COMPUTER-IMPLEMENTED SIMULATION AS A PLANNING AID FOR STATE FISHERIES MANAGEMENT AGENCIES

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COMPUTER-IMPLEMENTED SIMULATION AS A PLANNING AID FOR STATE FISHERIES MANAGEMENT AGENCIES[1]

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PREFACE

A problem facing all state fisheries agencies is evaluating how best to allocate limited financial resources to meet particular goals. Given the angler-day as a measure of output from a fisheries program, how can a management agency allocate its resources to increase angler-day production within a relatively fixed budget? For example, how many angler-days accrue from investments in the following: (1) building additional lakes; (2) improving support facilities at existing state-owned lakes; (3) stocking various species and numbers of fish; (4) managing intensively as with lake fertilization and fish population manipulation; (5) educating the angling public; (6) enforcing laws; and (7) improving access to fisheries. Some state agencies have additional methods of increasing the number of angler-days, while others have fewer alternatives.

As part of a research project supported by the Division of Federal Aid, Fish and Wildlife Service, United States Department of the Interior, the authors addressed the problem of developing a methodology which could be used to allocate limited financial resources to meet particular goals. The specific objective of the project was to develop methodology for predicting output (angler-days) resulting from state fisheries management agency programs and expenditures in order to better allocate Dingell-Johnson funds.

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ABSTRACT

A basic job of fisheries management agencies is to forecast the demand and produce the necessary supply of fishing opportunities. Present day angling consumption rates often exceed managers' ability to supply fishing opportunities of the desired quality. Therefore, a primary means for improving fisheries management may be to regulate angling consumption. Operations research techniques are well suited for handling the complexities involved with planning multiple action policies for regulating angler consumption.

PISCES is a computer-implemented simulator of the inland fisheries management system of Tennessee, but is adaptable for use in any state. The purpose of PISCES is to aid in planning fisheries management decision policies at the macro-level. PISCES generates predictions of how fisheries management agency activities will affect angler use for a fiscal year. Subjective probability distributions for random variables and Monte Carlo simulation techniques are employed to produce an expected value and standard deviation for each prediction. Test runs under realistic hypothetical situations and discussions with personnel of Tennessee Wildlife Resources Agency suggest that PISCES may help fisheries management agencies to improve budget allocation decisions, to formulate multiple action policies for regulating angler use, and to enhance fisheries development. A hypothetical application of PISCES in Tennessee is given.

INTRODUCTION

Fisheries are systems consisting of aquatic biota, aquatic habitat, and man, interacting through time and space (Fig. 1). Fisheries management is the practice of making and implementing decisions to maintain or alter the structure, dynamics, and interactions of fisheries to achieve specific human objectives. Throughout the United States, agencies in state government have fisheries management as their legal mandate. These agencies make decisions about where and when to stock fish, how long to hold seasons, how much to charge for licenses, and how to allocate millions of dollars in public funds.

Choosing among decision alternatives is a difficult task for fisheries agencies. A state fisheries management system contains many different fisheries types (i.e., lakes, ponds, streams, etc.), each complex and interacting. The impact of implementing different decisions in the management system may not be clear.

Methods for predicting the impact of alternative management decisions include rules of thumb, past experience, standard population models, experimentation, trial and error, and pure guess (Lackey 1974). Each has a place in fisheries management, but the complexity of fisheries may reduce the reliability of such predictions to unacceptable levels. Therefore, fisheries agencies may be inconsistent in their ability to choose the best decision alternatives.

Recognition of the problem of choosing among decision alternatives prompted the Division of Federal Aid, Fish and Wildlife Service, United States Department of the Interior, to sponsor a research project at Virginia Polytechnic Institute and State University. The objective of the research was to develop a methodology for predicting the consequences of fisheries management agency activities and expenditures on angler use of fisheries (angler-days). PISCES, a computer simulator, was developed in partial fulfillment of the project objective. The purpose of PISCES is to aid in planning fisheries management decision policies at the macro-level in state agencies.

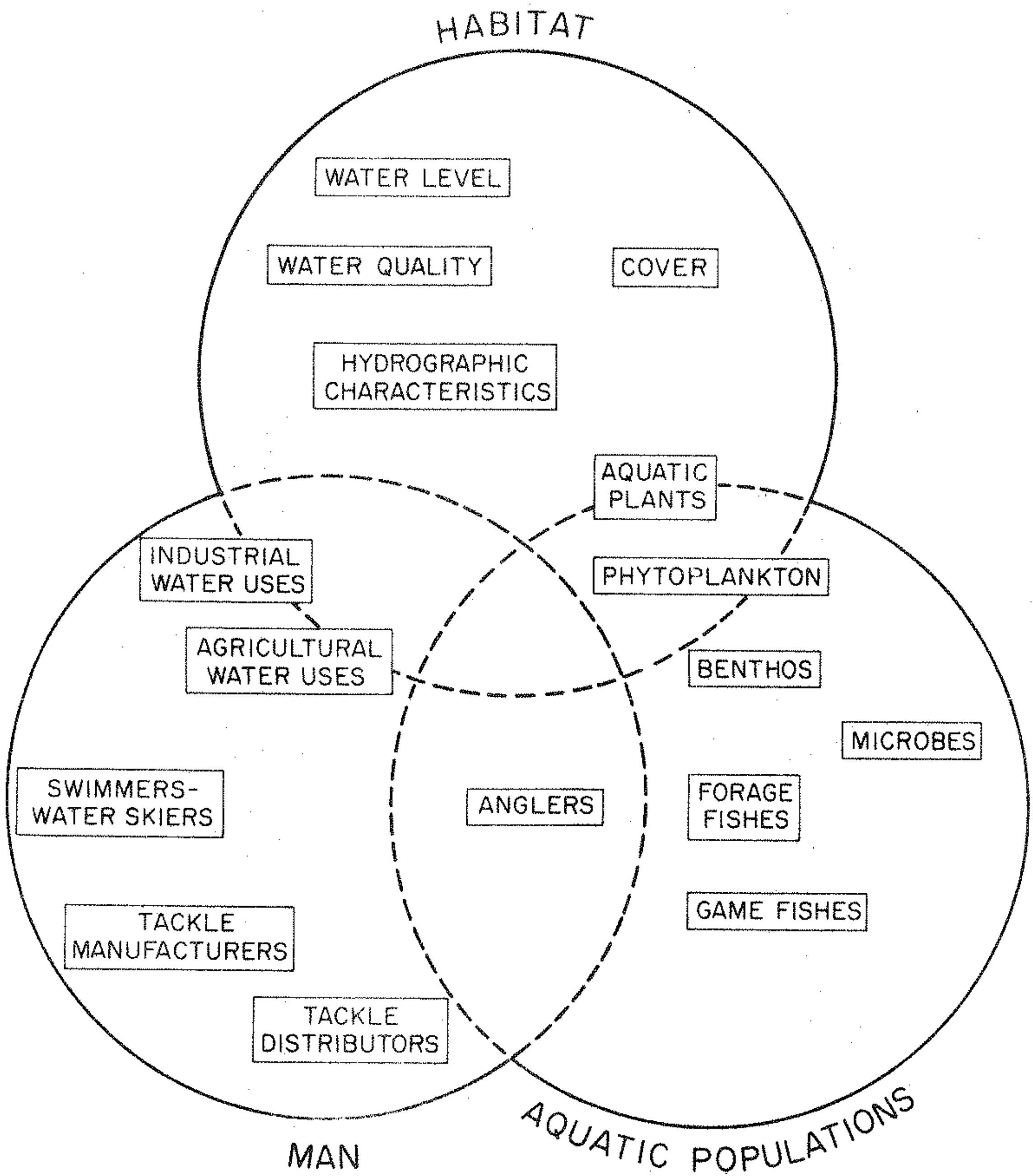


Figure 1. Graphical model of a generalized freshwater recreational fishery showing major system components.

Regulating Angling Use

Angling use is one of the major interactions of man with aquatic biota and habitat (Fig. 1); and thus, angling use should be a major concern of management agencies. Consumption trends of recreational fisheries are generally out of control (McFadden 1968). Functionally, consumption trends are nearly always viewed as phenomena extrinsic to fisheries management, but they are only partially extrinsic. Virtually all agency programs and activities have an effect on the location and intensity of angler consumption. Land acquisition, dam construction, pollution control, fish stocking, and access development are common examples.

Planning in fisheries management is largely involved with forecasting the demand and providing an adequate supply of future angling opportunities. Producing or maintaining the necessary supply of angling opportunities may be difficult. All agencies have political, technical, and biological constraints, and limited financial resources. Angling demand threatens to exceed managers' ability to supply angling opportunities of the desired quality.

Management policies are usually designed to respond to angling use trends, but rarely to shape them. If fisheries management policies were designed to regulate angling use, greater societal benefits might be achieved from the fisheries resource. Regulation of angling use could be achieved by limiting licenses, but such a tactic is not politically or culturally acceptable in most cases. A less dictatorial approach based on the relationships between individual management activities and angling use might also be effective.

Present day angling regulations, information distribution, and education programs address human components in fisheries management, but such efforts alone cannot be relied upon to direct angling use in a desirable direction. One or two actions in a complex management system are probably inadequate to achieve the desired change. For example, while information and education efforts are working to direct angler consumption along a particular course, other agency activities may be working subtly against that course. Multiple actions, each moving in the same direction with correct timing and proper force, are needed to regulate angling use successfully.

Operations Research

Operations research can be used effectively to identify optimal decision policies for complex systems. The performance of a policy is evaluated through a mathematical model representing the system under study. The effectiveness of operations research techniques for evaluating complex systems in many disciplines was well established in the past several decades. Impressive progress in operations research was due, largely, to the parallel development of the digital computer. Computer calculating speed and information storage capacity have enabled workers to address the large-scale computational problems typical of operations research. The current wide application of operations research techniques in industry, the military, and government serves to emphasize their effectiveness (Schmidt and Taylor 1970).

Operations research is identified primarily with use of mathematical models which can be divided into two categories: mathematical programming and simulation. A mathematical programming model is a set of symbols which represents the decision variables of a system (Taha 1971). The solution to most mathematical programming models defines the values of decision variables which maximize or minimize a given objective function.

A simulation model is a digital representation which imitates the behavior of a system. Statistics describing measures of change in the state of the system are accumulated as the simulator advances (Taha 1971). The performance of alternative decision policies is evaluated based on their effect upon system statistics.

The complexity of natural resource systems (i.e., fisheries) makes operations research techniques potentially useful for formulating and evaluating management policies. MAST is one example of a mathematical programming model developed for wildlife management (Lobdell 1972). In MAST, linear programming techniques are used to define optimal budget allocation for two common managerial objectives: (1) minimize management cost, subject to production requirements; and (2) maximize the value of management, subject to capital constraint.

The deer hunter participation simulator (DEPHAS) developed by Bell and Thompson (1973) is an example of a computer simulator for predicting outputs resulting from state wildlife agency activities. DEPHAS is designed to allow state wildlife administrators to analyze interaction between input and output of their proposed management policies. Many other examples of operations research models for use in natural resources management are given by Titlow and Lackey (1974), Mills (1974), and Bare (1971).

Operations research, in general, and computer simulation, in particular, were chosen to fulfill the objective of this study because:

(1) Operations research forces formal problem definition, and formulating the exact problem under review is a step toward the solution.

(2) Operations research methods include ways of structuring and measuring uncertainty which enhance decision-making.

(3) A computer simulator allows experimentation with various decision alternatives without endangering the resource.

(4) Simulation models are more flexible than mathematical programming models, and hence, may be used more easily to represent a system as complex as a fishery.

(5) Simulation methods can be applied in systems, such as fisheries, where much information is lacking or incomplete.

(6) Once constructed, a mathematical programming model optimizes a system for a single set of objectives and constraints, but a simulator can be used to evaluate the system using different objectives.

PROCEDURES

Tennessee's state fisheries management system was used as a case study for simulator development. Tennessee Wildlife Resources Agency literature, planning reports, and budget allocation records were analyzed to gain an understanding of the management system. Personal communication with Agency personnel was an integral part of the study.

A simulator, PISCES, was developed in four phases: (1) system components were identified; (2) important interactions between the components were identified; (3) mechanisms for the interactions were quantified; and (4) components and interactions were arranged in a logical order.

General Description of PISCES

In its present form, PISCES is a model of the inland fisheries management system of Tennessee, but it can be modified for use in any state. Decisions which constitute the fisheries agency's management policy for a fiscal year are treated as input. Simulator output includes a prediction of the number of angler-days (man-days of angling) which will occur within the year and predictions of how resource consumption (measured in angler-days) will be affected by the management policy.

Management activities may produce angler-days, cause angler-days to decrease, or cause angler-days to be displaced from one location to another. One example of an agency activity which produces angler-days is stocking catchable trout. A decrease in angler-days may result from decisions such as increasing the license fee. Access area development is an example of an activity which causes angler-days to be displaced from one location to another.

Angler-days are classified by their physical location (i.e., management area) and fisheries type (Fig. 2). Fisheries types considered in PISCES are typical of many states: (1) warmwater streams; (2) marginal trout streams; (3) natural trout streams; (4) ponds and small lakes; and (5) reservoirs and large lakes. In the simulator output, an angler-day in one part of the state can be distinguished from one in another part, and an angler-day on a natural trout stream can be distinguished from one on a reservoir.

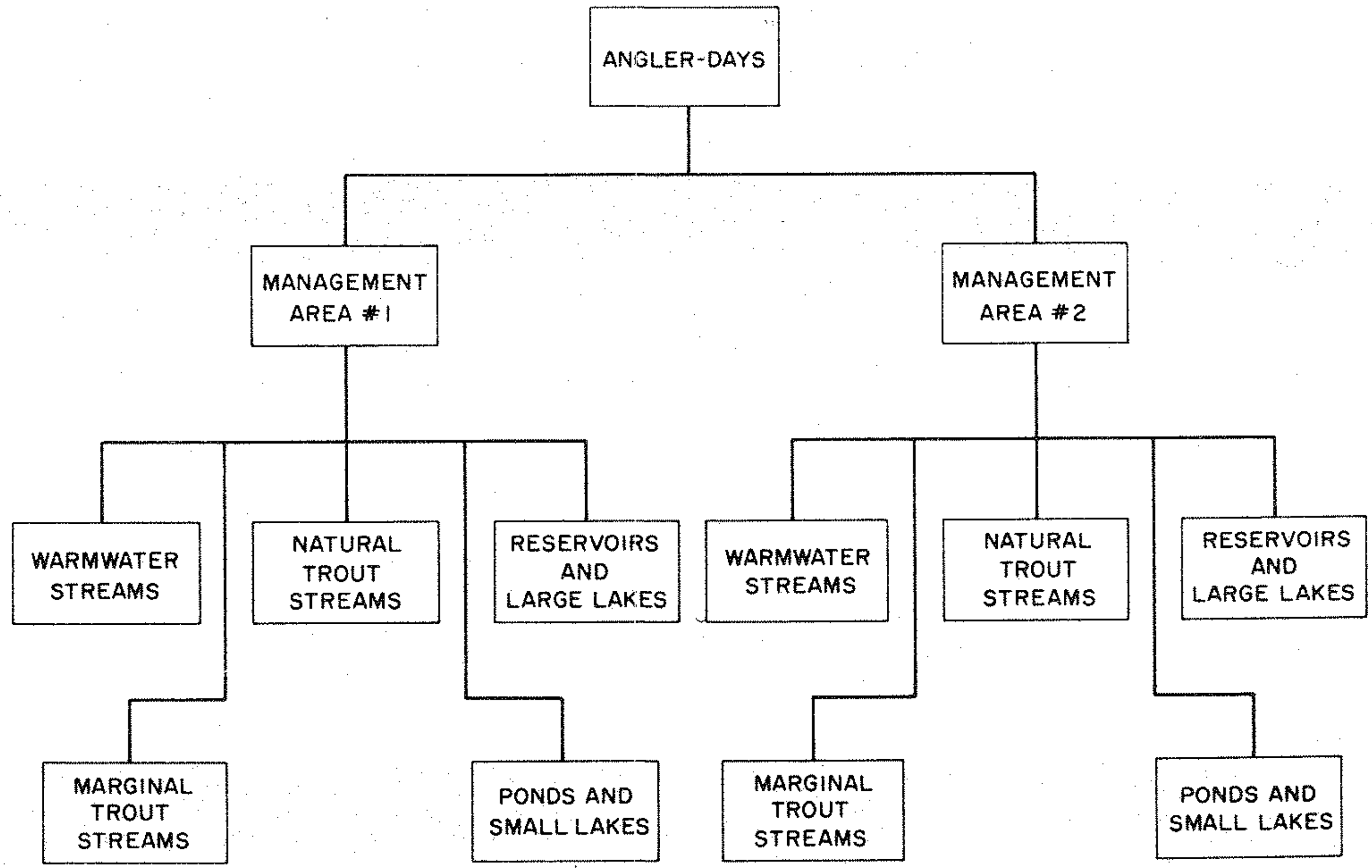


Figure 2. Classification of angler-days used in PISCES.

In planning, evaluations of management policies should be based on their performance toward reaching objectives and their cost of implementation. Angler-day predictions from PISCES are designed to serve as performance measures for fisheries management policies, and the cost of implementing the policies can be ascertained from simulator input. The planning sequence recommended for identifying the best management policy with PISCES is similar to other modes of decision analysis (Fig. 3).

PISCES was developed and tested on an IBM/370 computer. The program is written in FORTRAN IV, has an execution and compilation time of less than 5 min on a level "G" FORTRAN compiler, and requires 120 K bytes of storage.

Components of Angler-day Prediction

The major components of predictions of the number of angler-days which will occur in the planning year are: (1) estimates of the number of angler-days which occurred in the previous year; (2) the projected trend in angling popularity in the state; and (3) the change in angler-days resulting from the proposed management policy. The first two components are part of the input and the third is calculated by the simulator. All three components are added to obtain the final prediction.

Angler-day Estimates from Previous Year

Estimates of the number of angler-days which occurred in the year previous to the planning year must be provided as input. Angler-days realized on each fisheries type in all management areas must be estimated. Methods suitable for making the estimates include making surveys, extrapolating from existing data, direct counting, and random sampling. The method used should be the one which will obtain the most accurate estimates at a cost which the agency can afford.

Popularity Trends

Many factors extrinsic to fisheries management, such as human population growth, influence resource consumption. The sum of many extrinsic factors may be expressed as a popularity trend, data which most state fisheries agencies possess. High, low, and most probable estimates of the statewide change in popularity for each fishery are part of simulator input.

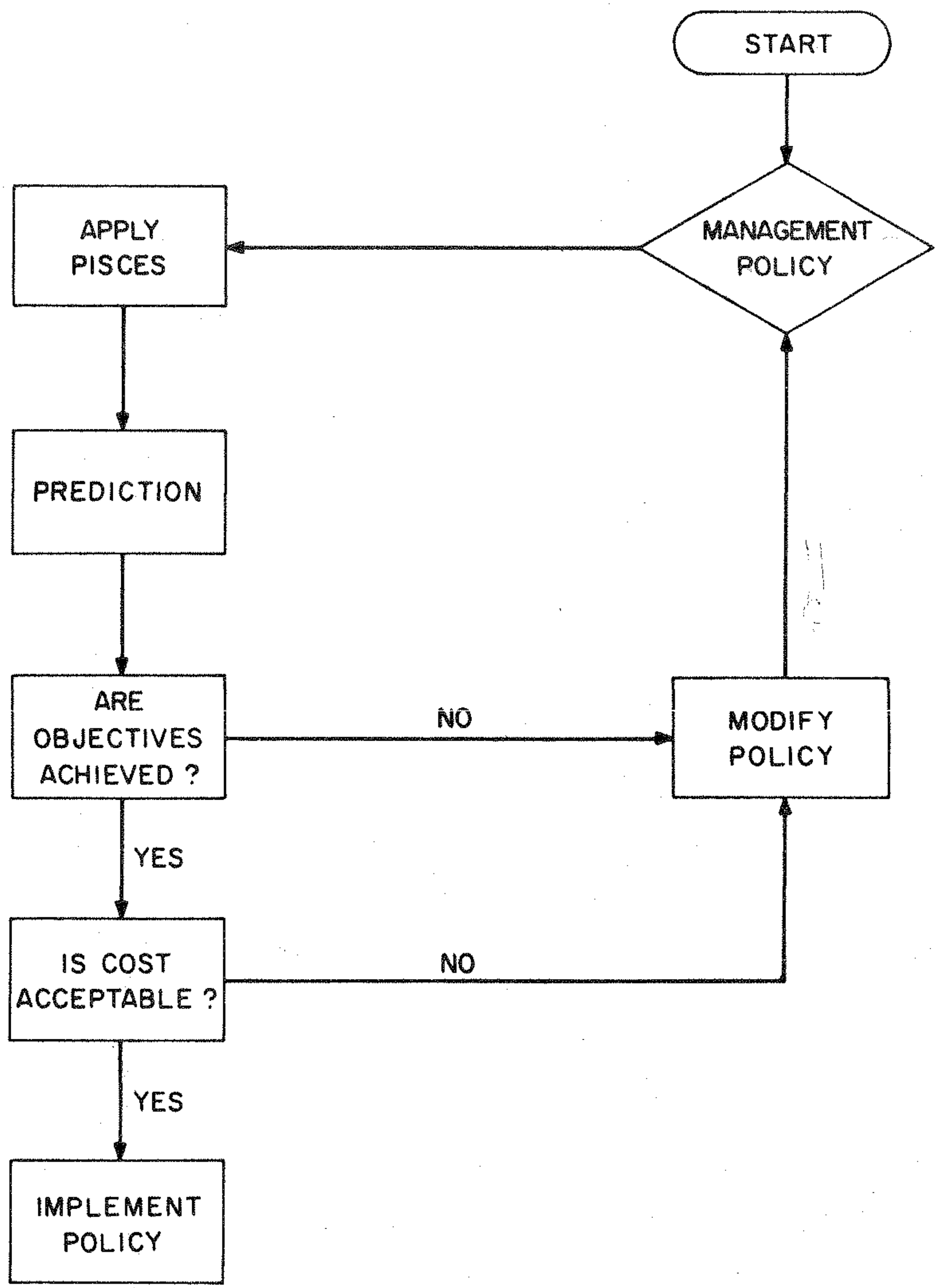


Figure 3. Recommended sequence of steps for use of PISCES in identifying the best management policy.

Change in Angler-days Resulting from Management

The largest part of PISCES is coded to calculate changes in angler-days resulting from management policy decisions. Knowledge of how management decisions affect resource consumption should give agency planners insight into which decisions are best for achieving their management objectives.

Mathematical Techniques

Fisheries management systems contain many complex variables which are poorly understood. Some of these variables, such as weather, appear to act randomly from year to year. In years with good weather, more anglers take to the field than in years with poor weather. Thus, the accuracy of predictions of the number of angler-days in a year depends, in part, upon the weather. It is difficult to obtain accurate predictions under such uncertain conditions, but management decisions must be made, regardless. Two techniques which can be applied to account for random variation in making predictions are the use of statistics and Monte Carlo simulation. PISCES is designed to use both techniques.

Statistics

Present-day statistics may be defined as decision-making under uncertainty. A range or pattern of possible values of a random variable can be determined based on past experience or experimental data (Hicks 1964). A measure of uncertainty associated with a given prediction can be calculated and the risks ascertained for each management decision.

Many of the random variables in a fisheries management system describe events which have never occurred in the past or for which very little or no data exist. Traditional statistical techniques for assigning objective probability distributions cannot be applied to such variables. PISCES uses a technique of subjective probability assignment developed by Lamb (1967) and modified by Clark and Lackey (1975). It is a method of fitting Weibull probability functions by utilizing best available subjective and objective information about variables. Low, most probable, and high estimates of the variables are used to develop the Weibull probability distributions (Appendix A).

Monte Carlo Simulation

Monte Carlo simulation is the process of producing frequency distributions for simulator outputs. One iteration of a simulator produces one set of output values, but iterating a number of times in a simulator containing random variables produces frequency distributions on the output variables.

Output for PISCES contains predictions of angler-day change. Producing frequency distributions for these predictions allows calculation of an expected value (mean) and standard deviation for each. Expected values are considered as the actual predictions and standard deviations are considered as a measure of risk associated with basing decisions on the predictions. A measure of risk in decision-making is an important statistic. For example, two different decision alternatives may produce the same predicted result, but the result may be much more certain for one alternative than for the other. If the costs of implementing each of the two alternatives are equal, then the alternative with the lesser risk is the better choice.

PISCES employs 50 iterations to produce an expected value and standard deviation for each prediction.

PROGRAM SEGMENTS

The activities of inland fisheries management agencies in most states can be encompassed in the following categories: (1) trout hatcheries; (2) access area development; (3) information and education; (4) land acquisition; (5) regulations; (6) research; (7) warmwater hatcheries; (8) pollution control; and (9) water development. Each category influences angling use and is considered in PISCES (Fig. 4).

Many factors influencing angling use are totally or partially independent of fisheries agencies. PISCES directly accounts for several of these factors such as reservoir construction, federal trout stocking programs, and popularity trends. Other independent factors, such as weather, are not directly addressed in the simulator, but are considered the cause of the random variation in the probability distributions.

Main Program and Subroutine TALLY

The main program has two functions: the subprograms are called in their proper order; and projected popularity trend changes are assigned to the appropriate fisheries type. The three components (i.e., last year's estimate, popularity trend projection, and change resulting from management policy) of the angler-day prediction are accumulated by subroutine TALLY.

Subroutines INPUT, ENVIRO, and OUTPUT

The purpose of subroutines INPUT and ENVIRO is to read the simulator input (Fig. 4). INPUT reads values describing the management policy for the year such as budget expenditures, locations of new access areas, and regulation changes. ENVIRO reads values which characterize the state fisheries management system such as costs of different management activities, inflation rate, regression coefficients, and high, low, and most probable estimates for Weibull distributions. Once the data for ENVIRO are obtained, they become a semi-permanent part of the simulator and need only slight maintenance in accordance to feedback. A complete list of simulator input in proper order and format is in source deck list of PISCES (Appendix G).

Subroutine OUTPUT instructs the computer to print the simulator output in an appropriate format.

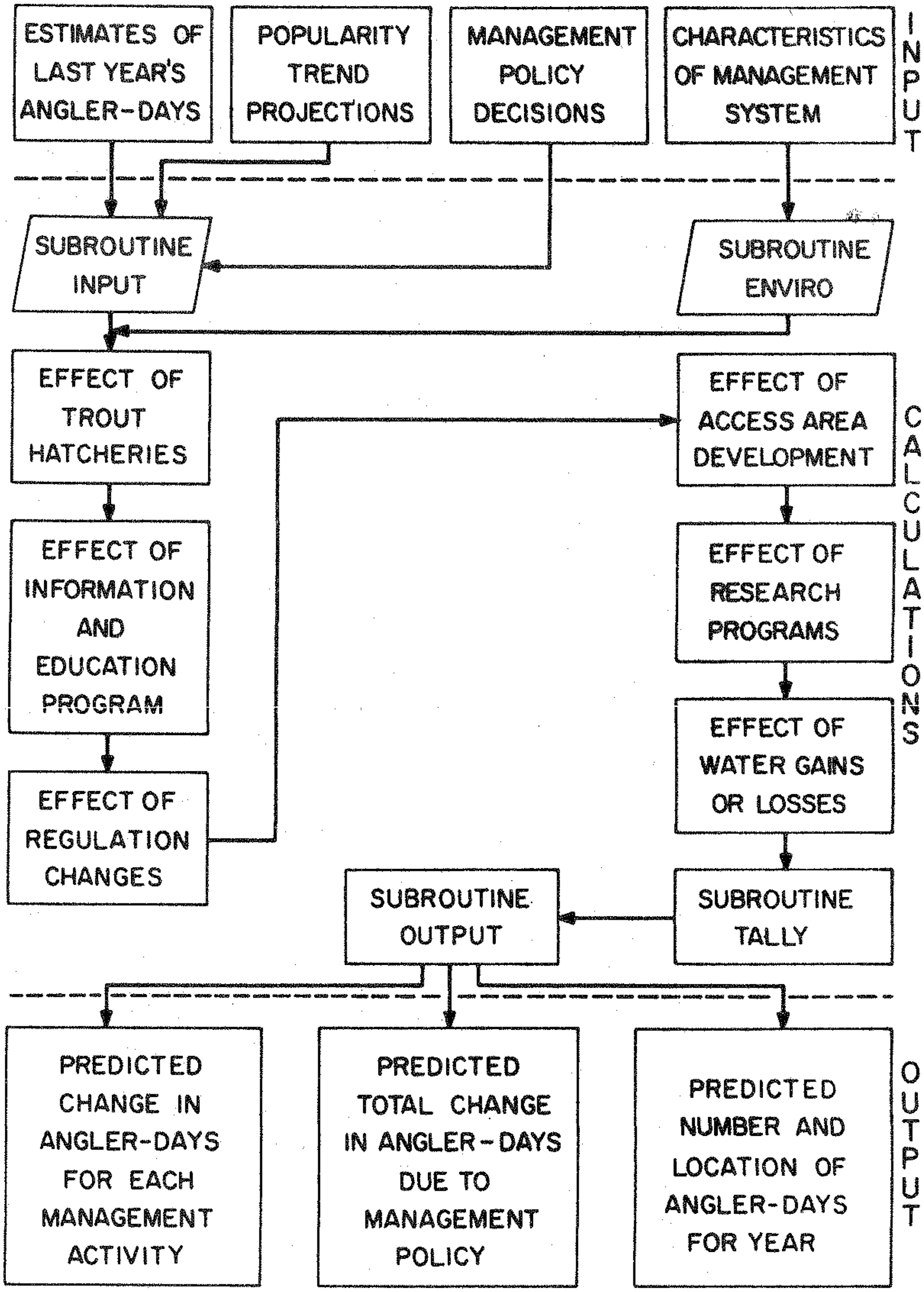


Figure 4. Flow chart of calculations done within PISCES.

Computing Instructions

Six subroutines which serve as computer instructions for calculating angler-day changes are HATCH, ACCESS, INED, RESEAR, REGULA, and WATER. Each subroutine calculates the increment of angler-day change expected from their respective management activities and outputs the result (Fig. 4). Subroutine HATCH contains instructions for calculating the change in angler-days resulting from catchable trout program; subroutine ACCESS from the access area development program; subroutine INED from the information and education program; subroutine RESEAR from the research program; and subroutine REGULA from regulation change. Subroutine WATER accounts for management activities (i.e., pollution abatement and land acquisition) and other activities (i.e., posting by landowners and reservoir construction) which cause changes in the amount of water available for angling. The sum of the increments of angler-day change calculated by these subprograms is the third component of the angler-day prediction.

Subroutine DRAW

A management activity, such as providing a new access area to a reservoir, usually increases the number of angler-days on the reservoir. Many of the increased angler-days are newly generated, but many may be redirected to the reservoir from nearby fisheries. Subroutine DRAW uses subjective probability to calculate the number and source of redirected angler-days.

Distance between fisheries and similarity in fisheries types are two factors in DRAW which are considered to influence angler-day displacement. Displacement is assumed to be significant only between adjacent management areas, and more angler-days are assumed displaced between fisheries types which are similar (i.e., reservoirs and ponds) than between those which are not similar (i.e., reservoirs and natural trout streams).

Mathematical Subroutines

PISCES contains five subroutines which describe mathematical relationships throughout the program: (1) subroutine WEIBUL calculates parameters for a Weibull distribution given high, low, and most probable estimates of a variable; (2) subroutine RANDU generates uniformly distributed random variables; (3) subroutine RANDOM contains a Weibull process generator; (4) subroutine MODEX defines a modified exponential relationship between a given management activity and angler-days; and (5) subroutine STAT calculates the mean and standard deviation for the output distributions.

Subroutine RANDU was developed by International Business Machines Corporation. The mathematical development of subroutines WEIBUL, RANDOM, and MODEX is given in Appendices A, B, and C, respectively. Results of sensitivity experiments on the important variables in subroutine MODEX are given in Appendix D.

HYPOTHETICAL APPLICATION IN TENNESSEE

Utilization of PISCES will be illustrated by a hypothetical application in Tennessee. Input data for the application are realistic hypothetical values derived from historical data provided by the Tennessee Wildlife Resources Agency (hereafter called "Agency"). A complete list of input values used for the application is given in Appendix F.

Definition of Variables

The first step in applying PISCES is to define the following variables: (1) management areas; (2) fisheries types; (3) water closed to fishing; (4) angler-days; (5) developed and undeveloped access areas; (6) trout hatcheries; (7) research activities; and (8) information and education activities. Definitions of variables are only restricted to what seems reasonable for a particular state.

Tennessee is divided into four management regions by the Agency. Each region is divided into three management areas. The areas were numbered 1 through 12 for the application (Fig. 5). Fisheries types were defined as follows: (1) warmwater streams include streams too warm for trout stocking; (2) marginal trout streams include streams stocked with trout; (3) natural trout streams include streams not stocked with trout but which support reproducing trout populations; (4) ponds and small lakes include all manmade impoundments (except Tennessee Valley Authority and United States Army Corps of Engineers reservoirs) and natural lakes under 1,000 acres; and (5) reservoirs and large lakes include Tennessee Valley Authority and United States Army Corps of Engineers reservoirs (including those under 1,000 acres) and natural lakes over 1,000 acres.

The types of water closed to fishing were defined as: (1) polluted water where fishkills recently occurred; (2) continuously polluted water in which fish are few or nonexistent; (3) water posted by private landowners; (4) water inundated by reservoirs or ponds; and (5) streams severely damaged by channelization.

Angler-days were defined as any part of a day a person spends fishing.

A developed access area consists of a parking lot, boat ramp, access road, and picnic area in a single location. An undeveloped access area is either a parking lot, boat ramp, access road, or a combination of two or three of these facilities.

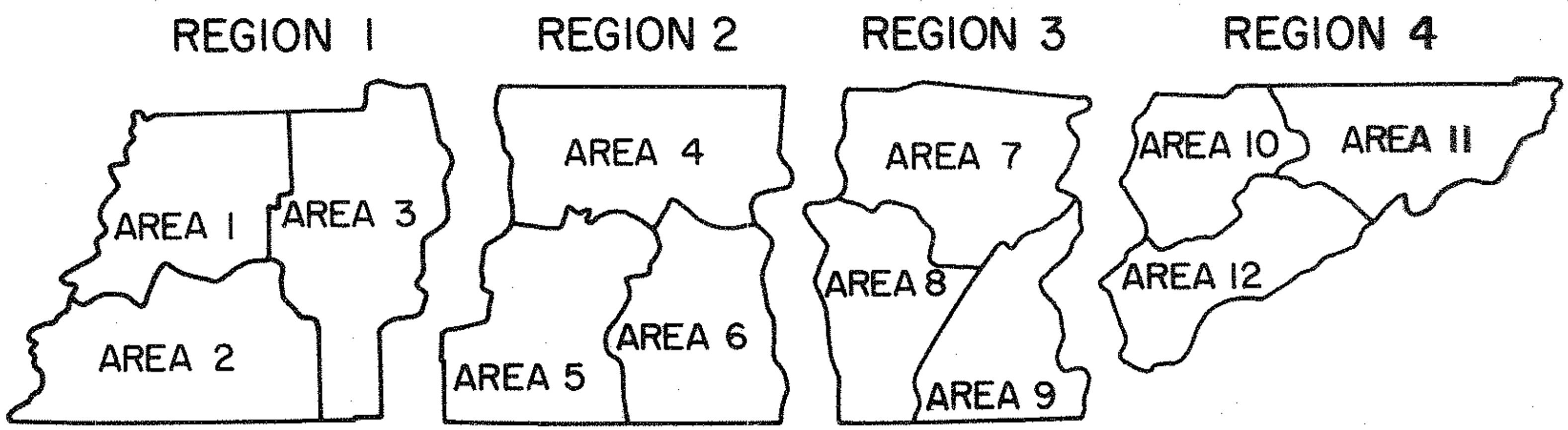


Figure 5. Fisheries management areas in Tennessee used by the Tennessee Wildlife Resources Agency.

The Agency operates four trout hatcheries, Erwin, Flintville, Tellico, and Buffalo Springs. In the BUDGET and COST arrays in PISCES, these hatcheries correspond to array members 1 through 4, respectively.

Research activities were defined as all research projects conducted in the planning year and the stocking of exotic warmwater fish species (i.e., striped bass and muskellunge).

Information and education activities were defined as popular publications and brochures, talks given by personnel, advertisements, and news releases.

Definition of Objectives

Most fisheries management agencies have objectives such as "to protect and reclaim fisheries habitats" or "to provide the best possible angling." PISCES requires definition of objectives pertaining to angler use which is consistent with other agency objectives. In the hypothetical application, the objective is "to reduce angler-days on trout streams." A constraint in achieving the objective is "the number of catchable trout stocked cannot be reduced." Other objectives which can be used in PISCES are discussed under OBJECTIVES FOR FISHERIES MANAGEMENT.

Background Data

Background data needed for PISCES include estimates of angler-days occurring in the previous year, estimates of random variables, and other information characterizing Tennessee. A list of background data used for the hypothetical application is given in Appendix F.

Estimates of angler-days occurring in the previous year were extrapolated from angling demand inventories taken in 1970 by the Tennessee Wildlife Resources Agency. High, low, and most probable estimates of random variables are hypothetical. Data classified as information characterizing Tennessee were taken from Tennessee Fish and Game Commission (1970a, 1970b, 1971a, 1971b) surveys.

Management Policy

A detailed list of decisions constituting the management policy for the hypothetical application is given in Appendix F. The policy was formulated by testing several alternative decision schemes in the planning system (Fig. 3) recommended for PISCES.

The following is a summary of the decisions which allowed satisfactory achievement of the objective of reducing angler-days on trout streams: (1) no access areas were developed on trout streams; (2) information and education and research efforts were increased on warmwater streams while decreased to minimal levels on trout streams; (3) catchable trout stocking was maintained at levels nearly equivalent to those of the previous year to satisfy the constraint; and (4) the trout season was closed in November, December, January, February, and March.

Tables 1 through 18 show the angler-day predictions for the chosen policy as given in the output of PISCES using input values summarized in Appendix F. The important events which occurred in the application year and resulted in a change in angler-days are:

(1) A public pond was constructed in management area 2 (Table 6). As a result, access areas were developed (Table 4) and substantial information and education efforts were allocated (Table 8) to area 2 on pond and small lake fisheries.

(2) The Tennessee Valley Authority opened a new reservoir to angling on the border of management areas 6 and 7 (Table 6). Consequently, access areas were developed (Table 4) and information and education efforts were allocated (Table 8) to areas 6 and 7 on reservoir and large lake fisheries.

(3) The new pond and reservoir inundated warmwater streams in areas 2, 6, and 7 and marginal trout streams in area 7 (Table 6).

(4) The tailwaters of the new reservoir increased the acreage of marginal trout streams in area 6 (Table 6).

(5) Warmwater streams in area 4, marginal trout streams in areas 8 and 11, ponds and small lakes in areas 4 and 9, and reservoirs and large lakes in area 10 were lost to Tennessee's fisheries system (Table 6).

Table 1.--Estimates of angler-days which occurred in year previous to year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	94,110	0	0	665,296	0
2	60,630	0	0	509,464	0
3	49,456	24,210	0	65,640	2,944,690
4	165,311	26,166	0	336,840	1,514,975
5	140,833	13,950	0	236,814	27,160
6	87,736	12,740	0	177,336	583,500
7	135,815	25,620	0	544,195	193,120
8	61,642	32,890	0	92,166	293,420
9	37,458	43,395	4,288	52,371	772,240
10	31,160	1,823	7,648	35,025	666,842
11	81,088	130,140	8,544	38,265	724,090
12	106,200	130,226	19,380	58,174	433,410

Table 2.--Projected trend in popularity of angling in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	-1,790	0	0	12,287	0
2	-1,153	0	0	9,410	0
3	-1,269	45	0	3,576	24,551
4	-1,209	33	0	4,268	8,300
5	-1,271	12	0	3,172	186
6	- 792	12	0	2,552	3,730
7	- 699	13	0	2,426	4,629
8	- 328	31	0	1,502	5,627
9	- 195	39	19	812	14,809
10	- 365	1	37	709	11,625
11	- 509	47	38	1,216	7,308
12	- 431	47	91	947	8,311

Table 3.--Standard deviations of popularity trend projections of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	52	0	0	217	0
2	34	0	0	166	0
3	37	3	0	63	266
4	35	2	0	76	90
5	37	1	0	56	2
6	23	1	0	45	40
7	20	1	0	43	50
8	10	2	0	27	61
9	6	3	2	14	160
10	11	0	4	13	126
11	15	3	4	22	79
12	13	3	9	17	90

Table 4.--Predicted changes in angler-days resulting from access area development in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	- 82	0	0	-110	0
2	-632	0	0	6,355	0
3	- 82	- 47	0	-110	- 81
4	-123	- 73	0	-124	-167
5	- 66	- 39	0	- 67	- 89
6	-778	-461	0	-780	7,799
7	-886	-526	0	-898	8,966
8	-123	- 73	0	-124	-167
9	- 57	- 34	-4	- 58	- 77
10	- 57	- 34	-4	- 58	- 77
11	0	0	0	0	0
12	0	0	0	0	0

Table 5.--Standard deviations of changes in angler-days resulting from access area development in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	20	0	0	27	0
2	111	0	0	991	0
3	20	12	0	27	19
4	23	14	0	22	27
5	13	9	0	13	17
6	120	83	0	107	822
7	111	79	0	22	27
8	23	14	0	22	27
9	11	1	1	11	41
10	11	7	1	11	14
11	0	0	0	0	0
12	0	0	0	0	0

Table 6.--Predicted changes in angler-days resulting from water gain or loss in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	59	0	0	- 2	0
2	-3,248	0	0	5,733	0
3	0	0	0	- 2	- 2
4	- 217	- 10	0	- 418	- 25
5	- 13	- 8	0	- 12	- 16
6	- 924	2,396	0	- 148	36,600
7	-4,658	-1,274	0	- 133	34,637
8	- 10	-2,148	0	- 14	- 26
9	831	- 3	1	-1,109	- 9
10	441	5	5	0	- 1,623
11	121	-8,974	38	23	3
12	- 91	5	5	631	- 1

Table 7.--Standard deviations of changes in angler-days resulting from water gain or loss in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	13	0	0	1	0
2	618	0	0	408	0
3	1	1	0	1	1
4	37	4	0	36	9
5	4	3	0	4	5
6	104	211	0	4	3,516
7	422	66	0	39	4,748
8	7	164	0	7	9
9	100	2	1	115	4
10	66	3	2	2	187
11	17	577	11	7	1
12	7	2	2	62	1

Table 8.--Predicted changes in angler-days resulting from information and education efforts in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	270	0	0	370	0
2	150	0	0	967	0
3	145	61	0	350	359
4	162	71	0	265	170
5	158	68	0	567	- 38
6	166	74	0	269	275
7	172	76	0	- 30	282
8	181	82	0	- 22	86
9	163	71	- 9	268	274
10	167	71	89	- 31	284
11	266	269	83	- 33	185
12	261	265	82	- 37	181

Table 9.--Standard deviations of changes in angler-days resulting from information and education efforts in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	15	0	0	21	0
2	9	0	0	55	0
3	9	4	0	20	19
4	9	4	0	15	9
5	9	5	0	32	6
6	9	5	0	16	15
7	10	5	0	3	16
8	10	5	0	2	5
9	9	5	1	16	15
10	10	5	5	3	11
11	11	16	5	3	11
12	16	16	5	3	10

Table 10.--Predicted changes in angler-days resulting from research efforts in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	389	0	0	886	0
2	327	0	0	2,339	0
3	569	-284	0	2,075	4,120
4	240	-171	0	741	2,264
5	265	-156	0	1,269	1,279
6	262	339	0	1,278	1,805
7	224	327	0	760	1,788
8	790	-154	0	789	1,313
9	745	-181	-21	240	2,787
10	730	-194	-28	228	2,773
11	755	320	-44	766	1,805
12	724	300	-46	736	1,775

Table 11.--Standard deviations of changes in angler-days resulting from research efforts in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	51	0	0	114	0
2	48	0	0	302	0
3	82	44	0	269	535
4	39	26	0	269	293
5	42	24	0	164	167
6	40	47	0	166	133
7	39	45	0	99	233
8	105	23	0	103	170
9	101	28	4	38	360
10	95	33	4	37	358
11	100	43	6	100	234
12	97	44	6	97	231

Table 12.--Predicted changes in angler-days resulting from catchable trout stocking in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	0	0	0	0	0
2	0	0	0	0	0
3	0	86	0	0	18
4	1	- 164	0	0	-31
5	-1	158	0	0	2
6	0	19	0	0	3
7	0	88	0	0	0
8	-1	280	0	-1	4
9	0	- 45	0	0	- 3
10	-2	76	-1	-1	82
11	-8	1,967	-8	-5	8
12	-1	75	-1	-1	1

Table 13.--Standard deviations of changes in angler-days resulting from catchable trout stocking in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	0	0	0	0	0
2	0	0	0	0	0
3	0	3	0	0	1
4	0	4	0	0	1
5	0	7	0	0	1
6	0	1	0	0	0
7	0	2	0	0	0
8	0	5	0	0	0
9	0	1	0	0	0
10	0	3	0	0	5
11	2	59	2	1	1
12	0	3	0	0	0

Table 14.--Predicted changes in angler-days resulting from shortening length of trout season in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	5	0	0	3	0
2	5	0	0	3	0
3	80	- 3,599	0	48	6
4	94	- 3,855	0	55	7
5	59	- 2,074	0	34	5
6	58	- 2,250	0	34	5
7	99	- 3,621	0	59	8
8	111	- 4,608	0	67	9
9	192	- 6,405	- 459	114	15
10	124	- 113	-1,058	74	10
11	434	-18,486	- 886	255	34
12	513	-19,491	-2,469	306	40

Table 15.--Standard deviations of changes in angler-days resulting from shortening length of trout season in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	1	0	0	0	0
2	1	0	0	0	0
3	7	2	0	5	1
4	7	3	0	4	1
5	5	3	0	4	1
6	5	3	0	3	1
7	6	5	0	5	1
8	8	4	0	7	1
9	11	9	11	10	2
10	12	16	13	9	1
11	28	7	32	23	5
12	37	14	34	26	5

Table 16.--Total changes in angler-days predicted for year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	-1,149	0	0	13,435	0
2	-4,552	0	0	24,806	0
3	- 558	- 3,737	0	5,936	28,973
4	-1,053	- 4,169	0	4,787	10,520
5	- 869	- 2,040	0	4,963	1,328
6	-2,008	130	0	3,205	50,217
7	-5,700	- 4,907	0	2,202	50,310
8	619	- 6,590	0	2,197	6,846
9	1,679	- 6,559	- 476	268	17,793
10	1,040	- 189	- 961	921	13,073
11	1,059	-24,859	- 779	2,222	9,343
12	975	-18,799	-2,340	2,582	10,308

Table 17.--Standard deviations of total changes in angler-days predicted for year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	151	0	0	382	0
2	820	0	0	1,922	0
3	156	68	0	386	842
4	149	59	0	252	431
5	110	51	0	273	200
6	301	349	0	379	4,628
7	608	203	0	309	6,028
8	163	218	0	168	273
9	239	55	19	204	556
10	206	66	29	75	707
11	177	705	61	156	331
12	170	81	57	205	337

Table 18.--Prediction of total number of angler-days which will occur in year of hypothetical application of PISCES

Area	Warmwater streams	Marginal trout streams	Natural trout streams	Ponds and small lakes	Reservoirs and large lakes
1	92,961	0	0	678,731	0
2	56,078	0	0	534,270	0
3	48,898	20,473	0	71,576	2,973,662
4	164,258	21,997	0	341,627	1,525,495
5	139,964	11,910	0	241,777	28,488
6	85,728	12,870	0	180,541	633,717
7	130,115	20,713	0	546,397	243,430
8	62,261	26,300	0	94,363	300,266
9	39,137	36,836	3,812	52,639	790,033
10	32,200	1,634	6,687	35,946	679,915
11	82,147	105,283	7,765	40,487	733,433
12	107,175	111,427	17,040	60,756	443,718

OBJECTIVES FOR FISHERIES MANAGEMENT

A reasonable objective for a state fisheries management agency is to maximize total angling benefits derived from the state's recreational fisheries within the limits of its fixed budget. Total angling benefits are a function of a number of factors, but the most significant and encompassing factors are quantity and quality of angler-days. That is,

$$\text{TOTAL ANGLING BENEFITS} = f\left[\begin{matrix}\text{QUANTITY OF} \\ \text{ANGLER-DAYS,}\end{matrix} \quad \begin{matrix}\text{QUALITY PER} \\ \text{ANGLER-DAY} \ldots\end{matrix}\right]$$

Maximizing angling benefits in an operations research model requires definition of the above function and precise measurement of quantity and quality of angler-days. Unfortunately, no totally acceptable definition of the exact functional relationship or method for measuring the quality aspect of angler-days has been developed. Research efforts should be directed toward developing acceptable formulas and methods, but managers cannot stop and wait for the answers. One immediate solution for management would be to use other, more quantifiable objectives to approximate maximizing angling benefits. Two such objectives are maximizing the quantity of angler-days and minimizing crowding of occurring angler-days.

It is desirable that a functional relationship, however imprecise, between quantity and quality of angler-days be defined. Many natural resource managers accept the premise that crowding reduces the quality of an outdoor experience (Stankey 1973, Moeller and Engelken 1972, Shafer and Moeller 1971, and Lime and Stankey 1971). If the premise is correct, crowding or quantity of angler-days occurring simultaneously in a fishery has some form of inverse relationship with quality. Thus, the quality of each individual angler-day would decrease as the quantity of angler-days increases (Fig. 6).

If the relationship in Fig. 6 is correct, two general shapes for the curve relating total derived angling benefits and the number of angler-days sustained in a fishery in a given time period are possible (Fig. 7). Which relationship, I or II, is true depends upon the slope of the curve in Fig. 6. Present inability to measure the quality aspect of angler-days prevents exact determination of the slope, so the true relationship between total benefits and number of angler-days cannot be specified.

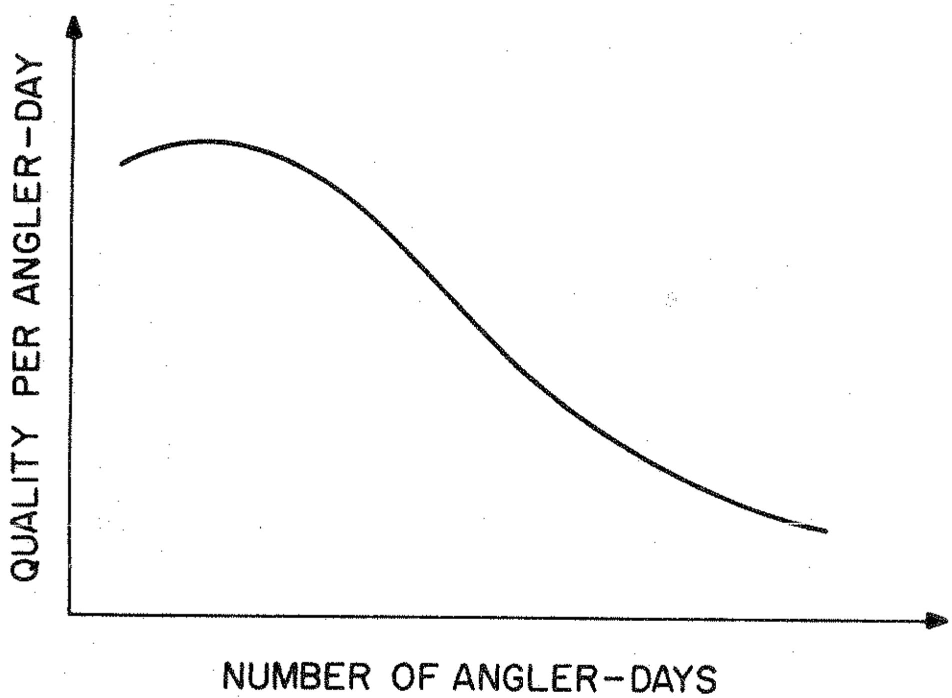


Figure 6. General relationship between number of angler-days sustained in a fishery and the quality per angler-day.

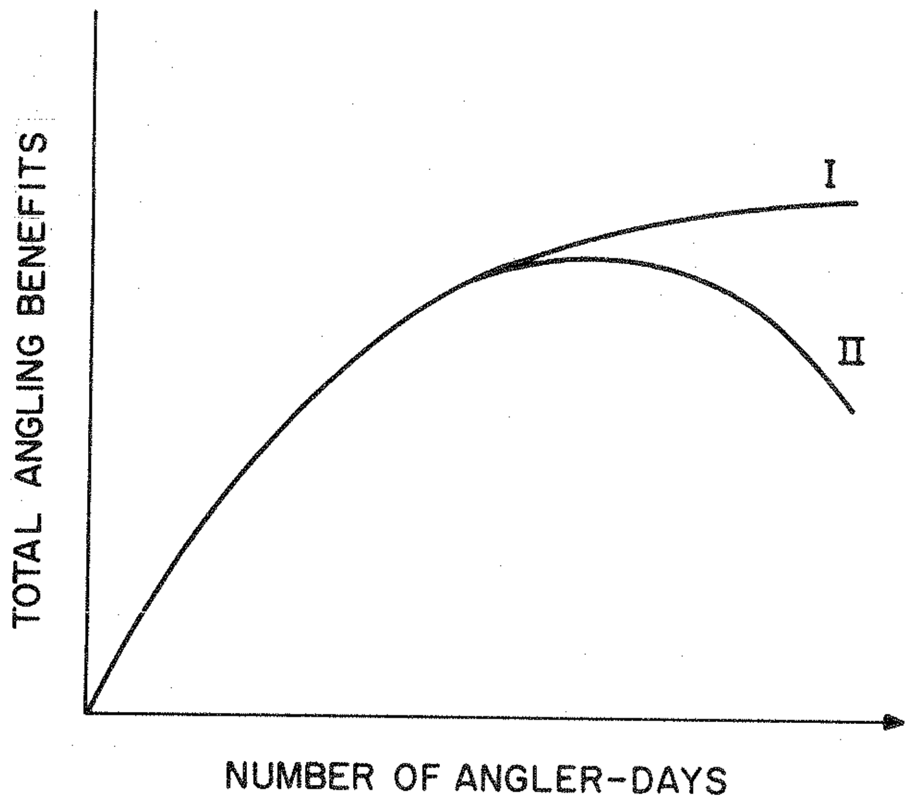


Figure 7. Two possible relationships between total angling benefits derived and number of angler-days sustained in a fishery in a given time period.

Maximizing Angler-days

Maximizing the number of angler-days has one particularly important advantage as an objective: the performance of management policies is relatively easy to measure and evaluate. Intuitively, maximizing the number of angler-days appears to approximate maximizing total angling benefits, but close inspection reveals that maximizing the number of angler-days has undesirable ramifications. First, if the true relationship between total benefits and number of angler-days follows curve II in Fig. 7, maximizing angler-days may produce angler-day numbers greater than the number corresponding to maximum benefits. Second, the relationship between quality per angler-day and number of angler-days (Fig. 6) shows that maximizing the number of angler-days is equivalent to minimizing the quality per angler-day. And finally, maximizing the number of angler-days may accelerate deterioration of fisheries resources through excessive use.

Minimizing Crowding

Minimizing crowding consists of dispersing existing resource use as evenly as possible among fisheries in a state or in proportion to the available resource in a particular part of a state. If the inverse relationship between quantity and quality of angler-days (Fig. 6) is accepted, then by minimizing crowding of a specific number of angler-days (i.e., the number expected to occur in a planning year), the quality per individual angler-day is maximized.

Maximizing quality per angler-day of a number of angler-days, say X, is equivalent to maximizing the total angling quality derived from the X angler-days. Total angling quality is defined as:

$$\text{TOTAL ANGLING QUALITY FOR X ANGLER-DAYS} = \left[\text{X ANGLER-DAYS}\right] \cdot \left[\text{QUALITY PER ANGLER-DAY}\right]$$

If the quantity of angler-days and the quality per angler-day are accepted as major components of total angling benefits, it seems reasonable to assume that total angling quality approximates total angling benefits. Thus, minimizing crowding approximates maximizing total angling benefits for a given number of angler-days. That is,

$$\text{MAX TOTAL ANGLING BENEFITS FOR X ANGLER-DAYS} \simeq \text{MAX TOTAL ANGLING QUALITY FOR X ANGLER-DAYS}$$

$$\text{MAX TOTAL ANGLING QUALITY FOR X ANGLER-DAYS} = \text{MAX QUALITY PER ANGLER-DAY}$$

$$\text{MAX QUALITY PER ANGLER-DAY} = \text{MIN CROWDING OF THE X ANGLER-DAY}$$

As an objective, minimizing crowding is not without complexities. For example, one fishery may accrue more benefits per angler-day than another fishery, regardless of crowding. Thus, if angler-days are displaced from the former to the latter fishery, total benefits may be reduced. Despite such difficulties, minimizing crowding warrants serious consideration as an objective for fisheries management agencies for two reasons: (1) it is a quantifiable objective dealing with the human component of management; and (2) it approximates maximization of angling benefits.

EVALUATION OF SIMULATOR UTILITY

The utility of PISCES was evaluated by test runs using hypothetical data and discussion with fisheries agency personnel, but evaluations should only be considered preliminary. The best method for thoroughly evaluating the utility of PISCES is an application study where actual management problems can be addressed.

Test runs under realistic, hypothetical situations show that PISCES may help fisheries agencies in several ways. First, PISCES should improve budget allocation decisions. Many of the decisions which constitute the total state management policy (input for PISCES) are budgetary in nature, and most others can be traced to a budgetary base. PISCES allows experimenting with alternative allocation policies, and thereby, identifies the best policy.

Second, PISCES can be used to formulate multiple-action decision policies for regulating resource consumption. Fisheries resource consumption might be manipulated in amounts significant enough to achieve objectives, such as minimizing crowding.

Third, regional fisheries development (i.e., construction of ponds or stocking fish) may be enhanced through use of PISCES. Angler use predictions may clarify how fisheries development in one area affects resource consumption in other areas. This information can be used in deciding where to locate access areas and state ponds.

A meeting was held with personnel from the Fish Division and Planning Section of the Agency to discuss PISCES. Some skepticism was expressed concerning the effectiveness of the use of PISCES in predicting and regulating trends in angler use. Fish Division personnel doubted that the Agency significantly influenced angling use. Aside from these criticisms, Planning Section personnel were very receptive to PISCES. Evaluations concerning simulator utility are inconclusive and concrete results can only be obtained through further investigation.

VALIDATION OF PISCES

Validity is a vague term which can be defined in many ways. Mills (1974) discussed different types of validity, and accepted the general definition that validity is a measure of the extent to which a model satisfies its design objectives. PISCES is designed as a pragmatic approach for predicting the effect of fisheries management upon angler use. Therefore, the validity of PISCES should be judged by its predictions.

PISCES simulates a system where actual data are very limited, so validation through statistical tests of fit to real data is not practical. One method of evaluating the predictions is through application. A feedback loop can be created (Fig. 8) which would evaluate the predictions by comparing them with estimates of angler-days formulated as the planning year progresses (i.e., estimates of the values which were predicted). A consistent bias between predictions and estimates would be a favorable comparison and would validate PISCES. A bias which is inconsistent would indicate input values were faulty or PISCES is invalid.

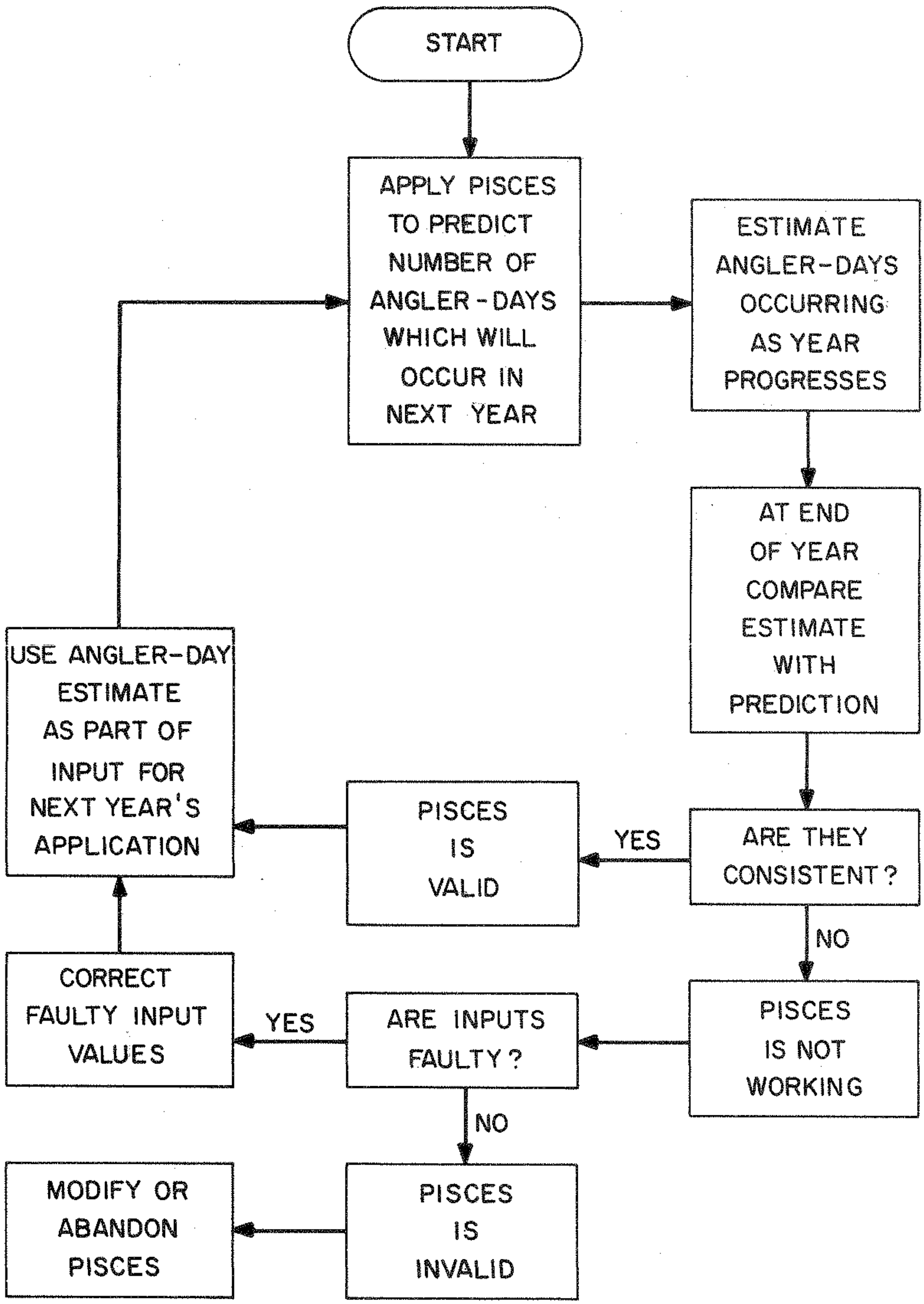


Figure 8. Feedback loop which will show if simulator predictions are accurate or show if simulator structure is invalid.

DISCUSSION

Some fisheries management activities have clearer relationships with angler use than others, and the clarity is usually reflected by the amount of historical data available upon which to base the relationship. Adequate historical data exist to derive the relationships between angler-days and access development, water development, regulation changes, and catchable trout stocking, so these relationships are probably the most reliable in PISCES. Little historical data exist to assess the effects of research and information and education activities upon the number of angler-days. Therefore, the segments of PISCES accounting for research and information and education are probably the least reliable parts of the model.

PISCES can be improved before it is utilized in decision analysis. First, the efficiency of the computer program could be improved. PISCES is functional, but computer time and storage space might be saved by altering the program. Second, sensitivity analysis of input variables would provide important information to future users of PISCES. And finally, an application study would reveal any unforeseen problems which might arise in using PISCES.

If PISCES is never used to formulate management decision policies, it is hoped that some of the modeling techniques employed will prove useful in future efforts to model natural resource systems. For example, the technique of subjective probability assignment used in PISCES has potential for improving decision analysis in resource management (Clark and Lackey 1975). Modeling natural resource systems is often hampered for two reasons: (1) system data may be incomplete and (2) experimental analysis of system variables may be impractical. Subjective probability assignment helps overcome these two problems by utilizing the best information about the system.

Operations research models, such as PISCES, can be powerful fisheries management tools, but management expertise must include modeling skills in order to use them effectively. While understanding how to use a particular model is fairly simple, obtaining the best results with it usually requires a degree of skill. Some models may be "one man dogs" with regard to producing desirable results, and the man such a model "obeys" is usually its creator. Our conclusion is that operations research models can be utilized to best advantage in fisheries management only if the manager and model builder are the same person.

LITERATURE CITED

Bare, B. 1971. Applications of operations research in forest management: a survey. Presented August 24, 1971, at Amer. Stat. Ass. Meet., Fort Collins, Colorado. 51 pp.

Bell, E. F., and E. F. Thompson. 1973. Planning resource allocation in state fish and game agencies. Trans. Thirty-Eighth N. Am. Wildl. and Nat. Resour. Conf. 38:369-377.

Butler, R. L., and D. P. Borgeson. 1965. California "catchable" trout fisheries. Calif. Dep. Fish and Game. Fish. Bull. 127. 47 pp.

Clark, R. D., Jr., and R. T. Lackey. 1975. Subjective probability assessment for aiding decision analysis in wildlife management. Mimeo Report, Virginia Polytechnic Institute and State University, Blacksburg, Va. 22 pp.

Croxton, F. E., D. J. Cowden, and S. Klein. 1967. Applied general statistics, 3rd ed. Prentice-Hall, Englewood Cliffs, N. J. 754 pp.

Hicks, C. R. 1964. Fundamental concepts in the design of experiments. Holt, Rhinehart, and Winston. New York. 293 pp.

Lackey, R. T. 1974. Introductory fisheries science. Sea Grant, Virginia Polytechnic Institute and State University, Blacksburg, Va. 275 pp.

Lamb, W. D. 1967. A technique for probability assignment in decision analysis. General Electric Tech. Inf. Ser. MAL Library, Appliance Park, Louisville, Ky. 20 pp.

Lime, D. W., and G. H. Stankey. 1971. Carrying capacity: maintaining outdoor recreation quality. Recreation Symposium Proceedings, Northeast. For. Exp. Sta. U.S.D.A., Upper Darby, Pa. 174-184.

Lobdell, C. H. 1972. MAST: A budget allocation system for wildlife management. Ph.D. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Va. 227 pp.

McFadden, J. T. 1968. Trends in freshwater sport fisheries of North America. Trans. Am. Fish. Soc. 98(1):136-150.

Mills, P. J. 1974. An application of simulation to deer management decisions. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Va. 119 pp.

Moeller, G. H., and J. H. Engelken. 1972. What fishermen look for in a fishing experience. J. wildl. Manage. 36(4):1253-1257.

Schmidt, J. W., and R. E. Taylor. 1970. Simulation and analysis of industrial systems. Richard D. Irwin, Inc. Homewood, Illinois. 644 pp.

Shafer, E. L., and G. H. Moeller. 1971. Predicting quantitative and qualitative values of recreation participation. Recreation Symposium Proceedings. Northeast. For. Exp. Sta. U.S.D.A., Upper Darby, Pa. 5-22.

Stankey, G. H. 1973. Visitor perception of wilderness recreation carrying capacity. U.S.D.A. For. Serv. Res. Pap. INT-142. 61 pp.

Taha, H. A. 1971. Operations research: an introduction. The MacMillan Co. New York. 703 pp.

Tennessee Game and Fish Commission. 1970a. Inventory of hunting and fishing access on private land and water. Planning Report No. 3. 50 pp.

____________. 1970b. Hunting and fishing demand and harvest inventory. Planning Report No. 4. 46 pp.

____________. 1971a. Hunting and fishing demand, habitat, and participation standards. Planning Report No. 7. 51 pp.

____________. 1971b. Pond and lake, reservoir and stream acreage analysis. Planning Report No. 8. 26 pp.

Titlow, F. B., and R. T. Lackey. 1974. DAM: A computer-implemented water resource teaching game. Trans. Am. Fish. Soc. 103(3): 601-609.

APPENDIX A

MATHEMATICAL DEVELOPMENT OF SUBROUTINE WEIBUL

[See Lamb (1967) and Clark and Lackey (1975)
for greater detail.]

Let:

X = random variable

$p(X)$ = probability density function for X

X_0 = mode of the probability density function

X_1 = lower estimate of X

P_1 = probability that X is less than X_1

X_2 = high estimate of X

P_2 = probability that X is greater than X_2

The above estimates describe properties of the probability distribution for X and form the basis for the following constraints:

$$\left.\frac{d(p(X))}{dX}\right|_{X_0} = 0 \qquad (1)$$

$$P_1 = \int_0^{X_1} p(X)dX \qquad (2)$$

$$P_2 = \int_{X_2}^{\infty} p(X)dX \qquad (3)$$

Theoretically, there are an infinite number of probability density functions which would satisfy the above constraints. Since the true distribution form is not known, the Weibull distribution was assumed for convenience and for its versatility. The Weibull distribution takes on a wide variety of shapes, skews left and right, and is relatively easily solved mathematically.

The three-parameter Weibull probability density function can be written in the form:

$$p(X) = \frac{m}{L^m} (X-K)^{m-1} \exp\left[-\left(\frac{X-K}{L}\right)^m\right] \qquad (4)$$

where,

$X \geq K$

$m \geq 0$

and,

m = shape parameter

L = scale parameter

K = constant

The objective is to determine the values for m, K, and L which satisfy equations (1), (2), and (3). First, it is convenient to determine the cumulative and complementary cumulative functions for the Weibull density function. The cumulative function is defined as:

$$F(X') = \int_0^{X'} p(X)dX$$

$$= 1 - \exp\left[-\left(\frac{X-K}{L}\right)^m\right] \qquad (5)$$

The complementary cumulative is:

$$R(X') = 1 - F(X')$$

$$= \exp\left[-\left(\frac{X'-K}{L}\right)^m\right] \qquad (6)$$

Applying the modal constraint in equation (1) to the Weibull density function in equation (4):

$$L = \left(\frac{m}{m-1}\right)^{1/m} (X_0-K) \qquad (7)$$

Equation (7) gives the scale parameter, L, in terms of the shape parameter, m, the constant, K, and the modal value, X_0.

Because the complementary cumulative function represents the probability that X is greater than X', equations (2) and (3) can be substituted into the expression for R(X') to obtain:

$$1-P_1 = \exp\left[-\left(\frac{m-1}{m}\right)\left(\frac{X_1-K}{X_0-K}\right)^m\right] \qquad (8)$$

$$P_2 = \exp\left[-\left(\frac{m-1}{m}\right)\left(\frac{X_2-K}{X_0-K}\right)^m\right] \qquad (9)$$

The results are two equations with two unknowns, m and K. However, these equations cannot be solved directly for these two parameters. An iterative scheme was employed to solve for m and K.

Selecting an initial value of m_1, equation (8) is solved for K_1. That is:

$$-\ln(1-P_1) = \left(\frac{m_1-1}{m_1}\right)\left(\frac{X_1-K_1}{X_0-K_1}\right)^{m_1}$$

or,

$$\frac{X_1-K_1}{X_0-K_1} = \left[\left(\frac{m_1}{m_1-1}\right)(-\ln(1-P_1))\right]^{1/m_1}$$

Let A equal the right side of the equation to arrive at:

$$K_1 = \frac{X_1 - X_0 A}{1 - A}$$

Substituting K_1 and m_1 into equation (9), the value of the complementary cumulative function, call it P_2', can be calculated. The process is repeated for another value of m, say m_2, and a value P_2'' is obtained. Unless by chance the correct value of m was selected, P_2' and P_2'' are different from P_2. Define:

$$f_1 = P_2 - P_2'$$

$$f_2 = P_2 - P_2''$$

The correct value of m is the one which makes f_i equal zero. The Newton-Raphson technique was employed to select progressively improved values of m as in equation (10).

$$m_{i+1} = m_i - f_i\left(\frac{m_i - m_{i-1}}{f_i - f_{i-1}}\right) \tag{10}$$

Iteration is continued until f_i is essentially zero. In this study, iteration was ceased when $f_i \leq 0.00001$.

The Weibull probability density function is nearly symmetric (approximating the normal distribution) when the shape parameter, m, is approximately 3.5. For greater values of m, the distribution assumes a skewed shape "tailing" to the left, and for values less than 3.5, the distribution tails to the right. It should be noted, under the assumption of an unimodal distribution, m must be greater than unity, since the Weibull density is monotonically decreasing for $X > K$ when $m \leq 1$.

APPENDIX B

MATHEMATICAL DEVELOPMENT OF SUBROUTINE RANDOM

The three-parameter Weibull probability density function can be written as (Clark and Lackey 1975):

$$p(X) = \frac{m}{L^m} (X-K)^{m-1} \exp \left[-\left(\frac{X-K}{L}\right)^m\right]$$

where,

$X \geq K$

$m \geq 0$

and,

X = random variable

m = shape parameter

L = scale parameter

K = constant

The cumulative distribution function is:

$$F(X') = \int_0^{X'} p(X)dX = 1 - \exp \left[-\left(\frac{X -K}{L}\right)^m\right]$$

To produce a process generator, set $R = F(X')$, where R is a uniformly distributed random variable such that $0<R<1$. Then:

$$R = 1 - \exp \left[-\left(\frac{X'-K}{L}\right)^m\right] \qquad (1)$$

Solve (1) for the random variable X'.

$$X' = K + L \; (-\ln(1-R))^{1/m} \qquad (2)$$

Since R and $1-R$ have the same uniform distribution, equation (2) can be written as:

$$X' = K + L \; (-\ln(R))^{1/m} \qquad (3)$$

Equation (3) can be used to generate Weibully distributed random variables.

APPENDIX C

MATHEMATICAL DEVELOPMENT OF SUBROUTINE MODEX

Subroutine MODEX defines modified exponential relationships between:

(I) X = information and education expenditures

Y = number of angler-days produced by information and education

(II) X = research expenditures

Y = number of angler-days produced by research

(III) X = pounds of catchable trout stocked

Y = number of angler-days produced by catchable trout stocking

where X is the abscissa and Y is the ordinate (Fig. 9).

Relationships I and II were derived empirically. Relationship III was based on the findings of Butler and Borgeson (1965) and showed that as catchable trout stocking increased, angling pressure increased. Crowding effects, such as space limitations, make the asymptote to relationship III seem reasonable.

The general form of the modified exponential relationship is:

$$Y = K + \alpha\beta^{X} \qquad (1)$$

$$\alpha < 0$$

$$\beta < 1$$

where,

X = abscissa $\qquad$ K = asymptote

Y = ordinate $\qquad$ α, β = parameters

Equation (1) describes relationships where the amount of change in Y declines by a constant percentage as X increases (Fig. 10). Parameter α represents the distance between Y and K when X = 0. Parameter β is the ratio between successive increments of Y. A complete discussion of the modified exponential relationship is given by Croxton, Cowden, and Klein (1967).

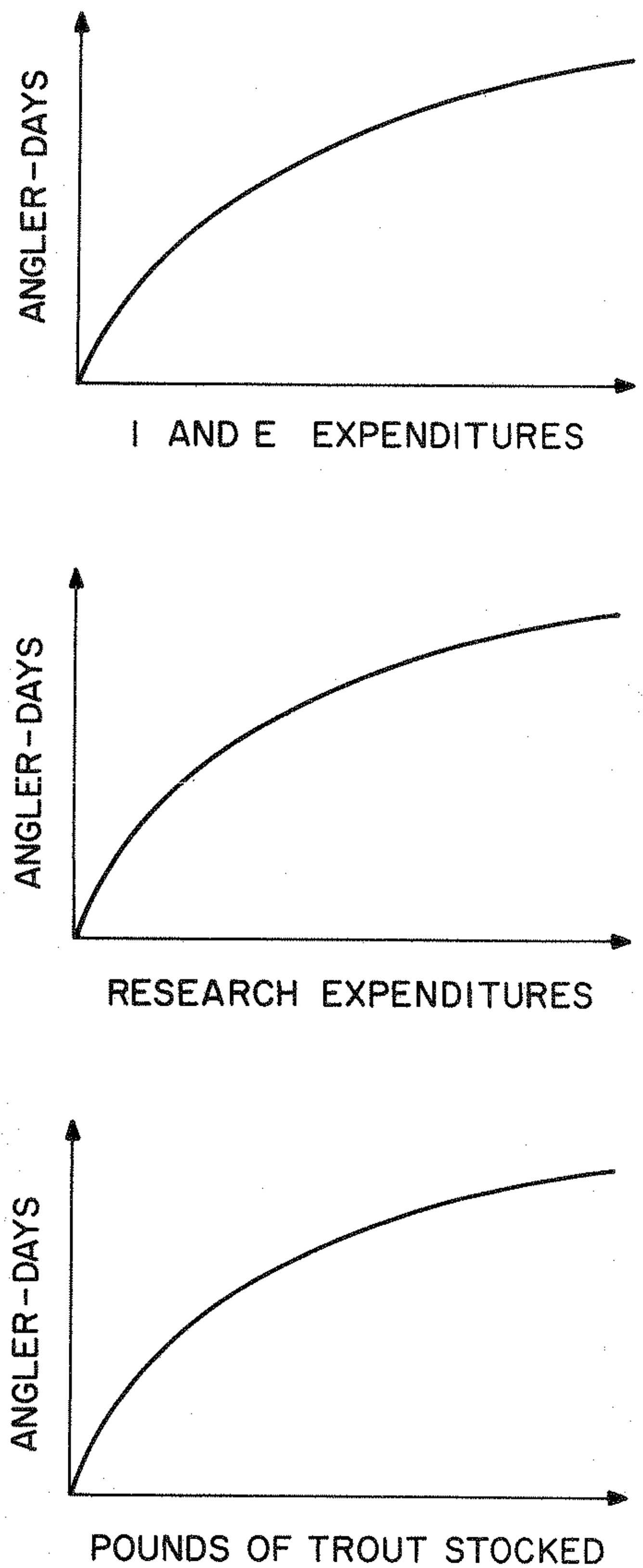


Figure 9. Modified exponential relationships in PISCES.

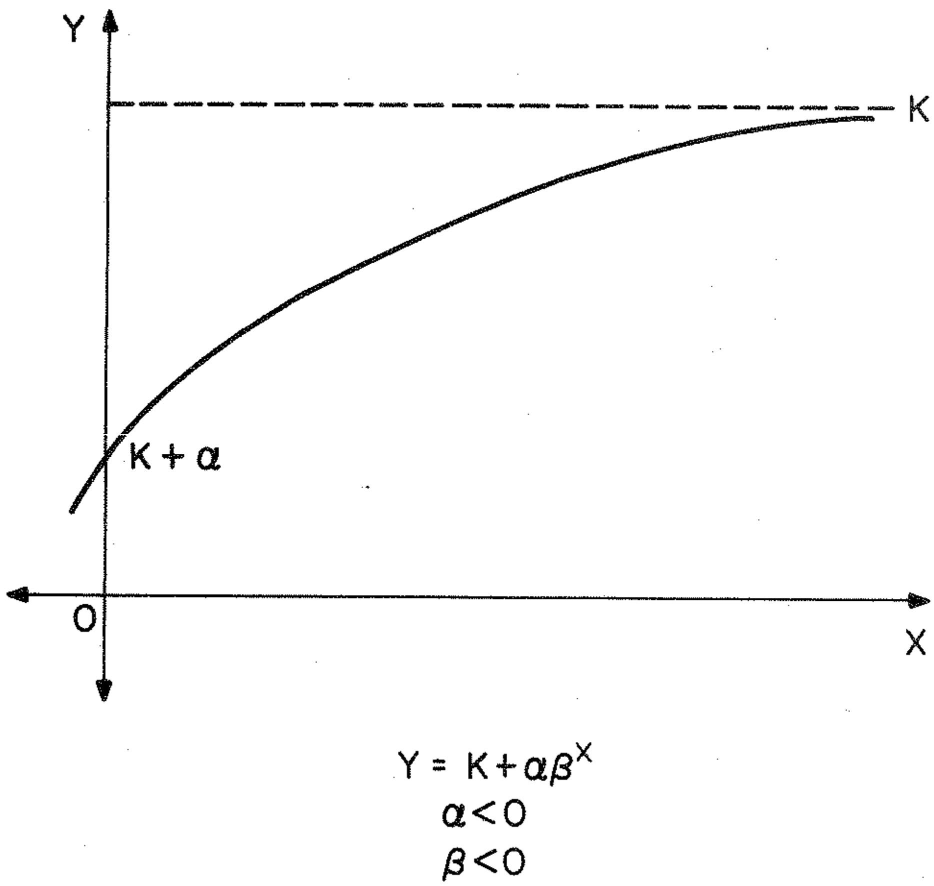


Figure 10. General form of modified exponential curve.

The asymptote, K, and the parameters, α and β, must be estimated for each of the three relationships in Fig. 9 to solve equation (1). K is estimated directly and is part of the input of PISCES. The asymptotes for these relationships are difficult to determine, but sensitivity experiments conducted during this study (Appendix D) show that great changes in the value of K have little effect upon the final MODEX prediction. The parameter α is, by definition, equal to negative K when the curve goes through the origin (Fig. 11).

In each of the three relationships, a value for X, say E, is known from last year (e.g., last year's budgets for relationships I and II and the pounds of trout stocked last year for relationship III). An estimate of the Y value, call it P, can be given a Weibull distribution as in Appendix A (Fig. 11). Then the following relationship can be formed:

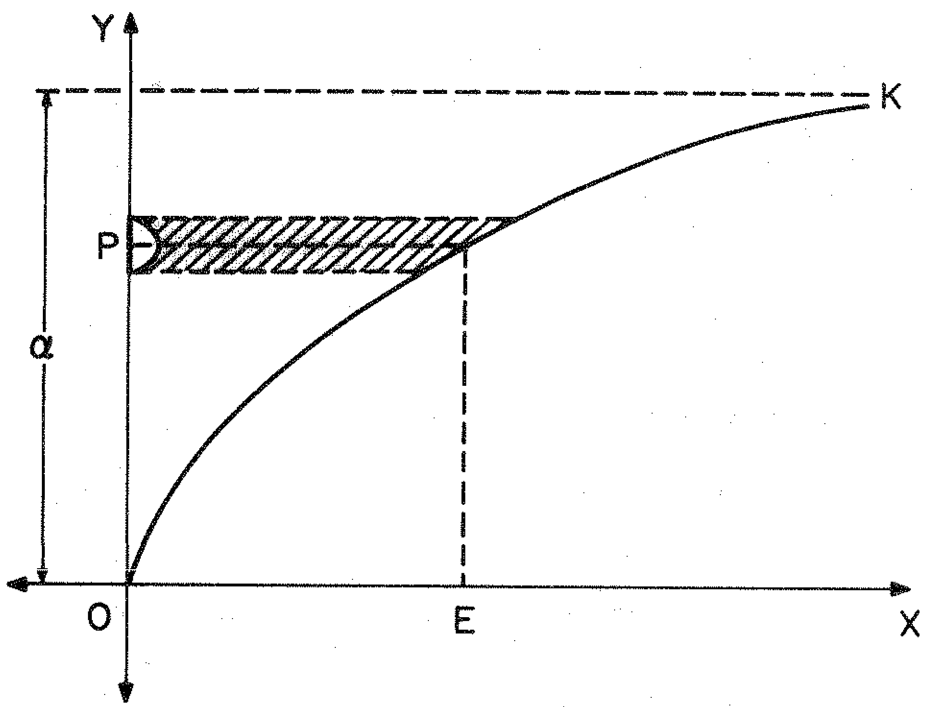
$$P = K + \alpha\beta^{E} \qquad (2)$$

Since β is the only unknown value it can be calculated as:

$$\beta = \left[\frac{(P-K)}{\alpha}\right]^{1/E}$$

Now that K, α, and β are known, this year's X value, say M, can be applied to equation (3) to give this year's prediction.

$$\text{Prediction} = K + \alpha\beta^{M} \qquad (3)$$



$P = K + \alpha\beta^{E}$

K = ASYMPTOTE

P = LAST YEAR'S Y VALUE (WEIBULL DISTRIBUTION)

E = LAST YEAR'S X VALUE

α = PARAMETER

β = PARAMETER

Figure 11. Form of modified exponential curve used in PISCES.

APPENDIX D

SENSITIVITY EXPERIMENTS ON SUBROUTINE MODEX

Control Curve

A control curve was constructed for sensitivity experiments on MODEX with the following variable values (see Appendix C, Fig. 11 for variable definitions).

$$K = 500{,}000$$

$$E = 75{,}000$$

$$P = 30{,}000 \leftrightarrow 40{,}000 \leftrightarrow 50{,}000$$

Where P varies from 30,000 to 50,000 with a most probable value of 40,000. Three different values were given to M [Appendix C, Equation (3)] in three different experimental runs. Table 19 gives the results of the control runs. It should be noted (Table 19) that in Run 2 where $M = E$, the prediction is very close to the most probable value of P ($39{,}895 \simeq 40{,}000$).

Experiment 1

Experiment 1 was conducted to test the effect of varying the width of Weibull probability distribution ranges for P upon the MODEX prediction. The low and high values of the distribution for P were varied, while other variables remained consistent with those of control runs (Table 20).

Results of experiment 1 show two important characteristics of MODEX: (1) the MODEX predictions are not sensitive to variations in range of Weibull distribution for P; (2) the standard deviations associated with the predictions show that the ranges of the output (prediction) distributions vary in width as the ranges of the P distributions vary in width.

Experiment 2

Experiment 2 was conducted in two parts. Part A tests the effect of varying the K value upon the MODEX predictions. Part B tests the effect of varying the location of the Weibull probability distribution for P.

Part A

The value of K was varied, while other variables remained consistent with those of control runs. Table 21 gives the results.

The results of Part A show that MODEX is not very sensitive to variations in the K value. These results are important because of the difficulty of precisely estimating K.

Table 19.--Results of control runs for sensitivity experiments using 50 iterations of subroutine MODEX

Run	M	Prediction (mean)	Standard deviation
1	500	277	20
2	75,000	39,895	2,824
3	500,000	212,577	11,820

Table 20.--Results of sensitivity experiment 1 using 50 iterations of subroutine MODEX

	Range of P Distribution					
	Low	Most Probable	High	M	Prediction (mean)	Standard deviation
Control	30,000	40,000	50,000	500	277	20
Narrow Range	35,000	40,000	45,000	500	277	10
Wide Range	20,000	40,000	60,000	500	277	41
Control	30,000	40,000	50,000	75,000	39,895	2,824
Narrow Range	35,000	40,000	45,000	75,000	39,947	1,412
Wide Range	20,000	40,000	60,000	75,000	39,790	5,647
Control	30,000	40,000	50,000	500,000	212,577	11,820
Narrow Range	35,000	40,000	45,000	500,000	212,947	5,888
Wide Range	20,000	40,000	60,000	500,000	212,534	23,832

Table 21.--Results of Part A of sensitivity experiment 2 using 50 iterations of subroutine MODEX

K	M	Prediction (mean)	Standard deviation
200,000	500	297	23
500,000 (control)	500	277	20
750,000	500	273	20
1,000,000	500	271	20
10,000,000	500	267	19
200,000	75,000	39,895	2,824
500,000 (control)	75,000	39,895	2,824
750,000	75,000	39,895	2,824
1,000,000	75,000	39,895	2,824
10,000,000	75,000	39,895	2,824
200,000	500,000	154,356	5,440
500,000 (control)	500,000	212,577	11,820
750,000	500,000	228,888	13,861
1,000,000	500,000	237,579	14,986
10,000,000	500,000	262,968	18,407

Part B

The location of the Weibull distribution for P was varied by changing the high, low, and most probable estimates for P. The values of all other variables remained consistent with those of control runs. Table 22 gives the results.

Results of Part B indicate that the MODEX prediction is sensitive to changes in location of the Weibull probability distribution for P.

Table 22.--Results of Part B of sensitivity experiment 2 using 50 iterations of subroutine MODEX

Location of P Distribution				
Low	Most probable	High	M	Prediction (mean)
1,900	2,000	2,100	500	13
30,000	40,000	50,000	500	277
59,000	60,000	61,000	500	426
74,000	75,000	76,000	500	541
300,000	350,000	400,000	500	4,000
1,900	2,000	2,100	75,000	1,999
30,000	40,000	50,000	75,000	39,895
59,000	60,000	61,000	75,000	59,989
74,000	75,000	76,000	75,000	74,989
300,000	350,000	400,000	75,000	349,374
1,900	2,000	2,100	500,000	13,177
30,000	40,000	50,000	500,000	212,577
59,000	60,000	61,000	500,000	286,731
74,000	75,000	76,000	500,000	330,759
300,000	350,000	400,000	500,000	499,801

APPENDIX E

VARIABLE DEFINITIONS

INPUT VARIABLES

Variable		Location		Definition
AFEE	–	REGULA	–	regression coefficient relating angler-days to license fee increases
BA(I)	–	HATCH	–	percent of catchable trout produced at Buffalo Springs hatchery going to each area (I = 1 through 12 areas)
BFEE	–	REGULA	–	regression coefficient relating angler-days to license fee increases
BUDGET(1)	–	HATCH	–	funds for Erwin hatchery
BUDGET(2)	–	HATCH	–	funds for Flintville hatchery
BUDGET(3)	–	HATCH	–	funds for Tellico hatchery
BUDGET(4)	–	HATCH	–	funds for Buffalo Springs hatchery
BUDGET(5)	–	INED	–	Information and Education budget
BUDGET(6)	–	RESEAR	–	Research budget
CM(I)	–	REGULA	–	percent of angler-days occurring in each month on marginal trout streams (I = 1 through 12 months)
CMLOST(I)	–	WATER	–	acres of marginal streams lost to fishery (I = 1 through 12 areas)
CN(I)	–	REGULA	–	percent of angler-days occurring in each month on natural trout streams (I = 1 through 12 months)

Variable		Location		Definition
CNLOST(I)	-	WATER	-	acres of natural trout streams lost to fishery (I = 1 through 12 areas)
COST(1)	-	HATCH	-	estimated cost of running Erwin hatchery at full capacity
COST(2)	-	HATCH	-	estimated cost of running Flintville hatchery at full capacity
COST(3)	-	HATCH	-	estimated cost of running Tellico hatchery at full capacity
COST(4)	-	HATCH	-	estimated cost of running Buffalo Springs hatchery at full capacity
DH,DL,DM	-	INED	-	high, low, and most probable estimates of effect upon angler-days of the information and education program from last year
EA(I)	-	HATCH	-	percent of catchable trout produced at Erwin hatchery going to each area (I = 1 through 12 areas)
EK	-	INED	-	maximum effect that an information and education program can have on angler-days in state
ERN(I)	-	INED	-	percent effort of I & E program spent on each region and fishery (I = 1 through 60, 1 through 5 = fisheries in area 1, etc.)

Variable		Location		Definition
EX	-	INED	-	last year's I & E budget
FA(I)	-	HATCH	-	percent of catchable trout produced at Flintville hatchery going to each area (I = 1 through 12 areas)
FED	-	HATCH	-	estimate of pounds of federal catchable trout produced for stocking
FEDA(I)	-	HATCH	-	percent of catchable trout produced at federal hatcheries going to each area (I = 1 through 12 areas)
FEE	-	REGULA	-	amount of license fee increase
HCH(I), HCL(I), HCM(I)	-	WATER	-	high, low, and most probable estimates of the change in angler-days per acre of marginal trout streams if gained or lost (I = 1 through 12 areas)
HNH(I), HNL(I), HNM(I)	-	WATER	-	high, low, and most probable estimates of the change in angler-days per acre of natural trout streams if gained or lost (I = 1 through 12 areas)
HPH(I), HPL(I), HPM(I)	-	WATER	-	high, low, and most probable estimates of the change in angler-days per acre of ponds and small lakes if gained or lost (I = 1 through 12 areas)

Variable	Location	Definition
HRH(I),HRL(I), HRM(I)	WATER	high, low, and most probable estimates of the change in angler-days per acre of reservoirs and large lakes if gained or lost (I = 1 through 12 areas)
HWH(I),HWL(I), HWM(I)	WATER	high, low, and most probable estimates of the change in angler-days per acre of warm streams if gained or lost (I = 1 through 12 areas)
IX	RANDU	random number seed - an odd integer with 1 to 9 digits
LDE(I,J)	ACCESS	number and location of new developed access areas which will become functional this year (I = 1 through 5 fisheries and J = 1 through 12 areas)
LUD(I,J)	ACCESS	number and location of new undeveloped access areas which will become functional this year (I = 1 through 5 fisheries and J = 1 through 12 areas)
MAXB	HATCH	maximum catchable trout production capacity of Buffalo Springs hatchery
MAXE	HATCH	maximum catchable trout production capacity of Erwin hatchery
MAXF	HATCH	maximum catchable trout production capacity of Flintville hatchery

Variable		Location		Definition
MAXT	-	HATCH	-	maximum catchable trout production capacity of Tellico hatchery
MOCM(I)	-	REGULA	-	months to be closed to angling on marginal trout streams (I = 1 through 12 months)
MOCN(I)	-	REGULA	-	months to be closed to angling on natural trout streams (I = 1 through 12 months)
MONTHS	-	REGULA	-	indicator of season length change (0 = no change, 1 = change)
MOPL(I)	-	REGULA	-	months to be closed to angling on ponds and small lakes (I = 1 through 12 months)
MORL(I)	-	REGULA	-	months to be closed to angling on reservoirs and large lakes (I = 1 through 12 months)
MOWS(I)	-	REGULA	-	months to be closed to angling on warm streams (I = 1 through 12 months)
PCM(I)	-	WATER	-	acres of marginal trout streams recruited to fishery this year (I = 1 through 12 areas)
PCN(I)	-	WATER	-	acres of natural trout streams recruited to fishery this year (I = 1 through 12 areas)
PL(I)	-	REGULA	-	percent of angler-days occurring in each month on ponds and small lakes (I = 1 through 12 months)

Variable		Location		Definition
PLLOST(I)	-	WATER	-	acres of ponds and small lakes lost to fishery (I = 1 through 12 areas)
PPL(I)	-	WATER	-	acres of ponds and small lakes recruited to fishery this year (I = 1 through 12 areas)
PRL(I)	-	WATER	-	acres of reservoirs and large lakes recruited to fishery this year (I = 1 through 12 areas)
PWS(I)	-	WATER	-	acres of warm streams recruited to fishery this year (I = 1 through 12 areas)
RATE	-	RESEAR, INED	-	estimate of inflation rate
RHP, RLP, RMP	-	RESEAR	-	high, low, and most probable estimates of effect upon angler-days of the research program from last year
RL(I)	-	REGULA	-	percent of angler-days occurring in each month on reservoirs and large lakes (I = 1 through 12 months)
RLLOST(I)	-	WATER	-	acres of reservoirs and large lakes lost to fishery (I = 1 through 12 areas)
RK	-	RESEAR	-	maximum effect that a research program can have on angler-days in the state
RN(I)	-	RESEAR	-	percent effort of research program spent on each region and fishery (I = 1 through 60, 1 through 5 = fisheries in area 1, etc.)

Variable		Location		Definition
RX	-	RESEAR	-	last year's research budget
SHP(I),SLP(I), SMP(I)	-	HATCH	-	high, low, and most probable estimates of last year's angler-day production from catchable trout stocked in marginal trout streams (I = 1 through 12 areas)
SK(I)	-	HATCH	-	maximum angler-days which can be produced in each area from catchable trout stocked in marginal trout streams (I = 1 through 12 areas)
SX(I)	-	HATCH	-	pounds of catchable trout stocked in each area in marginal trout streams last year (I = 1 through 12 areas)
TA(I)	-	HATCH	-	percent of catchable trout produced at Tellico hatchery going to each area (I = 1 through 12 areas)
TDCM(I)	-	MAIN,DRAW	-	acres of fishable marginal trout streams in each area (I = 1 through 12 areas)
TDCN(I)	-	MAIN,DRAW	-	acres of fishable natural trout streams in each area (I = 1 through 12 areas)
TDPL(I)	-	MAIN,DRAW	-	acres of fishable ponds and small lakes in each area (I = 1 through 12 areas)
TDRL(I)	-	MAIN,DRAW	-	acres of fishable reservoirs and large lakes in each area (I = 1 through 12 areas)
TDWS(I)	-	MAIN,DRAW	-	acres of fishable warm streams in each area (I = 1 through 12 areas)

Variable	Location	Definition
THP(I),TLP(I), TMP(I)	HATCH	same as SHP(I),SLP(I),SMP(I) but for reservoirs and large lakes
TK(I)	HATCH	maximum angler-days which can be produced in each area from catchable trout stocked in reservoirs and large lakes (I = 1 through 12 areas)
TL(I)	MAIN,REGULA	estimate of last year's angler-days on reservoirs and large lakes in each area (I = 1 through 12 areas)
TM(I)	MAIN,REGULA	estimate of last year's angler-days on marginal trout streams in each area (I = 1 through 12 areas)
TN(I)	MAIN,REGULA	estimate of last year's angler-days on natural trout streams in each area (I = 1 through 12 areas)
TP(I)	MAIN,REGULA	estimate of last year's angler-days on ponds and small lakes in each area (I = 1 through 12 areas)
TW(I)	MAIN,REGULA	estimate of last year's angler-days on warm streams in each area (I = 1 through 12 areas)
TX(I)	HATCH	pounds of catchable trout stocked in each area in reservoirs and large lakes last year (I = 1 through 12 areas)

Variable	Location	Definition
WS(I)	REGULA	percent of angler-days occurring in each month on warm streams (I = 1 through 12 months)
WSLOST(I)	WATER	acres of warm streams lost to fishery (I = 1 through 12 areas)
XDH(I,J)	ACCESS	high estimate for angler-day increase due to new developed access area (I = 1 through 5 fisheries, J = 1 through 12 areas)
XDL(I,J)	ACCESS	low estimate for angler-day increase due to new developed access area (I = 1 through 5 fisheries, J = 1 through 12 areas)
XDM(I,J)	ACCESS	most probable estimate for angler-day increase due to new developed access area (I = 1 through 5 fisheries, J = 1 through 12 areas)
XUH(I,J)	ACCESS	high estimate for angler-day increase due to new undeveloped access area (I = 1 through 5 fisheries, J = 1 through 12 areas)
XUL(I,J)	ACCESS	low estimate for angler-day increase due to new undeveloped access area (I = 1 through 5 fisheries, J = 1 through 12 areas)

Variable	Location	Definition
XUM(I,J)	ACCESS	most probable estimate for angler-day increase due to new undeveloped access area (I = 1 through 5 fisheries, J = 1 through 12 areas)
YR(I)	HATCH	percent of catchable trout stocked in reservoirs and large lakes for each area (I = 1 through 12 areas)
YS(I)	HATCH	percent of catchable trout stocked in marginal trout streams for each area (I = 1 through 12 areas)
ZAH,ZAL,ZAM	ACCESS	high, low, and most probable estimates of percent of angler-day increases from access area development which are new
ZEH,ZEL,ZEM	INED	high, low, and most probable estimates of percent of angler-day increases from I & E program which are new
ZH(1),ZL(1), ZM(1)	DRAW	high, low, and most probable estimates of percent of angler-days migrating which migrate from fisheries in the same area
ZH(2),ZL(2), ZM(2)	DRAW	high, low, and most probable estimates of angler-days migrating from second ranked fishery
ZH(3),ZL(3), ZM(3)	DRAW	high, low, and most probable estimates of angler-days migrating from third ranked fishery

Variable		Location		Definition
ZH(4),ZL(4), ZM(4)	-	DRAW	-	high, low, and most probable estimates of angler-days migrating from fourth ranked fishery
ZH(5),ZL(5), ZM(5)	-	DRAW	-	high, low, and most probable estimates of angler-days migrating from fifth ranked fishery
ZRH,ZRL,ZRM	-	REGULA	-	high, low, and most probable estimates of percent of angler-days lost when season is closed which do not migrate
ZWH,ZWL,ZWM	-	WATER	-	high, low, and most probable estimates of percent of angler-day increase from gain of a water type which are new (or percent angler-days lost which do not migrate when water is lost)
ZXH,ZXL,ZXM	-	RESEAR	-	high, low, and most probable estimates of percent of angler-day increases from research program which are new
ZZH(I),ZZL(I), ZZM(I)	-	MAIN	-	high, low, and most probable estimates of statewide popularity trend changes for each fishery (I = 1 through 5 fisheries)

INTERNAL VARIABLES

Variable	Location	Definition
A(I)	WATER	change in angler-days per acre of warm streams gained or lost (I = 1 through 12 areas)
AC(I)	ACCESS	change in angler-days due to new undeveloped access areas (I = 1 through 12 areas)
ACC(I)	ACCESS	change in angler-days due to new developed access areas (I = 1 through 12 areas)
ADCM(I)	MAIN, TALLY	accumulated angler-day changes on marginal trout streams (I = 1 through 12 areas)
ADCN(I)	MAIN, TALLY	accumulated angler-day changes on natural trout streams (I = 1 through 12 areas)
ADPL(I)	MAIN, TALLY	accumulated angler-day changes on ponds and small lakes (I = 1 through 12 areas)
ADR(I)	HATCH	angler-days produced on reservoirs and large lakes from catchable trout stocking (I = 1 through 12 areas)
ADS(I)	HATCH	angler-days produced on marginal trout streams from catchable trout stocking (I = 1 through 12 areas)

Variable		Location		Definition
ADRL(I)	-	MAIN, TALLY	-	accumulated angler-day changes on reservoirs and large lakes (I = 1 through 12 areas)
ADWS(I)	-	MAIN, TALLY	-	accumulated angler-day changes on warm streams (I = 1 through 12 areas)
AN(I)	-	WATER	-	change in angler-days per acre of marginal trout streams gained or lost (I = 1 through 12 areas)
ANG(I)	-	WATER	-	change in angler-days per acre of natural trout streams gained or lost (I = 1 through 12 areas)
ANGL(I)	-	WATER	-	change in angler-days per acre of ponds and small lakes gained or lost (I = 1 through 12 areas)
ANGLE(I)	-	WATER	-	change in angler-days per acre of reservoirs and large lakes gained or lost (I = 1 through 12 areas)
AREA(I)	-	WATER	-	pounds of trout stocked in each management area (I = 1 through 12 areas)
CHCM(I)	-	TALLY	-	angler-day changes on natural trout streams (I = 1 through 12 areas)
CHCN(I)	-	TALLY	-	angler-day changes on marginal trout streams (I = 1 through 12 areas)

Variable	Location	Definition
CHED(I)	INED	change in angler-days from information and education program (I = 1 through 60)
CHPL(I)	TALLY	angler-day changes on ponds and small lakes (I = 1 through 12 areas)
CHRE(I)	RESEAR	change in angler-days from research program (I = 1 through 60)
CHRL(I)	TALLY	angler-day changes on reservoirs and large lakes (I = 1 through 12 areas)
CHWS(I)	TALLY	angler-day changes on warm streams (I = 1 through 12 areas)
D(I)	DRAW	number of angler-days which will migrate (I = 1 through 12 areas)
DMCM(I)	INED, RESEAR, HATCH, ACCESS, WATER, REGULA	migrations from marginal trout streams to other marginal trout streams (I = 1 through 12 areas)
DMCN(I)	INED, RESEAR, HATCH, ACCESS, WATER, REGULA	migrations from natural trout streams to marginal trout streams (I = 1 through 12 areas)
DMPL(I)	INED, RESEAR, HATCH, ACCESS, WATER, REGULA	migrations from ponds and small lakes to marginal trout streams (I = 1 through 12 areas)

Variable	Location	Definition
DMRL(I)	INED,RESEAR, HATCH,ACCESS, WATER,REGULA	migrations from reservoirs and large lakes to marginal trout streams (I = 1 through 12 areas)
DMWS(I)	INED,RESEAR, HATCH,ACCESS, WATER,REGULA	migrations from warm streams to marginal trout streams (I = 1 through 12 areas)
DNCM(I)	INED,RESEAR, HATCH,ACCESS, WATER,REGULA	migrations from marginal trout streams to natural trout streams (I = 1 through 12 areas)
DNCN(I)	INED,REGULA, ACCESS,WATER, RESEAR	migrations from natural trout streams to other natural trout streams (I = 1 through 12 areas)
DNPL(I)	INED,REGULA, ACCESS,WATER, RESEAR	migrations from ponds and small lakes to natural trout streams (I = 1 through 12 areas)
DNRL(I)	INED,REGULA ACCESS,WATER, RESEAR	migrations from reservoirs and large lakes to natural trout streams (I = 1 through 12 areas)
DNWS(I)	INED,REGULA, ACCESS,WATER, RESEAR	migrations from warm streams to natural trout streams (I = 1 through 12 areas)

Variable		Location		Definition
DPCM(I)	–	INED,REGULA, ACCESS,WATER, RESEAR	–	migrations from marginal trout streams to ponds and small lakes (I = 1 through 12 areas)
DPCN(I)	–	INED,REGULA, ACCESS,WATER, RESEAR	–	migration from natural trout streams to ponds and small lakes (I = 1 through 12 areas)
DPPL(I)	–	INED,REGULA, ACCESS,WATER, RESEAR	–	migrations from ponds and small lakes to other ponds and small lakes (I = 1 through 12 areas)
DPRL(I)	–	INED,REGULA, ACCESS,WATER, RESEAR	–	migrations from reservoirs and large lakes to ponds and small lakes (I = 1 through 12 areas)
DPWS(I)	–	INED,REGULA, ACCESS,WATER RESEAR	–	migrations from warm streams to ponds and small lakes (I = 1 through 12 areas)
DRCM(I)	–	INED,REGULA, HATCH,ACCESS, WATER,RESEAR	–	migrations from marginal trout streams to reservoirs and large lakes (I = 1 through 12 areas)
DRCN(I)	–	INED,REGULA, HATCH,ACCESS, WATER,RESEAR	–	migrations from natural trout streams to reservoirs and large lakes (I = 1 through 12 areas)

Variable		Location		Definition
DRPL(I)	-	INED,REGULA, HATCH,ACCESS, WATER,RESEAR	-	migrations from ponds and small lakes to reservoirs and large lakes (I = 1 through 12 areas)
DRRL(I)	-	INED, REGULA, HATCH,ACCESS, WATER,RESEAR	-	migrations from reservoirs and large lakes to other reservoirs and large lakes (I = 1 through 12 areas)
DRWS(I)	-	INED,REGULA, HATCH,ACCESS WATER,RESEAR	-	migrations from warm streams to reservoirs and large lakes (I = 1 through 12 areas)
DWCM(I)	-	INED,RESEAR, ACCESS,WATER, REGULA	-	migrations from marginal trout streams to warm streams (I = 1 through 12 areas)
DWCN(I)	-	INED,RESEAR, ACCESS,WATER, REGULA	-	migrations from natural trout streams to warm streams (I = 1 through 12 areas)
DWPL(I)	-	INED,RESEAR, ACCESS,WATER, REGULA	-	migrations from ponds and small lakes to warm streams (I - 1 through 12 areas)
DWRL(I)	-	INED,RESEAR, ACCESS,WATER, REGULA	-	migrations from reservoirs and large lakes to warm streams (I = 1 through 12 areas)
DWWS(I)	-	INED,RESEAR, ACCESS,WATER, REGULA	-	migrations from warm streams to other warm streams (I = 1 through 12 areas)

Variable	Location	Definition
EAD	INED	total change in angler-days from I&E program
EP	INED	last year's total effect of I&E program on angler-days
GYPED	REGULA	percent of original angler-days left after an increase in license fee
IY	RANDU	random number seed transfer variable
J(I)	DRAW	the identities of adjacent areas (I = 1 through 4)
N	DRAW	number of areas adjacent to the area in question
P1(I), P2(I), P3(I),P4(I),P5(I)	DRAW	angler-day migrations (I = 1 through 12 areas)
PCTB	HATCH	percent of maximum production capacity at which Buffalo Springs hatchery is operating
PCTE	HATCH	percent of maximum production capacity at which Erwin hatchery is operating
PCTF	HATCH	percent of maximum production capacity at which Flintville hatchery is operating
PCTT	HATCH	percent of maximum production capacity at which Tellico hatchery is operating
Q	DRAW	the percent of migrating angler-days which will come from fisheries in the same area as the fishery in question

Variable		Location		Definition
R	-	DRAW	-	percent of new angler-days which will be created from program in question
R	-	RANDOM	-	random number (uniformly distributed)
RAD	-	RESEAR	-	total effect of research program on angler-days
RCM	-	REGULA	-	sum of monthly angler-day percentages for the closed months on marginal trout streams
RCN	-	REGULA	-	sum of monthly angler-day percentages for the closed months on natural trout streams
RP	-	RESEAR	-	last year's total effect of research program on angler-days
RPL	-	REGULA	-	sum of the monthly angler-day percentages for the closed months on ponds and small lakes
RRL	-	REGULA	-	sum of monthly angler-day percentages for the closed months on reservoirs and large lakes
SDCM(I)	-	STAT,TALLY	-	standard deviation of change in angler-days on marginal trout streams (I = 1 through 12 areas)
SDCN(I)	-	STAT,TALLY	-	standard deviation of change in angler-days on natural trout streams (I = 1 through 12 areas)
SDPL(I)	-	STAT,TALLY	-	standard deviations of change in angler-days on ponds and small lakes (I = 1 through 12 areas)

Variable		Location		Definition
SDRL(I)	-	STAT,TALLY	-	standard deviations of change in angler-days on reservoirs and large lakes (I = 1 through 12 areas)
SDWS(I)	-	STAT,TALLY	-	standard deviations of change in angler-days on warm streams (I = 1 through 12 areas)
SP(I)	-	HATCH	-	estimate of last year's angler-day production from stocking catchable trout in marginal trout streams (I = 1 through 12 areas)
SSCM(I),SSCN(I), SSPL(I),SSRL(I), SSWS(I)	-	STAT	-	sums of squares (I = 1 through 12)
SXCM(I),SXCN(I), SXPL(I),SXRL(I), SXWS(I)	-	STAT	-	transfer variables (I = 1 through 12)
TD1(I)	-	DRAW	-	acreage in each area of first ranked fishery (I = 1 through 12 areas)
TD2(I)	-	DRAW	-	acreage in each area of second ranked fishery (I = 1 through 12 areas)
TD3(I)	-	DRAW	-	acreage in each area of third ranked fishery (I = 1 through 12 areas)
TD4(I)	-	DRAW	-	acreage in each area of fourth ranked fishery (I = 1 through 12 areas)

Variable		Location		Definition
TD5(I)	-	DRAW	-	acreage in each area of fifth ranked fishery (I = 1 through 12 areas)
TR(I)	-	HATCH	-	pounds of catchable trout stocked in reservoirs and large lakes in each area (I = 1 through 12 areas)
TROUTB	-	HATCH	-	pounds of catchable trout produced at Buffalo Springs hatchery
TROUTE	-	HATCH	-	pounds of catchable trout produced at Erwin hatchery
TROUTF	-	HATCH	-	pounds of catchable trout produced at Flintville hatchery
TROUTT	-	HATCH	-	pounds of catchable trout produced at Tellico hatchery
TS(I)	-	HATCH	-	pounds of catchable trout stocked in marginal trout streams in each area (I = 1 through 12 areas)
TSCM	-	MAIN	-	total acreage of marginal trout streams in state
TSCN	-	MAIN	-	total acreage of natural trout streams in state
TSPL	-	MAIN	-	total acreage of ponds and small lakes in state
TSRL	-	MAIN	-	total acreage of reservoirs and large lakes in state

Variable		Location		Definition
TSWS	-	MAIN	-	total acreage of warm streams in state
VCM(I),VCN(I), VPL(I),VRL(I), VWS(I)	-	MAIN,TALLY	-	standard deviation accumulators (I = 1 through 12 areas)
X	-	RANDOM	-	random variable (Weibull distribution)
XB(I)	-	DRAW	-	angler-day changes before migrations (I = 1 through 12)
XBCM(I),XBCN(I), XBPL(I),XBRL(I), XBWS(I)	-	STAT,TALLY	-	average angler-day changes (I = 1 through 12 areas)
XCM(I),XCN(I), XPL(I),XRL(I), XWS(I)	-	INED,RESEAR, HATCH,ACCESS, WATER,REGULA	-	variables storing estimates of angler-day changes for each iteration (I = 1 through 50)
XH	-	WEIBUL	-	highest possible value for variable
XHIGH	-	RANDOM	-	highest possible value for variable
XK	-	RANDOM	-	location parameter of Weibull distribution
XL	-	WEIBUL	-	lowest possible parameter for variable
XLAMDA	-	RANDOM	-	scale parameter of Weibull distribution
XLOW	-	RANDOM	-	lowest possible value for variable

Variable		Location		Definition
XM	–	RANDOM	–	shape parameter of Weibull distribution
XM	–	WEIBUL	–	most probable value of variable
XMODE	–	RANDOM	–	most probable value of variable
Y(I)	–	DRAW	–	percent of angler-days migrating from fisheries ranked 1 through 5 (I = 1 through 5)
YFL	–	RANDU	–	uniformly distributed random variable
YH,YL,YM	–	DRAW	–	high, low, and most probable estimates of the percent of new angler-days which will be created from a management program
YN1,YN2,YN3, YN4,YN5	–	DRAW	–	number of angler-days migrating from fisheries ranked 1 through 5
ZA	–	MODEX	–	parameter of modified exponential relationship (distance between Y and K when X = 0)
ZAD	–	MODEX	–	angler-day prediction
ZB	–	MODEX	–	parameter of modified exponential relationship (ratio between successive increments of Y)
ZE	–	MODEX	–	last year's budget for program in question

Variable		Location		Definition
ZHP,ZLP,ZMP	-	MODEX	-	high, low, and most probable estimates of last year's effect on angler-days of program in question
ZHR,ZLR,ZMR	-	MODEX	-	high, low, and most probable estimates of minimum program budget which will affect angler-days
ZIP	-	MODEX	-	double precision exponent
ZK	-	MODEZ	-	asymptote of modified exponential relationship
ZK	-	WEIBUL	-	location parameter for Weibull distribution
ZM	-	MODEX	-	budget for program in question
ZM	-	WEIBUL	-	shape parameter of Weibull distribution
ZP	-	MODEX	-	last year's effect on angler-days of program in question
ZZ(I)	-	MAIN	-	statewide popularity trend estimates for each fishery (I = 1 through 5 fisheries)

APPENDIX F

INPUT FOR HYPOTHETICAL APPLICATION

Background Data

The following are background data for the hypothetical application listed according to the formats required by PISCES (APPENDIX G). Variable names are in the right margin, and variable definitions are given in APPENDIX E.

ANGLER-DAYS REALIZED IN PREVIOUS YEAR

94110.	60630.	49456.	165311.	140833.	87736.	TW-1
135815.	61642.	37458.	31160.	81088.	106200.	TW-2
0.0	0.0	24210.	26166.	13950.	12740.	TM-1
25620.	32890.	43395.	1823.	130140.	130226.	TM-2
0.0	0.0	0.0	0.0	0.0	0.0	TN-1
0.0	0.0	4288.	7648.	8544.	19380.	TN-2
665296.	509464.	65640.	336840.	236814.	177336.	TP-1
544195.	92166.	52371.	35025.	38265.	58174.	TP-2
0.0	0.0	2944690.	1514975.	27160.	583500.	TL-1
193120.	293420.	772240.	666342.	724090.	433410.	TL-2

HIGH, LOW, AND MOST PROBABLE VALUES FOR DRAW

.96	.98	1.0			ZTL,M,H
.40	.50	.60			ZAL,M,H
.96	.98	1.0			ZWL,M,H
.88	.90	.92			ZRL,M,H
.70	.80	.90			ZEL,M,H
.65	.75	.85			ZXL,M,H
.70	.20	.20	.10	.01	ZL
.80	.25	.25	.15	.02	ZM
.90	.30	.30	.20	.03	ZH

HIGH, LOW, AND MOST PROBABLE VALUES FOR POPULARITY TREND

9000.	200.	100.	40000.	85000.	ZZL
10000.	284.	189.	43064.	89200.	ZZM
11000.	350.	250.	45000.	93000.	ZZH

HIGH, LOW, AND MOST PROBABLE VALUES FOR WATER

2.	2.	1.	5.	5.	5.	12.	8.	10.	10.	8.	15.	HWL
6.	6.	4.	13.	10.	10.	23.	17.	20.	18.	14.	24.	HWM
10.	10.	7.	21.	15.	15.	30.	25.	28.	26.	20.	30.	HWH
0.	0.	12.	30.	40.	40.	90.	35.	35.	110.	100.	100.	HCL

0.	0.	30.	42.	62.	60.	122.	55.	55.	140.	135.	149.	HCM
0.	0.	40.	50.	75.	75.	145.	70.	70.	160.	155.	170.	HCH
0.	0.	0.	0.	0.	0.	0.	0.	10.	10.	10.	10.	HNL
0.	0.	0.	0.	0.	0.	0.	0.	16.	16.	16.	17.	HNM
0.	0.	0.	0.	0.	0.	0.	0.	25.	25.	25.	25.	HNH
35.	35.	4.	30.	45.	45.	100.	25.	25.	15.	10.	25.	HPL
43.	43.	8.	40.	58.	54.	127.	33.	33.	25.	15.	34.	HPM
55.	55.	12.	55.	75.	70.	145.	50.	50.	35.	20.	50.	HPH
0.	0.	15.	20.	20.	20.	5.	5.	5.	10.	12.	5.	HRL
0.	0.	23.	35.	28.	30.	8.	10.	10.	11.	19.	10.	HRM
0.	0.	30.	50.	35.	40.	12.	18.	18.	20.	25.	15.	HRH

HIGH, LOW, AND MOST PROBABLE VALUES FOR HATCH

0.0	0.0	20000.	24000.	10000.	10000.	SLP-1
22000.	28500.	37000.	1400.	118000.	118000.	SLP-2
0.0	0.0	24210.	26166.	13950.	12740.	SMP-1
25620.	32890.	43395.	1823.	130140.	130226.	SMP-2
0.0	0.0	28000.	30000.	17000.	15000.	SHP-1
28000.	35000.	47000.	2000.	150000.	150000.	SHP-2
0.0	0.0	3000.	3000.	10.	1000.	TLP-1
10.	300.	8000.	400.	2500.	1500.	TLP-2
0.0	0.0	4000.	4000.	100.	2000.	TMP-1
100.	400.	9000.	500.	3500.	2000.	TMP-2

0.0	0.0	5000.	5000.	300.	3000.	THP-1
200.	500.	10000.	600.	5000.	2500.	THP-2

HIGH, LOW, AND MOST PROBABLE VALUES FOR ACCESS

1200.	1500.	500.	3000.	2500.	XDL-1
1200.	1500.	500.	3000.	2500.	XDL-2
1200.	1500.	500.	3000.	2500.	XDL-3
1200.	1500.	500.	3000.	2500.	XDL-4
1200.	1500.	500.	3000.	2500.	XDL-5
1200.	1500.	500.	3000.	2500.	XDL-6
1200.	1500.	500.	3000.	2500.	XDL-7

1200.	1500.	500.	3000.	2500.	XDL-8
1200.	1500.	500.	3000.	2500.	XDL-9
1200.	1500.	500.	3000.	2500.	XDL-10
1200.	1500.	500.	3000.	2500.	XDL-11
1200.	1500.	500.	3000.	2500.	XDL-12
3000.	3000.	2000.	5000.	4500.	XDM-1
3000.	3000.	2000.	5000.	4500.	XDM-2
3000.	3000.	2000.	5000.	4500.	XDM-3
3000.	3000.	2000.	5000.	4500.	XDM-4
3000.	3000.	2000.	5000.	4500.	XDM-5
3000.	3000.	2000.	5000.	4500.	XDM-6

3000.	3000.	2000.	5000.	4500.	XDM-7
3000.	3000.	2000.	5000.	4500.	XDM-8
3000.	3000.	2000.	5000.	4500.	XDM-9
3000.	3000.	2000.	5000.	4500.	XDM-10
3000.	3000.	2000.	5000.	4500.	XDM-11
3000.	3000.	2000.	5000.	4500.	XDM-12
5000.	5000.	3500.	9000.	8500.	XDH-1
5000.	5000.	3500.	9000.	8500.	XDH-2
5000.	5000.	3500.	9000.	8500.	XDH-3
5000.	5000.	3500.	9000.	8500.	XDH-4
5000.	5000.	3500.	9000.	8500.	XDH-5

5000.	5000.	3500.	9000.	8500.	XDH-6
5000.	5000.	3500.	9000.	8500.	XDH-7
5000.	5000.	3500.	9000.	8500.	XDH-8
5000.	5000.	3500.	9000.	8500.	XDH-9
5000.	5000.	3500.	9000.	8500.	XDH-10
5000.	5000.	3500.	9000.	8500.	XDH-11
5000.	5000.	3500.	9000.	8500.	XDH-12
100.	300.	100.	500.	500.	XUL-1
100.	300.	100.	500.	500.	XUL-2
100.	300.	100.	500.	500.	XUL-3
100.	300.	100.	500.	500.	XUL-4

100.	300.	100.	500.	500.	XUL-5
100.	300.	100.	500.	500.	XUL-6
100.	300.	100.	500.	500.	XUL-7
100.	300.	100.	500.	500.	XUL-8
100.	300.	100.	500.	500.	XUL-9
100.	300.	100.	500.	500.	XUL-10
100.	300.	100.	500.	500.	XUL-11
100.	300.	100.	500.	500.	XUL-12
800.	900.	500.	1500.	1500.	XUM-1
800.	900.	500.	1500.	1500.	XUM-2
800.	900.	500.	1500.	1500.	XUM-3

800.	900.	500.	1500.	1500.	XUM-4
800.	900.	500.	1500.	1500.	XUM-5
800.	900.	500.	1500.	1500.	XUM-6
800.	900.	500.	1500.	1500.	XUM-7
800.	900.	500.	1500.	1500.	XUM-8
800.	900.	500.	1500.	1500.	XUM-9
800.	900.	500.	1500.	1500.	XUM-10
800.	900.	500.	1500.	1500.	XUM-11
800.	900.	500.	1500.	1500.	XUM-12
1400.	1500.	1000.	2000.	2000.	XUH-1
1400.	1500.	1000.	2000.	2000.	XUH-2

1400.	1500.	1000.	2000.	2000.	XUH-3
1400.	1500.	1000.	2000.	2000.	XUH-4
1400.	1500.	1000.	2000.	2000.	XUH-5
1400.	1500.	1000.	2000.	2000.	XUH-6
1400.	1500.	1000.	2000.	2000.	XUH-7
1400.	1500.	1000.	2000.	2000.	XUH-8
1400.	1500.	1000.	2000.	2000.	XUH-9
1400.	1500.	1000.	2000.	2000.	XUH-10
1400.	1500.	1000.	2000.	2000.	XUH-11
1400.	1500.	1000.	2000.	2000.	XUH-12

HIGH, LOW, AND MOST PROBABLE VALUES FOR INED

8000.   10000.   12000.   DL,DM,DH

HIGH, LOW, AND MOST PROBABLE VALUES FOR RESEAR

30000.   50000.   75000.   RLP,M,H

LAST YEAR'S BUDGETS

95000. 50000. EX,RX

ACRES OF WATER RECRUITED TO FISHERIES

10.	0.	0.	0.	0.	0.	0.	0.	42.	25.	6.	0.	PWS
0.	00.	0.	0.	0.	42.	16.	0.	0.	0.	0.	0.	PCM
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	PCN
0.	131.	0.	0.	0.	0.	0.	0.	0.	0.	0.	18.	PPL
0.	0.	0.	0.	0.	1207.	4498.	0.	0.	0.	0.	0.	PRL

ACRES OF WATER LOST TO FISHERIES

0.	526.	0.	15.	0.	76.	199.	0.	0.	0.	0.	4.	WSLOST
0.	0.	0.	0.	0.	0.	26.	39.	0.	0.	67.	0.	CMLOST
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	CNLOST
0.	0.	0.	10.	0.	0.	0.	0.	32.	0.	0.	0.	PLLOST
0.	0.	0.	0.	0.	0.	0.	0.	0.	135.	0.	0.	RLLOST

RANDOM NUMBER SEED

1973 IX

COSTS OF RUNNING HATCHERIES AT FULL CAPACITY

55000.	55000.	50000.	30000.	COST

INFLATION RATE

.05	RATE

ASYMPTOTES FOR HATCH

0.0	0.0	75000.	75000.	50000.	50000.	SK-1
75000.	100000.	125000.	8000.	500000.	500000.	SK-2
0.0	0.0	300000.	150000.	3000.	60000.	TK-1
20000.	30000.	80000.	70000.	70000.	45000.	TK-2

ASYMPTOTES FOR RESEAR

1000000.	200000.	EK,RK

MAXIMUM POUNDS OF FISH WHICH CAN BE PRODUCED AT EACH HATCHERY

57600	87600	90800	25000	MAX-

POUNDS OF FEDERAL TROUT PRODUCED

45000.	FED

ACRES OF FISHABLE WATER IN EACH AREA

15293.	9852.	10843.	10326.	10857.	6764.	TDWS-1
5716.	2803.	1665.	3116.	4350.	3682.	TDWS-2
0.0	0.0	708.	506.	191.	194.	TDCM-1
203.	478.	610.	10.	724.	727.	TDCM-2
0.0	0.0	0.0	0.0	0.0	0.0	TDCN-1
0.0	0.0	199.	382.	401.	949.	TDCN-2
11418.	8744.	3323.	3966.	2948.	2371.	TDPL-1
2254.	1396.	755.	659.	1130.	880.	TDPL-2
0.0	0.0	128030.	43285.	970.	19450.	TDRL-1
24140.	29342.	77224.	60622.	38110.	43341.	TDRL-2

NUMBER OF TROUT STOCKED IN EACH AREA LAST YEAR

0.0	0.0	2683.	5885.	9130.	8560.	SX-1
9947.	13050.	34800.	85.	59334.	61595.	SX-2
0.0	0.0	4567.	4815.	480.	2140.	TX-1
203.	1450.	14900.	1015.	3845.	1905.	TX-2

Management Policy Decisions

The following list of data represents the management policy decisions for the hypothetical application. Data are listed according to the formats required by PISCES (APPENDIX G). Variable names are in right margin, and variable definitions are given in APPENDIX E.

BUDGET EXPENDITURES

43000.	40000.	38000.	23000.	100000.	50000.	BUDGET

LOCATIONS OF NEW ACCESS AREAS

0	0	0	0	0	0	0	0	1	0	LDE-1
0	0	0	0	0	0	0	0	0	0	LDE-2
0	0	0	0	0	0	0	0	0	1	LDE-3
0	0	0	0	1	0	0	0	0	0	LDE-4
0	0	0	0	0	0	0	0	0	0	LDE-5
0	0	0	0	0	0	0	0	0	0	LDE-6

0	0	0	0	0	0	0	0	1	0	LUD-1
0	0	0	0	0	0	0	0	0	0	LUD-2
0	0	0	0	0	0	0	0	0	2	LUD-3
0	0	0	0	3	0	0	0	0	0	LUD-4
0	0	0	0	0	0	0	0	0	0	LUD-5
0	0	0	0	0	0	0	0	0	0	LUD-6

REGULATION CHANGES

1	MONTHS
0.0	FEE

MONTHS TO BE CLOSED TO ANGLING

0	0	0	0	0	0	0	0	0	0	0	0	MOWS
1	2	3	0	0	0	0	0	0	0	11	12	MOCM
1	2	3	0	0	0	0	0	0	0	11	12	MOCN
0	0	0	0	0	0	0	0	0	0	0	0	MOPL
0	0	0	0	0	0	0	0	0	0	0	0	MORL

PERCENT EFFORT IN EACH AREA OF I&E AND RESEARCH PROGRAMS

.03	.00	.00	.04	.00	.02	.00	.00	.10	.00	ERN-1
.02	.01	.00	.04	.04	.02	.01	.00	.03	.02	ERN-2
.02	.01	.00	.06	.00	.02	.01	.00	.03	.03	ERN-3
.02	.01	.00	.00	.03	.02	.01	.00	.00	.01	ERN-4
.02	.01	.00	.03	.03	.02	.01	.01	.00	.03	ERN-5
.03	.03	.01	.00	.02	.03	.03	.01	.00	.02	ERN-6
.01	.00	.00	.02	.00	.01	.00	.00	.05	.00	RN-1
.02	.00	.00	.05	.09	.01	.00	.00	.02	.05	RN-2
.01	.00	.00	.03	.03	.01	.01	.00	.03	.04	RN-3
.01	.01	.00	.02	.04	.02	.00	.00	.02	.03	RN-4

.02	.00	.00	.01	.06	.02	.00	.00	.01	.06	RN-5
.02	.01	.00	.02	.04	.02	.01	.00	.02	.04	RN-6

WHERE TROUT FROM EACH HATCHERY WILL BE STOCKED

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	EA
0.0	0.0	0.0	0.0	.02	.14	.16	.23	.42	.02	.01	0.0	FA
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.26	0.0	.70	.04	TA
0.0	0.0	.38	.46	.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	BA

PERCENT OF TROUT STOCKED IN RESERVOIRS AND STREAMS IN EACH AREA

.00	.00	.63	.45	.05	.20	.02	.10	.30	.93	.06	.03	YR
.00	.00	.37	.55	.95	.80	.98	.90	.70	.07	.94	.97	YS

WHERE FEDERAL TROUT WILL BE STOCKED

0.0	0.0	0.0	.04	.12	.04	0.0	0.0	.11	0.0	.34	.35	FEDA

PERCENT OF ANGLER-DAYS OCCURRING IN EACH MONTH FOR EACH FISHERY

.03	.03	.03	.08	.13	.15	.15	.13	.13	.08	.03	.03	WS
.03	.03	.03	.15	.15	.13	.13	.08	.13	.08	.03	.03	CM
.03	.03	.03	.15	.15	.13	.13	.08	.13	.08	.03	.03	CN
.03	.03	.03	.08	.08	.15	.15	.13	.13	.08	.03	.03	PL
.03	.03	.03	.08	.08	.15	.15	.13	.13	.08	.03	.03	RL

APPENDIX G

SOURCE DECK LISTING OF PISCES

```
C                                                                             ***
C                                                                             ***
C              ************                                                   ***
C              ************                                                   ***
C              ** PISCES **                                                   ***
C              ************                                                   ***
C              ************                                                   ***
C                                                                             ***
C                                                                             ***
C                                                                             ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,               ***
     1                BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),         ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK                     ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12),      ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),       ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,         ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,    RHP,RK, RL(12***
     8),    RLLOST(12),RLP,          RMP,    RN(60),RX,        SHP(12),      ***
     9SK(12)          ,SLP(12),                SMP(12),        SX(12),       ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),          THP(12***
     1),TK(12) ,TL(12),         TLP(12),         TM(12),        TMP(12),     ***
     2          TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                            ***
      DIMENSION CHWS(12),CHCM(12),CHCN(12),CHPL(12),CHRL(12),XBWS(12),        ***
     *XBCM(12),XBCN(12),XBPL(12),XBRL(12),SDWS(12),SDCM(12),SDCN(12),         ***
     *SDPL(12),SDRL(12)                                                       ***
      DATA TSWS,TSCM,TSCN,TSPL,TSRL,CHWS,CHCM,CHCN,CHPL,CHRL/65*0.0/          ***
```

```
      CALL INPUT
      CALL ENVIRO
      DO 93  I=1,12
      VWS(I)=0.0
      VCM(I)=0.0
      VCN(I)=0.0
      VPL(I)=0.0
      VRL(I)=0.0
      ADWS(I)=0.0
      ADCM(I)=0.0
      ADCN(I)=0.0
      ADPL(I)=0.0
   93 ADRL(I)=0.0
      WRITE(6,700)
  700 FORMAT(1H1,T50,'ANGLER-DAYS FROM LAST YEAR')
      CALL OUTPUT(TW,TM,TN,TP,TL)
C     TREND IN POPULARITY OF ANGLING
      DO 20  I=1,12
      TSWS=TSWS+TDWS(I)
      TSCM=TSCM+TDCM(I)
      TSCN=TSCN+TDCN(I)
      TSPL=TSPL+TDPL(I)
   20 TSRL=TSRL+TDRL(I)
      DO 150  M=1,50
      DO 15  I=1,5
      CALL RANDOM(ZZL(I),ZZM(I),ZZH(I),IX,IY,ZZ(I))
   15 CONTINUE
      DO 18  I=1,12
      CHWS(I)=CHWS(I)-(ZZ(1)/TSWS)*TDWS(I)
      CHCM(I)=CHCM(I)+(ZZ(2)/TSCM)*TDCM(I)
      CHCN(I)=CHCN(I)+(ZZ(3)/TSCN)*TDCN(I)
      CHPL(I)=CHPL(I)+(ZZ(4)/TSPL)*TDPL(I)
```

```
18    CHRL(I)=CHRL(I)+(ZZ(5)/TSRL)*TDRL(I)
      DO 71  I=1,12
      J=I+(12*M-12)
      XWS(J)=CHWS(I)
      XCM(J)=CHCM(I)
      XCN(J)=CHCN(I)
      XPL(J)=CHPL(I)
71    XRL(J)=CHRL(I)
      DO 123  I=1,12
      CHWS(I)=0.0
      CHCM(I)=0.0
      CHCN(I)=0.0
      CHPL(I)=0.0
123   CHRL(I)=0.0
150   CCNTINUE
      CALL STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,SDCM,S
     *DCN,SDPL,SDRL)
      CALL TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS,SDCM,
     *SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,70)
70    FORMAT(1H1,T52,'POPULARITY TREND')
      CALL OUTPUT(XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,80)
80    FORMAT(1H1,T52,'POPULARITY TREND - STANDARD DEVIATIONS')
      CALL OUTPUT(SDWS,SDCM,SDCN,SDPL,SDRL)
      CALL ACCESS
      CALL WATER
      CALL INED
      CALL RESEAR
      CALL HATCH
      IF(MONTHS.EQ.0.AND.FEE.EQ.0.0)GOTO8
      CALL REGULA
```

```
8     CONTINUE
      WRITE(6,601)
601   FORMAT(1H1,T53,'ANGLER-DAY CHANGE FOR YEAR')
      CALL OUTPUT(ADWS,ADCM,ADCN,ADPL,ADRL)
      WRITE(6,705)
705   FORMAT(1H1,T50,'CHANGE FOR YEAR - STANDARD DEVIATIONS')
      CALL OUTPUT(VWS,VCM,VCN,VPL,VRL)
      DO 810  I=1,12
      ADWS(I)=ADWS(I)+TW(I)
      ADCM(I)=ADCM(I)+TM(I)
      ADCN(I)=ADCN(I)+TN(I)
      ADPL(I)=ADPL(I)+TP(I)
810   ADRL(I)=ADRL(I)+TL(I)
      WRITE(6,930)
930   FORMAT(1H1,T55,'ANGLER-DAY PREDICTION')
      CALL OUTPUT(ADWS,ADCM,ADCN,ADPL,ADRL)
4     STOP
      END
```

```
      SUBROUTINE INPUT                                                  ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,         ***
     1                BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),   ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK              ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12), ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),  ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,    ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,    RHP,RK, RL(12***
     8),    RLLOST(12),RLP,          RMP,    RN(60),RX,        SHP(12),  ***
     9SK(12)           ,SLP(12),                 SMP(12),        SX(12), ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),         THP(12***
     1),TK(12)  ,TL(12),          TLP(12),        TM(12),        TMP(12), ***
     2           TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                       ***
C BUDGET EXPENDITURES                                                   ***
      READ(5,1)BUDGET                                                   ***
 1    FORMAT(6F10.2)                                                    ***
C     LAST YEAR'S BUDGETS                                               ***
      READ(5,2)EX,RX                                                    ***
 2    FORMAT(2F10.2)                                                    ***
C ACRES OF WATER RECRUITED TO FISHERIES                                 ***
      READ(5,3)PWS,PCM,PCN,PPL,PRL                                      ***
 3    FORMAT(12F6.0/12F6.0/12F6.0/12F6.0/12F6.0)                        ***
C ACRES OF WATER LOST                                                   ***
      READ(5,3)WSLOST,CMLOST,CNLOST,PLLOST,RLLOST                       ***
C ACCESS AREAS                                                          ***
      READ(5,8)LDE                                                      ***
```

```
      READ(5,8)LUD
 8    FORMAT(10I5/10I5/10I5/10I5/10I5/10I5)
C REGULATIONS
      READ(5,11)MONTHS
 11   FORMAT(I1)
      READ(5,12)FEE
 12   FORMAT(F5.2)
      IF(MONTHS.EQ.0)GOTO10
      READ(5,13)MOWS
      READ(5,13)MOCM
      READ(5,13)MOCN
      READ(5,13)MOPL
      READ(5,13)MORL
 13   FORMAT(12I5)
 10   CONTINUE
C PERCENT EFFORT IN EACH AREA OF I&E AND RESEARCH PROGRAMS
      READ(5,4)ERN,RN
 4    FORMAT(10F5.2/10F5.2/10F5.2/10F5.2/10F5.2/10F5.2/10F5.2/10F5.2/10F
     *5.2/10F5.2/10F5.2/10F5.2)
C ANGLER-DAYS REALIZED IN PREVIOUS YEAR
      READ(5,15)TW,TM,TN,TP,TL
 15   FORMAT(6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F1
     *0.0/6F10.0)
C RANDOM NUMBER SEED
      READ(5,16)IX
 16   FORMAT(I9)
      RETURN
      END
```

```
      SUBROUTINE ENVIRO                                                  ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,          ***
     1                 BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),   ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK                   ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12), ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),  ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,    ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,     RHP,RK, RL(12***
     8),     RLLOST(12),RLP,          RMP,    RN(60),RX,         SHP(12),   ***
     9SK(12)          ,SLP(12),                  SMP(12),          SX(12),   ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),          THP(12***
     1),TK(12) ,TL(12),           TLP(12),          TM(12),         TMP(12),  ***
     2            TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                        ***
C     COST PER MANAGEMENT UNIT                                           ***
      READ(5,1)COST                                                      ***
 1    FORMAT(4F10.2)                                                     ***
C     INFLATION RATE                                                     ***
      READ(5,4)RATE                                                      ***
 4    FORMAT(F5.2)                                                       ***
C     REGRESSION COEFFICIENTS                                            ***
      IF(FEE.EQ.0.0)GO TO 3                                              ***
      READ(5,23)AFEE,BFEE                                                ***
 23   FORMAT(2F10.2)                                                     ***
 3    CONTINUE                                                           ***
C HIGH, LOW, AND MOST LIKELY VALUES                                      ***
C     FOR DRAW                                                           ***
```

```
      READ(5,70)ZTL,ZTM,ZTH                                                  ***
      READ(5,70)ZAL,ZAM,ZAH                                                  ***
      READ(5,70)ZWL,ZWM,ZWH                                                  ***
      READ(5,70)ZRL,ZRM,ZRH                                                  ***
      READ(5,70)ZEL,ZEM,ZEH                                                  ***
      READ(5,70)ZXL,ZXM,ZXH                                                  ***
 70   FORMAT(3F10.2)                                                         ***
      READ(5,71)ZL,ZM,ZH                                                     ***
 71   FORMAT(5F10.2/5F10.2/5F10.2)                                           ***
C FOR POPULARITY TREND                                                        ***
      READ(5,71)ZZL,ZZM,ZZH                                                  ***
C FOR WATER                                                                  ***
      READ(5,5)HWL,HWM,HWH                                                   ***
      READ(5,5)HCL,HCM,HCH                                                   ***
      READ(5,5)HNL,HNM,HNH                                                   ***
      READ(5,5)HPL,HPM,HPH                                                   ***
      READ(5,5)HRL,HRM,HRH                                                   ***
 5    FORMAT(12F6.0/12F6.0/12F6.0)                                           ***
C FOR HATCH                                                                  ***
      READ(5,9)SLP,SMP,SHP                                                   ***
      READ(5,9)TLP,TMP,THP                                                   ***
      READ(5,90)SK,TK                                                        ***
 90   FORMAT(6F10.0/6F10.0/6F10.0/6F10.0)                                    ***
C FOR ACCESS                                                                 ***
      READ(5,6)XDL                                                           ***
      READ(5,6)XDM                                                           ***
      READ(5,6)XDH                                                           ***
      READ(5,6)XUL                                                           ***
      READ(5,6)XUM                                                           ***
      READ(5,6)XUH                                                           ***
 6    FORMAT(5F10.0/5F10.0/5F10.0/5F10.0/5F10.0/5F10.0/5F10.0/5F10.0/5F1***
     *0.0/5F10.0/5F10.0/5F10.0)                                              ***
```

```
C FOR I&E
      READ(5,7)DL,DM,DH
C FOR RESEAR
      READ(5,7)RLP,RMP,RHP
      READ(5,23)EK,RK
 7    FORMAT(3F10.0)
 9    FORMAT(6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F10.0)
C ACRES OF FISHABLE WATER IN EACH AREA
      READ(5,10)TDWS,TDCM,TDCN,TDPL,TDRL
 10   FORMAT(6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F10.0/6F1
     *0.0/6F10.0)
C MAXIMUM NUMBER OF FISH WHICH CAN BE PRODUCED AT EACH HATCHERY
      READ(5,12)MAXE,MAXF,MAXT,MAXB
 12   FORMAT(4I10)
C WHERE TROUT WILL BE STOCKED
      READ(5,2)EA,FA,TA,BA
 2    FORMAT(12F6.2/12F6.2/12F6.2/12F6.2)
C PERCENT OF TROUT STOCKED IN EACH AREA
      READ(5,15)YR,YS
 15   FORMAT(12F6.2/12F6.2)
C FEDERAL TROUT PRODUCED
      READ(5,16)FED
 16   FORMAT(F10.0)
C WHERE FEDERAL TROUT GO
      READ(5,17)FEDA
 17   FORMAT(12F6.2)
C TROUT STOCKED LAST YEAR
      READ(5,30)SX,TX
 30   FORMAT(6F10.0/6F10.0/6F10.0/6F10.0)
C PERCENT OF ANGLER-DAYS IN EACH MONTH
      IF(MONTHS.EQ.0)GOTO 13
      READ(5,14)WS,CM,CN,PL,RL
```

```
14    FORMAT(12F5.2/12F5.2/12F5.2/12F5.2/12F5.2)
13    RETURN
      END
```

```
      SUBROUTINE HATCH                                                   ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,          ***
     1              BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),      ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK                  ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12), ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),   ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,     ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,    RHP,RK, RL(12***
     8),     RLLOST(12),RLP,          RMP,     RN(60),RX,        SHP(12),   ***
     9SK(12)          ,SLP(12),                 SMP(12),         SX(12),    ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),        THP(12***
     1),TK(12) ,TL(12),          TLP(12),        TM(12),         TMP(12),   ***
     2          TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                        ***
      DIMENSION AREA(12),CHWS(12),CHCM(12),CHCN(12),CHPL(12),CHRL(12),   ***
     *ADS(12),ADR(12),TR(12),TS(12),SP(12),PP(12),XBWS(12),XBCM(1        ***
     *2),XBCN(12),XBPL(12),XBRL(12),SDWS(12),SDCM(12),SDCN(12),SDPL(12),***
     *SDRL(12),DRWS(12),DRCM(12),DRCN(12),DRPL(12),DRRL(12),DMWS(12),    ***
     *DMCM(12),DMCN(12),DMPL(12),DMRL(12)                                ***
      DATA AREA,CHWS,CHCM,CHCN,CHPL,CHRL/72*0.0/                         ***
C CALCULATE THE POUNDS OF TROUT PRODUCED AT EACH HATCHERY                ***
      PCTF=BUDGET(2)/COST(2)                                             ***
      PCTT=BUDGET(3)/COST(3)                                             ***
      PCTE=BUDGET(1)/COST(1)                                             ***
      PCTB=BUDGET(4)/COST(4)                                             ***
      TROUTE=MAXF*PCTE                                                   ***
      TROUTF=MAXF*PCTF                                                   ***
```

```
      TROUTT=MAXT*PCTT                                                  ***
      TROUTB=MAXB*PCTB                                                  ***
C     WHERE FISH GO                                                     ***
      DO 1  I=1,12                                                      ***
 1    AREA(I)=AREA(I)+TROUTE*EA(I)+TROUTF*FA(I)+TROUTT*TA(I)+TROUTB*BA(I***
     *)+FED*FEDA(I)                                                     ***
C DETERMINE THE POUNDS OF TROUT STOCKED IN EACH FISHERY IN A GIVEN AREA ***
      DO 2  I=1,12                                                      ***
      TR(I)=AREA(I)*YR(I)                                               ***
 2    TS(I)=AREA(I)*YS(I)                                               ***
C DETERMINE ANGLER-DAYS GENERATED ON RESERVOIRS                         ***
      DO 12  M=1,50                                                     ***
      DO 4  I=1,12                                                      ***
      IF(TR(I).LT.10.0)GOTO3                                            ***
      CALL MODEX(TLP(I),TMP(I),THP(I),TK(I),TX(I),TR(I),ADR(I),RP(I),   ***
     *IX,IY)                                                            ***
      GOTO 4                                                            ***
 3    ADR(I)=0.0                                                        ***
 4    CONTINUE                                                          ***
C DETERMINE ANGLER-DAYS GENERATED ON STREAMS                            ***
      DO 6  I=1,12                                                      ***
      IF(TS(I).LT.10.0)GOTO5                                            ***
      CALL MODEX(SLP(I),SMP(I),SHP(I),SK(I),SX(I),TS(I),ADS(I),SP(I),   ***
     *IX,IY)                                                            ***
      GO TO 6                                                           ***
 5    ADS(I)=0.0                                                        ***
 6    CONTINUE                                                          ***
C DETERMINE NET ANGLER-DAY CHANGE                                       ***
C ON RESERVOIRS                                                         ***
      DO 8  I=1,12                                                      ***
      IF(ADR(I).EQ.0.0)GOTO7                                            ***
      CHRL(I)=ADR(I)-RP(I)                                              ***
```

```
      GOTO 8
 7    CHRL(I)=0.0
 8    CONTINUE
C ON STREAMS
      DO 10  I=1,12
      IF(ADS(I).EQ.0.0)GOTO9
      CHCM(I)=ADS(I)-SP(I)
      GO TO 10
 9    CHCM(I)=0.0
 10   CONTINUE
      CALL DRAW(CHRL,ZTL,ZTM,ZTH,ZL,ZM,ZH,TDRL,TDPL,TDWS,TDCM,TDCN,DRRL,
     *DRPL,DRWS,DRCM,DRCN,IX,IY)
      CALL DRAW(CHCM,ZTL,ZTM,ZTH,ZL,ZM,ZH,TDCM,TDCN,TDWS,TDPL,TDRL,DMCM,
     *DMCN,DMWS,DMPL,DMRL,IX,IY)
      DO 500  I=1,12
      CHWS(I)=CHWS(I)-DRWS(I)-DMWS(I)
      CHCM(I)=CHCM(I)-DRCM(I)-DMCM(I)
      CHCN(I)=CHCN(I)-DRCN(I)-DMCN(I)
      CHPL(I)=CHPL(I)-DRPL(I)-DMPL(I)
 500  CHRL(I)=CHRL(I)-DRRL(I)-DMRL(I)
      DO 13  I=1,12
      J=I+(12*M-12)
      XWS(J)=CHWS(I)
      XCM(J)=CHCM(I)
      XCN(J)=CHCN(I)
      XPL(J)=CHPL(I)
 13   XRL(J)=CHRL(I)
      DO 123  I=1,12
      CHWS(I)=0.0
      CHCM(I)=0.0
      CHCN(I)=0.0
      CHPL(I)=0.0
```

```
123   CHRL(I)=0.0
12    CONTINUE
      CALL STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,SDCM,S
     *DCN,SDPL,SDRL)
      CALL TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS,SDCM,
     *SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,700)
700   FORMAT(1H1,T47,'ANGLER-DAY CHANGE DUE TO TROUT STOCKED')
      CALL OUTPUT(XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,800)
800   FORMAT(1H1,T50,'TROUT STOCKED - STANDARD DEVIATIONS')
      CALL OUTPUT(SDWS,SDCM,SDCN,SDPL,SDRL)
      RETURN
      END
```

```
      SUBROUTINE ACCESS                                                    ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,           ***
     1                BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),     ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK                ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12), ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),   ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,      ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,     RHP,RK, RL(12***
     8),     RLLOST(12),RLP,          RMP,     RN(60),RX,       SHP(12),   ***
     9SK(12)            ,SLP(12),                  SMP(12),      SX(12),   ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),          THP(12***
     1),TK(12) ,TL(12),         TLP(12),         TM(12),          TMP(12),  ***
     2         TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                          ***
      DIMENSION ACC(5,12),AC(5,12),CHWS(12),CHCM(12),CHCN(12),CHPL(12),C***
     *HRL(12),XBWS(12),DWWS(12),DWCM(12),DWCN(12),DWPL(12),DWRL(12)       ***
     *,XBCM(12),XBCN(12),XBPL(12),XBRL(12),SDWS(12),SDCM(12),SDCN(12),SD***
     *PL(12),SDRL(12),DMWS(12),DMCM(12),DMCN(12),DMPL(12),DMRL(12),       ***
     *DNWS(12),DNCM(12),DNCN(12),DNPL(12),DNRL(12),DPWS(12),DPCM(12),     ***
     *DPCN(12),DPPL(12),DPRL(12),DRWS(12),DRCM(12),DRCN(12),DRPL(12),     ***
     *DRRL(12)                                                             ***
      DATA ACC,AC,CHWS,CHCM,CHCN,CHPL,CHRL/180*0.0/                        ***
C     CALCULATE THE EFFECT OF ACCESS AREAS ON ANGLER-DAYS                  ***
      DO 22  M=1,50                                                        ***
      I=0                                                                  ***
    9 J=0                                                                  ***
   10 I=I+1                                                                ***
```

```
      IF(I.EQ.6)GOTO12
 11   J=J+1
      IF(J.EQ.13)GO TO 9
      IF(LDE(I,J).LT.1)GOTO 11
      CALL RANDOM(XDL(I,J),XDM(I,J),XDH(I,J),IX,IY,ACC(I,J))
      IF(I.EQ.1)CHWS(J)=CHWS(J)+ACC(I,J)*LDE(I,J)
      IF(I.EQ.2)CHCM(J)=CHCM(J)+ACC(I,J)*LDE(I,J)
      IF(I.EQ.3)CHCN(J)=CHCN(J)+ACC(I,J)*LDE(I,J)
      IF(I.EQ.4)CHPL(J)=CHPL(J)+ACC(I,J)*LDE(I,J)
      IF(I.EQ.5)CHRL(J)=CHRL(J)+ACC(I,J)*LDE(I,J)
      IF(J.EQ.12)GOTO 9
      GOTO 11
 12   CONTINUE
      I=0
 13   J=0
 14   I=I+1
      IF(I.EQ.6)GOTO 16
 15   J=J+1
      IF(J.EQ.13)GOTO 13
      IF(LUD(I,J).LT.1)GOTO 15
      CALL RANDOM(XUL(I,J),XUM(I,J),XUH(I,J),IX,IY,AC(I,J))
      IF(I.EQ.1)CHWS(J)=CHWS(J)+AC(I,J)*LUD(I,J)
      IF(I.EQ.2)CHCM(J)=CHCM(J)+AC(I,J)*LUD(I,J)
      IF(I.EQ.3)CHCN(J)=CHCN(J)+AC(I,J)*LUD(I,J)
      IF(I.EQ.4)CHPL(J)=CHPL(J)+AC(I,J)*LUD(I,J)
      IF(I.EQ.5)CHRL(J)=CHRL(J)+AC(I,J)*LUD(I,J)
      IF(J.EQ.12)GOTO 13
      GOTO 15
 16   CONTINUE
      CALL DRAW(CHWS,ZAL,ZAM,ZAH,ZL,ZM,ZH,TOWS,TDPL,TDCM,TORL,TDCN,DWWS,
     *DWPL,DWCM,DWRL,DWCN,IX,IY)
      CALL DRAW(CHCM,ZAL,ZAM,ZAH,ZL,ZM,ZH,TDCM,TDCN,TOWS,TDPL,TORL,DMCM,
```

```
     *DMCN,DMWS,DMPL,DMRL,IX,IY)                                       ***
      CALL DRAW(CHCN,ZAL,ZAM,ZAH,ZL,ZM,ZH,TDCN,TDCM,TDWS,TDPL,TDRL,DNCN,***
     *DNCM,DNWS,DNPL,DNRL,IX,IY)                                       ***
      CALL DRAW(CHPL,ZAL,ZAM,ZAH,ZL,ZM,ZH,TDPL,TDRL,TDWS,TDCM,TDCN,DPPL,***
     *DPRL,DPWS,DPCM,DPCN,IX,IY)                                       ***
      CALL DRAW(CHRL,ZAL,ZAM,ZAH,ZL,ZM,ZH,TDRL,TDPL,TDWS,TDCM,TDCN,DRRL,***
     *DRPL,DRWS,DRCM,DRCN,IX,IY)                                       ***
      DO 500  I=1,12                                                   ***
      CHWS(I)=CHWS(I)-DWWS(I)-DMWS(I)-DNWS(I)-DPWS(I)-DRWS(I)          ***
      CHCM(I)=CHCM(I)-DWCM(I)-DMCM(I)-DNCM(I)-DPCM(I)-DRCM(I)          ***
      CHCN(I)=CHCN(I)-DWCN(I)-DMCN(I)-DNCN(I)-DPCN(I)-DRCN(I)          ***
      CHPL(I)=CHPL(I)-DWPL(I)-DMPL(I)-DNPL(I)-DPPL(I)-DRPL(I)          ***
 500  CHRL(I)=CHRL(I)-DWRL(I)-DMRL(I)-DNRL(I)-DPRL(I)-DRRL(I)          ***
      DO 23  I=1,12                                                    ***
      J=I+(12*M-12)                                                    ***
      XWS(J)=CHWS(I)                                                   ***
      XCM(J)=CHCM(I)                                                   ***
      XCN(J)=CHCN(I)                                                   ***
      XPL(J)=CHPL(I)                                                   ***
 23   XRL(J)=CHRL(I)                                                   ***
      DO 123  I=1,12                                                   ***
      CHWS(I)=0.0                                                      ***
      CHCM(I)=0.0                                                      ***
      CHCN(I)=0.0                                                      ***
      CHPL(I)=0.0                                                      ***
 123  CHRL(I)=0.0                                                      ***
 22   CONTINUE                                                         ***
      CALL STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,SDCM,S***
     *DCN,SDPL,SDRL)                                                   ***
      CALL TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS,SDCM,***
     *SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)                         ***
      WRITE(6,700)                                                     ***
```

```
700   FORMAT(1H1,T47,'ANGLER-DAY CHANGE DUE TO ACCESS CHANGE')
      CALL OUTPUT(XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,800)
800   FORMAT(1H1,T50,'ACCESS CHANGE - STANDARD DEVIATIONS')
      CALL OUTPUT(SDWS,SDCM,SDCN,SDPL,SDRL)
      RETURN
      END
```

```
      SUBROUTINE REGULA                                                 ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,         ***
     1               BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),    ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK                  ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12), ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),  ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,    ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,    RHP,RK, RL(12***
     8),    RLLOST(12),RLP,         RMP,     RN(60),RX,         SHP(12),  ***
     9SK(12)          ,SLP(12),                  SMP(12),        SX(12),  ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),        THP(12***
     1),TK(12) ,TL(12),          TLP(12),         TM(12),        TMP(12),  ***
     2         TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                       ***
      DIMENSION CHWS(12),CHCM(12),CHCN(12),CHPL(12),CHRL(12),XBWS(12),XB***
     *CM(12),XBCN(12),XBPL(12),XBRL(12),SDWS(12),SDCM(12),SDCN(12),SDPL(***
     *12),SDRL(12),                                                     ***
     *DWWS(12),DWCM(12),DWCN(12),DWPL(12),DWRL(12),DMWS(12),DMCM(12),   ***
     *DMCN(12),DMPL(12),DMRL(12),                                       ***
     *DNWS(12),DNCM(12),DNCN(12),DNPL(12),DNRL(12),DPWS(12),DPCM(12),   ***
     *DPCN(12),DPPL(12),DPRL(12),DRWS(12),DRCM(12),DRCN(12),DRPL(12),   ***
     *DRRL(12)                                                          ***
      DATA RWS,RCM,RCN,RPL,RRL/5*0.0/                                   ***
      IF(MONTHS.EQ.0.AND.FEE.GT.0.0)GOTO5                               ***
C     REDUCTION IN SEASON LENGTH                                        ***
      DO 1  I=1,12                                                      ***
      IF(MOWS(I).EQ.I)RWS=RWS+WS(I)                                     ***
```

```
      IF(MOCM(I).EQ.I)RCM=RCM+CM(I)
      IF(MOCN(I).EQ.I)RCN=RCN+CN(I)
      IF(MOPL(I).EQ.I)RPL=RPL+PL(I)
      IF(MORL(I).EQ.I)RRL=RRL+RL(I)
1     CONTINUE
      DO 10  M=1,50
C     ADJUST ANGLER-DAYS
      DO 2  I=1,12
      CHWS(I)=-(TW(I)+ADWS(I))*RWS
      CHCM(I)=-(TM(I)+ADCM(I))*RCM
      CHCN(I)=-(TN(I)+ADCN(I))*RCN
      CHPL(I)=-(TP(I)+ADPL(I))*RPL
2     CHRL(I)=-(TL(I)+ADRL(I))*RRL
      CALL DRAW(CHWS,ZRL,ZRM,ZRH,ZL,ZM,ZH,TDWS,TDPL,TDCM,TDRL,TDCN,DWWS,
     *DWPL,DWCM,DWRL,DWCN,IX,IY)
      CALL DRAW(CHCM,ZRL,ZRM,ZRH,ZL,ZM,ZH,TDCM,TDCN,TDWS,TDPL,TDRL,DMCM,
     *DMCN,DMWS,DMPL,DMRL,IX,IY)
      CALL DRAW(CHCN,ZRL,ZRM,ZRH,ZL,ZM,ZH,TDCN,TDCM,TDWS,TDPL,TDRL,DNCN,
     *DNCM,DNWS,DNPL,DNRL,IX,IY)
      CALL DRAW(CHPL,ZRL,ZRM,ZRH,ZL,ZM,ZH,TDPL,TDRL,TDWS,TDCM,TDCN,DPPL,
     *DPRL,DPWS,DPCM,DPCN,IX,IY)
      CALL DRAW(CHRL,ZRL,ZRM,ZRH,ZL,ZM,ZH,TDRL,TDPL,TDWS,TDCM,TDCN,DRRL,
     *DRPL,DRWS,DRCM,DRCN,IX,IY)
      DO 500  I=1,12
      CHWS(I)=CHWS(I)-DWWS(I)-DMWS(I)-DNWS(I)-DPWS(I)-DRWS(I)
      CHCM(I)=CHCM(I)-DWCM(I)-DMCM(I)-DNCM(I)-DPCM(I)-DRCM(I)
      CHCN(I)=CHCN(I)-DWCN(I)-DMCN(I)-DNCN(I)-DPCN(I)-DRCN(I)
      CHPL(I)=CHPL(I)-DWPL(I)-DMPL(I)-DNPL(I)-DPPL(I)-DRPL(I)
500   CHRL(I)=CHRL(I)-DWRL(I)-DMRL(I)-DNRL(I)-DPRL(I)-DRRL(I)
      DO 9  I=1,12
      J=I+(12*M-12)
      XWS(J)=CHWS(I)
```

```
      XCM(J)=CHCM(I)                                                   ***
      XCN(J)=CHCN(I)                                                   ***
      XPL(J)=CHPL(I)                                                   ***
 9    XRL(J)=CHRL(I)                                                   ***
10    CONTINUE                                                         ***
      CALL STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,SDCM,S***
     *DCN,SDPL,SDRL)                                                   ***
      CALL TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS,SDCM,***
     *SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)                         ***
      WRITE(6,669)                                                     ***
669   FORMAT(1H1,T45,'ANGLER-DAY CHANGE FROM SHORTENING SEASON')       ***
      CALL OUTPUT(XBWS,XBCM,XBCN,XBPL,XBRL)                            ***
      WRITE(6,800)                                                     ***
800   FORMAT(1H1,T45,'SHORTENING SEASON - STANDARD DEVIATIONS')        ***
      CALL OUTPUT(SDWS,SDCM,SDCN,SDPL,SDRL)                            ***
C     INCREASE IN LICENSE FEE                                          ***
      IF(FEE.EQ.0.0)GOTO 30                                            ***
 5    GYPED=AFEE+BFEE*FEE                                              ***
C     ADJUST ANGLER-DAYS                                               ***
      DO 3  I=1,12                                                     ***
      CHWS(I)=CHWS(I)-(TW(I)+ADWS(I))*(1.0-GYPED)                      ***
      CHCM(I)=CHCM(I)-(TM(I)+ADCM(I))*(1.0-GYPED)                      ***
      CHCN(I)=CHCN(I)-(TN(I)+ADCN(I))*(1.0-GYPED)                      ***
      CHPL(I)=CHPL(I)-(TP(I)+ADPL(I))*(1.0-GYPED)                      ***
      CHRL(I)=CHRL(I)-(TL(I)+ADRL(I))*(1.0-GYPED)                      ***
      ADWS(I)=ADWS(I)+CHWS(I)                                          ***
      ADCM(I)=ADCM(I)+CHCM(I)                                          ***
      ADCN(I)=ADCN(I)+CHCN(I)                                          ***
      ADPL(I)=ADPL(I)+CHPL(I)                                          ***
 3    ADRL(I)=ADRL(I)+CHRL(I)                                          ***
      WRITE(6,700)                                                     ***
700   FORMAT(1H1,T45,'ANGLER-DAY CHANGE DUE TO LICENSE FEE INCREASE')  ***
```

```
      CALL OUTPUT(CHWS,CHCM,CHCN,CHPL,CHRL)
30    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WATER                                                  ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,         ***
     1                BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),   ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK                 ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12), ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),  ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,    ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,    RHP,RK, RL(12***
     8),     RLLOST(12),RLP,         RMP,    RN(60),RX,      SHP(12),   ***
     9SK(12)          ,SLP(12),                SMP(12),       SX(12),   ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),        THP(12***
     1),TK(12) ,TL(12),        TLP(12),         TM(12),        TMP(12), ***
     2          TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                       ***
      DIMENSION CHWS(12),CHCM(12),CHCN(12),CHPL(12),CHRL(12),A(12),AN(12***
     *),ANG(12),ANGL(12),ANGLE(12),                                     ***
     *                XBWS(12),XBCM(12),XBCN(12),XBPL(12),XBRL(12),SDWS(12)***
     *,SDCM(12),SDCN(12),SDPL(12),SDRL(12),                             ***
     *DWWS(12),DWCM(12),DWCN(12),DWPL(12),DWRL(12),DMWS(12),DMCM(12),   ***
     *DMCN(12),DMPL(12),DMRL(12),                                       ***
     *DNWS(12),DNCM(12),DNCN(12),DNPL(12),DNRL(12),DPWS(12),DPCM(12),   ***
     *DPCN(12),DPPL(12),DPRL(12),DRWS(12),DRCM(12),DRCN(12),DRPL(12),   ***
     *DRRL(12)                                                          ***
      DATA CHWS,CHCM,CHCN,CHPL,CHRL/60*0.0/                             ***
      DO 1  I=1,12                                                      ***
    1 IF(PRL(I).GT.0.0.AND.WSLOST(I)+CMLOST(I)+CNLOST(I)+PLLOST(I).LT.25***
     *.0)WRITE(6,2)                                                     ***
```

```
2     FORMAT(1H1,/////////////////////1X,'ERROR: IF RESERVOIR ACREAGE IS ***
     *GAINED THERE MUST BE A LOSS OF SOME OTHER TYPE OF WATER.')       ***
C DETERMINE THE CHANGE IN ANGLER-DAYS PER ACRE                          ***
      DO 81  M=1,50                                                     ***
      DO 7  I=1,12                                                      ***
      IF(PWS(I)-WSLOST(I).EQ.0.0)GOTO3                                  ***
      CALL RANDOM(HWL(I),HWM(I),HWH(I),IX,IY,A(I))                      ***
3     IF(PCM(I)-CMLOST(I).EQ.0.0)GOTO4                                  ***
      CALL RANDOM(HCL(I),HCM(I),HCH(I),IX,IY,AN(I))                     ***
4     IF(PCN(I)-CNLOST(I).EQ.0.0)GOTO5                                  ***
      CALL RANDOM(HNL(I),HNM(I),HNH(I),IX,IY,ANG(I))                    ***
5     IF(PPL(I)-PLLOST(I).EQ.0.0)GOTO6                                  ***
      CALL RANDOM(HPL(I),HPM(I),HPH(I),IX,IY,ANGL(I))                   ***
6     IF(PRL(I)-RLLOST(I).EQ.0.0)GOTO7                                  ***
      CALL RANDOM(HRL(I),HRM(I),HRH(I),IX,IY,ANGLE(I))                  ***
7     CONTINUE                                                          ***
C DETERMINE TOTAL CHANGE IN ANGLER-DAYS FOR EACH FISHERY IN EACH AREA   ***
      DO 70  I=1,12                                                     ***
      IF(PWS(I)-WSLOST(I).EQ.0.0)GOTO30                                 ***
      CHWS(I)=CHWS(I)+(PWS(I)-WSLOST(I))*A(I)                           ***
30    IF(PCM(I)-CMLOST(I).EQ.0.0)GOTO40                                 ***
      CHCM(I)=CHCM(I)+(PCM(I)-CMLOST(I))*AN(I)                          ***
40    IF(PCN(I)-CNLOST(I).EQ.0.0)GOTO50                                 ***
      CHCN(I)=CHCN(I)+(PCN(I)-CNLOST(I))*ANG(I)                         ***
50    IF(PPL(I)-PLLOST(I).EQ.0.0)GOTO60                                 ***
      CHPL(I)=CHPL(I)+(PPL(I)-PLLOST(I))*ANGL(I)                        ***
60    IF(PRL(I)-RLLOST(I).EQ.0.0)GOTO70                                 ***
      CHRL(I)=CHRL(I)+(PRL(I)-RLLOST(I))*ANGLE(I)                       ***
70    CONTINUE                                                          ***
      CALL DRAW(CHWS,ZWL,ZWM,ZWH,ZL,ZM,ZH,TDWS,TDPL,TDCM,TDRL,TDCN,DWWS,***
     *DWPL,DWCM,DWRL,DWCN,IX,IY)                                        ***
      CALL DRAW(CHCM,ZWL,ZWM,ZWH,ZL,ZM,ZH,TDCM,TDCN,TDWS,TDPL,TDRL,DMCM,***
```

```
      *DMCN,DMWS,DMPL,DMRL,IX,IY)                                             ***
       CALL DRAW(CHCN,ZWL,ZWM,ZWH,ZL,ZM,ZH,TDCN,TDCM,TDWS,TDPL,TDRL,DNCN,***
      *DNCM,DNWS,DNPL,DNRL,IX,IY)                                             ***
       CALL DRAW(CHPL,ZWL,ZWM,ZWH,ZL,ZM,ZH,TDPL,TDRL,TDWS,TDCM,TDCN,DPPL,***
      *DPRL,DPWS,DPCM,DPCN,IX,IY)                                             ***
       CALL DRAW(CHRL,ZWL,ZWM,ZWH,ZL,ZM,ZH,TDRL,TDPL,TDWS,TDCM,TDCN,DRRL,***
      *DRPL,DRWS,DRCM,DRCN,IX,IY)                                             ***
       DO 500  I=1,12                                                         ***
       CHWS(I)=CHWS(I)-DWWS(I)-DMWS(I)-DNWS(I)-DPWS(I)-DRWS(I)                ***
       CHCM(I)=CHCM(I)-DWCM(I)-DMCM(I)-DNCM(I)-DPCM(I)-DRCM(I)                ***
       CHCN(I)=CHCN(I)-DWCN(I)-DMCN(I)-DNCN(I)-DPCN(I)-DRCN(I)                ***
       CHPL(I)=CHPL(I)-DWPL(I)-DMPL(I)-DNPL(I)-DPPL(I)-DRPL(I)                ***
500    CHRL(I)=CHRL(I)-DWRL(I)-DMRL(I)-DNRL(I)-DPRL(I)-DRRL(I)                ***
       DO 71  I=1,12                                                          ***
       J=I+(12*M-12)                                                          ***
       XWS(J)=CHWS(I)                                                         ***
       XCM(J)=CHCM(I)                                                         ***
       XCN(J)=CHCN(I)                                                         ***
       XPL(J)=CHPL(I)                                                         ***
71     XRL(J)=CHRL(I)                                                         ***
       DO 123  I=1,12                                                         ***
       CHWS(I)=0.0                                                            ***
       CHCM(I)=0.0                                                            ***
       CHCN(I)=0.0                                                            ***
       CHPL(I)=0.0                                                            ***
123    CHRL(I)=0.0                                                            ***
81     CONTINUE                                                               ***
       CALL STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,SDCM,S***
      *DCN,SDPL,SDRL)                                                         ***
       CALL TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS,SDCM,***
      *SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)                               ***
       WRITE(6,700)                                                           ***
```

```
700   FORMAT(1H1,T44,'ANGLER-DAY CHANGE DUE TO WATER GAIN OR LOSS')
      CALL OUTPUT(XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,800)
800   FORMAT(1H1,T50,'WATER GAIN OR LOSS - STANDARD DEVIATIONS')
      CALL OUTPUT(SDWS,SDCM,SDCN,SDPL,SDRL)
10    RETURN
      END
```

```
      SUBROUTINE INED                                                   ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,         ***
     1             BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),      ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK                ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12), ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),  ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,    ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLCST(12),PPL(12),PRL(12),PWS(12),RATE,    RHP,RK, RL(12***
     8),    RLLOST(12),RLP,         RMP,    RN(60),RX,        SHP(12),  ***
     9SK(12)          ,SLP(12),                 SMP(12),       SX(12),  ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),        THP(12***
     1),TK(12) ,TL(12),         TLP(12),         TM(12),       TMP(12), ***
     2         TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                       ***
      DIMENSION CHWS(12),CHCM(12),CHCN(12),CHPL(12),CHRL(12),CHED(60),  ***
     *XBWS(12),XBCM(12),XBCN(12),                                       ***
     *           XBPL(12),XBRL(12),SDWS(12),SDCM(12),SDCN(12),SDPL(12),S***
     *DRL(12),                                                          ***
     *DWWS(12),DWCM(12),DWCN(12),DWPL(12),DWRL(12),DMWS(12),DMCM(12),   ***
     *DMCN(12),DMPL(12),DMRL(12),                                       ***
     *DNWS(12),DNCM(12),DNCN(12),DNPL(12),DNRL(12),DPWS(12),DPCM(12),   ***
     *DPCN(12),DPPL(12),DPRL(12),DRWS(12),DRCM(12),DRCN(12),DRPL(12),   ***
     *DRRL(12)                                                          ***
      DATA CHWS,CHCM,CHCN,CHPL,CHRL/60*0.0/                             ***
C     INFLATION                                                         ***
      BUDGET(5)=BUDGET(5)*(1.0-RATE)                                    ***
      DO 4  M=1,50                                                      ***
```

```
      CALL MODEX(DL,DM,DH,EK,EX,BUDGET(5),EAD,EP,IX,IY)
C     ADJUST ANGLER DAYS
      DO 1  I=1,60
 1    CHED(I)=EAD*ERN(I)
      DO 2  I=1,12
      J=I*5-4
      CHWS(I)=CHWS(I)+CHED(J)
      CHCM(I)=CHCM(I)+CHED(J+1)
      CHCN(I)=CHCN(I)+CHED(J+2)
      CHPL(I)=CHPL(I)+CHED(J+3)
 2    CHRL(I)=CHRL(I)+CHED(J+4)
      CALL DRAW(CHWS,ZEL,ZEM,ZEH,ZL,ZM,ZH,TDWS,TDPL,TDCM,TDRL,TDCN,DWWS,
     *DWPL,DWCM,DWRL,DWCN,IX,IY)
      CALL DRAW(CHCM,ZEL,ZEM,ZEH,ZL,ZM,ZH,TDCM,TDCN,TDWS,TDPL,TDRL,DMCM,
     *DMCN,DMWS,DMPL,DMRL,IX,IY)
      CALL DRAW(CHCN,ZEL,ZEM,ZEH,ZL,ZM,ZH,TDCN,TDCM,TDWS,TDPL,TDRL,DNCN,
     *DNCM,DNWS,DNPL,DNRL,IX,IY)
      CALL DRAW(CHPL,ZEL,ZEM,ZEH,ZL,ZM,ZH,TDPL,TDRL,TDWS,TDCM,TDCN,DPPL,
     *DPRL,DPWS,DPCM,DPCN,IX,IY)
      CALL DRAW(CHRL,ZEL,ZEM,ZEH,ZL,ZM,ZH,TDRL,TDPL,TDWS,TDCM,TDCN,DRRL,
     *DRPL,DRWS,DRCM,DRCN,IX,IY)
      DO 500  I=1,12
      CHWS(I)=CHWS(I)-DWWS(I)-DMWS(I)-DNWS(I)-DPWS(I)-DRWS(I)
      CHCM(I)=CHCM(I)-DWCM(I)-DMCM(I)-DNCM(I)-DPCM(I)-DRCM(I)
      CHCN(I)=CHCN(I)-DWCN(I)-DMCN(I)-DNCN(I)-DPCN(I)-DRCN(I)
      CHPL(I)=CHPL(I)-DWPL(I)-DMPL(I)-DNPL(I)-DPPL(I)-DRPL(I)
 500  CHRL(I)=CHRL(I)-DWRL(I)-DMRL(I)-DNRL(I)-DPRL(I)-DRRL(I)
      DO 5  I=1,12
      J=I+(12*M-12)
      XWS(J)=CHWS(I)
      XCM(J)=CHCM(I)
      XCN(J)=CHCN(I)
```

```
      XPL(J)=CHPL(I)
5     XRL(J)=CHRL(I)
      DO 123  I=1,12
      CHWS(I)=0.0
      CHCM(I)=0.0
      CHCN(I)=0.0
      CHPL(I)=0.0
123   CHRL(I)=0.0
4     CONTINUE
      CALL STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,SDCM,S
     *DCN,SDPL,SDRL)
      CALL TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS,SDCM,
     *SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,3)
3     FORMAT(1H1,T35,'ANGLER-DAY INCREASE DUE TO INFORMATION AND EDUCATI
     *CN PROGRAM')
      CALL OUTPUT(XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,800)
800   FORMAT(1H1,T50,'INFORMATION AND EDUCATION - STANDARD DEVIATIONS')
      CALL OUTPUT(SDWS,SDCM,SDCN,SDPL,SDRL)
      RETURN
      END
```

```
      SUBROUTINE RESEAR                                                    ***
      COMMON ADCM(12),ADCN(12),ADPL(12),ADRL(12),ADWS(12),AFEE,           ***
     1               BA(12),BFEE,BUDGET(6),CM(12),CMLOST(12),CN(12),      ***
     2CNLOST(12),COST(4),DH,DL,DM,EA(12),EK               ,ERN(60),EX***
     3,FA(12),FED,FEDA(12),FEE,HCH(12),HCL(12),HCM(12),HNH(12),HNL(12),   ***
     4HNM(12),HPH(12),HPL(12),HPM(12),HRH(12),HRL(12),HRM(12),HWH(12),   ***
     5HWL(12),HWM(12),IX,IY,LDE(5,12),LUD(5,12),MAXB,MAXE,MAXF,MAXT,     ***
     6MOCM(12),MOCN(12),MONTHS,MOPL(12),MORL(12),MOWS(12),PCM(12),PCN(12***
     7),PL(12),PLLOST(12),PPL(12),PRL(12),PWS(12),RATE,    RHP,RK, RL(12***
     8),    RLLOST(12),RLP,          RMP,    RN(60),RX,        SHP(12),   ***
     9SK(12)          ,SLP(12),                SMP(12),        SX(12),    ***
     *TA(12),TDCM(12),TDCN(12),TDPL(12),TDRL(12),TDWS(12),          THP(12***
     1),TK(12) ,TL(12),          TLP(12),          TM(12),        TMP(12),  ***
     2          TN(12),TP(12),TW(12),TX(12),VCM(12),VCN(12),VPL(12),VRL(12***
     3),VWS(12),WS(12),WSLOST(12),XCM(600),XCN(600),XDH(5,12),XDL(5,12),***
     4XDM(5,12),XP(600),XPL(600),XRL(600),XUH(5,12),XUL(5,12),XUM(5,12),***
     5XW(600),XWS(600),YR(12),YS(12),ZAH,ZAL,ZAM,ZEH,ZEL,ZEM,ZH(5),ZL(5)***
     6,ZM(5),ZRH,ZRL,ZRM,ZSH,ZSL,ZSM,ZTH,ZTL,ZTM,ZWH,ZWL,ZWM,ZXH,ZXL,ZXM***
     7,ZZ(5),ZZH(5),ZZL(5),ZZM(5)                                         ***
      DIMENSION CHRE(60),CHWS(12),CHCM(12),CHCN(12),CHPL(12),CHRL(12),    ***
     *XBWS(12),XBCM(12),XBCN(12),                                         ***
     *           XBPL(12),XBRL(12),SDWS(12),SDCM(12),SDCN(12),SDPL(12),S***
     *DRL(12),                                                            ***
     *DWWS(12),DWCM(12),DWCN(12),DWPL(12),DWRL(12),DMWS(12),DMCM(12),     ***
     *DMCN(12),DMPL(12),DMRL(12),                                         ***
     *DNWS(12),DNCM(12),DNCN(12),DNPL(12),DNRL(12),DPWS(12),DPCM(12),     ***
     *DPCN(12),DPPL(12),DPRL(12),DRWS(12),DRCM(12),DRCN(12),DRPL(12),     ***
     *DRRL(12)                                                            ***
      DATA CHWS,CHCM,CHCN,CHPL,CHRL/60*0.0/                               ***
C     INFLATION                                                           ***
      BUDGET(6)=BUDGET(6)*(1.0-RATE)                                      ***
      DO 4  M=1,50                                                        ***
```

```
      CALL MODEX(RLP,RMP,RHP,RK,RX,BUDGET(6),RAD,RP,IX,IY)
      DO 1  I=1,60
1     CHRE(I)=RAD*RN(I)
      DO 2  I=1,12
      J=I*5-4
      CHWS(I)=CHWS(I)+CHRE(J)
      CHCM(I)=CHCM(I)+CHRE(J+1)
      CHCN(I)=CHCN(I)+CHRE(J+2)
      CHPL(I)=CHPL(I)+CHRE(J+3)
2     CHRL(I)=CHRL(I)+CHRE(J+4)
      CALL DRAW(CHWS,ZXL,ZXM,ZXH,ZL,ZM,ZH,TDWS,TDPL,TDCM,TDRL,TDCN,DWWS,
     *DWPL,DWCM,DWRL,DWCN,IX,IY)
      CALL DRAW(CHCM,ZXL,ZXM,ZXH,ZL,ZM,ZH,TDCM,TDCN,TDWS,TDPL,TDRL,DMCM,
     *DMCN,DMWS,DMPL,DMRL,IX,IY)
      CALL DRAW(CHCN,ZXL,ZXM,ZXH,ZL,ZM,ZH,TDCN,TDCM,TDWS,TDPL,TDRL,DNCN,
     *DNCM,DNWS,DNPL,DNRL,IX,IY)
      CALL DRAW(CHPL,ZXL,ZXM,ZXH,ZL,ZM,ZH,TDPL,TDRL,TDWS,TDCM,TDCN,DPPL,
     *DPRL,DPWS,DPCM,DPCN,IX,IY)
      CALL DRAW(CHRL,ZXL,ZXM,ZXH,ZL,ZM,ZH,TDRL,TDPL,TDWS,TDCM,TDCN,DRRL,
     *DRPL,DRWS,DRCM,DRCN,IX,IY)
      DO 500  I=1,12
      CHWS(I)=CHWS(I)-DWWS(I)-DMWS(I)-DNWS(I)-DPWS(I)-DRWS(I)
      CHCM(I)=CHCM(I)-DWCM(I)-DMCM(I)-DNCM(I)-DPCM(I)-DRCM(I)
      CHCN(I)=CHCN(I)-DWCN(I)-DMCN(I)-DNCN(I)-DPCN(I)-DRCN(I)
      CHPL(I)=CHPL(I)-DWPL(I)-DMPL(I)-DNPL(I)-DPPL(I)-DRPL(I)
500   CHRL(I)=CHRL(I)-DWRL(I)-DMRL(I)-DNRL(I)-DPRL(I)-DRRL(I)
      DO 5  I=1,12
      J=I+(12*M-12)
      XWS(J)=CHWS(I)
      XCM(J)=CHCM(I)
      XCN(J)=CHCN(I)
      XPL(J)=CHPL(I)
```

```
5     XRL(J)=CHRL(I)
      DO 123  I=1,12
      CHWS(I)=0.0
      CHCM(I)=0.0
      CHCN(I)=0.0
      CHPL(I)=0.0
123   CHRL(I)=0.0
4     CONTINUE
      CALL STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,SDCM,S
     *DCN,SDPL,SDRL)
      CALL TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS,SDCM,
     *SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,3)
3     FORMAT(1H1,T43,'ANGLER-DAY INCREASE DUE TO RESEARCH PROGRAM')
      CALL OUTPUT(XBWS,XBCM,XBCN,XBPL,XBRL)
      WRITE(6,800)
800   FORMAT(1H1,T50,'RESEARCH PROGRAM - STANDARD DEVIATIONS')
      CALL OUTPUT(SDWS,SDCM,SDCN,SDPL,SDPL)
      RETURN
      END
```

```
      SUBROUTINE DRAW(XB,YL,YM,YH,ZL,ZM,ZH,TD1,TD2,TD3,TD4,TD5,P1,P2,P3,***
     *P4,P5,IX,IY)                                                      ***
      DIMENSION TD1(12),TD2(12),TD3(12),TD4(12),TD5(12),J(4),P1(12),    ***
     *P2(12),P3(12),P4(12),P5(12),XB(12),D(12),Y(5),ZL(5),ZM(5),ZH(5)   ***
      DO 30  I=1,12                                                     ***
      P1(I)=0.0                                                         ***
      P2(I)=0.0                                                         ***
      P3(I)=0.0                                                         ***
      P4(I)=0.0                                                         ***
 30   P5(I)=0.0                                                         ***
C DETERMINE THE PERCENT OF NEW ANGLER-DAYS FOR PROGRAM                  ***
      CALL RANDCM(YL,YM,YH,IX,IY,R)                                     ***
C DETERMINE THE NUMBER OF ANGLER-DAYS DRAWN                             ***
      DO 15  I=1,12                                                     ***
 15   D(I)=XB(I)*(1.0-R)                                                ***
C DETERMINE THE PERCENT OF ANGLER-DAYS DRAWN FROM FISHERIES IN THE SAME ***
      CALL RANDCM(ZL(1),ZM(1),ZH(1),IX,IY,Q)                            ***
      DO 1  I=1,12                                                      ***
      IF(I.EQ.1)GOTO101                                                 ***
      IF(I.EQ.2)GOTO102                                                 ***
      IF(I.EQ.3)GOTO103                                                 ***
      IF(I.EQ.4)GOTO104                                                 ***
      IF(I.EQ.5)GOTO105                                                 ***
      IF(I.EQ.6)GOTO106                                                 ***
      IF(I.EQ.7)GOTO107                                                 ***
      IF(I.EQ.8)GOTO108                                                 ***
      IF(I.EQ.9)GOTO109                                                 ***
      IF(I.EQ.10)GOTO110                                                ***
      IF(I.EQ.11)GOTO111                                                ***
      IF(I.EQ.12)GOTO112                                                ***
 101  N=2                                                               ***
      J(1)=2                                                            ***
```

```
      J(2)=3
      J(3)=0
      J(4)=0
      GOTO 200
102   N=2
      J(1)=1
      J(2)=3
      J(3)=0
      J(4)=0
      GOTO 200
103   N=4
      J(1)=1
      J(2)=2
      J(3)=4
      J(4)=5
      GOTO 200
104   N=4
      J(1)=3
      J(2)=5
      J(3)=6
      J(4)=7
      GOTO 200
105   N=3
      J(1)=3
      J(2)=4
      J(3)=5
      J(4)=0
      GOTO 200
106   N=3
      J(1)=4
      J(2)=5
      J(3)=8
```

```
      J(4)=0
      GOTO 200
107   N=4
      J(1)=4
      J(2)=8
      J(3)=9
      J(4)=10
      GOTO 200
108   N=3
      J(1)=6
      J(2)=7
      J(3)=9
      J(4)=0
      GOTO 200
109   N=3
      J(1)=7
      J(2)=8
      J(3)=12
      J(4)=0
      GOTO 200
110   N=3
      J(1)=7
      J(2)=11
      J(3)=12
      J(4)=0
      GOTO 200
111   N=2
      J(1)=10
      J(2)=12
      J(3)=0
      J(4)=0
      GOTO 200
```

```
 112  N=3
      J(1)=9
      J(2)=10
      J(3)=11
      J(4)=0
 200  CONTINUE
C DETERMINE HOW MANY ANGLER-DAYS ARE DRAWN FROM EACH FISHERY
      DO 59  IB=2,5
 59   CALL RANDCM(ZL(IB),ZM(IB),ZH(IB),IX,IY,Y(IB))
      Y(1)=1.0-(Y(2)+Y(3)+Y(4)+Y(5))
C DIVIDE ACROSS
      YN2=Y(2)*Q*D(I)
      YN3=Y(3)*Q*D(I)
      YN4=Y(4)*Q*D(I)
      YN5=Y(5)*Q*D(I)
C DIVIDE DOWN
      DR1=(Y(1)*(1.0-Q)*D(I))/N
      DR2=(Y(2)*(1.0-Q)*D(I))/N
      DR3=(Y(3)*(1.0-Q)*D(I))/N
      DR4=(Y(4)*(1.0-Q)*D(I))/N
      DR5=(Y(5)*(1.0-Q)*D(I))/N
C ANGLER-DAYS IN EACH FISHERY (DRAWN)
C ACROSS
 4    IF(TD2(I).LT.1.0)GOTO5
      P2(I)=P2(I)+YN2
 5    IF(TD3(I).LT.1.0)GOTO6
      P3(I)=P3(I)+YN3
 6    IF(TD4(I).LT.1.0)GOTO7
      P4(I)=P4(I)+YN4
 7    IF(TD5(I).LT.1.0)GOTO8
      P5(I)=P5(I)+YN5
 8    CONTINUE
```

```
C DOWN
      DO 1  M=1,4
      IF(J(M).EQ.0)GOTO1
      IF(TD1(J(M)).LT.1.0)GOTO10
      P1(J(M))=P1(J(M))+DR1
 10   IF(TD2(J(M)).LT.1.0)GOTO9
      P2(J(M))=P2(J(M))+DR2
 9    IF(TD3(J(M)).LT.1.0)GOTO11
      P3(J(M))=P3(J(M))+DR3
 11   IF(TD4(J(M)).LT.1.0)GOTO12
      P4(J(M))=P4(J(M))+DR4
 12   IF(TD5(J(M)).LT.1.0)GOTO1
      P5(J(M))=P5(J(M))+DR5
 1    CONTINUE
      RETURN
      END
```

```
SUBROUTINE MODEX(ZLP,ZMP,ZHP,ZK,ZE,ZM,ZAD,ZP,IX,IY)
DOUBLE PRECISION ZB,ZIP
CALL RANDOM(ZLP,ZMP,ZHP,IX,IY,ZP)
ZA=-ZK
ZIP=1/ZE
ZB=((ZP-ZK)/ZA)**ZIP
ZAD=ZK+ZA*ZB**ZM
RETURN
END
```

```
SUBROUTINE RANDOM(XLOW,XMODE,XHIGH,IX,IY,X)
CALL WEIBUL(XLOW,XMODE,XHIGH,XK,XLAMDA,XM)
CALL RANDU(IX,IY,R)
IX=IY
X=XK+XLAMDA*(-ALOG(R))**(1/XM)
RETURN
END
```

```
      SUBROUTINE RANDU(IX,IY,YFL)
       IY=IX*65539
      IF(IY)5,6,6
 5    IY=IY+2147483647+1
 6    YFL=IY
      YFL=YFL*.4656613E-9
      RETURN
      END
```

```
      SUBROUTINE WEIRUL(XL,XM,XH,ZK,ZL,ZM)
      DIMENSION Z(30),F(30),H(30)
      B=(XH-XL)/2+XI
      IF(XM.LT.B)GO TO 6
      GO TO 7
6     Z(1)=1.00001
      ZM=1.00001
      Z(2)=1.1
      GO TO 5
7     Z(1)=4.0
      ZM=4.0
      Z(2)=3.5
5     I=1
      GO TO 2
1     ZM=Z(2)
3     I=I+1
2     A=((ZM/(ZM-1))*(-ALOG(.99999)))**(1/ZM)
      C=1.0-A
      IF(ABS(C).LT..00001)A=A-.00001
      ZK=(XL-XM*A)/(1-A)
      G=EXP(-((ZM-1)/ZM)*((XH-ZK)/(XM-ZK))**ZM)
4     H(I)=G
      IF(I.EQ.1)GOTO1
      IF(I.EQ.2)J=1
      J=J+1
      K=J-1
      L=J+1
      F(K)=.00001-H(K)
      F(J)=.00001-H(J)
      IF(ABS(F(J)).LT..00001)GOTO11
      Z(L)=Z(J)-F(J)*((Z(J)-Z(K))/(F(J)-F(K)))
      ZM=Z(L)
```

```
      GO TO 3                                              *** 1060
11    ZL=((ZM/(ZM-1))**(1/ZM))*(XM-ZK)                     *** 1061
      RETURN                                               *** 1062
      END                                                  *** 1063
```

```
      SUBROUTINE STAT(XWS,XCM,XCN,XPL,XRL,XBWS,XBCM,XBCN,XBPL,XBRL,SDWS,
     *SDCM,SDCN,SDPL,SDRL)
      DIMENSION XWS(600),XCM(600),XCN(600),XPL(600),XRL(600),XBWS(12),
     *   XBCM(12),XBCN(12),XBPL(12),XBRL(12),SDWS(12),SDCM(12),SDCN(12),
     *SDPL(12),SDRL(12),SSWS(12),SSCM(12),SSCN(12),SSPL(12),SSRL(12),
     *SXWS(12),SXCM(12),SXCN(12),SXPL(12),SXRL(12)
      DO 2  I=1,12
      SXWS(I)=0.0
      SXCM(I)=0.0
      SXCN(I)=0.0
      SXPL(I)=0.0
      SXRL(I)=0.0
      SSWS(I)=0.0
      SSCM(I)=0.0
      SSCN(I)=0.0
      SSPL(I)=0.0
      SSRL(I)=0.0
      DO 1  J=1,50
      M=(J*12-11)+(I-1)
      SXWS(I)=SXWS(I)+XWS(M)
      SXCM(I)=SXCM(I)+XCM(M)
      SXCN(I)=SXCN(I)+XCN(M)
      SXPL(I)=SXPL(I)+XPL(M)
    1 SXRL(I)=SXRL(I)+XRL(M)
      XBWS(I)=SXWS(I)/50
      XBCM(I)=SXCM(I)/50
      XBCN(I)=SXCN(I)/50
      XBPL(I)=SXPL(I)/50
    2 XBRL(I)=SXRL(I)/50
      DO 4  I=1,12
      DO 3  J=1,50
      M=(J*12-11)+(I-1)
```

```
      SSWS(I)=SSWS(I)+(XWS(M)-XBWS(I))**2
      SSCM(I)=SSCM(I)+(XCM(M)-XBCM(I))**2
      SSCN(I)=SSCN(I)+(XCN(M)-XBCN(I))**2
      SSPL(I)=SSPL(I)+(XPL(M)-XBPL(I))**2
    3 SSRL(I)=SSRL(I)+(XRL(M)-XBRL(I))**2
      SDCM(I)=SQRT(SSCM(I)/(50-1))
      SDCN(I)=SQRT(SSCN(I)/(50-1))
      SDPL(I)=SQRT(SSPL(I)/(50-1))
      SDWS(I)=SQRT(SSWS(I)/(50-1))
    4 SDRL(I)=SQRT(SSRL(I)/(50-1))
      RETURN
      END
```

```
      SUBROUTINE TALLY(ADWS,ADCM,ADCN,ADPL,ADRL,VWS,VCM,VCN,VPL,VRL,SDWS***
     *,SDCM,SDCN,SDPL,SDRL,XBWS,XBCM,XBCN,XBPL,XBRL)                   ***
      DIMENSION ADWS(12),ADCM(12),ADCN(12),ADPL(12),ADRL(12),VWS(12),VCM***
     *(12),VCN(12),VPL(12),VRL(12),SDWS(12),SDCM(12),SDCN(12),SDPL(12),S***
     *DRL(12),XBWS(12),XBCM(12),XBCN(12),XBPL(12),XBRL(12)             ***
      DO 21  I=1,12                                                    ***
      VWS(I)=VWS(I)+SDWS(I)                                            ***
      VCM(I)=VCM(I)+SDCM(I)                                            ***
      VCN(I)=VCN(I)+SDCN(I)                                            ***
      VPL(I)=VPL(I)+SDPL(I)                                            ***
      VRL(I)=VRL(I)+SDRL(I)                                            ***
      ADWS(I)=ADWS(I)+XBWS(I)                                          ***
      ADCM(I)=ADCM(I)+XBCM(I)                                          ***
      ADCN(I)=ADCN(I)+XBCN(I)                                          ***
      ADPL(I)=ADPL(I)+XBPL(I)                                          ***
   21 ADRL(I)=ADPL(I)+XBRL(I)                                          ***
      RETURN                                                           ***
      END                                                              ***
```

```
      SUBROUTINE OUTPUT(ADWS,ADCM,ADCN,ADPL,ADRL)                      ***
      DIMENSION ADWS(12),ADCM(12),ADCN(12),ADPL(12),ADRL(12)           ***
      WRITE(6,701)                                                     ***
 701  FORMAT(1H0/1X,T12,'*',T36,'*',T41,'MARGINAL TROUT',T60,'*',T66, 'N***
     *ATURAL TROUT',T84,'*',T92,'PONDS & ',T108,'*',T113,'RESERVOIRS AND***
     *'/1X,T12,'*',T18,'WARM STREAMS',T36,'*',T45,'STREAMS',T60,'*',T69,***
     *'STREAMS',T84,'*',T91,'SMALL LAKES',T108,'*',T115,'LARGE LAKES'/1X***
     *,'*****************************************************************
     ******************************************************************
     *'*****',1X,T3,'**AREA**',T12,'*',T36,'*',T60,'*',T84,'*',T108,'*')  ***
      DO 705  I=1,12                                                   ***
      WRITE(6,702)                                                     ***
      WRITE(6,703)I,ADWS(I),ADCM(I),ADCN(I),ADPL(I),ADRL(I)            ***
 705  WRITE(6,704)                                                     ***
 702  FORMAT(1H ,T12,'*',T36,'*',T60,'*',T84,'*',T108,'*')             ***
 703  FORMAT(1H ,T7,I2,T12,'*',T19,F10.0,T36,'*',T43,F10.0,T60,'*',T67,F***
     *10.0,T84,'*',T91,F10.0,T108,'*',T115,F10.0)                      ***
 704  FORMAT(1H ,T12,'*',T36,'*',T60,'*',T84,'*',T108,'*'/1X,'*************
     ******************************************************************
     ***********************************************************')      ***
      RETURN                                                           ***
      END                                                              ***
```