
    3440
3502  IF J$ = "A" THEN  GOTO 3510

3504  PRINT
3506  PRINT "ENTER THE MAXIMUM TO
    TAL ANNUAL MORTALITYRATE WHI
    CH IS NOT TO BE EXCEEDED BY
    BOTHTHE ABOVE FISHERIES AND
    THE NATURAL      MORTALITY"
3507  PRINT
3508  INPUT "CHOOSE A VALUE BETWE
    EN 0.31 AND 1.00:";TM
3509  IF (TM < .31) OR (TM > 1.00
    ) THEN  PRINT "PLEASE FOLLOW
     INSTRUCTIONS.": GOTO 3508
3510 FL = 0
3511  REM  ZERO SUMMATION VARIABL
    ES
3512 SZ = 0
3513 LZ = 0
3514 TZ = 0
3515 PZ = 0
3516 RZ = 0
3517 EZ = 0
3520  FOR I = 1 TO 20
3525 N(I) = 0:SN(I) = 0
3530 LN(I) = 0:TN(I) = 0
3535 PN(I) = 0:RN(I) = 0
3540 NF(I) = 0:AN(I) = 0
3545 MN(I) = 0:FR(I) = 0
3547 A(I) = 0
3550  NEXT I
3560  FOR I = 1 TO 20
3565 N(1) = NS
3567  IF N(I) = 0 THEN  GOTO 3900

3570 SN(I) = SR(I) * ST
3575 SN(I) =  INT (SN(I))
3580 SZ = SZ + SN(I)
3585 LN(I) = LR(I) * LT
3590 LN(I) =  INT (LN(I))
3595 LZ = LZ + LN(I)
3600 TN(I) = TR(I) * TT
3605 TN(I) =  INT (TN(I))
3610 TZ = TZ + TN(I)
3615 PN(I) = PR(I) * PT
3620 PN(I) =  INT (PN(I))
3625 PZ = PZ + PN(I)
3630 RN(I) = RR(I) * RT
3635 RN(I) =  INT (RN(I))
3637 RZ = RZ + RN(I)
3640 NF(I) = SN(I) + LN(I) + TN(I
    ) + PN(I) + RN(I)
3645 NF(I) =  INT (NF(I))
3650 EZ = EZ + NF(I)
3655 FR(I) = NF(I) / N(I)
3662 U = FR(I)
3664 M = M(I)
3665 A(I) = M + U - (M * U)
3666  IF (A(I) > 1) AND (J$ <  >
    "C") THEN  GOSUB 4400
3667  IF J$ = "C" THEN  GOSUB 450
    0
3668  IF I = 20 THEN  GOTO 3690
3670 N(I + 1) = N(I) * (1 - (A(I)
    ))
3690 AN(I) = A(I) * N(I)
3695 AN(I) =  INT (AN(I))
3700 MN(I) = M(I) * N(I)
3705 MN(I) =  INT (MN(I))
3710 N(I) =  INT (N(I))
3712  IF I = 20 THEN  GOTO 3720
3715  IF N(I + 1) < 1 THEN N(I +
    1) = 0
3720  NEXT I
```

```
3725  REM  NOW COMPUTE THE NUMBER
      OF MATURE FISH AND AGE CLAS
     SES AND THE EGGS DEPOSITED
3730 MT = 0: REM  MATURE TROUT
3731  REM  SPAWNING ACRES
3732  IF CI$ = "1" THEN SA = 1445
     1
3733  IF CI$ = "2" THEN SA = 1404
     86
3734  IF CI$ = "3" THEN SA = 4371
     4
3735  IF CI$ = "4" THEN SA = 1986
     51
3737 MA = 0: REM  AGE CLASSES
3740 EG = 0: REM  EGGS DEPOSTED
3742 TA = 0: REM  MATURE TROUT/AC
     RE
3745 ER = 0.9: REM  FERT.RATE
3748 HR = 0.6: REM  HOMING RATE
3749  IF CI$ = "2" THEN HR = 0.8
3750  FOR I = 7 TO 20
3760 MT = MT + N(I)
3770  IF N(I) > 1 THEN MA = MA +
     1
3780 EG = EG + (((N(I) * 0.5) * (
     EF(I) * ER)) * HR)
3782  NEXT I
3784  REM  COMPUTE # EGGS/ACRE OF
      SPAWNING REEF
3786 EA =  INT (EG / SA)
3788  REM  COMPUTE # MATURE TROUT
     /ACRE OF SPAWNING REEF
3789 TA = (MT / SA) + 0.5
3790 TA =  INT (TA)
3800  GOTO 5000
3900  REM  ZERO OVERLOAD VALUES
3910  REM  FROM LINE 3718
3920  FOR I = I TO 20
3930 M(I) = 0
3940 FR(I) = 0
3950 A(I) = 0
3960  NEXT I
3970  GOTO 3725: REM  GO ON W/PGM

4000  REM  CHOICE 'B'
4010  HOME
4020  PRINT "YOU CHOSE TO SET THE
      TOTAL ALLOWABLE    NATURAL
     MORTALITY RATE."
4030  PRINT
4040  INPUT "ENTER THE ANNUAL LAK
     E TROUT STOCKING           RAT
     E: ";NS
4050  IF NS < 0 THEN NS = 1000000

4060  PRINT
4070  PRINT "ENTER THE TOTAL ANNU
     AL MORTALITY RATE"
4080  INPUT "CHOOSE A VALUE BETWE
     EN 0.25 AND 0.60: ";TA
4090  IF (TA < 0.25) OR (TA > 0.6
     ) THEN  PRINT "PLEASE FOLLOW
      INSTRUCTIONS.": GOTO 4080
4100 FL = 1: REM  CHOICE 'B'
4110  REM  COMPUTE THE NUMBER OF
     FISH IN EACH AGE CLASS
4120  FOR I = 1 TO 20: REM  ZERO
     VARIABLES
4130 N(I) = 0:MN(I) = 0
4140 AN(I) = 0:NF(I) = 0
4150 A(I) = TA
4160  NEXT I
4170  FOR I = 1 TO 20
4180 N(0) = NS
4190 N(1) = NS
4200 N(2) = NS * (1 - TA)
4210 N(I) = N(I - 1) * (1 - TA)
4220 N(1) = NS
4230 N(2) = NS * (1 - TA)
4240 AN(I) = N(I) * TA
4250 AN(I) =  INT (AN(I))
4255 M = M(I)
4260 U = (TA - M) / (1 - M)
4270 FR(I) = U
4280  IF FR(I) < 0 THEN FR(I) = 0

4290 MN(I) = M(I) * N(I)
4300 MN(I) =  INT (MN(I))
4310 NF(I) = FR(I) * N(I)
4320 NF(I) =  INT (NF(I))
4330  IF NF(I) < 0 THEN NF(I) = 0

4340 N(I) =  INT (N(I))
4350  IF N(I) < 1 THEN  GOTO 3900

4360  NEXT I
4370  GOTO 3725: REM  COMPUTE MAT
     URE FISH AND EGG PRODUCTION
4400  REM  REALOCATE SUBPRGM
4410  IF A(I) > 1 THEN A(I) = 1
4420  IF FR(I) > 1 THEN FR(I) = A
     (I):M(I) = 0: GOTO 4440
4430 M(I) = (A(I) - FR(I)) / (1 -
     FR(I))
4440  GOSUB 4700
4450  RETURN
4500  REM  SUBPRGM FOR MAX TOTAL
     MORT
4510  IF A(I) <  = TM THEN  GOTO
     4600
4520  IF M > TM THEN TM = M
4530 A(I) = TM
4540 U = TM - M
4590 FR(I) = U
4595  GOSUB 4700
4600  RETURN
```

```
4700  REM  SUBPRGM TO RECOMPUTE C
     ATCH'S
4710 EZ = EZ - NF(I)
4720 SZ = SZ - SN(I)
4730 LZ = LZ - LN(I)
4740 TZ = TZ - TN(I)
4750 PZ = PZ - PN(I)
4760 RZ = RZ - RN(I)
4765  IF NF(I) <  = 0 THEN NF(I) =
     1
4770 SY = SN(I) / NF(I)
4780 LY = LN(I) / NF(I)
4790 TY = TN(I) / NF(I)
4800 PY = PN(I) / NF(I)
4810 RY = RN(I) / NF(I)
4815 X = FR(I) * N(I)
4820 SN(I) =  INT (SY * X)
4830 LN(I) =  INT (LY * X)
4840 TN(I) =  INT (TY * X)
4850 PN(I) =  INT (PY * X)
4860 RN(I) =  INT (RY * X)
4870 SZ = SZ + SN(I)
4880 LZ = LZ + LN(I)
4890 TZ = TZ + TN(I)
4900 PZ = PZ + PN(I)
4910 RZ = RZ + RN(I)
4920 NF(I) = SN(I) + LN(I) + TN(I
     ) + PN(I) + RN(I)
4930 EZ = EZ + NF(I)
4950  RETURN
5000  REM  DISPLAY MENU ON THE TU
     BE
5005 KT = 0: REM  CONTINUE INDICA
     TOR
5010  HOME
5020  PRINT "CHOOSE ONE OF THE FO
     LLOWING: "
5030  PRINT
5040  PRINT "A : LIST OF THE PARA
     METERS AS USED IN          T
     HIS RUN"
5050  PRINT "B : TABLE 1."
5060  PRINT "       NUMBER OF FISH
      IN EACH AGE CLASS"
5070  PRINT "       MORTALITY RATE
     S"
5080  PRINT "       NUMBER OF MATU
     RE LAKE TROUT"
5090  PRINT "       NUMBER OF MATU
     RE AGE CLASSES"
5100  PRINT "       NUMBER OF FERT
     ILE EGGS PRODUCED"
5110  PRINT "C : TABLE 2."
5112  PRINT "       NUMBER OF FISH
      IN EACH AGE CLASS"
5114  PRINT "       MORTALITY NUMB
     ERS"
5116  PRINT "D : TABLE 3."
5120  PRINT "       NUMBER OF FISH
      CAUGHT BY AGE BY          F
     ISHERY"
5130  PRINT "       *** NOT AVAILA
     BLE WITH FIXED TOTAL       M
     ORTALITY RATES ***"
5140  PRINT "E : PRINT ALL THE AB
     OVE."
5150  PRINT "F : RETURN TO BEGINN
     ING OF THE PROGRAM."
5160  PRINT "G : QUIT."
5170  PRINT "KEY IN ONE LETTER: "

5175  GET AN$
5180  IF AN$ < "A" OR AN$ > "G" THEN
      PRINT "YOUR RESPONSE IS OUT
      OF RANGE.  PLEASE CHOOSE AN
     OTHER LETTER.": GOTO 5170
5190  IF AN$ = "A" THEN  GOTO 600
     0
5200  IF AN$ = "B" THEN  GOTO 700
     0
5210  IF AN$ = "C" THEN  GOTO 750
     0
5220  IF AN$ = "D" THEN  GOTO 800
     0
5230  IF AN$ = "E" THEN  GOTO 900
     0
5240  IF AN$ = "F" THEN  GOTO 105
     0
5250  IF AN$ = "G" THEN  GOTO 550
     0
5500  END
6000  REM  SUBROUTINE 'A'
6010  REM  PRINT PARAMETERS
6015  HOME
6022  IF CI$ = "1" THEN CI$ = "CL
     AY BANKS ZONE."
6024  IF CI$ = "2" THEN CI$ = "MI
     D-LAKE REEF ZONE."
6026  IF CI$ = "3" THEN CI$ = "KE
     NOSHA-KEWAUNEE ZONE."
6028  IF CI$ = "4" THEN CI$ = "EN
     TIRE LAKE SOUTH OF BAILEYS H
     ARBOR."
6030  PRINT : PRINT "THIS MODEL I
     S FOR THE ";CI$
6035  PRINT
6037  PRINT "THESE ARE THE VALUES
      FOR THE VARIABLES USED IN T
     HIS RUN."
6038  PRINT
6040  PRINT "NUMBER OF LAKE TROUT
      STOCKED: ";NS
6050  PRINT
6060  IF FL = 0 THEN  GOTO 6100
6070  IF FL = 1 THEN
```

```
6080  PRINT "THE TOTAL ALLOWABLE
     ANNUAL MORTALITY RATE IS ";T
     A
6085  PRINT : PRINT
6090  GOTO 6185
6100  PRINT "NUMBER OF FISH ALLOW
     ED TO BE CAUGHT BY FISHERY:"
6110  PRINT "SMALL MESH GILL NET:
      ";ST
6120  PRINT "LARGE MESH GILL NET:
      ";LT
6130  PRINT "TRAWL NET: ";TT
6140  PRINT "TRAP/POUND NET: ";PT
6150  PRINT "SPORT: ";RT
6160  PRINT
6170  PRINT "TOTAL ALLOWABLE CATC
     H: ";ET
6172  IF J$ < > "C" THEN  GOTO 6
     180
6174  PRINT
6176  PRINT "THE TOTAL ALLOWABLE
     ANNUAL MORTALITY RATE IS NOT
      TO EXCEED ";TM * 100;"%."
6180  PRINT
6182  PRINT "AFTER 20 YEARS THE P
     OPULATION DYNAMICS IN THE 20
     TH YEAR WOULD APPEAR AS FOLL
     OWS:"
6183  PRINT
6185  IF KT = 1 THEN  RETURN
6200  PRINT "PRESS THE SPACE BAR
     TO CONTINUE"
6210  GET A6$
6220  IF A6$ < > " " THEN  GOTO
     6200
6230  GOTO 5000
7000  REM  SUBROUTINE 'B'
7010  REM  TABLE 1.
7015  HOME
7020  PRINT "TABLE 1.  NUMBER OF
     LAKE TROUT SURVIVING AND THE
      MORTALITY RATES FOR EACH AG
     E CLASS."
7030  PRINT
7040  PRINT "--------------------
     ----------------------------
     ----------------------------
     ----"
7050  PRINT "  AGE             NUMB
     ER            NATURAL
     FISHING            TOTAL"
7060  PRINT " CLASS            SURVI
     VING         MORTALITY       M
     ORTALITY       MORTALITY"
7070  PRINT "--------------------
     ----------------------------
     ----------------------------
     ----"
7080  PRINT
7090  FOR I = 1 TO 20
7095  PRINT C$(I); TAB( 15);N(I);
      TAB( 35);M(I); TAB( 45);FR(
     I); TAB( 22);A(I)
7100  NEXT I
7110  PRINT
7120  PRINT "--------------------
     ----------------------------
     ----------------------------
     ----"
7130  PRINT
7135  PRINT "ASSUMING THIS MANAGE
     MENT STRATEGY CONTINUES FOR
     20 YEARS;"
7137  PRINT
7140  PRINT "THE TOTAL NUMBER OF
     SURVIVING MATURE LAKE TROUT
     IS: ";MT
7150  PRINT "THIS REPRESENTS ";MA
     ;" MATURE AGE CLASSES,"
7155  PRINT "AND ";TA;" MATURE LA
     KE TROUT PER ACRE OF USABLE
     SPAWNING REEF."
7160  PRINT
7170  PRINT "THE TOTAL NUMBER OF
     FERTILIZED EGGS PRODUCED IS:
      ";EG
7172  PRINT "THIS RESULTS IN ";EA
     ;" EGGS PER ACRE OF USABLE S
     PAWNING REEF IN LAKE MICHIGA
     N."
7175  IF KT > 0 THEN  GOTO 9060
7180  PRINT "PRESS THE SPACE BAR
     TO CONTINUE"
7190  GET A7$
7200  IF A7$ < > " " THEN  GOTO
     7180
7210  GOTO 5000
7500  REM  SUBROUTINE 'C'
7510  REM  TABLE 2.
7520  HOME
7530  PRINT "TABLE 2.  NUMBER OF
     LAKE TROUT SURVIVING AND THE
      MORTALITIES FOR EACH AGE CL
     ASS."
7540  PRINT
7550  PRINT "--------------------
     ----------------------------
     ----------------------------
     ----"
7560  PRINT "  AGE             NUMB
     ER            NATURAL
     FISHING            TOTAL"
```

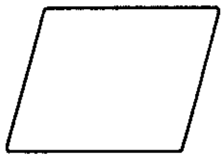
```
7570  PRINT " CLASS           SURVI
     VING         MORTALITY         M
     ORTALITY        MORTALITY"
7580  PRINT "-------------------
     ----------------------------
     ----------------------------
     ----"
7590  PRINT
7591 L = 0
7592 K = 0
7593 P = 0
7594 Q = 0
7595  FOR I = 1 TO 20
7596 L = L + N(I)
7597 K = K + NF(I)
7598 P = P + MN(I)
7599 Q = Q + AN(I)
7600  PRINT C$(I); TAB( 17);N(I);
      TAB( 33);MN(I); TAB( 47);NF
     (I); TAB( 24);AN(I)
7610  NEXT I
7620  PRINT
7622  PRINT "TOTAL"; TAB( 17);L; TAB(
     33);P; TAB( 47);K; TAB( 24);
     Q
7624  PRINT
7630  PRINT "-------------------
     ----------------------------
     ----------------------------
     ----"
7640  PRINT : PRINT
7650  IF KT > 0 THEN  GOTO 9090
7660  PRINT "PRESS THE SPACE BAR
     TO CONTINUE"
7670  GET AQ$
7680  IF AQ$ <  > " " THEN  GOTO
     7660
7690  GOTO 5000
8000  REM  SUBROUTINE 'D'
8010  REM  TABLE 3.
8015  HOME
8017  IF FL = 1 THEN  PRINT "***
     SORRY BUT THIS TABLE IS NOT
     AVAILABLE WITH OPTION  'B' -
      FIXING THE TOTAL MORTALITY
     RATE ***": GOTO 5000
8020  PRINT "TABLE 3.  NUMBER OF
     LAKE TROUT CAUGHT BY AGE BY
     FISHERY."
8030  PRINT
8040  PRINT "-------------------
     ----------------------------
     ----------------------------"

8050  PRINT "
                         TROUT CAUGHT"
8060  PRINT "  AGE           -----
     ----------------------------
     ----------------------------"

8070  PRINT " CLASS            SPOR
     T      SM MESH   LRG MSH   TR
     AWL      TRP/PD     TOTAL"
8080  PRINT "-------------------
     ----------------------------
     ----------------------------"

8090  PRINT
8100  FOR I = 1 TO 20
8110  IF (TN(I) < 10) AND (LN(I) =
     < 99) THEN  GOTO 8130
8120  PRINT C$(I); TAB( 17);RN(I)
     ; TAB( 28);SN(I); TAB( 38);L
     N(I); TAB( 7);TN(I); TAB( 17
     );PN(I); TAB( 27);NF(I): GOTO
     8140
8130  PRINT C$(I); TAB( 17);RN(I)
     ; TAB( 28);SN(I); TAB( 38);L
     N(I); TAB( 47);TN(I); TAB( 1
     7);PN(I); TAB( 27);NF(I)
8140  NEXT I
8150  PRINT
8154  IF (TZ < 10) AND (LZ =  < 9
     9) THEN  GOTO 8162
8160  PRINT "TOTAL"; TAB( 17);RZ;
      TAB( 28);SZ; TAB( 38);LZ; TAB(
     7);TZ; TAB( 17);PZ; TAB( 27)
     ;EZ: GOTO 8163
8162  PRINT "TOTAL"; TAB( 17);RZ;
      TAB( 28);SZ; TAB( 38);LZ; TAB(
     47);TZ; TAB( 17);PZ; TAB( 27
     );EZ
8163  PRINT
8164  IF (TT < 10) AND (LT =  < 9
     9) THEN  GOTO 8166
8165  PRINT "QUOTA"; TAB( 17);RT;
      TAB( 28);ST; TAB( 38);LT; TAB(
     7);TT; TAB( 17);PT; TAB( 27)
     ;ET: GOTO 8168
8166  PRINT "QUOTA"; TAB( 17);RT;
      TAB( 28);ST; TAB( 38);LT; TAB(
     47);TT; TAB( 17);PT; TAB( 27
     );ET
8168  PRINT
8169  IF RT = 0 THEN RP = 0: GOTO
     8171
8170 RP =  INT ((((RZ - RT) / RT)
      * 100) + .5)
8171  IF ST = 0 THEN SP = 0: GOTO
     8173
8172 SP =  INT ((((SZ - ST) / ST)
      * 100) + .5)
```

```
8173  IF LT = 0 THEN SP = 0: GOTO
     8175
8174 LP =  INT ((((LZ - LT) / LT)
      * 100) + .5)
8175  IF TT = 0 THEN TP = 0: GOTO
     8177
8176 TP =  INT ((((TZ - TT) / TT)
      * 100) + .5)
8177  IF PT = 0 THEN PP = 0: GOTO
     8179
8178 PP =  INT ((((PZ - PT) / PT)
      * 100) + .5)
8179  IF ET = 0 THEN EP = 0: GOTO
     8181
8180 EP =  INT ((((EZ - ET) / ET)
      * 100) + .5)
8181  PRINT "DEFICIT"; TAB( 17);R
     P;"%"; TAB( 28);SP;"%"; TAB(
     38);LP;"%"; TAB( 7);TP;"%"; TAB(
     17);PP;"%"; TAB( 27);EP;"%"
8183  PRINT
8184  PRINT "-------------------
     ----------------------------
     ---------------------------"

8185  IF KT > 0 GOTO 9130
8190  PRINT "PRESS THE SPACE BAR
     TO CONTINUE"
8200  GET A8$
8210  IF A8$ <  > " " THEN  GOTO
     8190
8220  GOTO 5000
9000  REM  SUBROUTINE 'E'
9010  REM  PRINT OUT TABLES
9020 KT = 1: REM  CNTRL RETURN CH
     R
9030  PR# 1
9035  PRINT  CHR$ (27); CHR$ (108
     ); CHR$ (15)
9040  GOSUB 6000: REM  PARAMETERS

9045  PR# 1
9050  GOTO 7000: REM  TABLE 1
9060  PR# 1
9070  PRINT  CHR$ (12)
9072  GOSUB 6000: REM  PARAMETERS

9074  PR# 1
9080  GOTO 7500: REM  TABLE 2
9090  IF FL = 1 GOTO 9130
9100  PR# 1
9110  PRINT  CHR$ (12)
9112  GOSUB 6000: REM  PARAMETERS
9114  PR# 1
9120  GOTO 8000: REM  TABLE 3
9130  PRINT  CHR$ (12)
9135  PRINT  CHR$ (27); CHR$ (108
     ); CHR$ (0)
9140  PR# 0
9150  GOTO 5000
```

APPENDIX 4.

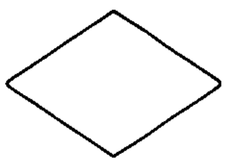
Flow diagram of the computational section of the simulation model.

LEGEND

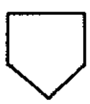


INPUT/OUTPUT

PROCESS

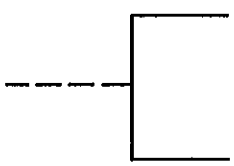


DECISION

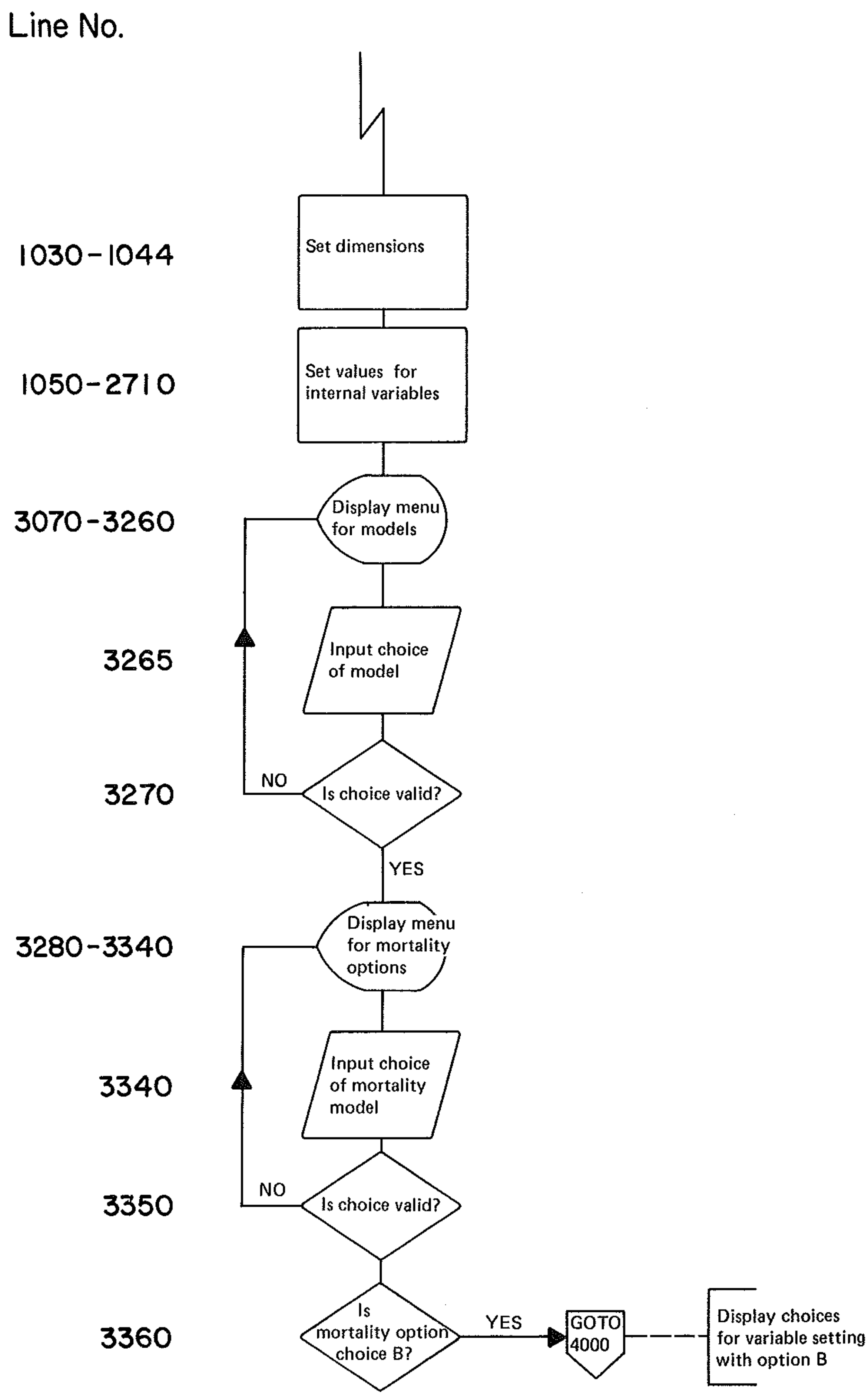


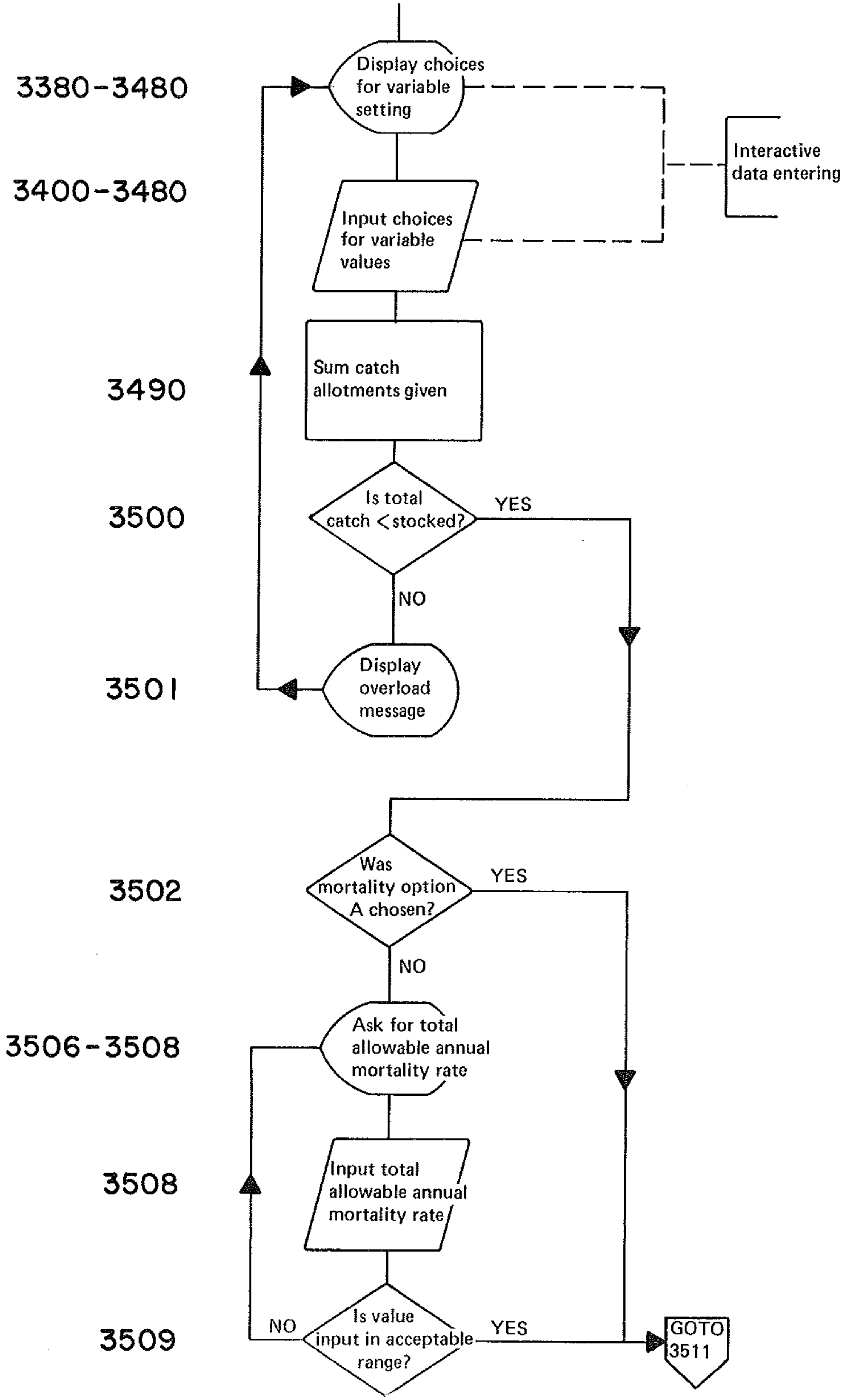
OFF PAGE CONNECTOR

CONNECTOR

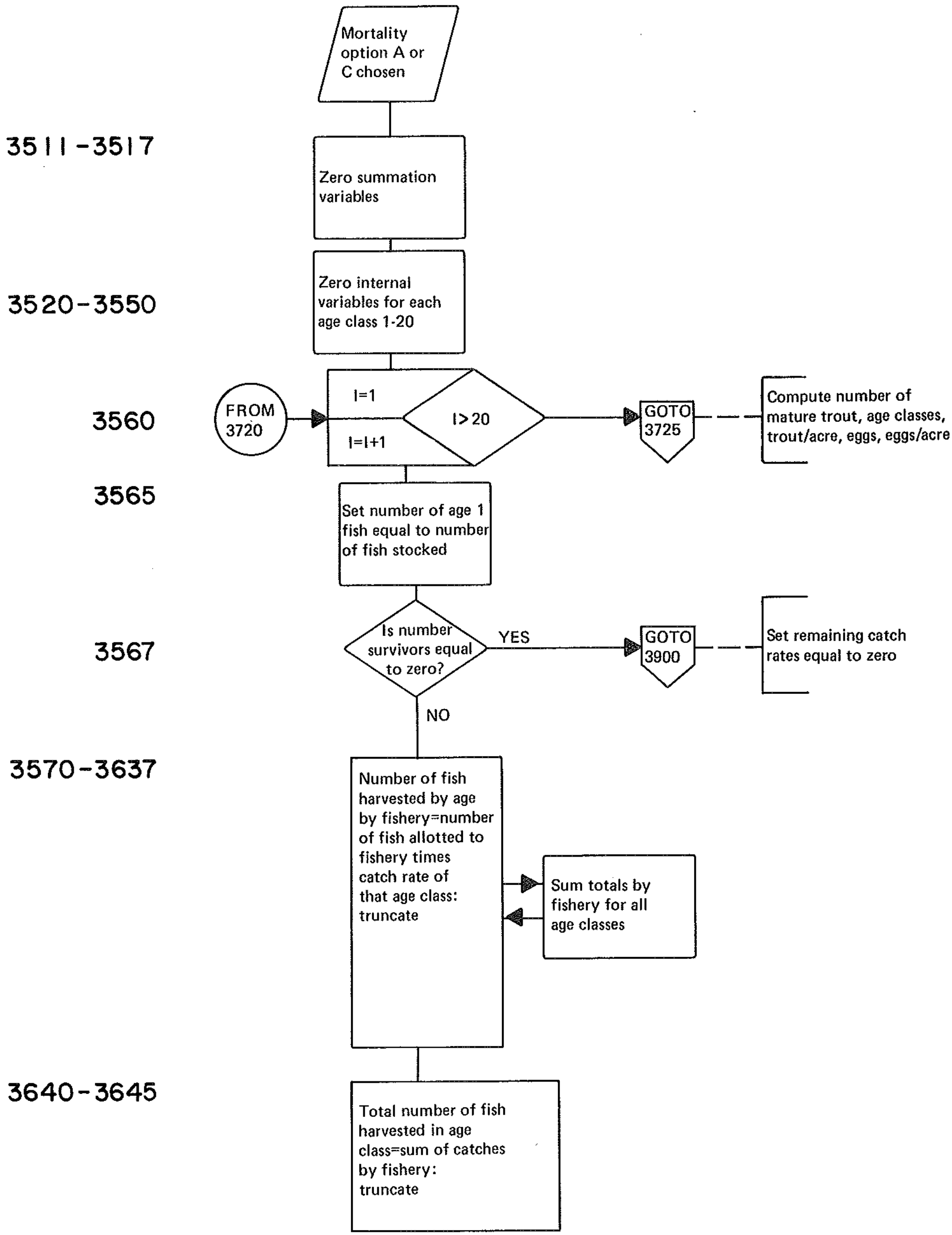


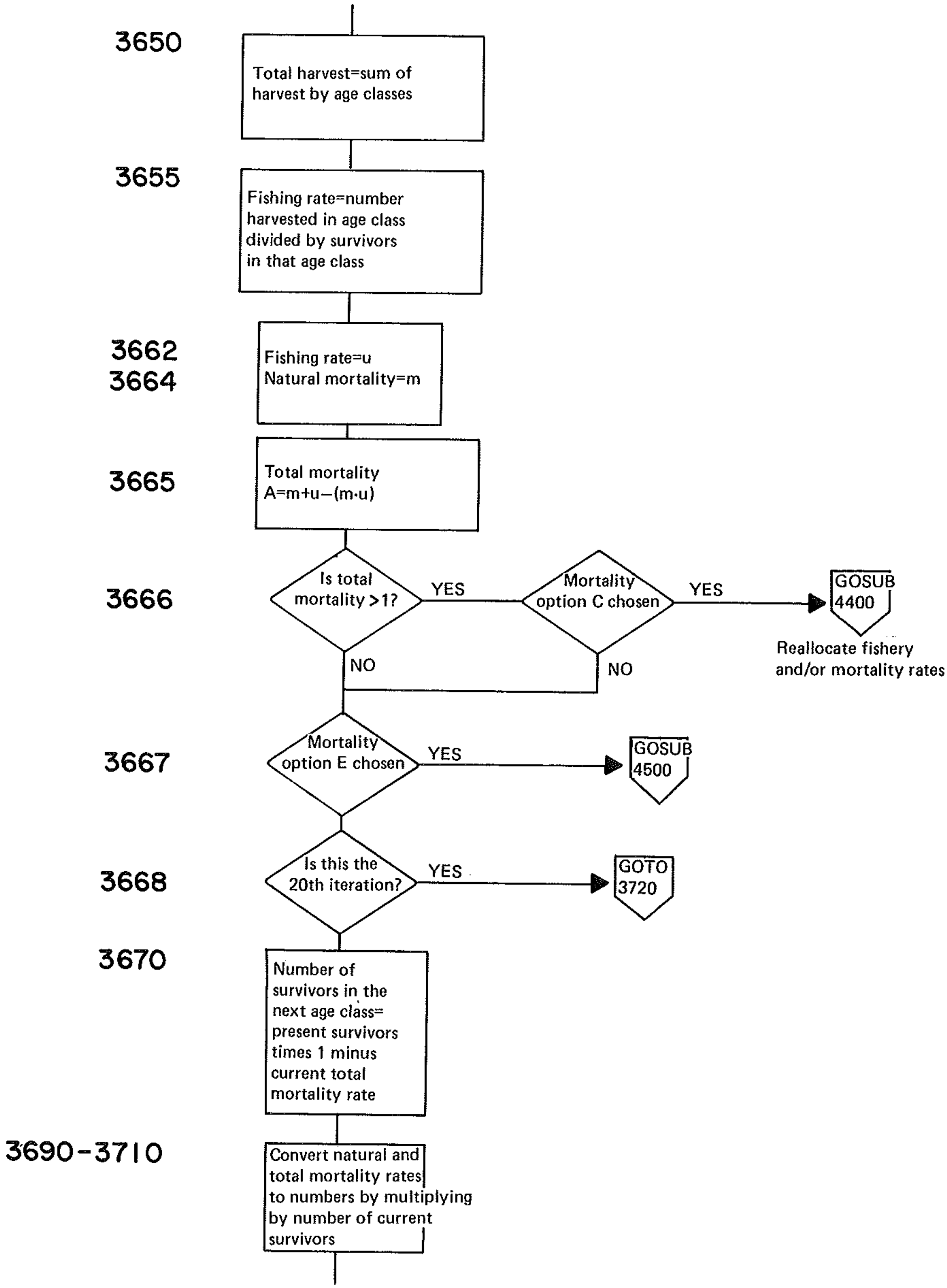
COMMENT

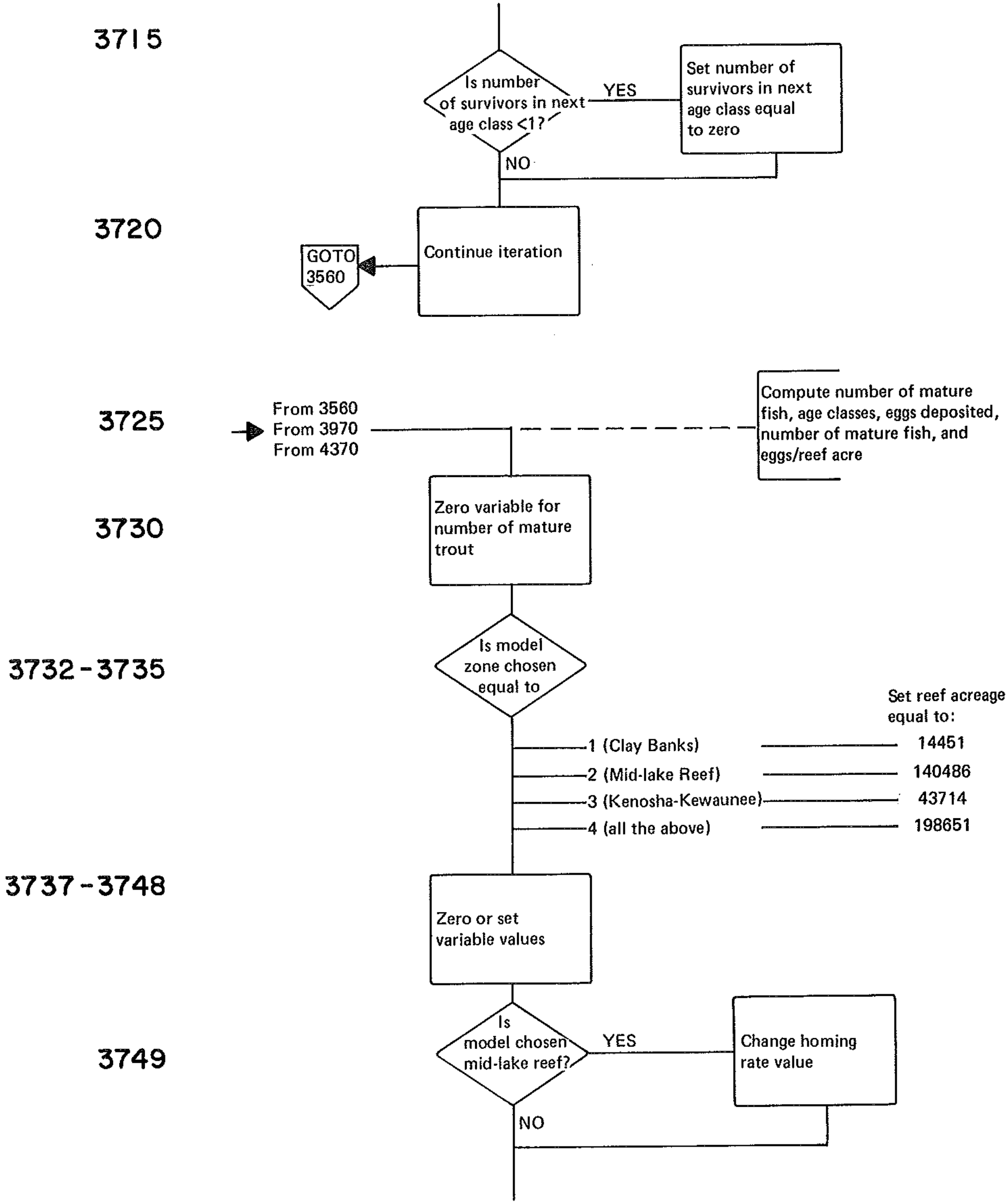

Line No.
1030-1044
Set dimensions
1050-2710
Set values for internal variables
3070-3260
Display menu for models
3265
Input choice of model
3270
Is choice valid?
NO
YES
3280-3340
Display menu for mortality options
3340
Input choice of mortality model
3350
Is choice valid?
NO
3360
Is mortality option choice B?
YES
GOTO 4000
Display choices for variable setting with option B

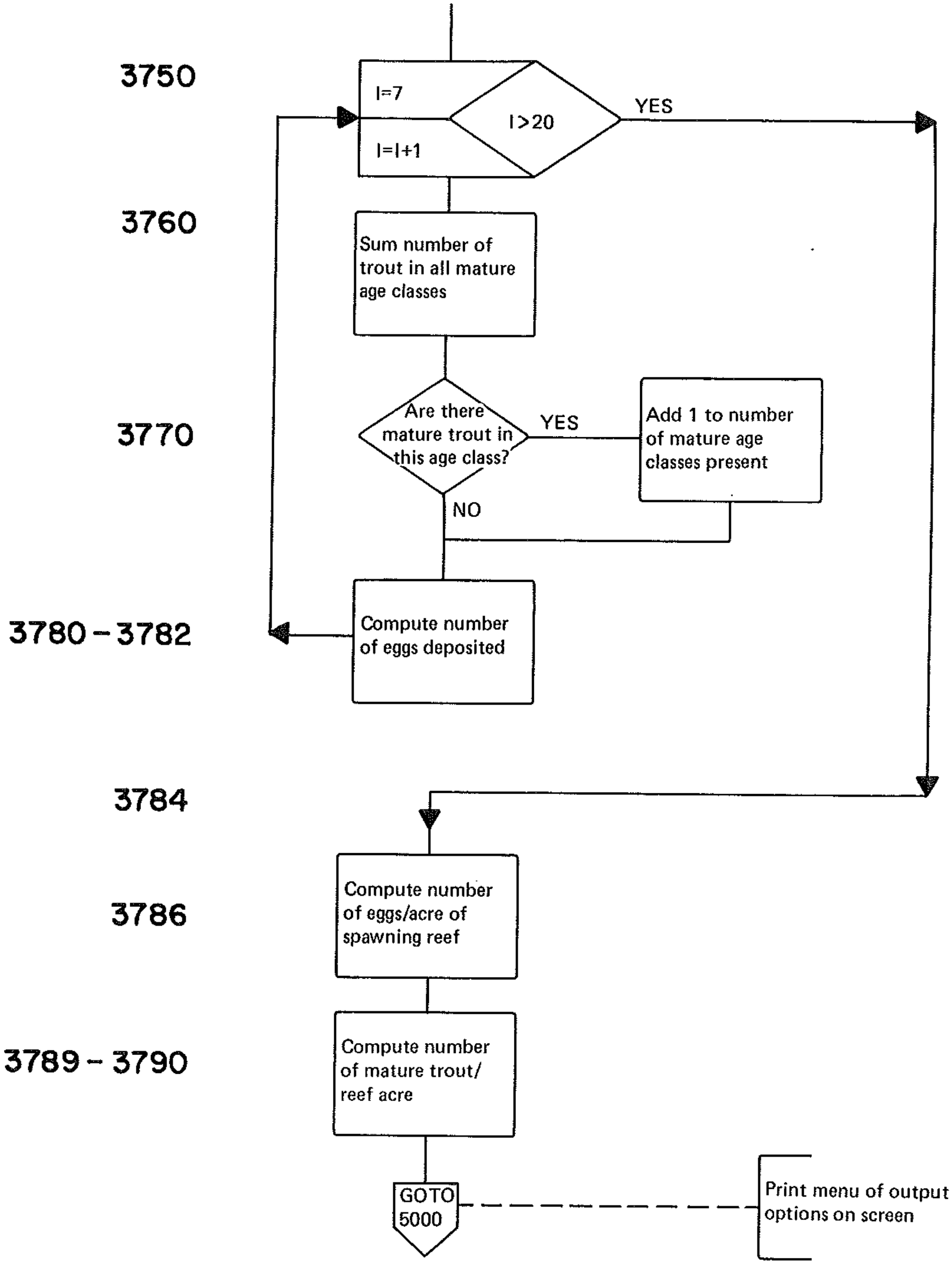


3380-3480
Display choices for variable setting
3400-3480
Input choices for variable values
Interactive data entering
3490
Sum catch allotments given
3500
Is total catch <stocked?
YES
NO
3501
Display overload message
3502
Was mortality option A chosen?
YES
NO
3506-3508
Ask for total allowable annual mortality rate
3508
Input total allowable annual mortality rate
3509
Is value input in acceptable range?
NO
YES
GOTO 3511

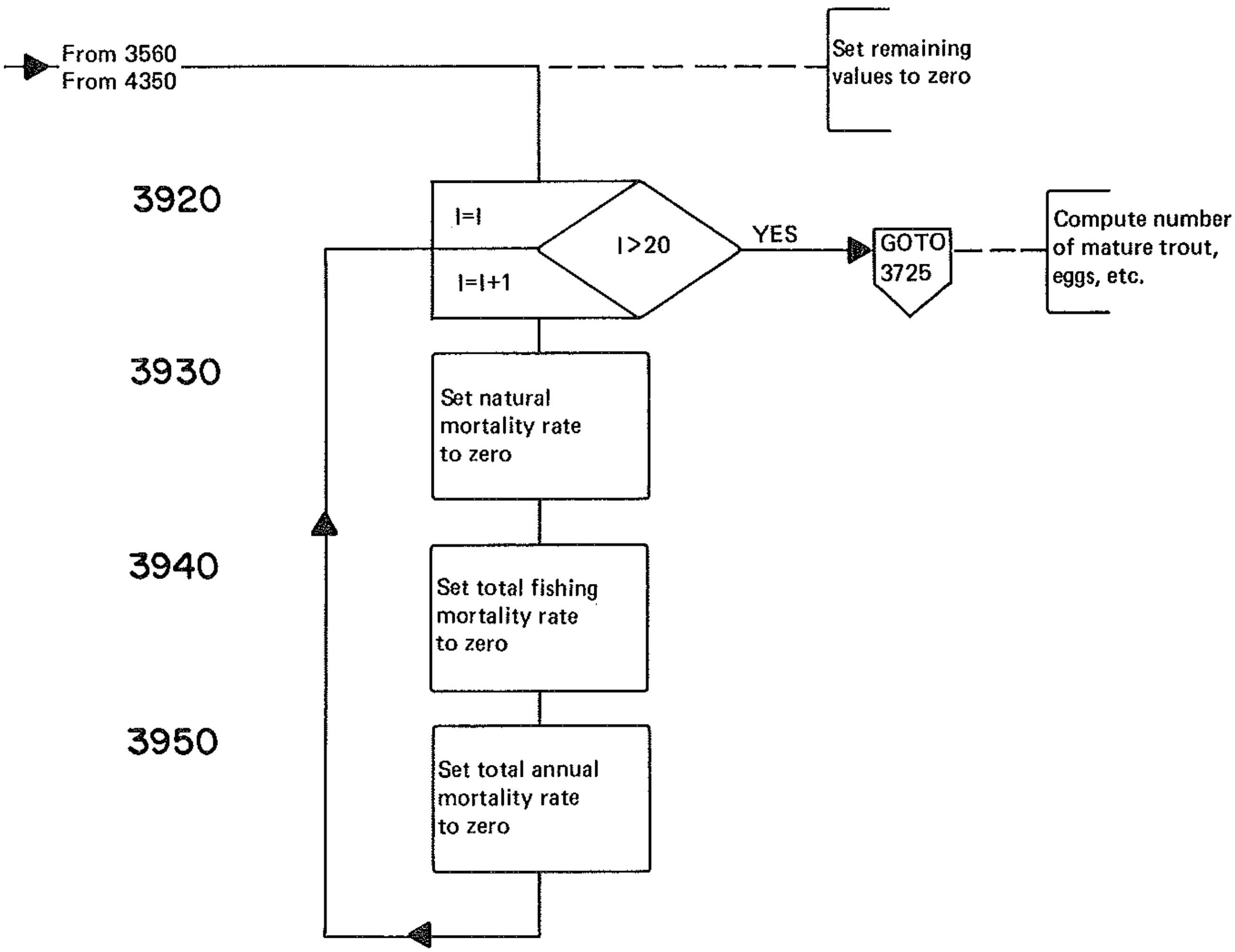

Mortality option A or C chosen
3511-3517
Zero summation variables
3520-3550
Zero internal variables for each age class 1-20
3560
FROM 3720
I=1
I=I+1
I>20
GOTO 3725
Compute number of mature trout, age classes, trout/acre, eggs, eggs/acre
3565
Set number of age 1 fish equal to number of fish stocked
3567
Is number survivors equal to zero?
YES
GOTO 3900
Set remaining catch rates equal to zero
NO
3570-3637
Number of fish harvested by age by fishery=number of fish allotted to fishery times catch rate of that age class: truncate
Sum totals by fishery for all age classes
3640-3645
Total number of fish harvested in age class=sum of catches by fishery: truncate

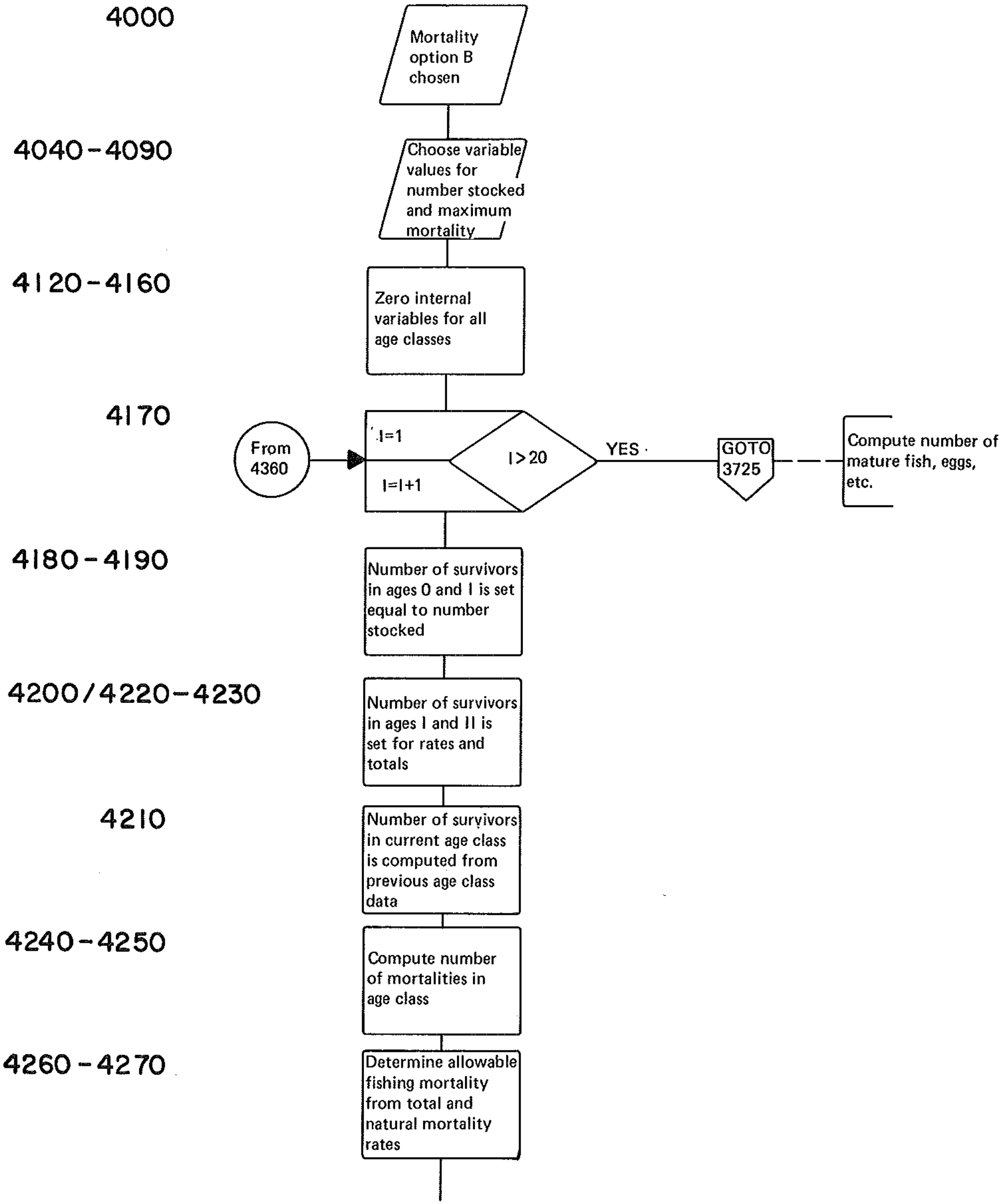

3650
Total harvest=sum of harvest by age classes
3655
Fishing rate=number harvested in age class divided by survivors in that age class
3662
3664
Fishing rate=u
Natural mortality=m
3665
Total mortality
A=m+u−(m·u)
3666
Is total mortality >1?
YES
Mortality option C chosen
YES
GOSUB 4400
Reallocate fishery and/or mortality rates
NO
NO
3667
Mortality option E chosen
YES
GOSUB 4500
3668
Is this the 20th iteration?
YES
GOTO 3720
3670
Number of survivors in the next age class= present survivors times 1 minus current total mortality rate
3690-3710
Convert natural and total mortality rates to numbers by multiplying by number of current survivors

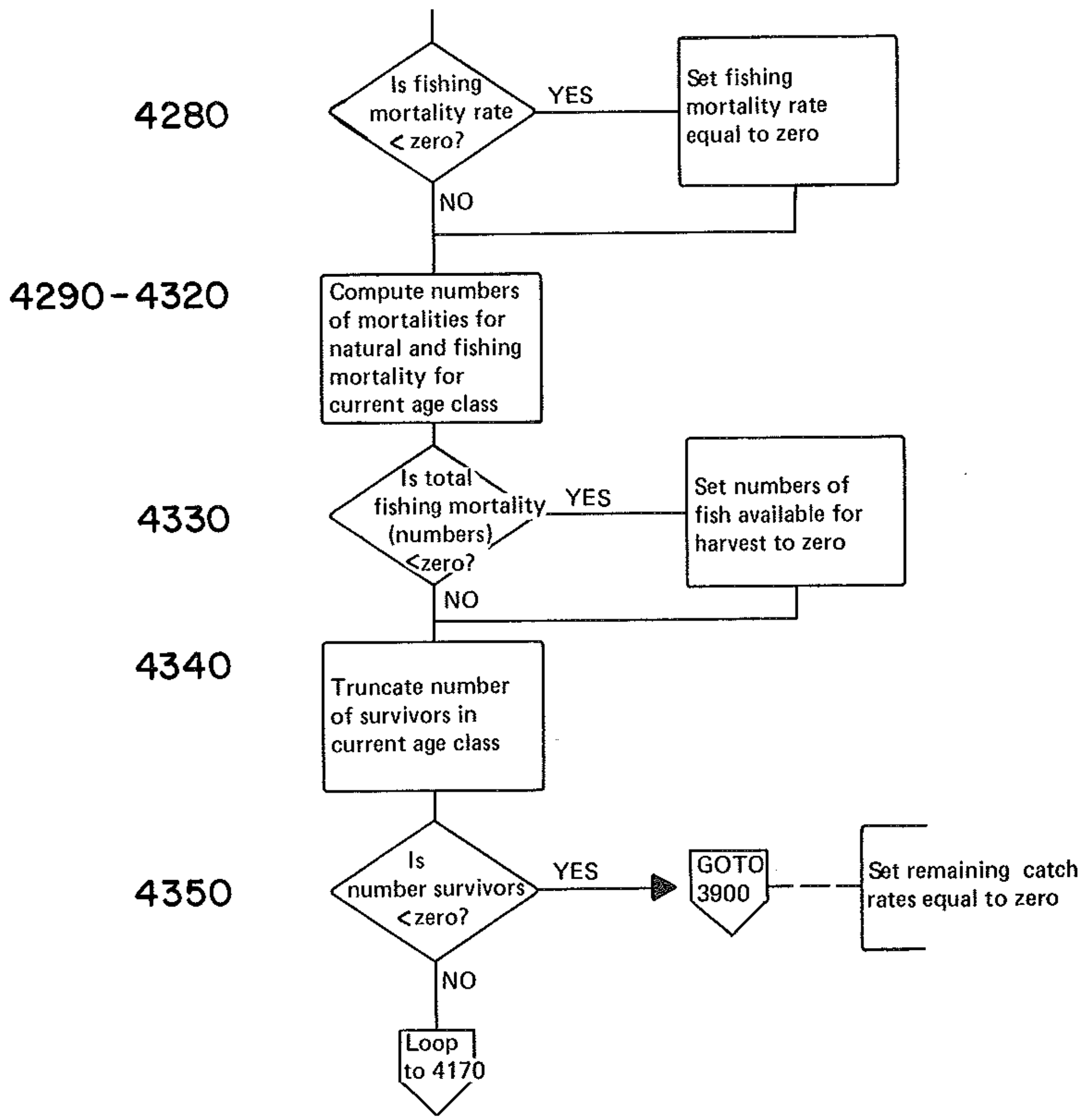

3715
Is number of survivors in next age class <1?
YES
Set number of survivors in next age class equal to zero
NO
3720
Continue iteration
GOTO 3560
3725
From 3560
From 3970
From 4370
Compute number of mature fish, age classes, eggs deposited, number of mature fish, and eggs/reef acre
3730
Zero variable for number of mature trout
3732-3735
Is model zone chosen equal to
Set reef acreage equal to:
1 (Clay Banks)
14451
2 (Mid-lake Reef)
140486
3 (Kenosha-Kewaunee)
43714
4 (all the above)
198651
3737-3748
Zero or set variable values
3749
Is model chosen mid-lake reef?
YES
Change homing rate value
NO


3750
I=7
I>20
I=I+1
YES
3760
Sum number of trout in all mature age classes
3770
Are there mature trout in this age class?
YES
Add 1 to number of mature age classes present
NO
3780 – 3782
Compute number of eggs deposited
3784
3786
Compute number of eggs/acre of spawning reef
3789 – 3790
Compute number of mature trout/ reef acre
GOTO 5000
Print menu of output options on screen

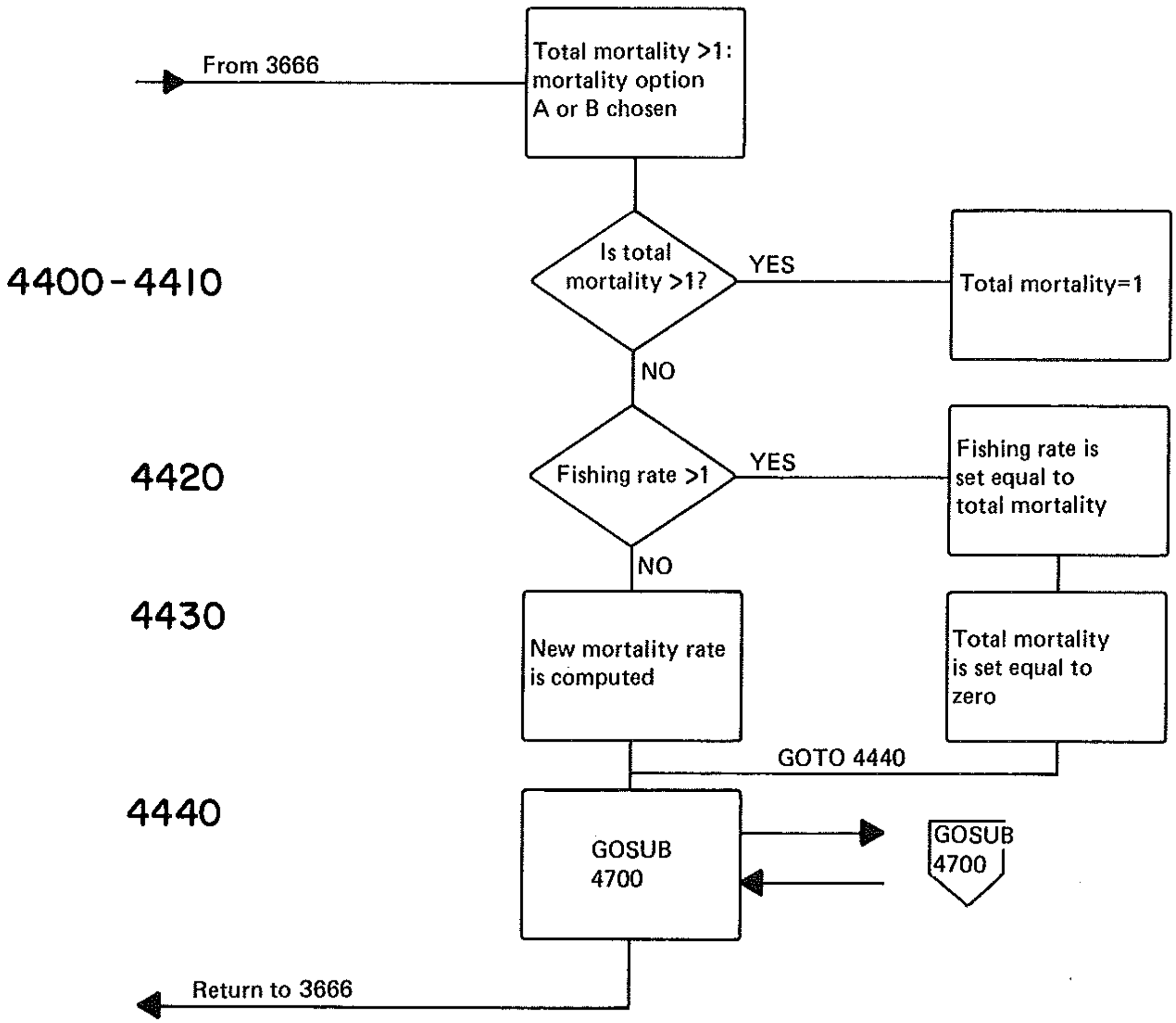
SubProgram 3900



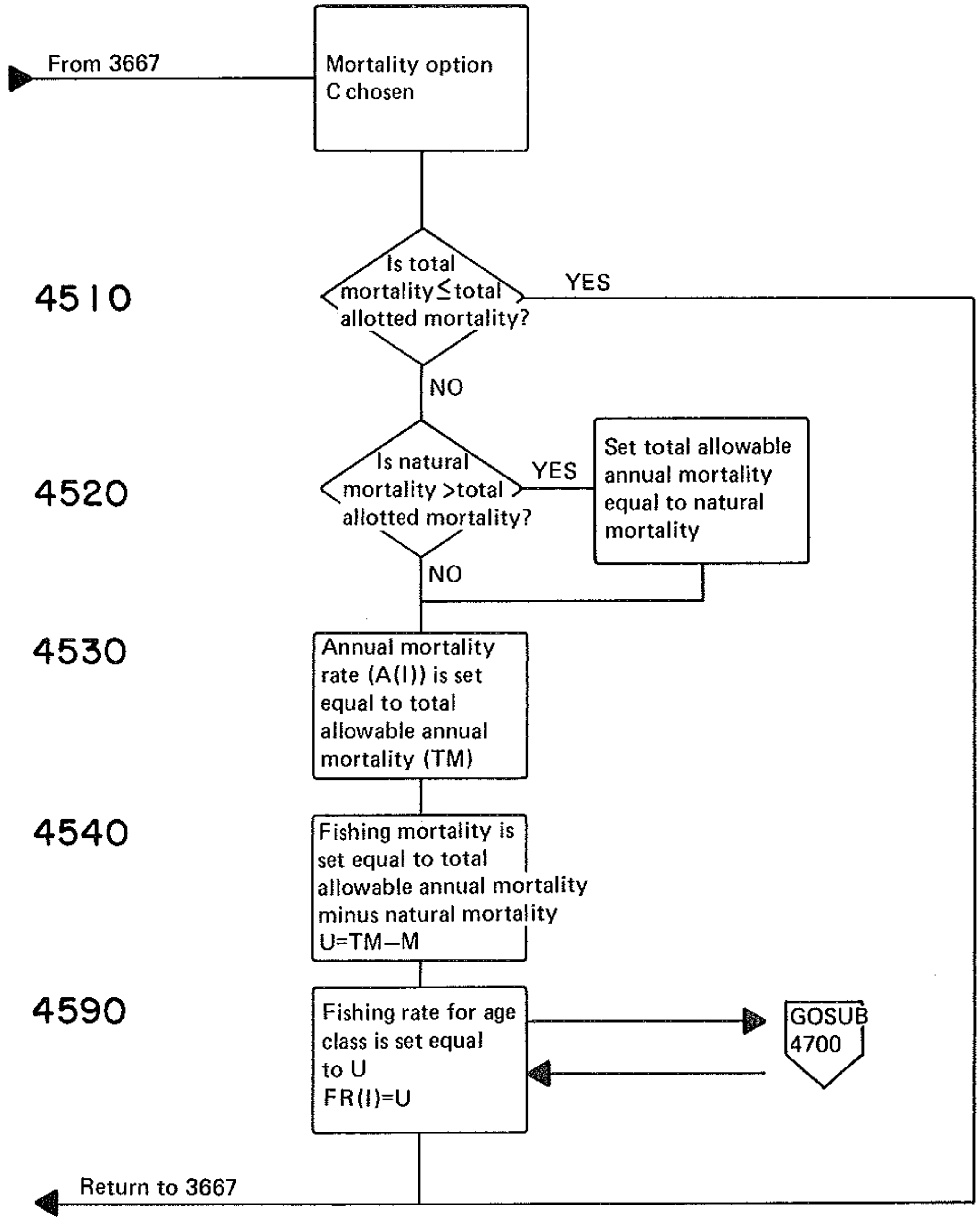

4000
Mortality option B chosen
4040-4090
Choose variable values for number stocked and maximum mortality
4120-4160
Zero internal variables for all age classes
4170
From 4360
I=1
I=I+1
I>20
YES
GOTO 3725
Compute number of mature fish, eggs, etc.
4180-4190
Number of survivors in ages 0 and I is set equal to number stocked
4200/4220-4230
Number of survivors in ages I and II is set for rates and totals
4210
Number of survivors in current age class is computed from previous age class data
4240-4250
Compute number of mortalities in age class
4260-4270
Determine allowable fishing mortality from total and natural mortality rates


4280
Is fishing mortality rate < zero?
YES
Set fishing mortality rate equal to zero
NO
4290-4320
Compute numbers of mortalities for natural and fishing mortality for current age class
4330
Is total fishing mortality (numbers) <zero?
YES
Set numbers of fish available for harvest to zero
NO
4340
Truncate number of survivors in current age class
4350
Is number survivors <zero?
YES
GOTO 3900
Set remaining catch rates equal to zero
NO
Loop to 4170

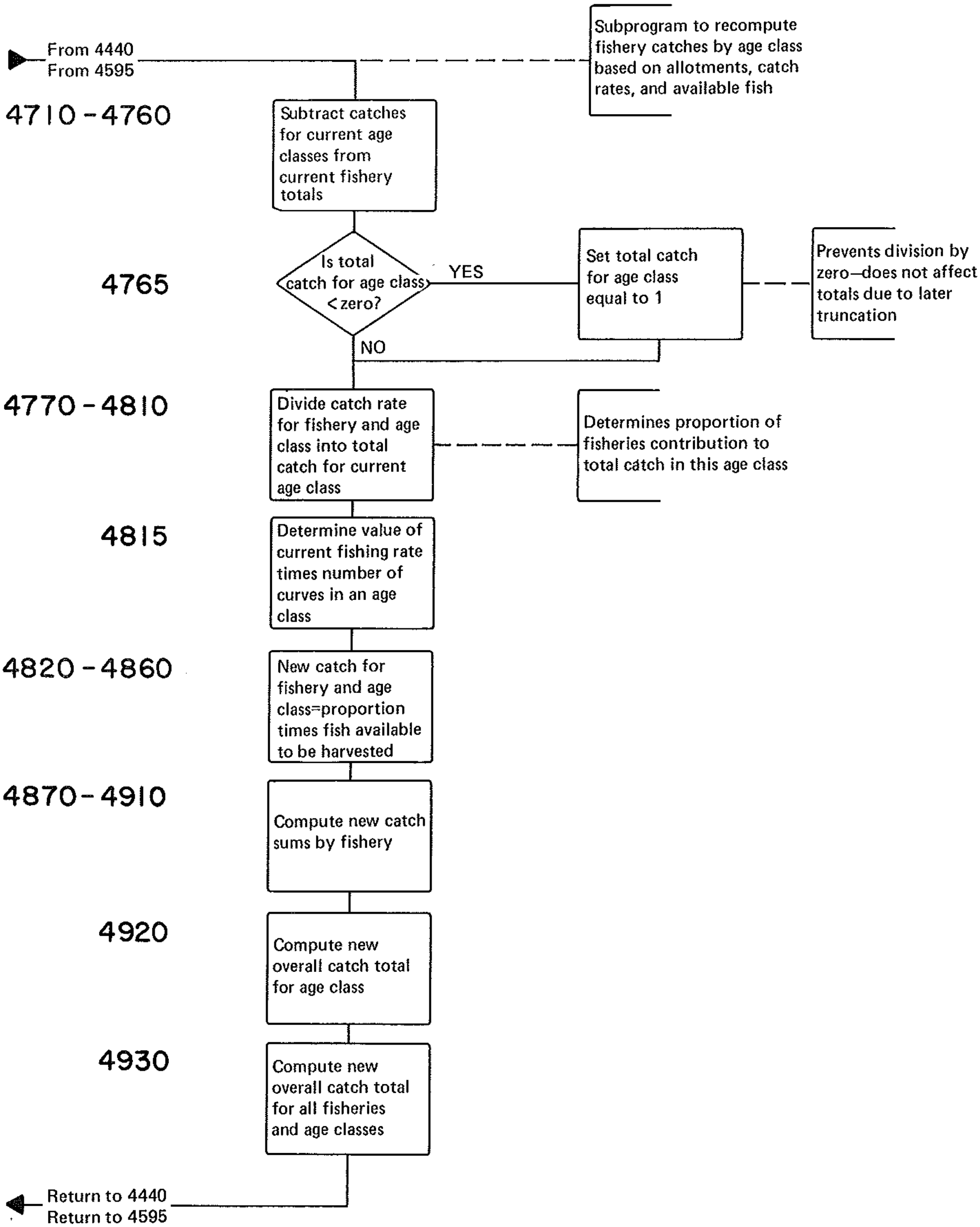
SubProgram 4400



SubProgram 4500



SubProgram 4700



APPENDIX 5.

Example operation of the simulation model.

The program is self-driven, requiring only the insertion of the diskette into drive #1 and turning on the computer. The program will introduce itself and present the first menu on the monitor screen. A choice of four models is available, each representing a different area of Lake Michigan. The screen appears as follows:

```
THIS PROGRAM COMPUTES THE NUMBER OF LAKE
TROUT SURVIVING IN EACH AGE CLASS IN A
GIVEN AREA SOUTH OF THE BAILEYS HARBOR
LINE.

DO YOU WISH TO RUN THE MODEL FOR:

1)  THE CLAY BANKS ZONE
2)  THE MID-LAKE REEF ZONE
3)  KENOSHA - KEWAUNEE ZONE
4)  ALL OF THE ABOVE

KEY IN ONE CHOICE:  3
```

These models reflect the lake trout management zones in the Wisconsin waters of Lake Michigan (Fig. 1).

After choosing the desired model (We have chosen model '3'), another menu appears on the monitor screen as follows:

```
CHOOSE ONE OF THE FOLLOWING:

A: SET ALLOWABLE CATCH NUMBERS FOR
     EACH FISHERY
B: SET TOTAL ALLOWABLE ANNUAL MORTAL-
     ITY RATE
C: SET ALLOWABLE CATCH NUMBERS FOR
     EACH FISHERY WITH A MAXIMUM TOTAL
     ANNUAL MORTALITY RATE NOT TO BE
     EXCEEDED

     ENTER YOUR CHOICE:  A
```

For a detailed description of each option, see the PROGRAM DESCRIPTION section of this report. After your response (we chose option A) more input is requested. The screen will display a statement and you are to enter the appropriate value and press the [RETURN] key. This next menu appears as follows and example input is included.

```
YOU CHOSE TO SET ALLOWABLE CATCH NUMBERS
FOR EACH FISHERY. FILL IN THE DATA AS
IT IS ASKED FOR.

ENTER THE ANNUAL LAKE TROUT STOCKING
     RATE: 700000 [RETURN]

ENTER THE ALLOWABLE CATCH (IN NUMBERS)
     FOR THE:
```

```
SMALL MESH GILL NET FISHERY: 8000 [RETURN]
LARGE MESH GILL NET FISHERY: 0    [RETURN]
TRAWL NET FISHERY: 0 [RETURN]
TRAP AND POUND NET FISHERY: 0 [RETURN]
SPORT FISHERY: 25000  [RETURN]
```

After the required inputs are entered, the program performs the computations and displays the output menu on the screen as given below.

```
CHOOSE ONE OF THE FOLLOWING:

A:  LIST OF THE PARAMETERS USED IN
     THIS RUN
B:  TABLE 1.
     NUMBER OF FISH IN EACH AGE CLASS
     MORTALITY RATES
     NUMBER OF MATURE LAKE TROUT
     NUMBER OF MATURE AGE CLASSES
     NUMBER OF FERTILE EGGS PRODUCED
C:  TABLE 2.
     NUMBER OF FISH IN EACH AGE CLASS
     MORTALITY NUMBERS
D:  TABLE 3.
     NUMBER OF FISH CAUGHT BY AGE BY
     FISHERY
     *** NOT AVAILABLE WITH
     MORTALITY OPTION   B  ***
E:   PRINT ALL OF THE ABOVE.
F:   RETURN TO BEGINNING OF THE PROGRAM.
G:  QUIT
KEY IN ONE LETTER:   E
```

With all of the options (except F and G), the program will provide the output. Wait for a cue, and then return to the above menu.

If option B, C, or D is chosen, the output will scroll up the screen at a rapid pace. To stop the screen, hold down the [CTRL] key and the S key. This causes the screen to stop. Scrolling can be resumed by tapping the space bar. The output displays are prepared for a 80 column printout while the screen is only 40 columns wide. For this reason, the output on the screen wraps itself around and may be hard to follow.

If option E is chosen, the printer is automatically activated and all of the available tables are printed along with the associated user defined parameters. After all the tables are printed, the printer is deactivated, and control is returned to the keyboard.

For our example, we chose option E. The printout, with the details of the inputs appears on the pages that follow.

THIS MODEL IS FOR THE KENOSHA-KEWAUNEE ZONE.

THESE ARE THE VALUES FOR THE VARIABLES USED IN THIS RUN.

NUMBER OF LAKE TROUT STOCKED: 700000

NUMBER OF FISH ALLOWED TO BE CAUGHT BY FISHERY:
SMALL MESH GILL NET: 8000
LARGE MESH GILL NET: 0
TRAWL NET: 0
TRAP/POUND NET: 0
SPORT: 25000

TOTAL ALLOWABLE CATCH: 33000

AFTER 20 YEARS THE POPULATION DYNAMICS IN THE 20TH YEAR WOULD APPEAR AS FOLLOWS:

TABLE 1. NUMBER OF LAKE TROUT SURVIVING AND THE MORTALITY RATES FOR EACH AGE CLASS.

AGE CLASS	NUMBER SURVIVING	NATURAL MORTALITY	FISHING MORTALITY	TOTAL MORTALITY
I	700000	.37	3.28571429E-05	.3700207
II	440985	.37	1.34471539E-03	.370847171
III	277447	.37	.0156714457	.379873011
IV	172052	.37	9.84001706E-03	.376199211
V	107326	.25	.0576372019	.293227901
VI	75855	.25	.0955502354	.321662677
VII	51455	.25	.0593716445	.294528733
VIII	36300	.25	.056087529	.292065647
IX	25698	.25	.0676698367	.300752377
X	17969	.25	.0826957818	.312021836
XI	12362	.25	.110170926	.332628195
XII	8250	.25	.146416147	.35981211
XIII	5281	.25	.205420756	.404065567
XIV	3147	.25	.294507147	.47088036
XV	1665	.25	0	.25
XVI	1249	.25	0	.25
XVII	936	.25	0	.25
XVIII	702	.25	0	.25
XIX	526	.25	0	.25
XX	395	.25	0	.25

ASSUMING THIS MANAGEMENT STRATEGY CONTINUES FOR 20 YEARS;

THE TOTAL NUMBER OF SURVIVING MATURE LAKE TROUT IS: 165935
THIS REPRESENTS 14 MATURE AGE CLASSES,
AND 4 MATURE LAKE TROUT PER ACRE OF USABLE SPAWNING REEF.

THE TOTAL NUMBER OF FERTILIZED EGGS PRODUCED IS: 264774034
THIS RESULTS IN 6056 EGGS PER ACRE OF USABLE SPAWNING REEF IN LAKE MICHIGAN.

THIS MODEL IS FOR THE KENOSHA-KEWAUNEE ZONE.

THESE ARE THE VALUES FOR THE VARIABLES USED IN THIS RUN.

NUMBER OF LAKE TROUT STOCKED: 700000

NUMBER OF FISH ALLOWED TO BE CAUGHT BY FISHERY:
SMALL MESH GILL NET: 8000
LARGE MESH GILL NET: 0
TRAWL NET: 0
TRAP/POUND NET: 0
SPORT: 25000

TOTAL ALLOWABLE CATCH: 33000

AFTER 20 YEARS THE POPULATION DYNAMICS IN THE 20TH YEAR WOULD APPEAR AS FOLLOWS:

TABLE 2. NUMBER OF LAKE TROUT SURVIVING AND THE MORTALITIES FOR EACH AGE CLASS.

AGE CLASS	NUMBER SURVIVING	NATURAL MORTALITY	FISHING MORTALITY	TOTAL MORTALITY
I	700000	259000	23	259014
II	440985	163164	593	163538
III	277447	102655	4348	105394
IV	172052	63659	1693	64726
V	107326	26831	6186	31471
VI	75855	18963	7248	24399
VII	51455	12863	3055	15155
VIII	36300	9075	2036	10602
IX	25698	6424	1739	7728
X	17969	4492	1486	5606
XI	12362	3090	1362	4112
XII	8250	2062	1208	2968
XIII	5281	1320	1085	2134
XIV	3147	786	927	1482
XV	1665	416	0	416
XVI	1249	312	0	312
XVII	936	234	0	234
XVIII	702	175	0	175
XIX	526	131	0	131
XX	395	98	0	98
TOTAL	1939600	675750	32989	699695

THIS MODEL IS FOR THE KENOSHA-KEWAUNEE ZONE.

THESE ARE THE VALUES FOR THE VARIABLES USED IN THIS RUN.

NUMBER OF LAKE TROUT STOCKED: 700000

NUMBER OF FISH ALLOWED TO BE CAUGHT BY FISHERY:
SMALL MESH GILL NET: 8000
LARGE MESH GILL NET: 0
TRAWL NET: 0
TRAP/POUND NET: 0
SPORT: 25000

TOTAL ALLOWABLE CATCH: 33000

AFTER 20 YEARS THE POPULATION DYNAMICS IN THE 20TH YEAR WOULD APPEAR AS FOLLOWS:

TABLE 3. NUMBER OF LAKE TROUT CAUGHT BY AGE BY FISHERY.

AGE CLASS	TROUT CAUGHT					
	SPORT	SM MESH	LRG MSH	TRAWL	TRP/PD	TOTAL
I	0	23	0	0	0	23
II	27	566	0	0	0	593
III	82	4266	0	0	0	4348
IV	457	1236	0	0	0	1693
V	5385	801	0	0	0	6186
VI	6937	311	0	0	0	7248
VII	2814	241	0	0	0	3055
VIII	1822	214	0	0	0	2036
IX	1635	104	0	0	0	1739
X	1420	66	0	0	0	1486
XI	1339	23	0	0	0	1362
XII	1180	28	0	0	0	1208
XIII	1017	68	0	0	0	1085
XIV	880	47	0	0	0	927
XV	0	0	0	0	0	0
XVI	0	0	0	0	0	0
XVII	0	0	0	0	0	0
XVIII	0	0	0	0	0	0
XIX	0	0	0	0	0	0
XX	0	0	0	0	0	0
TOTAL	24995	7994	0	0	0	32989
QUOTA	25000	8000	0	0	0	33000
DEFICIT	0%	0%	0%0%		0%	0%

THIS MODEL IS FOR THE KENOSHA-KEWAUNEE ZONE.

THESE ARE THE VALUES FOR THE VARIABLES USED IN THIS RUN.

NUMBER OF LAKE TROUT STOCKED: 700000

NUMBER OF FISH ALLOWED TO BE CAUGHT BY FISHERY:
SMALL MESH GILL NET: 8000
LARGE MESH GILL NET: 0
TRAWL NET: 0
TRAP/POUND NET: 0
SPORT: 25000

TOTAL ALLOWABLE CATCH: 33000

AFTER 20 YEARS THE POPULATION DYNAMICS IN THE 20TH YEAR WOULD APPEAR AS FOLLOWS:

TABLE 2. NUMBER OF LAKE TROUT SURVIVING AND THE MORTALITIES FOR EACH AGE CLASS.

AGE CLASS	NUMBER SURVIVING	NATURAL MORTALITY	FISHING MORTALITY	TOTAL MORTALITY
I	700000	259000	23	259014
II	440985	163164	593	163538
III	277447	102655	4348	105394
IV	172052	63659	1693	64726
V	107326	26831	6186	31471
VI	75855	18963	7248	24399
VII	51455	12863	3055	15155
VIII	36300	9075	2036	10602
IX	25698	6424	1739	7728
X	17969	4492	1486	5606
XI	12362	3090	1362	4112
XII	8250	2062	1208	2968
XIII	5281	1320	1085	2134
XIV	3147	786	927	1482
XV	1665	416	0	416
XVI	1249	312	0	312
XVII	936	234	0	234
XVIII	702	175	0	175
XIX	526	131	0	131
XX	395	98	0	98
TOTAL	1939600	675750	32989	699695

THIS MODEL IS FOR THE KENOSHA-KEWAUNEE ZONE.

THESE ARE THE VALUES FOR THE VARIABLES USED IN THIS RUN.

NUMBER OF LAKE TROUT STOCKED: 700000

NUMBER OF FISH ALLOWED TO BE CAUGHT BY FISHERY:
SMALL MESH GILL NET: 8000
LARGE MESH GILL NET: 0
TRAWL NET: 0
TRAP/POUND NET: 0
SPORT: 25000

TOTAL ALLOWABLE CATCH: 33000

AFTER 20 YEARS THE POPULATION DYNAMICS IN THE 20TH YEAR WOULD APPEAR AS FOLLOWS:

TABLE 3. NUMBER OF LAKE TROUT CAUGHT BY AGE BY FISHERY.

AGE CLASS	TROUT CAUGHT					
	SPORT	SM MESH	LRG MSH	TRAWL	TRP/PD	TOTAL
I	0	23	0	0	0	23
II	27	566	0	0	0	593
III	82	4266	0	0	0	4348
IV	457	1236	0	0	0	1693
V	5385	801	0	0	0	6186
VI	6937	311	0	0	0	7248
VII	2814	241	0	0	0	3055
VIII	1822	214	0	0	0	2036
IX	1635	104	0	0	0	1739
X	1420	66	0	0	0	1486
XI	1339	23	0	0	0	1362
XII	1180	28	0	0	0	1208
XIII	1017	68	0	0	0	1085
XIV	880	47	0	0	0	927
XV	0	0	0	0	0	0
XVI	0	0	0	0	0	0
XVII	0	0	0	0	0	0
XVIII	0	0	0	0	0	0
XIX	0	0	0	0	0	0
XX	0	0	0	0	0	0
TOTAL	24995	7994	0	0	0	32989
QUOTA	25000	8000	0	0	0	33000
DEFICIT	0%	0%	0%0%		0%	0%

APPENDIX 6.

Lake trout spawning reefs in the Wisconsin waters of Lake Michigan and their estimated acreage.

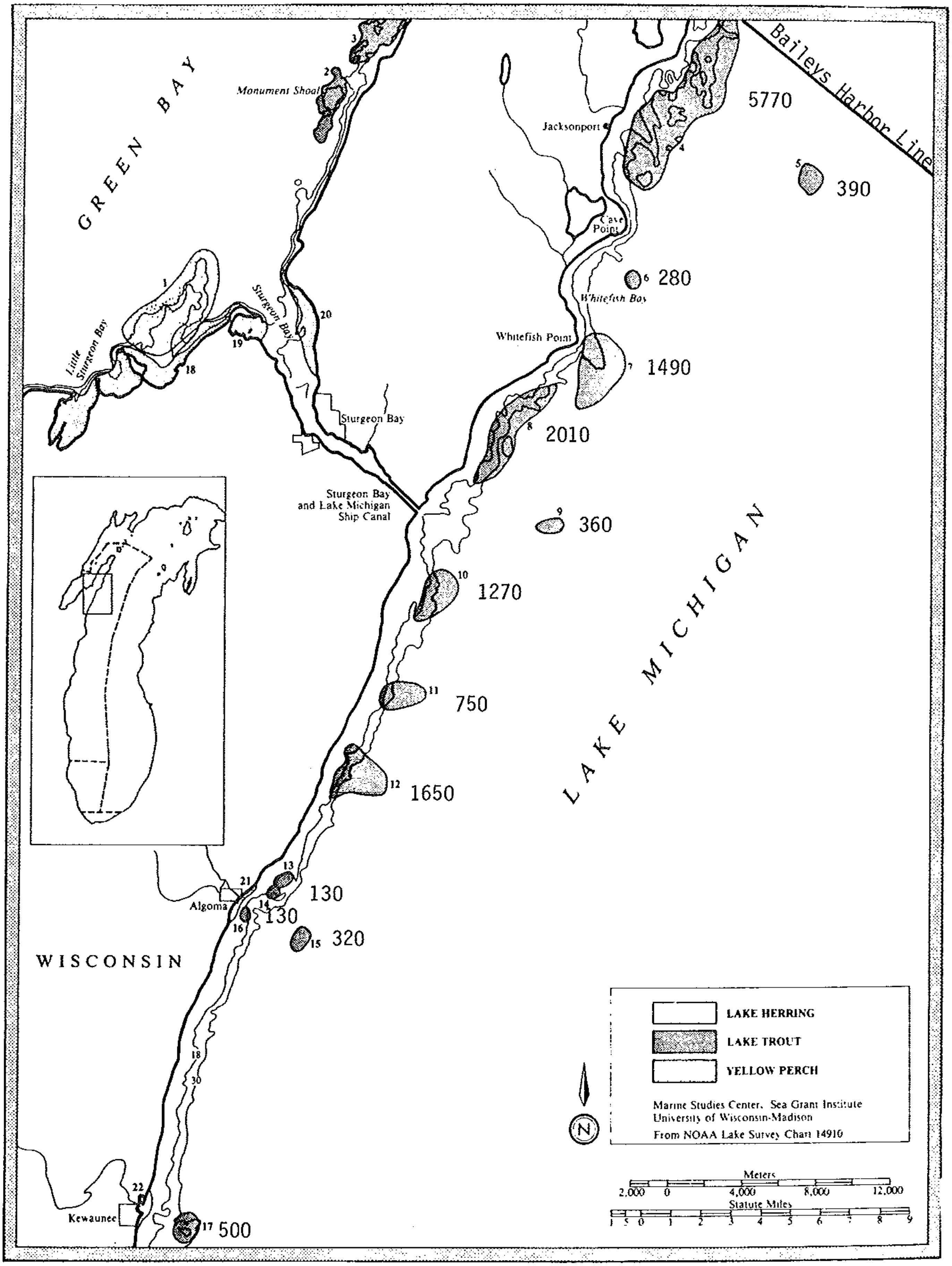


FIGURE 4. Lake trout spawning reefs in Lake Michigan from the Baileys Harbor line to Kewaunee and their estimated acreage (from Coberly and Horrall 1980).

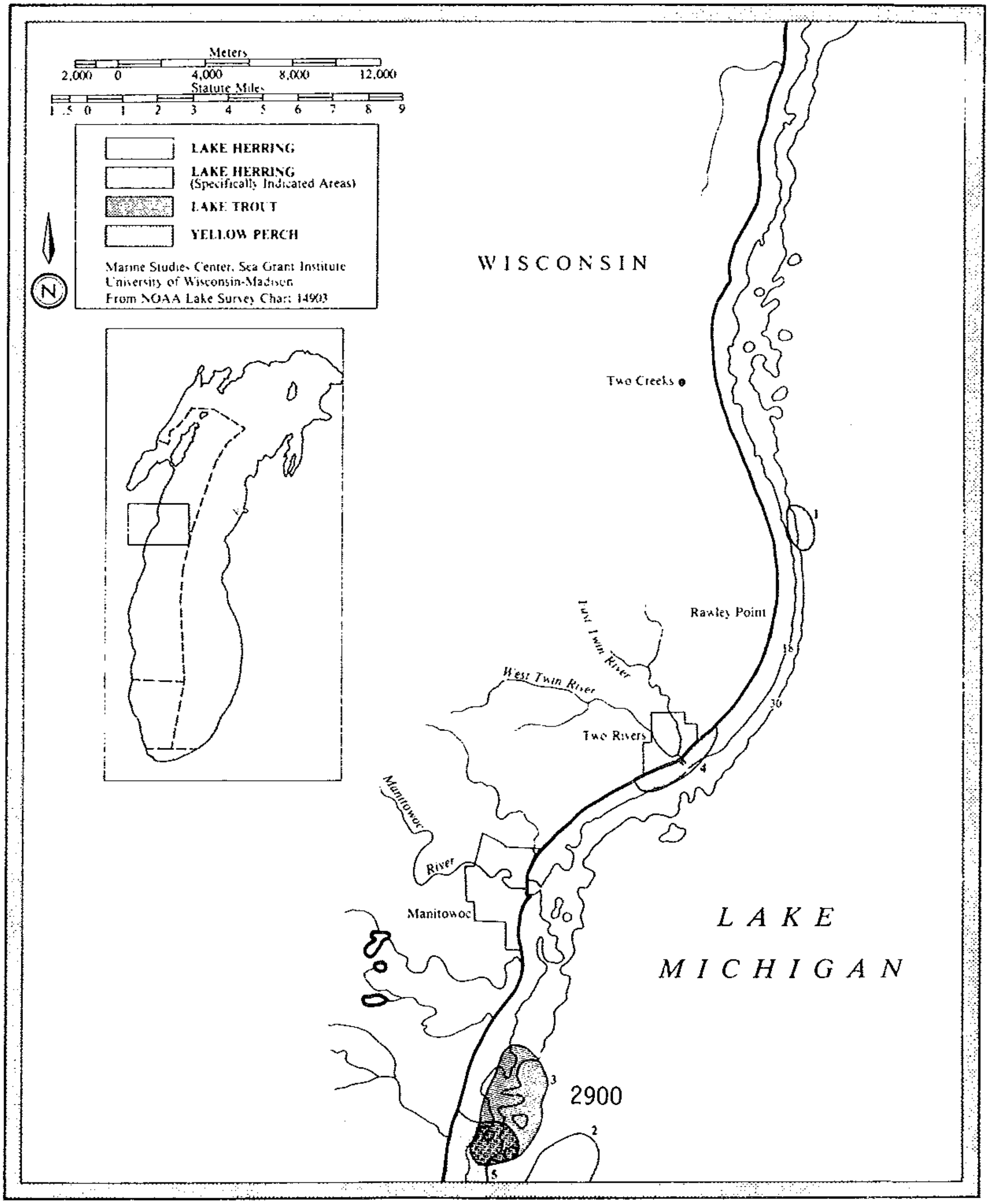


FIGURE 5. Lake trout spawning reefs in the Manitowoc area of Lake Michigan and their estimated acreage (from Coberly and Horrall 1980).

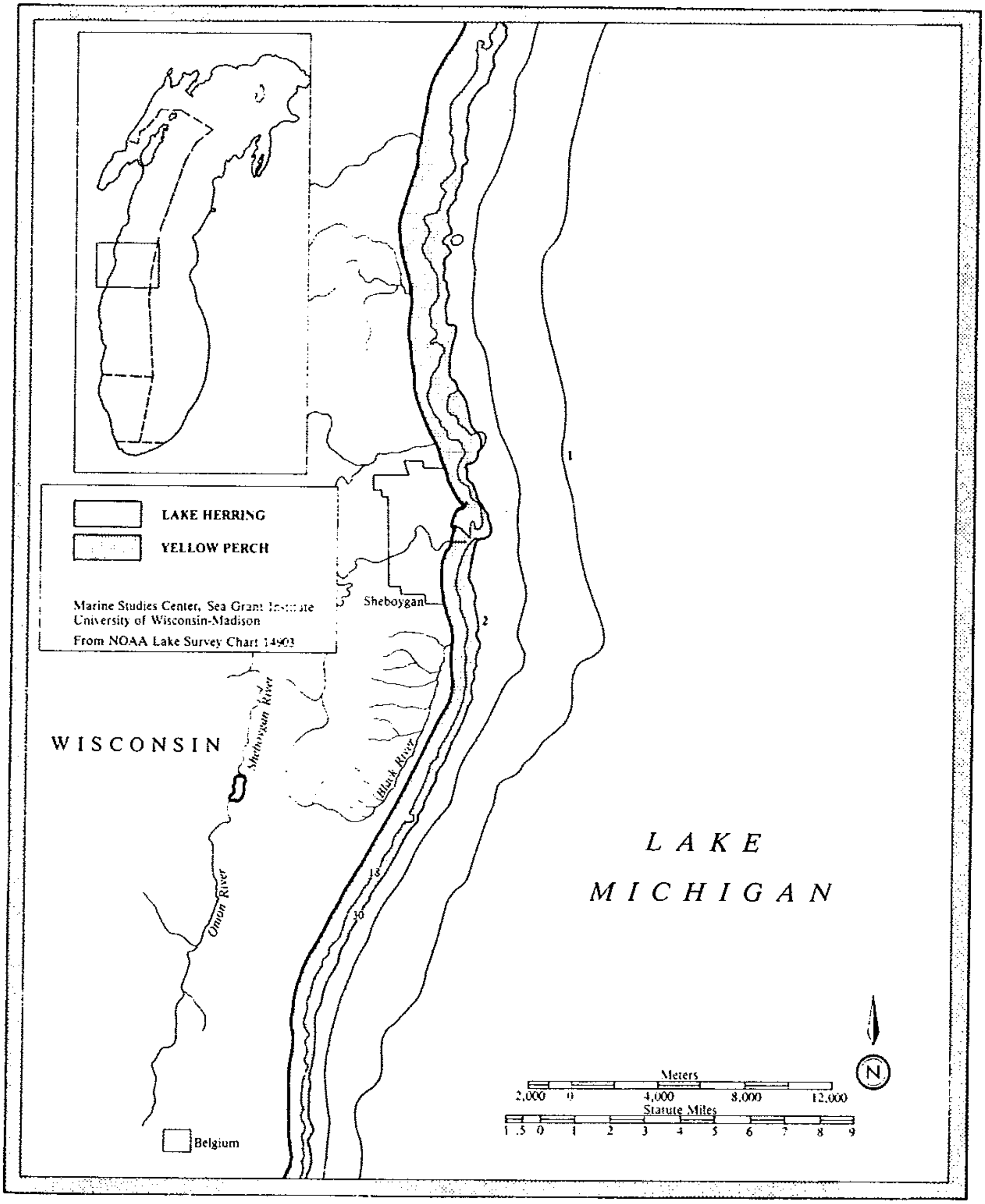


FIGURE 6. Lake trout spawning reefs in the Sheboygan area of Lake Michigan and their estimated acreage (from Coberly and Horall 1980).

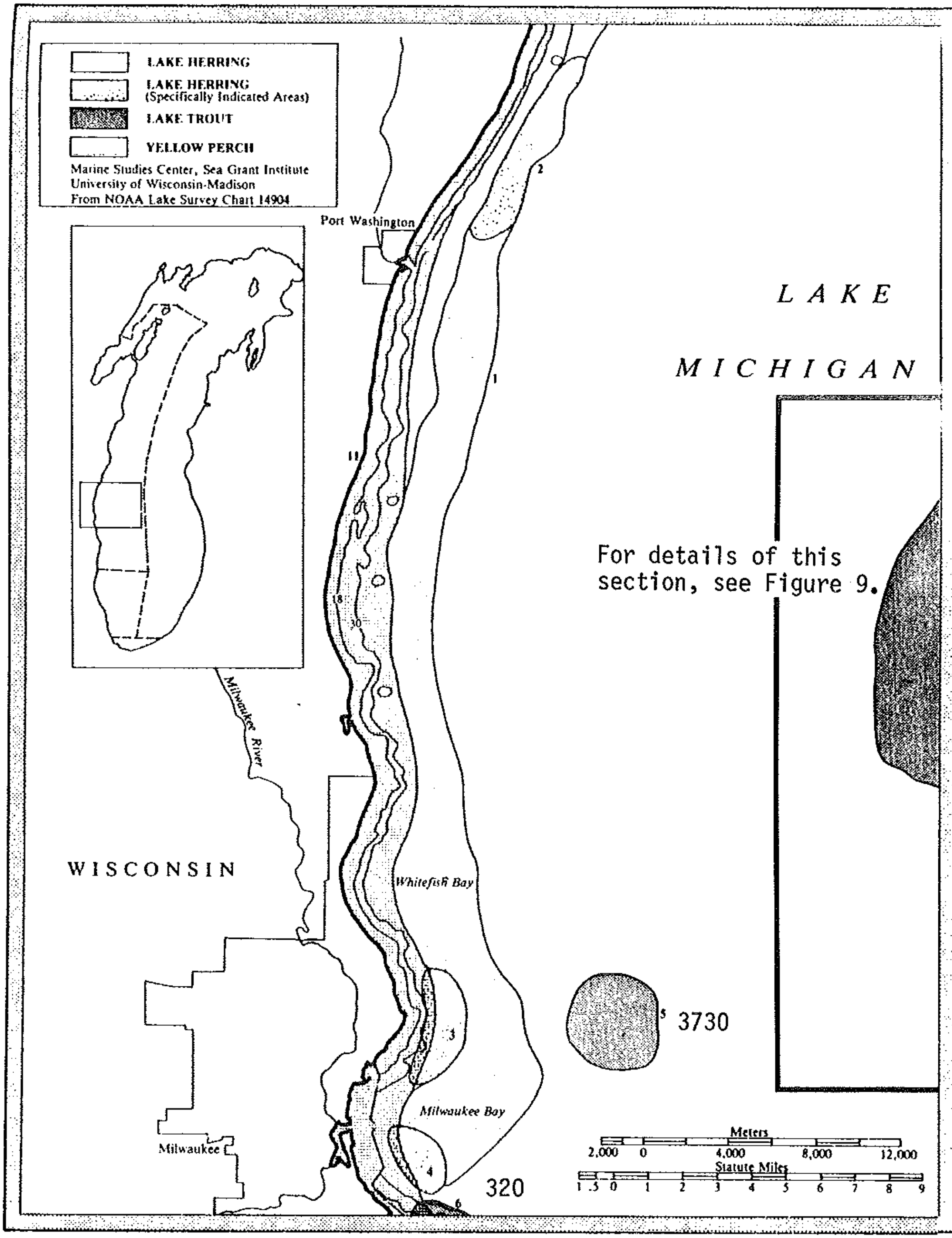


FIGURE 7. Lake trout spawning reefs in the Port Washington to Milwaukee area of Lake Michigan and their estimated acreage (from Coberly and Horrall 1980).

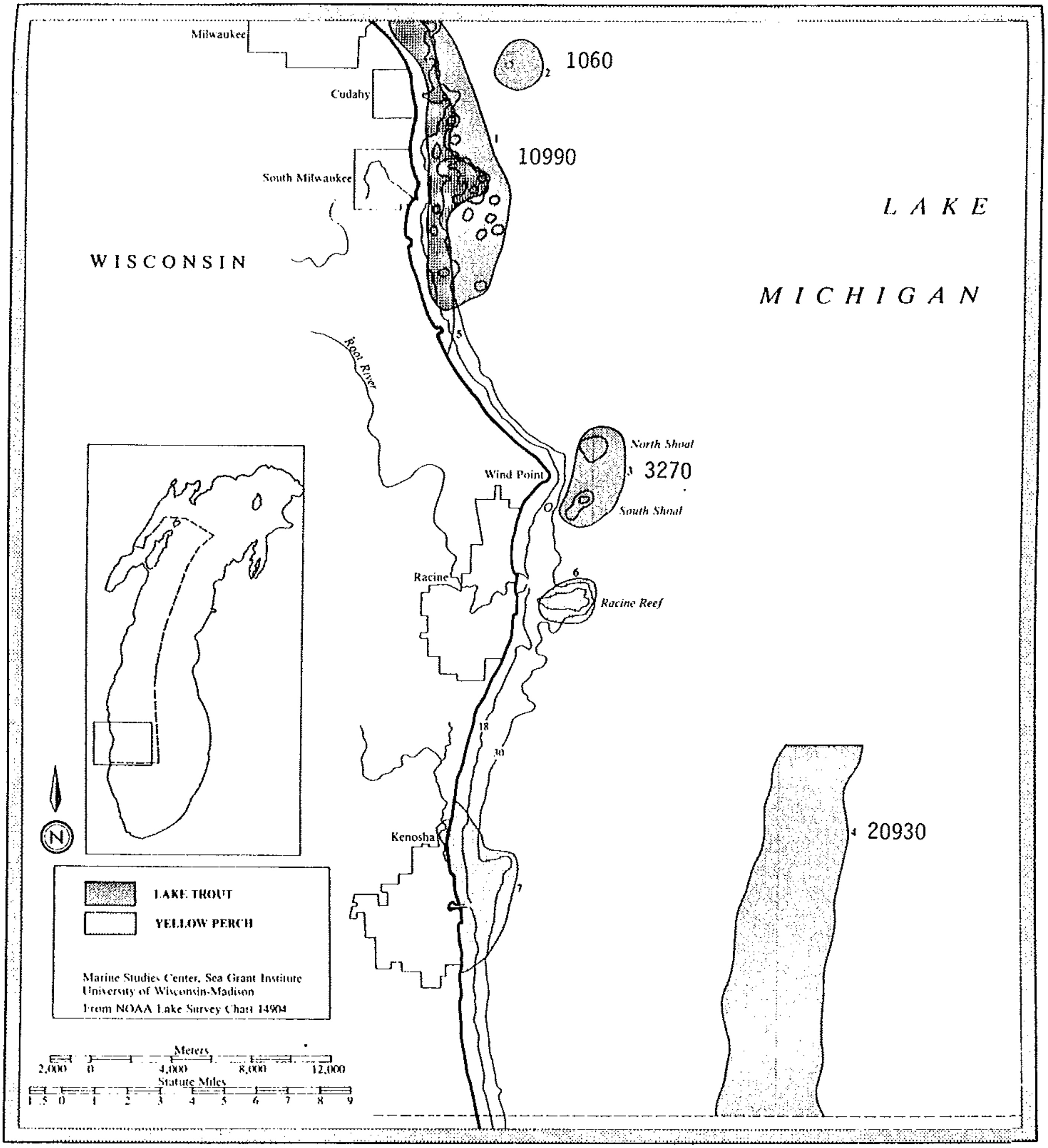


FIGURE 8. Lake trout spawning reef areas in the Milwaukee to Illinois area and their estimated acreage (from Coberly and Horrall 1980).

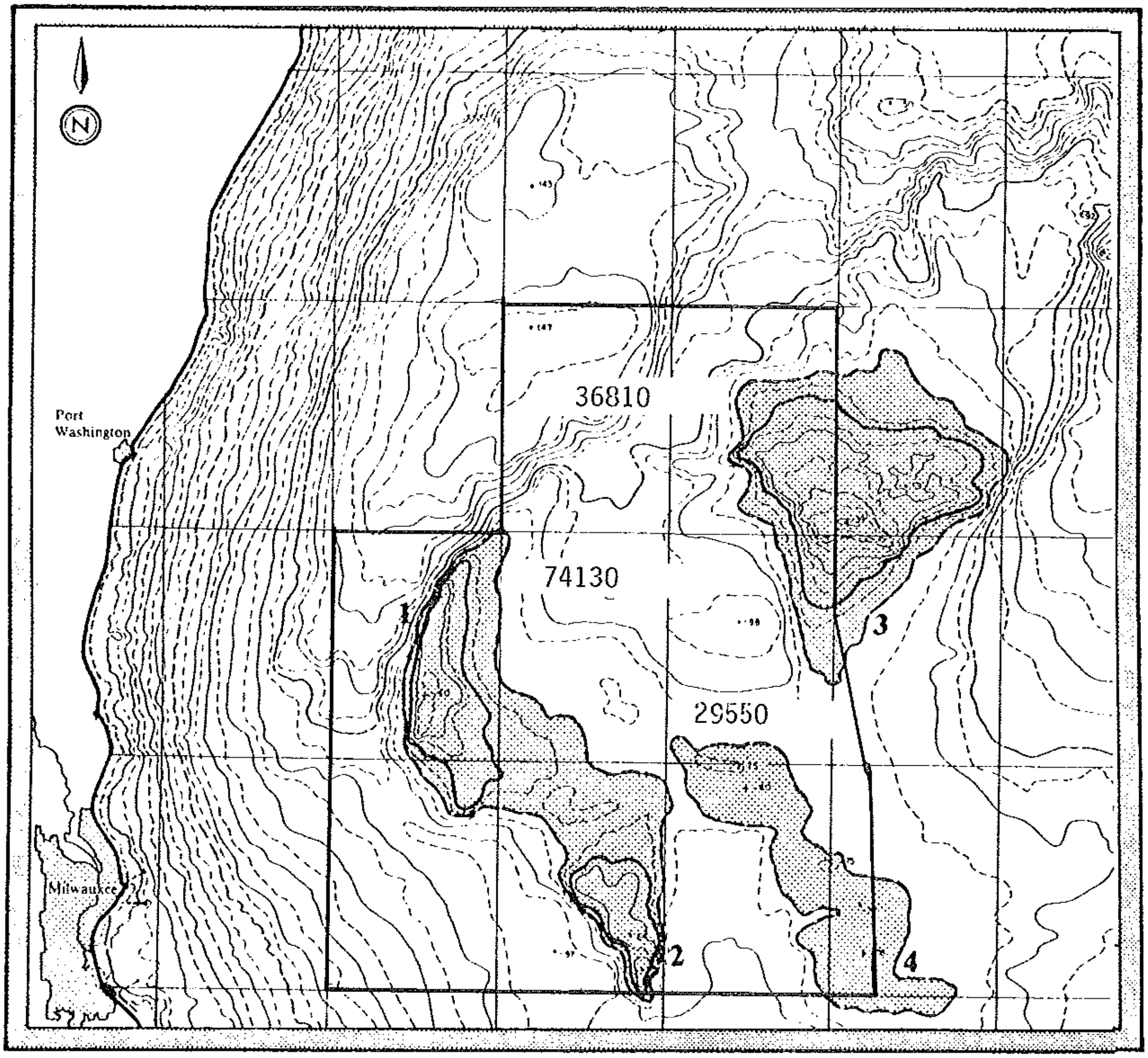


FIGURE 9. Lake trout spawning reefs in the mid-lake reef area of the Wisconsin waters of Lake Michigan and their estimated acreage (from Bathymetric Chart of Middle Lake Michigan, R. J. Ristic and C. H. Mortimer, Center for Great Lake Studies, U.W.-Milwaukee.