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**A Generalized Fish Life-Cycle
Population Model and Computer Program**

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ENVIRONMENTAL SCIENCES DIVISION
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AND COMPUTER PROGRAM**

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PREFACE

Oak Ridge National Laboratory is providing technical assistance to the U.S. Nuclear Regulatory Commission and other agencies in their assessments of the environmental impacts of electric power plants. These assessments have required the development of new analytical techniques and the expansion of many existing ones. The work reported here, while begun in support of the analysis of a particular nuclear plant, has wide application in other areas. Much of the model development has been financed by the Division of Biomedical and Environmental Research, U.S. Energy Research and Development Administration.

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ABSTRACT

DEANGELIS, D. L., W. VAN WINKLE, S. W. CHRISTENSEN, S. R. BLUM, B. L. KIRK, and C. ROSS. 1977. A generalized fish life-cycle population model and computer program. ORNL/TM-6125. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 176 pp.

A generalized fish life-cycle population model and computer program have been prepared to evaluate the long-term effect of changes in mortality in age class 0. The general question concerns what happens to a fishery when density-independent sources of mortality are introduced that act on age class 0, particularly entrainment and impingement at power plants. This paper discusses the model formulation and computer program, including sample results.

The population model consists of a system of difference equations involving age-dependent fecundity and survival. The fecundity for each age class is assumed to be a function of both the fraction of females sexually mature and the weight of females as they enter each age class. Natural mortality for age classes 1 and older is assumed to be independent of population size. Fishing mortality is assumed to vary with the number and weight of fish available to the fishery. Age class 0 is divided into six life stages. The probability of survival for age class 0 is estimated considering both density-independent mortality (natural and power plant) and density-dependent mortality for each life stage. Two types of density-dependent mortality are included. These are (1) cannibalism of each life stage by older age classes and (2) intra-life-stage competition.

A computer code for implementing this population model has been written in FORTRAN. This code consists of a main program and numerous subroutines which perform calculations and control input and output. The most important feature of the computer code is its flexibility. By appropriate specification of a set of input cards, the user can run the model for several years using one set of parameter values and then change some of the parameter values and continue running the model using the new values. The unique population vector resulting in a steady-state system for fixed values of the adjustable parameters is determined analytically. Comparison of similar cases via graphic and tabular output is possible.

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I. INTRODUCTION

This simulation model is a generalized and expanded version of the striped bass population model described by Van Winkle et al. (1974). Since this earlier report is now out of print, those sections of the earlier report not changed in generalizing the model have been repeated or paraphrased in this report in order to make the present report self-contained.

This simulation model has been developed to forecast the long-range impact on a fish population of entrainment and impingement of eggs, larvae and juveniles due to the withdrawal of water by power plants. The model is designed to help regulatory agencies, power companies, and society make sound decisions concerning alternative cooling methods and alternative sites. This is being done in two ways. First, the model provides quantitative forecasts of impact on a fish population. Second, the model is useful in placing previously qualitative statements into a quantitative framework and in defining issues where field and laboratory research are essential for more accurate forecasts (Christensen et al. 1976; Van Winkle 1976).

The model focuses on the long-term (e.g., 10 or more years) impact on the fishery and on the relative size and age structure of the fish population. Entrainment and impingement probably act in most situations as density-independent sources of mortality; that is, the probability of entrainment or impingement mortality for an individual is a constant independent of the size of the population. The general question we are addressing is what happens to a fishery when

density-independent sources of mortality that act on age class 0, such as entrainment and impingement, are introduced. The application of Leslie matrix population models to address questions of this type appears to be gaining favor (Beland 1974, Hess et al. 1975, Jensen 1971, LMS 1975, Miller et al. 1975, Sommani 1972, Horst 1977).

The changes made from the original model improve the ability of the model to simulate the striped bass population and also make the program more adaptable to other fish populations. The major changes are modification of the fishing mortality function and consideration of six sequential life stages within age class 0. Complex entrainment and impingement scenarios can now be simulated. The model is presently being applied to the striped bass, white perch, and Atlantic tomcod populations in the Hudson River.

Part of the effort in updating the life cycle model and program has gone into providing more comment cards for those program subroutines which constitute the heart of the computer model; i.e., those which set up the Leslie matrix. The comment cards make the subroutines more understandable, facilitating possible debugging or further modification of the program.

II. POPULATION MODEL

The population model is based on Leslie's (1945, 1948) deterministic, discrete-time model, which incorporates age-dependent fecundity and survival (Keyfitz 1968, Pielou 1969). In contrast to our earlier model (Van Winkle et al. 1974), which assumed a constant sex

ratio and only dealt with female striped bass, this generalized model does not assume the same sex ratio for all age classes and deals with the total fish population, i.e., both males and females. The time and the age intervals have a duration of a year. Aging (i.e., formation of the annulus or annual growth ring on the scales) and recruitment to the fishery (i.e., attaining a large enough size such that the fish are in that component of the population legally fished) are assumed to occur immediately prior to spawning.

The fish population is divided into M age classes, with the oldest age class including all fish $M-1$ years old and older. The age distribution vector for year t , $n(t)$, gives the number of fish in each of the M age classes (Fig. 1).

The survival-fecundity matrix for year t , $A(t)$, is an $M \times M$ matrix having fecundity values in the first row, survival probabilities along the subdiagonal and in position (M,M) , and all other elements equal to zero (Fig. 1). The element f_i denotes the average number of eggs produced per fish (both sexes combined) upon entering age class i at the beginning of year t . The element p_i denotes the probability that a fish in age class i at the start of the year t will survive to the start of year $t+1$. The age distribution vector for year $t+1$, $N(t+1)$, is calculated by matrix multiplication (Fig. 1).

Figure 2 is an alternative representation of the matrix equation. Aging transfers occur yearly and are represented by the transfer arrows down the diagonal. As females become sexually mature (e.g., as 4-year-olds), they add to the complement of eggs spawned at the start

$$\begin{aligned}
 \mathbf{n}(t+1) &= \begin{bmatrix} n_{0,t+1} \\ n_{1,t+1} \\ \vdots \\ n_{M-1,t+1} \end{bmatrix} = \begin{bmatrix} \rho_0 f_1 & \rho_1 f_2 & \cdots & \rho_{M-2} f_{M-1} & \rho_{M-1} f_{M-1} \\ \rho_0 & 0 & \cdots & 0 & 0 \\ 0 & \rho_1 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & \rho_{M-2} & \rho_{M-1} \end{bmatrix} \begin{bmatrix} n_{0,t} \\ n_{1,t} \\ \vdots \\ n_{M-1,t} \end{bmatrix} = A(t) * \mathbf{n}(t)
 \end{aligned}$$

The diagram at the bottom shows two horizontal axes. The top axis is labeled 'YEARS (AGE)' and has tick marks at 0, 1, 2, 3, and 4. Below this axis, a horizontal line is divided into segments by vertical brackets. The segments are labeled with ρ_0 , ρ_1 , ρ_2 , and ρ_3 from left to right. Below these segments, the age vector elements n_0 , n_1 , n_2 , n_3 , and n_4 are listed. Below the age vector elements, the fecundity elements f_0 , f_1 , f_2 , f_3 , and f_4 are listed. The diagram illustrates the relationship between age, survival probabilities (ρ), fecundity (f), and population size (n) over time.

Fig. 1. Formulation of the life-cycle population model as a deterministic, discrete-time model incorporating age-dependent fecundity and survival. The diagram at the bottom defines the age and times associated with elements of the age vector, $\mathbf{n}(t)$, and the Leslie matrix, $A(t)$. The first subscript on the elements of the age vectors denotes age and the second subscript denotes year.

Fig. 2. Box and arrow diagram illustrating aging transfers, production of eggs, and losses due to natural mortality, fishing mortality, entrainment, and impingement.

of each year, as represented by the upward-directed arrows to the egg compartments. The total complement of eggs represents the input at the start of the year to age class 0, which in this modified model consists of six life stages, some of which are entrainable and some of which are impingable. Natural mortality (e.g., mortality due to predation, disease and parasites) occurs for each age class. In addition, there is mortality in age class 0 due to entrainment and impingement by power plants, and there is mortality of older fish due to fishing. Mortality and aging transfers occur first, followed by spawning.

All fish populations are probably controlled in the long term by density-dependent mechanisms acting on certain ages or sizes. In line with the thinking of Ricker (1954, 1975), Backiel and LeCren (1967), Cushing (1974), and others, we envision natural, density-dependent mechanisms operating primarily in age class 0. In addition, for species subjected to a large sport and/or commercial fishery, we assume that the population may be controlled, in part, by density-dependent fishing mortality.

Detailed discussion of the elements of the fecundity-survival matrix is given in the following subsections.

A. Fecundity

Let f_i denote the average number of eggs produced per fish (both sexes combined) upon entering age class i . The quantities f_i ($i = 1, 2, \dots, M-1$) in the first row of the matrix $A(t)$ are calculated as:

$$f_i = FF_i FMAT_i EGGS_i, \quad (1)$$

where FF_i is the ratio of female fish to the total number of fish entering age class i , $FMAT_i$ is the probability that a female entering age class i is sexually mature, and $EGGS_i$ is the average number of mature (i.e., ripe) eggs in the ovaries of a sexually mature female entering age class i .

The average number of mature eggs in the ovaries of a sexually mature female entering age class i is calculated as:

$$EGGS_i = B_1 + B_2 WT_i \quad (2)$$

where WT_i is the average weight of a fish at the i^{th} annulus formation, and B_1 and B_2 are the intercept and slope, respectively, of a straight-line regression equation. If some other regression model (e.g., second degree polynomial) is more appropriate to characterize the relationship between weight and egg production, or if it is more appropriate to estimate egg production from $LENGTH_i$, the average total length of a fish at the i^{th} annulus formation, then the computer code must be modified accordingly (see subroutine MAKMAT in listing of computer code in Appendix A).

The average weight of a fish at the i^{th} annulus formation, WT_i , is estimated using the allometric relationship:

$$\text{LOG}_{10}(WT_i) = B_3 + B_4 \text{LOG}_{10}(LENGTH_i) \quad , \quad (3)$$

where B_3 and B_4 are the intercept and slope, respectively, of the straight-line regression equation. The average total length of a fish at the i^{th} annulus formation, $LENGTH_i$ is estimated as:

$$\text{LENGTH}_i = \text{ACON} + B \cdot \text{AGE}_i + C \cdot \text{AGE}_i^2, \quad (4)$$

where AGE_i is the age in years of a fish at the i^{th} annulus formation, and ACON, B and C are the coefficients of a quadratic regression model. If some other regression model (e.g., first-degree or third-degree polynomial or von Bertalanffy growth function) is more appropriate to characterize the relationship between age and length, the computer code must be modified accordingly.

Equations (3) and (4) above are empirical regression models for fish of both sexes combined rather than for females only as in the earlier model (Van Winkle et al. 1974). If it is judged important to treat the relationships between length and weight and between age and length separately for males and females, then the computer code must be modified accordingly. Such modification must include the calculation of TOTP (Section II.C).

B. Natural Mortality (Age Classes 1 to M-1)

Natural mortality is assumed to be density independent for fish in age classes 1 to M-1, although it may vary from age class to age class. The instantaneous natural mortality rate for age class i , M_i , is input to the model.

C. Fishing Mortality

The following assumptions are made with respect to the dependence of fishing mortality on the size of the fishable population:

- a. Fishing mortality may be divided into density-independent and density-dependent components.

- b. The density-independent component, which by definition is not influenced by the size of the fishable population, constitutes a time-invariant, background fishing mortality. This background fishing mortality arises from two sources:
 - 1. nonspecies-specific directed fishing effort (i.e., commercial and sport fishing effort directed at whatever species are available).
 - 2. fishing effort directed at the species being modeled that is not sensitive to the availability of fish of this species (i.e., the hard-core and habitual fishermen).
- c. The density-dependent component of fishing mortality is a function of the number of fish and the size of the fish available to the fishery for the current year. The following assumptions are made with respect to this density-dependent component:
 - 1. For population sizes greater than some minimum (below which the fishing is not good enough to significantly influence the fishing effort directed at the species being modeled), fishing mortality increases with increasing population size. This relationship exists because high levels of abundance increase fishing effort, which in turn increases fishing mortality.
 - 2. A maximum fishing mortality exists that depends on the maximum fishing effort that can be expended, which in turn depends on the number of fishermen, boats, etc., available for the current year.

One function for fishing mortality that incorporates these assumptions is (see Fig. 3)

$$F[\text{TOTP}(t)] \equiv F = \text{FDI} + \text{FDD}[\text{TOTP}(t)] \quad , \quad (5)$$

where F is the instantaneous coefficient of fishing mortality and consists of the sum of a density-independent term (FDI) and a density-dependent term (FDD), and $\text{TOTP}(t)$ is an index of the usable stock during year t . The density-dependent term is given by

$$\text{FDD} [\text{TOTP}(t)] \quad \text{FDD} = \begin{cases} 0, & \text{if } \text{TOTP}(t) < \text{TOTP1} \\ \frac{(\text{TOTP}(t) - \text{TOTP1}) \text{FDDMAX}}{\text{TOTP2} - \text{TOTP1}} & , \quad (6) \\ \text{if } \text{TOTP1} \leq \text{TOTP}(t) \leq \text{TOTP2} \\ \text{FDDMX}, & \text{if } \text{TOTP}(t) > \text{TOTP2} \end{cases}$$

where TOTP1 is the population index below which fishing effort is a minimum and independent of density ($\text{FDD} = 0$), and TOTP2 is the population index above which fishing effort is a maximum and again independent of density ($\text{FDD} = \text{FDDMX}$).

The independent variable $\text{TOTP}(t)$ in this density-dependent (compensatory) function for fishing mortality is the biomass of fish available to the fishery at the start of year t . As mentioned in Assumption (c), the fishing effort directed towards the fish population being modeled is a function of both the number of fish and the size (i.e., age) of the fish. This assumption is implemented in the model by defining $\text{TOTP}(t)$ as:

Fig. 3. Curve for the instantaneous coefficient of fishing mortality during year t as a function of the biomass of fish available to the fishery at the start of year t .

$$\text{TOTP}(t) = \sum_{i=1}^{M-1} \text{CATCH}_i \text{VULN}_i \text{WT}_i n_i(t) \quad (7)$$

Again, M is the number of age classes in the population (starting with 0). CATCH_i is the fraction of the year for which the average length of fish in age class i (LENGTH_i) is greater than or equal to the minimum legal length (LEGAL); it is an approximation of the effective fraction of fish in age class i at the beginning of the year legally available to the fishery. CATCH_i will be equal to 0.0 or 1.0 in general for all but the pivotal age class (i.e., i such that $\text{LENGTH}_i < \text{LEGAL} \leq \text{LENGTH}_{i+1}$). VULN_i is the vulnerability to the fishery of fish in age class i relative to the most vulnerable age class (for which $\text{VULN}_i = 1.0$). This parameter reflects that different parts of a stock legally available to the fishery may differ in their actual availability because different ages are subjected to different rates of removal by the fishery. WT_i is the average weight of fish in age class i at the start of year t . For the pivotal age class, WT_i is set equal to the weight corresponding to the minimum legal length. $n_i(t)$ is the number of fish in age class i at the start of year t .

The minimum value for the instantaneous coefficient of fishing mortality ($F = \text{FDI}$) occurs when the population size for year t is less than some minimum (TOTP1) (see Fig. 3), such that the fishing is not good enough to significantly influence the fishing effort for year t directed at the species being modeled. The maximum value for the instantaneous coefficient of fishing mortality ($F = \text{FDI} + \text{FDDMX}$) occurs

when the population size for year t is greater than some maximum (TOPT2) (see Fig. 3), such that maximum fishing effort for year t is already directed at the species being modeled. TOTP2 is calculated as a multiple of TOTP1 by specifying a proportionality constant (RATIO) such that

$$\text{TOTP2} = \text{RATIO} \cdot \text{TOTP1} \quad (8)$$

The present model has been generalized to allow either FDI or FDDMX to vary linearly in time in order to reflect real or hypothesized changes in fishing effort.

$$\begin{aligned} \text{FDI} &= \text{FDIO} + \text{IYRI} \cdot \text{STEPDI} \\ \text{and } \text{FDDMX} &= \text{FDMXO} + \text{IYRI} \cdot \text{STEPDD} \end{aligned} \quad (9)$$

where IYRI is the model year and STEPDI and STEPDD are the yearly changes in FDI and FDDMX, respectively. The plus sign in Eq. (9) is for increasing fishing effort, while the minus sign is for decreasing fishing effort. The variables STEPDI and STEPDD are calculated as

$$\begin{aligned} \text{STEPDI} &= \text{CHGDI} \cdot \text{FDIO} / \text{IYRCH} \\ \text{and } \text{STEPDD} &= \text{CHGDD} \cdot \text{FDMXO} / \text{IYRCH} \end{aligned} \quad (10)$$

The quantities CHGDI FDIO and CHGDD FDMXO are the final values for FDI and FDDMX, respectively, which are reached after IYRCH years. IYRCH is the number of years over which it is assumed the specified change in fishing effort occurs.

This function for fishing mortality is simpler (four parameters instead of five) than the relatively complicated function presented in Van Winkle et al. (1974) and LMS (1975). This simpler formulation is

more in line with our limited knowledge concerning the relationship between fishing effort and the size of a fish population.

Eqs. (5) and (6) can be readily modified if information for a particular fish population suggests a different relationship between stock size and fishing effort. An example of such a modification would be incorporation of a time lag; e.g., data and general knowledge may suggest that fishing effort does not vary with the size of the population for the current year $\{TOTP(t)\}$ but for the previous year $\{TOTP(t-1)\}$.

The Leslie matrix utilizes age-specific estimates of p_i , the probability that an individual entering age class i will survive to enter age class $i+1$. The age-specific, instantaneous coefficient of fishing mortality (F_i) is calculated from F (Eq. 5) as follows:

$$F_i = CATCH_i VULN_i F, \quad (11)$$

where $CATCH_i$ and $VULN_i$ are defined as in Eq. (7). Then

$$p_i = e^{-(M_i + F_i)} = e^{-Z_i}, \quad (12)$$

where M_i is the age-specific, instantaneous coefficient of natural mortality (see Section II.B), and Z_i is the age-specific, instantaneous coefficient of total mortality (Ricker 1975). Thus, the number of $i+1$ -year-old fish at the start of year $t+1$, $n_{i+1}(t+1)$, is calculated from the number of i -year-old fish at the start of the year t , $n_i(t)$, as follows:

$$n_{i+1}(t+1) = p_i n_i(t). \quad (13)$$

D. Yield to the Fishery

Yield for year t is calculated as follows:

$$\text{YIELD}[\text{TOTP}(t)] \equiv \text{YIELD} = \sum_{i=1}^{M-1} \text{WT}_i (1.0 - e^{-Z_i}) (F_i/Z_i) n_i(t) \quad (14)$$

We have simplified the equation for yield by using weights at the beginning of the year, WT_i , as opposed to weights at the middle of the year, AVWT_i (Van Winkle et al. 1974). The term $(1.0 - e^{-Z_i})$ is the probability of mortality for age class i from all sources, while the ratio F_i/Z_i specifies the fraction of the total mortality for age class i due to fishing (Ricker 1975, p. 11). Yield will be underestimated by Eq. (14) if fishing occurs before natural mortality. It will also be underestimated because growth during the year is not assumed.

E. Probability of Survival for Age Class 0

Although Van Winkle et al. (1974) discuss possible density-dependent mechanisms for fish in age class 0 (i.e., young-of-the-year or y-o-y), they do not actually provide for such mechanisms in their computer program because of the lack of data. The amount of data available for specifying compensation functions or parameters is still not at a satisfactory state, but since the possible long-term consequences of compensation in life-cycle models should be explored, such mechanisms are now included in the program. The model for y-o-y mortality in the present life cycle model was developed by Christensen et al. (1977). It is outlined below.

Assume that age class 0 is divided into six sequential life stages from spawning time, t_0 , to the time of recruitment of y-o-y fish into age class 1 one year later. The choice of six life stages is arbitrary. The relative durations of these life stages are denoted by Δt_i ($i = 1, 6$), and they must add up to a year; i.e.,

$$\sum_{i=1}^6 \Delta t_i = 1 \text{ year.} \quad (15)$$

The numbers of fish within the six life stages are represented by $x_1(t)$, ($t_0 \leq t < t_1$); $x_2(t)$, ($t_1 \leq t < t_2$); ...; $x_6(t)$, ($t_5 \leq t \leq t_0+1$), where $t_1 = t_0 + \Delta t_1$, $t_2 = t_0 + \Delta t_1 + \Delta t_2$, etc. A hypothetical survival curve through these life stages is shown in Fig. 4. $x_1(t_0)$, which is equal to $n_0(t_0)$ in the previous notation, is the number of eggs spawned at time t_0 , and $x_6(t_0+1)$ is the number of y-o-y fish at the end of the sixth life stage, which become recruits to age class 1.

Within each life stage, mortality results from three principal factors: (1) Density-independent effects such as predation by other species, unfavorable environmental conditions, and power plant entrainment and impingement; (2) intra-life-stage regulation through competition for food and resources; and (3) predation by and competition from older age classes. A simple differential equation combining these three factors to describe the population dynamics of the i th life stage is,

$$\frac{dx_i(t)}{dt} = - (d_i + g_i x_i(t)) x_i(t) - \sum_{j=1}^{M-1} c_{ij} n_j(t) x_i(t) \quad (16)$$

Fig. 4. Hypothetical survival curve of number of y-o-y fish through the six life stages.

$$(t_{i-1} \leq t \leq t_i) ,$$

where $n_j(t)$ is the number of fish in the j th age class at time t within the duration of the i th life stage. The parameter d_i represents the rate of density-independent mortality, including both natural mortality, d_n , and power plant related mortality, d_p , where

$$d_i = d_{n,i} + d_{p,i} . \quad (17)$$

The term "density-independent" means that the coefficient, d_i , of $x_i(t)$ in the first term on the right side of Eq. (16), is itself independent of the number of fish. The parameters g_i and c_{ij} represent, respectively, rates of intra-life-stage regulation and rate of predation by and competition from older age-class fish of the same species. Both of these latter forms of mortality are called "density-dependent" because the coefficients of $x_i(t)$ are $g_i x_i(t)$ and $\sum_{j=1}^{m-1} c_{ij} n_j(t)$, which involve number of fish. It should be noted that competition for food, represented by $g_i x_i(t)$, usually does not in itself cause mortality, but renders the fish more susceptible to other forms of mortality such as predation or disease.

The rate of mortality of fish in age class 0 is almost always much greater (e.g., by more than a factor of 10) than the rate of mortality of older fish. Thus, one can assume that the $n_j(t)$'s ($j = 1, \dots, M-1$) are approximately constant over a year in Eq. (16). Therefore, the number of fish in age class j at the beginning of the year, $n_j(t_0)$, is substituted for $n_j(t)$. Then Eq. (16) can be solved analytically to yield

$$x_i(t_i) = \frac{(d_i + C_i)x_i(t_{i-1}) \exp(-(d_i + C_i)\Delta t_i)}{(d_i + C_i) + g_i x_i(t_{i-1}) (1 - \exp(-(d_i + C_i)\Delta t_i))}, \quad (18)$$

where

$$C_i = \sum_{j=1}^{M-1} c_{ij} n_j(t_0). \quad (19)$$

There are a total of six equations of the form of Eq. (18), one for each life stage. Eq. (18) can be written in abbreviated form as

$$x_i(t_i) = f_i(x_i(t_{i-1})) \quad (20)$$

Observe from Figure 4 that

$$x_{i-1}(t_i) = x_i(t_i) \quad (i = 2, 6), \quad (21)$$

mathematically expressing the fact that the number of fish leaving the (i-1)th life stage at time t_i equals the number entering the ith life stage at the same time.

Starting with a number of spawned eggs, $x_1(t_0)$, at the beginning of the year, the final number of y-o-y fish at the end of the year is found by applying Eq. (21) six times:

$$n_1(t_0+1) \quad x_6(t_0+1) = f_6(f_5(f_4(f_3(f_2(f_1(x_1(t_0))))))) \quad (22)$$

The survival probability for y-o-y fish through the entire year, p_0 (see Fig. 1), is then

$$p_0 = x_6(t_0+1)/x_1(t_0) \quad (23)$$

In setting up the model for a fish population it is necessary to assign values to the natural mortality rates, $d_{n,i}$, g_i , and c_{ij} .

This may be difficult because of insufficient data. The strategy for applying the model under such circumstances is to try a sequence of different cases, with each of these parameters taking different values over a plausible range. It may be possible to estimate directly the values of power plant mortality, $d_{p,i}$, but it is more likely that these will be deduced from empirical models or from indirect evidence such as estimates calculated with transport models (Eraslan et al. 1976, LMS 1975, Hess et al. 1975, Warsh, 1975).

The survival probability through age class 0, p_0 , can be decomposed into survival probabilities, p_{0i} , through each of the six life stages;

$$p_0 = p_{01} p_{02} \dots p_{06}, \quad (24a)$$

or

$$PNS_0 = p_{01} p_{02} \dots p_{06} \quad (24b)$$

in the absence of power plant mortality (i.e., $d_{p,i} = 0.0$, $i=1, \dots, 6$). PNS_0 is the y-o-y survival under natural conditions, in the absence of power plant mortality, and from Eq. (18)

$$p_{0i} = x_i(t_i)/x_i(t_{i-1})$$

$$= \frac{(d_{n,i} + C_i) \exp(- (d_{n,i} + C_i) \Delta t_i)}{d_{n,i} + C_i + g_i x_i(t_{i-1}) (1.0 - \exp(- (d_{n,i} + C_i) \Delta t_i))} \quad (25)$$

It may be easier to estimate p_{0i} than $d_{n,i}$ for a particular life stage. In this case, when the other mortality rates (i.e., g_i , c_{ij}) and $x_i(t_{i-1})$ are known, $d_{n,i}$ can be calculated from (25). This option is available in the computer code.

F. Steady-State Analysis

The negative feedback of the y-o-y mortality functions and the fishing mortality functions compels the great majority of realistic cases to converge eventually to a steady-state population. The remaining cases will run asymptotically toward infinity or to extinction or, in some instances, will run to a stable but oscillating population. In general, the probability of survival for age class 0 in the absence of power plant mortality, PNS_0 , cannot easily be determined from field and/or laboratory data. This parameter is commonly the least accurately known parameter in a life-cycle model.

This section will show that exactly one PNS_0 value and steady-state population vector exist when the biomass available to the fishery is assumed known and all other adjustable parameters are fixed. An analytic derivation of the solution is provided. A similar analytical technique originally was proposed and used in the earlier striped bass life-cycle model (Van Winkle et al. 1974) and recently was proposed and used by Vaughan and Saila (1976). Lawler, Matusky and Skelly Engineers (1975) adopted the same general approach, although they selected the first-order exponential mortality rate (i.e., the instantaneous mortality rate, Z) for adults as the free parameter to be uniquely determined. They then estimated this parameter using an iterative convergence scheme instead of an analytical expression.

A steady-state solution by definition has the property

$$n_i(t+1) = n_i(t) \quad i = 0, 1, 2, \dots, M-1, \quad (26)$$

where M-1 is the oldest age class. Since such a solution is time invariant, the notation for time, t, can be omitted.

Based on the steady-state definition and assuming no power plant mortality, we have

$$n_1 = n_0 \text{PNS}_0$$

$$n_2 = n_1 p_1 = n_0 \text{PNS}_0 p_1$$

and correspondingly for higher n_i . In general,*

$$n_i = n_0 \text{PNS}_0 \prod_{j=1}^{i-1} p_j \quad (i = 2, \dots, M-1) \quad (27)$$

The average number of eggs produced per fish (both sexes combined) upon entering age class i at the beginning of a year is given by f (see Eqs. 1-4). Thus, the total number of eggs produced is

$$n_0 = \sum_{i=1}^{M-1} n_i f_i \quad (28)$$

*Equation (27) is not valid for n_{M-1} without some redefinition. The equation assumes $n_{M-1} = n_{M-2} p_{M-2}$. In the model, however, age class M-1 is actually considered to consist of age class M-1 plus all older age classes. Therefore,

$$n_{M-1} = n_{M-2} p_{M-2} + n_{M-1} p_{M-1}$$

or

$$n_{M-1} = \frac{n_{M-2} p_{M-2}}{1.0 - p_{M-1}}$$

If we temporarily redefine p_{M-2} as $\{p_{M-1}\}_{\text{new}} = p_{M-2} / (1.0 - p_{M-1})$, Eq. (27) becomes valid.

or, by Eq. (27),

$$n_0 = n_0 \text{PNS}_0 \left(f_1 + \sum_{i=2}^{M-1} f_i \prod_{j=1}^{i-1} p_j \right) , \quad (29)$$

Solving for PNS_0 , we obtain finally

$$\text{PNS}_0 = 1.0 / \left(f_1 + \sum_{i=2}^{M-1} f_i \prod_{j=1}^{i-1} p_j \right) . \quad (30)$$

The value of TOTP (see Section II.C) which the steady-state solution is selected to satisfy is

$$\text{TOTP} = (\text{TOTP1} + \text{TOTP2}) / 2.0 . \quad (31)$$

Given this value of TOTP, steady-state F_j values may be calculated by Eq. (11). Given the M_j values, then PNS_0 is determined by Eq. (30). Once n_0 is specified, Eq. (27) will immediately yield the rest of the population vector.

Note that the selected value of TOTP (Eq. 31) must equal its defined value:

$$\text{TOTP} = \sum_{i=1}^{M-1} \text{VULN}_i \text{CATCH}_i \text{WT}_i n_i . \quad (32)$$

Substituting from Eq. (27)

$$\text{TOTP} = n_0 \text{PNS}_0 \sum_{i=1}^{M-1} \text{VULN}_i \text{CATCH}_i \text{WT}_i \prod_{j=1}^{i-1} p_j , \quad (33)$$

or

$$n_0 = \text{TOTP/PNS}_0 \left(\sum_{i=1}^{M-1} \text{VULN}_i \text{CATCH}_i \text{WT}_i \prod_{j=1}^{i-1} p_j \right) . \quad (34)$$

G. Stock and Recruits

Two variables of potential interest in evaluating a fish population at equilibrium are stock and recruits (or progeny) (Ricker, 1954 and 1975). In a multiple-age-class model, and particularly in one which incorporates density-dependent mortality rates for most age classes (Sections C and E), the choice of indices of stock and progeny is not clear cut. Rather, the choice and definition of the indices must depend both on the manner of application of the model and on the use to which information on stock and progeny will be put. For this reason, we have not incorporated specific indices into the model, but simply note that stock-recruitment or stock-progeny relationships could be obtained.

H. Concept and Definition of the Impact Factor

Two quantities of interest in impact analysis are the potential annual percentage reduction in survival through the first year of life due to a power plant and the resulting long-term, steady-state change in adult population size. The reciprocal of the ratio of these two quantities, which we call the "impact factor", has sometimes been estimated on the basis of professional judgment, particularly in cases where y-o-y models have been used without life-cycle models in an attempt to forecast population-level impacts (Warsh, 1975). With a life-cycle model the impact factor, I , is defined as

$$I = \frac{FR_A}{FR_Y}, \quad \text{for } FR_Y > 0. \quad (35)$$

The numerator of Eq. (35) is defined as

$$FR_A = \frac{AI_{T,0} - AI_{T,P}}{AI_{T,0}}. \quad (36)$$

AI_T is the chosen index of adult population size (e.g., TOTP; see Eq. 7), evaluated at a time T such that the index is either stable or has reached a minimum. The subscript 0 represents a model run without power plant mortality. The subscript P denotes a run with power plant mortality. Thus, FR_A is the resulting long-term, steady-state fractional reduction in the chosen index of the adult population size.

The denominator (FR_Y) of the expression for the impact factor (Eq. 35) is defined as the fractional reduction in the number of survivors from egg to age 1 owing to power plant mortality in the absence of compensation. A value for this parameter is input to the model. FR_Y has the property that

$$FR_Y = \frac{PNS_0 - P_0}{P_0}, \quad (37)$$

where PNS_0 is the probability of survival through age class 0 without power plant mortality, and P_0 is the probability of survival through age class 0 with power plant mortality - in both cases with no compensation. In a model simulation using y-o-y compensation, the actual

fractional reduction in survival from eggs to yearlings will not be as large as FR_Y , and it will change as the older age classes respond to the impact.

Power plant mortality for each of the six life stages within the 0th age class is determined by specifying the relative fractional reduction in the number of survivors from eggs through life stage i in the absence of compensation (RFR_i ; $i = 1, \dots, 6$; $RFR_6 = 1.0$). Then

$$FR_i = RFR_i FR_Y ; \quad i = 1, \dots, 6 , \quad (38)$$

where FR_i is the fractional reduction in the number of survivors from eggs through life stage i owing to power plant mortality in the absence of compensation. Note that $FR_6 = FR_Y$, since $RFR_6 = 1.0$. Values for relative fractional reduction from egg to yearling (FR_Y) may be estimated empirically (Texas Instruments, 1975) or from the results of y-o-y simulation models. FR_Y may be varied to represent different power plant configurations (e.g., once-through cooling versus closed-cycle cooling) and the RFR_i values may be varied to represent different vulnerabilities of the individual y-o-y life stages to power plant mortality. Once the values of FR_i calculated (Eq. 38), the values of $d_{i,p}$ (Eq. 17) may be calculated sequentially starting with eggs as follows:

For eggs

$$FR_1 = \frac{x_{1,0}(t_1) - x_{1,p}(t_1)}{x_{1,0}(t_1)} , \quad (39)$$

where $x_{1,0}(t_1)$ is the number of eggs at the end of the egg life stage (i.e., at time t_1) without power plant mortality, and $x_{1,p}(t_1)$ is the same quantity but with power plant mortality. However, in the absence of compensation,

$$x_{1,0}(t_1) = x_1(t_0) \exp(-d_{1,n}\Delta t_1) \quad (40)$$

and

$$x_{1,p}(t_1) = x_1(t_0) \exp(-(-d_{1,n} + d_{1,p})\Delta t_1), \quad (41)$$

where $x_1(t_0)$ is the number of eggs spawned at time t_0 , Δt_1 is the duration of the egg life stage, $d_{1,n}$ is the rate of density-independent mortality for eggs, and $d_{1,p}$ is the rate of power plant mortality for eggs (see Section II.E). After substitution of Eqs. (40) and (41) into Eq. (39) and some simplification,

$$FR_1 = 1.0 - \exp(-d_{1,p}\Delta t_1)$$

or

$$d_{1,p} = -\ln(1.0 - FR_1)/\Delta t_1 \quad (42)$$

For life stage i

$$FR_i = \frac{x_{i,0}(t_i) - x_{i,p}(t_i)}{x_{i,0}(t_i)}, \quad (43)$$

where $x_{i,0}(t_i)$ is the number of individuals in life stage i at the end of that life stage (e.g., at time t_i) without power plant mortality, and $x_{i,p}(t_i)$ is the same quantity but with power plant mortality. However, in the absence of compensation

$$x_{i,0}(t_i) = \prod_{j=1}^i x_1(t_0) \exp(-d_{j,n} \Delta t_j) \quad (44)$$

and

$$x_{i,p}(t_i) = \prod_{j=1}^i x_1(t_0) \exp(-(d_{j,n} + d_{j,p}) \Delta t_j), \quad (45)$$

where $x_1(t_0)$ is again the number of eggs spawned at time t_0 , t_j is the duration of life stage j , $d_{j,n}$ is the rate of density-independent natural mortality for life stage j , and $d_{j,p}$ is the rate of power plant mortality for life stage j (see Section II.E). After substitution of Eqs. (44) and (45) into Eq. (43) and some simplification,

$$FR_i = 1.0 - \prod_{j=1}^i \exp(-d_{j,p} \Delta t_j)$$

or

$$d_{i,p} = -\frac{1}{\Delta t_i} \left\{ \ln(1.0 - FR_i) + \sum_{j=1}^{i-1} d_{j,p} \Delta t_j \right\} \quad (46)$$

I. Limitations of the Model

It is useful to summarize the main approximating assumptions in our model, since these impose limits on the model's usefulness. The model is a "single-species" model; effects of changes in lower trophic levels are not taken into account. Density-dependent influences on

growth are not included except indirectly as they are related to y-o-y mortality. Possible density-dependent effects on fecundity and on the lengths, Δt_i , of y-o-y life stages, are also ignored. Finally, we neglect possible density-dependent power-plant mortality. As C. P. Goodyear (personal communication) has pointed out, power-plant induced mortality could be density-dependent when y-o-y fish are weakened by intra-life-stage competition for food.

Despite these and other simplifying assumptions in our model, we expect it to adequately simulate the important features of a fish population subjected to additional y-o-y mortality.

J. Summary of Data Necessary for Model

In the above sections, we have described the theoretical development of the life cycle model. It may be confusing to the reader at this point as to what data actually have to be supplied to the model. These are described briefly below, with reference to Fig. 5.

The data that must be supplied are:

1. The number of age classes, M (see line 38 of Fig. 5); this is currently limited to 16. Many dimension statements would have to be changed to increase this.
2. Initial population number estimates for each age class (lines 39 and 40).
3. FMT_i ; the fraction of females which are mature in age class i (lines 43 - 46). This parameter is designated $FMAT_i$ in the text (Eq. 1).

MATH

1	1	PMT1	PMT2	PMT3	PMT4	PMT5	PMT6	PMT7	
2	2	PMT8	PMT9	PMT10	PMT11	PMT12	PMT13	PMT14	
3	3	PMT15	PMT0	PMT1	PMT2	PMT3	PMT4	PMT5	
4	4	PMT6	PMT7	PMT8	PMT9	PMT10	PMT11	PMT12	
5	5	PMT13	PMT14	PMT15	PRY	PDIO	FDMX0	EPS	
6	6	TOTP1	LEGAL	RATIO	B3	B4	B1	B2	
7	7	ATMAX	FP0	FP1	FP2	FP3	FP4	FP5	
8	8	FP6	FP7	FP8	FP9	FP10	FP11	FP12	
9	9	FP13	FP14	FP15	ACON	B	C	VOL0	
10	10	VOL1	VOL2	VOL3	VOL4	VOL5	VOL6	VOL7	
11	11	VOL8	VOL9	VOL10	VOL11	VOL12	VOL13	VOL14	
12	12	VOL15	IYRCH	CHGDI	CHGDD	DELT1	DELT2	DELT3	
13	13	DELT4	DELT5	DELT6	DAP1	DAP2	DAP3	DAP4	
14	14	DAP5	DAP6	ZS1	ZS2	ZS3	ZS4	ZS5	
15	15	ZS6	CA11	CA12	CA13	CA14	CA15	CA21	
16	16	CA22	CA23	CA24	CA25	CA31	CA32	CA33	
17	17	CA34	CA35	CA41	CA42	CA43	CA44	CA45	
18	18	CA51	CA52	CA53	CA54	CA55	CA61	CA62	
19	19	CA63	CA64	CA65	GA1	GA2	GA3	GA4	
20	20	GA5	GA6	DAN1	DAN2	DAN3	DAN4	DAN5	
21	21	DAN6	RPR1	RPR2	RPR3	RPR4	RPR5	RPR6	
22	22	RJAGE							
23	23								
24	24								
25	25								
26	26								
27	27								
28	28								
29	29								
30	30								
31	31								
32	32								
33	33								
34	34								
35	35								
36	36								
37	37								
38	38								
39	39	FDI	16						
40	40	5.2E10	1.1E06	4.4E05	2.6E05	2.1E05	1.3E05	7.7E04	
41	41	2.5E04	1.4E04	8.3E03	4.5E03	2.5E03	1.5E03	8.3E02	
42	42	PT							
43	43	RDP	148						
44	44	PMT1	0.0	PMT2	3.0	PMT3	0.0	PMT4	0.06
45	45	PMT5	0.23	PMT6	3.71	PMT7	0.95	PMT8	1.0
46	46	PMT9	1.	PMT10	1.	PMT11	1.	PMT12	1.
47	47	PMT13	1.	PMT14	1.	PMT15	1.	PMT0	2.E-5
48	48	PMT1	.6	PMT2	.4	PMT3	.2	PMT4	.2
49	49	PMT5	.2	PMT6	.2	PMT7	.2	PMT8	.2
50	50	PMT9	.2	PMT10	.2	PMT11	.2	PMT12	.2
51	51	PMT13	.2	PMT14	.2	PMT15	.2	PRY	0.0
52	52	PDIO	.319	PDIOX0	.40	EPS	.00001	TOTP1	1E06
53	53	LEGAL	438.	RATIO	3.	B3	-5.34	B4	3.13
54	54	B1	98212.	B2	73030.	ATMAX	100.	FP0	.5
55	55	FP1	.5	FP2	.5	FP3	.5	FP4	.5
56	56	FP5	.5	FP6	.5	FP7	.5	FP8	.5
57	57	FP9	.5	FP10	.5	FP11	.5	FP12	.5
58	58	FP13	.5	FP14	.5	FP15	.5	ACON	
59	59	B	115.1	C	-3.09	VOL0		VOL1	
60	60	VOL2		VOL3	0.667	VOL4	1.0	VOL5	1.0
61	61	VOL6	1.0	VOL7	0.833	VOL8	0.833	VOL9	0.667
62	62	VOL10	0.667	VOL11	0.500	VOL12	0.500	VOL13	0.333
63	63	VOL14	0.333	VOL15	0.333	IYRCH		CHGDI	
64	64	CHGDD		DELT1	.00548	DELT2	.01667	DELT3	.0609
65	65	DELT4	.1111	DELT5	.337	DELT6	.471	DAP1	
66	66	DAP2		DAP3		DAP4		DAP5	
67	67	DAP6		ZS1		ZS2	1.1	ZS3	0.1
68	68	ZS4	0.2154	ZS5	0.2154	ZS6	0.2154	CA11	
69	69	CA12		CA13		CA14		CA15	
70	70	CA21		CA22		CA23		CA24	
71	71	CA25		CA31		CA32		CA33	
72	72	CA34		CA35		CA41		CA42	
73	73	CA43		CA44		CA45		CA51	
74	74	CA52		CA53		CA54		CA55	
75	75	CA61		CA62		CA63		CA64	
76	76	CA65		GA1		GA2		GA3	
77	77	GA4		GA5		GA6		DAN1	
78	78	DAN2	0.0	DAN3	0.0	DAN4	0.0	DAN5	0.0
79	79	DAN6	0.0	RPR1	0.01	RPR2	0.10	RPR3	0.30
80	80	RPR4	0.40	RPR5	0.45	RPR6	0.50	RJAGE	5
81	81	BEGH		1					
82	82	ITR							
83	83	PP							
84	84	RO	40	15	5	10	20	40	
85	85	CP	1						
86	86	PRY	0.3						
87	87	RO	40	15	5	10	20	40	1
88	88	OUT	15						
89	89								
90	90								

Fig. 5. Example 1 - Input data.

4. FNM_i ; the instantaneous natural mortality rate for fish of age class i (lines 47 - 50). This parameter is written M_i in the text (Eq. 12).
5. FRY ; the relative fractional reduction in the number of survivors from eggs through yearlings owing to power plant mortality in the absence of compensation (line 50). This is designated FR_Y in the text (Eq. 38). NOTE: If the instantaneous rates of power plant mortality, $d_{p,i}$, are specified for the individual life stages, it is not necessary to specify FRY since knowledge of FRY , along with RFR_i (see item 24 below) is equivalent to knowledge of the six $d_{p,i}$. See item 19 below for further information.
6. $FDIO$ and $FDMXO$; density-independent and maximum density-dependent fishing mortality rate coefficients, respectively (line 51). These are referred to in Eq. 9 of the text.
7. EPS ; measure of convergence of Newton's method for solving Eq. (25) (line 51). The current value of $EPS = 0.00001$ is probably appropriate for most purposes.
8. $TOTP1$; a population index below which fishing effort is a minimum, and is independent of fish density (line 51). See Eq. (6) of the text.
9. $LEGAL$; minimum legal length (mm) for fishing (line 52).
10. $RATIO$; ratio of $TOTP2$ to $TOTP1$, where $TOTP2$ is the population index above which fishing effort is a maximum (line 52). See Eq. (8) of the text.
11. $B3$ and $B4$; coefficients of weight-length regression (line 52). These coefficients are written B_3 and B_4 in the text (Eq. 3).

12. B1 and B2; coefficients of eggs vs. weight regression equation (line 53). These coefficients are written B_1 and B_2 in the text (Eq. 2).
13. ATMAX; the maximum number of iterations performed in the solution by Newton's method of Eq. (25) (line 53). This can normally be set to 100.
14. FF_i ; the ratio of female fish to the total number of fish entering age class i (lines 53 - 57). See Eq. (1) of text.
15. ACON, B, and C; coefficients of the length vs. age regression equation (lines 57 - 58). See Eq. (4) of the text.
16. VUL_i ; vulnerability to the fishery of fish in age class i relative to the most vulnerable age class (lines 58 - 62). This is denoted $VULN_i$ in the text (Eq. 7).
17. IYRCH, CHGDI, and CHGDD; parameters related to changes in the minimum and maximum fishing effort through time (lines 62 - 63). See Eqs. (9) and (10) in the text.
18. $DELT_i$; durations of y-o-y life stages (lines 63 - 64). These are denoted Δt_i in the text (Eq. 15).
19. DAP_i ; instantaneous rate of density-independent power plant mortality of fish in the i^{th} y-o-y life stage (lines 64 - 66). In the text this is denoted $d_{p,i}$ (Eq. 17). NOTE: If FRY and RFR_i are known, it is not necessary to specify the DAP_i 's. These values should be set to zero. If the DAP_i 's are set to nonzero values, they will be used instead of FRY and RFR_i .

20. ZS_i ; the probability of survival through the i^{th} y-o-y life stage in the absence of power plant mortality (lines 66 - 67). This is designated by p_{0i} in the text (Eq. 25). NOTE: If the density-independent instantaneous natural mortality rates, $d_{n,i}$, are specified, the ZS_i 's need not be specified and can be set to zero.
21. CA_{ij} ; instantaneous rate of mortality of fish in the i^{th} y-o-y life stage caused by cannibalism and competition from the j^{th} age class (lines 67 - 75). This is referred to as c_{ij} in the text (Eq. 16).
22. GA_i ; instantaneous rate of density-dependent natural mortality through competition for food and other resources among y-o-y fish in the i^{th} life stage (lines 75 - 76). This is called g_i in the text (Eq. 16).
23. DAN_i ; instantaneous rate of density-independent natural mortality of fish in the i^{th} y-o-y life stage (lines 76 - 78). This is called $d_{n,i}$ in the text. NOTE: If the ZS_i 's are specified, the values of DAN_i must be set to zero in the input data; if the DAN_i 's are nonzero, the program will use these instead of the ZS_i values.
24. RFR_i ; relative fractional reduction in the number of survivors from eggs through life stage i in the absence of compensation (lines 78 - 79). This is discussed following Eq. (38) in the text. NOTE: If the instantaneous rates of power plant mortality, $d_{p,i}$, are specified, it is not necessary to specify FRY and RFR_i .

25. RJAGE; a adjustable input parameter which determines which value of $A(I, I+1)$ is to be stored as OUTPT(8) for later printing in a summary table (e.g., RJAGE = 5 implies $A(5,6)$ is printed).

III. COMPUTER PROGRAM

A. Introduction

This chapter contains a description of the FORTRAN computer program implementing the population model as well as detailed instructions for using this program. The program is general in design, allowing different types of fish populations to be simulated by simply changing the input values of the "adjustable" parameters and initial population densities. "Command" cards in the input data are used to specify the desired sequence of data input, parameter changes, simulations, and printout of results. In this respect the program is highly flexible, offering a variety of options.

Succeeding sections describe in detail the input and output and document the routines. Following documentation of the routines, two sample cases (Section III.F) are presented, parts of which are referred to earlier in discussing the input and output from the model. The Appendix provides a complete program listing.

B. Input Setup

The input is based upon a set of short mnemonic commands (e.g., EP, RO). Each "command card" contains a field for the command, followed

by fields which supply further information. With one exception,* command cards are sequentially read and executed in a "once through" procedure. The format is always A5, 10I5.

Command cards which request reading or changing of the initial vector of parameter values are immediately followed by cards containing the pertinent values. An example of input setup (command cards and parameter values) is given in Fig. 5. The reader may find it easiest to refer to these examples first and then look up the meanings of the commands listed alphabetically below. The reader should refer to Table 1 for the meaning of various input parameters.

1. BEGN - Begin by Resetting to Input Values

This command is used to denote the beginning of a set of related cases and to restore initial population vector or parameter set input values. Although its use is not required, it aids in output identification. In the absence of this card, graphic and tabular output from this set will not have a unique identifying set number; also, the parameter set and initial population vector will remain at their present values, which may be appropriate only for previous cases.

Col. 1-5 Format A5 'BEGN', left adjusted.

*The "DO section" is a group of commands which may be reexecuted by means of another command.

Table 1. Program Variables

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
A	(M,M)	$A(t)$	Survival-fecundity matrix for the current year; $A(I,I-1) = p_i$	1, 2, 8, 26
ACON		ACON	Coefficient of the zero-order term in the quadratic relation between LENGTH and AGE	8
AGE		AGE_i	Age of fish in years at the i th annulus formation	8
ALG10			Intermediate variable used in calculating weights of fish at annulus formation from their lengths	8
ANAM			Temporary intermediate storage	11
ARRAY	(6,9,54)		Storage array for values of OUTPT, REL, and IMPACT, which are later printed	19
ATMAX			Maximum number of iterations performed in SUBROUTINE SOLVE to find the unknown $d_{n,i}$'s from Eq. (23)	2
AVAL	(4)		Temporary intermediate storage for parameter values	11
B		B	Coefficient of the first-order term in the quadratic relation between LENGTH and AGE	8
B1		B1	Coefficient of the zero-order term in the linear relationship between EGGS and WT (weight) of fish	8
B2		B2	Coefficient of the first-order term in the linear relationship between EGGS and WT	8

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
B3		B3	Coefficient of the zero-order term in the linear relationship between $\text{LOG}_{10}(\text{WT}_i)$ and $\text{LOG}_{10}(\text{LENGTH}_i)$	8
B4		B4	Coefficient of the first-order term in the linear relationship between $\text{LOG}_{10}(\text{WT}_i)$ and $\text{LOG}_{10}(\text{LENGTH}_i)$	8
BC	(6,9,7)		Storage array for benefit/cost information, which is later printed	19
BLOCKA			COMMON/BLOCKA/ OUTPT(20),IMPACT(20),REL(20)	1, 2, 8, 9, 10, 24
BLOCKL			COMMON/BLOCKL/ VNAME(256)	1, 11
BLOCKN			COMMON/BLOCKN/ N,NVARB, MVARB	1, 2, 8, 9, 10, 11
BLOCKV			COMMON/BLOCKV/ VARB(256)	1, 2, 8, 9, 10, 11, 25
BLOCKY			COMMON/BLOCKY/ YIELD,FTP,CATCH(16),FFM(16),F(16),WT(17),JYP	1, 2, 8, 9, 22, 25, 26
BLOKNS			COMMON/BLOKNS/ GAS(6),ZSS(6),CCAS(6),DELTS(6),XX(7),DAPS(6)	1, 2
C		C	Coefficient of the second-order term in the quadratic relationship between LENGTH and AGE	8
C _{ij}	(6,M)	C _{ij}	Rate of mortality of fish in the i^{th} y-o-y life stage caused by cannibalism and competition from the j^{th} age class ($j > 0$)	2, 10

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
IDETPR			Integer variable whose value determines whether program prints detailed yearly output or summary output	1
IER			An integer set equal to 1 if an invalid parameter name is encountered in input	11
IGPH			Index identifying graph to be plotted	15
IMPACT	(20)		Storage array containing values of impact factors ($\text{IMPACT}(I) = (1.0 - \text{REL}(I))/\text{FR}_y$)	1, 9, 10, 21, 24
IN			Integer specifying mode of reading input (IN=5 or 10)	11, 15
INTRY	(6)		Years for which the output of a run are to be listed in a summary table	18
IOP	(10)		Vector field following each command and supplying further information	1
IROW	(9)		Years for which summary table data are printed out	1
ISSET			Identification number for sets of related cases	1, 8
IV			Subscript and running index	
IY			Subscript and running index	8, 11
IYC			Subscript and running index	13
IYR			Subscript and running index	1, 21

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
FMAT	(M-1)	$FMAT_i$	Array giving for each age class the probability that a female is sexually mature upon entering that age class	8
FM		M_i	Age-class specific coefficient of instantaneous natural mortality	2, 8, 25
FR		FR_i	Fractional reduction in the number of survivors from eggs through life stage i in the absence of compensation	10
FRY		FR_y	Fractional reduction in the number of survivors from eggs to age 1 due to power plant mortality in the absence of compensation	24
FTP		F	Non-age-class specific coefficient of instantaneous fishing mortality	9, 24
GA	(6)	g_i	Rate of density-dependent self-regulation through competition for food and other resources among y-o-y fish of the i th life stage	2, 10
GAS	(6)	g_i	Same as GA	2
I			Subscript and running index	1, 2, 7, 8, 10, 11, 15, 16, 18 21, 24, 26
IAT			Part of the logic involved in reading in commands in a DO section	1, 16
IDEL	(9)		An array which stores the years for which values are to be plotted out in graphs 1 and 2	1

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
EX			Variable used in reading and recognizing commands in a DO section	14
F	(M)	f_i	Array giving the average number of mature eggs in the ovaries of a fish, male and female combined, upon entering age class i	2, 8, 24
FALSE			Logical variable set to the logical value 'FALSE' and used in logical comparisons for controlling the flow of the program	1
FDI		FDI(t)	Density-independent term in instantaneous coefficient of fishing mortality	9
FDIO		FDIO	Initial value of time-changing FDI(t)	9
FDD		FDD(TOTP(t))	Density-dependent term in instantaneous coefficient of fishing mortality	9
FDDMX		FDDMX	Maximum value of time-changing FDD	9
FDDMO		FDDMO	Initial value of time-changing FDD	9
FEEDBK			Logical parameter used to specify which option should be used in subroutine MAKMAT	1
FF	(M-1)	FF_i	Array giving for each age class the ratio of female fish to total number of fish entering that age class	2, 8
FFM		F_i	Age-class specific coefficient of instantaneous fishing mortality	2, 8, 9, 24, 25

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
DAP	(6)	$d_{p,i}$	Rate of density-independent power plant induced mortality of fish in the i th y-o-y life stage	2, 10
DAPS	(6)	$d_{p,i}$	Same as DAP	2
DELT	(6)	Δt_i	Duration of the i th y-o-y life stage	2, 10
DELTS	(6)	Δt_i	Same as DELT	2
DUMMY	VARIOUS		Dummy name used by a subroutine for a block of variables appearing in a COMMON statement in that subroutine but not actually used by the subroutine	2, 8, 9, 10
EGGS		$EGGS_i$	Average number of mature eggs in the ovaries of a sexually mature female striped bass upon entering age class i	8
EGTABL			Logical function; if TRUE, a table of "vital statistics" - lengths, weights, fecundities, etc., for each age class is printed out	2, 8
ENTRY			Variable used in reading and recognizing commands	7, 14
EPS		EPS	The measure of convergence of Newton's method in solving for the root of an equation (currently $EPS = 1.0 \times 10^{-5}$)	2
EPSI			Same as EPS	2
ENDD			Final value of time-varying FDDMX	9

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
CATCH	(M)	$CATCH_i$	Array giving for each age class the effective fraction of fish at the beginning of the year legally available to the fishery. Each $CATCH_i$ is approximated as the fraction of the year for which the average length of fish in age class i is greater than or equal to the minimum legal length, $LEGAL$	2, 8, 9, 24
CCA	(6)	C_i	Rate of mortality of fish in the i th y-o-y life stage caused by cannibalism and competition from the sum of all older age classes	2
CHGDI		CHGDI	Coefficient of the yearly change in FDI, the density-independent coefficient of fishing mortality	9
CHGDD		CHGDD	Coefficient of the yearly change in FDMX, the maximum possible coefficient of fishing mortality	9
CMND	(20)		Array of command names	7
COLHD			Column headings, representing different values of $FRY-1.0$, for the table of fractional change in survival probability for age class 0	19
DAN	(6)	$d_{n,i}$	Rate of density-independent natural mortality of fish in i th y-o-y life stage	2, 13

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
MR		M	Maximum row dimension of the Leslie matrix (=M)	1, 2, 11
MUSDO			The number of commands in a DO section	1, 16
MVARB			Number of variable parameters whose values can be adjusted	1
N			Number of elements in the population vector (=M)	1, 2, 8, 9, 11, 18, 25
NCHGS			Number of different cases of power plant impacts run in a particular series	1, 21, 24
NCOLS			Number of columns printed out in table of fractional changes in survival probability for age class 0, (NCOLS = NCHGS)	21
NEGGS			Total number of eggs spawned by all females in all age classes	8
NEXT			Part of the logic involved in reaching in commands in a DO section	1, 16
NM			Number of age classes which can cannibalize young (=5 presently)	2
NMI			N-1	2, 8
NOUT			Total number of output variables stored in OUTPT array for printing out of sum- mary table (=16)	21
NROWS			Number of years for which summary table data and graphs are printed out	1, 15, 18, 21

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
IYRS	(9)		An array which stores years for which data are plotted out in graphs 1 and 2	13
IYRCH		IYRCH	Number of years over which it is assumed a specified change in fishing effort occurs	2, 9, 10, 24
IYRI			Running index used to keep up with the number of elapsed years in a run	1, 8, 9, 24
J			Subscript and running index	2, 9, 10, 11, 15, 16, 21, 25, 26
JAGE			J for which A(J+1, J) is printed in summary table	
JYR			Age class in which fish enter the fishery	2, 8, 24
K			Subscript and running index	11, 15, 18, 21
KMND			The number of a particular command	
LEGAL		LEGAL	Minimum legal length of striped bass for the fisheries	8
LENGTH		LENGTH _i	Mean total length of a fish at the ith annulus formation	8
LES			The number of years that impacted values of yield, TOTP, or n, have fallen below a certain percentage, PER, of the base case	21
LNGTMI		LENGTH _{i-1}	Average total length of a fish at the (i-1)th annulus formation	8

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
VNAME	(256)		Dummy name used by main program for array of names of the adjustable parameters	1, 11, 12
VULN	(M)	$VULN_i$	Relative vulnerability of fish in age class i to fishing	2, 8, 9
WATE			Intermediate variable used in calculating TOTP	2
WT	(M+1)	WT_i	Array giving for each age class the average weight of a female at annulus formation	2, 8, 24, 25
X		P_{0i}	Fraction surviving through successive y-o-y life stages	2, 10
XW			Fraction surviving through successive y-o-y life stages in the absence of power plant effects	10
Y			Number of y-o-y fish remaining at end of successive life stages	10
YIELD		$YIELD(TOTP(t))$	Current yield of biomass to the fisheries	1, 24, 25
YR			Year number (in floating point) of current year	1
YW			Number of y-o-y fish remaining at end of successive life stages in the absence of power plant effects	10

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
RJAGE			An adjustable input parameter which determines which value of $A(I, I+1)$ is to be stored as $OUTPT(8)$ for later printing in summary table	8
SAVP	(256)		An array which stores initial population data	1
SET			Identification number of a set of related cases	15, 21
STEPDD		STEPDD	Yearly change in FDI	9
STEPDI		STEPDI	Yearly change in FDDMX	9
TEMP	(16)		Vector of temporary storage	1, 15, 24, 26
TITLE	(14)		Array for storing title to be printed on hard copy	
TOTP		TOTP(t)	Total biomass of fish legally available to the fishery at the start of the current year	1, 2, 8, 9, 24
TOTPl, TOTP2		TOTPl, TOTP2	The minimum and maximum biomasses expected to be actually available to the fishery over, for example, a 10-year period; only TOTPl is adjustable	1, 9
TRUE			Logical variable set to the logical value "TRUE" and used for logical comparison in controlling the flow of the program	1
VARB	(256)		Dummy name used by main program for entire array of adjustable parameters	1, 11

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
PNZ	(16)		Used in manipulating initial vector of population estimates	1
PNO	(M)	$n(t_0)$	Initial population vector with elements n_{i,t_0}	1, 11, 18
PPX			Survival from spawning to the end of y-o-y life stage i	8, 10
PSET	(16)		Storage array which stores NCHGS values of FR_y for later printing out of column headings in summary table	1, 15, 21
RASH	(16)		RASH(I) is the ratio of fish in age class i to fish initially entering age class 1	2
RATIO		RATIO	The average ratio of the maximum to the minimum biomass actually available to the fishery within, for example, 10 or 20 year periods; used in calculating TOTP2 from TOTP1	1, 9
RCPUE			Relative catch per unit effort	1, 24
REL	(20)		Array storing relative values of OUTPT variables $(REL(I) - OUTPT(I)_t / OUTPT(I)_0)$, for printing out in summary table	1, 21, 24
RFR	(6)		Relative fractional reduction in the number of survivors from eggs through life stage i in the absence of compensation	10

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
NP			Parameter specifying location in the array of adjustable parameters for the parameter of interest	11
NREL			Total number of output variables stored in REL and IMPACT arrays for printing out in summary table (=7)	21
NTYPS			Number of types of data (i.e., OUTPT, REL, IMPACT and BC) printed out in summary table (NTYPS = 4)	
NVARB			Number of adjustable parameters whose values can be varied interactively	1, 11, 12
NYR			Parameter for storing number of years in a run	1
OUTPT	(20)		Array storing assorted variables, described in section III.C.2.a, to be printed out in summary table	1, 8, 9, 10, 21, 24
OUTNAM	(4)		Array storing captions 'OUTPT', 'REL', 'IMPACT' and 'B/C' for use in summary table	21
PARAM			Parameter containing name of one of the adjustable parameters for comparison with parameters in input data	12
PER			A percentage value which is compared with the percentage which impacted values of yield, TOTP, and n, have fallen below the base case values	21
PN	(M)	$n(t)$	Current population vector with elements $n_{i,t}$	1, 2, 8, 10, 11, 18, 24, 26

Table 1. (continued)

Fortran variable name	Dimension (if array)	Mathematical symbol	Definition	Found in subroutine
YRVAL	(101,9,4)		Stores yearly values of PFM,YIELD,PN(2), and TOTP for later printing	1, 15, 21, 24
ZS	(6)	$P_{z,i}$	Probability of survival through the ith y-o-y life stage	2
ZSS	(6)		Same as ZS	2

Col. 6-10	Format I5	To return to the input population vector, leave this field blank or enter a zero.* To keep the present value of the initial vector, enter a nonzero number.
Col. 11-15	Format I5	To return to the input parameter set values, leave this field blank. To keep the present values of the parameter set, enter a nonzero number.
Col. 16-20	Format I5	The user may specify the set number here. Otherwise, the set number is incremented from the previous set.

2. CI - Change Initial Values

This card specifies how many of the values of the initial population vector are to be changed. The command card format is:

Col. 1-5	Format A5	'CI', left adjusted
Col. 6-10	Format I5	The number of the initial values of the population vector to be changed

*In integer fields, a zero is equivalent to no entry.

Immediately following the command card are the changed initial values with the format,

4(I5,E10.0,5X)

The I5 field contains the age class, from 1 to M, followed by the new value in the E field. Thus, the age class is entered in columns 1-5, 21-25, 41-45, 61-65, while the value for the number of fish in the corresponding age class is entered in 6-15, 26-35, 46-55, 66-75.

3. CP - Change Parameter Values

This card specifies how many adjustable parameter values are to be changed. The command card format is:

Col. 1-5	Format A5	'CP', left adjusted.
Col. 6-10	Format I5	The number of parameters to be changed.

Therefore, up to four parameters are entered per card, the parameter names being left adjusted to columns 1, 21, 41, and 61, and the new parameter values located in columns 6-15, 26-35, 46-55, and 66-75.

4. DO - Execute and Save the Commands Following

The cards following this card through an ENDO card are to be executed normally but also saved for reexecution (REDO). This set of cards comprises a 'DO section'. Note that the DO card introduces, but is not a part of, the DO section. A DO section may contain only one ENDO card and no DO or REDO cards. All other cards are permissible.

Only one DO section at a time is saved, that being the one most recently encountered.

Note that after this command is read, the full DO section is read, listed, and stored, and then is executed.

Col. 1-5 Format A5 'DO', left adjusted.

5. ENDO - Terminate the 'DO' Section'

This command performs no operation other than specifying the end of a 'DO section'. This is always the last card of a DO section.

Col. 1-5 Format A5 'ENDO', left adjusted.

6. ITR - Calculate PNSO to Achieve a Target TOTP

A routine is called which analytically calculates the PNS_0 value and population vector associated with a target value of TOTP equal to $(TOTP1 + TOTP2)/2$.

Col. 1-5 Format A5 'ITR', left adjusted.

7. OUT - Generate Graphic or Tabular Output

The OUT card requests that part or all of the data specified by the RO card be output.

After the processing of each 'OUT' card, the data are cleared. Thus, each collection of related data may be accessed once only by an 'OUT' card. There are two tables and two graphs that may be requested. The content of these tables and graphs is discussed in detail in the next section on Output (Section III.C).

Col. 1-5	Format A5	'OUT', left adjusted
Col. 6-10	Format I5	<p>Enter the sum of the code numbers of all desired types of output:</p> <p>Summary table = 1; Benefit/Cost (b/c) table = 2; Graph 1 = 4; Graph 2 = 8; Thus to request the summary table and graphs 1 and 2 enter 1 + 4 + 8 = 13 in columns 9 and 10.</p>
Col. 11-15	Format I5	<p>Some sets (as defined by the BEGN card) have more than one OUT card. If the user enters any nonzero number here, the output from each such 'subset' will have a positive subset number appended to the set number. For example, if set 5 has three subsets and thus three 'OUT' cards for which this field is marked, they will be designated 5.1, 5.2, 5.3 in the output. When this field is blank, the subset number is always zero.</p>
Col. 20	Format I1	<p>To specify the reference case from which differences in relative yields are calculated for the benefit/cost output, enter in this column the</p>

sequence number of the reference case. The first case for which b/c output is generated is number 1, the second case number 2, etc.

8. PI - Print Initial Vector

Inclusion of this card generates output of the current population vector.

Col. 1-5	Format A5	'PI', left adjusted.
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9. PP - Print Parameter Set

Inclusion of this card generates output of the current parameter set, consisting of names and values.

Col. 1-5	Format A5	'PP', left adjusted.
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10. RO - Run from Year Zero

This card requests a run for a specified number of years starting with the current initial population vector and the current parameter set. All other fields on the card supply output information.

Col. 1-5	Format A5	'RO' ("R-zero"), left adjusted.
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Col. 6-10	Format A5	The number of years to run.
-----------	-----------	-----------------------------

Col. 11-15	Format A5	IDETPR, yearly printing detail:
------------	-----------	---------------------------------

IDETPR > 0 generates detailed yearly values;

= 0 generates one line of output per year;

< 0 suppresses yearly output.

Col. 16-20 Format I5

Enter the sum of the code numbers of all desired types of output (same as for the 'OUT' card).

Summary table = 1;

Benefit/Cost (b/c) table = 2;

Graph 1 = 4; Graph 2 = 8;

The content of these tables and graphs is discussed in the next section on Output (Section III.C).

Col. 21-25, Format 6I5

26-30,

31-35,

36-40,

41-45,

46-50.

If the values in this run (and all RC continuations) are to be listed in a summary table, enter the years for which values are to be output.

Up to six years are permitted.

These entries are necessary only for the first such R0 card associated with each OUT card.

Col. 51-55 Format I5

Enter a nonzero number in column 54 to generate a table of "vital statistics": age, length, weight, eggs per female, sex ratio, fraction of females sexually mature, fecundity, legal catchability,

vulnerability, and conditional probability of natural mortality for each age. Enter a nonzero number in column 55 to suppress printing of the final population vector of this run and any RC continuations.

11. RC - Continuc Running

Continue running from the last point for a specified number of years. All output other than yearly printing detail is determined by the most recent previous RO card.

Col. 1-5	Format A5	'RC', left adjusted.
Col. 6-10	Format I5	The number of years to run.
Col. 11-15	Format I5	IDETPR, yearly printing detail:
		IDETPR > 0 generates detailed yearly values;
		= 0 generates one line of output per year;
		< 0 suppresses yearly output.

12. RDI - Read Initial Population Vector

Col. 1-5	Format A5	'RDI', left adjusted.
Col. 6-10	Format I5	M, the number of age classes or values in the initial population vector. Presently ≤ 16 .

This is generally one of the first three command cards in the input deck. It is followed immediately by cards with the values of the initial population vector with format 8E10.0.

The RDI card and the data it references must precede the first RO card. Later redefinition of the initial vector by the RDI command is permitted at any point. The PI command is used to print the initial vector.

13. RDP - Read Adjustable Parameters

Col. 1-5	Format A5	'RDP', left adjusted.
Col. 6-10	Format I5	The number of adjustable parameters, presently 148.

This is generally one of the first three command cards in the input deck. It is followed immediately by cards with the complete set of adjustable parameter names and values in any order. The user enters the alphanumeric name of each parameter, followed by its value. The format is

4(A5,E10.0,5X)

Thus, four parameters are entered per card, the names left adjusted to columns 1, 21, 41, and 61, and the values located in columns 6-15, 26-35, 46-55, and 66-75.

As with the RDI command, the RDP command and its data must always precede the first RO command. The RDP command may precede or follow the RDI command.

The PP command will generate a list of parameter names and values at any time.

14. REDO - Reexecute the DO Section

Earlier in the program, a DO section of instructions was executed. This command requests that they be executed again. The user may also modify the DO section by the feature described below.

The REDO option may be used an unlimited number of times.

Col. 1-5	Format A5	'REDO', left adjusted.
Col. 11-15	Format I5	To replace one command in the DO section by another, enter here the sequential number* within the DO section of the command to be replaced; then immediately following this REDO card, put the replacement card. Commands which control reading of further data (RDI, RDP, CP, CI) should not be replaced or used as replacements. Replacement affects only this REDO execution, not any later REDO's.

*The first command after the DO card has sequential number one; the next command, two; and so on.

15. RI - Replace Initial Population Vector

The initial population vector is the population by age class at the start of a run, which may differ from the input initial vector. This command enables the user to replace the present initial vector with either the current vector or the input initial vector.

Col. 1-5	Format A5	'RI', left adjusted.
Col. 6-10	Format I5	To replace the initial vector with the current vector, leave this field blank. To replace the initial vector with the input vector (as with the BEGN command), enter a nonzero number.

16. TRA - Transfer to Another Command

This card is useful to modify the DO section in a REDO operation. If K is the entry in the integer field, this command transfers control to the Kth command below this card. Thus, K = 1 has no effect on execution. As in FORTRAN, transfer into the middle of a DO section is illegal.

Col. 1-5	Format A5	'TRA', left adjusted.
Col. 6-10	Format I5	K, the transfer value. K=0 is equivalent to K=1.

C. Output

The three main components of the output are run-command (RO and RC) output, tables, and graphs. Other output includes error messages

and the job summary page. Cases* are grouped into "sets" as determined by the BEGN card; corresponding "set numbers" identify output, particularly the tables and graphs.

1. Run Command Output

The quantity of RO or RC output is completely user controlled. It may include any or all of the following: yearly output in either summary or detailed form, a "vital statistics" table, and the final population vector.

The yearly output is exhibited in some of the figures presented with the examples. The summary form prints one line of data for each year. YIELD and variables involving YIELD are calculated as occurring during the listed year, while N1, TOTP, and variables involving TOTP are calculated as occurring at the beginning of the listed year. TOTP is calculated by Eq. (7), F is the non-age-class specific instantaneous fishing mortality (Eq. 5 and Fig. 3), and YIELD is calculated by Eq. (14). N1 is the beginning of the year population of age class 1. The other quantities are

$$\begin{aligned}
 \text{REL TOTP (relative TOTP)} &= \text{TOTP}(t)/\text{TOTP}(0) \\
 \text{REL EFRT (relative effort)} &= F(t)/F(0) \\
 \text{REL YIELD (relative yield)} &= \text{YIELD}(t)/\text{YIELD}(0) \\
 \text{IMPACTP (TOTP impact)} &= (1.0 - \text{REL TOTP})/\text{FR}_Y \\
 \text{IMPACTY (YIELD impact)} &= (1.0 - \text{REL YIELD})/\text{FR}_Y
 \end{aligned}$$

*Each case consists of an RO run plus any succeeding RC runs. Output data are generally organized by cases rather than runs.

$$\begin{aligned} \text{RCPUE (relative catch per} \\ \text{unit effort)} &= \text{REL YIELD/REL EFRT} \end{aligned}$$

Detailed yearly output consists of the summary line just described plus the population vector at the beginning of the listed year. The default option (blank or zero in the pertinent field) on yearly output is the summary form. The user may also suppress all yearly output.

The vital statistics table lists the following information for each age class: average total length of a fish at the i^{th} annulus formation, LENGTH_i (Eq. 4); average weight of a fish at the i^{th} annulus formation, WT_i (Eq. 3); average number of eggs in the ovaries of a sexually mature female entering age class i , EGGS_i (Eq. 2); ratio of female fish to the total number of fish entering age class i , FF_i , written as FEMALE in the output; probability that a female entering age class i is sexually mature, FMAT_i ; average number of eggs produced per fish (both sexes combined) upon entering age class i , f_i (Eq. 1) written as FSUBI in the output; effective fraction of fish in age class i at the beginning if the year legally available to the fishery, CATCH_i ; vulnerability to the fishery in age class i relative to the most vulnerable age class, VULN_i ; and conditional probability of natural mortality ($= 1.0 - \exp(-M_i)$) for fish in age class i , NAT.MORT_i . The default option is suppression of this table.

The population vector at the end of the last year of the RO run (and each RC run) is printed unless suppressed by an entry on the RO card.

2. Tabular Output

a. Summary Table

The summary table (see the figures presented with the examples in III.F) is generated by request on the OUT command card and all R0 cards associated with that OUT card. It provides a means of comparing up to nine related cases by listing values of output variables side by side for selected years. The cases and years are specified on the R0 command card.

All summary tables are printed in a separate output section (logical number 9) for easier access and special printing options. Each table is identified by its set number, printed at the top of the first page. The set number is incremented by means of the BEGN card.

Since comparative cases are presently being generated by varying FR_Y , the fractional reduction in the number of survivors to age 1 due to the power plants in the absence of compensation (Eq. 37), the values of FR_Y are the column headings identifying each case. Cases which consist of multiple runs (R0 plus RC runs) are identified by the FR_Y value of the R0 run. One of the cases in the table must have $FR_Y = 0.0$ (i.e., no power plant impact) for the entire duration of the case. This is the base case used in generating relative output values.

Values are listed for up to six years, as specified on the R0 card.

The first 16 output variable are

OUTPT(1)	=	TOTP(t)
OUTPT(2)	=	YIELD(t)
OUTPT(3)	=	F(t)
OUTPT(4)	=	NO(t)

$$\begin{aligned}
\text{OUTPT}(5) &= N1(t) \\
\text{OUTPT}(6) &= NM(t) \\
\text{OUTPT}(7) &= PO(t) \\
\text{OUTPT}(8) &= A(J+1, J) \quad (J \geq 4) \\
\text{OUTPT}(9) &= FDI/F(t) \\
\text{OUTPT}(10) &= (F(t) - FDI)/F(t) \\
\text{OUTPT}(11) &= p_{01}(t) \\
\text{OUTPT}(12) &= p_{02}(t) \\
\text{OUTPT}(13) &= p_{03}(t) \\
\text{OUTPT}(14) &= p_{04}(t) \\
\text{OUTPT}(15) &= p_{05}(t) \\
\text{OUTPT}(16) &= p_{06}(t)
\end{aligned}$$

where $TOTP(t)$, $YIELD(t)$, $N1(t)$, and $F(t)$ are defined under yearly output; $NO(t)$, $NM(t)$ are the beginning of the year populations of age class 0 and age class M (oldest age class), respectively; $PO(t)$ is survival through the first year, $A(J+1, J)$ is survival from age class J to age class J+1; $FDI/F(t)$ is the ratio of density-independent fishing mortality to total fishing mortality; and p_{0i} is the survival probability through the i^{th} y-o-y life stage.

The next 7 output variables are relative values, or yearly values divided by the base case,

$$REL(I) = \text{OUTPT}(I)_t / \text{OUTPT}(I)_0 \quad (I=1,7).$$

Note that $REL(3) = REL \text{ EFRT}$, as defined in the yearly output.

The next 7 output variables are defined by

$$\text{IMPACT}(I) = (1.0 - \text{REL}(I)) / \text{FR}_Y \quad (I=1,7).$$

Note that $\text{IMPACT}(2) = \text{IMPACTY}$ and $\text{IMPACT}(2) = \text{IMPACTP}$, as defined in the preceding section.

3. Benefit/Cost Analysis

Provision has been made in the computer program for the calculation and printing out of various benefit/cost indices. Because interpretation of these indices is still problematic, their description is omitted from this report.

4. Graphic Output

Graphic output is plotted by means of the DISSPLA computer display system (Integrated Software Systems Corporation, P.O. Box 9906, San Diego, California). This system has been implemented at many computer facilities. If the life cycle model is to be used at a facility without this feature, alternative arrangements must be made if plots are desired.

Two graphs enable the user to display data from related cases in a set:

- a. Graph 1 plots relative TOTP vs. time.
- b. Graph 2 plots relative yield vs. time.

Additional graphic capabilities can easily be added to the program if desired.

The user makes entries on the RO cards of those cases for which graphic output is desired. The graphs are then generated by request of the OUT command card. Each of Graphs 1 and 2 may contain data for up

to nine different cases. The "base case", $FR_y = 0.0$, need not be present on a graph. Data from the first year of an RC run replace corresponding data from the final year of the previous run.

Graphs 1 and 2 each have the same format, one curve for each case plotted. The legend to the right of each graph lists the FR_y value associated with each curve. As in the table, cases which consist of multiple runs (RO plus RC) are identified by the FR_y value of the RO run. The curves are drawn using values for each year (in cases of up to 100 years), although plotting symbols are entered only every 5 or 10 years. Cases of no more than 100 years duration* may be plotted in graphs 1 and 2.

5. Miscellaneous Output

The remaining output may be categorized as being printed either with the standard output (logical number 6) or in a separate final page of output (logical number 11) as the "job summary" page. The job summary page is always the page following the end of the standard output unless a special printing option is requested for the standard output.

The job summary page provides the user with a quick summary of what may be dozens of pages of standard output. For each set of cases successfully completed including all output, the following message is printed:

*There is one exception to this requirement: graphs may be gathered from a set of cases which consists only of RO runs of length 101 years to 200 years.

OUTPUT COMPLETED, SET x.x

Whenever a significant input error is encountered, it is printed both in the standard output and on the job summary page. Finally, since normal job termination is caused by encountering an end-of-file card in the input stream, the last line of both the standard output and the job summary page should be:

EXIT AT END-OF-FILE CARD.

As each command card is processed it is printed in the standard output. Each of the ten integer fields on the command card is printed below the heading Ik, for the kth integer field. Other standard output not related to the run commands includes data printed in response to the PI, PP, and CP commands.

When the DO command is processed, all cards following it, through the ENDO command card, are read and printed with their associated sequential command numbers. This is the number which may be referenced in the REDO statement.

When a plot has been completed, a page listing the graph specifications is printed. The message,

DISPLA i COMPLETED -- CONTAINS m CASES

signifies successful completion of the plotting.

Nearly all the error messages are self-explanatory. However, the following two messages are explained here.

FOLLOWING CARD TO MODIFY DO SECTION WAS NEVER READ. READ NOW WITHOUT EXECUTING.

A REDO command used the option to replace a command in the DO section by another. The sequential command number listed was never reached while reexecuting the DO section. The replacement card is now read, printed immediately below the error message, and the program continues with the next command.

WARNING: NO FRY = 0 CASE WAS REQUESTED ON GRAPH i

Inclusion of the base case, $FRY = 0$, is not necessary, but since it is routinely used, exceptions are noted.

D. Definitions of the Variables

Before describing the subroutines which perform most of the calculations in the model, it is useful to define the variable names used in the calculations. Table 1 lists alphabetically all the important FORTRAN variable names used in any of the subroutines concerned with the actual calculations for the models.

Column 1 of Table 1 gives the FORTRAN name of the variable.

Column 2 gives the dimension of storage block reserved for the variable if it is an array variable.

Column 3 contains the symbol used for the variable in the mathematical formulation of the model which was given in the earlier sections of this report.

Column 4 contains the definition and/or description of the variable and its use in the program.

Column 5 lists the subroutine number (see Table 2) of the subroutines in which the variable is used.

Many of the vector variables in the model have zero-subscripts (e.g., $n_0(t)$), but zero-subscripts are not allowed in FORTRAN. Table 3 gives a complete list of the arrays in columns corresponding to age class. In some cases the FORTRAN program does not store the variable as an array so only the mathematical names and subscripts are given. In cases where the FORTRAN program does treat the variable as a FORTRAN array, the mathematical names and subscripts are given first and the corresponding FORTRAN names and subscripts are given directly below. By referring to Table 3 the user can easily determine for each variable the FORTRAN subscript corresponding to any age class.

E. Description of Routines

The programming package consists of a main program and a number of subroutines (Table 2). These components of the program are arranged in the table in the order in which they appear in the listing of the code in the Appendix. This ordering is roughly alphabetical except that subroutines which are not called by the main program but only by another subroutine are listed under that subroutine. The subroutines labelled ENTRY are actually parts of the subroutines they are listed under. The advantage of using ENTRY statements is that particular information can be obtained from or entered into a subroutine without having to enter it from the beginning. The second and third columns of

Table 2. Subroutines of the life cycle model code

Subroutine name	Calling subroutine	Subroutines called
1. MAIN	-	2,7,8,11,13-26,3
2. ANALYT	1	3
3. SOLVE	2	4,6
4. SCAN	3	5,6
5. BISECT	4	6
6. FUNCTION FF	2,3,4	
7. GETCMD	1,14	
8. MAKMAT	1	9,10
9. PFMCLC	8	
10. YOYMRT	8	
11. NITPRM	1	12,17,18
12. FINDNP	11	
13. PLOTST	1	
14. ENTRY PLTSV	1	
15. PLT123	1	
16. PROCDO	1	7
17. REREAD	1	
18. RPLACE	1,11	
19. ENTRY PVEC	1,11	
20. ENTRY RDYRS	1	
21. TABLE	1	
22. ENTRY BCTAB	1	
23. ENTRY PRETAB	1	
24. YEARLY	1	
25. YLDCLC	1	
26. YRRUN	1	
27. BLOCK DATA		

Table 3. Subscripting Scheme for the Vector Variables

AGE CLASS	0	1	2	...	M-1
M A T H E M A T I C A L A N D F O R T R A N S N A M E S	CATCH(1)	CATCH ₁ CATCH(2)	CATCH ₂ CATCH(3)	...	CATCH _{M-1} CATCH(M)
	f ₀	f ₁ F(1)	f ₂ F(2)	...	f _{M-1} F(M-1)
	FF ₀ FF(1)	FF ₁ FF(2)	FF ₂ FF(3)	...	FF _{M-1} FF(M)
	F ₀ FFM(1)	F ₁ FFM(2)	F ₂ FFM(3)	...	F _{M-1} FFM(M)
		FMAT ₁ FMAT(1)	FMAT ₂ FMAT(2)	...	FMAT _{M-1} FMAT(M-1)
	M ₀ FNM(1)	M ₁ FNM(2)	M ₂ FNM(3)	...	M _{M-1} FNM(M)
	VULN ₀ VULN(1)	VULN ₁ VULN(2)	VULN ₂ VULN(3)	...	VULN _{M-1} VULN(M)
	WT ₀ WT(1)	WT ₁ WT(2)	WT ₂ WT(3)	...	WT _{M-1} WT(M)
	n ₀ (t) PN(1)	n ₁ (t) PN(2)	n ₂ (t) PN(3)	...	n _{M-1} (t) PN(M)

Table 2 tell where a particular subroutine is called from and what other subroutines it calls.

The core of the model calculations is performed in ANALYT, MAKMAT, YRRUN, and YLDCLC and in their subsidiary subroutines, SOLVE, SCAN, BISECT, FUNCTION FF, PFMCLC, and YOYMRT. The other subroutines are designed primarily to facilitate the input and output of data in a flexible manner.

A complete listing of the program is given in the Appendix. Below, the component subroutines of the program are described.

1. Main Program

The main program controls the reading of all input data, executes many of the commands including the run commands RO and RC, supervises data storage for the graphs and tables, and generates much of the standard output.

At the major control point in the program (see comment card "THIS IS THE COMMAND POINT") a command card is read and identified and a branching to the area in the main program which processes that command is made. Every operation including loading of the adjustable parameter set and initial population vector must be requested here by a specific command card. Additional information is supplied on further fields of each command card and stored in the array IOP. After each command card is executed, a branching back to the command point is made and the next command card is read and executed.

An abridged flow chart of the main program is given in Fig. 6. The command loops shows in detail only three of the most important command

Fig. 6. Abridged flow chart of the main program.

options for carrying out the calculations of the model. The initialization segment is abbreviated in the flow chart.

The program first reads the input data for the initial population vector, $n(t_0)$ (FORTRAN array PN), which contains the initial estimates of the number of fish in each age class. It next reads in the adjustable values.

After the initial vector is defined, the program initializes the Leslie matrix in subroutine MAKMAT, which is described in more detail in a later section. For the present purposes it suffices to say that MAKMAT is called in different parts of the main program to accomplish one of two purposes: either to initialize the Leslie matrix before beginning a run of the model or to update the Leslie matrix with the feedback information in a run at the end of each year. Which task it does is decided by the logical variable FEEDBK, which is set to the logical value 'FALSE' for initialization and 'TRUE' for updating.

The call to MAKMAT, which immediately follows the initialization of the adjustable parameters and the initial vector, is an initialization call. Upon return from MAKMAT, the main program enters the command loop at the COMMAND POINT. Many of the possible commands (see Section III.B) require more information than the simple two-character command codes which initiate them. This additional information is coded in the columns following the commands.

The command code CP (see Fig. 6) is used for changing one or more of the adjustable parameters. This card is followed by cards with the names of the parameters to be changed and the new values of these parameters.

The names of the adjustable parameters in the package are given in Table 4. The first column gives the name used for inputting of parameters. The second column gives the corresponding FORTRAN name used internally by the programs. The third column gives the mathematical name used in the mathematical formulation of the model given in the earlier sections of this report. Further definitions of these variables used during the calculations are given in Table 1.

In addition to specifying the changes in the parameter values, the user can indicate whether his next run of the model will start from the year zero or from the year where the preceding run left off. Given this information, the program calls MAKMAT to initialize the Leslie matrix accordingly.

The flow chart in Fig. 6 shows both of the run options, RO and RC. Actually, the two options are identical except for the initialization of the starting population vector. RO means run the model starting with year zero and the starting vector set equal to the initial vector. RC means continue running the model from the current model year using the solution vector from the preceding year as the starting vector. Before beginning the run, both options call MAKMAT in order to initialize the Leslie matrix using the current starting vector. The next step is to call Subroutine YLDCLC to compute the yearly yield. Following this the main program calls ENTRY PRETAB, in which it stores information for later printing out in the summary table in Subroutine TABLE.

After printing the headings for the subsequent printing out of yearly output, the program enters the run loop. One pass through the

Table 4. The Adjustable Parameters

Input Variable Name	Fortran Variable Name	Mathematical Symbol
FMT1	FMAT(I)	$FMAT_i$
FMT2	I = 1,M-1	i = 1,M-1
⋮		
FMTM		
FNMO	FNMI(I)	M_i
FNMI	I = 1,M	i = 1,M
⋮		
FNMI(M-1)		
FFO	FF(I)	FF_i
FF1	I = 1,M	i = 1,M
⋮		
FF(M-1)		
VULO	VULNI(I)	$VULN_i$
VUL1	I = 1,M	i = 1,M
⋮		
VUL(M-1)		
FRY	FRY	FR_Y
FDIO	FDIO	FDIO
FDMXO	FDMXO	FDMXO
EPS	EPS	EPS
TOTP1	TOTP1	TOTP1
LEGAL	LEGAL	LEGAL
RATIO	RATIO	RATIO

Table 4. (continued)

Input Variable Name	Fortran Variable Name	Mathematical Symbol
B3	B3	B3
B4	B4	B4
B1	B1	B1
B2	B2	B2
ATMAX	ATMAX	ATMAX
ACON	ACON	ACON
B	B	B
C	C	C
IYRCH	IYRCH	IYRCH
CHGDI	CHGDI	CHGDI
CHGDD	CHGDD	CHGDD
DELT1	DELT(I)	Δt_i
DELT2	I = 1,6	i = 1,6
⋮		
DELT6		
DAP1	DAP(I)	$d_{p,i}$
DAP2	I = 1,6	i = 1,6
⋮		
DAP6		
ZS1	ZS(I)	p_{0i}
ZS2	I = 1,6	i = 1,6
⋮		
ZS6		

Table 4. (continued)

Input Variable Name	Fortran Variable Name	Mathematical Symbol
CA11	CA(I,J)	c_{ij}
CA12	I = 1,6	i = 1,6
⋮	J = 1,5	j = 1,5
CA65		
GA1	GA(I)	g_i
GA2	I = 1,6	i = 1,6
⋮		
GA6		
DAN1	DAN(I)	$d_{n,i}$
DAN2	I = 1,6	i = 1,6
⋮		
DAN6		
RFR1	RFR(I)	RFR_i
RFR2	I = 1,M	i = 1,M
⋮		
RFR6		
RJAGE	RJAGE	RJAGE

loop runs the model for one year. At each pass there is a call to MAKMAT with FEEDBK equal to the logical value "TRUE" (this call is to update the Leslie matrix with the feedback information). Upon return from MAKMAT, the program then calls Subroutine YRRUN in order to advance the model by another year. The subroutines MAKMAT and YRRUN are described in more detail in later sections of this report. Subroutines YEARLY, YLDCLC, and ENTRY PRETAB are called each year for the purposes mentioned in the above paragraph.

2. Subroutine ANALYT

Subroutine ANALYT(TOTP,PN,A,MR) is called from the main program whenever the ITR command is processed. It first calculates the baseline survival percentage through the first year in the absence of power plant effects, PNS_0 . It then calculates the stable population vector, $n_i(t)$, ($i=1,M$), which in FORTRAN variables is $PN(I)$, ($I=1,M$), corresponding to the assumed value of the biomass of fish available to the fishery at the start of year t , TOTP (Eq. 7). This calculated value of PNS_0 is then used to calculate the density-independent natural mortality rates, $DAN(I)$ ($= d_{n,i}$, $i=1,6$), of the six y-o-y life stages, if these are not given as data input. If these values are given as input, ANALYT calculates PNS_0 and the intra-life stage survivals for the six y-o-y life stages directly from the y-o-y mortality rates.

To calculate PNS_0 , the subroutine first calls MAKMAT to calculate fish fecundities, weights, and survival probabilities for the given value of TOTP. Fixing ISET = -99 prevents MAKMAT from

recalculating TOTP. The temporary value for survival in age class M-2, p_{M-2} , is then calculated as described in the footnote to Eq. (27). Following this, PNS_0 is calculated using Eq. (30), and then $PN(1)$ ($= n_0$) using Eq. (29), and finally the remainder of the population vector $PN(I)$ using Eq. (27).

The input values $ZS1, \dots, ZS6$ (which become $ZS(I)$, $I=1,6$ internally in the code) are the survival percentages through the individual life stages, as defined by Eq. (25). From Eq. (24b),

$$ZS(1)*ZS(2)*\dots*ZS(6) = PNS_0 .$$

First, suppose the values of the density-independent natural mortality, $DAN(I)$, are unknown, but the values of $ZS(I)$, $I=2,6$ can be determined. Then ANALYT uses Eq. (34) to compute $ZS(1)$. Next Eq. (25), which is an implicit equation for $DAN(I)$, is used to compute the six values of $DAN(I)$. This is done by calling Subroutine SOLVE, which in turn calls SCAN, BISECT, AND FUNCTION FF.

If the values of $DAN(I)$ are prescribed as input data, then these values, along with $GA(I)$ ($= g_i$), $DELT(I)$ ($= \Delta t_i$) and $CA(I,J)$ ($= c_{ij}$) are used to calculate $ZS(I)$ from Eq. (25). Then Eq. (34) is used to compute PNS_0 .

3. Subroutine SOLVE

Subroutine SOLVE ($Z, I, EPS, ITMAX$) is called by ANALYT to compute the (assumed unknown) $d_{n,i}$'s by using Newton's method to find the roots of Eq. (25). EPS is a measure of the convergence of the method (currently $EPS = 1. \times 10^{-5}$) and $ITMAX$ is the maximum number of

iterations permitted before an error message is printed (currently ITMAX = 100).

4. Subroutine SCAN

Subroutine SCAN (Z0,I) is called by SOLVE to provide initial lower and upper bounds on $d_{n,i}$. The lower bound is $B_L = C_i + 1. \times 10^{-6}$, where the constant $1. \times 10^{-6}$ is added to avoid the false root of Eq. (23) at $d_{n,i} + C_i = 0$. The upper bound B_U is a constant to be set by the user. Currently $B_U = 500$.

5. Subroutine BISECT

Subroutine BISECT (FF, A, B, XTOL, IFLAG, I) is called by SCAN to compute an initial estimate of $d_{n,i}$. It uses the bisection method for finding the roots of a function. The initial estimate is computed to two decimal place accuracy and is returned via SCAN (as Z0) to SOLVE, where Newton's method computes the final value.

6. DOUBLE PRECISION FUNCTION FF

DOUBLE PRECISION FUNCTION FF (X, I) is called by SOLVE, SCAN and BISECT, and contains the particular function (Eq. 25) for which the roots are being solved.

7. Subroutine GETCMD

Subroutine GETCMD (ENTRY,KMND,*) is called by the main program to identify a command (ENTRY). If the command is identified, the command number (KMND) is returned. Otherwise, a nonstandard return is made.

8. Subroutine MAKMAT

Subroutine MAKMAT(A,FEEDBK,MR,PN,TOTP,EGTABL,ISET,IYRI) is the sub-program that initially forms and later updates the Leslie matrix, taking into account the feedback effects on this matrix. Definitions of all the quantities in the argument list except MR, which is set to 16, can be found in Table 1. The calling program supplies the values of FEEDBK, MR, PN, EGTABL, ISET, and IYRI to MAKMAT which computes A and (except during the initializing call to MAKMAT) TOTP and returns them to the calling program. The main program is the only part of the program which calls MAKMAT.

A flow chart of MAKMAT is given in Fig. 7. The values of WT_j are computed by Eq. (3) with the $LENGTH_j$ being computed by Eq. (4). The fecundities, $F(J)$ ($= f_i$), are computed according to Eq. (1) with $EGGS_j$ being first computed from Eq. (2). The fecundity $F(M)$, which applies to all fish in age classes M and above, is set equal to the value $F(M-1)$. The program then calculates the number of eggs,

$$\begin{aligned} \text{NEGGS} &= \sum_{J=2}^M F(J-1) * \text{PN}(J) \\ &= \sum_{j=1}^{M-1} f_j * n_{j,t} , \end{aligned}$$

where the $F(J)$ are the fecundities that were just computed, and the $\text{PN}(J)$ are the elements of the current population vector except the first, $\text{PN}(1)$, which is the number of eggs in the current population vector. The value of $\text{PN}(1)$ is replaced by this value; i.e.,

$$\text{PN}(1) = \text{NEGGS} .$$

Fig. 7. Flow chart of Subroutine MAKMAT.

Once the fishing mortality rates are calculated by calling the Subroutine PFMCLC, the program must decide whether to initialize the entire Leslie matrix or just to update those elements which are affected by the new survival rates. The decision is made by checking the value of the logical parameter FEEDBK, which was transmitted from the calling program. If that value is "FALSE", the program sets up the matrix shown in Fig. 1. Every element A_{ij} of the matrix is initialized, including the elements which have the value zero. If FEEDBK has the value "TRUE", only those elements which depend on density-dependent natural and fishing mortality are recomputed. After the Leslie matrix has been formed, or updated, MAKMAT returns control to the calling program.

9. Subroutine PFMCLC

Subroutine PFMCLC(TOTP,IYRI) is called from MAKMAT and calculates the mortality from fishing of legally available fish, using relationships described in section II.C. The computed survival coefficients are then used to update the Leslie matrix. The coefficients are density-dependent because they are functions of TOTP, Leslie matrix. The coefficients are density-dependent because they are functions of TOTP, the index of standing crop available to fishing. The fishing survival rate can also be specified to change linearly with time.

10. Subroutine YOYMRT

Subroutine YOYMRT(PN,PPX) is called by MAKMAT to calculate the survival of y-o-y fish using the formulae derived in section II.E. The

y-o-y fish are assumed divided into six life stages. In the present model only age classes 1 through 5 are able to contribute to y-o-y mortality through cannibalism or competition. The FORTRAN equivalents to the mathematical symbols are $DAN(I) = d_{n,i}$, $DAP(I) = d_{p,i}$, $GA(I) = g_i$, $CA(I,J) = c_{ij}$, and $DELT(I) = \Delta t_i$.

Subroutine YOYMRT also computes the fractional y-o-y population reduction, FR_Y , and relative fractional reductions, RFR_i , defined in section II.H., using the values of density-dependent mortality, $DAP(I)$, if the $DAP(I)$'s are known and given as input parameters. If the $DAP(I)$ values are not initially known, but FR_Y and the RFR_i 's can be prescribed as input data, then the $DAP(I)$'s are computed from the latter quantities.

11. Subroutine NITPRM

Subroutine NITPRM(KMND,IOP,PN,PNO,PNZ,SAVP,IN,MR) processes all commands dealing with initial population values or parameter data. These commands include RDI, RDP, CP, CI, RI, PP, and PI.

12. Subroutine FINDNP

Subroutine FINDNP(PARAM,NP) finds requested parameters in the array of adjustable parameters. The calling program supplies the name of the input parameters in the PARAM array. In FINDNP the name of each input parameter is compared with the valid parameter names. If the input parameter name matches a valid parameter name, the subroutine returns its location in the array to the calling routine by NP. If the name of the input parameter does not match a valid parameter name, FINDNP

returns NP = -1 to the calling routine and an error message is printed out.

13. Subroutine PLOTST

Subroutine PLOTST (IPL, NST) stores the output data for later plotting. No plots are made during the run itself, but the output is stored in arrays for plotting at the user's option after the run is completed.

14. Subroutine ENTRY PLTSV

15. Subroutine PLT123

Subroutine PLT123(IGPH,NPLTSI,NPTSI,IYRS,PSET,SET) generates on the CALCOMP plotter either of two graphs using the DISSPLA plotting package (Integrated Software Systems Corporation, P.O. Box 9906, San Diego, California). The user requests plots on the OUT card and specifies which runs to put on the plots on the RO cards.

The argument IGPH contains the graph number requested -- each call to PLT123 requests one particular graph. The argument VALS is a doubly dimensioned array storing the values to be plotted, where VALS(I,J) is the I^{th} point of the J^{th} curve on the graph. Arguments NPLTSI and NPTSI indicate the number of curves per graph requested and the number of points per curve, respectively. IYRS is the array of x-coordinate values of the points. A total of NCHGS different RO cards have requested tabular or graphic output. Each has an associated FRY value, PSET(I).

For Graph 1 the variable of interest is relative TOTP and for Graph 2 it is yield.

16. Subroutine PROCDO

Subroutine PROCDO(KMND,IOP,MUSDO,IN,IAT,NEXT,EX,ENTRY,*) processes all DO commands. These commands include DO, ENDO, REDO, and TRA.

17. Subroutine REREAD

Subroutine REREAD permits the program to read again, as many times as desired and into different formats and lists, the last physical record via a formatted READ statement. (This subroutine is an IBM package).

18. Subroutine RPLACE

Subroutine RPLACE(PN,PNO,N) is called when the main program is processing RO cards.

19. ENTRY PVEC

ENTRY PVEC(VEC,N,K) is an entry point in Subroutine RPLACE which prints the initial and final population year class vectors.

20. ENTRY RDYRS

ENTRY RDYRS(INTRY,IROW,NROWS) is an entry point in Subroutine RPLACE which is called when the RO card is being processed.

21. Subroutine TABLE

Subroutine TABLE(IROW,PSET,SET,NYRS) prints a summary table of previous cases. It is called by the main program when an 'OUT' card is processed containing a request for a summary table. Data for the table were gathered in each previous run for which tabular output was requested.

Most of the data in the table consists of NTYPS different output parameter types originally stored in the OUTPT, REL, and IMPACT arrays (see section III.C.2), each evaluated for several years and several cases, as specified on the RO card. These data are stored in ARAY(I,J,K) and BC(I,J,K), where I is the year subscript, J is the case number, and K is the output parameter number. Most of the ARAY values were loaded in earlier calls to ENTRY PRETAB.

PSET is the array containing the FRY value associated with each case. The values stored in the arrays OUTPT, REL, AND IMPACT were calculated for the base case (FRY = 0.0) and passed as arguments to calculate the relative ARAY values in TABLE.

The array YRVAL(I,J,K) was loaded in the main program with values of yield, TOTP, and the number of one-year-olds (n_1) for each case which requested tabular output, where I is the year number, J is the case number, and K=2 for yield, K=3 for number of one-year-olds, and K=4 for TOTP. For each case, the routine calculates the number of years (LES) the yield, TOTP, and n_1 fall below each of two percentages (PER) of the base case values of these quantities. From these data an "index of risk" is calculated and printed out.

Subroutine TABLE also prints a table of relative yields for each year. The difference between the relative yields for different cases is computed and printed.

22. ENTRY BCTAB

ENTRY BCTAB(PSET,SET,NYRS) is an entry point in Subroutine TABLE which computes benefit/cost information.

23. ENTRY PRETAB

ENTRY PRETAB(IS,RCPUE,PN,IMPACT,REL,OUTPT,FTP,FRY) is an entry point in Subroutine TABLE which stores data for later printing in a summary table. PRETAB is called by the main program for specific years during an RO or RC run as requested on the pertinent RO card. The data are loaded into the array ARAY(I,J,K).

24. Subroutine YEARLY

Subroutine YEARLY(IYRI,TOTP,PN,RCPUE,FRY) is called by the main program for each year. Values of the probability of fishing mortality, yield, $n_j(t)$, TOTP, and other values described in section III.C.2.a are stored for each year in the arrays YRVAL(I,J,K), OUTPUT(I), REL(I), and IMPACT(I) for later output by Subroutines TABLE and PLT123. Relative effort, relative catch per unit effort, the impact factor for yield and the impact factor for TOTP are calculated and returned to the main program for possible printing.

25. Subroutine YLDCLC

Subroutine YLDCLC(PN,A,MR,N) is used for calculating the yield to the fisheries for each year. The arguments PN, A, MR, and N are all supplied to the subroutine by the calling program. The value of yield is computed by Eq. (14) and the value is returned to the calling program through the COMMON block BLOCKY. YLDCLC is always called immediately after a call to MAKMAT so that the values a A and PN used for calculating YIELD(t) for a year t are the ones corresponding to the beginning of the year.

26. Subroutine YRRUN

Subroutine YRRUN(PN,A,MR,N,TEMP) is called on each pass through the run-loop in order to advance the model by one year. The arguments A, MR, N, and TEMP are supplied by the calling program (the main program), and PN is computed and returned to the calling program. YRRUN advances the model through one year by simply multiplying the current population vector, PN(J), by the current Leslie matrix, A(I,J). This is done by the matrix multiplication

$$PN(I) = \sum_{J=1}^M A(I,J) * PN(J) ,$$

without taking advantage of the many zeros in the Leslie matrix.

Although such a procedure is not computationally efficient, it has the advantage that it can be used without any changes, no matter what form the Leslie matrix takes when the model is altered.

F. Sample Results

1. Example 1 (Figs. 5, 8-16)

This example is designed to illustrate the differences in behavior of the life cycle model when power plant effects are absent and present, as well as to exhibit some of the basic capabilities of the "command" logic of the program.

The input data are shown in Fig. 5. The parameter values used in this example are derived mainly from the Final Environmental Statement Related to Operation of Indian Point Generating Plant Unit No. 3,

COMMAND	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
RDI	16	0	0	0	0	0	0	0	0	0

COMMAND	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
FI	0	0	0	0	0	0	0	0	0	0

YEAR CLASS	INITIAL VECTOR
0	5.20000E 10
1	1.10000E 06
2	4.40000E 05
3	2.60000E 05
4	2.10000E 05
5	1.30000E 05
6	7.70000E 04
7	4.30000E 04
8	2.50000E 04
9	1.40000E 04
10	8.00000E 03
11	4.50000E 03
12	2.60000E 03
13	1.50000E 03
14	8.30000E 02
15	1.10000E 03

COMMAND	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
RDP	148	0	0	0	0	0	0	0	0	0

COMMAND	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
BEGN	0	0	1	0	0	0	0	0	0	0

Fig. 8. Example 1 - Standard output.

```

***** SET 1 *****

REPLACE INITIAL POP'N VECTOR WITH MOST RECENT INPUT VECTOR.
REPLACE PRESENT PARM SET WITH INPUT SET.

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
ITR      0  0  0  0  0  0  0  0  0  0

TARGT= 2.000E 06
        PDIO CHANGES FROM 0.400 TO 0.400 IN STEPS OF 0.0
        PDIO CHANGES FROM 0.319 TO 0.319 IN STEPS OF 0.0
TOTP = 2.000000E 06

ANALYTIC PNSO= 1.7098E-05

Y-O-Y PARAMETERS COMPUTED IN ANALYT

DAN(1) 0.32219458E 03
DAN(2) 0.13812750E 03
DAN(3) 0.37809280E 02
DAN(4) 0.13818714E 02
DAN(5) 0.45556641E 01
DAN(6) 0.32595720E 01

YEAR CLASS INITIAL VECTOR
0 6.45016E 10
1 1.10282E 06
2 6.05241E 05
3 4.05705E 05
4 3.32163E 05
5 1.89336E 05
6 9.22518E 04
7 4.49487E 04
8 2.38837E 04
9 1.26907E 04
10 7.34995E 03
11 4.25681E 03
12 2.68860E 03
13 1.69812E 03
14 1.16964E 03
15 2.58865E 03

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
PP      0  0  0  0  0  0  0  0  0  0

LIST OF ADJUSTABLE PARAMETERS

PMT1 0.0 PMT2 0.0 PMT3 0.0 PMT4 6.0000E-02 PMT5 2.3000E-01
PMT6 7.1000E-01 PMT7 9.5000E-01 PMT8 1.0000E 00 PMT9 1.0000E 00 PMT10 1.0000E 00
PMT11 1.0000E 00 PMT12 1.0000E 00 PMT13 1.0000E 00 PMT14 1.0000E 00 PMT15 1.0000E 00
PMM0 2.0000E-05 PMM1 6.0000E-01 PMM2 4.0000E-01 PMM3 2.0000E-01 PMM4 2.0000E-01
PMM5 2.0000E-01 PMM6 2.0000E-01 PMM7 2.0000E-01 PMM8 2.0000E-01 PMM9 2.0000E-01
PMM10 2.0000E-01 PMM11 2.0000E-01 PMM12 2.0000E-01 PMM13 2.0000E-01 PMM14 2.0000E-01
PMM15 2.0000E-01 PMM16 0.0 PMM17 3.1900E-01 PMM18 4.0000E-01 PMM19 1.0000E-05
TOTP1 1.0000E 06 LEGAL 4.3800E 02 RATIO 3.0000E 00 B3 -5.3400E 00 B4 3.1300E 00
B1 9.8212E 04 B2 7.3030E 04 ATMAX 1.0000E 02 PFO 5.0000E-01 PP1 5.0000E-01
PF2 5.0000E-01 PF3 5.0000E-01 PF4 5.0000E-01 PF5 5.0000E-01 PF6 5.0000E-01
PF7 5.0000E-01 PF8 5.0000E-01 PF9 5.0000E-01 PF10 5.0000E-01 PF11 5.0000E-01
PF12 5.0000E-01 PF13 5.0000E-01 PF14 5.0000E-01 PF15 5.0000E-01 ACON 0.0
B 1.1510E 02 C -3.0900E 00 VOL0 0.0 VOL1 0.0 VOL2 0.0
VOL3 6.6700E-01 VOL4 1.0000E 00 VOL5 1.0000E 00 VOL6 1.0000E 00 VOL7 8.3300E-01
VOL8 8.3300E-01 VOL9 6.6700E-01 VOL10 6.6700E-01 VOL11 5.0000E-01 VOL12 5.0000E-01
VOL13 3.3300E-01 VOL14 3.3300E-01 VOL15 3.3300E-01 IYRCH 1.0000E-02 CHGDI 0.0
CHGDD 0.0 DELT1 5.4800E-03 DELT2 1.6670E-02 DELT3 6.0900E-02 DELT4 1.1110E-01
DELT5 2.2700E-01 DELT6 4.7100E-01 DAP1 0.0 DAP2 0.0 DAP3 0.0
DAP4 0.0 DAP5 0.0 DAP6 0.0 DAP7 2.1540E-01 ZS1 1.7108E-01 ZS2 1.0000E-01
ZS3 1.0000E-01 ZS4 2.1540E-01 ZS5 2.1540E-01 ZS6 2.1540E-01 CA11 0.0
CA12 0.0 CA13 0.0 CA14 0.0 CA15 0.0 CA21 0.0
CA22 0.0 CA23 0.0 CA24 0.0 CA25 0.0 CA31 0.0
CA32 0.0 CA33 0.0 CA34 0.0 CA35 0.0 CA41 0.0
CA42 0.0 CA43 0.0 CA44 0.0 CA45 0.0 CA51 0.0
CA52 0.0 CA53 0.0 CA54 0.0 CA55 0.0 CA61 0.0
CA62 0.0 CA63 0.0 CA64 0.0 CA65 0.0 GA1 0.0
GA2 0.0 GA3 0.0 GA4 0.0 GA5 0.0 GA6 0.0
DAN1 3.2219E 02 DAN2 1.3813E 02 DAN3 3.7809E 01 DAN4 1.3819E 01 DAN5 4.5557E 00
DAN6 3.2596E 00 RPR1 1.0000E-02 RPR2 1.0000E-01 RPR3 3.0000E-01 RPR4 4.0000E-01
RPR5 4.5000E-01 RPR6 5.0000E-01 RJAGE 5.0000E 00

```

Fig. 9. Example 1 - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
R0 40 0 13 5 10 20 40 0 0 10

VITAL STATISTICS - SET 1

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PMAT	PSOBI	CATCH	VOLN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.003E-05
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	1.813E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,R,C= 0.0 115.10 -3.09 LEGAL,B3,D4= 438.0 -5.34 3.13
F1,B2= 0.982E 05 0.730E 05

PDMX CHANGES FROM 0.400 TO 0.400 IN STEPS OF 0.0
FDIO CHANGES FROM 0.319 TO 0.319 IN STEPS OF 0.0

YEAR	TOTP	F	YIELD	REL TOTP	REL ZPRT	REL YIELD	IMPACTY	IMPACTP	H1	RCBPZ
0.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
1.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
2.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
3.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
4.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
5.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
6.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
7.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
8.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
9.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
10.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
11.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
12.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
13.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
14.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
15.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
16.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
17.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
18.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
19.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
20.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
21.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
22.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
23.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
24.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
25.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
26.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
27.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
28.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
29.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
30.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
31.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
32.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
33.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
34.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
35.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
36.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
37.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
38.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
39.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
40.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00

YEAR CLASS	FINAL VECTOR
0	6.45016E 10
1	1.10282E 06
2	6.05242E 05
3	4.05706E 05
4	3.32164E 05
5	1.89336E 05
6	9.22518E 04
7	4.49488E 04
8	2.19937E 04
9	1.26907E 04
10	7.34996E 03
11	4.25682E 03
12	2.68860E 03
13	1.69812E 03
14	1.16964E 03
15	2.58865E 03

Fig. 10. Example 1 - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(3) --
PRY 3.0000E-01

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
R0 40 0 15 5 10 20 40 0 0 10

VITAL STATISTICS - SET 1

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PMAT	PSUBI	CATCH	VOLN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.003E-05
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	1.813E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B3,B4= 438.0 -5.34 3.13
E1,B2= 0.582E 05 0.730E 05

FDMX0 CHANGES FROM 0.400 TO 0.400 IN STEPS OF 0.0
FDIO CHANGES FROM 0.319 TO 0.319 IN STEPS OF 0.0

YEAR	TOTP	F	YIELD	REL TOTP	REL EPRT	REL YIELD	IMPACTY	IMPACTP	H1	RCTP02
0.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	1.103E 06	1.000E 00
1.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.374E 05	1.000E 00
2.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.374E 05	1.000E 00
3.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.374E 05	1.000E 00
4.	1.947E 06	0.5084	7.334E 05	9.734E-01	9.795E-01	9.564E-01	1.454E-01	8.861E-02	9.374E 05	9.764E-01
5.	1.881E 06	0.4953	6.948E 05	9.407E-01	9.543E-01	9.061E-01	3.129E-01	1.976E-01	9.328E 05	9.495E-01
6.	1.845E 06	0.4880	6.738E 05	9.224E-01	9.402E-01	8.787E-01	4.043E-01	2.587E-01	9.263E 05	9.346E-01
7.	1.833E 06	0.4857	6.671E 05	9.167E-01	9.358E-01	8.699E-01	4.335E-01	2.777E-01	9.119E 05	9.296E-01
8.	1.824E 06	0.4838	6.617E 05	9.120E-01	9.322E-01	8.629E-01	4.569E-01	2.933E-01	9.027E 05	9.257E-01
9.	1.819E 06	0.4829	6.589E 05	9.097E-01	9.304E-01	8.593E-01	4.691E-01	3.010E-01	8.980E 05	9.236E-01
10.	1.809E 06	0.4809	6.530E 05	9.046E-01	9.265E-01	8.516E-01	4.947E-01	3.179E-01	8.965E 05	9.191E-01
11.	1.799E 06	0.4788	6.471E 05	8.996E-01	9.226E-01	8.439E-01	5.203E-01	3.348E-01	8.949E 05	9.147E-01
12.	1.789E 06	0.4768	6.415E 05	8.946E-01	9.188E-01	8.365E-01	5.450E-01	3.514E-01	8.933E 05	9.105E-01
13.	1.784E 06	0.4757	6.383E 05	8.918E-01	9.166E-01	8.324E-01	5.588E-01	3.607E-01	8.907E 05	9.081E-01
14.	1.780E 06	0.4749	6.361E 05	8.898E-01	9.151E-01	8.295E-01	5.685E-01	3.672E-01	8.885E 05	9.064E-01
15.	1.777E 06	0.4744	6.345E 05	8.885E-01	9.140E-01	8.274E-01	5.753E-01	3.717E-01	8.865E 05	9.052E-01
16.	1.774E 06	0.4739	6.330E 05	8.872E-01	9.131E-01	8.255E-01	5.817E-01	3.760E-01	8.853E 05	9.041E-01
17.	1.772E 06	0.4734	6.316E 05	8.859E-01	9.121E-01	8.236E-01	5.880E-01	3.802E-01	8.845E 05	9.030E-01
18.	1.769E 06	0.4729	6.302E 05	8.847E-01	9.111E-01	8.218E-01	5.941E-01	3.843E-01	8.838E 05	9.019E-01
19.	1.767E 06	0.4725	6.290E 05	8.837E-01	9.103E-01	8.202E-01	5.992E-01	3.877E-01	8.832E 05	9.010E-01
20.	1.766E 06	0.4721	6.281E 05	8.829E-01	9.097E-01	8.190E-01	6.032E-01	3.904E-01	8.825E 05	9.003E-01
21.	1.765E 06	0.4719	6.274E 05	8.823E-01	9.093E-01	8.182E-01	6.061E-01	3.924E-01	8.819E 05	8.998E-01
22.	1.764E 06	0.4717	6.269E 05	8.818E-01	9.089E-01	8.175E-01	6.085E-01	3.940E-01	8.815E 05	8.994E-01
23.	1.763E 06	0.4716	6.264E 05	8.814E-01	9.086E-01	8.168E-01	6.105E-01	3.954E-01	8.811E 05	8.990E-01
24.	1.762E 06	0.4714	6.260E 05	8.810E-01	9.083E-01	8.163E-01	6.124E-01	3.966E-01	8.808E 05	8.987E-01
25.	1.761E 06	0.4713	6.256E 05	8.807E-01	9.080E-01	8.158E-01	6.140E-01	3.977E-01	8.806E 05	8.984E-01
26.	1.761E 06	0.4712	6.253E 05	8.804E-01	9.078E-01	8.154E-01	6.154E-01	3.987E-01	8.804E 05	8.982E-01
27.	1.760E 06	0.4711	6.250E 05	8.802E-01	9.076E-01	8.150E-01	6.165E-01	3.994E-01	8.802E 05	8.980E-01
28.	1.760E 06	0.4710	6.248E 05	8.800E-01	9.075E-01	8.148E-01	6.174E-01	4.000E-01	8.801E 05	8.978E-01
29.	1.760E 06	0.4709	6.246E 05	8.798E-01	9.074E-01	8.146E-01	6.181E-01	4.005E-01	8.799E 05	8.977E-01
30.	1.759E 06	0.4709	6.245E 05	8.797E-01	9.073E-01	8.144E-01	6.188E-01	4.009E-01	8.798E 05	8.976E-01
31.	1.759E 06	0.4708	6.244E 05	8.796E-01	9.072E-01	8.142E-01	6.193E-01	4.013E-01	8.797E 05	8.975E-01
32.	1.759E 06	0.4708	6.243E 05	8.795E-01	9.071E-01	8.141E-01	6.198E-01	4.016E-01	8.797E 05	8.974E-01
33.	1.759E 06	0.4708	6.242E 05	8.794E-01	9.071E-01	8.139E-01	6.202E-01	4.019E-01	8.796E 05	8.973E-01
34.	1.759E 06	0.4707	6.241E 05	8.794E-01	9.070E-01	8.138E-01	6.205E-01	4.021E-01	8.795E 05	8.973E-01
35.	1.759E 06	0.4707	6.240E 05	8.793E-01	9.070E-01	8.138E-01	6.208E-01	4.023E-01	8.795E 05	8.972E-01
36.	1.759E 06	0.4707	6.240E 05	8.793E-01	9.070E-01	8.137E-01	6.210E-01	4.024E-01	8.795E 05	8.972E-01
37.	1.758E 06	0.4707	6.239E 05	8.792E-01	9.069E-01	8.136E-01	6.212E-01	4.026E-01	8.794E 05	8.971E-01
38.	1.758E 06	0.4707	6.239E 05	8.792E-01	9.069E-01	8.136E-01	6.213E-01	4.027E-01	8.794E 05	8.971E-01
39.	1.758E 06	0.4707	6.239E 05	8.792E-01	9.069E-01	8.136E-01	6.215E-01	4.028E-01	8.794E 05	8.971E-01
40.	1.758E 06	0.4707	6.238E 05	8.791E-01	9.069E-01	8.135E-01	6.216E-01	4.028E-01	8.794E 05	8.971E-01

Fig. 11. Example 1 - Standard output (cont.).

YEAR CLASS	FINAL VECTOR
0	6.05074E 10
1	8.79369E 05
2	4.82618E 05
3	3.23517E 05
4	2.64881E 05
5	1.56168E 05
6	7.98618E 04
7	4.08399E 04
8	2.25926E 04
9	1.24981E 04
10	7.47564E 03
11	4.47149E 03
12	2.89328E 03
13	1.87211E 03
14	1.31041E 03
15	3.05669E 03

COMMAND	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
OUT	15	0	0	0	0	0	0	0	0	0

--- JOB SUMMARY ---

OUTPUT COMPLETED, SET 1.0

EXIT AT END-OF-PILE CARD

Fig. 12. Example 1 - Standard output (cont.).

SET 1.0					
FRACTIONAL CHANGE IN SURVIVAL PROBABILITY FOR AGE CLASS 0, FRY					
	YEAR	0.0	0.30		
OUTPT	1... 5	2.000E 06	1.881E 06		
	1... 10	2.000E 06	1.809E 06		
	1... 20	2.000E 06	1.766E 06		
	1... 40	2.000E 06	1.758E 06		
OUTPT	2... 5	7.668E 05	6.948E 05		
	2... 10	7.668E 05	6.530E 05		
	2... 20	7.668E 05	6.281E 05		
	2... 40	7.668E 05	6.238E 05		
OUTPT	3... 5	5.190E-01	4.953E-01		
	3... 10	5.190E-01	4.809E-01		
	3... 20	5.190E-01	4.721E-01		
	3... 40	5.190E-01	4.707E-01		
OUTPT	4... 5	6.450E 10	6.374E 10		
	4... 10	6.450E 10	6.158E 10		
	4... 20	6.450E 10	6.069E 10		
	4... 40	6.450E 10	6.051E 10		
OUTPT	5... 5	1.103E 06	9.328E 05		
	5... 10	1.103E 06	8.965E 05		
	5... 20	1.103E 06	8.825E 05		
	5... 40	1.103E 06	8.794E 05		
OUTPT	6... 5	2.589E 03	2.598E 03		
	6... 10	2.589E 03	2.769E 03		
	6... 20	2.589E 03	3.043E 03		
	6... 40	2.589E 03	3.057E 03		
OUTPT	7... 5	1.710E-05	1.453E-05		
	7... 10	1.710E-05	1.453E-05		
	7... 20	1.710E-05	1.453E-05		
	7... 40	1.710E-05	1.453E-05		
OUTPT	8... 5	5.700E-01	5.795E-01		
	8... 10	5.700E-01	5.854E-01		
	8... 20	5.700E-01	5.889E-01		
	8... 40	5.700E-01	5.896E-01		
OUTPT	9... 5	6.146E-01	6.441E-01		
	9... 10	6.146E-01	6.634E-01		
	9... 20	6.146E-01	6.756E-01		
	9... 40	6.146E-01	6.778E-01		
OUTPT	10... 5	3.854E-01	3.559E-01		
	10... 10	3.854E-01	3.366E-01		
	10... 20	3.854E-01	3.244E-01		
	10... 40	3.854E-01	3.222E-01		
OUTPT	11... 5	1.711E-01	1.706E-01		
	11... 10	1.711E-01	1.706E-01		
	11... 20	1.711E-01	1.706E-01		
	11... 40	1.711E-01	1.706E-01		
OUTPT	12... 5	1.000E-01	9.729E-02		
	12... 10	1.000E-01	9.729E-02		
	12... 20	1.000E-01	9.729E-02		
	12... 40	1.000E-01	9.729E-02		
OUTPT	13... 5	1.000E-01	9.381E-02		
	13... 10	1.000E-01	9.381E-02		
	13... 20	1.000E-01	9.381E-02		
	13... 40	1.000E-01	9.381E-02		
OUTPT	14... 5	2.154E-01	2.083E-01		
	14... 10	2.154E-01	2.083E-01		
	14... 20	2.154E-01	2.083E-01		
	14... 40	2.154E-01	2.083E-01		
OUTPT	15... 5	2.154E-01	2.117E-01		
	15... 10	2.154E-01	2.117E-01		
	15... 20	2.154E-01	2.117E-01		
	15... 40	2.154E-01	2.117E-01		
OUTPT	16... 5	2.154E-01	2.117E-01		
	16... 10	2.154E-01	2.117E-01		
	16... 20	2.154E-01	2.117E-01		
	16... 40	2.154E-01	2.117E-01		
REL	1... 5	1.000E 00	9.407E-01		
	1... 10	1.000E 00	9.046E-01		
	1... 20	1.000E 00	8.829E-01		
	1... 40	1.000E 00	8.791E-01		
REL	2... 5	1.000E 00	9.061E-01		
	2... 10	1.000E 00	8.516E-01		
	2... 20	1.000E 00	8.190E-01		
	2... 40	1.000E 00	8.135E-01		

Fig. 13. Example 1 - Summary table.

REL	3...	5	1.000E 00	9.543E-01
	3...	10	1.000E 00	9.265E-01
	3...	20	1.000E 00	9.097E-01
	3...	40	1.000E 00	9.069E-01
REL	4...	5	1.000E 00	9.882E-01
	4...	10	1.000E 00	9.547E-01
	4...	20	1.000E 00	9.408E-01
	4...	40	1.000E 00	9.381E-01
FEL	5...	5	1.000E 00	8.459E-01
	5...	10	1.000E 00	8.129E-01
	5...	20	1.000E 00	8.002E-01
	5...	40	1.000E 00	7.974E-01
REL	6...	5	1.000E 00	1.004E 00
	6...	10	1.000E 00	1.070E 00
	6...	20	1.000E 00	1.175E 00
	6...	40	1.000E 00	1.181E 00
REL	7...	5	1.000E 00	1.000E 00
	7...	10	1.000E 00	1.000E 00
	7...	20	1.000E 00	1.000E 00
	7...	40	1.000E 00	1.000E 00
IMPACT	1...	5	1.000E 50	1.976E-01
	1...	10	1.000E 50	3.179E-01
	1...	20	1.000E 50	3.904E-01
	1...	40	1.000E 50	4.028E-01
IMPACT	2...	5	1.000E 50	3.129E-01
	2...	10	1.000E 50	4.947E-01
	2...	20	1.000E 50	6.032E-01
	2...	40	1.000E 50	6.216E-01
IMPACT	3...	5	1.000E 50	1.523E-01
	3...	10	1.000E 50	2.450E-01
	3...	20	1.000E 50	3.009E-01
	3...	40	1.000E 50	3.105E-01
IMPACT	4...	5	1.000E 50	3.936E-02
	4...	10	1.000E 50	1.510E-01
	4...	20	1.000E 50	1.972E-01
	4...	40	1.000E 50	2.064E 01
IMPACT	5...	5	1.000E 50	5.138E-01
	5...	10	1.000E 50	6.235E-01
	5...	20	1.000E 50	6.659E-01
	5...	40	1.000E 50	6.754E-01
IMPACT	6...	5	1.000E 50	-1.182E-02
	6...	10	1.000E 50	-2.321E-01
	6...	20	1.000E 50	-5.846E-01
	6...	40	1.000E 50	-6.027E-01
IMPACT	7...	5	1.000E 50	0.0
	7...	10	1.000E 50	0.0
	7...	20	1.000E 50	0.0
	7...	40	1.000E 50	0.0
B/C	1...	5	1.000E 00	9.495E-01
	1...	10	1.000E 00	9.191E-01
	1...	20	1.000E 00	9.003E-01
	1...	40	1.000E 00	8.971E-01
B/C	2...	5	0.0	0.0
	2...	10	0.0	3.619E-02
	2...	20	0.0	5.884E-02
	2...	40	0.0	6.277E-02
B/C	3...	5	0.0	0.0
	3...	10	0.0	1.395E-02
	3...	20	0.0	8.746E-03
	3...	40	0.0	1.387E-03
B/C	4...	5	0.0	0.0
	4...	10	0.0	1.443E-02
	4...	20	0.0	2.314E-02
	4...	40	0.0	2.462E-02
B/C	5...	5	0.0	0.0
	5...	10	0.0	5.562E-03
	5...	20	0.0	3.439E-03
	5...	40	0.0	5.441E-04
B/C	6...	5	0.0	0.0
	6...	10	0.0	1.023E-02
	6...	20	0.0	1.596E-02
	6...	40	0.0	1.690E-02
B/C	7...	5	0.0	0.0
	7...	10	0.0	3.944E-03
	7...	20	0.0	2.372E-03
	7...	40	0.0	3.734E-04
YRS RELYD LT .50		0		0
YRS RELN1 LT .50		0		0
YRS RELTOTP LT .50		0		0
INDEX OF RISK		0.0		0.0

Fig. 14. Example I - Summary table (cont.).

SET 1.0
RELATIVE YIELD VS. TIME

Fig. 15. Example 1 - Graph 1.

SET 1.0
RELATIVE TOTP VS. TIME

Fig. 16. Example 1 - Graph 2.

Consolidated Edison Company of New York, Inc., Docket No. 50-286, United States Nuclear Regulatory Commission (1975), and from McFadden (1977). In this example there are no density-dependent effects in age class 0, but fishing is assumed to act in a density-dependent manner.

The command RDI calls for the reading in of an initial population vector with 16 age classes. The command PI calls for this vector to be printed (Fig. 8). The command ITR specifies that Subroutine ANALYT is called to calculate a value of PNSO from the target value of TOTP, and then an initial population vector is generated from the base case (Fig. 9). The first RO command causes a run of 40 years to be made. The vital statistics are first printed out (Fig. 9) and then the population statistics over the 40 year period (Fig. 9). Note the integer 13 or 15 in columns 19 and 20 of the RO card, which causes values to be stored for the eventual printing out of a summary table and plotting of graphs 1 and 2. The final population vector is next printed.

The CP command specifies that a change in parameter values is needed for the next run. The following card causes FRY, the power plant impact factor, to be changed from 0.0 to 0.3 (Fig. 11). Another run of 40 years, starting with the original population vector, is then made (Figs. 11, 12). As is clear from the numbers, the power plant impact has changed the equilibrium state of the fish population. Finally, the OUT card calls for the printing out of a summary table as well as the plotting of graphs 1 and 2, using data stored from the RO runs. The summary table is shown in Figs. 13-14 and graphs 1 and 2 are shown in Figs. 15 and 16.

No DO sections were used in this example since they are primarily used to simplify and condense the number of cards needed for the execution of repetitive (with slight modifications) of long series of runs.

2. Example 2 (Figs. 17-35)

This example illustrates the long-term effects of power plant impacts both with and without compensation in age class 0. The usefulness of the RC cards in simulating the "turning off" of the power plant after a given number of years of operation, and the succinctness afforded by the DO commands are taken advantage of here.

The input data are shown in Fig. 17. The initial parameter values are similar to those of Example 1.

The command BEGN denotes the beginning of a set of related cases (Fig. 18). The cards from the DO to the ENDO commands constitute a "DO section". The commands within this section are saved for reexecution (REDO). They call first for the running of a "base-line" case of 80 years, in which $FRY = 0.0$. The standard output generated for this case looks very similar to Figs. 9 and 10 and is omitted here. The following commands call for a pair of RO-RC runs, with the power plant impact factor, FRY , having various values for the first 40 years, and then being turned off to simulate the shutting down of the plant. The simulations continue to run for another 40 years, as specified by the RC cards. In the first RO-RC run, $FRY = 0.3$ (Figs. 19-20) while in the second run, $FRY = 0.1$ (Figs. 21-22).

MAIN

1	1	PMT1	PMT2	PMT3	PMT4	PMT5	PMT6	PMT7
2	2	PMT8	PMT9	PMT10	PMT11	PMT12	PMT13	PMT14
3	3	PMT15	PMT16	PMT17	PMT18	PMT19	PMT20	PMT21
4	4	PMT22	PMT23	PMT24	PMT25	PMT26	PMT27	PMT28
5	5	PMT29	PMT30	PMT31	PMT32	PMT33	PMT34	PMT35
6	6	PMT36	PMT37	PMT38	PMT39	PMT40	PMT41	PMT42
7	7	PMT43	PMT44	PMT45	PMT46	PMT47	PMT48	PMT49
8	8	PMT50	PMT51	PMT52	PMT53	PMT54	PMT55	PMT56
9	9	PMT57	PMT58	PMT59	PMT60	PMT61	PMT62	PMT63
10	10	PMT64	PMT65	PMT66	PMT67	PMT68	PMT69	PMT70
11	11	PMT71	PMT72	PMT73	PMT74	PMT75	PMT76	PMT77
12	12	PMT78	PMT79	PMT80	PMT81	PMT82	PMT83	PMT84
13	13	PMT85	PMT86	PMT87	PMT88	PMT89	PMT90	PMT91
14	14	PMT92	PMT93	PMT94	PMT95	PMT96	PMT97	PMT98
15	15	PMT99	PMT100	PMT101	PMT102	PMT103	PMT104	PMT105
16	16	PMT106	PMT107	PMT108	PMT109	PMT110	PMT111	PMT112
17	17	PMT113	PMT114	PMT115	PMT116	PMT117	PMT118	PMT119
18	18	PMT120	PMT121	PMT122	PMT123	PMT124	PMT125	PMT126
19	19	PMT127	PMT128	PMT129	PMT130	PMT131	PMT132	PMT133
20	20	PMT134	PMT135	PMT136	PMT137	PMT138	PMT139	PMT140
21	21	PMT141	PMT142	PMT143	PMT144	PMT145	PMT146	PMT147
22	22	PMT148	PMT149	PMT150	PMT151	PMT152	PMT153	PMT154
23	23	PMT155	PMT156	PMT157	PMT158	PMT159	PMT160	PMT161
24	24	PMT162	PMT163	PMT164	PMT165	PMT166	PMT167	PMT168
25	25	PMT169	PMT170	PMT171	PMT172	PMT173	PMT174	PMT175
26	26	PMT176	PMT177	PMT178	PMT179	PMT180	PMT181	PMT182
27	27	PMT183	PMT184	PMT185	PMT186	PMT187	PMT188	PMT189
28	28	PMT190	PMT191	PMT192	PMT193	PMT194	PMT195	PMT196
29	29	PMT197	PMT198	PMT199	PMT200	PMT201	PMT202	PMT203
30	30	PMT204	PMT205	PMT206	PMT207	PMT208	PMT209	PMT210
31	31	PMT211	PMT212	PMT213	PMT214	PMT215	PMT216	PMT217
32	32	PMT218	PMT219	PMT220	PMT221	PMT222	PMT223	PMT224
33	33	PMT225	PMT226	PMT227	PMT228	PMT229	PMT230	PMT231
34	34	PMT232	PMT233	PMT234	PMT235	PMT236	PMT237	PMT238
35	35	PMT239	PMT240	PMT241	PMT242	PMT243	PMT244	PMT245
36	36	PMT246	PMT247	PMT248	PMT249	PMT250	PMT251	PMT252
37	37	PMT253	PMT254	PMT255	PMT256	PMT257	PMT258	PMT259
38	38	PMT260	PMT261	PMT262	PMT263	PMT264	PMT265	PMT266
39	39	PMT267	PMT268	PMT269	PMT270	PMT271	PMT272	PMT273
40	40	PMT274	PMT275	PMT276	PMT277	PMT278	PMT279	PMT280
41	41	PMT281	PMT282	PMT283	PMT284	PMT285	PMT286	PMT287
42	42	PMT288	PMT289	PMT290	PMT291	PMT292	PMT293	PMT294
43	43	PMT295	PMT296	PMT297	PMT298	PMT299	PMT300	PMT301
44	44	PMT302	PMT303	PMT304	PMT305	PMT306	PMT307	PMT308
45	45	PMT309	PMT310	PMT311	PMT312	PMT313	PMT314	PMT315
46	46	PMT316	PMT317	PMT318	PMT319	PMT320	PMT321	PMT322
47	47	PMT323	PMT324	PMT325	PMT326	PMT327	PMT328	PMT329
48	48	PMT330	PMT331	PMT332	PMT333	PMT334	PMT335	PMT336
49	49	PMT337	PMT338	PMT339	PMT340	PMT341	PMT342	PMT343
50	50	PMT344	PMT345	PMT346	PMT347	PMT348	PMT349	PMT350
51	51	PMT351	PMT352	PMT353	PMT354	PMT355	PMT356	PMT357
52	52	PMT358	PMT359	PMT360	PMT361	PMT362	PMT363	PMT364
53	53	PMT365	PMT366	PMT367	PMT368	PMT369	PMT370	PMT371
54	54	PMT372	PMT373	PMT374	PMT375	PMT376	PMT377	PMT378
55	55	PMT379	PMT380	PMT381	PMT382	PMT383	PMT384	PMT385
56	56	PMT386	PMT387	PMT388	PMT389	PMT390	PMT391	PMT392
57	57	PMT393	PMT394	PMT395	PMT396	PMT397	PMT398	PMT399
58	58	PMT400	PMT401	PMT402	PMT403	PMT404	PMT405	PMT406
59	59	PMT407	PMT408	PMT409	PMT410	PMT411	PMT412	PMT413
60	60	PMT414	PMT415	PMT416	PMT417	PMT418	PMT419	PMT420
61	61	PMT421	PMT422	PMT423	PMT424	PMT425	PMT426	PMT427
62	62	PMT428	PMT429	PMT430	PMT431	PMT432	PMT433	PMT434
63	63	PMT435	PMT436	PMT437	PMT438	PMT439	PMT440	PMT441
64	64	PMT442	PMT443	PMT444	PMT445	PMT446	PMT447	PMT448
65	65	PMT449	PMT450	PMT451	PMT452	PMT453	PMT454	PMT455
66	66	PMT456	PMT457	PMT458	PMT459	PMT460	PMT461	PMT462
67	67	PMT463	PMT464	PMT465	PMT466	PMT467	PMT468	PMT469
68	68	PMT470	PMT471	PMT472	PMT473	PMT474	PMT475	PMT476
69	69	PMT477	PMT478	PMT479	PMT480	PMT481	PMT482	PMT483
70	70	PMT484	PMT485	PMT486	PMT487	PMT488	PMT489	PMT490
71	71	PMT491	PMT492	PMT493	PMT494	PMT495	PMT496	PMT497
72	72	PMT498	PMT499	PMT500	PMT501	PMT502	PMT503	PMT504
73	73	PMT505	PMT506	PMT507	PMT508	PMT509	PMT510	PMT511
74	74	PMT512	PMT513	PMT514	PMT515	PMT516	PMT517	PMT518
75	75	PMT519	PMT520	PMT521	PMT522	PMT523	PMT524	PMT525
76	76	PMT526	PMT527	PMT528	PMT529	PMT530	PMT531	PMT532
77	77	PMT533	PMT534	PMT535	PMT536	PMT537	PMT538	PMT539
78	78	PMT540	PMT541	PMT542	PMT543	PMT544	PMT545	PMT546
79	79	PMT547	PMT548	PMT549	PMT550	PMT551	PMT552	PMT553
80	80	PMT554	PMT555	PMT556	PMT557	PMT558	PMT559	PMT560
81	81	PMT561	PMT562	PMT563	PMT564	PMT565	PMT566	PMT567
82	82	PMT568	PMT569	PMT570	PMT571	PMT572	PMT573	PMT574
83	83	PMT575	PMT576	PMT577	PMT578	PMT579	PMT580	PMT581
84	84	PMT582	PMT583	PMT584	PMT585	PMT586	PMT587	PMT588
85	85	PMT589	PMT590	PMT591	PMT592	PMT593	PMT594	PMT595
86	86	PMT596	PMT597	PMT598	PMT599	PMT600	PMT601	PMT602
87	87	PMT603	PMT604	PMT605	PMT606	PMT607	PMT608	PMT609
88	88	PMT610	PMT611	PMT612	PMT613	PMT614	PMT615	PMT616
89	89	PMT617	PMT618	PMT619	PMT620	PMT621	PMT622	PMT623
90	90	PMT624	PMT625	PMT626	PMT627	PMT628	PMT629	PMT630
91	91	PMT631	PMT632	PMT633	PMT634	PMT635	PMT636	PMT637
92	92	PMT638	PMT639	PMT640	PMT641	PMT642	PMT643	PMT644
93	93	PMT645	PMT646	PMT647	PMT648	PMT649	PMT650	PMT651
94	94	PMT652	PMT653	PMT654	PMT655	PMT656	PMT657	PMT658
95	95	PMT659	PMT660	PMT661	PMT662	PMT663	PMT664	PMT665
96	96	PMT666	PMT667	PMT668	PMT669	PMT670	PMT671	PMT672
97	97	PMT673	PMT674	PMT675	PMT676	PMT677	PMT678	PMT679
98	98	PMT680	PMT681	PMT682	PMT683	PMT684	PMT685	PMT686
99	99	PMT687	PMT688	PMT689	PMT690	PMT691	PMT692	PMT693
100	100	PMT694	PMT695	PMT696	PMT697	PMT698	PMT699	PMT700
101	101	PMT701	PMT702	PMT703	PMT704	PMT705	PMT706	PMT707
102	102	PMT708	PMT709	PMT710	PMT711	PMT712	PMT713	PMT714
103	103	PMT715	PMT716	PMT717	PMT718	PMT719	PMT720	PMT721

Fig. 17. Example 2 - Input data.

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
FDI 16 0 0 0 0 0 0 0 0 0

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
PI 0 0 0 0 0 0 0 0 0 0

```

```

YEAR CLASS INITIAL VECTOR

```

```

0 5.20000E 10
1 1.10000E 06
2 4.40000E 05
3 2.60000E 05
4 2.10000E 05
5 1.30000E 05
6 7.70000E 04
7 4.30000E 04
8 2.50000E 04
9 1.40000E 04
10 8.00000E 03
11 4.50000E 03
12 2.60000E 03
13 1.50000E 03
14 8.30000E 02
15 1.10000E 03

```

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RNP 14R 0 0 0 0 0 0 0 0 0

```

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
BEGN 0 0 1 0 0 0 0 0 0 0

```

```

***** SET 1 *****

```

```

REPLACE INITIAL POP'N VECTOR WITH MOST RECENT INPUT VECTOR.
REPLACE PRESENT PARM SET WITH INPUT SET.

```

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
DO 0 0 0 0 0 0 0 0 0 0

```

```

COMMAND NO.

```

```

1 ITR
2 PP
3 RO 80 15 10 20 40 80 1
4 CP 1
5 PRY 0.3
6 RO 40 15 10 20 40 80 1
7 CP 1
8 PRY 0.0
9 RC 40 15
10 CP 1
11 PRY 0.1
12 RO 40 15 10 20 40 80 1
13 CP 1
14 PRY 0.0
15 RC 40 15
16 OUT 15
17 ENDO

```

```

DO SECTION IS SAVED. 13 RECOGNIZABLE COMMANDS.

```

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
ITR 0 0 0 0 0 0 0 0 0 0

```

```

TARGET= 2.000E 06

```

```

PDHXO CHANGES FROM 0.400 TO 0.400 IN STEPS OF 0.0

```

```

PDIO CHANGES FROM 0.319 TO 0.319 IN STEPS OF 0.0

```

```

TOTP = 2.000000E 06

```

```

ANALYTIC PNSO= 1.7098E-05

```

```

Y-O-Y PARAMETERS COMPUTED IN ANALYT

```

```

DAN (1) 0.32219458E 03
DAN (2) 0.13812750E 03
DAN (3) 0.37809280E 02
DAN (4) 0.13818714E 02
DAN (5) 0.45556641E 01
DAN (6) 0.32595720E 01

```

Fig. 18. Example 2 (set 1: without age class 0 compensation) - Standard output.

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE *****

1 CHANGED PARAMETER(S)--
PHY J.00000E-01

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
R0 40 0 15 10 20 40 80 0 0 10

VITAL STATISTICS - SET 1

AGE	LENGTH	WEIGHT	EGGS	FEMALE	FMAF	PSUBI	CATCH	VULN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.003E-05
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	1.813E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B4= 438.0 -5.34 3.13
B1,B2= 0.582E 05 0.730E 05

PDIXO CHANGES FROM 0.400 TO 0.400 IN STEPS OF 0.0
PDIO CHANGES FROM 0.319 TO 0.319 IN STEPS OF 0.0

YEAR	TOTP	P	YIELD	REL TOTP	REL EPRT	REL YIELD	INPACTY	INPACTP	N1	RCTPZ
0.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	1.103E 06	1.000E 00
1.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.374E 05	1.000E 00
2.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.374E 05	1.000E 00
3.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.374E 05	1.000E 00
4.	1.947E 06	0.5084	7.334E 05	9.734E-01	9.795E-01	9.564E-01	1.454E-01	8.861E-02	9.374E 05	9.764E-01
5.	1.881E 06	0.4953	6.948E 05	9.407E-01	9.543E-01	9.061E-01	3.129E-01	1.976E-01	9.328E 05	9.495E-01
6.	1.845E 06	0.4880	6.738E 05	9.224E-01	9.402E-01	8.787E-01	4.043E-01	2.587E-01	9.263E 05	9.346E-01
7.	1.833E 06	0.4857	6.671E 05	9.167E-01	9.358E-01	8.699E-01	4.335E-01	2.777E-01	9.199E 05	9.296E-01
8.	1.824E 06	0.4838	6.617E 05	9.120E-01	9.322E-01	8.629E-01	4.569E-01	2.933E-01	9.027E 05	9.257E-01
9.	1.819E 06	0.4829	6.589E 05	9.097E-01	9.304E-01	8.593E-01	4.691E-01	3.010E-01	8.980E 05	9.236E-01
10.	1.809E 06	0.4809	6.530E 05	9.046E-01	9.265E-01	8.516E-01	4.947E-01	3.179E-01	8.965E 05	9.191E-01
11.	1.799E 06	0.4788	6.471E 05	8.996E-01	9.226E-01	8.439E-01	5.203E-01	3.348E-01	8.949E 05	9.147E-01
12.	1.789E 06	0.4768	6.415E 05	8.946E-01	9.188E-01	8.365E-01	5.450E-01	3.514E-01	8.933E 05	9.105E-01
13.	1.784E 06	0.4757	6.383E 05	8.918E-01	9.166E-01	8.324E-01	5.588E-01	3.607E-01	8.907E 05	9.081E-01
14.	1.780E 06	0.4749	6.361E 05	8.898E-01	9.151E-01	8.295E-01	5.685E-01	3.672E-01	8.885E 05	9.064E-01
15.	1.777E 06	0.4744	6.345E 05	8.885E-01	9.140E-01	8.274E-01	5.753E-01	3.717E-01	8.865E 05	9.052E-01
16.	1.774E 06	0.4739	6.330E 05	8.872E-01	9.131E-01	8.255E-01	5.817E-01	3.760E-01	8.853E 05	9.041E-01
17.	1.772E 06	0.4734	6.316E 05	8.859E-01	9.121E-01	8.236E-01	5.880E-01	3.802E-01	8.845E 05	9.030E-01
18.	1.769E 06	0.4729	6.302E 05	8.847E-01	9.111E-01	8.218E-01	5.941E-01	3.843E-01	8.838E 05	9.019E-01
19.	1.767E 06	0.4725	6.290E 05	8.837E-01	9.103E-01	8.202E-01	5.992E-01	3.877E-01	8.832E 05	9.010E-01
20.	1.766E 06	0.4721	6.281E 05	8.829E-01	9.097E-01	8.190E-01	6.032E-01	3.904E-01	8.825E 05	9.003E-01
21.	1.765E 06	0.4719	6.274E 05	8.823E-01	9.093E-01	8.182E-01	6.061E-01	3.924E-01	8.819E 05	8.998E-01
22.	1.764E 06	0.4717	6.269E 05	8.818E-01	9.089E-01	8.175E-01	6.085E-01	3.940E-01	8.815E 05	8.994E-01
23.	1.763E 06	0.4716	6.264E 05	8.814E-01	9.086E-01	8.168E-01	6.105E-01	3.954E-01	8.811E 05	8.990E-01
24.	1.762E 06	0.4714	6.260E 05	8.810E-01	9.083E-01	8.163E-01	6.124E-01	3.966E-01	8.808E 05	8.987E-01
25.	1.761E 06	0.4713	6.256E 05	8.807E-01	9.080E-01	8.158E-01	6.140E-01	3.977E-01	8.806E 05	8.984E-01
26.	1.761E 06	0.4712	6.253E 05	8.804E-01	9.078E-01	8.154E-01	6.154E-01	3.987E-01	8.804E 05	8.982E-01
27.	1.760E 06	0.4711	6.250E 05	8.802E-01	9.076E-01	8.150E-01	6.165E-01	3.994E-01	8.802E 05	8.980E-01
28.	1.760E 06	0.4710	6.248E 05	8.800E-01	9.075E-01	8.148E-01	6.174E-01	4.000E-01	8.801E 05	8.978E-01
29.	1.760E 06	0.4709	6.246E 05	8.798E-01	9.074E-01	8.146E-01	6.181E-01	4.005E-01	8.799E 05	8.977E-01
30.	1.759E 06	0.4709	6.245E 05	8.797E-01	9.073E-01	8.144E-01	6.188E-01	4.009E-01	8.798E 05	8.976E-01
31.	1.759E 06	0.4708	6.244E 05	8.796E-01	9.072E-01	8.142E-01	6.193E-01	4.013E-01	8.797E 05	8.975E-01
32.	1.759E 06	0.4708	6.243E 05	8.795E-01	9.071E-01	8.141E-01	6.198E-01	4.016E-01	8.797E 05	8.974E-01
33.	1.759E 06	0.4708	6.242E 05	8.794E-01	9.071E-01	8.139E-01	6.202E-01	4.019E-01	8.796E 05	8.973E-01
34.	1.759E 06	0.4707	6.241E 05	8.794E-01	9.070E-01	8.138E-01	6.205E-01	4.021E-01	8.795E 05	8.973E-01
35.	1.759E 06	0.4707	6.240E 05	8.793E-01	9.070E-01	8.138E-01	6.208E-01	4.023E-01	8.795E 05	8.972E-01
36.	1.759E 06	0.4707	6.240E 05	8.793E-01	9.070E-01	8.137E-01	6.210E-01	4.024E-01	8.795E 05	8.972E-01
37.	1.758E 06	0.4707	6.239E 05	8.792E-01	9.069E-01	8.136E-01	6.212E-01	4.026E-01	8.794E 05	8.971E-01
38.	1.758E 06	0.4707	6.239E 05	8.792E-01	9.069E-01	8.136E-01	6.213E-01	4.027E-01	8.794E 05	8.971E-01
39.	1.758E 06	0.4707	6.239E 05	8.792E-01	9.069E-01	8.136E-01	6.215E-01	4.028E-01	8.794E 05	8.971E-01
40.	1.758E 06	0.4707	6.238E 05	8.791E-01	9.069E-01	8.135E-01	6.216E-01	4.028E-01	8.794E 05	8.971E-01

YEAR CLASS FINAL VECTOR

0	6.05074E 10
1	8.79369E 05
2	4.82618E 05
3	3.23517E 05
4	2.64881E 05
5	1.56168E 05
6	7.98618E 04
7	4.08399E 04
8	2.25926E 04
9	1.24981E 04
10	7.47564E 03
11	4.47149E 03
12	2.89328E 03
13	1.87211E 03
14	1.31041E 03
15	3.05669E 03

Fig. 19. Example 2 (set 1: without age class 0 compensation) - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(S) --
PRY 0.0

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RC 40 0 15 0 0 0 0 0 0 0

VITAL STATISTICS - SET 1

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PHAT	PSUBI	CATCH	VULN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0				
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	2.003E-05
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.270E 01	1.762E 06	5.000E-01	1.000E 00	8.011E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B3,B4= 438.0 -5.34 3.13
B1,B2= 0.982E 05 0.730E 05

YEAR	TOTP	F	YIELD	REL TOTP	REL EPRT	REL YIELD	IMPACTY	IMPACTP	N1	RCPR
40.	1.758E 06	0.4707	6.238E 05	8.791E-01	9.069E-01	8.135E-01	1.000E 50	1.000E 50	8.794E 05	8.971E-01
41.	1.758E 06	0.4707	6.238E 05	8.791E-01	9.068E-01	8.135E-01	1.000E 50	1.000E 50	1.035E 06	8.971E-01
42.	1.758E 06	0.4706	6.238E 05	8.791E-01	9.068E-01	8.135E-01	1.000E 50	1.000E 50	1.035E 06	8.970E-01
43.	1.758E 06	0.4706	6.238E 05	8.791E-01	9.068E-01	8.134E-01	1.000E 50	1.000E 50	1.035E 06	8.970E-01
44.	1.808E 06	0.4806	6.532E 05	9.040E-01	9.260E-01	8.518E-01	1.000E 50	1.000E 50	1.034E 06	9.198E-01
45.	1.872E 06	0.4935	6.903E 05	9.362E-01	9.508E-01	9.001E-01	1.000E 50	1.000E 50	1.040E 06	9.467E-01
46.	1.909E 06	0.5009	7.117E 05	9.547E-01	9.651E-01	9.280E-01	1.000E 50	1.000E 50	1.048E 06	9.616E-01
47.	1.920E 06	0.5031	7.184E 05	9.602E-01	9.694E-01	9.368E-01	1.000E 50	1.000E 50	1.065E 06	9.665E-01
48.	1.929E 06	0.5049	7.238E 05	9.647E-01	9.728E-01	9.438E-01	1.000E 50	1.000E 50	1.076E 06	9.702E-01
49.	1.934E 06	0.5059	7.269E 05	9.672E-01	9.747E-01	9.479E-01	1.000E 50	1.000E 50	1.082E 06	9.725E-01
50.	1.946E 06	0.5082	7.340E 05	9.730E-01	9.792E-01	9.571E-01	1.000E 50	1.000E 50	1.084E 06	9.775E-01
51.	1.958E 06	0.5106	7.413E 05	9.790E-01	9.838E-01	9.667E-01	1.000E 50	1.000E 50	1.085E 06	9.825E-01
52.	1.969E 06	0.5128	7.479E 05	9.845E-01	9.881E-01	9.753E-01	1.000E 50	1.000E 50	1.088E 06	9.871E-01
53.	1.975E 06	0.5140	7.515E 05	9.875E-01	9.904E-01	9.800E-01	1.000E 50	1.000E 50	1.091E 06	9.895E-01
54.	1.979E 06	0.5148	7.539E 05	9.895E-01	9.919E-01	9.831E-01	1.000E 50	1.000E 50	1.094E 06	9.912E-01
55.	1.982E 06	0.5153	7.556E 05	9.909E-01	9.930E-01	9.853E-01	1.000E 50	1.000E 50	1.096E 06	9.923E-01
56.	1.985E 06	0.5159	7.573E 05	9.923E-01	9.940E-01	9.876E-01	1.000E 50	1.000E 50	1.097E 06	9.935E-01
57.	1.987E 06	0.5165	7.591E 05	9.937E-01	9.951E-01	9.899E-01	1.000E 50	1.000E 50	1.098E 06	9.947E-01
58.	1.990E 06	0.5170	7.607E 05	9.950E-01	9.962E-01	9.920E-01	1.000E 50	1.000E 50	1.099E 06	9.959E-01
59.	1.992E 06	0.5174	7.620E 05	9.961E-01	9.970E-01	9.937E-01	1.000E 50	1.000E 50	1.099E 06	9.967E-01
60.	1.994E 06	0.5177	7.629E 05	9.968E-01	9.975E-01	9.949E-01	1.000E 50	1.000E 50	1.100E 06	9.973E-01
61.	1.995E 06	0.5179	7.636E 05	9.974E-01	9.980E-01	9.958E-01	1.000E 50	1.000E 50	1.101E 06	9.978E-01
62.	1.996E 06	0.5181	7.641E 05	9.978E-01	9.983E-01	9.965E-01	1.000E 50	1.000E 50	1.101E 06	9.982E-01
63.	1.996E 06	0.5183	7.646E 05	9.982E-01	9.986E-01	9.971E-01	1.000E 50	1.000E 50	1.101E 06	9.985E-01
64.	1.997E 06	0.5184	7.650E 05	9.985E-01	9.989E-01	9.976E-01	1.000E 50	1.000E 50	1.102E 06	9.988E-01
65.	1.998E 06	0.5185	7.654E 05	9.988E-01	9.991E-01	9.981E-01	1.000E 50	1.000E 50	1.102E 06	9.990E-01
66.	1.998E 06	0.5186	7.657E 05	9.990E-01	9.993E-01	9.985E-01	1.000E 50	1.000E 50	1.102E 06	9.992E-01
67.	1.998E 06	0.5187	7.659E 05	9.992E-01	9.994E-01	9.988E-01	1.000E 50	1.000E 50	1.102E 06	9.994E-01
68.	1.999E 06	0.5187	7.660E 05	9.994E-01	9.995E-01	9.990E-01	1.000E 50	1.000E 50	1.102E 06	9.995E-01
69.	1.999E 06	0.5188	7.662E 05	9.995E-01	9.996E-01	9.992E-01	1.000E 50	1.000E 50	1.102E 06	9.996E-01
70.	1.999E 06	0.5188	7.663E 05	9.996E-01	9.997E-01	9.993E-01	1.000E 50	1.000E 50	1.102E 06	9.996E-01
71.	1.999E 06	0.5189	7.664E 05	9.996E-01	9.997E-01	9.994E-01	1.000E 50	1.000E 50	1.103E 06	9.997E-01
72.	1.999E 06	0.5189	7.665E 05	9.997E-01	9.998E-01	9.995E-01	1.000E 50	1.000E 50	1.103E 06	9.998E-01
73.	2.000E 06	0.5189	7.666E 05	9.998E-01	9.998E-01	9.996E-01	1.000E 50	1.000E 50	1.103E 06	9.998E-01
74.	2.000E 06	0.5189	7.666E 05	9.998E-01	9.999E-01	9.997E-01	1.000E 50	1.000E 50	1.103E 06	9.998E-01
75.	2.000E 06	0.5189	7.666E 05	9.998E-01	9.999E-01	9.998E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
76.	2.000E 06	0.5189	7.667E 05	9.999E-01	9.999E-01	9.998E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
77.	2.000E 06	0.5190	7.667E 05	9.999E-01	9.999E-01	9.998E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
78.	2.000E 06	0.5190	7.667E 05	9.999E-01	9.999E-01	9.999E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
79.	2.000E 06	0.5190	7.668E 05	9.999E-01	9.999E-01	9.999E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
80.	2.000E 06	0.5190	7.668E 05	9.999E-01	1.000E 00	9.999E-01	1.000E 50	1.000E 50	1.103E 06	1.000E 00

YEAR CLASS	FINAL VECTOR
0	6.44994E 10
1	1.10278E 06
2	6.05211E 05
3	4.05681E-05
4	3.32139E 05
5	1.89322E 05
6	9.22459E 04
7	4.49464E 04
8	2.38827E 04
9	1.26903E 04
10	7.34986E 03
11	4.25683E 03
12	2.68865E 03
13	1.69818E 03
14	1.16969E 03
15	2.58909E 03

Fig. 20. Example 2 (set 1: without age class 0 compensation) - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(S)--
FRT 1.0000E-01

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RO 40 0 15 10 20 40 80 0 0 10

VITAL STATISTICS - SET 1

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PHAT	PSUBI	CATCH	VULN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.003E-05
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	1.813E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.151E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B3,B4= 438.0 -5.34 3.13
B1,B2= 0.982E 05 0.730E 05

FDMXO CHANGES FROM 0.400 TO 0.400 IN STEPS OF 0.0
PDIO CHANGES FROM 0.319 TO 0.319 IN STEPS OF 0.0

YEAR	TOTP	F	YIELD	REL TOTP	REL EPRT	REL YIELD	IMPACTY	IMPACTP	NI	RCPU
0.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	1.103E 06	1.000E 00
1.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	1.048E 06	1.000E 00
2.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	1.048E 06	1.000E 00
3.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	1.048E 06	1.000E 00
4.	1.982E 06	0.5155	7.556E 05	9.911E-01	9.932E-01	9.854E-01	1.462E-01	8.861E-02	1.048E 06	9.922E-01
5.	1.961E 06	0.5111	7.426E 05	9.803E-01	9.848E-01	9.684E-01	3.160E-01	1.970E-01	1.048E 06	9.833E-01
6.	1.949E 06	0.5088	7.357E 05	9.744E-01	9.803E-01	9.593E-01	4.066E-01	2.558E-01	1.048E 06	9.786E-01
7.	1.945E 06	0.5081	7.336E 05	9.727E-01	9.790E-01	9.567E-01	4.333E-01	2.726E-01	1.038E 06	9.772E-01
8.	1.943E 06	0.5075	7.319E 05	9.713E-01	9.779E-01	9.545E-01	4.554E-01	2.867E-01	1.035E 06	9.760E-01
9.	1.941E 06	0.5072	7.310E 05	9.706E-01	9.773E-01	9.532E-01	4.679E-01	2.943E-01	1.034E 06	9.753E-01
10.	1.938E 06	0.5065	7.288E 05	9.688E-01	9.760E-01	9.505E-01	4.955E-01	3.117E-01	1.033E 06	9.738E-01
11.	1.934E 06	0.5058	7.267E 05	9.671E-01	9.746E-01	9.477E-01	5.229E-01	3.291E-01	1.033E 06	9.724E-01
12.	1.931E 06	0.5052	7.248E 05	9.655E-01	9.738E-01	9.452E-01	5.480E-01	3.452E-01	1.032E 06	9.710E-01
13.	1.929E 06	0.5049	7.238E 05	9.646E-01	9.727E-01	9.439E-01	5.612E-01	3.537E-01	1.031E 06	9.703E-01
14.	1.928E 06	0.5046	7.231E 05	9.641E-01	9.723E-01	9.430E-01	5.700E-01	3.593E-01	1.031E 06	9.699E-01
15.	1.927E 06	0.5045	7.226E 05	9.637E-01	9.720E-01	9.424E-01	5.762E-01	3.633E-01	1.030E 06	9.695E-01
16.	1.927E 06	0.5043	7.222E 05	9.633E-01	9.717E-01	9.418E-01	5.824E-01	3.672E-01	1.030E 06	9.692E-01
17.	1.926E 06	0.5042	7.217E 05	9.629E-01	9.715E-01	9.411E-01	5.887E-01	3.712E-01	1.029E 06	9.688E-01
18.	1.925E 06	0.5040	7.212E 05	9.625E-01	9.711E-01	9.405E-01	5.946E-01	3.749E-01	1.029E 06	9.685E-01
19.	1.924E 06	0.5039	7.209E 05	9.622E-01	9.709E-01	9.401E-01	5.992E-01	3.779E-01	1.029E 06	9.683E-01
20.	1.924E 06	0.5038	7.206E 05	9.620E-01	9.707E-01	9.397E-01	6.027E-01	3.801E-01	1.029E 06	9.681E-01
21.	1.924E 06	0.5037	7.204E 05	9.618E-01	9.706E-01	9.395E-01	6.051E-01	3.817E-01	1.029E 06	9.680E-01
22.	1.923E 06	0.5037	7.203E 05	9.617E-01	9.705E-01	9.393E-01	6.071E-01	3.829E-01	1.028E 06	9.679E-01
23.	1.923E 06	0.5036	7.201E 05	9.616E-01	9.704E-01	9.391E-01	6.088E-01	3.840E-01	1.028E 06	9.678E-01
24.	1.923E 06	0.5036	7.200E 05	9.615E-01	9.703E-01	9.390E-01	6.104E-01	3.851E-01	1.028E 06	9.678E-01
25.	1.923E 06	0.5036	7.199E 05	9.614E-01	9.703E-01	9.388E-01	6.117E-01	3.859E-01	1.028E 06	9.678E-01
26.	1.923E 06	0.5035	7.198E 05	9.613E-01	9.702E-01	9.387E-01	6.129E-01	3.866E-01	1.028E 06	9.678E-01
27.	1.923E 06	0.5035	7.198E 05	9.613E-01	9.702E-01	9.386E-01	6.137E-01	3.872E-01	1.028E 06	9.678E-01
28.	1.922E 06	0.5035	7.197E 05	9.612E-01	9.701E-01	9.386E-01	6.144E-01	3.876E-01	1.028E 06	9.678E-01
29.	1.922E 06	0.5035	7.197E 05	9.612E-01	9.701E-01	9.385E-01	6.149E-01	3.879E-01	1.028E 06	9.678E-01
30.	1.922E 06	0.5035	7.196E 05	9.612E-01	9.701E-01	9.385E-01	6.154E-01	3.882E-01	1.028E 06	9.678E-01
31.	1.922E 06	0.5035	7.196E 05	9.611E-01	9.701E-01	9.384E-01	6.158E-01	3.885E-01	1.028E 06	9.678E-01
32.	1.922E 06	0.5035	7.196E 05	9.611E-01	9.700E-01	9.384E-01	6.161E-01	3.887E-01	1.028E 06	9.678E-01
33.	1.922E 06	0.5034	7.196E 05	9.611E-01	9.700E-01	9.384E-01	6.164E-01	3.889E-01	1.028E 06	9.678E-01
34.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	6.166E-01	3.890E-01	1.028E 06	9.678E-01
35.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	6.168E-01	3.891E-01	1.028E 06	9.678E-01
36.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	6.169E-01	3.892E-01	1.028E 06	9.678E-01
37.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	6.171E-01	3.893E-01	1.028E 06	9.678E-01
38.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	6.172E-01	3.894E-01	1.028E 06	9.678E-01
39.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	6.172E-01	3.894E-01	1.028E 06	9.678E-01
40.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	6.173E-01	3.895E-01	1.028E 06	9.678E-01

YEAR CLASS FINAL VECTOR

0	6.32868E 10
1	1.02795E 06
2	5.64155E 05
3	3.78166E 05
4	3.09618E 05
5	1.78414E 05
6	8.82956E 04
7	4.36967E 04
8	2.35218E 04
9	1.26617E 04
10	7.40976E 03
11	4.33628E 03
12	2.76020E 03
13	1.75697E 03
14	1.21647E 03
15	2.73773E 03

Fig. 21. Example 2 (set 1: without age class 0 compensation) - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(S)--
FRI 0.0

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RC 40 0 15 0 0 0 0 0 0 0

VITAL STATISTICS - SET 1

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PHAT	PSUBI	CATCH	VOLN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.003E-05
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	1.813E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.503E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.968E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 03	1.142E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	9.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.462E 02	2.013E 01	1.588E 06	5.000E-01	1.000E 00	7.040E 05	1.000E 00	5.000E 00	1.813E-01
13	9.701E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E 00	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B3,B4= 438.0 -5.34 3.13
B1,B2= 0.982E 05 0.730E 05

YEAR	TOTP	F	YIELD	REL TOTP	REL EFRT	REL YIELD	IMPACTY	IMPACTP	N1	RCPU2
40.	1.922E 06	0.5034	7.195E 05	9.611E-01	9.700E-01	9.383E-01	1.000E 50	1.000E 50	1.028E 06	9.673E-01
41.	1.922E 06	0.5034	7.195E 05	9.610E-01	9.700E-01	9.383E-01	1.000E 50	1.000E 50	1.082E 06	9.673E-01
42.	1.922E 06	0.5034	7.195E 05	9.610E-01	9.700E-01	9.383E-01	1.000E 50	1.000E 50	1.082E 06	9.673E-01
43.	1.922E 06	0.5034	7.195E 05	9.610E-01	9.700E-01	9.383E-01	1.000E 50	1.000E 50	1.082E 06	9.673E-01
44.	1.939E 06	0.5069	7.303E 05	9.697E-01	9.767E-01	9.523E-01	1.000E 50	1.000E 50	1.082E 06	9.751E-01
45.	1.961E 06	0.5112	7.432E 05	9.805E-01	9.850E-01	9.691E-01	1.000E 50	1.000E 50	1.084E 06	9.839E-01
46.	1.973E 06	0.5136	7.502E 05	9.864E-01	9.895E-01	9.783E-01	1.000E 50	1.000E 50	1.086E 06	9.886E-01
47.	1.976E 06	0.5142	7.522E 05	9.881E-01	9.908E-01	9.809E-01	1.000E 50	1.000E 50	1.092E 06	9.900E-01
48.	1.979E 06	0.5148	7.539E 05	9.895E-01	9.919E-01	9.831E-01	1.000E 50	1.000E 50	1.095E 06	9.912E-01
49.	1.981E 06	0.5151	7.549E 05	9.903E-01	9.925E-01	9.844E-01	1.000E 50	1.000E 50	1.097E 06	9.919E-01
50.	1.984E 06	0.5158	7.571E 05	9.921E-01	9.939E-01	9.874E-01	1.000E 50	1.000E 50	1.097E 06	9.934E-01
51.	1.988E 06	0.5166	7.594E 05	9.939E-01	9.953E-01	9.903E-01	1.000E 50	1.000E 50	1.098E 06	9.950E-01
52.	1.991E 06	0.5172	7.614E 05	9.956E-01	9.966E-01	9.929E-01	1.000E 50	1.000E 50	1.099E 06	9.963E-01
53.	1.993E 06	0.5176	7.625E 05	9.964E-01	9.973E-01	9.943E-01	1.000E 50	1.000E 50	1.099E 06	9.970E-01
54.	1.994E 06	0.5178	7.631E 05	9.970E-01	9.977E-01	9.952E-01	1.000E 50	1.000E 50	1.100E 06	9.975E-01
55.	1.995E 06	0.5180	7.636E 05	9.974E-01	9.980E-01	9.958E-01	1.000E 50	1.000E 50	1.101E 06	9.978E-01
56.	1.996E 06	0.5181	7.641E 05	9.978E-01	9.983E-01	9.965E-01	1.000E 50	1.000E 50	1.101E 06	9.982E-01
57.	1.996E 06	0.5183	7.646E 05	9.982E-01	9.986E-01	9.971E-01	1.000E 50	1.000E 50	1.101E 06	9.985E-01
58.	1.997E 06	0.5184	7.651E 05	9.986E-01	9.989E-01	9.978E-01	1.000E 50	1.000E 50	1.102E 06	9.988E-01
59.	1.998E 06	0.5186	7.655E 05	9.989E-01	9.991E-01	9.982E-01	1.000E 50	1.000E 50	1.102E 06	9.991E-01
60.	1.998E 06	0.5186	7.657E 05	9.991E-01	9.993E-01	9.986E-01	1.000E 50	1.000E 50	1.102E 06	9.993E-01
61.	1.999E 06	0.5187	7.659E 05	9.993E-01	9.994E-01	9.988E-01	1.000E 50	1.000E 50	1.102E 06	9.994E-01
62.	1.999E 06	0.5188	7.661E 05	9.994E-01	9.995E-01	9.990E-01	1.000E 50	1.000E 50	1.102E 06	9.995E-01
63.	1.999E 06	0.5188	7.662E 05	9.995E-01	9.996E-01	9.992E-01	1.000E 50	1.000E 50	1.102E 06	9.996E-01
64.	1.999E 06	0.5188	7.663E 05	9.996E-01	9.997E-01	9.993E-01	1.000E 50	1.000E 50	1.102E 06	9.997E-01
65.	1.999E 06	0.5189	7.664E 05	9.997E-01	9.997E-01	9.995E-01	1.000E 50	1.000E 50	1.103E 06	9.997E-01
66.	1.999E 06	0.5189	7.665E 05	9.997E-01	9.998E-01	9.996E-01	1.000E 50	1.000E 50	1.103E 06	9.998E-01
67.	2.000E 06	0.5189	7.666E 05	9.998E-01	9.998E-01	9.997E-01	1.000E 50	1.000E 50	1.103E 06	9.998E-01
68.	2.000E 06	0.5189	7.666E 05	9.998E-01	9.999E-01	9.997E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
69.	2.000E 06	0.5189	7.667E 05	9.999E-01	9.999E-01	9.998E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
70.	2.000E 06	0.5190	7.667E 05	9.999E-01	9.999E-01	9.998E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
71.	2.000E 06	0.5190	7.667E 05	9.999E-01	9.999E-01	9.998E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
72.	2.000E 06	0.5190	7.667E 05	9.999E-01	9.999E-01	9.999E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
73.	2.000E 06	0.5190	7.668E 05	9.999E-01	1.000E 00	9.999E-01	1.000E 50	1.000E 50	1.103E 06	9.999E-01
74.	2.000E 06	0.5190	7.668E 05	9.999E-01	1.000E 00	9.999E-01	1.000E 50	1.000E 50	1.103E 06	1.000E 00
75.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	9.999E-01	1.000E 50	1.000E 50	1.103E 06	1.000E 00
76.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	9.999E-01	1.000E 50	1.000E 50	1.103E 06	1.000E 00
77.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
78.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
79.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00
80.	2.000E 06	0.5190	7.668E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	1.103E 06	1.000E 00

YEAR CLASS FINAL VECTOR

0	6.45010E 10
1	1.10281E 06
2	6.05233E 09
3	4.05698E 05
4	3.32156E 05
5	1.89332E 05
6	9.22502E 04
7	4.49881E 04
8	2.38834E 04
9	1.26906E 04
10	7.34993E 03
11	4.25682E 03
12	2.68662E 03
13	1.69813E 03
14	1.16965E 03
15	2.58877E 03

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
OUT 15 0 0 0 0 0 0 0 0 0

Fig. 22. Example 2 (set 1: without age class 0 compensation) - Standard output (cont.).

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP      8  0  0  0  0  0  0  0  0  0

```

***** NOTE- *****

```

      8 CHANGED PARAMETER(S)--
FDIO  1.7800E-01
PDMX0 5.3600E-01
CA21  1.0000E-08
CA31  1.0000E-08
CA41  1.0000E-08
GA2   1.0000E-08
GA3   1.0000E-08
GA4   1.0000E-08

```

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
REDO    0  0  0  0  0  0  0  0  0  0

```

```

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
ITR     0  0  0  0  0  0  0  0  0  0

```

```

TARGET= 2.000E 06
      PDMX0 CHANGES FROM 0.536 TO 0.536 IN STEPS OF 0.0
      FDIO CHANGES FROM 0.178 TO 0.178 IN STEPS OF 0.0
TOTP =  2.000000E 06

```

ANALYTIC PNS0= 1.3329E-05

Y-O-Y PARAMETERS COMPUTED IN ANALYT

```

DAN(1)  0.36762817E 03
DAN(2)  0.10459288E 03
DAN(3)  0.34239761E 02
DAN(4)  0.13333221E 02
DAN(5)  0.45504560E 01
DAN(6)  0.32500839E 01

```

YEAR CLASS INITIAL VECTOR

```

0      7.11843E 10
1      9.48833E 05
2      5.20730E 05
3      3.49056E 05
4      2.85783E 05
5      1.71410E 05
6      8.98426E 04
7      4.70899E 04
8      2.65902E 04
9      1.50146E 04
10     9.12977E 03
11     5.55145E 03
12     3.63664E 03
13     2.38228E 03
14     1.68126E 03
15     4.03212E 03

```

Fig. 23. Example 2 (set 2: with age class 0 compensation) - Standard output.

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(S)--
PRY 3.0000E-01

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RO 40 0 15 10 20 40 80 0 0 10

VITAL STATISTICS - SET 2

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PRAT	PSUBI	CATCH	VULN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.003E-05
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	1.813E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B1,B4= 438.0 -5.34 3.13
B1,B2= 0.982E 05 0.730E 05

PDHXO CHANGES FROM 0.536 TO 0.536 IN STEPS OF 0.0
PDIO CHANGES FROM 0.178 TO 0.178 IN STEPS OF 0.0

YEAR	TOTP	F	YIELD	REL TOTP	REL EPRT	REL YIELD	IMPACTY	IMPACTP	M1	RCPUE
0.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.488E 05	1.000E 00
1.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	8.220E 05	1.000E 00
2.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	8.225E 05	1.000E 00
3.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	8.227E 05	1.000E 00
4.	1.959E 06	0.4351	6.516E 05	9.796E-01	9.755E-01	9.590E-01	1.366E-01	6.793E-02	8.227E 05	9.831E-01
5.	1.910E 06	0.4219	6.197E 05	9.551E-01	9.460E-01	9.121E-01	2.930E-01	1.498E-01	8.215E 05	9.642E-01
6.	1.888E 06	0.4149	6.032E 05	9.420E-01	9.303E-01	8.878E-01	3.740E-01	1.933E-01	8.205E 05	9.543E-01
7.	1.878E 06	0.4133	5.992E 05	9.389E-01	9.265E-01	8.819E-01	3.935E-01	2.036E-01	8.175E 05	9.518E-01
8.	1.872E 06	0.4117	5.956E 05	9.360E-01	9.231E-01	8.766E-01	4.114E-01	2.133E-01	8.159E 05	9.496E-01
9.	1.872E 06	0.4116	5.954E 05	9.359E-01	9.230E-01	8.763E-01	4.122E-01	2.137E-01	8.152E 05	9.495E-01
10.	1.869E 06	0.4108	5.935E 05	9.344E-01	9.211E-01	8.735E-01	4.216E-01	2.187E-01	8.154E 05	9.483E-01
11.	1.868E 06	0.4106	5.928E 05	9.339E-01	9.205E-01	8.726E-01	4.247E-01	2.204E-01	8.155E 05	9.479E-01
12.	1.866E 06	0.4100	5.915E 05	9.328E-01	9.193E-01	8.706E-01	4.314E-01	2.239E-01	8.157E 05	9.471E-01
13.	1.866E 06	0.4100	5.915E 05	9.328E-01	9.193E-01	8.706E-01	4.313E-01	2.239E-01	8.157E 05	9.471E-01
14.	1.865E 06	0.4099	5.913E 05	9.327E-01	9.191E-01	8.704E-01	4.322E-01	2.244E-01	8.157E 05	9.470E-01
15.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.190E-01	8.702E-01	4.325E-01	2.246E-01	8.156E 05	9.469E-01
16.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.190E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
17.	1.865E 06	0.4099	5.913E 05	9.327E-01	9.191E-01	8.703E-01	4.322E-01	2.244E-01	8.155E 05	9.470E-01
18.	1.865E 06	0.4099	5.913E 05	9.327E-01	9.191E-01	8.703E-01	4.322E-01	2.244E-01	8.156E 05	9.470E-01
19.	1.865E 06	0.4099	5.913E 05	9.327E-01	9.191E-01	8.703E-01	4.322E-01	2.244E-01	8.156E 05	9.470E-01
20.	1.865E 06	0.4099	5.913E 05	9.327E-01	9.191E-01	8.703E-01	4.323E-01	2.245E-01	8.156E 05	9.469E-01
21.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
22.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
23.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
24.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
25.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
26.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
27.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
28.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
29.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
30.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
31.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
32.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
33.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
34.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
35.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
36.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
37.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
38.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
39.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01
40.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	4.324E-01	2.245E-01	8.156E 05	9.469E-01

YEAR CLASS FINAL VECTOR

0	6.98002E 10
1	8.15574E 05
2	4.47597E 05
3	3.00033E 05
4	2.45646E 05
5	1.51095E 05
6	8.21059E 04
7	4.46168E 04
8	2.59622E 04
9	1.51080E 04
10	9.41044E 03
11	5.86157E 03
12	3.40473E 03
13	2.60783E 03
14	1.86269E 03
15	4.65634E 03

Fig. 24. Example 2 (set 2: with age class 0 compensation) - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(S) --
PRY 0.0

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RC 40 0 15 0 0 0 0 0 0 0

VITAL STATISTICS - SET 2

AGE	LENGTH	WEIGHT	EGGS	MALE	PHAT	PSUBI	CATCH	VOLN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.003E-05
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	1.813E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.151E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B3,B4= 438.0 -5.34 3.13
B1,B2= 0.582E 05 0.730E 05

YEAR	TOTP	F	YIELD	REL TOTP	REL EPRT	REL YIELD	IMPACTY	IMPACTP	N1	RCPUE
40.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	1.000E 50	1.000E 50	8.156E 05	9.469E-01
41.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	1.000E 50	1.000E 50	9.416E 05	9.469E-01
42.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	1.000E 50	1.000E 50	9.410E 05	9.469E-01
43.	1.865E 06	0.4099	5.913E 05	9.326E-01	9.191E-01	8.703E-01	1.000E 50	1.000E 50	9.408E 05	9.469E-01
44.	1.906E 06	0.4208	6.179E 05	9.529E-01	9.434E-01	9.095E-01	1.000E 50	1.000E 50	9.408E 05	9.641E-01
45.	1.956E 06	0.4303	6.507E 05	9.781E-01	9.737E-01	9.577E-01	1.000E 50	1.000E 50	9.422E 05	9.836E-01
46.	1.983E 06	0.4414	6.679E 05	9.914E-01	9.896E-01	9.831E-01	1.000E 50	1.000E 50	9.435E 05	9.934E-01
47.	1.988E 06	0.4428	6.716E 05	9.941E-01	9.929E-01	9.885E-01	1.000E 50	1.000E 50	9.470E 05	9.956E-01
48.	1.993E 06	0.4443	6.751E 05	9.967E-01	9.961E-01	9.936E-01	1.000E 50	1.000E 50	9.488E 05	9.975E-01
49.	1.998E 06	0.4443	6.751E 05	9.968E-01	9.961E-01	9.937E-01	1.000E 50	1.000E 50	9.495E 05	9.975E-01
50.	1.997E 06	0.4451	6.772E 05	9.983E-01	9.980E-01	9.967E-01	1.000E 50	1.000E 50	9.492E 05	9.987E-01
51.	1.998E 06	0.4454	6.780E 05	9.989E-01	9.987E-01	9.980E-01	1.000E 50	1.000E 50	9.490E 05	9.992E-01
52.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
53.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	9.999E-01	1.000E 50	1.000E 50	9.488E 05	1.000E 00
54.	2.000E 06	0.4460	6.795E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
55.	2.000E 06	0.4460	6.795E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
56.	2.000E 06	0.4460	6.795E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.489E 05	1.000E 00
57.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.489E 05	1.000E 00
58.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.489E 05	1.000E 00
59.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
60.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
61.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
62.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
63.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
64.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
65.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
66.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
67.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
68.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
69.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
70.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
71.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
72.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
73.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
74.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
75.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
76.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
77.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
78.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
79.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
80.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00

YEAR CLASS FINAL VECTOR

0	7.11845E 10
1	9.48836E 05
2	5.20732E 05
3	3.49057E 05
4	2.85784E 05
5	1.71411E 05
6	8.98428E 04
7	4.70900E 04
8	2.65902E 04
9	1.50146E 04
10	9.12978E 03
11	5.55145E 03
12	3.63663E 03
13	2.38228E 03
14	1.68125E 03
15	4.03211E 03

Fig. 25. Example 2 (set 2: with age class 0 compensation) - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(S) --
PRY 1.0000E-01

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RO 40 0 15 10 20 40 80 0 0 10

VITAL STATISTICS - SET 2

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PMAT	PSUBI	CATCH	VULN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0				
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	2.003E-05
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.668E 06	5.000E-01	1.000E 00	7.040E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B3,B4= 438.0 -5.34 3.13
B1,B2= 0.982E 05 0.730E 05

PDMXO CHANGES FROM 0.536 TO 0.536 IN STEPS OF 0.0
PDIO CHANGES FROM 0.178 TO 0.178 IN STEPS OF 0.0

YEAR	TOTP	F	YIELD	REL TOTP	REL EPRT	REL YIELD	IMPACTY	IMPACTP	H1	RCPUZ
0.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.488E 05	1.000E 00
1.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.071E 05	1.000E 00
2.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.073E 05	1.000E 00
3.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	0.0	0.0	9.073E 05	1.000E 00
4.	1.987E 06	0.4424	6.702E 05	9.933E-01	9.919E-01	9.864E-01	1.357E-01	6.709E-02	9.073E 05	9.944E-01
5.	1.971E 06	0.4381	6.596E 05	9.853E-01	9.823E-01	9.708E-01	2.919E-01	1.474E-01	9.069E 05	9.883E-01
6.	1.962E 06	0.4359	6.542E 05	9.811E-01	9.773E-01	9.629E-01	3.706E-01	1.886E-01	9.065E 05	9.853E-01
7.	1.961E 06	0.4354	6.531E 05	9.803E-01	9.763E-01	9.613E-01	3.871E-01	1.971E-01	9.055E 05	9.866E-01
8.	1.959E 06	0.4350	6.520E 05	9.794E-01	9.753E-01	9.597E-01	4.033E-01	2.056E-01	9.050E 05	9.840E-01
9.	1.959E 06	0.4350	6.520E 05	9.794E-01	9.753E-01	9.597E-01	4.034E-01	2.056E-01	9.048E 05	9.840E-01
10.	1.958E 06	0.4347	6.514E 05	9.790E-01	9.747E-01	9.587E-01	4.126E-01	2.104E-01	9.049E 05	9.836E-01
11.	1.958E 06	0.4346	6.512E 05	9.788E-01	9.745E-01	9.584E-01	4.159E-01	2.120E-01	9.050E 05	9.835E-01
12.	1.957E 06	0.4345	6.507E 05	9.785E-01	9.741E-01	9.578E-01	4.221E-01	2.152E-01	9.050E 05	9.832E-01
13.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.742E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
14.	1.957E 06	0.4345	6.507E 05	9.785E-01	9.741E-01	9.578E-01	4.223E-01	2.154E-01	9.051E 05	9.832E-01
15.	1.957E 06	0.4345	6.507E 05	9.785E-01	9.741E-01	9.578E-01	4.223E-01	2.154E-01	9.050E 05	9.832E-01
16.	1.957E 06	0.4345	6.507E 05	9.785E-01	9.741E-01	9.578E-01	4.221E-01	2.153E-01	9.050E 05	9.832E-01
17.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.152E-01	9.050E 05	9.832E-01
18.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
19.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
20.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.152E-01	9.050E 05	9.832E-01
21.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.152E-01	9.050E 05	9.832E-01
22.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.152E-01	9.050E 05	9.832E-01
23.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
24.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
25.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
26.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
27.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
28.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
29.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
30.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
31.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
32.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
33.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
34.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
35.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
36.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
37.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
38.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.218E-01	2.151E-01	9.050E 05	9.832E-01
39.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01
40.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	4.217E-01	2.151E-01	9.050E 05	9.832E-01

YEAR CLASS FINAL VECTOR

0	7.07702E 10
1	9.05029E 05
2	4.96690E 05
3	3.32941E 05
4	2.72589E 05
5	1.64818E 05
6	8.73891E 04
7	4.63352E 04
8	2.64165E 04
9	1.50605E 04
10	9.22841E 03
11	5.65475E 03
12	3.72573E 03
13	2.45476E 03
14	1.73907E 03
15	4.22580E 03

Fig. 26. Example 2 (set 2: with age class 0 compensation) - Standard output (cont.).

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
CP 1 0 0 0 0 0 0 0 0 0

***** NOTE- *****

1 CHANGED PARAMETER(S)--
PRY 0.0

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
RC 40 0 15 0 0 0 0 0 0 0

VITAL STATISTICS - SET 2

AGE	LENGTH	WEIGHT	EGGS	FEMALE	PMAT	FSUBI	CATCH	VULN	NAT. MORT
0	0.0	0.0	0.0	0.0	0.0				
1	1.120E 02	2.615E-02	1.001E 05	5.000E-01	0.0	0.0	0.0	0.0	2.003E-05
2	2.178E 02	2.097E-01	1.135E 05	5.000E-01	0.0	0.0	0.0	0.0	4.512E-01
3	3.175E 02	6.819E-01	1.480E 05	5.000E-01	0.0	0.0	0.0	0.0	3.297E-01
4	4.110E 02	1.529E 00	2.099E 05	5.000E-01	6.000E-02	6.297E 03	0.0	6.670E-01	1.813E-01
5	4.982E 02	2.795E 00	3.023E 05	5.000E-01	2.300E-01	3.477E 04	6.977E-01	1.000E 00	1.813E-01
6	5.794E 02	4.481E 00	4.254E 05	5.000E-01	7.100E-01	1.510E 05	1.000E 00	1.000E 00	1.813E-01
7	6.543E 02	6.557E 00	5.770E 05	5.000E-01	9.500E-01	2.741E 05	1.000E 00	1.000E 00	1.813E-01
8	7.230E 02	8.964E 00	7.529E 05	5.000E-01	1.000E 00	3.764E 05	1.000E 00	8.330E-01	1.813E-01
9	7.856E 02	1.162E 01	9.470E 05	5.000E-01	1.000E 00	4.735E 05	1.000E 00	8.330E-01	1.813E-01
10	8.420E 02	1.444E 01	1.153E 06	5.000E-01	1.000E 00	5.764E 05	1.000E 00	6.670E-01	1.813E-01
11	8.922E 02	1.731E 01	1.362E 06	5.000E-01	1.000E 00	6.812E 05	1.000E 00	6.670E-01	1.813E-01
12	9.362E 02	2.013E 01	1.568E 06	5.000E-01	1.000E 00	7.840E 05	1.000E 00	5.000E-01	1.813E-01
13	9.741E 02	2.278E 01	1.762E 06	5.000E-01	1.000E 00	8.811E 05	1.000E 00	5.000E-01	1.813E-01
14	1.006E 03	2.518E 01	1.937E 06	5.000E-01	1.000E 00	9.687E 05	1.000E 00	3.330E-01	1.813E-01
15	1.031E 03	2.724E 01	2.087E 06	5.000E-01	1.000E 00	1.044E 06	1.000E 00	3.330E-01	1.813E-01

WITH THESE PARAMETERS-- ACON,B,C= 0.0 115.10 -3.09 LEGAL,B3,B4= 438.0 -5.34 3.13
B1,B2= 0.982E 05 0.730E 05

YEAR	TOTP	F	YIELD	REL TOTP	REL EPRT	REL YIELD	IMPACTY	IMPACTP	N1	RCPUE
40.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	1.000E 50	1.000E 50	9.050E 05	9.832E-01
41.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	1.000E 50	1.000E 50	9.467E 05	9.832E-01
42.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	1.000E 50	1.000E 50	9.465E 05	9.832E-01
43.	1.957E 06	0.4345	6.508E 05	9.785E-01	9.741E-01	9.578E-01	1.000E 50	1.000E 50	9.465E 05	9.832E-01
44.	1.970E 06	0.4381	6.599E 05	9.852E-01	9.822E-01	9.712E-01	1.000E 50	1.000E 50	9.464E 05	9.888E-01
45.	1.987E 06	0.4424	6.706E 05	9.933E-01	9.919E-01	9.870E-01	1.000E 50	1.000E 50	9.469E 05	9.950E-01
46.	1.995E 06	0.4446	6.760E 05	9.974E-01	9.969E-01	9.950E-01	1.000E 50	1.000E 50	9.473E 05	9.980E-01
47.	1.996E 06	0.4451	6.771E 05	9.982E-01	9.979E-01	9.966E-01	1.000E 50	1.000E 50	9.484E 05	9.987E-01
48.	1.998E 06	0.4455	6.781E 05	9.991E-01	9.989E-01	9.981E-01	1.000E 50	1.000E 50	9.489E 05	9.993E-01
49.	1.998E 06	0.4455	6.782E 05	9.991E-01	9.989E-01	9.981E-01	1.000E 50	1.000E 50	9.491E 05	9.993E-01
50.	1.999E 06	0.4457	6.788E 05	9.995E-01	9.994E-01	9.991E-01	1.000E 50	1.000E 50	9.490E 05	9.997E-01
51.	1.999E 06	0.4458	6.790E 05	9.997E-01	9.997E-01	9.994E-01	1.000E 50	1.000E 50	9.489E 05	9.998E-01
52.	2.000E 06	0.4460	6.795E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
53.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
54.	2.000E 06	0.4460	6.795E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
55.	2.000E 06	0.4460	6.795E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
56.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.489E 05	1.000E 00
57.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.489E 05	1.000E 00
58.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
59.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
60.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
61.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
62.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
63.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
64.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
65.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
66.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
67.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
68.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
69.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
70.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
71.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
72.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
73.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
74.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
75.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
76.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
77.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
78.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
79.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00
80.	2.000E 06	0.4460	6.794E 05	1.000E 00	1.000E 00	1.000E 00	1.000E 50	1.000E 50	9.488E 05	1.000E 00

YEAR CLASS FINAL VECTOR

0	7.11845E 10
1	9.48836E 05
2	5.20732E 05
3	3.49057E 05
4	2.85784E 05
5	1.71411E 05
6	8.98428E 04
7	4.70900E 04
8	2.65902E 04
9	1.50146E 04
10	9.12977E 03
11	5.55144E 03
12	3.63663E 03
13	2.38222E 03
14	1.68125E 03
15	4.03211E 03

COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10
OUT 15 0 0 0 0 0 0 0 0 0

Fig. 27. Example 2 (set 2: with age class 0 compensation) -
Standard output (cont.).

SET 1.0				
FRACTIONAL CHANGE IN SURVIVAL PROBABILITY FOR AGE CLASS 0, FRY				
	YEAR	0.0	0.30	0.10
OUTPT	1... 10	2.000E 06	1.809E 06	1.938E 06
	1... 20	2.000E 06	1.766E 06	1.924E 06
	1... 40	2.000E 06	1.758E 06	1.922E 06
	1... 80	2.000E 06	2.000E 06	2.000E 06
OUTPT	2... 10	7.668E 05	6.530E 05	7.288E 05
	2... 20	7.668E 05	6.281E 05	7.206E 05
	2... 40	7.668E 05	6.238E 05	7.195E 05
	2... 80	7.668E 05	7.668E 05	7.668E 05
OUTPT	3... 10	5.190E-01	4.809E-01	5.065E-01
	3... 20	5.190E-01	4.721E-01	5.038E-01
	3... 40	5.190E-01	4.707E-01	5.034E-01
	3... 80	5.190E-01	5.190E-01	5.190E-01
OUTPT	4... 10	6.450E 10	6.158E 10	6.358E 10
	4... 20	6.450E 10	6.069E 10	6.333E 10
	4... 40	6.450E 10	6.051E 10	6.329E 10
	4... 80	6.450E 10	6.450E 10	6.450E 10
OUTPT	5... 10	1.103E 06	8.965E 05	1.033E 06
	5... 20	1.103E 06	8.825E 05	1.029E 06
	5... 40	1.103E 06	8.794E 05	1.028E 06
	5... 80	1.103E 06	1.103E 06	1.103E 06
OUTPT	6... 10	2.589E 03	2.769E 03	2.647E 03
	6... 20	2.589E 03	3.043E 03	2.733E 03
	6... 40	2.589E 03	3.057E 03	2.738E 03
	6... 80	2.589E 03	2.589E 03	2.589E 03
OUTPT	7... 10	1.710E-05	1.453E-05	1.624E-05
	7... 20	1.710E-05	1.453E-05	1.624E-05
	7... 40	1.710E-05	1.710E-05	1.710E-05
	7... 80	1.710E-05	1.710E-05	1.710E-05
OUTPT	8... 10	5.700E-01	5.854E-01	5.750E-01
	8... 20	5.700E-01	5.889E-01	5.761E-01
	8... 40	5.700E-01	5.896E-01	5.762E-01
	8... 80	5.700E-01	5.700E-01	5.700E-01
OUTPT	9... 10	6.146E-01	6.634E-01	6.298E-01
	9... 20	6.146E-01	6.756E-01	6.332E-01
	9... 40	6.146E-01	6.778E-01	6.337E-01
	9... 80	6.146E-01	6.147E-01	6.147E-01
OUTPT	10... 10	3.854E-01	3.366E-01	3.702E-01
	10... 20	3.854E-01	3.244E-01	3.668E-01
	10... 40	3.854E-01	3.222E-01	3.663E-01
	10... 80	3.854E-01	3.853E-01	3.853E-01
OUTPT	11... 10	1.711E-01	1.706E-01	1.709E-01
	11... 20	1.711E-01	1.706E-01	1.709E-01
	11... 40	1.711E-01	1.711E-01	1.711E-01
	11... 80	1.711E-01	1.711E-01	1.711E-01
OUTPT	12... 10	1.000E-01	9.729E-02	9.910E-02
	12... 20	1.000E-01	9.729E-02	9.910E-02
	12... 40	1.000E-01	1.000E-01	1.000E-01
	12... 80	1.000E-01	1.000E-01	1.000E-01
OUTPT	13... 10	1.000E-01	9.381E-02	9.798E-02
	13... 20	1.000E-01	9.381E-02	9.798E-02
	13... 40	1.000E-01	1.000E-01	1.000E-01
	13... 80	1.000E-01	1.000E-01	1.000E-01
OUTPT	14... 10	2.154E-01	2.083E-01	2.132E-01
	14... 20	2.154E-01	2.083E-01	2.132E-01
	14... 40	2.154E-01	2.154E-01	2.154E-01
	14... 80	2.154E-01	2.154E-01	2.154E-01
OUTPT	15... 10	2.154E-01	2.117E-01	2.143E-01
	15... 20	2.154E-01	2.117E-01	2.143E-01
	15... 40	2.154E-01	2.154E-01	2.154E-01
	15... 80	2.154E-01	2.154E-01	2.154E-01
OUTPT	16... 10	2.154E-01	2.117E-01	2.143E-01
	16... 20	2.154E-01	2.117E-01	2.143E-01
	16... 40	2.154E-01	2.154E-01	2.154E-01
	16... 80	2.154E-01	2.154E-01	2.154E-01
REL	1... 10	1.000E 00	9.046E-01	9.688E-01
	1... 20	1.000E 00	8.829E-01	9.620E-01
	1... 40	1.000E 00	8.791E-01	9.611E-01
	1... 80	1.000E 00	9.999E-01	1.000E 00
REL	2... 10	1.000E 00	8.516E-01	9.505E-01
	2... 20	1.000E 00	8.190E-01	9.397E-01
	2... 40	1.000E 00	8.135E-01	9.383E-01
	2... 80	1.000E 00	9.999E-01	1.000E 00

Fig. 28. Example 2 - Summary table, set 1.

REL	3...	10	1.000E 00	9.265E-01	9.760E-01
	3...	20	1.000E 00	9.097E-01	9.707E-01
	3...	40	1.000E 00	9.069E-01	9.700E-01
	3...	80	1.000E 00	1.000E 00	1.000E 00
REL	4...	10	1.000E 00	9.547E-01	9.858E-01
	4...	20	1.000E 00	9.408E-01	9.818E-01
	4...	40	1.000E 00	9.381E-01	9.812E-01
	4...	80	1.000E 00	1.000E 00	1.000E 00
REL	5...	10	1.000E 00	8.129E-01	9.370E-01
	5...	20	1.000E 00	8.002E-01	9.329E-01
	5...	40	1.000E 00	7.974E-01	9.321E-01
	5...	80	1.000E 00	1.000E 00	1.000E 00
REL	6...	10	1.000E 00	1.070E 00	1.022E 00
	6...	20	1.000E 00	1.175E 00	1.056E 00
	6...	40	1.000E 00	1.181E 00	1.058E 00
	6...	80	1.000E 00	1.000E 00	1.000E 00
REL	7...	10	1.000E 00	1.000E 00	1.000E 00
	7...	20	1.000E 00	1.000E 00	1.000E 00
	7...	40	1.000E 00	1.176E 00	1.053E 00
	7...	80	1.000E 00	1.176E 00	1.053E 00
IMPACT	1...	10	1.000E 50	3.179E-01	3.117E-01
	1...	20	1.000E 50	3.904E-01	3.801E-01
	1...	40	1.000E 50	1.000E 50	1.000E 50
	1...	80	1.000E 50	1.000E 50	1.000E 50
IMPACT	2...	10	1.000E 50	4.947E-01	4.955E-01
	2...	20	1.000E 50	6.032E-01	6.027E-01
	2...	40	1.000E 50	1.000E 50	1.000E 50
	2...	80	1.000E 50	1.000E 50	1.000E 50
IMPACT	3...	10	1.000E 50	2.450E-01	2.402E-01
	3...	20	1.000E 50	3.099E-01	2.930E-01
	3...	40	1.000E 50	1.000E 50	1.000E 50
	3...	80	1.000E 50	1.000E 50	1.000E 50
IMPACT	4...	10	1.000E 50	1.510E-01	1.425E-01
	4...	20	1.000E 50	1.972E-01	1.821E-01
	4...	40	1.000E 50	1.000E 50	1.000E 50
	4...	80	1.000E 50	1.000E 50	1.000E 50
IMPACT	5...	10	1.000E 50	6.235E-01	6.304E-01
	5...	20	1.000E 50	6.659E-01	6.715E-01
	5...	40	1.000E 50	1.000E 50	1.000E 50
	5...	80	1.000E 50	1.000E 50	1.000E 50
IMPACT	6...	10	1.000E 50	-2.321E-01	-2.236E-01
	6...	20	1.000E 50	-5.846E-01	-5.568E-01
	6...	40	1.000E 50	1.000E 50	1.000E 50
	6...	80	1.000E 50	1.000E 50	1.000E 50
IMPACT	7...	10	1.000E 50	0.0	0.0
	7...	20	1.000E 50	0.0	0.0
	7...	40	1.000E 50	1.000E 50	1.000E 50
	7...	80	1.000E 50	1.000E 50	1.000E 50
B/C	1...	10	1.000E 00	9.191E-01	9.738E-01
	1...	20	1.000E 00	9.003E-01	9.681E-01
	1...	40	1.000E 00	8.971E-01	9.673E-01
	1...	80	1.000E 00	1.000E 00	1.000E 00
B/C	2...	10	0.0	0.0	0.0
	2...	20	0.0	2.198E-02	6.787E-03
	2...	40	0.0	2.579E-02	7.720E-03
	2...	80	0.0	-9.118E-02	-3.044E-02
B/C	3...	10	0.0	0.0	0.0
	3...	20	0.0	3.267E-03	1.007E-03
	3...	40	0.0	5.699E-04	1.706E-04
	3...	80	0.0	-4.451E-05	-1.486E-05
B/C	4...	10	0.0	0.0	0.0
	4...	20	0.0	8.710E-03	2.738E-03
	4...	40	0.0	1.020E-02	3.112E-03
	4...	80	0.0	-3.812E-02	-1.246E-02
B/C	5...	10	0.0	0.0	0.0
	5...	20	0.0	1.295E-03	4.069E-04
	5...	40	0.0	2.253E-04	6.875E-05
	5...	80	0.0	-1.861E-05	-6.084E-06
B/C	6...	10	0.0	0.0	0.0
	6...	20	0.0	6.100E-03	2.109E-03
	6...	40	0.0	7.105E-03	2.396E-03
	6...	80	0.0	-3.115E-02	-1.007E-02
B/C	7...	10	0.0	0.0	0.0
	7...	20	0.0	9.067E-04	3.135E-04
	7...	40	0.0	1.570E-04	5.295E-05
	7...	80	0.0	-1.521E-05	-4.918E-06
YRS RELYD LT .50			0	0	0
YRS RELN1 LT .50			0	0	0
YRS RELTOTP LT .50			0	0	0
INDEX OF RISK			0.0	0.0	0.0

Fig. 29. Example 2 - Summary table, set 1 (cont.).

SET 1.0
RELATIVE YIELD VS. TIME

Fig. 30. Example 2 - Graph 1, set 1.

SET 1.0
RELATIVE TOTP VS. TIME

Fig. 31. Example 2 - Graph 2, set 1.

SET 2.0

FRACTIONAL CHANGE IN SURVIVAL PROBABILITY FOR AGE CLASS 0, FRY

	YEAR	0.0	0.30	0.10
CCTFT	1... 10	2.000E C6	1.869E 06	1.869E 06
	1... 20	2.000E C6	1.865E 06	1.865E 06
	1... 40	2.000E C6	1.865E 06	1.865E 06
	1... 80	2.000E C6	1.865E 06	1.865E 06
CCTFT	2... 10	6.794E C5	5.535E 05	5.935E 05
	2... 20	6.794E C5	5.513E C5	5.913E 05
	2... 40	6.794E C5	5.913E 05	5.913E 05
	2... 80	6.794E C5	5.513E 05	5.913E 05
OCFTT	3... 10	4.460E-C1	4.108E-C1	4.108E-01
	3... 20	4.460E-C1	4.099E-01	4.099E-01
	3... 40	4.460E-C1	4.099E-C1	4.099E-01
	3... 80	4.460E-C1	4.099E-01	4.099E-01
CCTFT	4... 10	7.118E 10	6.978E 10	6.978E 10
	4... 20	7.118E 10	6.980E 10	6.980E 10
	4... 40	7.118E 10	6.980E 10	6.980E 10
	4... 80	7.118E 10	6.980E 10	6.980E 10
OCFTT	5... 10	9.488E C5	8.154E C5	8.154E 05
	5... 20	9.488E C5	8.156E 05	8.156E 05
	5... 40	9.488E C5	8.156E C5	8.156E 05
	5... 80	9.488E C5	8.156E C5	8.156E 05
CCTFT	6... 10	4.032E C3	4.208E 03	4.308E 03
	6... 20	4.032E C3	4.659E C3	4.655E 03
	6... 40	4.032E C3	4.656E 03	4.656E 03
	6... 80	4.032E C3	4.656E C3	4.656E 03
OCFTT	7... 10	1.333E-C5	1.169E-C5	1.169E-05
	7... 20	1.333E-C5	1.168E-05	1.168E-05
	7... 40	1.333E-C5	1.168E-05	1.168E-05
	7... 80	1.333E-C5	1.168E-05	1.168E-05
CCTFT	8... 10	5.998E-C1	6.147E-01	6.147E-01
	8... 20	5.998E-C1	6.151E-C1	6.151E-01
	8... 40	5.998E-C1	6.151E-01	6.151E-01
	8... 80	5.998E-C1	6.151E-C1	6.151E-01
OCFTT	9... 10	3.991E-C1	4.333E-C1	4.333E-01
	9... 20	3.991E-C1	4.343E-01	4.343E-01
	9... 40	3.991E-C1	4.343E-01	4.343E-01
	9... 80	3.991E-C1	4.343E-01	4.343E-01
CCTFT	10... 10	6.009E-C1	5.667E-01	5.667E-01
	10... 20	6.009E-C1	5.657E-C1	5.657E-01
	10... 40	6.009E-C1	5.657E-01	5.657E-01
	10... 80	6.009E-C1	5.657E-C1	5.657E-01
OCFTT	11... 10	1.334E-C1	1.330E-C1	1.330E-01
	11... 20	1.334E-C1	1.330E-01	1.330E-01
	11... 40	1.334E-C1	1.330E-C1	1.330E-01
	11... 80	1.334E-C1	1.330E-01	1.330E-01
CCTFT	12... 10	1.000E-C1	9.866E-02	9.866E-02
	12... 20	1.000E-C1	9.864E-C2	9.864E-02
	12... 40	1.000E-C1	9.864E-02	9.864E-02
	12... 80	1.000E-C1	9.864E-C2	9.864E-02
OCFTT	13... 10	1.000E-C1	9.486E-C2	9.486E-02
	13... 20	1.000E-C1	9.485E-C2	9.485E-02
	13... 40	1.000E-C1	9.485E-C2	9.485E-02
	13... 80	1.000E-C1	9.485E-02	9.485E-02
CCTFT	14... 10	2.154E-C1	2.094E-01	2.094E-01
	14... 20	2.154E-C1	2.094E-C1	2.094E-01
	14... 40	2.154E-C1	2.094E-01	2.094E-01
	14... 80	2.154E-C1	2.094E-C1	2.094E-01
OCFTT	15... 10	2.154E-C1	2.118E-C1	2.118E-01
	15... 20	2.154E-C1	2.118E-01	2.118E-01
	15... 40	2.154E-C1	2.118E-C1	2.118E-01
	15... 80	2.154E-C1	2.118E-01	2.118E-01
CCTFT	16... 10	2.154E-C1	2.118E-01	2.118E-01
	16... 20	2.154E-C1	2.118E-C1	2.118E-01
	16... 40	2.154E-C1	2.118E-01	2.118E-01
	16... 80	2.154E-C1	2.118E-C1	2.118E-01
REI	1... 10	1.000E CC	9.344E-C1	9.344E-01
	1... 20	1.000E CC	9.327E-01	9.327E-01
	1... 40	1.000E CC	9.326E-C1	9.326E-01
	1... 80	1.000E CC	9.326E-01	9.326E-01
FEI	2... 10	1.000E CC	8.735E-01	8.735E-01
	2... 20	1.000E CC	8.703E-C1	8.703E-01
	2... 40	1.000E CC	8.703E-01	8.703E-01
	2... 80	1.000E CC	8.703E-C1	8.703E-01

Fig. 32. Example 2 - Summary table, set 2.

REL	3...	10	1.000E CC	9.211E-C1	9.211E-01
	3...	20	1.000E CC	9.191E-01	9.191E-01
	3...	40	1.000E CC	9.191E-01	9.191E-01
	3...	80	1.000E CC	9.191E-01	9.191E-01
DEI	4...	10	1.000E CC	9.002E-01	9.002E-01
	4...	20	1.000E CC	9.006E-01	9.006E-01
	4...	40	1.000E CC	9.006E-01	9.006E-01
	4...	80	1.000E CC	9.006E-01	9.006E-01
REI	5...	10	1.000E CC	8.593E-C1	8.593E-01
	5...	20	1.000E CC	8.596E-01	8.596E-01
	5...	40	1.000E CC	8.596E-01	8.596E-01
	5...	80	1.000E CC	8.596E-01	8.596E-01
EEL	6...	10	1.000E CC	1.068E 00	1.068E 00
	6...	20	1.000E CC	1.155E 00	1.155E 00
	6...	40	1.000E CC	1.155E 00	1.155E 00
	6...	80	1.000E CC	1.155E 00	1.155E 00
REL	7...	10	1.000E CC	1.012E 00	1.012E 00
	7...	20	1.000E CC	1.012E 00	1.012E 00
	7...	40	1.000E CC	1.012E 00	1.012E 00
	7...	80	1.000E CC	1.012E 00	1.012E 00
INEFACT	1...	10	1.000E 50	2.187E-C1	6.561E-01
	1...	20	1.000E 50	2.245E-C1	6.735E-01
	1...	40	1.000E 50	1.000E 50	1.000E 50
	1...	80	1.000E 50	1.000E 50	1.000E 50
INEFACT	2...	10	1.000E 50	4.216E-C1	1.265E 00
	2...	20	1.000E 50	4.323E-01	1.297E 00
	2...	40	1.000E 50	1.000E 50	1.000E 50
	2...	80	1.000E 50	1.000E 50	1.000E 50
INEFACT	3...	10	1.000E 50	2.628E-01	7.885E-01
	3...	20	1.000E 50	2.698E-01	8.054E-01
	3...	40	1.000E 50	1.000E 50	1.000E 50
	3...	80	1.000E 50	1.000E 50	1.000E 50
INEFACT	4...	10	1.000E 50	6.584E-C2	1.975E-01
	4...	20	1.000E 50	6.473E-C2	1.942E-01
	4...	40	1.000E 50	1.000E 50	1.000E 50
	4...	80	1.000E 50	1.000E 50	1.000E 50
INEFACT	5...	10	1.000E 50	4.689E-01	1.407E 00
	5...	20	1.000E 50	4.661E-01	1.404E 00
	5...	40	1.000E 50	1.000E 50	1.000E 50
	5...	80	1.000E 50	1.000E 50	1.000E 50
INEFACT	6...	10	1.000E 50	-2.278E-C1	-6.835E-01
	6...	20	1.000E 50	-5.181E-01	-1.554E 00
	6...	40	1.000E 50	1.000E 50	1.000E 50
	6...	80	1.000E 50	1.000E 50	1.000E 50
INEFACT	7...	10	1.000E 50	-4.012E-02	-1.204E-01
	7...	20	1.000E 50	-3.548E-C2	-1.184E-01
	7...	40	1.000E 50	1.000E 50	1.000E 50
	7...	80	1.000E 50	1.000E 50	1.000E 50
E/C	1...	10	1.000E CC	9.463E-C1	9.463E-01
	1...	20	1.000E CC	9.469E-01	9.469E-01
	1...	40	1.000E CC	9.469E-01	9.469E-01
	1...	80	1.000E CC	9.469E-01	9.469E-01
E/C	2...	10	C.0	0.0	0.0
	2...	20	C.0	1.403E-C3	1.403E-03
	2...	40	C.0	1.407E-03	1.407E-03
	2...	80	C.0	1.408E-C3	1.408E-03
E/C	3...	10	C.0	0.0	0.0
	3...	20	C.0	2.085E-04	2.085E-04
	3...	40	C.0	3.110E-05	3.110E-05
	3...	80	C.0	6.872E-07	6.872E-07
E/C	4...	10	C.0	0.0	0.0
	4...	20	C.0	9.302E-C4	9.302E-04
	4...	40	C.0	9.335E-04	9.335E-04
	4...	80	C.0	9.335E-04	9.335E-04
E/C	5...	10	C.0	0.0	0.0
	5...	20	C.0	1.383E-04	1.383E-04
	5...	40	C.0	2.063E-05	2.063E-05
	5...	80	C.0	4.557E-C7	4.557E-07
E/C	6...	10	C.0	0.0	0.0
	6...	20	C.0	7.709E-04	7.709E-04
	6...	40	C.0	7.733E-04	7.733E-04
	6...	80	C.0	7.730E-04	7.730E-04
E/C	7...	10	C.0	0.0	0.0
	7...	20	C.0	1.146E-04	1.146E-04
	7...	40	C.0	1.709E-05	1.709E-05
	7...	80	C.0	3.776E-07	3.776E-07
YES RELY IT .50	0		C	0	
YES RELN1 IT .50	0		0	0	
YES RELCTF LT .50	0		C	0	
INDEX OF RISK	C.0		0.0	0.0	

Fig. 33. Example 2 - Summary table, set 2 (cont.).

SET 2.0
RELATIVE YIELD VS. TIME

Fig. 34. Example 2 - Graph 1, set 2.

SET 2.0
RELATIVE TOTP VS. TIME

Fig. 35. Example 2 - Graph 2, set 2.

Following the DO section, a CP card calls for changes in the parameter values governing the compensatory mechanisms, namely the parameters FDMXO, FDIO, GA2, GA3, GA4, CA21, CA31, and CA41 (Fig. 23). The entire DO section is rerun (REDO command) using the values prescribed following the CP card (Figs. 24-27). These parameter values are designated as Set 2, to distinguish them from the original parameter values, Set 1. One can readily observe that additional compensation decreases the effect of the power plant impact on the population.

In the present example, both the RO and OUT cards have a value of 15 in columns 19-20 and 9-10, respectively, meaning that a summary table and graphs 1 and 2 are output. The summary table for Set 1 is given in Figs. 28-29, and graphs 1 and 2 in Figs. 30 and 31. The summary table for Set 2 is given in Figs. 32-33, and graphs 1 and 2 in Figs. 34 and 35.

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APPENDIX

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1 C
2 C.....MAIN PROGRAM FOR THE GENERAL LIFE CYCLE MODEL, 1977 VERSION.
3 C
4 C
5 C
6 C
7 C
8 C
9 REAL*8 VNAME
10 REAL*4 IMPACT
11 COMMON /BLOCKA/ OUTPT(20),IMPACT(20),REL(20)
12 COMMON /BLOCKL/ VNAME(256)
13 COMMON /BLOCKN/ N,NVARB,MVARB
14 COMMON /BLOCKY/ YIELD,FTP,CATCH(16),PPH(16),P(16),WT(17),JTR
15 COMMON /BLOCKV/ VARB(256)
16 COMMON /BLOCKP/ NPTS(9)
17 COMMON /DATA/ TRVAL(101,9,11), TEMP(101), NCHGS
18 LOGICAL TRUE,FALSE,PEDDBK, EGTABL
19 DATA TRUE,FALSE/,TRUE.,FALSE./, MR/16/
20 DIMENSION A(16,16),PN(16),PNO(16),EX(20),IOP(10),PNZ(16),IROW(9),
21          2 PSET(16),SAVP(256)
22 DIMENSION IDEL(9)
23 REAL*4 CMND(20) /'RDI','RDP','CP ','CI ','RI ','PP ','PI ',
24          8 'RO ','RC ','GT ','GC ','OUT','ITR','CN ',
25          P 'BEGN','DO','ENDO','REDO','TRA',' '/
26 EQUIVALENCE (PMO,VARB(16)),(PRI,VARB(32))
27          1 , (TOTP,VARB(36)), (RATIO,VARB(38))
28 CALL REREAD
29 C
30 C
31 C.....INITIALIZE VNAME, THE ARRAY OF PARAMETER NAMES.
32 C
33 C
34 CALL CALCMP
35 READ(5,50)(VNAME(I),I=1,256)
36 50 FORMAT ((10X,7(A5,5X)))
37 C
38 C
39 NPOWS = 0
40 NPLTS = 0
41 KOPLOT = 0
42 NCHGS = 0
43 IAT = 0
44 NEXT = 0
45 MUSDO = 0
46 IN=5
47 DO 80 I=1,20
48   IMPACT(I) = 0.
49   REL(I) = 0.
50   OUTPT(I) = 0.
51 80 CONTINUE
52 DO 100 I=1,6
53 100 IROW(I)=0
54   ISPT = 0
55   WRITE(11,6900)
56 6900 FORMAT(' --- JOB SUMMARY ---'/)
57 C
58 C
59 220 CONTINUE
60 C
61 C.....THIS IS THE COMMAND POINT, WHERE THE PROGRAM ENTERS THE COMMAND LOOP.
62 C
63 TAT = TAT+1
64 READ(IN,7000,END=2000) ENTRY,IOP
65 230 IF (IAT.EQ.NEXT) READ(5,7000,END=2000) ENTRY,IOP
66 IF (IAT.EQ.NEXT) NEXT=-NEXT
67 7000 FORMAT(A4,1X,10I5)
68 IF (ENTRY .NE. CMND(3) .AND. ENTRY .NE. CMND(3)) GO TO 231
69 WRITE(6,2999)
70 2999 FORMAT(1H1)
71 231 CONTINUE
72 WRITE(6,7020) ENTRY,IOP
73 7020 FORMAT('0COMMAND I1 I2 I3 I4 I5 I6 I7 I8 I9 I10',
74          1 /1X,A5,10I5)
75 CALL GETCMD(ENTRY,KMND,6260)
76 C
77 C
78 C
79 COMMAND IS RDI RDP CP CI RI PP PI RO RC GT GC OUT ITR CN
80 GO TO(300,300,300,300,300,300,300,500,555,675,675,1070,750,300
81          1 ,1660,1800,1800,1800,1800), KMND
82 COMMAND IS BEGN DO ENDO REDO TRA
83 C
84 C
85 C.....AN INVALID COMMAND WAS ENTERED IN THE DATA.
86 C
87 260 WRITE(6,270)
88 WRITE(11,270)
89 270 FORMAT('NOTE -- THE COMMAND FIELD ON THE ABOVE CARD',
90          1 ' DOES NOT CONTAIN A VALID COMMAND. IGNORE THE CARD.')

```

MAIN

```

91      GO TO 220
92      C
93      300 CONTINUE
94      C
95      C.....PROCESS INITIAL OR PARAMETER DATA.
96      C
97      CALL HITPRM(KMND,IOP,PN,PNO,PNZ,SAVP,IN,MR)
98      GO TO 220
99      500 CONTINUE
100     C
101     C
102     C.....RUN THE MODEL FROM THE YEAR ZERO.
103     C
104     C
105     IF (NCHGS.EQ.0.OR.IYRI.EQ.NYRS) GO TO 510
106     WRITE(6,7040) NCHGS
107     WRITE(11,7040) NCHGS
108     7040 FORMAT('WARNING: CASE NO.',I2,' IN THIS SET DISAGREES WITH',
109              1 ' THE BASE CASE IN NO. OF YEARS.')
110     510 CONTINUE
111     NYR = IOP(1)
112     IDETPR = IOP(2)
113     NCHGS = NCHGS+1
114     PSET(NCHGS) = FRY
115     IF (NROWS.EQ.0) CALL RDYRS(IOP(4),IROW,NROWS)
116     NPLTS = NPLTS + 1
117     NPTS(NPLTS) = 0
118     C
119     C
120     C.....INITIALIZE FOR RO RUN
121     C
122     IPOPN = MOD(IOP(10),10)
123     EGTABL = IOP(10)/10.NE.0
124     YR=0.0
125     IYRI=0
126     TOTP = 0.
127     YIELD=0.0
128     CALL RPLACE(PNO,PN,N)
129     GO TO 560
130     C
131     C
132     C.....RC COMMAND -- CONTINUE RUNNING FROM THE LAST STOP.
133     C
134     555 NYR = IOP(1)
135     IDETPR = IOP(2)
136     C
137     C.....NOW SUBTRACT OUT LAST YEAR DATA OF PREVIOUS RUN BEFORE ADDING
138     C      IN YEAR ZERO DATA OF RC RUN.
139     C
140     560 CONTINUE
141     FEEDBK=FALSE
142     CALL MAKMAT (A,FEEDBK,MR,PN,TOTP,EGTABL,ISET,IYRI)
143     CALL YLDCLC (PN,A,MR,N)
144     CALL YEARLY(IYRI,TOTP,PN,RCPOE,FRY)
145     DO 570 I=1,NROWS
146     IF (IYRI.NE.IROW(I)) GO TO 570
147     TCONNT = 2
148     IF (IYRI.EQ.IROW(NROWS)) ICOUNT = 1
149     615 IF ((IYRI.EQ.IROW(NROWS)) .AND. (ICOUNT.EQ.1)) GO TO 565
150     CALL PRETAB(I,OUTPT,IMPACT,REL)
151     565 GO TO 575
152     570 CONTINUE
153     575 CONTINUE
154     C
155     C
156     C.....DETERMINE PARAMETERS USED IN PLOTTING
157     C
158     C
159     IRES = ((NYR-1)/100) + 1
160     IPL = 0
161     CALL PLOTST(IPL,NST)
162     C
163     C
164     IF (IDETPR.EQ.0) WRITE(6,7100)
165     IF (IDETPR.EQ.0)
166     1 PRINT 595,YR,TOTP,FTP,YIELD,REL(1),REL(3),REL(2),IMPACT(2),
167     2 IMPACT(1),PN(2),RCPOE
168     7100 FORMAT('0 YEAR TOTP P YIELD REL TOTP
169     1 REL EPRT REL YIELD IMPACTY IMPACTP Y1
170     2RCPOE')
171     IF (NYR.EQ.0) GO TO 220
172     C
173     C
174     C.....BEGIN RUN LOOP.
175     C
176     C
177     DO 650 IYB=1,NYR
178     C
179     IYBI=IYRI+1
180     YR=IYRI

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MAIN

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181      CALL YBRUN (PN,A,HR,N,TEMP)
182      FEEDBK=TRUE
183      CALL HAKHAT (A,FEEDBK,HR,PN,TOTP,FALSE,ISET,IYRI)
184      CALL YLDCLC (PN,A,HR,N)
185      CALL YEARLY(IYRI,TOTP,PN,RCPU,PRY)
186      IF (IDETPR.EQ.0)
187      1 PRINT 595,YR,TOTP,FTP,YIELD,REL(1),REL(3),REL(2),IMPACT(2),
188      2 IMPACT(1),PN(2),RCPU
189      595 FORMAT(P8.0,1PE14.3,OPF10.4,2X,1P8E12.3)
190      IPL = IPL + 1
191      IF (((IPL/IRES)*IRES).EQ.IPL) CALL PLOTST(IPL,NST)
192      DO 605 I=1,NROWS
193      IF (IYRI.NE.IROW(I)) GO TO 605
194      CALL PRETAB(I,OUTPT,IMPACT,REL)
195      620 GO TO 650
196      605 CONTINUE
197      C
198      650 CONTINUE
199      C
200      C-----END RUN LOOP.
201      C
202      CALL PLTSV(NST,NPLTS)
203      IDEL(NPLTS) = IRES
204      IF (IOPN.EQ.0) CALL PVEC(PN,N,2)
205      IF (NCHGS.NE.1) GO TO 660
206      IF (ABS(PRY).GT.1E-5) WRITE(6,7280)
207      IF (ABS(PRY).GT.1E-5) WRITE(11,7280)
208      7280 FORMAT('O*** WARNING: PRY IS NOT EQUAL TO ZERO IN BASE CASE.')
209      NYRS = NYR
210      660 CONTINUE
211      GO TO 220
212      675 CONTINUE
213      C
214      GO TO 220
215      C
216      750 CONTINUE
217      C
218      C
219      C-----COMMAND 'ITR' BRINGS ONE HERE. THE STABLE POPULATION VECTOR AND
220      C PNSO ASSOCIATED WITH A GIVEN TARGET VALUE OF TOTP ARE CALCULATED.
221      C
222      TARGET = TOTP1*(1.+RATIO)/2.0
223      --THIS EQUATION IS EQUIV. TO TARGET=(TOTP1+TOTP2)/2.
224      PRINT 7310, TARGET
225      7310 FORMAT('O TARGET=',1PE10.3)
226      CALL ANALYT(TARGET,PNO,A,HR)
227      CALL PVEC(PNO,N,1)
228      GO TO 220
229      C
230      1070 CONTINUE
231      C
232      C
233      C-----COMMAND 'OUT' BRINGS ONE HERE. DATA IS OUTPUT.
234      C
235      IF (ISET.EQ.0) ISET=1
236      KOPLT = KOPLT + 1
237      IF (IOP(2).EQ.0) KOPLT=0
238      SET = ISET + .1*KOPLT
239      C
240      C-----PRINT SUMMARY TABLE
241      C
242      I1 = IOP(1)
243      IF (MOD(I1,2).NE.0) CALL TABLE(IROW,PSET,SET,NYRS)
244      1100 CONTINUE
245      C
246      C-----PRINT BENEFIT/COST ANALYSIS TABLE.
247      C
248      I1 = I1/2
249      IF (MOD(I1,2).NE.0) CALL BCTAB(PSET,SET,NYRS)
250      I1 = I1/2
251      IF (I1.EQ.0) GO TO 1550
252      C
253      C-----GENERATE GRAPHIC OUTPUT
254      C
255      IF (MOD(I1,2).NE.0) CALL PLT123(2,NPLTS,NPTS,IDEL,PSET,SET)
256      I1 = I1 / 2
257      IF (MOD(I1,2).NE.0) CALL PLT123(8,NPLTS,NPTS,IDEL,PSET,SET)
258      1550 CONTINUE
259      C
260      C-----REINITIALIZE GRAPH, PLOT PARAMETERS BEFORE READING NEXT CARD.
261      C
262      NPLTS = 0
263      NCHGS = 0
264      NROWS = 0
265      DO 1570 I=1,6
266      1570 IROW(I)=0
267      WRITE(11,7650) SET
268      7650 FORMAT(' OUTPUT COMPLETED, SET',F5.1)
269      GO TO 220
270      C

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MAIN

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271 C.....COMMAND 'BEGIN' BRINGS ONE HERE.. MOST RECENT PARAMETER OR POPULATION
272 C VALUES ARE RESTORED.
273 C
274 1660 CONTINUE
275 ISET = ISET+1
276 IF (IOP(3).GT.0) ISET=IOP(3)
277 KOPLOT=0
278 PRINT 7690, ISET,ISET
279 7690 FORMAT('1 ***** SET',I3,' *****'/
280 1 ' ***** SET',I3,' *****'//)
281 IF (IOP(1).NE.0) GO TO 1700
282 CALL RPLAC(PNZ,PH0,N)
283 PRINT 7700
284 7700 FORMAT(' REPLACE INITIAL POP''N VECTOR WITH MOST RECENT INPUT ',
285 1 ' VECTOR.')
286 1700 IF (IOP(2).NE.0) GO TO 1720
287 CALL RPLAC(SAVP,VARB,NVARB)
288 PRINT 7720
289 7720 FORMAT(' REPLACE PRESENT PARM SET WITH INPUT SET.')
290 1720 CONTINUE
291 GO TO 220
292 C
293 1800 CONTINUE
294 C
295 C.....PROCESS 'DO SECTION COMMANDS -- DO, ENDO, REPO, TRA.
296 C
297 KORD=KMND
298 CALL PROCDO(KMND,IOP,MUSDO,IN,IAT,NEXT,EX,ENTRY,82000)
299 C ... NONSTANDARD RETN WHEN HITTING END-OF-FILE
300 IF (KORD-19) 220,230,220
301 C
302 C.....TERMINATE EXECUTION
303 C
304 2000 CONTINUE
305 PRINT 9100
306 WRITE (11,9100)
307 9100 FORMAT('0 EXIT AT END-OF-FILE CARD')
308 C
309 C
310 C
311 C
312 RETURN
313 ENC

```

ANALYT

```

1      SUBROUTINE ANALYT(TOTP,PN,A,MR)
2      C
3      C
4      C-----THIS SUBROUTINE IS CALLED ONLY IF THE COMMAND 'ITR' IS USED. IT
5      C CALCULATES THE POPULATION VECTOR, PN, AND THE SURVIVAL FROM NATURAL
6      C MORTALITY THROUGH THE AGE CLASS ZERO, PNSO, ASSOCIATED WITH A TARGET
7      C VALUE OF TOTP, WHERE TOTP IS THE TOTAL FEMALE BIOMASS LEGALLY AVAILABLE
8      C TO THE FISHERY AT THE START OF THE CURRENT YEAR.
9      C
10     C
11     DOUBLE PRECISION Z,GAS,ZSS,CCAS,DELTS,XX,DAPS,EPS1
12     REAL*4 IMPACT,IYRCH
13     COMMON /BLOCKA/ OUTPT(20),IMPACT(20),REL(20)
14     COMMON /BLOCKV/ PHAT(15),PNH(16),PRY,PDI0,PDHX0,EPS,TOTP1,LEGAL
15     1      ,RATIO,B3,B4,B1,B2,ATHAX,PF(16),ACON,B,C,VULN(16)
16     2      ,IYRCH,CHGDI,CHGDD,DELT(6),DAP(6),ZS(6),CA(6,5)
17     3      ,GA(6),DAN(6),RFR(6),RJAGE,DURMY(108)
18     COMMON /BLOCKY/ YIELD,PTP,CATCH(16),PPH(16),F(16),WT(17),JYR
19     COMMON /BLOCKN/ N,NVARB,NVARB
20     COMMON /BLOCKS/ GAS(6),ZSS(6),CCAS(6),DELTS(6),XX(7),
21     1      DAPS(6)
22     DIMENSION CCA(6),X(7)
23     DIMENSION PN(1),RASH(16),A(MR,1),PNS(16)
24     LOGICAL EGTABLE
25     EGTABLE = .FALSE.
26     EPS1 = EPS
27     ITHAX = ATHAX
28     C
29     C
30     C
31     C-----MAKNAT IS CALLED TO CALCULATE FISH WEIGHTS, EGGS AND SURVIVALS, DATA
32     C WHICH IS NECESSARY TO CALCULATE THE DENSITY OF THE ZEROETH AGE CLASS,
33     C PN(1), FOR A GIVEN VALUE OF TOTP.
34     C
35     C
36     C
37     CALL MAKNAT(A,.FALSE.,MR,PN,TOTP,EGTABLE,-99,0)
38     C
39     C-----PNSO (=PNS(1)) IS CALCULATED ALONG WITH RATIOS OF SUCCESSIVE AGE CLASS
40     C DENSITIES CONSISTENT WITH A STEADY-STATE POPULATION.
41     C
42     RASH(1) = 1.0
43     SUM = 0
44     NM1 = N - 1
45     DO 50 I=2,NM1
46     RASH(I) = RASH(I-1) * EXP(-(PNH(I)+PPH(I)))
47     IF (I.NE. NM1) GO TO 49
48     RASH(I) = RASH(I) / (1.-EXP(-(PNH(I+1)+PPH(I+1))))
49     CONTINUE
50     SUM = SUM + P(I)*RASH(I)
51     C
52     C-----RASH(I) IS THE POPULATION RATIO PN(I+1)/PN(2)
53     C
54     50 CONTINUE
55     PNS(1) = 1.0/SUM
56     C
57     C-----ENO (=PN(1)) IS CALCULATED WHICH IS CONSISTENT WITH A TARGET VALUE
58     C OF TOTP.
59     C
60     SUM = 0.
61     DO 80 I=2,N
62     WATE = WT(I)
63     80 SUM = SUM + WATE*CATCH(I)*RASH(I)*VULN(I)
64     PRINT 300, TOTP
65     300 FORMAT(1H,'TOTP = ',1PE14.6)
66     PN(1) = TOTP/(PNS(1)*SUM)
67     X(1) = PN(1)
68     XX(1) = X(1)
69     C
70     C-----USING THE ABOVE RESULTS THE REMAINDER OF THE STEADY-STATE POPULATION
71     C VECTOR CAN BE COMPUTED.
72     C
73     DO 100 I=2,N
74     PN(I) = PN(1)*PNS(1)*RASH(I-1)
75     100 CONTINUE
76     PRINT 1000, PNS(1)
77     1000 FORMAT('ANALYTIC PNSO=',1PE12.4)
78     C
79     C-----CALCULATION OF INTRA-AGE GROUP DENSITY-DEPENDENT MORTALITY
80     C COEFFICIENTS
81     C
82     WRITE(6,2000)
83     2000 FORMAT('//,5X,'Y-O-Y PARAMETERS COMPUTED IN ANALYT',/)
84     ZS(1) = PNS(1) / (ZS(2)*ZS(3)*ZS(4)*ZS(5)*ZS(6))
85     DO 200 I=1,6
86     CCA(I) = 0.0
87     NM = 5
88     DO 150 J=1,NM
89     JP = J + 1
90     CCA(I) = CCA(I) + CA(I,J)*PN(JP)

```

ANALYT

```

91      150 CONTINUE
92      GAS(I) = GA(I)
93      ZSS(I) = ZS(I)
94      CCAS(I) = CCA(I)
95      DELTS(I) = DELT(I)
96      DAFS(I) = DAP(I)
97      DC = DAN(I) + CCA(I)
98      EX = EXP(-DC*DELT(I))
99      IF (DAN(I).EQ.0.0) GO TO 170
100     ZS(I) = DC*EX/(DC + GA(I)*X(I)*(1.-EX))
101     ZSS(I) = ZS(I)
102     X(I+1) = ZSS(I) * X(I)
103     XX(I+1) = X(I+1)
104     WRITE(6,2001) I,ZS(I)
105 2001  FORMAT(9X,'ZS(',I1,')',E15.8)
106     GO TO 190
107 170 CONTINUE
108     CALL SOLVE(Z,I,EPS1,ITMAX)
109     DAN(I) = Z
110 1750 X(I+1) = ZS(I) * X(I)
111     XX(I+1) = X(I+1)
112 171 CONTINUE
113     WRITE(6,2002) I,DAN(I)
114 2002  FORMAT(9X,'DAN(',I1,')',E15.8)
115     190 CONTINUE
116     200 CONTINUE
117     WRITE(6,2003)
118 2003  FORMAT(//)
119     RETURN
120     END

```


SOLVE

```

1      SUBROUTINE SOLVE(Z,I,EPS,ITMAX)
2      IMPLICIT REAL*8(A-H,O-Z)
3
4      C
5      C-----THIS SUBROUTINE IS CALLED BY SUBROUTINE ANALYT TO COMPUTE THE Y-O-Y
6      C      LINEAR NATURAL MORTALITY RATES BY USING NEWTON'S METHOD
7      C
8      C
9      C      EXTERNAL PP
10     DOUBLE PRECISION GAS,ZSS,CCAS,DELTS,XX,DAPS,ZX(500)
11     COMMON /BLOKNS/ GAS(6),ZSS(6),CCAS(6),DELTS(6),XX(7),
12     1      DAPS(6)
13
14     C
15     C      INITIALIZE Z0 FOR NEWTON'S METHOD.
16     C
17     C
18     CALL SCAN(Z0,I)
19     ZX(1) = Z0
20     PS = ZSS(I)
21     DC1 = CCAS(I)
22
23     C
24     C      BEGIN THE ITERATIONS.
25     C
26     C
27     DO 500 J=1,ITMAX
28     ITER = J
29     X = ZX(J)
30     FUNC = PP(X,I)
31     DC = ZX(J) + DC1
32     EX = DEXP(-DC*DELTS(I))
33     AN = DC * EX
34     DPUNC = PS + PS * GAS(I) * XX(I) * EX * DELTS(I)
35     1      -EX + AN * DELTS(I)
36     RATIO = FUNC / DPUNC
37     ZX(J+1) = ZX(J) - RATIO
38     Z = ZX(J+1)
39     IF ( DABS(RATIO/ZX(J+1)) -GT. EPS) GO TO 300
40     GO TO 700
41     300 IF ( ITER.EQ.ITMAX) GO TO 600
42     500 CONTINUE
43     600 PRINT 620, ITER
44     620 FORMAT (1H0,'NO CONVERGENCE IN',3X,I5,3X,'ITERATIONS'/)
45     GO TO 900
46     700 CONTINUE
47     900 CONTINUE
48     RETURN
49     END

```

```

1      SUBROUTINE SCAN(20,I)
2      IMPLICIT REAL*8(A-H,O-Z)
3
4      C
5      C-----THIS SUBROUTINE IS CALLED BY SUBROUTINE SOLVE TO PROVIDE INITIAL LOWER
6      C      AND UPPER BOUNDS ON THE Y-O-Y LINEAR NATURAL MORTALITY RATES
7      C
8      C
9      DOUBLE PRECISION GAS,ZSS,CCAS,DELTS,XX,DAPS
10     EXTERNAL PP
11     COMMON /BLOCKS/ GAS(6),ZSS(6),CCAS(6),DELTS(6),XX(7),DAPS(6)
12     A = CCAS(I) + .000001
13     B = 500.
14     XTOL = 1.E-2
15     CALL BISECT(PP,A,B,XTOL,IPLAG,I)
16     IF (IPLAG.GT.1) GO TO 200
17     ZO = (A+B)/2.
18     ERROR = DABS((A-B)/2.)
19     200 CONTINUE
20     RETURN
21     END

```

BISECT

```

1      SUBROUTINE BISECT(FP,A,B,XTOL,IFLAG,I)
2      IMPLICIT REAL*8(A-H,O-Z)
3
4      C
5      C-----THIS SUBROUTINE IS CALLED BY SUBROUTINE SCAN TO COMPUTE AN INITIAL
6      C      ESTIMATE OF THE Y-O-Y LINEAR NATURAL MORTALITY RATES
7      C
8      C
9      C      EXTERNAL FP
10     IFLAG = 0
11     N = -1
12     FA = FP(A,I)
13     FB = FP(B,I)
14
15     C
16     C-----CHECK FOR SIGN CHANGE.
17     C
18     C
19     IF (FA*FB .LE. 0.) GO TO 200
20     IFLAG = 2
21     PRINT 100, A, B
22     100 FORMAT (1H0,'FP(X) IS OF THE SAME SIGN AT THE TWO ENDPOINTS',
23     1 1PE13.6,3X,1PE13.6)
24     RETURN
25     200 CONTINUE
26     ERROR = DABS(B-A)
27     250 ERROR = ERROR/2.
28
29     C
30     C-----CHECK FOR SUFFICIENTLY SMALL INTERVAL.
31     C
32     C
33     IF (ERROR.LE.XTOL) RETURN
34     XM = (A+B)/2.
35
36     C
37     C-----CHECK FOR UNREASONABLE ERROR REQUIREMENT.
38     C
39     C
40     IF (XM+ERROR.EQ.XM) GO TO 1000
41     FM = FP(XM,I)
42     N = N+1
43
44     C
45     C-----CHANGE TO NEW INTERVAL.
46     C
47     C
48     IF (FA*FM.LE.0.) GO TO 500
49     A = XM
50     FA = FM
51     GO TO 250
52     500 B = XM
53     GO TO 250
54     1000 IFLAG = 1
55     RETURN
56     END

```

PP

```

1      DOUBLE PRECISION FUNCTION PF(X,I)
2      IMPLICIT REAL*8(A-H,O-Z)
3
4      C
5      C----- THIS FUNCTION IS CALLED BY SUBROUTINES SOLVE, SCAN AND BISECT. IT
6      C          CONTAINS THE PARTICULAR FUNCTION FOR WHICH THE ROOTS ARE BEING SOLVED.
7      C
8      C
9      DOUBLE PRECISION GAS,ZSS,CCAS,DELTS,XX,DAPS
10     COMMON /BLOKNS/ GAS(6),ZSS(6),CCAS(6),DELTS(6),XX(7),DAPS(6)
11     PS = ZSS(I)
12     DC = X + CCAS(I)
13     EX = DEXP(-DC*DELTS(I))
14     AN = DC*EX
15     DN = DC + GAS(I) * XX(I) * (1.-EX)
16     PF = PS * DN - AN
17     RETURN
18     END

```

GETCHD

```

1      SUBROUTINE GETCHD(ENTRY,KHND,*)
2      C
3      C
4      C-----THIS SUBROUTINE IS CALLED BY THE MAIN PROGRAM TO IDENTIFY A
5      C COMMAND (ENTRY). IF THE COMMAND IS IDENTIFIED, THE COMMAND
6      C NUMBER (KHND) IS RETURNED.
7      C
8      C
9      REAL*4 CMND(20) /'BDI','BDP','CP ','CI ','RI ','PP ','PI ',
10     8      'RO ','RC ','GT ','GC ','OUT','ITR','CH ',
11     F      'BEGN','DO','ENDO','REDO','TRA',' '/
12      DO 50 I=1,19
13      IF (ENTRY.EQ.CMND(I)) GO TO 70
14      50 CONTINUE
15      RETURN 1
16      70 KHND = I
17      IF (ENTRY .NE. CMND(3) .AND. ENTRY .NE. CMND(8)) GO TO 80
18      2000 FORMAT(1H1)
19      80 CONTINUE
20      RETURN
21      END

```

NAKHAT

```

1      SUBROUTINE NAKHAT (A,FEEDBK,NR,PN,TOTP,EGTABL,ISET,IYRI)
2      C
3      C
4      C-----THIS SUBROUTINE CALCULATES THE ELEMENTS, A(I,J), OF THE LESLIE POPULATION
5      C      MATRIX
6      C
7      C
8      REAL*4 IMPACT,IYRCH
9      COMMON /BLOCKA/ OUTPT(20),IMPACT(20),REL(20)
10     COMMON /BLOCKN/ N,NVARB,NVABB
11     COMMON /BLOCKY/ YIELD,PTP,CATCH(16),PFH(16),F(16),WT(17),JYR
12     COMMON /BLOCKV/ PHAT(15),FNM(16),PHY,FDO,FDMIO,EFS,TOTPI,LEGAL
13     1      ,RATIO,B3,B4,B1,B2,ATHAL,PF(16),ACON,B,C,VULN(16)
14     2      ,IYRCH,CHGDI,CHGDD,DELT(6),DAP(6),ZS(6),CA(6,5)
15     3      ,GA(6),DAN(6),RFR(6),RJAGE,DUNNY(108)
16     C
17     LOGICAL FEEDBK, EGTABL
18     REAL*4 NEGGS,LEGAL,LENGTH,LNGINH
19     DIMENSION A(NR,1),PN(1)
20     C
21     C-----'FEEDBK' IS FALSE WHEN THIS SUBROUTINE IS FIRST CALLED FROM THE MAIN
22     C      PROGRAM (YEAR = 0), SO NAKHAT CALCULATES THE INITIAL LESLIE MATRIX.
23     C      WHEN NAKHAT IS CALLED IN SUCCEEDING YEARS, 'FEEDBK' IS TRUE, SO AN
24     C      UPDATED LESLIE MATRIX REFLECTING THE EFFECTS OF DENSITY-DEPENDENCE, IS
25     C      CALCULATED. WHEN NAKHAT IS CALLED FROM SUBROUTINE ANALYT, FEEDBK IS
26     C      FALSE.
27     C
28     JAGE = RJAGE
29     IF (FEEDBK) GO TO 1000
30     C
31     C-----BELOW CATCH(J), WT(J), F(J) AND WTLEGL ARE CALCULATED, WHERE
32     C      CATCH(J) = FRACTION OF FISH IN YEAR CLASS J AVAILABLE TO FISHING
33     C      (LONGER THAN LEGAL MINIMUM)
34     C      WT(J) = AVERAGE WEIGHT OF A FISH IN AGE CLASS J
35     C      F(J) = AVERAGE FECUNDITY OF A FISH IN AGE CLASS J
36     C      WTLEGL = EFFECTIVE LEGAL MINIMUM WEIGHT
37     C
38     IF (EGTABL) PRINT 7000, ISET
39     7000 FORMAT(' ',30X,'VITAL STATISTICS - SET',I3/'0',
40     1 'AGE',3X,'LENGTH',5X,'WEIGHT',6X,'EGGS',8X,'FEMALE',6X,'PHAT',8X
41     2 ', 'FSUBI',7X,'CATCH',7X,'VULN',8X,'NAT. MORT')
42     NM1 = N-1
43     WT(1) = 0.0
44     LNGINH = 0.0
45     JYR = 0
46     IF (EGTABL) PRINT 7050, JYR,LNGINH,WT(1),WT(1),WT(1),WT(1)
47     DO 1 J=1,N
48     AGE=J
49     LENGTH=ACON*(B*AGE)*(C*(AGE**2))
50     CATCH(J) = 0.0
51     IF (LENGTH.LT.LEGAL) GO TO 70
52     CATCH(J) = 1.0
53     IF (LNGINH.GE.LEGAL) GO TO 70
54     C
55     C-----AGELEG IS CALCULATED FROM THE EQUATION FOR 'LENGTH' ABOVE. AGELEG
56     C      WILL GENERALLY BE A NON-INTEGER. WHEN DECOMPOSED INTO AN INTEGER, J,
57     C      PLUS A FRACTIONAL RESIDUE, THEN 1.-RESIDUE EQUALS THE PERCENTAGE OF
58     C      FISH IN AGE CLASS J AVAILABLE TO THE FISHERY. THE 'J-J' WAS ADDED
59     C      TO PREVENT OPT=2 FROM CALCULATING THE SQUARE ROOT OUTSIDE THE LOOP.
60     C
61     AGELEG = (-B + SQRT(J-J*B**2-4.*C*(ACON-LEGAL)))/(2.*C)
62     CATCH(J) = AGE - AGELEG
63     70 CONTINUE
64     IF (CATCH(J)*(CATCH(J)-1.) .NE. 0.) JYR=J
65     ALG10 = B3 + B4*ALOG10(LENGTH)
66     WT(J+1) = (10.0*ALG10)/453.6
67     IF (J.EQ.N) GO TO 1
68     EGGS = B1 + B2 * WT(J+1)
69     F(J) = PF(J)*PHAT(J)*EGGS
70     LNGINH = LENGTH
71     FNMCHD = 1. - EXP(-FNM(J))
72     7050 FORMAT (1H,I3,3I,1P9E12.3)
73     IF (EGTABL) PRINT 7050,J,LENGTH,WT(J+1),EGGS,PF(J),PHAT(J),F(J),
74     1 CATCH(J),VULN(J),FNMCHD
75     1 CONTINUE
76     IF (EGTABL) PRINT 7100, ACON,B,C,LEGAL,B3,B4,B1,B2
77     7100 FORMAT('OWITH THESE PARAMETERS-- ACON,B,C= ',F7.3,F7.2,F6.2,
78     1 'LEGAL,B3,B4=',F6.1,F6.2,F5.2/
79     2 '26X,B1,B2=',2E10.3//)
80     ALG10 = B3 + B4*ALOG10(LEGAL)
81     F(N)=F(NM1)
82     1000 CONTINUE
83     C
84     C-----COMPUTE THE NUMBER OF EGGS PRODUCED USING THE CALCULATED FECUNDITIES.
85     C
86     C
87     C-----WHEN SUBROUTINE ANALYT CALLS THIS SUBROUTINE WITH A GIVEN TARGET VALUE
88     C      OF TOTP, ISET=-99 SO THE NAKHAT CALCULATION OF TOTP BELOW IS SKIPPED.
89     C
90     IF (ISET.EQ.-99) GO TO 700

```

NAKNAT

```

91      C----- ISET=-99 WHEN ANALYT CALLS NAKNAT WITH A GIVEN TOTP.
92      NEGGS=0.0
93      DO 2 J=2,N
94      NEGGS = NEGGS + P(J-1)*PN(J)
95      2 CONTINUE
96      PN(1)=NEGGS
97      C
98      4 CONTINUE
99      TOTP=0.0
100     DO 6 IY=1,N
101     WATE = WT(IY)
102     TOTP=TOTP+PN(IY)*WATE*CATCH(IY)*VULN(IY)
103     6 CONTINUE
104     700 CONTINUE
105     C
106     C----- SUBROUTINE PPMCLC IS CALLED TO CALCULATE THE SURVIVAL FROM FISHING FOR
107     C AGE CLASS J
108     C
109     CALL PPMCLC(TOTP,IYRI)
110     IF(PFEDBK) GO TO 50
111     C
112     C----- BELOW THE INITIAL VALUES OF THE ELEMENTS OF THE LESLIE MATRIX ARE
113     C COMPUTED (YEAR = 0)
114     C
115     DO 20 J=1,N
116     A(1,J)=P(J)
117     DO 10 I=2,N
118     A(I,J)=0.0
119     10 CONTINUE
120     IF (J.LT.N) A(J+1,J)=EXP(-PNH(J))
121     IF ((J.GT.1).AND.(J.LT.N)) A(J+1,J)=EXP(-PNH(J))*A(J+1,J)
122     IF (J.LT.N) A(1,J) = A(1,J)*A(J+1,J)
123     IF (J.NE.JAGE) GO TO 21
124     OUTPT(8) = A(J+1,J)
125     21 CONTINUE
126     20 CONTINUE
127     A(N,N) = EXP(-(PNH(N)+PPH(N)))
128     A(1,N)=A(1,N)*A(N,N)
129     CALL YOYHRT(PH,PPX)
130     A(2,1) = PPX
131     A(1,1) = P(1) * PPX
132     RETURN
133     C
134     C----- BELOW THE VALUES OF THE ELEMENTS OF THE LESLIE MATRIX ARE CALCULATED
135     C FOR YEARS AFTER 0. THESE VALUES INCLUDE DENSITY-DEPENDENT FEEDBACK
136     C CALCULATED IN SUBROUTINES PSPCLC AND YOYHRT.
137     C
138     50 CONTINUE
139     CALL YOYHRT(PH,PPX)
140     A(2,1) = PPX
141     A(1,1) = PPX * P(1)
142     DO 60 J=2,NH1
143     A(J+1,J) = EXP(-(PNH(J)+PPH(J)))
144     A(1,J) = P(J)*A(J+1,J)
145     IF (J.NE.JAGE) GO TO 61
146     OUTPT(8) = A(J+1,J)
147     61 CONTINUE
148     60 CONTINUE
149     A(N,N) = EXP(-(PNH(N)+PPH(N)))
150     A(1,N)=P(N)*A(N,N)
151     RETURN
152     C
153     C
154     C
155     END

```

YOYHRT

```

1      SUBROUTINE YOYHRT(PN,PPX)
2      C
3      C----- THIS SUBROUTINE CALCULATES YOUNG-OF-THE-YEAR SURVIVAL USING A
4      C CHRISTENSEN-DEANGELIS-CLARK TYPE OF STOCK-RECRUITMENT FORMULA. THE
5      C YOUNG-OF-THE-YEAR ARE ASSUMED DIVIDED INTO SIX LIFE STAGES.
6      C
7      REAL*4 IMPACT,IYRCH
8      COMMON /BLOCKA/ OUTPT(20),IMPACT(20),REL(20)
9      COMMON /BLOCKN/ N,NVARB,NVARB
10     COMMON /BLOCKV/ PHAT(15),PNH(16),PRY,PDIO,PDHX0,EPS,TOTP1,LEGAL
11     1      ,RATIO,B3,B4,B1,B2,ATMAX,PF(16),ACON,B,C,VULN(16)
12     2      ,IYRCH,CHGDI,CHGDD,DELT(6),DAP(6),ZS(6),CA(6,5)
13     3      ,GA(6),DAN(6),RFR(6),RJAGE,DUNNY(108)
14     DIMENSION PN(1),CCA(6)
15     DIMENSION PR(6)
16     X = 1.0
17     Y = PN(1)
18     PPX = 1.0
19     XW = 1.
20     YW = PN(1)
21     PPIX = 1.
22     C
23     C
24     C COMPUTE DAP(I) .
25     C
26     C
27     DO 5 I=1,6
28     IF (DAP(I) .GT. 0.0) GO TO 31
29     5 CONTINUE
30     DO 10 I=1,6
31     PR(I) = RFR(I) * PRY
32     10 CONTINUE
33     DAP(1) = -ALOG(1.-PR(1))/DELT(1)
34     DO 30 I=2,6
35     I1 = I-1
36     SUM = 0.
37     DO 20 J=1,I1
38     SUM = SUM + DAP(J) * DELT(J)
39     20 CONTINUE
40     DAP(I) = -(ALOG(1.-PR(I)) + SUM) / DELT(I)
41     30 CONTINUE
42     31 CONTINUE
43     C
44     C----- THE DA(I)'S ARE DENSITY-INDEPENDENT Y-O-Y MORTALITIES FOR THE 6 LIFE
45     C STAGES. THE GA(I)'S ARE DENSITY-DEPENDENT MORTALITIES. THE CA(I)'S
46     C REPRESENT NEGATIVE EFFECTS FROM OLDER AGE CLASSES. THE DELT(I)'S ARE
47     C THE LENGTHS OF THE 6 LIFE STAGES.
48     C
49     DO 100 I=1,6
50     CCA(I) = 0.0
51     NM = 5
52     DO 50 J=1,NM
53     JP = J + 1
54     CCA(I) = CCA(I) + CA(I,J)*PN(JP)
55     50 CONTINUE
56     DC = DAP(I) + DAN(I) + CCA(I)
57     DCW = DAN(I) + CCA(I)
58     EX = EXP(-DC*DELT(I))
59     EXW = EXP(-DCW*DELT(I))
60     IF ((DC+GA(I)*Y*(1.-EX)).EQ.0.) GO TO 80
61     X = DC*EX/(DC+GA(I)*Y*(1.-EX))
62     XW = DCW*EXW/(DCW+GA(I)*YW*(1.-EXW))
63     OUTPT(10+I) = X
64     Y = X*Y
65     YW = XW*YW
66     GO TO 90
67     80 X = 0.
68     90 CONTINUE
69     PPIX = X*PPIX
70     100 CONTINUE
71     OUTPT(7) = PPIX
72     RETURN
73     END

```


PFHCLC

```

1      SUBROUTINE PFHCLC(TOTP,IYRI)
2      C
3      C
4      C-----THIS SUBROUTINE IS CALLED FROM MAKHAT. IT CALCULATES AGE-SPECIFIC
5      C SURVIVAL FROM FISHING FOR TWO DIFFERENT FISHING MORTALITY FUNCTIONS.
6      C THE COMPUTED SURVIVALS ARE USED TO UPDATE THE LESLIE MATRIX.
7      C SURVIVAL FROM FISHING IS DENSITY-DEPENDENT BECAUSE IT IS A FUNCTION OF
8      C TOTP, THE CURRENT BIOMASS AVAILABLE TO FISHING.
9      C CALLED FROM MAKHAT.
10     C
11     C
12     REAL*4 IMPACT,IYRCH
13     COMMON /BLOCKA/ OUTPT(20),IMPACT(20),REL(20)
14     COMMON /BLOCKY/ YIELD,FTP,CATCH(16),PFH(16),P(16),WT(17),JYR
15     COMMON /BLOCKN/ N,NVARB,HVARB
16     COMMON /BLOCKV/ PHAT(15),FPH(16),PRY,PDIO,PDHXO,EPS,TOTP1,LEGAL
17     1      ,RATIO,B3,B4,B1,B2,ATMAX,PP(16),ACON,B,C,VULN(16)
18     2      ,IYRCH,CHGDI,CHGDD,DELT(6),DAP(6),ZS(6),CA(6,5)
19     3      ,GA(6),DAN(6),RFR(6),RJAGE,DUNNY(108)
20     IF (IYRI.NE.0) GO TO 20
21     IYRCH = IYRCH + 0.01
22     20 IF (IYRI.GT.IYRCH.AND.IYRCH.GT.0) GO TO 100
23     PDHX = PDHXO
24     FDI = PDIO
25     C
26     C-----IF THERE IS NO PERIOD DURING WHICH FISHING INTENSITY CHANGES
27     C (I.E., IYRCH=0.0), DO NOT CHANGE VALUES
28     C
29     IF (IYRCH.EQ.0) GO TO 100
30     IF (IYRI.NE.0) GO TO 60
31     C ... ONE TIME CALCS FOR MOVING FISHING FN.
32     STEPDD = CHGDD * PDHXO / IYRCH
33     STEPDI = CHGDI * PDIO / IYRCH
34     ENDD = PDHXO * (1.-CHGDD)
35     ENDDI = PDIO * (1.-CHGDI)
36     WRITE (6,7000) PDHXO,ENDD,STEPDD
37     WRITE (6,7010) PDIO,ENDDI,STEPDI
38     7000 FORMAT (T10,'PDHXO CHANGES FROM',F6.3,' TO',
39     1      F6.3,' IN STEPS OF',F7.4)
40     7010 FORMAT (T10,'PDIO CHANGES FROM',F6.3,' TO',
41     1      F6.3,' IN STEPS OF',F7.4)
42     60 PDDHX = PDHXO - IYRI * STEPDD
43     FDI = PDIO - IYRI * STEPDI
44     100 CONTINUE
45     C
46     C-----PIECEWISE LINEAR FISHING MORTALITY FUNCTION
47     C
48     TOTP2 = RATIO * TOTP1
49     IF (TOTP.LT.TOTP1) PDD = 0.
50     IF (TOTP.GT.TOTP2) PDD = PDDHX
51     IF (TOTP.GE.TOTP1.AND.TOTP.LE.TOTP2)
52     1 PDD = (TOTP-TOTP1) * PDDHX / (TOTP2-TOTP1)
53     PTE = FDI + PDD
54     OUTPT(9) = FDI/FTP
55     OUTPT(10) = (FTP-PDI) / FTP
56     300 CONTINUE
57     DO 350 J=1,N
58     PPH(J) = VULN(J) * CATCH(J) * FTP
59     350 CONTINUE
60     RETURN
61     END

```

NITPRM

```

1      SUBROUTINE NITPRM(KMND,IOP,PN,PNO,PHZ,SAVP,IN,HR)
2
3      C
4      C-----THIS SUBROUTINE PROCESSES ALL COMMANDS DEALING WITH INITIAL POPULATION
5      C      VALUES OR PARAMETER DATA.
6      C
7      C
8      REAL*8 ANAM, VNAME
9      COMMON /BLOCKL/ VNAME(256)
10     COMMON /BLOCKN/ N,NVAB,VARB
11     COMMON /BLOCKV/ VARB(256)
12     DIMENSION IOP(10), PNO(16), PHZ(16), SAVP(60), ANAM(4), AVAL(4)
13     1      ,PH(16)
14
15     C
16     EQUIVALENCE (B1,VARB(41)), (B2,VARB(42))
17
18     C
19     IF (KMND.EQ.14) GO TO 1600
20     GO TO (140,170,400,430,445,460,480), KMND
21     C CONMANC: RDI RDP CP CI RI PP PI
22     C
23     C-----READ INITIAL VALUES
24     C
25     140 CONTINUE
26     N=IOP(1)
27     READ(IN,160) (PNO(IY),IY=1,N)
28     160 FORMAT(8G10.0)
29     CALL RPLAC(PNO,PHZ,N)
30     IF (N.EQ.NB) GO TO 168
31     IDUM = N+1
32     DO 167 I=IDUM,HR
33     PHZ(I) = 0
34     167 PNO(I) = 0
35     168 RETURN
36
37     C
38     C-----READ AND LOAD ADJUSTABLE PARAMETERS
39     C
40     170 CONTINUE
41     NREAD = ICP(1)
42     175 CONTINUE
43
44     C
45     C-----READ AND LOAD CHANGED PARAMETERS
46     C
47     IER = 0
48     KDS = (NREAD+3)/4
49     DO 200 I=1,KDS
50     READ(IN,180) (ANAM(K),AVAL(K),K=1,4)
51     180 FORMAT(4(A5,F10.0,5X))
52     DO 190 J=1,4
53     NUM = 4*(I-1) + J
54     CALL FINDNP(ANAM(J),NP)
55     IF (NP.GT.0) GO TO 187
56     IF (NUM.GT.NREAD) GO TO 210
57     WRITE(6,6950) ANAM(J)
58     WRITE(11,6950) ANAM(J)
59     6950 FORMAT('WARNING: THE FOLLOWING CHARACTERS DO NOT',
60     1      ' FORM A VALID PARAMETER NAME: ',A5,'. PROCESS REST',
61     2      ' . WHEN NEXT.')
62     IER = 1
63     GO TO 190
64     187 CONTINUE
65     VARB(NP) = AVAL(J)
66     IF (KMND.EQ.3) WRITE(6,475) VNAME(NP),VARB(NP)
67     190 CONTINUE
68     200 CONTINUE
69     210 CONTINUE
70     IF (IER.EQ.1) STOP
71     IF (KMND.EQ.2) CALL RPLAC(VARB,SAVP,NVARB)
72     RETURN
73
74     C
75     400 CONTINUE
76
77     C
78     C-----CHANGE SOME OF THE PARAMETERS
79     C
80     WRITE(6,405)
81     405 FORMAT('***** NOTE *****')
82     NREAD = IOP(1)
83     WRITE(6,410) NREAD
84     410 FORMAT('0',I4,' CHANGED PARAMETER(S)---')
85     GO TO 175
86
87     C
88     430 CONTINUE
89
90     C
91     C-----CHANGE AN ELEMENT OF THE INITIAL VECTOR
92     C
93     NREAD = IOP(1)
94     READ(5,440) (J,PNO(J),I=1,NREAD)
95     440 FORMAT(4(I5,E10.0,5X))
96     RETURN
97
98     C
99     445 CONTINUE
100    C

```

NITPRM

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91      C.....REPLACE THE INITIAL VECTOR WITH THE CURRENT SOLUTION VECTOR
92      C
93          CALL RPLACE(PN,PNO,N)
94          IF (IOP(1).NE.0) CALL RPLACE(PNZ,PNO,N)
95          RETURN
96      C
97      460 CONTINUE
98      C
99      C.....PRINT OUT THE ENTIRE SET OF ADJUSTABLE PARAMETERS
100     C
101         WRITE (6,465)
102     465  FORMAT (1H0,'LIST OF ADJUSTABLE PARAMETERS',//)
103         NK = NVARB / 5
104         DO 470 I=1,NK
105             J1 = 5 * (I-1) + 1
106             J2 = 5 * I
107             WRITE (6,475) (VNAME(J),VARB(J), J=J1,J2)
108     470  CONTINUE
109         NV1 = 5 * NK + 1
110         WRITE (6,475) (VNAME(I),VARB(I),I=NV1,NVARB)
111     475  FORMAT (' ',5(A5,1PE13.4,6X))
112         RETURN
113     480  CONTINUE
114     C
115     C.....PRINT THE INITIAL VECTOR
116     C
117         CALL PVEC(PNO,N,1)
118         RETURN
119     C
120     C
121     1600 CONTINUE
122     C
123     C.....'CN', COMMAND.14 -- CHANGE N, THE NUMBER OF AGE CLASSES
124     C
125         N = IOP(1)
126         IF (N.LE.16.AND.N.GE.2) RETURN
127         PRINT 7680, N
128     7680  FORMAT('0THE NUMBER OF AGE CLASSES,'I3,', IS OUT OF RANGE. EXIT')
129         STCF
130         END

```

FINDNP

```

1      SUBROUTINE FINDNP (PARAM,NP)
2      C
3      C----- A SUBROUTINE FOR FINDING THE POSITION NP IN THE
4      C          PARAMETER ARRAY WHICH CORRESPONDS TO THE NAME IN
5      C          PARAM. RETURNS NP=-1 IF NAME IN PARAM DOES
6      C          NOT MATCH ONE OF THE PARAMETER NAMES.
7      C
8      REAL*8 VNAME,PARAM
9      COMMON /BLOCKN/N,NVARB,NVARB
10     COMMON /BLOCKL/ VNAME(256)
11     DO 20 IV=1,NVARB
12     NP=IV
13     IF (PARAM.EQ.VNAME(IV)) GO TO 30
14     20 CONTINUE
15     NP=-1
16     30 RETURN
17     END

```

PLT123

```

1      SUBROUTINE PLOTST(IPL,NST)
2      COMMON /BLOCKP/ NPTS(9)
3      IF (IPL.EQ.0) NST = 0
4      NST = NST + 1
5      RETURN
6
7      C
8      C      ENTRY PLTSV(NST,NPLTS)
9      C
10     C
11     IF (NPTS(NPLTS).EQ.0) ISEG = 0
12     ISEG = ISEG + 1
13     IPREV = NPTS(NPLTS) - 1
14     IF (ISEG.EQ.1) IPREV = 0
15     NPTS(NPLTS) = IPREV + NST
16     RETURN
17     END

```

PROCDO

```

1      SUBROUTINE PLT123 (IGPH,NPLTSI,NPTSI,IYRS,PSET,SET)
2      C
3      C
4      C-----THIS SUBROUTINE GENERATES PLOTS OF RELATIVE TOTP VS. TIME
5      C      AND RELATIVE YIELD VS. TIME.
6      C
7      C
8      COMMON /DATA/ YRVAL(101,9,11),TEMP(101),NCHGS
9      DIMENSION VAL(101),PSET(16),ABSI(16),IPAK(120)
10     DIMENSION IYRS(9),NPTSI(9)
11     C
12     C
13     C-----INITIALIZE VALUES NEEDED FOR PLOTTING.
14     C
15     C
16     XLONG = 5.0
17     YLCNG = 7.5
18     DO 200 I=1,NPLTSI
19     ABSI(I) = PSET(I)
20     200 CONTINUE
21     MAX = 0
22     DO 250 I=1,NPLTSI
23     IDUM = NPTSI(I)
24     MAX = MAX0(MAX,IDUM)
25     250 CONTINUE
26     MAX = (MAX-1) / 5
27     INARK = MAX / 2
28     C
29     C
30     C-----BEGIN PLOTTING.
31     C
32     C
33     CALL BGNPL(1)
34     IF (IGPH.EQ.2)
35     1CALL TITLE ('RELATIVE YIELD VS. TIMES',100,'TIME, YEARS$',100,
36     2'RELATIVE YIELDS',100,XLONG,YLONG)
37     IF (IGPH.EQ.4)
38     1CALL TITLE ('RELATIVE TOTP VS. TIMES',100,'TIME, YEARS$',100,
39     2'RELATIVE TOTPS',100,XLONG,YLONG)
40     CALL GRAPH(0,MAX,0.5,0.125)
41     CALL GRID(2,2)
42     DO 600 I=1,NPLTSI
43     IDUM = NPTSI(I)
44     DO 300 K = 1, IDUM
45     VAL(K) = YRVAL(K,I,IGPH) / YRVAL(1,1,IGPH)
46     300 CONTINUE
47     CALL MARKER(I)
48     DO 400 L=1,IDUM
49     TEMP(L) = (L-1) * IYRS(I)
50     400 CONTINUE
51     CALL CURVE(TEMP,VAL,IDUM,INARK)
52     CALL RESET('MARKER')
53     600 CONTINUE
54     CALL MESSAG('SET',3,2.,8.25)
55     CALL REALNO(SET,1,2.55,8.25)
56     CALL HEIGHT(0.1)
57     IDUM = LINEST(IPAK,120,2)
58     DO 650 I=1,NPLTSI
59     CALL LINES(' $',IPAK,I)
60     650 CONTINUE
61     CALL LEGEND(IPAK,NPLTSI,5.25,4.0)
62     DO 700 I=1,NPLTSI
63     J = NPLTSI - I + 1
64     ADD = 4. + (I-1) * .12
65     CALL REALNO(ABSI(J),2,5.9,ADD)
66     700 CONTINUE
67     CALL MESSAG('PRY',3,5.9,ADD*.12)
68     CALL ENDPL(1)
69     PRINT 1000, IGPH,NPLTSI
70     1000 FORMAT ('ODISSPLA',I2,' COMPLETED -- CONTAINS',I2,' CASES')
71     C
72     C
73     C
74     C-----END OF PLOTTING.
75     C
76     RETURN
77     END

```

RPLAC

```

1      SUBROUTINE PROCDO(KMND,IOP,MUSDO,IN,IAT,NEXT,EX,ENTRY,*)
2      DIMENSION IOP(10), EX(20)
3
4      C
5      C-----THIS SUBROUTINE PROCESSES 'DO' COMMANDS -- DO,ENDO,REDO,TRA
6      C
7      C
8      KOM = KMND-15
9      GO TO (1800,1880,1920,2060), KOM
10     C COMMAND: DO ENDO REDO TRA
11     C
12     C
13     C-----'DC' -- DO AND SAVE THE FOLLOWING CARDS UNTIL THE 'ENDO' CARD
14     C
15     1800 CONTINUE
16         REWIND 10
17         MUSDO = 0
18         PRINT 7730
19     7730 FORMAT('OCOMMAND NO. ')
20         DO 1820 J=1,200
21         READ(5,7732,END=2990) EX
22         PRINT 7735,EX
23     7732 FORMAT(20A4)
24     7735 FORMAT(15X,20A4)
25         WRITE(10,7740) EX
26     7740 FORMAT(20A4)
27         CALL GETCHD(EX(1),KMND,81820)
28         MUSDO = MUSDO + 1
29         PRINT 7750, MUSDO
30     7750 FORMAT('+',I6)
31         IF(KMND.EQ.17) GO TO 1840
32     1820 CONTINUE
33     1840 CONTINUE
34         PRINT 7760, MUSDO
35     7760 FORMAT('ODO SECTION IS SAVED. ',I3,' RECOGNIZABLE COMMANDS.')
36         IN = 10
37         IAT = 0
38         REWIND 10
39         RETURN
40     C
41     C-----'ENDO', COMMAND 17 -- SIGNIFIES THE END OF A DO SECTION
42     C
43     1880 CONTINUE
44         IN = 5
45         PRINT 7780
46     7780 FORMAT(' END PROCESSING DO SECTION')
47         IF(NEXT.LE.0) GO TO 1900
48         PRINT 7770
49         WRITE(11,7770)
50     7770 FORMAT('OFOLLOWING CARD TO MODIFY DO SECTION WAS NEVER READ. '
51             ' ,READ NOW WITHOUT EXECUTING.')
52         READ(5,7732,END=3000) EX
53         PRINT 7735,EX
54         WRITE(11,7735) EX
55     1900 CONTINUE
56         NEXT = 0
57         RETURN
58     C
59     C-----'REDO', COMMAND 18 -- REEXECUTE A DO SECTION
60     C
61     1920 CONTINUE
62         IF(MUSDO.EQ.0) GO TO 1940
63         IN = 10
64         IAT = 0
65         NEXT = IOP(2)
66         REWIND 10
67         RETURN
68     1940 PRINT 7790
69     7790 FORMAT('OCANNOT EXECUTE REDO BECAUSE NO DO SECTION EXISTS.',
70             ' 1 ' IGNORE REDO COMMAND.')
71         RETURN
72     C
73     C-----'TRA', COMMAND 19 -- TRANSFER OVER SEVERAL INSTRUCTIONS
74     C         TRANSFER DOWN 'IOP(1)' INSTRUCTIONS.
75     C
76     2060 CONTINUE
77         J = IOP(1)
78         IF(J.EQ.0) J=1
79         DO 2080 I=1,J
80     2070 READ(IN,7732,END=3000) EX
81         PRINT 7735,EX
82         CALL GETCHD(EX(1),KMND,82070)
83         IF(KMND.EQ.17) GO TO 2090
84     2080 CONTINUE
85     2090 READ(99,7000) ENTRY,IOP
86     7000 FORMAT(A4,IY,10I5)
87         IAT = IAT+J
88         RETURN
89     C
90     C-----ENCOUNTERED END-OF-FILE CARD

```

RPLACE

91
92
93
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97

```
C
2990 PRINT 9000
9000 FORMAT('END OF FILE ENCOUNTERED WHILE PROCESSING DO SECTION.',
1      ' EXIT.')
3000 CONTINUE
      RETURN 1
      END
```


TABLE

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1      SUBROUTINE RPLACE(PH,PNO,N)
2      C
3      C
4      C.....THIS SUBROUTINE IS CALLED WHEN THE MAIN PROGRAM IS PROCESSING RO
5      C      CARDS.
6      C
7      C
8      DIMENSION PH(N),PNO(N)
9      DO 100 I=1,N
10     PNO(I) = PH(I)
11     RETURN
12     C
13     C
14     ENTRY RDIYS(INTRY,IROW,NROWS)
15     C
16     C
17     DIMENSION INTRY(1) , IROW(1)
18     NROWS = 0
19     DO 200 I=1,6
20     IF (INTRY(I).EQ.0) GO TO 210
21     IROW(I)=INTRY(I)
22     NROWS = I
23     200 CONTINUE
24     210 RETURN
25     C
26     C
27     C
28     ENTRY PVEC(VEC,N,K)
29     C
30     C
31     DIMENSION VEC(N)
32     IF (K.EQ.1) PRINT 3800
33     IF (K.EQ.2) PRINT 3900
34     DO 490 I=1,N
35     IYC = I-1
36     PRINT 4000, IYC,VEC(I)
37     490 CONTINUE
38     3800 FORMAT(1H0,'YEAR CLASS    INITIAL VECTOR'//)
39     3900 FORMAT(1H0,'YEAR CLASS    FINAL VECTOR'//)
40     4000 FORMAT(1H ,3X,I3,7X,1PE12.5)
41     RETURN
42     END

```

YEARLY

```

1      SUBROUTINE TABLE(IROW,PSET,SET,NYRS)
2      COMMON /DATA/ YRVAL(101,9,11), TEXP(101), NCHGS
3
4      C----- THIS SUBROUTINE PRINTS A TABLE: PARAMETRIC ANALYSIS OF CALCULATED
5      C      VARIABLES FOR SEVERAL VALUES OF AN ADJUSTABLE PARAMETER, E.G., PRY
6      C
7      C      --- ARRAY(I1,I2,I3) CONTAINS THE CALCULATED TABLE OUTPUT:
8      C          I1      : ROW SUBSCRIPT, YEAR NO.
9      C          I2      : COLUMN SUBSCRIPT, FOR DIFF'NT VALS OF ADJ PARM
10     C          I3: SELECTS OUTPUT VARIABLE
11     C
12     C      DIMENSION ARRAY(6,9,54), COLHD(9), IROW(1), PSET(16), LES(3,9), RISK(9)
13     C      DIMENSION BC(6,9,7)
14     C      DIMENSION BCSDIP(4)
15     C      REAL*8 OUTNAM(4) /'OUTPT','REL','IMPACT','B/C'/
16     C      2      ,HEAD(4) / 'YRS BELT','D LT ','YRS RELH','1 LT '/
17     C      3      ,PER*4/.50/, CASE/'CASE'/, DIFF/'DIFF'/
18     C      EQUIVALENCE (NCOLS,NCHGS)
19
20     C
21     C      PER = .75
22     C      PER = .50
23     C      SI = .1
24
25     C
26     C      NTYPES = 4
27     C      NOUT = 16
28     C      NREL = 7
29
30     C
31     C      NOUT1 = NOUT + 1
32     C      NOUT2 = NOUT + NREL
33     C      NYRSP1 = NYRS+1
34     C      LIF = 9
35
36     C
37     C      DO 20 I=1,NCHGS
38     C          COLHD(I) = PSET(I)
39     C      20 CONTINUE
40     C      DO 50 I=1,NROWS
41     C          DO 50 J=1,NCOLS
42     C              BC(I,J,1) = ARRAY(I,J,18) / ARRAY(I,J,19)
43     C              BC(I,J,2) = ARRAY(I,J,9) * (ARRAY(I,J,18)-ARRAY(I,J,18))
44     C              BC(I,J,3) = BC(I,J,2) / (1.0+SI)**IROW(I)
45     C              BC(I,J,4) = ARRAY(I,J,3) - ARRAY(I,J,3)
46     C              BC(I,J,5) = BC(I,J,4) / (1.0+SI)**IROW(I)
47     C              BC(I,J,6) = ARRAY(I,J,10) * (BC(I,J,1)-BC(I,J,1))
48     C              BC(I,J,7) = BC(I,J,6) / (1.0+SI)**IROW(I)
49     C      50 CONTINUE
50     C      WRITE(LIP,55) SET
51     C      55 FORMAT('1',40X,'SET',P5.1/'0',18X,'FRACTIONAL CHANGE IN SURVIVAL'
52     C      1      , ' PROBABILITY FOR AGE CLASS 0, PRY')
53     C      WRITE(LIP,60) COLHD(I),I=1,NCOLS
54     C      60 FORMAT('0',21X,9(P5.2,7X))
55     C      WRITE(LIP,65)
56     C      65 FORMAT(11X,'YRAN')
57     C      DO 100 KK=1,NOUT
58     C          WRITE(LIP,70) OUTNAM(1)
59     C          70 FORMAT(' ',A8)
60     C          DO 100 I=1,NROWS
61     C              WRITE(LIP,80) KK,IROW(I), (ARRAY(I,J,KK),J=1,NCOLS)
62     C          80 FORMAT('+',I11,'...',I3,1P9E12.3)
63     C      100 WRITE(LIP,85)
64     C      85 FORMAT(' ')
65     C          DO 110 K=2,NTYPES
66     C              DO 110 KK=1,NREL
67     C                  WRITE(LIP,70) OUTNAM(K)
68     C                  DO 110 I=1,NROWS
69     C                      IF (K.EQ.4) GO TO 105
70     C                      WRITE(LIP,80) KK,IROW(I), (ARRAY(I,J,KK+(K-2)*NREL+NOUT),
71     C                      1      J=1,NCOLS)
72     C          GO TO 107
73     C      105 CONTINUE
74     C      WRITE(LIP,80) KK,IROW(I), (BC(I,J,KK),J=1,NCOLS)
75     C      107 CONTINUE
76     C      110 WRITE(LIP,85)
77     C          DO 120 J=1,3
78     C              DO 120 K=1,NCOLS
79     C                  LES(J,K) = 0
80     C                  DO 120 IYB=1,NYRSP1
81     C                      IF (YRVAL(IYR,K,J+1).LT.PER*YRVAL(IYB,1,J+1)) LES(J,K)=LES(J,K)+1
82     C      120 CONTINUE
83     C          DO 140 K=1,NCOLS
84     C              RISK(K) = 0.
85     C              DO 140 IYB=1,NYRSP1
86     C                  THE = PER - YRVAL(IYR,K,4)/YRVAL(IYB,1,4)
87     C          140 IF (THE.GT.0.) RISK(K) = RISK(K)+THE
88     C          WRITE(LIP,6100) HEAD(1),HEAD(2), PER, (LES(1,J),J=1,NCOLS)
89     C          WRITE(LIP,6100) HEAD(3),HEAD(4), PER, (LES(2,J),J=1,NCOLS)
90     C          WRITE(LIP,6150) PER, (LES(3,J),J=1,NCOLS)

```

YEARLY

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91      6100 FORMAT('0',A8,A5,F3.2,9(I7,5X))
92      6150 FORMAT('0YRS RELTOT LT ',F3.2,I5,8(5X,I7))
93      WRITE(LTP,6200) (RTSK(K),K=1,NCOLS)
94      6200 FORMAT('0INDEX OF RISK',9F12.2)
95      RETURN
96
97      C
98      C
99      ENTRY PRETAB(IS,OUTPT,IMPACT,REL)
100
101      C
102      C.....PRETAB STORES VARIABLES FOR LATER PRINTING IN SUMMARY TABLE.
103      C
104      REAL*4 OUTPT(20),IMPACT(20),REL(20)
105      DO 220 I=1,16
106      ARAY(IS,NCOLS,I) = OUTPT(I)
107      220 CONTINUE
108      DO 230 I=1,7
109      ARAY(IS,NCOLS,16+I) = REL(I)
110      ARAY(IS,NCOLS,23+I) = IMPACT(I)
111      230 CONTINUE
112      NROWS = IS
113      RETURN
114
115      C
116      C
117      C
118      C
119      C
120      NYRSP1 = NYRS+1
121      IGC = 9
122      DO 250 I=1,NCHGS
123      COLHD(I) = PSET(I)
124      250 CONTINUE
125      WRITE (IGO,6600) SET
126      6600 FORMAT ('1',27X,'SET',F5.1/'0',10X,'YEARLY BENEFIT/COST ANALYSIS'
127      )
128      WRITE (IGO,6610)
129      6610 FORMAT ('1',15X,'REL YIELD/REL EFFORT')
130      WRITE (IGO,6630) (CASE,I=1,NCOLS), (DIFF,I=1,NCOLS)
131      6630 FORMAT (1H,1X,'YR',1X,9(5X,A4,5X))
132      WRITE (IGO,6650) (I,I=1,NCOLS), (I,I=1,NCOLS)
133      6650 FORMAT (1H,4X,9(5X,I4,5X))
134      DO 350 I=1,NYRSP1
135      IYR = I-1
136      DO 325 J=1,NCOLS
137      BCSUB(J) = YRVAL(I,J,8)
138      325 BCDIF(J) = YRVAL(I,J,8) - YRVAL(I,1,8)
139      WRITE (IGO,6700) IYR, (BCSUB(J),J=1,NCOLS), (BCDIF(J),J=1,NCOLS)
140      6700 FORMAT (1H,14,1P9E14.6)
141      350 CONTINUE
142      WRITE (IGO,6001)
143      6001 FORMAT (1H1)
144      DO 500 K=1,6
145      SK = K
146      KR = K/2
147      SKH = KH
148      IF (K.EQ.1) WRITE (IGO,6611)
149      IF (K.EQ.2) WRITE (IGO,6612)
150      IF (K.EQ.3) WRITE (IGO,6613)
151      IF (K.EQ.4) WRITE (IGO,6614)
152      IF (K.EQ.5) WRITE (IGO,6615)
153      IF (K.EQ.6) WRITE (IGO,6616)
154      WRITE (IGO,6630) (CASE,I=1,NCOLS), (DIFF,I=1,NCOLS)
155      WRITE (IGO,6650) (I,I=1,NCOLS), (I,I=1,NCOLS)
156      DO 450 I=1,NYRSP1
157      IYR = I-1
158      DO 425 J=1,NCOLS
159      IF (SKH.EQ..5*SK) GO TO 410
160      BCSUB(J) = YRVAL(I,J,9+KH)
161      BCDIF(J) = YRVAL(I,J,9+KH) - YRVAL(I,1,9+KH)
162      GO TO 420
163      410 CONTINUE
164      BCSUB(J) = YRVAL(I,J,8+KH) / (1.0+SI)**I
165      BCDIF(J) = (YRVAL(I,J,8+KH) - YRVAL(I,1,8+KH)) / (1.0+SI)**I
166      420 CONTINUE
167      425 CONTINUE
168      WRITE (IGO,6700) IYR, (BCSUB(J),J=1,NCOLS), (BCDIF(J),J=1,NCOLS)
169      450 CONTINUE
170      WRITE (IGO,6001)
171      500 CONTINUE
172      6611 FORMAT ('1',10X,'FDI/F(T)*(REL YIELD(0) - REL YIELD(T))')
173      6612 FORMAT ('1',5X,'DISCOUNTED BCYR1')
174      6613 FORMAT ('1',17X,'F(0) - F(T)')
175      6614 FORMAT ('1',17X,'DISCOUNTED F(0) - F(T)')
176      6615 FORMAT ('1',5X,'BCYR5')
177      6616 FORMAT ('1',5X,'BCYR6')
178      RETURN
179      END

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YLDCLC

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SUBROUTINE YEARLY(IYRI,TOTP,PN,RCPUE,PRY)
C
C-----THIS SUBROUTINE IS CALLED BY THE MAIN PROGRAM FOR EACH YEAR. SEVERAL
C QUANTITIES ARE STORED FOR LATER OUTPUT BY SUBROUTINES TABLE AND PLT123.
C
C
C REAL*8 IMPACT,IYRCH
C DIMENSION PR(16)
C COMMON /BLOCKA/ OUTPT(20),IMPACT(20),REL(20)
C COMMON /BLOCKY/ YIELD,FTP,CATCH(16),PPH(16),P(16),WT(17),JYB
C COMMON /DATA/ YRVAL(101,9,11),TEMP(101),NCHGS
C ALAZY8 = 1850
C
C-----STORE VALUES IN THE ARRAY YRVAL.
C
C YRVAL(IYRI+1,NCHGS,1) = FTP
C YRVAL(IYRI+1,NCHGS,2) = YIELD
C YRVAL(IYRI+1,NCHGS,3) = PN(2)
C YRVAL(IYRI+1,NCHGS,4) = TOTP
C YRVAL(IYRI+1,NCHGS,5) = PN(1)
C YRVAL(IYRI+1,NCHGS,6) = PN(16)
C YRVAL(IYRI+1,NCHGS,7) = OUTPT(7)
C
C-----STORE VALUES IN ARRAY OUTPT.
C
C OUTPT(1) = TOTP
C OUTPT(2) = YIELD
C OUTPT(3) = FTP
C OUTPT(4) = PN(1)
C OUTPT(5) = PN(2)
C OUTPT(6) = PN(16)
C
C-----STORE VALUES IN ARRAY REL.
C
C REL(1) = TOTP / YRVAL(1,NCHGS,4)
C REL(2) = YIELD / YRVAL(1,NCHGS,2)
C REL(3) = FTP / YRVAL(1,NCHGS,1)
C REL(4) = PN(1) / YRVAL(1,NCHGS,5)
C REL(5) = PN(2) / YRVAL(1,NCHGS,3)
C REL(6) = PN(16) / YRVAL(1,NCHGS,6)
C REL(7) = OUTPT(7) / YRVAL(1,NCHGS,7)
C
C-----STORE VALUES IN ARRAY IMPACT.
C
C DO 500 I=1,7
C   DIFF = 1. - REL(I)
C   IF (ABS(DIFF).LT.1.E-5) DIFF = 0.
C   IMPACT(I) = ALAZY8
C   IF (PRY.NE.0.) IMPACT(I) = DIFF / PRY
C 500 CONTINUE
C   RCPUE = ALAZY8
C   IF (REL(3).NE.0.) RCPUE = REL(2) / REL(3)
C
C-----STORE YEARLY BENEFIT COST VALUES IN YRVAL.
C
C YRVAL(IYRI+1,NCHGS,8) = REL(2) / REL(3)
C IF (IYRI.GT.0) GO TO 600
C REL2SV = REL(2)
C OUT13SV = OUTPT(3)
C 600 CONTINUE
C YRVAL(IYRI+1,NCHGS,9) = OUTPT(9) * (REL2SV-REL(2))
C YRVAL(IYRI+1,NCHGS,10) = OUT13SV - OUTPT(3)
C YRVAL(IYRI+1,NCHGS,11) = OUTPT(10) + (YRVAL(1,NCHGS,8)
C 1 YRVAL(IYRI+1,NCHGS,8))
C RETURN
C END

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YBRUN

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1      SUBROUTINE YLDCLC (PH,A,UR,N)
2      C
3      C=... SUBROUTINE FOR CALCULATING THE YIELD
4      C
5      COMMON /BLOCKV/ DUM1(15),PPH(16),DUM2(225)
6      COMMON /BLOCKY/ YIELD,PTP,CATCH(16),PPH(16),P(16),WT(17),JYR
7      DIMENSION A(NR,1),PH(1)
8      YIELD=0.0
9      DO 35 J=2,N
10     PSUM = PPH(J) + PNH(J)
11     YIELD = YIELD + WT(J)*PH(J)*(1.-EXP(-PSUM))*(PPH(J)/PSUM)
12 35 CONTINUE
13     RETURN
14     END

```

BLOCK

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1      SUBROUTINE YRRUN (PN,A,HR,N,TEMP)
2      C
3      C.....SUBROUTINE FOR ADVANCING THE POPULATION VECTOR BY 1 YEAR
4      C      USING MATRIX A
5      C
6      COMMON /BLOCKY/ YIELD,FTP,CATCH(16),FFH(16),P(16),WT(17),JYR
7      DIMENSION A(HR,1),PN(1),TEMP(1)
8      NM1=N-1
9      DO 30 I=1,N
10     TEMP(I)=0.0
11     DO 20 J=1,N
12     TEMP(I)=TEMP(I)+A(I,J)*PN(J)
13 20 CONTINUE
14 30 CONTINUE
15     DO 40 I=1,N
16     PN(I)=TEMP(I)
17 40 CONTINUE
18     RETURN
19     END

```

```
1      BLCK DATA  
2      COMMON/BLOCKN/N,NVAB,NVAB  
3      DATA      NVAB/256/  
4      DATA      NVAB/148/, N/1/  
5      END
```

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