MASTER

AN ANALYSIS OF THE VALIDITY OF THE UTILITIES'
STOCK-RECRUITMENT CURVE-FITTING EXERCISE

TESTIMONY OF

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PREPARED FOR THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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PREFACE

During the summer of 1977, Dr. Christensen explained a project he was interested in at the time to an informal group consisting of about eight of the quantitative, mathematical, and statistical scientists in the Environmental Sciences Division at Oak Ridge National Laboratory. That project was an investigation of the validity of the utilities' stock-recruitment curve-fits. By way of explaining the fits, he showed the group Figures 10.6-1 and 10.6-2 (the latter Figure has since been withdrawn by the utilities) in Exhibit UT-4, Figure 2-IV-1 of Exhibit UT-3, and some of Dr. Goodyear's computer-generated graphs of other curve-fits in Exhibit UT-3. The group's overall reaction was that a technical analysis of the validity of the fits would be a waste of time. That the fits were absurd and useless, they felt, was obvious just from looking at the graphs. They did not believe that complex analysis was needed or appropriate.

Several members of this group with little or no experience with adjudicatory hearings on environmental matters felt that all that would be necessary to repel the utilities' stock-recruitment curve-fitting exercise would be to have one or two expert statisticians testify in person, based solely on graphs of the fits, that they were useless. Dr. Christensen was uncertain that this would necessarily be adequate, either to convince a lay decision-maker or to settle all of the technical questions. Subsequently, he completed the conceptualization of the approach to investigating the validity of the curve-fits which is presented in this testimony. On discussing this approach with

Dr. Goodyear, he found that Dr. Goodyear had independently conceived and begun to apply the same general approach. They agreed to cooperate on the work. This testimony is the result of that cooperative effort.

The conclusions reached in this testimony clearly support the initial opinion of the group of scientists mentioned above, that the utilities' curve-fitting exercise was virtually useless. In view of the fact that the utilities' witnesses defended the curve-fitting exercise vigorously in cross-examination (e.g., TR 2119-21; TR 2471-73), the extensive analysis in this testimony seems justified. For the purpose of this analysis, it was necessary to take seriously some of the propositions underlying the utilities' stock-recruitment curve-fitting exercise. It was not the authors' intent in doing this to lend credibility to the utilities' curve-fitting exercise, nor to the assumptions which underlie it. The conclusions reached in this work are strongly opposed to the concept that the utilities' curve-fitting exercise provides reliable or unbiased results. The reader who is surprised at these conclusions may find that the anecdote recounted helps to make the conclusions less surprising.

SUMMARY

The use of a particular stock-recruitment model, called the Ricker model, forms a cornerstone of the utilities' case. Based on estimates of a parameter termed "alpha" in the Ricker model, the utilities convert estimates of annual entrainment and impingement impacts of the Hudson River power plants on young-of-the-year (YOY) striped bass to estimates of long-term reduction in the equilibrium population size of adult striped bass. The value of alpha they choose to use is 4. Had they used a lower value, predicted power plant impacts would have been substantially higher. The utilities abstract this value of 4 for alpha from the results of a "curve-fitting exercise," which they conduct as follows.

First, they assume that the Ricker model applies to the Hudson River striped bass population, i.e., they assume that the relevant biological characteristics of the Hudson River striped bass population are adequately described by the model. Second, they subject a 26-year time series of "catch-per-unit-effort" (CPUE) numbers, obtained by manipulation of various historical statistics, to further manipulation in a number of alternative ways to yield values which they treat as indices of "stock" (parents) and "recruits" (offspring of the parents). Third, they apply linear regression to "fit" a transformed version of the model to the various sets of stock-recruit data obtained from the indices. From this procedure, they obtain estimates of the value of

alpha.

This procedure is vulnerable to challenge on many grounds. This particular portion of the Environmental Protection Agency's testimony addresses a single fundamental question: if the Ricker model really did apply to the Hudson River striped bass population, could the utilities' estimates of the parameter alpha, obtained from the curve-fitting exercise, be considered to be reliable?

In Chapter 2, we lay the conceptual groundwork for this investigation. This testimony is a "validation analysis," in that it is intended to ascertain the validity, or lack thereof, of the utilities' approach to estimating the parameter alpha in the Ricker model. The technique that we use is an adaptation of one proposed some sixteen years ago by Dr. James T. McFadden (McFadden 1963), the utilities' primary biological consultant. The technique involves specifying, for the purpose of the analysis, a particular numerical value for the parameter in question (in this case, alpha). Second, we use a model to generate simulated time series data. These simulated data are designed to match the salient characteristics of the Hudson River data used as a CPUE index by the utilities. Third, we manipulate these simulated data in the same ways the utilities manipulate the "real" data. Next, we apply the curve-fitting procedure to the simulated data to produce <u>estimates</u> of the parameter alpha, which of course is known in the model to begin with. If the estimates were the same as the specified value, or very close, we would conclude that the curve-fitting technique gave reliable estimates in the case of that particular model and that particular specified value of alpha. If this entire procedure is repeated, specifying each time a different value of alpha, we can determine whether, for the particular conditions in the model used to generate the data, the curve-fitting exercise gives reliable results for all actual (i.e., specified) values of alpha, only for some values, or for none at all. The final step is to repeat the entire procedure, perhaps several times, with different conditions in the model. In this way, we can assess the reliability of the curve-fitting exercise for a variety of possible conditions. The model itself, and the conditions chosen for its application, are discussed in Chapter 3.

By way of illustrating this procedure, we address the "proxy approach" in Chapter 4. The "proxy approach" was advanced by the utilities' witnesses during cross-examination as a justification for their preference for the alpha estimates obtained using a "five year lag" to manipulate the data. A "five year lag" as used in this sense means that when a CPUE index from some year (t) is used as an index of stock, the CPUE index for year (t + 5), five years later, is used as the corresponding index of recruits. The more conventional approach, known as the "generation time" approach, suggests that a longer lag, related to the generation time of the population, would be more appropriate. For a multiple-age spawning population, the generation time is approximately the age by which a given "average" female fish has spawned half of her total lifetime contribution of eggs. The methodology we have developed is perfectly suited to investigate this controversy. We apply the methodology to a test case that Dr. Savidge of Texas Instruments, Inc., one of the utilities' consultants, proposed during cross-examination as an example of a situation where the "proxy approach" should be appropriate. All of the results support the generation time approach in preference to the proxy approach.

Next, in Chapter 5, we apply this methodology to Dr. Lawler's curve-fitting exercise involving the fitting of the Ricker model to the Hudson River 1950-1975 CPUE time series for striped bass. We chose this subset of the utilities' curve-fitting exercise because it represents the latest of the utilities' efforts and the one on which they have placed greatest emphasis. We include in the analysis some other approaches to manipulating the data which the utilities still maintain are valid concepts, even though they have deleted the results from the original application of these approaches and have not replaced them, or have not bothered to apply them to the updated data set. The unequivocal conclusion reached from these studies is that none of these techniques used by the utilities produces reliable estimates of alpha. For most values of alpha in the model, the estimates are substantially biased. In addition, the statistical test used to determine the significance of the term "beta" in the Ricker model, which accounts for biological compensation, yields spurious results. This test usually indicates that beta is greater than zero, implying compensation, even when beta is in fact zero. In short, the utilities' curve-fitting exercise is a failure.

The failure of the utilities' curve-fitting exercise to produce reliable estimates of alpha is not surprising, in view of the transformation of the model which is required for linear regression, the amount of variation in the data, and the conceptual lack of suitability of any of the techniques for manipulating the basic data to provide accurate indices of stock and recruits because of the biological complexities introduced by multiple-age spawning. Taking the value of Ricker's alpha to be a measure of compensatory capacity, as the utilities would have us do, the validation procedure shows that the utilities' curve-fitting exercise provides virtually no useful information about the short-term or long-term consequences of power plant impact on the striped bass population in the Hudson River.

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Chapter 1

INTRODUCTION

In an attempt to quantify the likely consequences of power plant operation on the striped bass population of the Hudson River, the utilities have made substantial use of stock-recruitment theory and models. The development and application of these models is detailed in Chapter 10 of Exhibit UT-4, and particularly in Section 2-IV of Exhibit UT-3 and in Exhibit UT-58. Witnesses for the utilities present arguments supporting the reality of compensation in animal populations, make claims that compensatory mechanisms have been demonstrated in the Hudson River striped bass population, and propose the Ricker stock-recruitment model (Ricker 1954, 1958, and 1975) as a basis for quantitatively estimating the degree of existing compensation, or "compensatory reserve," in the population. They then fit the Ricker model to Hudson River catch-per-unit-effort (CPUE) data, derived from historical information, in order to obtain numerical estimates of "alpha," a key parameter in the Ricker model. Next, they use this value of alpha to make forecasts of power-plant impact via application of an "Equilibrium Reduction Equation" [Exhibit UT-3, Eq. (2-VI-3) on page 2-VI-6]. Finally, they propose some alternative stock-recruitment models, and they conclude that the numerical value 4 is a conservative estimate (i.e., an underestimate) of "alpha" in the Ricker model for application to the Hudson River striped bass population. Use of this "conservative" value of alpha in the Equilibrium Reduction Equation is considered to yield long-term estimates of power-plant impact which overestimate the actual reduction the striped bass population would suffer assuming continued operation of the power plants with once-through cooling.

We do not dispute the existence of compensation and depensation in general, nor their reality as natural phenomena. The question of whether compensatory mechanisms have been demonstrated in Hudson River striped bass or not is addressed elsewhere, as is the question of the applicability of the Ricker model to the striped bass and other Hudson River fish populations. In this testimony, we address a single question only: if the Ricker model were an appropriate model for the Hudson River striped bass population, could the utilities' curve-fitting exercise be expected to produce reliable estimates of alpha? In order for the stock-recruitment approach to be of any help in predicting the effects of entrainment and impingement on the adult fish population, alpha must be known (TR 2316, line 20 - TR 2317, line 4).

We will show that the answer to this question is "no."

Chapter 2

RATIONALE FOR THIS APPROACH TO VALIDATION

Summary

This chapter begins by discussing some potential problems with the utilities' curve-fitting exercise. A procedure is then discussed for testing the validity of the curve-fitting exercise. This procedure involves using the Ricker model to generate simulated data. The ability of the utilities' curve-fitting exercise to retrieve the known model parameters when applied to the simulated data provides a direct test of the reliability of estimates from the utilities' curve-fitting exercise when applied to real-world data.

The utilities' curve-fitting exercise relies on least-squares regression. In this instance, the Ricker stock-recruitment model (Ricker, 1954, 1958, 1975), as modified for a multiple-age spawning stock, is assumed to describe the processes which regulate the population (Exhibit UT-3, p. 2-IV-2; TR 2300, lines 9-14). In its basic form, the Ricker model is:

$$R = \text{alpha} \times P \times \exp(-\text{beta} \times P) \ , \qquad (1)$$

where R denotes recruits, P denotes parents, or the fish stock that produced the recruits, and alpha and beta are unknown parameters in the model which describe the relationship between the size of the recruit population and the size of the parent population.

In the case of the utilities' curve-fitting exercise, there is reason to question the appropriateness of some aspects of the regression procedure (Robson 1979). There is also reason for concern about the ability to construct meaningful indices of stock and of recruitment from the available data. The basic problem is that the striped bass is a long-lived fish and is present on the fishing grounds not just at one age but at many ages. The fishermen's catch will inevitably reflect not just the abundance of fish of one age, but of several and perhaps many ages. In order to properly fit the Ricker model to a multiple-aged spawner like the striped bass, accurate estimates of both <u>stock</u> size, involving many ages, and <u>recruitment</u> from the stock, involving one age, must be derived. No clearly satisfactory way to do this has been found for the Hudson River, since only crude fishery statistics exist.

These statistics consist of a single 26-year time series of catch-per-unit-effort (CPUE) indices. Each striped bass CPUE value is calculated by first forming a ratio, the numerator of which consists of estimates of the number of pounds of striped bass caught by commercial fishermen in the Hudson River for a given year, and the denominator of which consists of an adjusted estimate of the year's fishing effort using anchor, set, and stake gillnets. The entire ratio is multiplied by a scaling factor. Some additional adjustments have been made to part of the data. While it is not our purpose here to critique the reliability of the CPUE index itself, it is relevant to note that there is ample reason to believe that substantial error arising from a number of different causes attends the CPUE index (Dovel 1979, Fletcher 1979, Goodyear 1979).

The utilities have tried to deal with this problem of constructing both stock and recruit indices from the single Hudson River striped bass CPUE time series in a number of ways. They have applied lags of varying length to the data (e.g., Exhibit UT-3, p. 2-IV-28). They have devised the "spawner-recruit abundance matrix" approach (Exhibit UT-4, pp. 10.45 - 10.49, and Exhibit UT-3, pp. 2-IV-14 - 2-IV-25, particularly Equations 2-IV-8, 2-IV-13, and 2-IV-14*). This technique assumes fish are caught at only one age and that adult survival and fecundity rates are constant, and it uses a matrix approach to construct indices of both spawners and recruits. They have applied a seven-year running average

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*These equations will hereafter be referred to as Eqs. (8U), (13U), and (14U), respectively. Throughout our testimony, a capital U following an equation number will indicate that it refers to a utility equation in Section 2-IV of Exhibit UT-3, as opposed to one of the numbered equations in our testimony.

lagged by four years to the data [Exhibit UT-3, pp. 2-IV-25 - 2-IV-26 and Eq. 2-IV-15; hereafter this equation will be referred to as Eq. (15U)]. Finally, they have developed the "multiple age" and the "eggs on eggs" models (Exhibit UT-58). These models involve constructing the recruit index as a weighted series of CPUE values. The weighting factors are based on either the relative proportion of females by age (the "multiple age" model) or on the relative recruit egg production by age (the "eggs on eggs" model), for ages five through nine.

This multiplicity of approaches to the problem of converting the catch-per-unit-effort time series to indices of both stock and recruits for a multiple-aged spawner is, in itself, cause for skepticism. Some of the methods are nearly opposite in their effect on the data. The spawner-recruit abundance matrix approach, for example, reduces the observed spread of the spawning stock while preserving variation in the recruit index; the "eggs on eggs" model retains variation in stock size but reduces variation in the recruit index; and Equation 15U reduces variation in both indices.

Obviously, since these various approaches are not mechanistically consistent, they cannot all be right. In fact, it can be shown that none of them can be perfect in a situation where more than one age is reflected in the CPUE statistic. The nature of the catch statistics and the degree of variability which generally applies to natural systems, and which appears to apply to the Hudson River striped bass population, are two solid reasons to doubt that there is any substantive relationship between the CPUE index and either stock or recruitment.

Assuming that there is, it is only prudent to wonder what effect manipulation of the CPUE data to extract stock and recruit indices has on the validity of the final regression estimates.

Some of the potential problems with the utilities' curve-fitting exercise can be treated analytically (Robson 1979). Still, the fact that the basic CPUE index is a selective subsample of a continuously changing and unknown age structure makes it impossible that a complete analytical treatment can be found. We have, therefore, devised an alternative method of testing the validity of the curve-fitting exercise.

The utilities' witnesses have stated, under cross-examination, that their approach to estimating alpha for subsequent use in estimating power-plant impact involves several assumptions:

1. The Ricker model applies to the Hudson River striped bass population (TR 2300, lines 9-14).

2. There exists a true value of "alpha," a parameter in the Ricker model, which characterizes the compensatory reserve of the population (TR 2314, lines 11-21).

3. The true value of alpha can generally be reliably estimated through the curve-fitting exercise employed by the utilities (Exhibit UT-3, p. 2-IV-9).

4. Alpha represents the balance between fecundity and density-independent mortality in the population (TR 2307, lines 7-11). It varies from year to year as environmental variation

causes changes in population parameters, particularly in mortality (as opposed to fecundity) (TR 2314, lines 15-21; TR 2316, lines 16-19).

5. Life-history characteristics of the striped bass, such as (a) survival from age to age, (b) survival from one year to the next, or (c) fecundity, are also variable, although they need not vary for the curve-fitting exercise to work (TR 2471-73).

6. It is not necessary to know the particular values of life-history parameters, nor their degree of variability, to have confidence in the estimates of alpha which result from the curve-fitting exercise. Variability in life-history characteristics, uncertainty in the CPUE index, etc. will simply be reflected as "noise" around the curve-fits (TR 2471-73).

These asserted propositions suggest to us a conceptually simple and straightforward test of the reliability of the utilities' estimates of alpha. The existence of high-speed digital computers makes it practical to build a mathematical model of the striped bass population. This model, termed a "simulation" model, can conform exactly to the assumptions the utilities have made about the real population. It can also mimic the entire curve-fitting exercise from start to finish, ending with estimates of alpha, just as the utilities do, but using model-generated CPUE values rather than the Hudson River data. There is one very important advantage to going through this exercise. For the

Hudson River population, the true alpha (assuming such a thing exists) is unknown. For the model population as we have designed it, the true model alpha will be known, because it will be specified.* The estimates of the true model alpha, from the curve-fitting procedure, will also be available. In building the model, we have made it possible to compare estimates of alpha from the model data with the true model alpha, as a means of testing how well the curve-fitting exercise works. This technique is a "validation analysis," in that it is intended to ascertain the validity, or lack thereof, of the utilities' approach to estimating the parameter alpha in the Ricker model. The technique is an adaptation of one proposed some sixteen years ago by Dr. James T. McFadden (McFadden 1963), the utilities' primary biological consultant. In addition, this procedure was used on one occasion by Texas Instruments, Inc. (Exhibit UT-4, pp. 7.209 - 7.211) to assess the validity of estimates of the contribution of the Hudson River striped bass stock to the Atlantic coastal fishery.

The key concept on which this entire testimony is founded is this: if the utilities' curve-fitting exercise, when applied to simulated CPUE data generated by the model, can produce reliable estimates of the known alpha in the model, then the exercise may also provide reliable estimates of the true alpha for the Hudson River striped bass population, if alpha applies and if the model population is similar to

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*Because of the influence of random variation on multiple-age-spawner populations, discussed in Appendix A, the "true" value of alpha in the model is not known exactly, but only approximately. For the purpose of our analyses here, the difference between our "approximate" knowledge and an exact knowledge is unimportant. We will use the word "known" in connection with alpha in the model, rather than the strictly more accurate phrase "approximately known".

the Hudson River striped bass population. Conversely, if the utilities' curve-fitting exercise, when applied to the simulated data, produces unreliable (i.e., poor) estimates of the known alpha in the simulation model, then their estimates of alpha based on the Hudson River data will at best be similarly unreliable.

Of course, a model is only a simplified abstraction of a possible real-world situation. In order to realistically simulate the Hudson River CPUE data, it is necessary to introduce random variation into the model, but the form of the real-world variation is generally not known, and may not coincide with that used in the model. Also, it is not practical to put variation at every point in the model where it is likely to exist in the real world. Finally, many mechanisms will exist in nature which are not incorporated into the model. It is appropriate, therefore, to ask what the effect of all of these necessary simplifications is likely to be on the success or failure of the curve-fitting exercise.

The simplifications are of two general kinds. The first kind consists of mechanisms which in the real world may be contributing to controlling the size, or the estimation of size, of the population but which are not included in the model. Suppose that the Ricker model does apply to the real population, but that other phenomena are also important in regulating the size of the population. Perhaps density-dependent growth occurs in young-of-the-year striped bass, for example, and this affects mortality. Complex interactions with other species may operate in a density-dependent manner and may be depensatory as well as compensatory. With respect to the estimation of population size, the relationship of the CPUE index to the actual catch-per-unit-effort may be influenced by complex economic and sociological factors.

The model does not include these phenomena, and in that sense it is unrealistic as a model of the real world. But by the same token, curve-fits of the Ricker model to the real-world population are similarly unrealistic. It would not be reasonable *a priori* to expect to obtain good estimates of the parameters of a Ricker model from a time series of data in which Ricker-type stock-dependent mortality were not by far the predominant regulating mechanism. Since the "Equilibrium Reduction Equation" becomes progressively less applicable as this stock-dependent mortality plays a lesser role in regulating the population, the estimates of alpha for the Ricker model would not be as useful, even if they did happen to accurately represent the Ricker curve which in part applied to the population.

These problems notwithstanding, however, simplification of the simulation model in assuming that only the Ricker function regulates the model population should maximize the ability of the curve-fitting exercise, which assumes the Ricker function, to work well (i.e., to produce accurate and reliable estimates of the value of alpha in the model). If the curve-fitting exercise does not work under these favorable simplifying assumptions, it is likely useless for any purpose. On the other hand, if the curve-fitting exercise does work well here, with model-generated results, there is still no guarantee that it will work well in extracting a real alpha from the more complicated real world.

The second set of simplifications in the model involves the inability to incorporate variation in the model everywhere it exists in nature, and in the same manner. Such variation, if not density-dependent, is necessarily density-independent. It may represent the consequences of environmental factors or of competition with or predation by populations of other organisms not closely coupled to striped bass. Variation also results from factors of uncertainty surrounding the CPUE index itself. Our simulation model incorporates variation in several places. This variation is made large enough to make the model results approximate the variability in the Hudson River CPUE index (Chapter 5). Still, information simply does not exist to define the location, extent, and statistical nature of the real-world variation which the model is attempting to simulate.

It is not possible to determine the precise degree to which the location, extent, and statistical nature of the real variation influenced the success of the utilities' curve-fitting exercise, without knowing more about the specific nature of the real variation. However, expert witnesses for the utilities have made statements to the effect that the curve-fitting exercise should work well whether population parameters such as survival and fecundity vary or remain constant (TR 2471-73). In the utilities' view, variation in population parameters simply explains variation in the data around the curve-fits, and it is not a cause for concern about the validity of the curve-fits themselves. That logic would apply equally to the modeling exercise undertaken here. While we do not agree with their view as a general proposition, their view permits comparability between their curve-fitting exercise and our validation methodology. In addition, as a means of exploring the effect that the location, extent, and statistical nature of the random variation might have on the success of the curve-fitting exercise, we looked at a range of assumptions about the random variation.

Chapter 3

DESCRIPTION OF THE SIMULATION MODEL

Summary

The first part of this chapter describes the model which forms the basis of the validation exercise. Following this, we discuss the way the model is applied and the conditions governing the Cases which are investigated. These Cases involve the specification of the biological characteristics of the population being simulated by the model, as well as the location of the random variation in the model.

The primary model used in this investigation is a computer simulation model for the Hudson River striped bass population. This model, named SRVAL, incorporates within it the Ricker stock-recruitment model as the means of population regulation. The model itself can be described by four main equations:

$$N_0(t-1) = \sum_{i=1}^{15} a_i N_i(t-1) \ , \tag{2}$$

$$N_i(t) = N_{i-1}(t-1) S_i(t-1) \quad \text{(for } i = 1 \text{ to } 14) \ , \tag{3}$$

$$N_{15}(t) = [N_{14}(t-1) + N_{15}(t-1)] S_{15}(t-1) \ , \tag{4}$$

$$CPUE'(t) = T \left[N_1(t) L_1 W_1 + \sum_{i=2}^{15} \left(N_i(t) L_i W_i \Big/ \prod_{j=2}^{i} \bar{S}_j \right) \right] , \tag{5}$$

where N is number of fish, the subscript on N indicates the age of the fish at the time of spawning, and t is time in years. The term a_i represents the average fecundity (egg production) of a fish of the subscripted age, calculated as

$$a_i = (ff_i)(fm_i)(emf_i) \ , \tag{6}$$

where ff_i is the fraction of age i which is female, fm_i is the fraction of females which is mature, and emf_i is the number of eggs produced by each mature female. The term S_i represents the probability of survival from age i-1 to age i. CPUE'(t) represents the catch-per-unit-effort index for year t before the introduction of an error term. The term T in Eq. (5) is a scaling factor, calculated within the model, which causes the equilibrium value of CPUE' to correspond to the mean Hudson River CPUE value. The term L_i is the relative number of fish of age i in the catch from a steady-state population (i.e., one which is at equilibrium and constant through time). The term W_i is the weight of a fish of age i. While the terms S_i in Eqs. (3) and (4) can, in general, be time-varying, we have varied only S_1 in this testimony. The term $\bar{S}_j$ in Eq. (5) represents these constant survival probabilities for fish age 1 and older.

All of the parameters in these equations are specified by the modeler prior to a Run except for S_1, the probability of surviving from age 0 (an egg) to age 1. This term is related to the Ricker model as follows:

$$S_1(t) = \left(\frac{\text{alpha}}{\bar{V}\ \bar{E}}\right) \exp(r(t) - C + (\text{gamma})(H7(t))) \exp(-\text{beta} \times F(t)) , \qquad (7)$$

where alpha and beta are parameters in the Ricker model, r(t) is a random variable with mean zero and adjustable variance, C is a correction factor to remove from the population a tendency for random variation of the form used to cause a population to increase (see Appendix A), gamma is a specified term relating river flow to young-of-the-year (YOY) mortality (see Exhibit UT-58), H7 represents a random variable with mean zero and variance of 3,471, simulating the variance in Hudson River flow over the period 1950-1975 (Exhibit UT-58), and F(t) is a component of the "feedback" term in the Ricker model. The "feedback" term (beta x F(t)) constitutes the stock-dependent mortality (Harris 1975) which causes the Ricker model to have an equilibrium point. It expresses the general concept that the abundance of older fish, or of parents, or of eggs spawned, exerts a negative influence on survival during early life (here, the first year), and that the negative influence becomes stronger as this abundance of older fish, parents, or eggs increases. This component of the feedback term is calculated in one of two ways, depending on the mechanism being modeled:

$$F(t) = \sum_{i=1}^{15} a_i N_i(t) \ , \qquad (8)$$

for feedback based on the number of eggs spawned, or

$$F(t) = \sum_{i=1}^{15} N_i(t) \ , \qquad (9)$$

for feedback based on the number of older fish (i.e., older than age zero). The term $\overline{V}$ in Eq. (7) is defined as

$$\overline{V} = 1 + \sum_{i=2}^{15} \prod_{j=2}^{i} \overline{S}_j \ . \qquad (10)$$

Thus, $\overline{V}$ represents the total contribution of a yearling fish to all subsequent age classes. The term $\overline{E}$ in Eq. (7) represents the equilibrium (i.e., from a population at steady state) egg production per fish of age one or older, and it is calculated as

$$\bar{E} = \frac{a_1 + \sum_{i=2}^{15} a_i \prod_{j=2}^{i} \bar{S}_j}{1 + \sum_{i=2}^{15} \prod_{j=2}^{i} \bar{S}_j} \quad . \tag{11}$$

This explains all of the terms in Eq. (7) except for alpha and beta. In the present application, alpha is first specified for the purpose of afterwards evaluating the ability of curve-fitting to estimate alpha as a function of the particular value of alpha. For any one Run alpha in the model is always fixed at a predetermined value. Once this has been done, a corresponding value of beta which results in an equilibrium yearling population of 2.5 million fish (an arbitrary number which has no bearing on the outcome of the study) is calculated internally in the model, as

$$\text{beta} = \frac{\ln \text{alpha}}{\bar{F}} \quad , \tag{12}$$

where $\bar{F}$ is obtained by applying Eq. (8) or (9), as appropriate, to a population at steady state.

Two final equations are needed to complete the description of the model. These describe the introduction of random error into the model's CPUE index. For the case of a lognormally-distributed error term the equation is

$$\text{CPUE}(t) = \text{CPUE}'(t) \exp(G(t) - s^2/2) \quad , \tag{13}$$

where G(t) is a normally-distributed random variable with a mean of zero and specified variance s^2. The function of the term $s^2/2$ is discussed in Appendix A. For the case of a normally-distributed error term, the equation is

$$CPUE(t) = CPUE'(t)(1+G(t)) , \tag{14}$$

where G(t) is as defined for Eq. (13). Note that in both cases, the error terms are multiplied by the CPUE' index, rather than being added to it. This usually avoids the problem of creating negative CPUE terms, which would be impossible in either the model or in nature. Infrequently, the term (1 + G(t)) in Eq. (14) was negative; when this occurred, another random value was obtained and substituted for G(t). As a result of this multiplicative form of variation, the amount of variance is a function of the size of the value of CPUE' itself, and it is not appropriate to refer to the overall error distribution in the term CPUE as lognormal or normal. To distinguish these two cases from each other in the remainder of this testimony, we refer to the use of either a lognormal or a normal random coefficient, representing the application of Equation (13) or (14), respectively.

As described, our model is similar to one developed and applied by Allen and Basasibwaki (1974), and somewhat simpler than the model developed by Christensen, DeAngelis, and Clark (1977). The present model differs substantially in detail from these other models in several respects, however:

1. The model "samples" the simulated striped bass population each year, in the same manner in which the commercial fishermen might, but without error - except when error is intentionally

introduced. This sampling process simulates the Hudson River catch-per-unit-effort (CPUE) statistic which is the basis for the utilities' curve-fitting exercise.

2. The model simulates the population over a long time period (nearly 3200 years). Each such simulation is termed a "Run." The first 50 years of each simulation are not used, to allow time for the population to be influenced by the random variation. Beginning with the fifty-first year the model separates the time series of CPUE values (one value for each "year" in the model) into 120 groups, each containing 26 CPUE values. Each group (termed a "Replicate") thus simulates the single 26-year time series of CPUE values from the real Hudson River which the utilities use.

3. In the same manner in which the utilities process the single 26-year CPUE time series from the real Hudson River, the model processes each Replicate. The result of this processing is 12 simulated data sets for each Replicate, eleven of which correspond to a particular interpretation or approach which the utilities have applied to the Hudson River data (e.g., the five year lag approach, or the "eggs on eggs" approach), and one of which (the four year lag) the utilities have not utilized. Each of these 12 data sets consists of up to 22 simulated stock-recruit data points, the exact number depending on the particular processing approach used. For example, with a four year lag there are 26 - 4 = 22 data points.

4. The same curve-fitting procedure that the utilities apply to each of the approaches used to process the Hudson River data is applied to each of these data sets. This curve-fitting procedure consists of fitting the data set with the Ricker model in a linearized form:

$$\ln(R/P) = \ln(\text{alpha}) - \text{beta} \times P \,, \qquad (15)$$

where R and P denote the corresponding indices of recruits and of stock, respectively. This results in a two-parameter curve fit, consisting of an estimate of both alpha and beta. It is the estimate of alpha which is important here, as it controls the prediction of power-plant impact in the Equilibrium Reduction Equation (ERE). Alpha is the slope at the origin of the untransformed Ricker curve.* A second model, a modification of the Ricker model which includes flow, is also fit in a linearized form, as the utilities did in Exhibit UT-58:

$$\ln(R/P) = \ln(\text{alpha}) + \text{gamma} \times H7 - \text{beta} \times P \,, \qquad (16)$$

where the new term gamma expresses the relation between flow and YOY morality. The term H7 is, for each spawning year, the difference between the flow in that year and the mean flow for

*It is important to note that, with respect to the classical presentation of the Ricker model, the alpha of interest here is the residual alpha related to the escapement curve, rather than the alpha for the Ricker spawner-recruit curve <u>per se</u>. In other words, the Ricker curves we are working with here are those for the exploited population, rather than those for the virgin stock.

the spawning years included in the particular data set.

Each "Replicate" from the model, then, simulates the CPUE time series from the Hudson River and is subjected to the same general processing used by the utilities on the real CPUE time series. In other words, we use an artificial model-produced set of values with similar characteristics to the CPUE data from the Hudson River to examine the various curve-fitting exercises engaged in by the utilities.

To use our simulation model, it is first necessary to establish a "Case." A given Case represents a set of choices for the population model. The choices which were varied in this work are as follows (a brief summary of Cases is provided in Table D-1):

1. Annual survival of fish age one and older. Specified as 0.43 for all Cases except Case 2, where 0.60 was used. The value 0.43 was chosen because we understand that Dr. McFadden feels that this is a good estimate of annual survival probability, based upon his interpretation of the data (TR 153, line 13, through TR 154, line 11). We do not mean to imply concurrence with this estimate. The value of 0.60 is the survival rate used by the utilities in their application, now discarded for other reasons, of the spawner-recruit abundance matrix approach in Exhibits UT-3 and UT-4.

2. Type of feedback in the Ricker model. From the equations in Section 2-IV of Exhibit UT-3, it is clear that the utilities consider both feedback based on the number of eggs produced in

a given year and feedback based on the number of fish as biological mechanisms represented by the Ricker model which are possibly applicable to the Hudson River. Feedback based on eggs was used in Cases 1-3 and 5-6; Feedback based on the number of fish was used in Cases 4 and 7.

3. Value of gamma, the coefficient relating flow to young-of-the-year mortality. Except for the investigation of the proxy approach in Chapter 4, where it was not used, gamma was held constant at 0.000036, which was calculated as the average of the estimates obtained for gamma from those fitting approaches used in Exhibit UT-58 with flow included. The utilities used an incorrect CPUE data set in Exhibit UT-58.* With these incorrect data, flow appeared to be "significant" in explaining the variation in the data (sometimes only at the 0.1 level, meaning that the 90% confidence interval for gamma did not include 0.0) for the five year lag and the "multiple age" and "eggs on eggs" models. This "significance" disappears with use of the correct data set. By the time we had confirmed the error, the simulation model had already been expanded to incorporate the concept of flow. In order to retain this

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*Corrections for the Exhibit UT-58 CPUE data, prompted by an EPA request, were provided in a letter dated January 9, 1979, from Kenneth L. Marcellus, Consolidated Edison Company of New York, Inc., to Henry Gluckstern, Environmental Protection Agency (Region II). Values for several years were "updated," involving very minor changes. In addition, the 1972 value was changed from 2835 to 3399, reflecting information which became available during cross-examination. The 1956 value was corrected from 8634 to 5830. The value 8634, which was utilized in the fits in Exhibit UT-58, was felt to be a transcription error. Alpha estimates using the corrected and updated data were generally lower than those originally obtained in Exhibit UT-58.

concept in the model, we elected to use the mean gamma estimated from the five year lag, "multiple age," and "eggs on eggs" approaches, obtained using the correct data set, even though the values involved in calculating this mean were nonsignificant. The value used makes flow a relatively unimportant influence in the model runs, but it does retain a minimal degree of variation in young-of-the-year mortality, which is useful in those Cases which would otherwise lack such variation and settle to steady state.

4. Location of random variation in the model. Flow is introduced into the model as a random variable, with the degree of random variation based on the degree of variation in the actual "Q7" freshwater flow data (Table 3 in Exhibit UT-58). The random "flow" variable in the model, via gamma, causes YOY mortality to vary in all Runs (except in Chapter 4). Additional randomness in YOY mortality was sometimes introduced directly, and/or randomness was sometimes applied to the CPUE index. Only YOY mortality, and not CPUE, was varied randomly in Cases 1 and 2. In Case 3, all of the random variation was in the CPUE index except for the influence of flow. In Cases 4-7, random variation was used in both YOY mortality and the CPUE index.

5. Form of random variation in the model. While this might have been varied everywhere random variation was used, we have varied the form of the random variation only on the CPUE index. In Cases 3, 4, and 5, a lognormally-distributed random

coefficient of CPUE' was used [Eq. (13)]. In Cases 6 and 7, a normally-distributed random coefficient was used [Eq. (14)].

6. Magnitude of random variation. *A priori*, increased random variation would be expected to result in lower reliability of parameter estimates, and if the estimates are biased, in greater bias of parameter estimates. The magnitude of random variation should therefore be important. In this work, there is one guide which can be used to specify the appropriate amount of random variation in the Hudson River CPUE index which the model is generating. If the CPUE values output from the model consistently had more, or consistently had less, variation than exists in the single 26-year Hudson River CPUE series, then the model would not be simulating the real data well. In order to appropriately specify variation in the model, the coefficient of variation for the Hudson River CPUE series was calculated as 0.423. For a given model Run, 120 simulated CPUE time series (one for each Replicate) were generated. The amount of variation in the model was adjusted until the median of the 120 coefficients of variation of simulated CPUE time series from the 120 model-generated Replicates was equal to the coefficient of variation of the Hudson River CPUE time series (0.423 ± 0.01).

For Runs where random variation was used in both the YOY mortality and the CPUE index, an additional constraint was imposed in order to increase comparability among Runs within a Case. For each Replicate, the ratio of the maximum to the minimum number of yearlings during the 26 model years in the Replicate was calculated. Variation in the young-of-the-year mortality was adjusted so that the median value of this ratio among all Replicates within a Run was 10.0 ± 0.11. This ratio was chosen in an uncritical attempt to meet the expectations of Dr. McFadden, one of the utilities' main witnesses, who feels that fluctuations in the number of juveniles, as reflected in the available beach-seine data for young-of-the-year striped bass (Exhibit 3, Table 2-VIII-9 as amended), might be roughly tenfold, rather than the larger 24-fold fluctuations actually present in those data (TR 2772, lines 4-9; TR 2775, lines 11-14). Dr. McFadden would expect this ratio of ten to "close" somewhat (i.e., become smaller) before the fish became yearlings (due to mechanisms not present in the Ricker model), but these available beach-seine data for young-of-the-year striped bass cover only 11 years, whereas a Replicate contains 26 years. In such a longer time series, beach-seine data would be expected to show larger fluctuations, which we suppose Dr. McFadden would consider to reflect greater than tenfold fluctuations. Tenfold variation in the model yearlings is thus deemed to adequately represent Dr. McFadden's expectations, although we do not necessarily subscribe to his expectations.

Once a Case is established, the next step involves choosing values of alpha to use. Specifying alpha permits beta to be calculated. Each value of alpha, together with the various conditions described above as constituting a Case, defines a "Run" which results in 120 Replicates, each Replicate simulating the 26-year Hudson River CPUE time series. As mentioned above, each Replicate was processed as the utilities processed the Hudson River CPUE time series. The estimates of alpha thus derived could then be compared with the known true value of alpha in the model, to evaluate how well the curve-fitting exercise worked for that Case. This brief synopsis is elaborated below, since these terms and concepts are fundamental to an understanding of the remainder of our testimony.

A Case represents a set of choices for our simulation model. These choices concern life-history parameters, the type of feedback in the underlying Ricker model, and the location and distribution of random variation in the model. The one important parameter which is _not_ specified in a Case is alpha, since we want to explore, within the context of the Case, the effect of varying alpha. Cases are summarized in Table D-1.

Once the Case is specified, a set of alpha values is chosen for use. Each alpha value within a Case defines a particular Run (i.e., a single execution of the computer program). Within a Case, the Runs thus differ from each other with respect to alpha level, and also with respect to the "seeds" which initiate the random number generator. The different alpha levels also require adjustment of the amounts of variation specified in the model, so that the model-generated CPUE values will have the proper amount of variation (i.e., typically the same amount of variation as does the "real" CPUE time series). The functional difference between Runs within a Case, however, is that the alpha levels differ.

Within a single Run, there are 120 Replicates. Each Replicate consists of a 26-year time series of model-generated CPUE values. Each Replicate results from our having specified, in the Run, the biological characteristics of our model population, including the degree of population self-regulation (via alpha). The 26-year CPUE time series which comprises each Replicate is comparable to the Hudson River CPUE time series. The model time series represents a contiguous sampling of the model fish population, in a manner consistent with the utilities' "simulated commercial fishery" (Exhibit UT-3, p. 2-VIII-12), just as the utilities take the Hudson River striped bass CPUE index to represent a sampling of the striped bass population.

The same type of curve-fitting exercise which the utilities carry out on the "real" CPUE data is carried out on each Replicate. Twelve "processing approaches," which will be elaborated in Chapter 4, are applied to each Replicate. Each processing approach is intended by the utilities to convert the single 26-year simulated CPUE time series to indices of stock and recruits. The indices resulting from the application of each processing approach are used twice in regression, or curve-fitting, procedures; once to obtain an alpha estimate from the basic Ricker model in a linearized form without flow [Eq. (15)], and once to obtain a corresponding estimate utilizing the model's simulated river flow values [Eq. (16)]. It is these estimated alpha values which, by comparison with the corresponding true model alpha values, form the basis of our validation analysis.

For the first two Cases, alpha values of 1.0, 1.25, 2.5, 5, 10, 20, and 40 were initially chosen for the Runs. The value of 40 could not be used, however, since it generated too much variation in the CPUE index based upon our criterion that the median coefficient of variation be 0.423. It was replaced for Case 1 with a value of 30, which could be used if random variation was kept very low. For Case 2, the alpha value of 30 could not be used because it generated excessive variation, and it was dropped. Values of alpha lower than 1.0 could have been used, but would have required some restructuring of the model. Alpha values lower than 1.0 imply a population which is declining toward extinction. When beta is positive in such an instance, this "compensatory" term in the Ricker model, which supplies a part of the total mortality for the population, actually hastens the population decline.

For Cases 3-7, three alpha values were used: 1.25, 5.0, and 20. These values cover a range wider than generally considered likely by the utilities, and serve rather well to illustrate the behavior of the curve-fitting exercise.

Our simulation model was validated in three different ways. First, a parallel model was developed independently by Dr. Goodyear. The identical set of 21 random numbers was used repetitively in both models to produce the variation in YOY mortality, and both models were started with the same initial conditions. Results from the curve-fitting exercise for several of the lag approaches were compared, and were found to be the same within rounding error. Second, a subroutine in the model permits the first Replicate to be replaced with the Hudson River CPUE and flow time series. This permitted us to repeat the utilities' analyses, as well as to obtain values based upon the corrected data set (see Chapter 5). The fact that in comparable cases we always obtained the same estimates of alpha, beta, and gamma (and indications of "significance") reported by the utilities provides confirmation that we and the utilities were conducting the curve-fitting exercise in an identical manner. Third, two of the matrix methods [(Eqs. (8U) and (13U)]) are conceptually "perfect" methods under certain idealized conditions, in that the fitted model, utilizing the matrix method, incorporates the same values for the biological and abiotic characteristics that were used by the source model to generate the data. These idealized conditions are: perfect knowledge of flow provided to the matrix model, with flow the only random variable; perfect knowledge of fecundity and survival provided to the matrix model; all reproductive ages included in the matrix; only one age of fish caught in the CPUE index; and the appropriate feedback term used in the underlying Ricker model. Special test cases were set up meeting these conditions, and it was confirmed that perfect parameter estimates (within rounding error) were obtained from both Eqs. (8U) and (13U). This result validates most parts of both the simulation model and the curve-fitting calculations.

In Chapter 4, we describe an application of the model to the utilities' "proxy" approach. This application will both illustrate the way the model is used, and determine whether the "proxy" approach is reasonable or not. The application of this model to testing the Hudson River curve-fits will then be described in Chapter 5.

Chapter 4

THE PROXY APPROACH

Summary

In this chapter, the use of the validation methodology is illustrated by applying it to test a novel proposition, known as the "proxy" approach, set forth by Dr. McFadden and supported by Dr. Lawler and other of the utilities' consultants. The proxy approach purports to be a rationale for choosing a lag time different from the lag related to the generation time. The lag chosen by the utilities under this rationale (i.e., five years) for manipulating the CPUE data also happened to give a higher estimate of alpha than did other lags. We conclude that, even using a sample Case constructed by Dr. Savidge as one to which the proxy approach should apply, the more conventional generation time approach is superior, and there is no valid basis for the proxy approach.

During cross-examination, Dr. McFadden set forth a proposition, which we will call the "proxy approach," as a justification for his preference for estimates of alpha obtained after applying a five year lag, as opposed to longer lags, to the Hudson River striped bass CPUE data (TR 1250-53). The proxy approach, as used by the utilities to try to justify use of a five year lag for processing the CPUE data, can be stated as follows:

Proposition 1: The spawning stock and the commercial stock are essentially identical (TR 1916, lines 11-14; TR 2607, lines 19-25).

Proposition 2: The CPUE index in a particular year is a measure of the spawning stock in that same year (TR 2543, lines 14-17; TR 2544, lines 12-15).

Proposition 3: Five year old fish dominate the CPUE index (TR 2608, lines 12-23).

Proposition 4: For purposes of constructing a recruit index, the fish older than five years which are represented in the CPUE index can, under approximate equilibrium assumptions, be considered as proxies, representing the contribution of the five year olds later in life (TR 1251-52).

In this proxy approach, proposition 2 is based on proposition 1 (TR 2623, lines 6-11). Given proposition 2, the age of dominance in the CPUE index, by weight, would determine the appropriate lag (TR 2622, lines 5-9); this appears to be a revision of Dr. McFadden's earlier view, expressed on TR 1257, lines 20-25, which implies that the age of numerical abundance rather than the age of dominance by weight would determine the lag.

This "proxy approach" stands in contrast to another, more classical approach, which we will term the "generation time" approach. This approach is also recognized by the utilities' witnesses, including Dr. McFadden (TR 2492, lines 12-16), and was in fact preferred over the proxy approach by at least two of them (Dr. Savidge and Mr. Croom; TR 2519, lines 10-11 and TR 2520, lines 22-24). This latter approach holds that the best lag to use would be the lag closest to the generation time for the population. The generation time is approximately the age by which a given "average" female fish has contributed one-half of her total expected lifetime egg production. The generation time is a function of the survival rates and age-specific fecundity rates of females in a population. For the life-history parameters (Exhibit UT-3, Tables 2-VIII-1 and 2-VIII-5) and survival rate of 0.43 preferred by the utilities, the generation time of the Hudson River striped bass population is roughly 5.75 years. This estimate of generation time is based on Figures B-32 to B-36, which show the period of oscillation of the population to be approximately 11.5 years, and Ricker's (1954) statement that the period of oscillation in a multiple-age-class population governed by processes described by what is now called a Ricker curve will be approximately twice the mean length of time from parental egg to filial egg (e.g., twice the generation time). For higher survival rates, the generation time will become longer.

Thus, when trying to construct spawner and recruit indices from the Hudson River striped bass CPUE data, the generation time approach would argue for using a longer lag than that suggested by Dr. McFadden's proxy approach. In our view, the generation time is the best guide to use in arriving at a preferred lag for a population regulated by a Ricker-type feedback mechanism with the feedback based on the number of eggs spawned (recognizing, of course, that any lag will be imperfect for a multiple-age spawning population). If the lag indicated by the generation time approach differs from that indicated by the proxy approach, the likely explanation is that one or more of the propositions in the proxy approach is not met. In the case of the Hudson River striped bass population, it is easy to find suspect propositions. Proposition 1 is likely incorrect because older fish are relatively more abundant in the spawning stock than in the commercial catch (Fletcher 1979). Proposition 2 is therefore unsupported. Proposition 3 is questionable in that six year old fish may, by weight, exceed five year old fish in the CPUE index (Fletcher 1979; compare TR 2622, lines 5-10). Proposition 4 is predicated on near-equilibrium conditions, which do not appear to hold for the Hudson River striped bass.

By way of probing the reasoning behind the proxy approach, the following hypothetical question was asked during cross examination: Suppose there is a fish population that spawns at only a single age (say, at age 7) and for which there is an index of population size available each year. Let us suppose that this index of population size is a catch-per-unit-effort index which measures only five-year-old fish. Then one can construct stock-recruitment data points from this time series. The CPUE value for year 1900, for example, measures five-year-olds in 1900 which will be seven years old (and hence spawners, or "stock") in 1902. The 1900 CPUE index is therefore an index of 1902 spawning. The recruits from the 1902 spawning would be measured by the fishery in 1907, as the 1907 CPUE index. Thus the 1900 CPUE value, when used to represent stock, would be paired with the 1907 CPUE value to obtain the corresponding the estimate of recruitment. This stock-recruit point would involve the application of a seven year lag to the CPUE data. Given enough other points, similarly obtained, a stock-recruitment curve could be fitted. Drs. McFadden and Lawler agreed to the appropriateness of the use of a seven year lag in this hypothetical case (TR 2521-24). This seven year lag is based on the generation time of the hypothetical population, that is, there is a seven year gap between the time of spawning and the time the offspring themselves spawn in this hypothetical.

On further cross-examination, the utilities were presented with three more hypothetical examples of increasing complexity, which involved generally more realistic assumptions: three ages involved in spawning, three ages represented in the catch, and two ages in both the spawning and the catch. Despite the utilities' attempts to justify their use of the proxy approach, they agreed to the appropriateness of the generation time approach for the determination of lag times for the first three hypotheticals. They agreed that the generation time approach could be applied to the fourth hypothetical, although they maintained that the proxy approach could also be applied to this final hypothetical. The utilities argued that all but the final hypothetical differed from the Hudson River in that there was no overlap between the spawning ages and the ages caught in the fishery.

During the course of this investigation of the proxy approach in cross-examination, Dr. Savidge set up an example to which he felt the proxy approach would apply. The example is stated at TR 2576, line 22, through TR 2577, line 2, and again at TR 2578, lines 5-25. Restated for clarity, the example is as follows: on the average, five-year-olds make up 40% of the catch, and six, seven, and eight year olds each make up 20% of the catch. The six, seven, and eight year old fish do all of the spawning, in equal proportions (i.e., each of these ages contributing 33.3% of the eggs, on the average). Then, according to the proxy approach, the five-year lag would be appropriate to use in constructing stock-recruit pairs. According to the generation time approach, seven years would be the most appropriate lag.

The validation methodology is an ideal tool to use in investigating this controversial question of which lag works best. Table 1 shows a set of input parameter values that were developed to match exactly Dr. Savidge's hypothetical. These values were used in the simulation model. The proxy analyses were designated as Cases 101 and 102, to distinguish them from the "real" Cases (i.e., Cases based on characteristics at least asserted to represent Hudson River striped bass). Flow was not used in the simulation model, nor in the fitted model. Case 101 has no random variation, and consists solely of Run 931. Case 102 has random variation in YOY mortality, and consists of Runs 932 and 933.

Table 1. Life-history data constructed to investigate the applicant's "proxy" approach[a]

Age	Fraction female	Fraction of females mature	Eggs per mature female	Fraction surviving from previous age	Relative representation in CPUE index[b]	Weight (pounds)[c]
1	0.5	0.0	0.0	d	0.00	0.023
2	0.5	0.0	0.0	0.5	0.00	0.211
3	0.5	0.0	0.0	0.5	0.00	1.010
4	0.5	0.0	0.0	0.5	0.00	2.570
5	0.5	0.0	0.0	0.5	0.40	3.850
6	0.5	1.0	500000.0	0.5	0.20	5.880
7	0.5	1.0	1000000.0	0.5	0.20	8.260
8	0.5	1.0	2000000.0	0.5	0.20	12.800
9	0.5	0.0	0.0	0.5	0.00	14.400

[a]See TR 1250-1253 for a general statement of the "proxy" or "five-year-lag" approach. See TR 2576, lines 22-25 and TR 2578, lines 5-25 for the actual specification of this case.

[b]These values specify the age-frequency distribution by number of fish of the particular age-class in the CPUE index for an equilibrium population.

[c]Based on Exhibit UT-4, Tables 7.8-1 and 7.8-2, and equations and coefficients provided on p. 7.140 (as corrected by Exhibit UT-4E-1).

[d]Survival from age 0 to age 1 is calculated in the model.

For Case 101 (no random variation), an alpha value of 10 was chosen for Run 931 as a value which caused substantial and sustained oscillations in this hypothetical population (Ricker 1954). The size of the initial population in the simulation model was set at below equilibrium size so that the oscillations could become established. As in all runs, the population was simulated for 50 years prior to use of the data as a CPUE index.

Figures 1 and 2 show the results for the first three of the 120 Replicates in Run 931. The order of the graphs is as you would read a page of text - the first row from left to right, then the second row, etc. The first graph in Fig. 1 shows the CPUE time series for Replicate 1. The oscillatory nature of the population is quite evident. The period is fourteen years, as would be expected for a generation time of seven years (Ricker 1954). The second graph illustrates four points. First, the 45-degree line is the "replacement" line; where a Ricker curve intersects this line there is an equilibrium point. An equilibrium point, in a loose sense, indicates an approximate average population size to be expected. Second, there are 22 data points (eight are superimposed due to the regular nature of the time series caused by the unrealistic absence of any random variation), which result from application of a four year lag to the CPUE time series. Third, there is a solid Ricker curve, which represents the true Ricker model which underlies the population simulation. The slope of this solid curve at the origin (lower-left corner of the graph) is the "true alpha" in the model, namely, 10. Finally, the dashed curve represents the Ricker curve which has been fitted to the data points. Clearly, the dashed

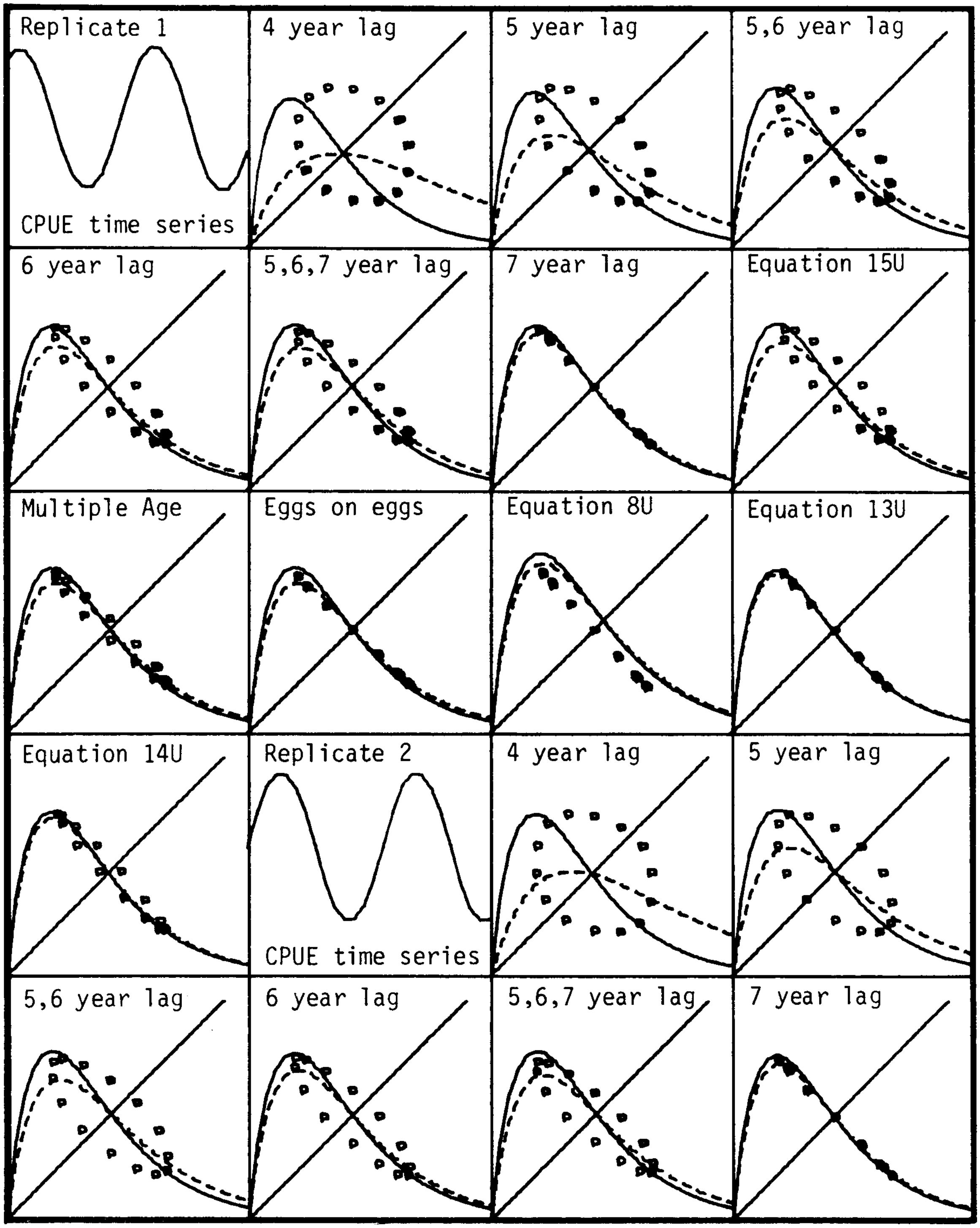

Figure 1. Results from Replicate 1 and part of Replicate 2 for Case 101, Run 931 - the proxy test case with alpha of 10 and no random variation. Solid Ricker curves are the source model, dashed curves are the fitted model.

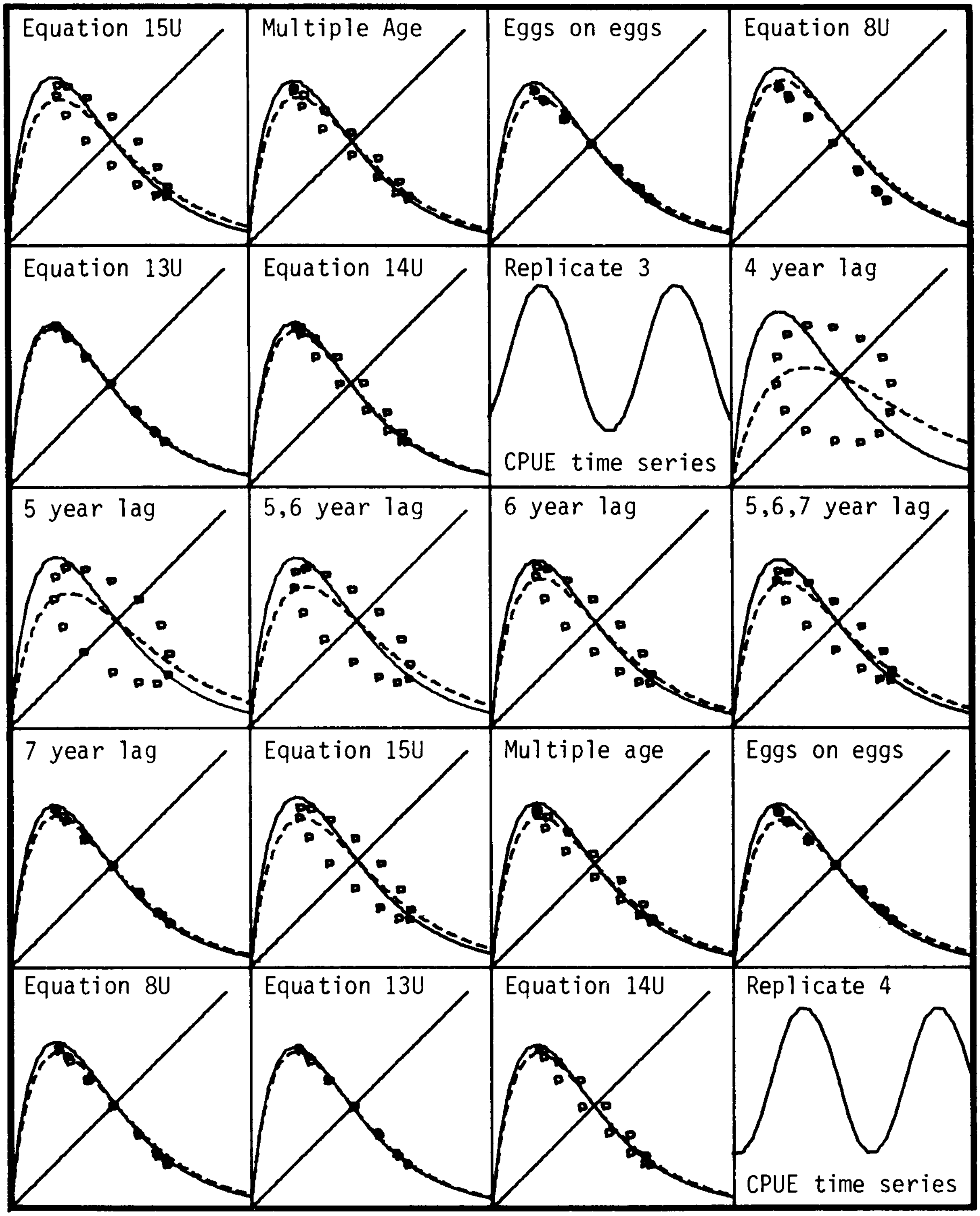

Figure 2. Results from the remainder of Replicate 2 and all of Replicate 3 for Case 101, Run 931 - the proxy test case with alpha of 10 and no random variation. Solid Ricker curves are the source model, dashed curves are the fitted model.

curve in this four year lag case does a very poor job of matching the solid curve. The parameter estimates are poor. In this case, the fitted, or estimated, alpha was 3.01 when the true value was 10. A value of alpha of 1.0 would give a curve which lay along the replacement line. A value of alpha less than 1.0 would suggest a population which, if that situation persisted, would eventually become extinct (TR 2332, lines 6-12).

The next graph shows the fit obtained using the five year lag which was suggested by the utilities' witnesses in advocating the "proxy" approach. The estimated alpha is 5.14; the true alpha is, of course, for this hypothetical Run, 10. The next graph shows the results when "recruits" from five and six years later are averaged together. The next three graphs complete the "lag" analysis. Note that for the seven year lag, which corresponds to the actual generation time in the hypothetical, the dashed curve is closer to the solid curve than is the case for any of the other lags. Thus, the fitted model matches the source model more closely for the seven year lag than for the other lags. As this observation implies, the alpha estimate of 9.08 for the seven year lag is closest to the true value of 10.

The next graph, labelled Eq. (15U), represents the application of Eq. 2-IV-15 on page 2-IV-25 of Exhibit UT-3, but here restructured (or "tuned") to the conditions of the "proxy" hypothetical. When we refer to "tuning" a particular processing approach, we mean that the approach has been set up to conform, as nearly as possible, to the biological characteristics of the simulation model which is generating the simulated CPUE data. The next two graphs represent the "multiple age" and "eggs on eggs" models presented in Exhibit UT-58, but once again tuned to the conditions of the hypothetical. The final three graphs for Replicate 1 are for Equations (8U), (13U), and (14U), respectively, found on pages 2-IV-18 and 2-IV-20 of Exhibit UT-3. These equations are an elaboration of the "second interpretation" originally described on pages 10.45 through 10.49 of Exhibit UT-4. They represent a "matrix" approach to the problem of constructing stock and recruit data points. These three equations have also been "tuned" to the underlying "proxy" hypothetical here.

The graph of Eq. (8U) requires some explanation. Neither of the two curves go through the points. This is because Eq. (8U) (REP = ALPHA x PEP x exp(- BETA x P) has three variables: REP, PEP, and P, representing recruit egg production, parent egg production, and number of parents, respectively. On a two-dimensional graph, only two of these three variables can be plotted. Accordingly, the points are REP and PEP pairs, and the curves here have been plotted by setting P equal to PEP and then rescaling beta as necessary for plotting purposes. In this graph, as in all of the stock-recruitment graphs, beta for the source model has been rescaled to cause the source model to have the same equilibrium point as the fitted model (for graphing purposes only). Thus, the slopes at the origin, which represent the value of alpha, can be compared by eye. The failure of either of the two curves to pass through the points on graphs of Eq. (8U) is an artifact of the restriction to two dimensions.

Note that for this Replicate (Replicate 1), only the four year lag does a poorer job of retrieving the underlying model than the five year lag suggested by the "proxy" approach. Two of the matrix equations [(13U) and (14U)] provide better estimates than the simple seven year lag suggested by the generation time approach. However, these equations have been provided with considerable information about the population (i.e., survival and fecundity rates for reproductive adults, and exact age represented by the CPUE index) which in real situations will not be perfectly known. It would not be appropriate to conclude that Eqs. (13U) and (14U) would necessarily be "better" in a real-world case.

The remainder of Figures 1 and 2 show similar information for Replicates 2 and 3. Some variation in particular results is apparent, even though there is no random variation in population parameters. This variation in particular results is likely the result of different "starting points" for the periodic CPUE series. In the three Replicates here (and in the 117 other ones for which graphs were not prepared), the seven year lag corresponding to generation time was always better than the five year lag advocated under the proxy approach.

Table 2 presents summary statistics for these 120 Replicates. The "processing codes" in the first column simply identify the different ways of processing the CPUE values, as explained in the footnote. The mean values of the estimates of alpha are tabulated in the third column. The column headed "bias" represents the difference between the mean estimated alpha and the true alpha for the model Run. A desirable property for an estimator is that it have zero bias; the larger the magnitude of the bias, the poorer the estimator, other things being equal. The standard deviation (equal to the square root of the variance) is a standard statistical measure of variability. A second

TABLE 2. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 101 (RUN NUMBER 931). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000000

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MINIMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.86	-6.14	0.42	38.24	3.01	3.97	4.33
B	120	5.97	-4.03	0.40	16.52	5.14	6.11	6.38
C	120	6.97	-3.03	0.30	9.37	6.59	7.05	7.51
D	120	8.11	-1.89	0.21	3.65	7.82	8.16	8.49
E	120	7.61	-2.39	0.22	5.82	7.34	7.56	8.08
F	120	9.05	-0.95	0.06	0.92	8.94	9.07	9.10
N	120	7.90	-2.10	0.27	4.50	7.51	7.84	8.39
P	120	8.37	-1.63	0.14	2.69	8.11	8.38	8.61
Q	120	8.42	-1.58	0.07	2.54	8.31	8.43	8.50
X	120	8.82	-1.18	0.38	1.54	8.26	8.86	9.43
Y	120	9.52	-0.48	0.05	0.24	9.44	9.51	9.61
Z	120	9.19	-0.81	0.15	0.68	8.96	9.19	9.36

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 3 YEARS, WITH A 6 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

desirable property of an estimator is that it have minimum variance (or equivalently, minimum standard deviation); that is, that there be no other estimator with a smaller variance. The "mean square error" (MSE) is a useful measure of both bias and variability. The following discussion considers the calculation and the use of MSE.

If a_1 and a_2 are two unbiased estimators of the true a, then the relative efficiency (RE) of the estimators is defined as

$$RE(a_1, a_2) = \frac{\text{variance of } a_1}{\text{variance of } a_2} \quad . \tag{17}$$

Without loss of generality, assume that the variance of a_1 is less than or equal to the variance of a_2. If RE is equal to 1.0, and if one needed to choose between the estimators, one would need to use some other criterion (ease of calculation, for example) as a basis for the choice. If RE is substantially less than 1.0, then one would tend to choose the estimator a_1 over a_2.

If the estimators are biased, one must consider both the bias and the variance in comparing the two estimators. Based upon one's needs, one might choose one estimator over another because it has a smaller variance or because it has a smaller bias. One could also use the mean square error (MSE) which is given by

$$MSE = \text{variance} + (\overline{\text{bias}})^2 \quad . \tag{18}$$

Note that the MSE is a linear combination of the variance and the square of the mean bias. A natural extension of the concept of RE defined earlier is

$$RE(a_1,a_2) = \frac{MSE(a_1)}{MSE(a_2)} \quad . \tag{19}$$

Again without loss of generality, assume that the MSE of a_1 is less than or equal to the MSE of a_2. One could then use the value of RE in Eq. (19) to choose between the two estimators. If the value of RE is substantially less than 1.0, then one would tend to choose the estimator a_1 over a_2.

In our summary tabular comparisons of estimates of alpha (e.g., Table 2), we have tabulated the mean square error (MSE) for each processing approach as a basis for comparing the processing approach with others in the table. In such comparisons, it should be remembered that the larger the MSE for an estimator (as compared to some other estimator), the higher the variance and/or the bias.

The final three columns in Table 2 indicate the minimum, median, and maximum estimates of alpha from the curve-fitting exercise. The median value is the "middle" value, in the sense that half of the values will be higher, and half lower, than the median. The median is sometimes, but not always, close to the mean, or arithmetic average.

Table 2 has been explained in detail because the primary conclusions of this study are based on many such tables, included mainly in Appendix D. What Table 2 tells us is that, for this test case based on Dr. Savidge's hypothetical and with no random variation and a true alpha of 10, the seven years, or mean generation time, lag (processing code F) is superior to all other lags, and it is surpassed by only two of the matrix approaches (which utilize additional information). The five year lag suggested by the proxy argument is the second poorest approach; only the four year lag is worse.

For the other Case in the proxy investigation (Case 102, consisting of Runs 932 and 933), random variation has been added to the young-of-the-year mortality. For the first Run (Run 932) in Case 102, alpha has been held at the same value of 10 used in Run 931. Figures 3 and 4 show the results for the first three Replicates from Run 932, with this random variation and a source alpha of 10. The effect of the random variation is fairly dramatic, and in comparing Figure 3 to Figure 1, it is obvious that the random variation causes poorer, or more biased, estimates of alpha. Expressed another way, the "matches" between the slopes at the origin for the dashed curves (the fitted curves) and the solid Ricker curves (the true curves) are poorer in the presence of the random variation. The tendency to underestimate the true alpha, with a true alpha as high as ten, is increased relative to the Case with no random variation. This tendency does not hold for all individual Replicates. All of the processing approaches, except the four and the five year lags, resulted in an estimate of alpha higher than 10 for at least one Replicate out of the 120 Replicates, while estimates higher than 10 never occurred in Case 101 (no random variation).

Table 3 shows summary statistics for Run 932. Once again, the

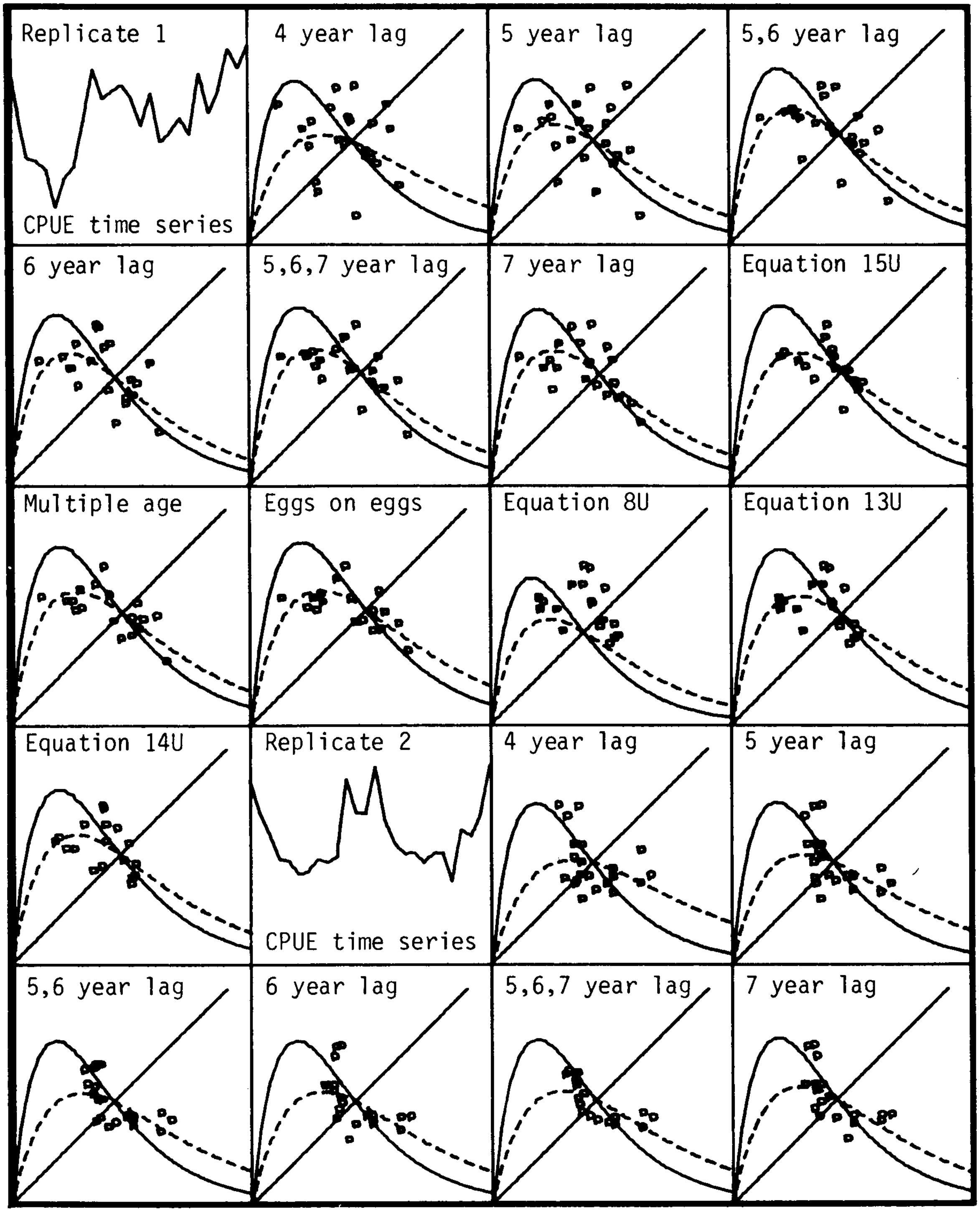

Figure 3. Results from Replicate 1 and part of Replicate 2 for Case 102, Run 932 - the proxy test case with alpha of 10 and random variation in YOY mortality. Solid Ricker curves are the source model, dashed curves are the fitted model.

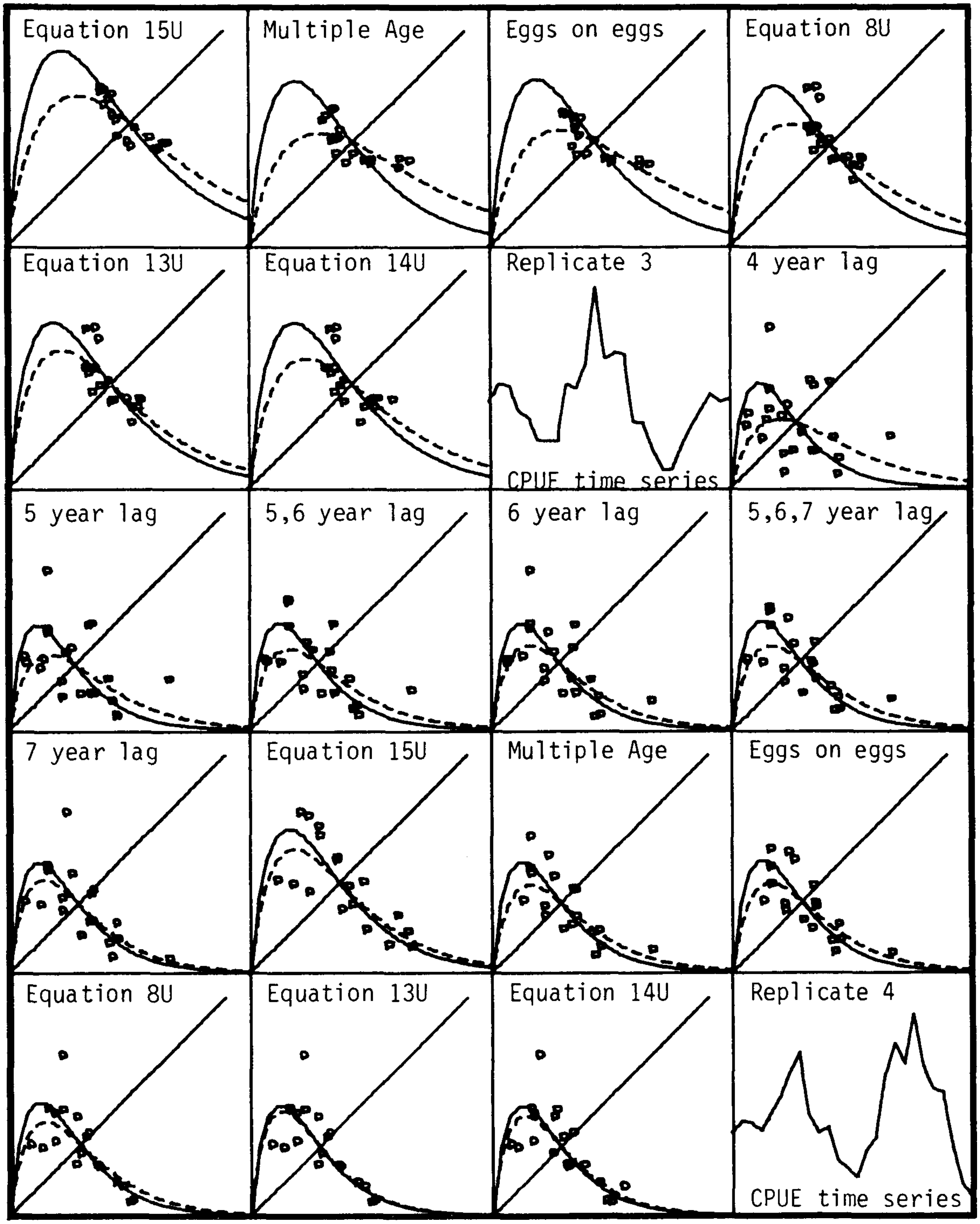

Figure 4. Results from the remainder of Replicate 2 and all of Replicate 3 for Case 102, Run 932 - the proxy test case with alpha of 10 and random variation in YOY mortality. Solid Ricker curves are the source model, dashed curves are the fitted model.

TABLE 3. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 102 (RUN NUMBER 932). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000000

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.79	-6.21	0.85	39.58	2.05	3.70	7.02
B	120	5.27	-4.73	1.35	24.33	2.51	5.20	9.27
C	120	6.06	-3.94	1.58	18.16	2.84	5.95	10.02
D	120	6.92	-3.08	1.85	13.03	2.79	6.90	10.89
E	120	6.53	-3.47	1.75	15.23	3.06	6.34	10.72
F	120	7.52	-2.48	2.14	10.78	2.90	7.36	12.87
N	120	7.56	-2.44	2.23	10.98	3.70	7.40	14.58
P	120	7.12	-2.88	1.96	12.19	3.16	7.16	12.22
Q	120	7.16	-2.84	1.93	11.89	3.21	7.21	11.85
X	120	8.01	-1.99	2.39	9.74	3.18	7.93	14.72
Y	120	9.12	-0.88	3.01	9.81	4.09	8.94	20.00
Z	120	8.54	-1.46	2.59	8.85	3.73	8.45	15.97

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 3 YEARS, WITH A 6 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

seven year lag representing the generation time approach is substantially superior to the five year lag suggested by the proxy approach. All three of the matrix methods perform slightly better than the seven year lag by the MSE criterion. It is interesting to note that the "Eq. (13U)" version of the matrix (processing code Y) gives, on the average, the least biased estimate, but it also has the highest variation, as evidenced by the value of the standard deviation. In the presence of random variation in survival in the model, all of the processing methods show considerably greater variability (or uncertainty) in estimates of alpha (as evidenced by both the standard deviation and the range between the minimum and the maximum estimates) than was apparent in Case 101, a Case which is unrealistic in that it lacked any random variation in the model (Table 2).

One other Run (Run 933) was made for Case 102. In this Run, the true alpha value was decreased from 10.0 to 1.25, and the magnitude of the random variation in YOY mortality was increased so that the degree of variation in the simulated CPUE time series was almost as high as for Run 932. (In general, decreasing alpha decreases variation in the "output" CPUE, because the variations in stock size have less influence on YOY mortality).

Figures 5 and 6 show the first three Replicates from Run 933.* Here, the solid Ricker curve indicating the source model lies close to the replacement line. An alpha value of 1.25 represents a population

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*The CPUE time series for Replicates 3 and 4 appear somewhat more periodic than would be expected for these conditions. Dr. Christensen has examined the time series from the first seventeen Replicates in this Run, and found that the other Replicates do not have this periodic appearance.

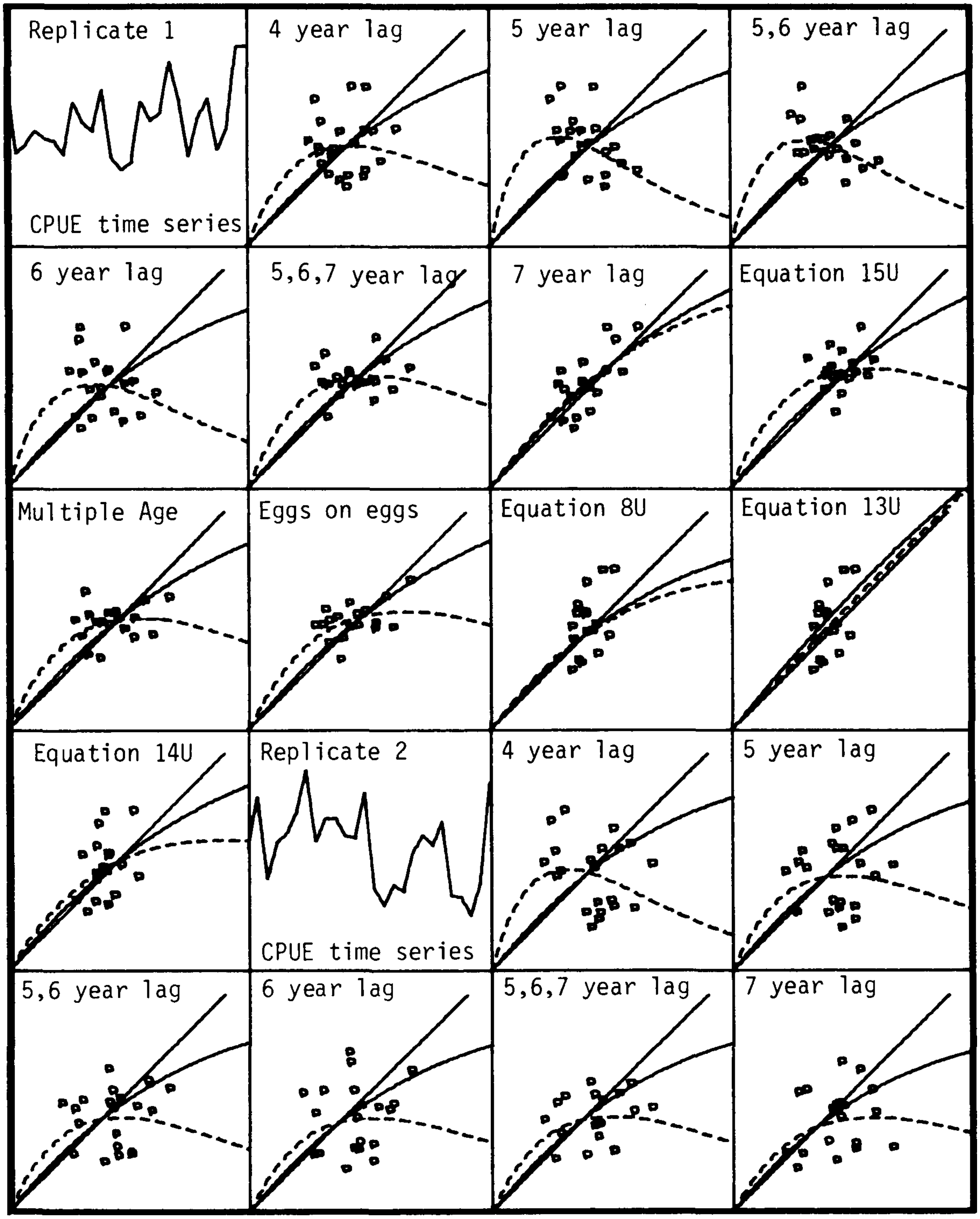

Figure 5. Results from Replicate 1 and part of Replicate 2 for Case 102, Run 933 - the proxy test case with alpha of 1.25 and random variation in YOY mortality. Solid Ricker curves are the source model, dashed curves are the fitted model.

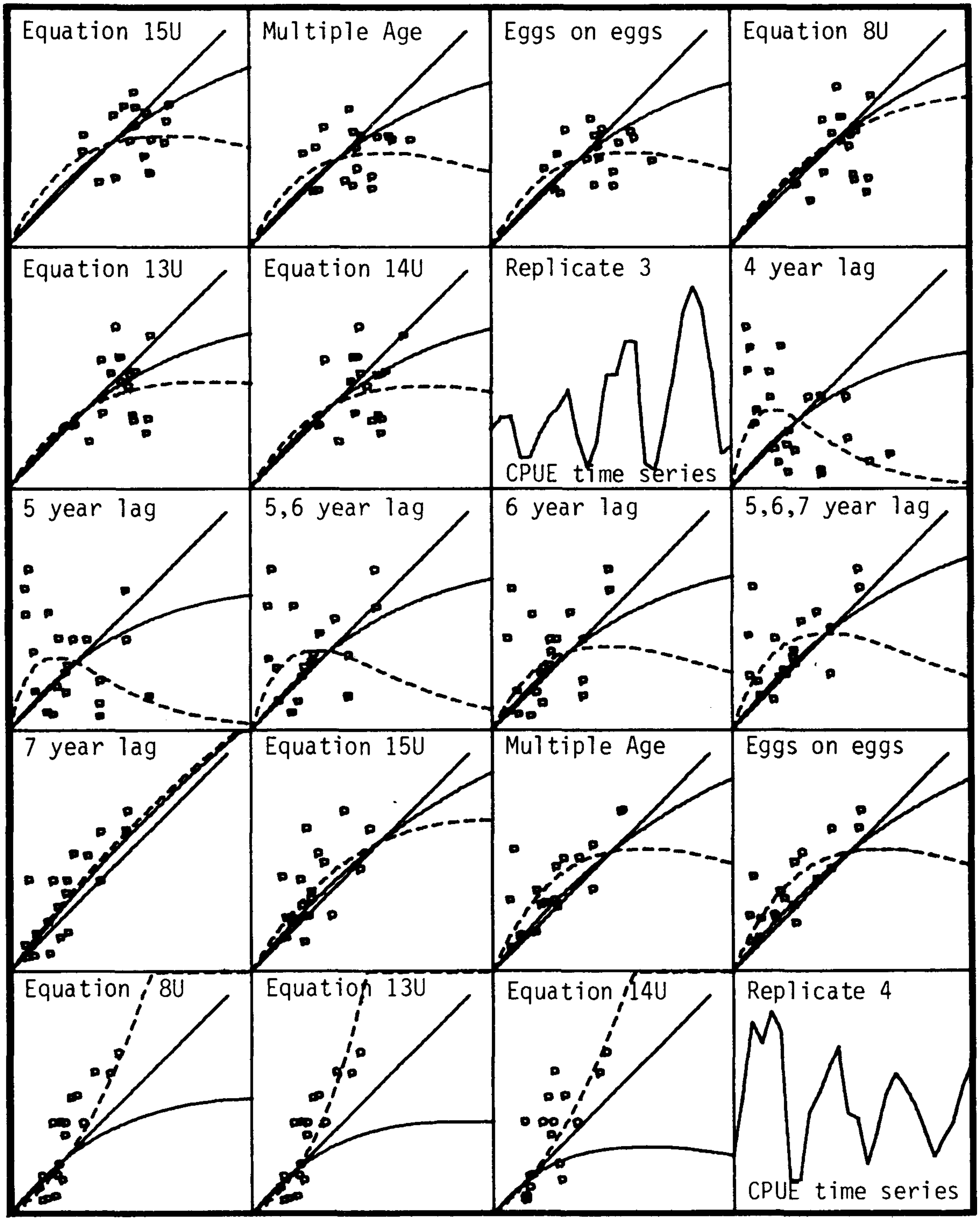

Figure 6. Results from the remainder of Replicate 2 and all of Replicate 3 for Case 102, Run 933 - the proxy test case with alpha of 1.25 and random variation in YOY mortality. Solid Ricker curves are the source model, dashed curves are the fitted model.

with very little compensatory capacity (Goodyear 1977), or ability to resist additional mortality. The fitted curves tend, with a few exceptions, to overestimate the true value of alpha. Sometimes (as in the final three graphs), an alpha value less than 1.0 is estimated, usually implying a negative estimate of beta in the Ricker model. A negative value of beta in the Ricker model is not biologically meaningful (compare TR 2310, lines 18-20). Dr. Lawler has dealt with such reversals in sign in a different stock-recruitment model by excluding the model (p. 2-IV-40, Exhibit UT-3). Both Lawler's procedure and the lack of biological meaning associated with negative estimates of beta suggest an alternative approach to examining the estimates, namely, to exclude estimates of alpha which are associated with a negative beta.

Tables 4 and 5 summarize Run 933 without and with exclusions of alpha estimates associated with negative beta estimates, respectively. Each of the approaches to processing the CPUE values, on the average, overestimates the true alpha in the model. According to the MSE criterion, the seven year lag is either best or second best depending on whether estimates of alpha associated with negative estimates of beta are excluded or not. The five year lag approach, based on the proxy approach, is the second poorest estimator by the MSE criterion; although it has less variation than several other estimators, it produces more biased estimates than all processing approaches except the four year lag.

The reader may note that, compared to Run 932, the biases in the estimates of alpha for Run 933 are relatively small (Tables 4 and 5 of

TABLE 4. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 102 (RUN NUMBER 933). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000000

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.72	2.47	1.28	7.80	1.08	3.64	7.52
B	120	2.96	1.71	0.88	3.73	0.92	2.99	4.93
C	120	2.73	1.48	0.78	2.82	0.90	2.74	4.70
D	120	2.37	1.12	0.77	1.85	0.92	2.29	5.13
E	120	2.58	1.33	0.72	2.31	0.98	2.59	4.32
F	120	2.13	0.88	0.76	1.35	0.82	2.13	4.54
N	120	2.53	1.28	1.08	2.83	0.60	2.44	5.91
P	120	2.37	1.12	0.71	1.77	0.90	2.40	4.17
Q	120	2.37	1.12	0.70	1.75	0.91	2.34	4.18
X	120	1.80	0.55	0.95	1.21	0.38	1.55	5.20
Y	120	1.96	0.71	1.16	1.85	0.39	1.60	7.17
Z	120	2.04	0.79	1.10	1.83	0.54	1.81	7.48

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 3 YEARS, WITH A 6 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE 5. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 102 (RUN NUMBER 933). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000000

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.72	2.47	1.28	7.80	1.08	3.64	7.52
B	120	2.96	1.71	0.88	3.73	0.92	2.99	4.93
C	120	2.73	1.48	0.78	2.82	0.90	2.74	4.70
D	120	2.37	1.12	0.77	1.85	0.92	2.29	5.13
E	120	2.58	1.33	0.72	2.31	0.98	2.59	4.32
F	119	2.13	0.88	0.76	1.37	0.82	2.14	4.54
N	118	2.56	1.31	1.06	2.87	0.92	2.45	5.91
P	120	2.37	1.12	0.71	1.77	0.90	2.40	4.17
Q	120	2.37	1.12	0.70	1.75	0.91	2.34	4.18
X	98	2.03	0.78	0.90	1.42	0.74	1.85	5.20
Y	100	2.20	0.95	1.12	2.16	0.78	2.01	7.17
Z	103	2.23	0.98	1.06	2.11	0.83	2.01	7.48

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 3 YEARS, WITH A 6 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
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- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

Table 3). This would not, however, necessarily make them more reliable for decision-making purposes if this were a real situation. With a true mean alpha value of 1.25, application of the utilities' Equation 2-V-2 of p. 2-V-1 of Exhibit UT-3 indicates that any sustained total conditional mortality rate in excess of 20% would drive the population to extinction, if all other factors were held constant. Using the least biased mean estimate of alpha from Table 5, namely, 2.03 for the first matrix method (Proc. Code X), would lead to the conclusion that a total conditional mortality rate in excess of 50% would be needed to cause eventual extinction. This illustrates the important point that, as the true value of alpha becomes smaller, it is increasingly important to have an accurate estimate of that true alpha (TR 2339, lines 3-10). Therefore, while the curve-fitting exercise may have greater accuracy for low values of alpha than for high values of alpha, the risk associated with even small inaccuracies can be very substantial, if alpha is accepted as an applicable concept and is in fact low.

Many other Cases could be constructed to investigate the proxy approach. It is likely that some sets of assumptions can be made that would make both the generation time approach and the proxy approach equally useless. It is conceivable that a reasonable hypothetical situation can be found where the proxy approach sometimes produces more accurate estimates than the generation time approach, but if this happened, it would likely be due to the use of a feedback term in the Ricker model which altered the relationship between periodicity in the population and generation time, rather than due to the reasoning behind the proxy approach itself. As applied by the utilities to the Hudson

River striped bass population in an attempt to justify the alpha estimates obtained using a five year lag, we feel the approach is fallacious.

Chapter 5

RELIABILITY OF THE UTILITIES' ESTIMATES OF ALPHA

Summary

In the previous chapter (Chapter 4), the validation methodology was applied to a hypothetical population in order to probe the "proxy approach." Now, in this chapter, the validation methodology is applied to the Hudson River striped bass population. First, the utilities' methods are applied to the Hudson River CPUE time series (including recent corrections). Next, the same methods are applied to simulated CPUE values generated from our model, where the underlying alpha values are known at the outset. The estimates of the known alpha values obtained from conducting the curve-fitting exercise on the simulated data are shown to be very unreliable. Furthermore, the statistical tests for the significance of the density-dependent term in the Ricker model yield spurious results. We conclude that the utilities' estimates of alpha cannot be relied on, even if the Ricker model were known to apply to the Hudson River striped bass population.

The preceding chapters have explained the validation model and have illustrated its application to the proxy approach. In this chapter, we apply the model to investigate the reliability of the utilities' attempts to estimate alpha for the Hudson River striped bass population.

The utilities' most recent estimates of alpha (Marcellus 1979) are based on the corrected and updated CPUE data presented in Table 6. In addition to the CPUE data, the utilities have utilized data on freshwater flow rates for the years involved in the CPUE index in a multiple regression analysis (Exhibit UT-58). Table 6 also presents the "Q7" flow values used in the fits presented by the utilities. These values represent a seven-month (February through August) average of flows within each year at Green Island, New York, above Troy Dam.

The utilities have not performed the full curve-fitting exercise (i.e., involving application of all processing approaches) on the corrected and updated data. The results of such an exercise are presented in Table 7, which provides estimates of alpha and of gamma (the coefficient relating flow to YOY mortality) based on the data presented in Table 6. The processing codes refer to the processing approaches used by the utilities to manipulate the CPUE data in an attempt to extract indices of stock and recruits. These methods are described in Chapter 4. For all of the applications described in this chapter, the "multiple age," "eggs on eggs," and three matrix models have been set up using the utilities' current best estimates of population parameters (i.e., fecundities in the matrix models are based on Table 2-VIII-5 of Exhibit UT-3; parameters for the "multiple age" and

Table 6. Hudson River striped bass catch-per-unit-effort (CPUE) data and "Q7" flow data[a]

Year	Striped Bass CPUE	Hudson River flow
1950	2522	14092
1951	7663	18349
1952	9935	18469
1953	5394	17927
1954	7623	17333
1955	4657	15166
1956	5830	16899
1957	5357	9893
1958	4932	14708
1959	8496	13373
1960	9250	17177
1961	4939	14296
1962	3232	12444
1963	4548	12258
1964	3324	11387
1965	4673	7912
1966	5879	12134
1967	8378	12002
1968	7153	14444
1969	9994	16200
1970	4986	14375
1971	5020	18191
1972	3399	24557
1973	10736	19637
1974	1950	17061
1975	2698	16861
1976		25234

[a]Source of data: Exhibit UT-58, and letter dated January 9, 1979, from Kenneth L. Marcellus, Consolidated Edison Company of New York, Inc., to Henry Gluckstern, Environmental Protection Agency (Region II), and references contained therein. "Q7" flow is an index of freshwater flow in cubic feet per second at Green Island over the period February through August. The CPUE data reported here are presented for the sake of completeness, but we do not endorse their use as an index of striped bass population size.

Table 7. Estimates of alpha, a parameter in the Ricker model, and gamma, a term relating river flow to mortality of young-of-the-year fish, based on the Hudson River striped bass 1950-1975 CPUE index

			Flow included in fit					
	Flow not included in fit		No lag between CPUE and flow			One year lag between CPUE and flow		
Processing code[a]	Alpha	r^2	Alpha	Gamma ($\times 10^5$)	r^2	Alpha	Gamma ($\times 10^5$)	r^2
A	2.89[b]	0.43	2.52	- 3.9	0.46	2.58	- 5.8[c]	0.54
B	4.03[b]	0.63	4.77	4.4	0.65	3.84	-1.8	0.63
C	3.82[b]	0.72	4.24	2.7	0.73	3.98	1.3	0.72
D	3.18[b]	0.50	3.36	1.4	0.50	3.38	2.1	0.51
E	3.08[b]	0.69	3.54	3.5	0.73	3.11	0.25	0.69
F	2.69[b]	0.37	3.63	7.4	0.47	2.73	0.41	0.37
N	3.40[b]	0.54	d	d	d	d	d	d
P	3.27[b]	0.72	3.89	3.7	0.76	3.31	0.34	0.72
Q	2.78[b]	0.70	3.14	2.6	0.73	2.91	1.3	0.71
X_e	1.62	0.09	2.02	- 6.8	0.17			
X_f	1.58	0.06	1.79	- 6.0	0.14			
Y_e	30.62[b]	0.38	55.17	4.2	0.41			
Y_f	11.56	0.21	10.61	- 0.61	0.21			
Z_e	3.94	0.38	4.52	- 4.2	0.41			
Z_f	5.23[b]	0.37	5.73	- 4.4	0.41			

[a]Key to processing codes:
- A: 4 year lag.
- B: 5 year lag.
- C: Recruits obtained by averaging 5 and 6 year lags.
- D: 6 year lag.
- E: Recruits obtained by averaging 5, 6, and 7 year lags.
- F: 7 year lag.
- N: Equation 15U: Parents and recruits each obtained by summing over 7 years, with a 4 year lag.
- P: "Multiple age" model, Exhibit UT-58.
- Q: "Eggs on eggs" model, Exhibit UT-58.
- X: Matrix model REP = alpha * PEP * exp (-beta * P) (Equation 8U).
- Y: Matrix model REP = alpha * PEP * exp (-beta * PEP) (Equation 13U).
- Z: Matrix model R = alpha * P * exp (-beta * P) (Equation 14U).

[b]The associated parameter beta is "significantly" different from zero at the 0.05 level. As is discussed in the text, the results of this statistical test are not reliable.

[c]The only "significant" gamma value, using the 0.1 level of significance chosen by the utilities in Exhibit UT-58, is the one for the 4 year lag with a 1 year lag between CPUE and flow.

[d]It is not clear how to associate flow with a spawning year for this approach.

[e]The matrix is set up using 0.43 annual survival and ages 3-10, with the catch assumed to be exclusively five-year-olds. Fecundity indices for the matrix are derived from Secton 2-VIII of Exhibit 3.

[f]The matrix is set up using 0.60 annual survival and ages 3-11, with the catch assumed to be exclusively five-year-olds. Fecundity indices for the matrix are derived from Section 2-VIII of Exhibit 3.

"eggs on eggs" models are those used in Exhibit UT-58). Survival in the matrix models was set equal to the survival used in our simulation model (usually 0.43, except for Case 2, where 0.6 was used). Figures 7 and 8 are graphs of most of the fits corresponding to the alpha estimates in the second and fourth columns of Table 7.

Of the fits summarized in Table 7, the ones which we understand to be in agreement with testimony sponsored by the utilities are the alpha estimates, with flow not included in the fit, for processing codes B, D, F, P, and Q (Marcellus 1979). These estimates are the alpha values obtained from the Exhibit UT-58 analysis, but using the corrected and updated data (see footnote on p. 24 in Chapter 3). The utilities did not initially (in Exhibit UT-58) present values for alpha with flow included in the fit, except when gamma was significant at least at the 0.1 level; none of the estimates of gamma now meet even that test of significance.

The average of these estimates of alpha, with flow not included in the fit, for processing codes B, D, F, P, and Q is 3.2, using the corrected data (Table 7). The corresponding average from Exhibit UT-58 (using the uncorrected data set) was 3.4. In addition, in three cases (the five year lag, the "multiple age" model, and the "eggs on eggs" model), flow was "significant" (at the 0.1 level) in the fitted model in the Exhibit UT-58 analysis. The average of the alpha estimates, with flow include in the fits, was 4.6 for these three cases in Exhibit UT-58. Thus, the estimates of alpha in Exhibit UT-58, taken at face value, could have been considered, more or less, to support the utilities' choice of 4 as a "reasonable working level of alpha" (TR

KEY TO FIGURE 7

A: Hudson River CPUE time series, 1950 - 1975 (see Table 6).

B: Approximate Hudson River Flow at Green Island, New York, averaged over the months of February through August, for the years 1950 - 1975 (see Table 6).

C: 4 year lag, flow not included in fit.

D: 4 year lag, flow included in fit.

E: 5 year lag, flow not included in fit.

F: 5 year lag, flow included in fit.

G: 5,6 year lag, flow not included in fit.

H: 5,6 year lag, flow included in fit.

I: 6 year lag, flow not included in fit.

J: 6 year lag, flow included in fit.

K: 5,6,7 year lag, flow not included in fit.

L: 5,6,7 year lag, flow inlcuded in fit.

M: 7 year lag, flow not included in fit.

N: 7 year lag, flow included in fit.

O: Equation 15U, flow not included in fit.

P: Equation 15U, flow included in fit.

Q: Multiple Age Model, flow not included in fit.

R: Multiple Age Model, flow included in fit.

S: Eggs on Eggs Model, flow not included in fit.

T: Eggs on Eggs Model, flow included in fit.

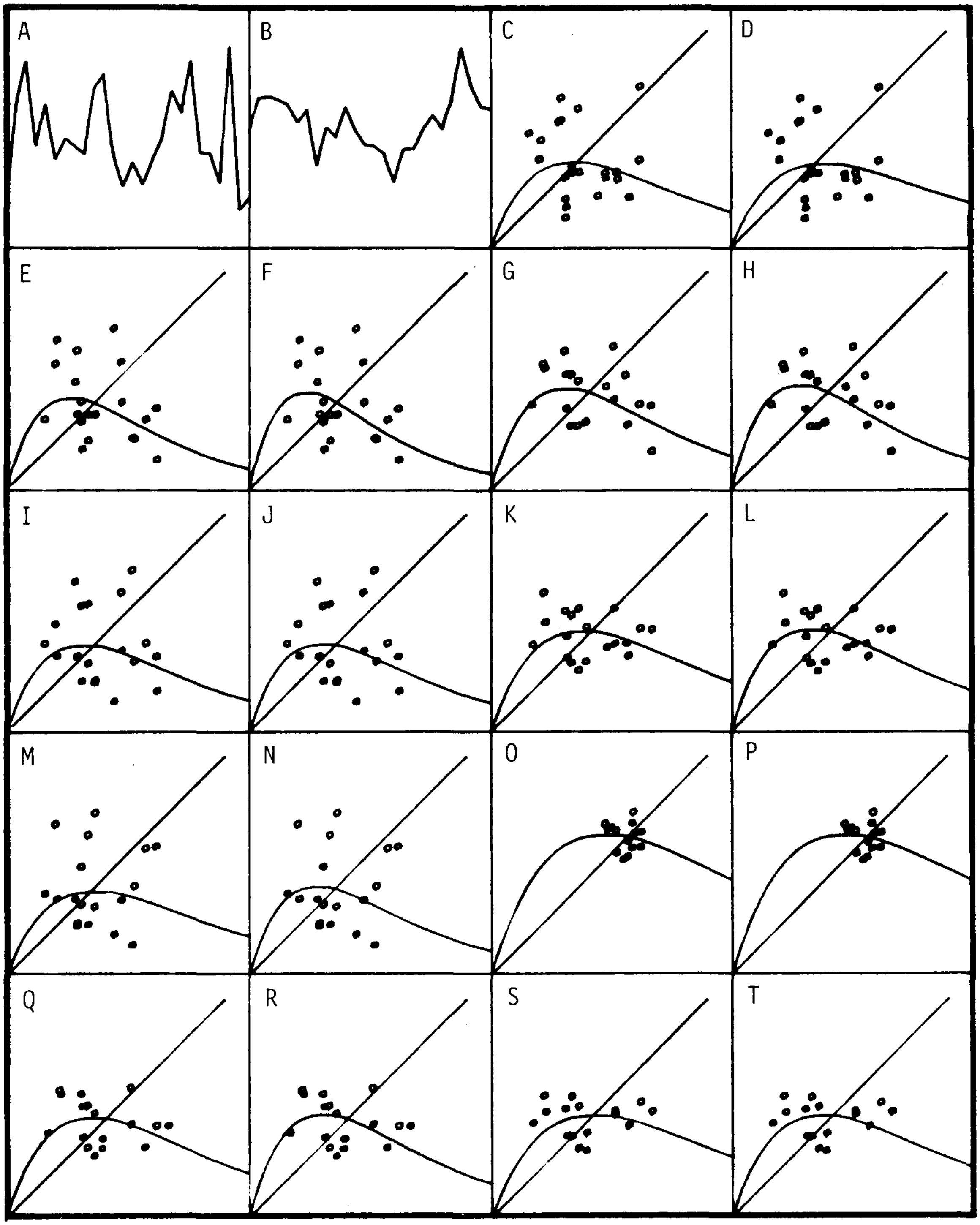

Figure 7. Results of the curve-fitting exercise using Hudson River CPUE data, for fits not utilizing flow and for fits utilizing flow not lagged with CPUE. Matrix models shown here use 0.43 survival and include ages 3-11. See key.

KEY TO FIGURE 8

A: Matrix model - Equation 8U, flow not included in fit.

B: Matrix model - Equation 8U, flow included in fit.

C: Matrix model - Equation 13U, flow not included in fit.

D: Matrix model - Equation 13U, flow included in fit.

E: Matrix model - Equation 14U, flow not included in fit.

F: Matrix model - Equation 14U, flow included in fit.

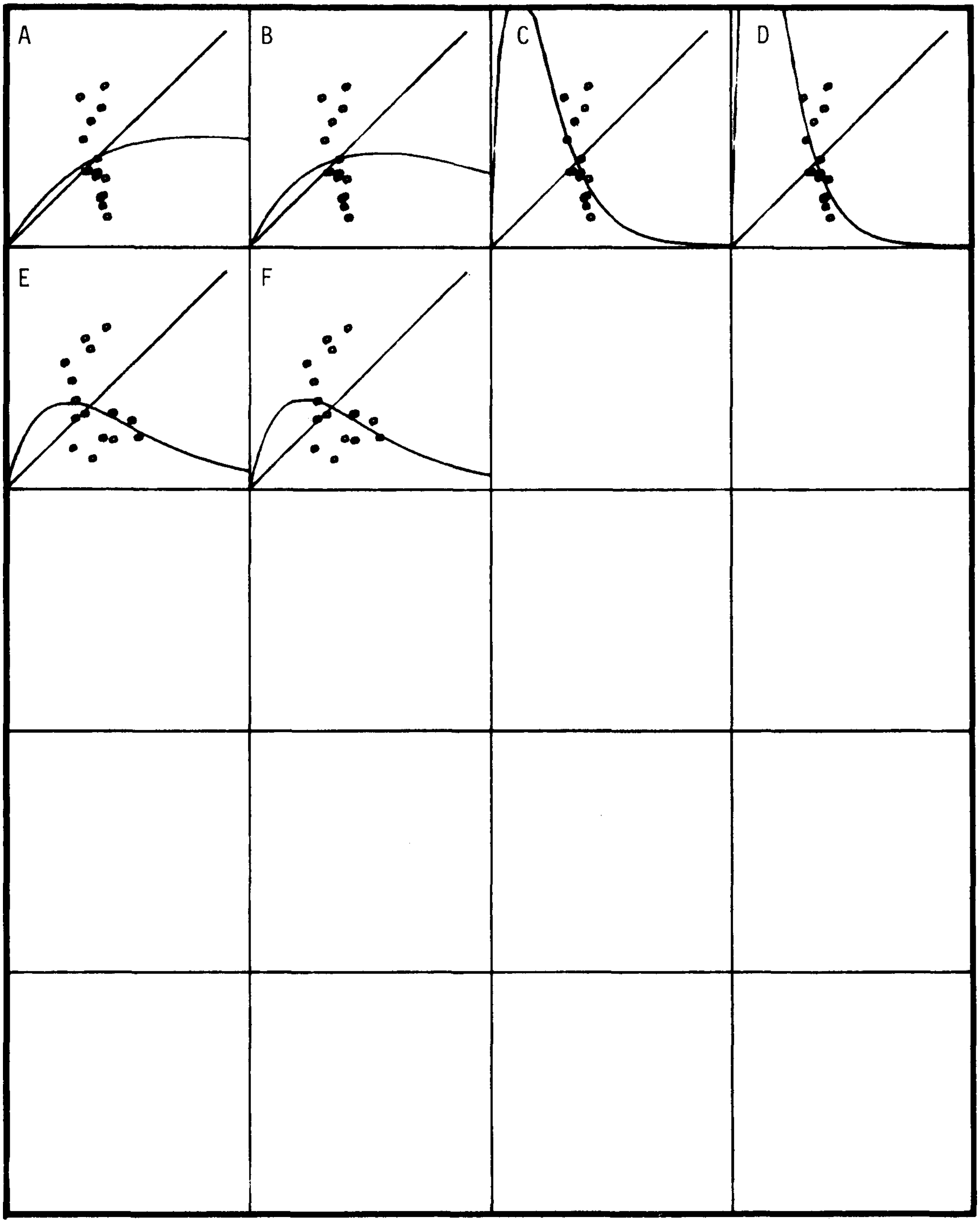

Figure 8. Continuation of Figure 7.

1882, lines 9-10) in the Hudson River striped bass population. However, the average alpha estimate of 3.2 obtained by applying the Exhibit UT-58 analysis to the corrected and updated data, taken at face value, would support an alpha value of 3 rather than 4. As will be shown later in this chapter, the estimates are unreliable, and therefore cannot be taken at face value.

Processing code A (the four year lag) is not one for which the utilities have presented results. It is included here (Table 7) because, if the Ricker model applied to the Hudson River with cannibalism providing the "feedback," a shorter lag might conceivably be more effective in estimating alpha. This possibility arises because the feedback term would be more influenced by younger ages than in the case where eggs provide the feedback. This shift toward younger ages in the feedback term would cause oscillations with a shorter period. All of the other processing codes in Table 7 represent approaches that the utilities have actually used in their direct testimony, although they were not applied by the utilities to the expanded or corrected CPUE data set. In the case of specifying parameters for the matrix approach using the newer data, we applied the technique as we thought the utilities would have, guided by their earlier applications of this method. We chose, for the 0.43 survival assumption, ages 3-10 in order to include most of the egg production and, for the 0.6 survival assumption, ages 3-11 for the same reason; the catch was assumed to consist of five year old fish. These choices were also retained for our analysis of output from the simulation model using the matrix approaches.

The results including flow are presented for the sake of completeness, even though the ability of flow to explain variation in the data is non-significant in almost all of the applications (the frequency of statistical significance at the 0.1 level is one out of 22 trials). The biological assumption underlying Dr. Lawler's inclusion of flow in the fitted model is that flow influences young-of-the-year striped bass mortality (technical conference between EPA's consultants and Dr. Lawler, February 28, 1978; TR 2132-33). Therefore, the flow index for a given year needs to be associated with an index of spawning for that same year. The only possible basis for pairing the flow index from a given year with the CPUE index from that same year would be if the CPUE index in any particular year were the best measure of actual spawning in that same year. When the utilities utilized flow in multiple regressions, they associated each particular CPUE value with the flow value from the same year. This would be supported by the utilities' contention, utilized in Exhibit UT-58, that "the age composition of the commercial catch is a good reflection of the age composition of the spawning stock" (Exhibit UT-3, p. 2-VIII-15; also see TR 1916, lines 11-14). However, we believe this conclusion is untenable (Fletcher 1979). We have added to Table 7 an analysis with flow which pairs the CPUE value for a given year with the Q7 flow value from the following year. This is a somewhat more logical pairing of CPUE values with flow, since the CPUE value in a given year is likely a better index of spawning in the next year than in the present year. Flow results have not been presented for Eq. (15U) (processing code N), because it is unclear how to define a single spawning year which is associated with a particular stock index. For the matrix models, the spawning year is explicit (depending on the age assumed caught), and there is no need to lag flow. In our view, attempts to include flow with any of the non-matrix-model approaches are unlikely to provide any useful information about the population (or about alpha) in part because of substantial ambiguity about the particular spawning year best associated with a particular CPUE value.

The fundamental question our study was designed to answer is: are the estimates of alpha obtained by the utilities' curve-fitting techniques, as presented in Table 7, reliable estimates (always assuming, of course, that the Ricker model is applicable to the Hudson River striped bass population). Up to this point, we have been concerned with describing the model (Chapters 2 and 3), illustrating its application and addressing the "proxy approach" (Chapter 4), and describing the application of the utilities' techniques to the Hudson River CPUE data (this Chapter). We now turn to the simulation results to examine the reliability of the use of the utilities' techniques for attempting to estimate alpha (assuming it applies) for the Hudson River striped bass population.

A description of the choices involved in constructing Cases for our simulation model Runs is provided in Chapter 3. Table 8 presents the life-history data for the Hudson River striped bass population which was used in our runs with the validation model. In general, our intent in choosing these life-history parameters was to base them on the utilities' preferred estimates, so that dispute over choice of parameter values could be avoided in the context of our validation analysis. The values in Table 8 for the fraction of females mature and eggs per mature female correspond to the utilities' current best estimates. The

Table 8. Life-history data used for the Hudson River striped bass population[a]

Age	Fraction of females mature	Eggs per mature female	Fraction surviving from previous age	Relative representation in CPUE index[b]	Weight (pounds)[c]
1	0.0	0	d	0.0	0.023
2	0.0	0	0.43	0.006	0.211
3	0.04	658,000	0.43	0.164	1.01
4	0.07	658,000	0.43	0.128	2.57
5	0.19	578,000	0.43	0.291	3.85
6	0.43	714,000	0.43	0.240	5.88
7	0.86	928,000	0.43	0.087	8.26
8	0.89	1,310,000	0.43	0.022	12.8
9	1.00	1,570,000	0.43	0.004	14.4
10	1.00	1,760,000	0.43	0.023	16.6
11	1.00	1,980,000	0.43	0.023	17.7
12	1.00	2,090,000	0.43	0.005	20.6
13	1.00	2,130,000	0.43	0.006	22.7
14	1.00	2,190,000	0.43	0.0	21.3
15	1.0	2,590,000	0.43	0.0	21.6

[a]Source of data: Exhibit UT-3, Tables 2-VIII-1 and 2-VIII-5; fraction female assumed constant at 0.5; relative representation by number in CPUE index based on data tape supplied by utilities, including fish caught by all four fishermen.

[b]These values specify the age-frequency distribution by number of fish of the particular age class in the CPUE index for an equilibrium population.

[c]Based on Exhibit UT-4, Tables 7.8-1 and 7.8-2, and equations and coefficients provided on p. 7.140 (as corrected by Exhibit UT-4E-1).

[d]Survival from age 0 to age 1 is calculated in the model. Survivals for other ages were held constant at either 0.43 (shown in this table) or at 0.60 for Runs 33-38.

fraction female was assumed constant at 0.5. An alternative might have been to utilize a value for fraction female which increased with age, as the utilities did in one case (Exhibit UT-3, Table 3-IV-15). Use of this alternative would have lengthened the effective generation time in our simulations, but the utilities seem to prefer parameter values which shorten the generation time (e.g., the use of an assumed annual adult survival of only 40% in calculating a generation time of 5.6 years from Table 2-VIII-5 in Exhibit UT-3; see TR 3847).

In Table 8, the value of 0.43 chosen for most runs for the annual adult survival represents a value Dr. McFadden has indicated he feels is a good estimate of survival, based on the recent Hudson River data (TR 153). Higher values could easily be argued for, but in the interests of avoiding contention in the validation work we used 0.43 for most runs.

The age-frequency distribution by number of fish in the CPUE index was estimated using the combined catches of all four fishermen (A, B, C, and D) from the 1976 "simulated commercial fishery." The utilities have tended to ignore fishermen C and D in analyzing the age composition of the commercial catch (e.g., Table 2-VIII-8 of Exhibit UT-3), but they have offered no basis for this. If anything, the fact that Fishermen C and D were paid at least in part on a per-fish basis (TR 2696, lines 13-15), while fishermen A and B were paid on a fixed-fee basis (TR 2696, lines 13-15), would argue that Fishermen C and D's catches might be more representative of the actual commercial catch, all other factors being equal. For Fisherman D, this fact is offset by the fact that he used drift gill nets (Exhibit UT-3, Table 2-VIII-6), and catch from this kind of gear is not represented in 10 of the 26 years in the CPUE index (Exhibit UT-58, footnote 1.a to Table 2).

As mentioned earlier, the values for fecundity and survival used in applying the matrix approaches to model-generated CPUE time series were the same values used in the particular Case in question (i.e., used in the simulation model itself). Thus, these approaches were "tuned" (see Chapter 4) to the conditions of the simulation, except that the ages included in the matrix were chosen, as mentioned earlier in this chapter, to include most of the egg production. Table D-1 (Appendix D) summarizes the seven main Cases which comprise this study. As explained in Chapter 2, the estimates of the true model alpha obtained using curve-fits to model-generated data are expected to be more accurate and reliable than estimates of the true Hudson River alpha (if one exists) obtained using the Hudson River CPUE time series. This result is expected because the causes of the "behavior" of the CPUE index are necessarily more closely related to the Ricker model in our simulation than one could expect them to be in nature.

In order for this validation exercise to be meaningful, the salient characteristics of the Hudson River CPUE time series should also be found in typical, model-generated Replicates of the CPUE time series. For example, if there were a characteristic significant periodicity in the Hudson River CPUE time series that were due to the feedback effect corresponding to the (-beta x P) term in the Ricker model, this periodicity would provide a criterion to use in judging the realism of model-generated CPUE time series. Accordingly, we subjected the Hudson River CPUE time series to spectral analysis (Jenkins and Watts 1968, Burg 1972, Kirk et al. 1979) to test for statistically significant periodicities. The results of this test are shown in Figures B-1 through B-8 in Appendix B. No significant, or even nearly-significant, periodicities were found.

If we had a basis for believing that the Hudson River striped bass CPUE values were non-normally distributed, or non-lognormally distributed, then we might logically design our model Cases so that simulated CPUE values in typical model Replicates were similarly distributed. Thus, as a second possible criterion for model realism, we tested the null hypotheses that the CPUE values, or the natural logarithms of the CPUE values, are normally distributed. The null hypothesis was not rejected in either case, based on either the Kolmogorov-Smirnov statistic or the Fisher G-statistics for sample skewness or kurtosis.

The remaining salient characteristic of the Hudson River CPUE time series is its variability (see Graph A of Figure 7). Clearly, if most of the model replicates had much more, or much less, variation than the Hudson River CPUE time series, the model would not be producing very realistic simulations of those data. Accordingly, as explained in Chapter 3, the median of the distribution of coefficients of variation of simulated CPUE time series from the Replicates within each Run was constrained to be approximately the same as the coefficient of variation of the Hudson River CPUE time series. This constraint was achieved by varying the magnitude of random variation in the model as needed. In general, less random variation was required in order to achieve the requisite variation in model-generated CPUE values as higher alpha values were used, because the feedback term in the Ricker model caused increasingly higher variation in CPUE as alpha increased. Appendix C consists of graphs of the simulated CPUE time series from Runs 46 and 48, with a low alpha and a high alpha, respectively.

Summary results from application of the validation model in Cases 1 through 7 are presented in Appendix D. Each Case consists of from 3 to 7 Runs. Results from each Case are presented together. For a particular type of analysis (e.g., alpha estimated without flow in the fit, and excluding alpha values associated with negative estimates of beta), the tables for the Runs within the Case are presented in order, from low true (i.e., initially-specified) alpha values to high true alpha values. These tables contain the same kind of information as was presented in Tables 2 - 5, in connection with the proxy approach. Tables of alpha estimates are provided both with and without flow included (but with flow always paired with the CPUE value from the same year, as Dr. Lawler did in Exhibit UT-58), and with and without exclusion of alpha estimates associated with negative beta estimates.

Several important conclusions can be reached based on the information presented in Appendix D:

1. For low true model alpha values (1.0 or 1.25), the curve-fitting exercise consistently tends to overestimate the true value of alpha. In other words, there is a positive bias. True alpha values of 2.5 are usually, but not always, overestimated. Alpha values of five and higher are usually underestimated. For alpha values on the order of 10 and

higher, most of the methods of processing the CPUE values produce maximum estimates of alpha which are almost always lower than the true value of alpha.

2. As the true value of alpha is increased over the range of 1.25 to 20, the mean value of the estimated alpha values increases from around 2 - 3 for a true alpha of 1.25 to around 4 - 6 for a true alpha of 20, for most processing approaches. In other words, the estimates of alpha tend to be very unresponsive to the change in the underlying true alpha. The beginning and end points of the range of estimates, and the degree of change in the mean estimates as alpha increases, depend on the processing approach involved and on the particular Case.

3. There is considerable variation in estimates of alpha for a particular processing approach within a Run, indicated by the standard deviation, or somewhat more dramatically by the range from the minimum to the maximum estimated alpha.

The conclusion to be drawn from the combined effect of this variation and the unresponsiveness of estimates of alpha mentioned in conclusion (2) is that a particular estimate of alpha cannot be relied on. For example, for every true value of alpha (ranging from 1.0 to as high as 30), and using the five year lag approach, estimates of alpha were generated using the model which were both higher and lower than the value of 4.03 obtained using the same five year lag approach on the Hudson River CPUE time series. In other words, an estimate of alpha of 4.03 could be obtained by applying a five year lag to the model-generated CPUE time series, given true alpha values in the model ranging from at least 1.0 to 30. Therefore, we could expect that, if the Ricker model is applicable to the real Hudson River, the estimate of 4.03, which is obtained by applying the five year lag to the real Hudson River CPUE time series, could be obtained given an actual value of alpha for the Hudson River striped bass population of 1.0 or of 30.

4. The relative efficiency of the various processing methods within Runs, as judged by the mean square error (MSE) criterion, varies among true alpha values and among Cases. Looking at the fits without flow and with alphas associated with negative betas excluded, the minimum MSE was associated once with the four year lag, once with the average of five and six year lag, three times with the seven year lag, once with Eq. (15U), seven times with the "eggs on eggs" model, eight times with the Eq. (8U) version of the matrix, and six times with the Eq. (13U) version of the matrix. In many instances, however, other processing methods had nearly as low MSE values as these "best" values for a particular Run. The MSE criterion does not show any of these processing methods to be either noticeably better or noticeably worse than the others for all Cases.

5. Of the lag approaches (processing codes A through F), neither the proxy approach nor the generation time approach provides clearly better estimates. When the model alpha values are low,

the stock-dependent mortality, or "feedback," is weak, and we might expect the behavior of the various lags to be indistinct from one another. When the model alpha values are high, the "feedback" is relatively stronger, and we might expect to see more differentiation between the results from the various lags.

For Cases 1 and 2 (with the random variation solely in the YOY mortality), if we examine the "bias" columns in the tables of summary statistics in Appendix D for alpha with flow not included in the fitted model and with alpha estimates associated with negative estimates of beta excluded, we find this expectation to be the case. For low true model alpha values (1.0, 1.25, or 2.5), all of the lags produce similar biases; the minimum biases are associated with the five year lag in most of these cases. As alpha is increased to 5 and above, however, two things occur. First, the minimum bias shifts and becomes associated with longer lags, and for the highest alpha values becomes associated with the simple lag most closely related to the generation time (i.e., six years for Case 1; seven years for Case 2). Second, the absolute differences in the biases become greater, reflecting more of a differentiation in the results among the various lags when alpha is high. All of these results are highly biased, however, so one should not conclude that the curve-fitting exercise is working "better" with these high true alpha values.

The above observations do not persist very well for Cases 3 through 7, which have the random variation "shared" between the young-of-the-year mortality and the CPUE values. The bias shows little pattern in most cases, and it is not possible to conclude that any of the lags are consistently "better" in a relative sense for particular levels of alpha. For all seven Cases, the pattern in the mean square error (MSE) is very similar to the pattern in the bias. It seems likely that all of these lags are so unable to supply good indices of stock and recruitment to fulfill the needs of the curve-fitting exercise for this particular population that it is virtually pointless to attempt to choose among them. The lag approaches (and in fact all of the approaches) are, in general, much less successful when applied to the striped bass life-history parameters in Table 8 than they were when applied to the simpler "proxy" situation.

6. The Eq. 13U version of the matrix approach (processing code Y) stands apart from the other methods. It tends to be the most biased method for low true alpha values and the least biased method for high true alpha values. It is also highly variable, particularly for low true alpha values, and it occasionally produces very high alpha estimates. As a result, the MSE value using the Eq. (13U) version of the matrix approach with low true model alpha values is frequently more than an order of magnitude higher than the MSE values from many other approaches, indicating that it is a very bad estimator in comparison with the other estimators. On the other hand, for high true alpha values the Eq. (13U) version of the matrix

approach is frequently the "best" estimator (i.e., with markedly lower MSE than any other method, but still with very substantial bias and variance; it is a poor estimator surrounded by even worse estimators in these instances).

7. Gamma, the term relating flow to YOY mortality, is estimated rather poorly when it is included in the model. This would certainly cast serious doubt on the usefulness of attempting to include flow in such curve-fitting models in an attempt to "improve" estimates of alpha. Usually, the estimated value is less than the true value of gamma, which is always 0.000036 in these Runs. The estimates of gamma are usually positive more than half the time, but not much more than half the time. If a series of random numbers unrelated to the source model were used in the fitted model instead of the simulated flow values, the results would likely be very similar.

8. When flow is included in the curve-fits, the mean estimates of alpha are generally affected very little. The mean estimated alpha is sometimes closer to, and sometimes farther away from, the true value as a result of including flow in the fit.

Several other conclusions were reached apart from those drawn from the information presented in Appendix D. These include:

1. Spectral analysis of a few of our model-generated CPUE time series was undertaken (Appendix B). Statistically significant periodicities were found in all Replicates analyzed with a true

alpha of 30, and occasionally with a true alpha of 20 (e.g., Figures B-17 to B-20). No significant periodicity was found in the two Replicates analyzed with a true alpha of 1.25.

2. The frequency of indications of statistical significance for gamma is approximately what would be expected due to chance alone.

3. Frequently, the estimates of alpha obtained using a particular processing approach within a given Run, and/or the logarithms of these estimates of alpha, were non-normally distributed.

4. Since the amount of variation in our model-generated CPUE time series varied somewhat within a given Run, we examined the correlation between the magnitude of alpha estimates and the coefficient of variation of individual CPUE series for Cases 1 and 2 by processing method. The results were not uniform. Particularly for lower true alpha values, there was a tendency for negative correlations which, although weak, were frequently significant. This result suggests that the degree of variation in a data set may sometimes influence the magnitude of the estimates of alpha, and that our decision to hold the median coefficient of variation of simulated CPUE time series constant was sound.

5. Again based on an examination of results from Cases 1 and 2, there was usually a highly significant positive correlation between the magnitude of the estimate of alpha and the r^2 value for the fit. This correlation was found for all source values

of alpha used and for all processing methods, except matrix Equation (13U). Exceptions to this general conclusion about highly significant positive correlation [e.g., the "eggs on eggs" model for Run 35, and Eq. (13U) in most Cases] appear to be due to failure of unusually high estimates of alpha, which occasionally occur, to be associated with particularly high r^2 values. Even with a true alpha value of 1.0, and estimates of alpha which were substantially higher than 1.0 (as was usually the case when the true alpha was really 1.0), the higher and, therefore, less accurate estimates of alpha are associated with higher r^2 values. In other words, the r^2 value, which ordinarily tells one the percentage of variation which is explained by the model, cannot be used in this context to evaluate the reliability of the estimate of alpha. Hence, basing conclusions about the validity of the parameter estimates on the magnitude of r^2, as the utilities have done extensively in Exhibit UT-3 (e.g., p. 2-IV-23; p. 2-IV-28), can lead to erroneous conclusions.

6. The test for significance of beta, which the utilities have used extensively in Exhibit UT-3 (e.g., p. 2-IV-26; p. 2-IV-28) and in Exhibit UT-58, is also not reliable. In Run 26, for example, the true value of alpha is 1.0 and the true value of beta is 0.0. Yet, for the five year lag approach, of the 114 positive estimates of beta (out of 120 fits), 92 (or 81%) were "significantly" higher than 0.0 at the 0.05 level (i.e., the 95% confidence interval does not include 0.0)

according to the test employed by Dr. Lawler. The reasons for this spurious statistical result are beyond the scope of this testimony, but the result is consistent with the findings from other studies (Goodyear 1979; Robson 1979). It is obvious that "95% confidence intervals" for alpha, derived from the curve-fitting exercise (Table 1, UT-58; TR 2130-31), can be expected to be misleading.

The inevitable conclusion to be drawn from these various findings is that the estimates of alpha obtained by the utilities' curve-fitting techniques are unreliable. As was discussed in Chapter 2, simplification of the simulation model in assuming that only the Ricker function regulates the model population should maximize the ability of the curve-fitting exercise, which assumes the Ricker function, to work well (i.e., to produce accurate and reliable estimates of the value of alpha in the model). The utilities' curve-fitting exercise produces extremely unreliable estimates of alpha when applied to model-generated CPUE data. The estimates from the utilities' curve-fitting exercise applied to the actual Hudson River CPUE time series can be expected to be, if anything, less reliable still. These estimates cannot form the basis for a sound decision about the Hudson River striped bass population, even if the Ricker model were known accurately to describe the sole mechanism regulating the population. The fact that this constraint is obviously an absurd notion makes the estimates still more useless. The attempt to incorporate flow into the model fails, even according to the utilities' relaxed criterion for statistical significance ($p \leq 0.10$), when the updated and corrected flow data are used. Even if flow had been a "significant" independent variable in the model, neither the estimate of the effect of flow (the parameter gamma) nor the estimates of alpha with flow included could have been expected to be reliable. The statistical tests for the significance of beta are similarly unreliable; beta may be "significant" in the fitted model but this says nothing useful about whether beta is nonzero in the source model, nor in the real world if the Ricker model applies. The utilities' curve-fitting exercise is clearly inappropriate to the problem and produces misleading results. The utilities' estimates of alpha are unreliable to the point of being useless.

There is nothing surprising about this inevitable conclusion. Dr. Lawler himself has stated, quite candidly, that none of the approaches that were tried fully represented the information called for by the Ricker model (TR 2663-2664). The utilities have, nonetheless, taken the position that what problems there were with the various approaches would simply be reflected as "noise" around the curve-fits (TR 1260-61; TR 2545, lines 2-6). Our extensive analysis has been required to show not so much that there is, indeed, such "noise," but that there is so much noise, in fact, that the results are virtually useless.

When one delves into the data base itself, and the assumptions involved in processing the CPUE time series into data points, one's confidence in the results is further eroded. The validation analysis simply confirms what already appeared likely: even under ideal conditions, the curve-fitting exercise as applied to striped bass in the

Hudson River is a failure. The utilities' witnesses must have felt strongly that they carried the burden of proving and of quantifying compensation. That burden appears to be an impossible one.

We will end this chapter with an analogy. A clock that has stopped is still right twice a day. Similarly, if the Ricker model and the concept of alpha as a measure of compensatory capacity apply to the Hudson River striped bass population, and if alpha happens to have a true value in the neighborhood of 3, some of the utilities' estimates of alpha will, largely by chance, be approximately correct. But the fact that the average of the estimates of alpha obtained by applying the utilities' latest analysis to the corrected and updated data set is in the neighborhood of 3 does not mean that alpha for the Hudson River striped bass is 3, any more than a clock which is stopped at 3:00 means that the time is 3:00. The analogy is admittedly not exact, because there is a very weak response of the mean estimates of alpha to changes in the true value of alpha, but the analogy is close. That the data are simply not suitable to support, with any tolerable reliability, the curve-fitting exercise in which the utilities have indulged has been demonstrated herein for the Ricker model.

The methodology would be expected to lead to similar conclusions if extended to the utilities' other models which were fitted to the CPUE data, or if slightly different curve-fitting techniques were used (e.g., non-linear least squares). In fact, the general concept of validation which we have developed here should be applied to <u>any</u> stock-recruitment curve-fitting exercise for which there is reasonable question about the appropriateness of the data and on which important decisions could depend.

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GLOSSARY

For the reader's convenience, the following terms are briefly defined here in the context of their use in this testimony.

Alpha: (a) a parameter in the Ricker model which, if the model applies, can be used to predict the long-term consequences of power-plant impact on a population via the Equilibrium Reduction Equation (ERE); (b) the balance between fecundity and mortality in a population described by a Ricker function; (c) the slope at the origin of a Ricker curve.

Beta: A parameter in the Ricker model which accounts for the biological compensation in the model.

Case: A set of choices for the simulation model. Chosen are values for adult survival, the type of feedback in the underlying Ricker model, and the location(s) and form(s) of random variation in the model.

CPUE: An abbreviation for "catch-per-unit-effort." This index is considered by the utilities to be an index of population size.

Fecundity: The capacity of female fish to produce eggs at the time of spawning.

Feedback term: In the Ricker model, the term, involving beta, which constitutes the stock-dependent mortality. It is the operation of this term which causes the model to have an equilibrium point.

Gamma: A parameter in the Ricker model, as modified in Exhibit UT-58, which relates freshwater flow to mortality of young-of-the-year (YOY) striped bass.

MSE: An abbreviation for "mean square error." MSE is a linear combination of the variance and the square of the mean bias of an estimator. The larger the MSE for an estimator (as compared to some other estimator), the higher the variance and/or the bias.

Processing approach: One of the techniques proposed by the utilities to attempt to convert a time series of CPUE values into indices of stock and recruits, prior to fitting the Ricker stock-recruitment model.

Replicate: Within a Run, a contiguous set of 26 simulated catch-per-unit-effort (CPUE) values. This set of values is conceptually analogous to the "real" 26-year CPUE time series for the Hudson River striped bass population.

Run: Within a Case, the additional specification of a value of alpha for the simulation model.

Simulation model: A computer model (SRVAL) for a population of a single species of fish. The simulation model embodies the Ricker stock-recruitment model as the regulating mechanism, and simulates the movement of the population through time. The age structure of the population is preserved, and a simulated CPUE index is produced for each "year." The computer code also contains subroutines which perform the utilities' curve-fitting exercise on the model's output.

TR: An abbreviation for "transcript." This refers to the written transcripts of the adjudicatory proceeding for which this testimony was prepared.

YOY: An abbreviation for "young-of-the-year." As applied to fish, this term identifies a fish which is in the first year of its life.

APPENDIX A

THE CORRECTION FACTOR

In this appendix, we will discuss some of the effects that random variation can have on population size, how these effects relate to the parameter alpha in the Ricker model, and how we have compensated for these effects in our model runs.

Random variation was introduced into our model in two ways: by modifying the probability of surviving the first year of life according to a random term [see Eq. (7)] and by modifying the simulated catch-per-unit-effort (CPUE) value according to a random term [Eqs. (13) or (14)]. Let us consider the latter situation first.

When Eq. (14) is used, each year's CPUE value is multiplied by a term (1 + G(t)), where G(t) is a normally-distributed random variable with a mean of 0.0 and a specified variance s^2. The expected value of (1 + G(t)), or the approximate average of a large number of these terms, is 1.0, and no "shift" in the average CPUE value occurs as a result of the application of the random term. (A very slight upward "shift" may occur, because if the term assumes a negative value, it is discarded and a new term is used).

A different situation would have occurred when Eq. (13) was applied, except that a "correction term" ($-s^2/2$) was added. The term exp(G(t)) means that e, the base of the natural logarithm, is raised to the power (G(t)). With G a random number as previously defined, the expected value of exp(G(t)) is equal to $\exp(s^2/2)$. Since CPUE is simply an output variable from the model, and is not used by the model, the term exp(G(t)) could have been used without "correction." This would simply have elevated the mean value of the simulated CPUE indices above the specified value, which was arbitrarily chosen to match the Hudson River CPUE time series. However, by using the term $\exp(G(t) - (s^2/2))$ instead, we "corrected" the offset introduced by the random variation. We reiterate that it was not necessary to make this correction, since the magnitude of the model-generated CPUE values was not of importance.

A different situation arises in the case of random variation introduced into the young-of-the-year mortality [Eq. (7)]. The form of the randomness that we chose to use was lognormal, the same as that just discussed. The effect of this randomness is to cause the number of one-year-old fish to vary, much as the previously-discussed random variation caused the CPUE value to vary. Further, without the correction factor, C, in Eq. (7), the same sort of offset will be applied to each year class of one-year-old fish, in that the average size of the yearling age-class would be higher in the presence of random variation than without it. In this case, however, there is a critical difference. While the CPUE value is an "output" value and does not affect the workings of the model in any way, the yearling population size does have substantial influence in two potential ways over many years: it affects the subsequent egg production, and it affects the stock-dependent mortality or "feedback" term in the Ricker model. This increase in the average yearling population size results in an increase in the size of the overall population.

Ricker himself (1954) recognized the consequences of the effect of symmetrical random variation in YOY mortality on the future course of the population. In a density-independent model, such random variation (albeit of a slightly different form than we have used) was observed to cause a tendency for population increase. The form of random variation we have used, without the correction factor, would have caused the same effect under the same circumstances.

Let us define a "balanced" population as one which, in the long term, tends neither to grow nor to decline. Since beta is equal to 0.0 under the assumption of only density-independent mortality, and since with no random variation alpha will be 1.0 if the population is to be "balanced", how should one interpret the observation that addition of random variation of a particular form causes population growth? First, since there is no _a priori_ reason to expect the random variation to necessarily be of any particular form, one could choose a form of random variation which did not have a mean of 0.0, but rather of some other value. This is, in fact, what the correction factor accomplishes. Alternatively, one could use different probability distributions which might counteract the tendency of the population to grow. A third possibility would be simply to let the population grow.

Since the purpose of this investigation was to study the reliability of parameter estimates for the Ricker model, however, it was necessary for us to investigate the relationship between the effect of the random variation and the true parameters of the Ricker model. The reason for this is that the Equilibrium Reduction Equation, or ERE (Exhibit UT-3, Eq. 2-V-5), is written in terms of the equilibrium Ricker model, which does not admit of random or stochastic effects. Yet the equilibrium Ricker model, without stochastic effects, cannot account for the Hudson River CPUE time series. It is important to realize that this entire discussion of the effects of random variation on population models and on the parameters in the Ricker model as they relate to the ERE, and the need for a correction factor in our simulation model runs, does not at all imply a shortcoming in our model. Rather, the discussion is necessitated by the inconsistency of the assumption of equilibrium conditions implicitly made in the ERE with the presence of random variation in the real world. We have had considerable experience (O'Neill 1973; O'Neill and Gardner, in press; Gardner and Mankin, in press; Gardner et al., submitted) with the effects of parameter uncertainty on the accuracy of model predictions. In particular, we have examined the effects of parameter uncertainty on both density-independent and density-dependent life cycle models for the striped bass population. For these models, parameter uncertainty can have unforseen consequences for model predictions, sometimes reversing the conclusions which can be drawn from the deterministic model.

Our interpretation of the tendency for random variation to cause a population increase in an equilibrium multiple-aged spawner model with only density-independent mortality is that this increase implies a concomitant increase in alpha in the Ricker model. Thus, since alpha represents the balance between fecundity and mortality in the model population, the random variation can be expected to have increased mean fecundity or to have decreased mean mortality, or both, if it is causing a model population to increase. In fact, it has done both.

Once we became aware of this phenomenon, the next step was to find a way to adjust some parameter in the simulation model to restore the desired value of alpha. For the case of alpha equal to 1.0, we would be able to realize this goal by removing any tendency for either population growth or decline; in other words, we would want to "balance" the population. If we developed a correction term which achieved this result for alpha equal to 1.0, the same correction term would work for other alpha values as well.

We undertook a special study of the effects of random variation in the case of only density-independent mortality. For this work, the random numbers used were "zeroed," meaning that a value was added or subtracted from each random number to cause their mean to truly be 0.0, rather than simply close to 0.0. This precaution removed from the results any tendency for population change due to random offset in the random numbers themselves. Populations were initialized at equilibrium,* with the probability of survival through the first year of life calculated to maintain the population at the initial equilibrium conditions over time in the absence of random variation. In this study, we observed the following:

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*In the balance of this appendix, the term equilibrium will be taken to mean that the population is at a steady state.

1. In a two-age-class case, where all reproduction is by one-year-old fish, no correction factor is needed to cause the final population to "balance" in the sense that, at the end of the simulation, the population has the same size as at the beginning, even with random variation.

2. As reproduction is spread out among several age-classes, there is a tendency for population growth in the presence of random variation. This tendency for growth increases as the variation of the random numbers is increased (Goodyear and Christensen, in preparation).

We explain these two observations as follows. As Ricker (1954) pointed out, the reason for this tendency for growth is that the contribution of different year classes to a given year's spawning are summed, while the expectation of survival of an egg is distributed such that increases in survival result in a greater absolute effect on the strength of subsequent year classes than corresponding, equally probable, decreases in survival.

This phenomenon becomes immediately apparent when we consider that the value of $\bar{S}_1$, the probability of surviving the first year of life under equilibrium conditions, is determined as the ratio of the equilibrium number of age 1 individuals to the equilibrium total fecundity of the population, i.e.,

$$\bar{S}_1 = \frac{\text{equilibrium number of age 1 individuals}}{\text{equilibrium total population fecundity}} \quad . \tag{A.1}$$

Because the effect of the random variable is to cause the average year class strength to be greater than the equilibrium year class strength, the average fecundity of the simulated population with random variation is higher than that of the equilibrium population. Since the number of age 1 fish in the simulated population is calculated as the product of S_1 and the number of eggs spawned, the average number surviving to age class 1 is greater than the equilibrium number. Since S_1 is constant except for the random term, the population will increase through time.

For the case of single-age spawners, as opposed to multiple-age spawners, there are no additive effects (i.e., a given year's spawn is not obtained by summing over several ages). As a consequence, the effect of the random multiplier on age 0 survival causes an equal change in fecundity for the following year's spawn, which is itself subjected to another random multiplier. Since the geometric mean of the set of random multipliers is 1.0, the population trajectory does not have a propensity for infinite increase.

These observations on the effect of random variation on pre-reproductive survival indicate that the nature of the distribution selected to represent the random effect can have a profound effect on the comparability of the deterministic model to its stochastic counterpart. Furthermore, it is apparent that the addition of a lognormally-distributed random variation in survival to a single pre-reproductive age class of a population in which individuals reproduce more than once in their lifetime will increase the intrinsic growth rate of the population. The degree of this increase is directly related to the variance of the natural logarithm of the random multiplier.

In order to establish the proper correspondence between alpha in our model and alpha in the ERE, it was necessary to develop a correction factor [C in Eq. (7)] in our model to cause the population to be balanced in the presence of random variation. We accomplished this by means of the following procedure:

1. A generalized population simulator was adapted for the purpose of calculating correction factors. This simulator is called "SIMCOR." The population was always initialized at equilibrium, with an equilibrium value of S_1 in Eq. (7), denoted $\overline{S}_1$, calculated so that the population would remain constant in the absence of random variation. Other parameters in the population were the same as those used in the main simulation model (i.e., as shown in Table 1 or Table 8).

2. A level of random variation was specified, as the magnitude of variance for the random variable. The random numbers were "zeroed" as previously described. Random variation entered the model in the following way:

$$S_1(t) = \overline{S}_1 \exp(r(t) - C) \qquad (A.2)$$

where r(t) is the random variable and C is a correction term.

The correction term C was composed of two parts:

$$C = CF \times s^2 , \qquad (A.3)$$

where s^2 is the specified variance of the random variable and CF is found by iteration, as will be described.

3. The egg production input to the model in each year was artificially held constant at the equilibrium value. The egg production output from the model was calculated each year. Initially, the term CF in Eq. (A.3) was set to 0.0. The population was simulated for 50 years to allow the variation to affect the population. Then the population was simulated for an additional 500 years, and for each year, the ratio of output egg production to the specified equilibrium egg production was calculated. Next, the geometric mean of these 500 ratios was calculated. Then, the natural logarithm of this geometric mean was taken, and was divided by the variance of the random number. This result was added to the former CF term in Eq. (A.3) (which was initially zero for the first iteration) to obtain a revised estimate of the correction term. Another iteration was then made with this revised CF value. Iterations were continued until nine iterations had been completed or until the absolute value of the increment for CF was less than 1.0×10^{-6}.

4. A new value of the variance of the random term was chosen, and the entire process was repeated. Levels of variance ranging

from 0.05 to 1.60 were used, with adjacent levels having a ratio of 1.414 to 1.0.

5. Steps three and four were repeated for a total of ten sets of random-number seeds per level of variation. Thus, for each level of variation of the random term, ten correction factors were obtained. Typical magnitudes for these correction factors, for the set of life-history parameters used for most runs (Table 8), were in the range of 0.3 to 0.5, with most values between 0.35 and 0 45 (see Table A.1).

A separate program, named "CORCAL," was used to obtain a correction factor value to use for any particular Run of the validation model. This program accepted as input the standard deviation of the random YOY survival coefficient and values for gamma and the standard deviation of the simulated flow value. From these data, the variance of the overall random variation was calculated. Next, second-degree Lagrangian interpolation was used to interpolate a value of the correction factor for each of the ten sets of random-number seeds which had been used in SIMCOR. These ten values were then averaged to obtain the final estimate of the correction factor, CF, for Eq. (A.3). This enabled calculation of the term C in Eq. (A.3), which was then used in Eq. (7).

The use of this term C in Eq. (7) was intended to approximately counteract the tendency for randomness in YOY mortality to cause population growth. The effect of the correction factor is to cause the geometric mean of the ratio of realized egg production to equilibrium egg production in the density-independent case to be approximately 1.0.

Table A-1. Values of the correction factor [CF in Eq. (A.2)] obtained using the life-history parameters from Table 8, for eleven levels of variance and ten sets of random number seeds.

Random Seed Set No.	Total variance of the random numbers										
	0.0500	0.0707	0.1000	0.1414	0.2000	0.2828	0.4000	0.5657	0.8000	1.1314	1.6000
	Correction factor values										
1	0.3287	0.3449	0.3562	0.3643	0.3698	0.3736	0.3755	0.3752	0.3711	0.3605	0.3404
2	0.2843	0.3299	0.3622	0.3851	0.4014	0.4129	0.4204	0.4238	0.4218	0.4111	0.3880
3	0.2497	0.3030	0.3404	0.3670	0.3857	0.3987	0.4071	0.4111	0.4094	0.3994	0.3774
4	0.4489	0.4473	0.4462	0.4456	0.4454	0.4453	0.4448	0.4427	0.4370	0.4237	0.3985
5	0.3498	0.3566	0.3613	0.3646	0.3667	0.3679	0.3679	0.3660	0.3607	0.3497	0.3301
6	0.4209	0.4238	0.4254	0.4262	0.4261	0.4249	0.4221	0.4166	0.4064	0.3889	0.3611
7	0.4188	0.4135	0.4099	0.4076	0.4063	0.4057	0.4050	0.4031	0.3976	0.3851	0.3620
8	0.4366	0.4350	0.4337	0.4327	0.4318	0.4309	0.4292	0.4257	0.4183	0.4033	0.3774
9	0.3271	0.3542	0.3733	0.3865	0.3955	0.4012	0.4040	0.4035	0.3983	0.3859	0.3629
10	0.5140	0.4988	0.4878	0.4797	0.4734	0.4680	0.4624	0.4549	0.4431	0.4235	0.3929

This result has the consequence of removing from the population the tendency for growth imparted by the random variation, as desired. The correction is approximate only, because the exact value of the correction factor needed to precisely neutralize the tendency for growth depends on the pattern of the random numbers, and hence, on the particular starting "seed" for the random number generator. Rather than attempting to make our random variation achieve deterministic* results, which in some sense defeats the "random" nature of the variation, we accepted an approximate correction of the effects of random variation.

An empirical test of having achieved a proper correction term is to specify some alpha value greater than 1.0, to calculate beta in the usual manner [i.e., according to Eq. (12)], and to run the model with random variation and with the correction term. When this is done both with and without a simulated conditional power plant mortality (m in Eq. 2-V-5 of Exhibit UT-3), the realized equilibrium reduction can be calculated directly from the model. Then the ERE can be used to calculate the equilibrium reduction for the same source alpha and m value. If the two predictions match, the correction term has been properly determined. The process can then be repeated without the correction term. In this case, the results from the ERE should no longer match the results from the model. Dr. Goodyear has, in fact, applied this empirical test to the results of our methodology for obtaining correction factors (here using "exact" correction factors

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*The term "deterministic" as used here means that some index of population size at the end of the simulation would be constrained to have the same value as that index at the beginning of the simulation, given beta = 0.0 in the Ricker model.

obtained for the particular random number seeds used for the test). He has found that for values of alpha well below those which are capable of sustaining persistent oscillations, our correction factor caused the model to give essentially the same result as the ERE. Removing the correction factor, but keeping everything else the same (e.g., alpha and beta), caused the equilibrium reduction from the ERE to be greater than that from the model.

Hence, our correction-factor methodology is working as intended, that is, it causes the interpretation of alpha in our model to be the same as the interpretation implicit in the ERE. Had we not introduced the correction factor, one could justifiably object that when we were testing the ability of the curve-fitting exercise to retrieve a true alpha value of 1.0, the actual value was greater than 1.0 and more consistent with the typical estimates of alpha obtained (which are substantially higher than 1.0). In fact, however, with the correction factor in the model the actual achieved value of alpha in Run 33, for example, is less than 1.0, as evidenced by both a mean CPUE value and a final CPUE value substantially lower than the initial conditions. For this Run, then, our conclusions concerning the failure of the curve-fitting exercise to yield reliable estimates of alpha are even more conservative than if the "true alpha" had been exactly 1.0. Most of the tests for the significance of beta in Run 33 still indicate that beta is positive, implying alpha greater than unity, when in fact beta is 0.0 and the true alpha value is slightly less than 1.0. Thus, the results from our simulation model, which indicate that the curve-fitting exercise does not yield reliable estimates of alpha, cannot be ascribed to the small uncertainty in the true values of alpha which underlie our model runs.

APPENDIX B

SPECTRAL ANALYSIS OF SELECTED DATA

Appendix B consists primarily of plots showing the results of spectral analysis of selected CPUE time series. More information about spectral analysis can be found in Kirk et al. (1979). Table B-1 provides an index of the figures contained in Appendix B. For the Hudson River CPUE time series presented in Table 6 in the main text, there are a total of 8 plots. The following paragraphs explain these figures.

Figure B-1 represents the Hudson River CPUE time series (diamond-shaped markers connected by solid line). Using a linear least squares routine, the straight line Y = A + B * X (where the * indicates multiplication) was fitted to the Hudson River CPUE data. The resulting fit is seen in Figure B-1 in the form of the dashed line. This straight line fit is called the linear trend of the data.

Figure B-2 is the plot of the residuals or detrended Hudson River CPUE time series. That is, it is a plot of the Hudson River CPUE time series minus its straight line fit. The horizontal straight line in Figure B-2 is the line Y=0. The presence of this line aids the viewer in looking for the spread of positive and negative residuals, and also in seeing whether there are other trends in the data. (By residuals we mean the Hudson River CPUE time series data minus its straight line fit).

Figure B-3 shows the plot of the residuals against the straight line fit of the Hudson River CPUE data If the residuals exhibited a pattern of behavior, then this might indicate a definite characteristic of the data (like, for example, a non-constant variance).

Figure B-4 is a periodogram, so-called because the points on the plot correspond to periods in the time series. The horizontal axis is labeled as frequency. We note that if f stood for frequency and P for period, then P=1/f. The frequency at which the tallest peak in the plot occurs therefore corresponds to the most dominant period; the frequency for the second tallest peak to the second most dominant period, and so on. Note, however, that "dominant" does not imply statistical significance. The lack of smoothness of the plot of the periodogram is due to the fact that the total number of frequencies is always half the number of data points. Frequency is defined within the interval from 0 to 0.5. The frequency f=0.5 corresponds to a period of P=2 unit cycles and is the highest frequency that can be resolved.

Figure B-5 shows the cumulative periodogram, the curve bounded by the two straight lines. These two lines represent the Kolmogorov-Smirnov boundary lines at the probability level of 0.05. (One may choose different probability levels). If the curve of the cumulative periodogram crosses either one of these lines, then it means that the data probably do not comprise white noise. This would indicate the presence of a "significant" period, the approximate frequency of which is given by the frequency of the most dominant period in the periodogram or in the Fourier amplitude spectrum.

It was pointed out in a previous paragraph that the curve for the periodogram is not smooth. In Figure B-6, one is allowed to sample as many frequencies as possible. This figure is called the Fourier amplitude spectrum and closely resembles the periodogram formula except for a constant factor and the choice of the total number of frequencies. Like the periodogram, the frequency at which the tallest peak occurs signifies the most important period in the time series. We also note that the height of the peak is directly proportional to the strength of contribution of the period to the time series.

Figure B-7 is the cumulative Fourier amplitude spectrum. Its function is similar to that of the periodogram.

In Figure B-8, we see the maximum entropy spectrum. Maximum entropy spectral analysis provides a more accurate and precise estimate of the periods than does Fourier spectral analysis. Unlike the Fourier amplitude spectrum, the tallest peak does not necessarily correspond to the most dominant period. Rather, it is the area under the curve at which the peak occurs which is directly proportional to the strength of contribution of a period. Since it is sometimes difficult to judge by eye which peak curve can have the most area under it, one need only refer to the Fourier amplitude spectrum to get the interval at which the most important period occurs.

For the next sets of CPUE time series, only 4 plots were used for each set. These are: the CPUE time series plot, the cumulative periodogram, the Fourier amplitude spectrum, and the maximum entropy spectrum. Within a given Run, the model generated time series were randomly chosen for the spectral analysis except for Run 32, Replicates 111-113. In this instance, our intention was to obtain an accurate estimate of the obvious period. Three Replicates near the end of the Run were chosen to prevent any possible residual effects due to the initial conditions.

Table B-1. Summary of spectral analysis plots[a]

Figures B-1 to B-8:	Hudson River CPUE time series.
Figures B-9 to B-12:	Model-generated CPUE time series from Case 5, Run 46, Replicate 4, with a source alpha of 1.25.
Figures B-13 to B-16:	Model-generated CPUE time series from Case 5, Run 46, Replicate 79, with a source alpha of 1.25.
Figures B-17 to B-20:	Model-generated CPUE time series from Case 5, Run 48, Replicate 30, with a source alpha of 20.0.
Figures B-21 to B-24:	Model-generated CPUE time series from Case 5, Run 48, Replicate 87, with a source alpha of 20.0.
Figures B-25 to B-28:	Model-generated CPUE time series from Case 5, Run 48, Replicate 66, with a source alpha of 20.0.
Figures B-29 to B-32:	Model-generated CPUE time series from Case 1, Run 32, Replicate 74, with a source alpha of 30.0.
Figures B-33 to B-36:	Model-generated CPUE time series from Case 1, Run 32, Replicates 111-113, with a source alpha of 30.0.

[a]On each maximum entropy spectrum plot, the label "MESA VALUE" for the vertical axis is an abbreviation for "maximum entropy spectral analysis value."

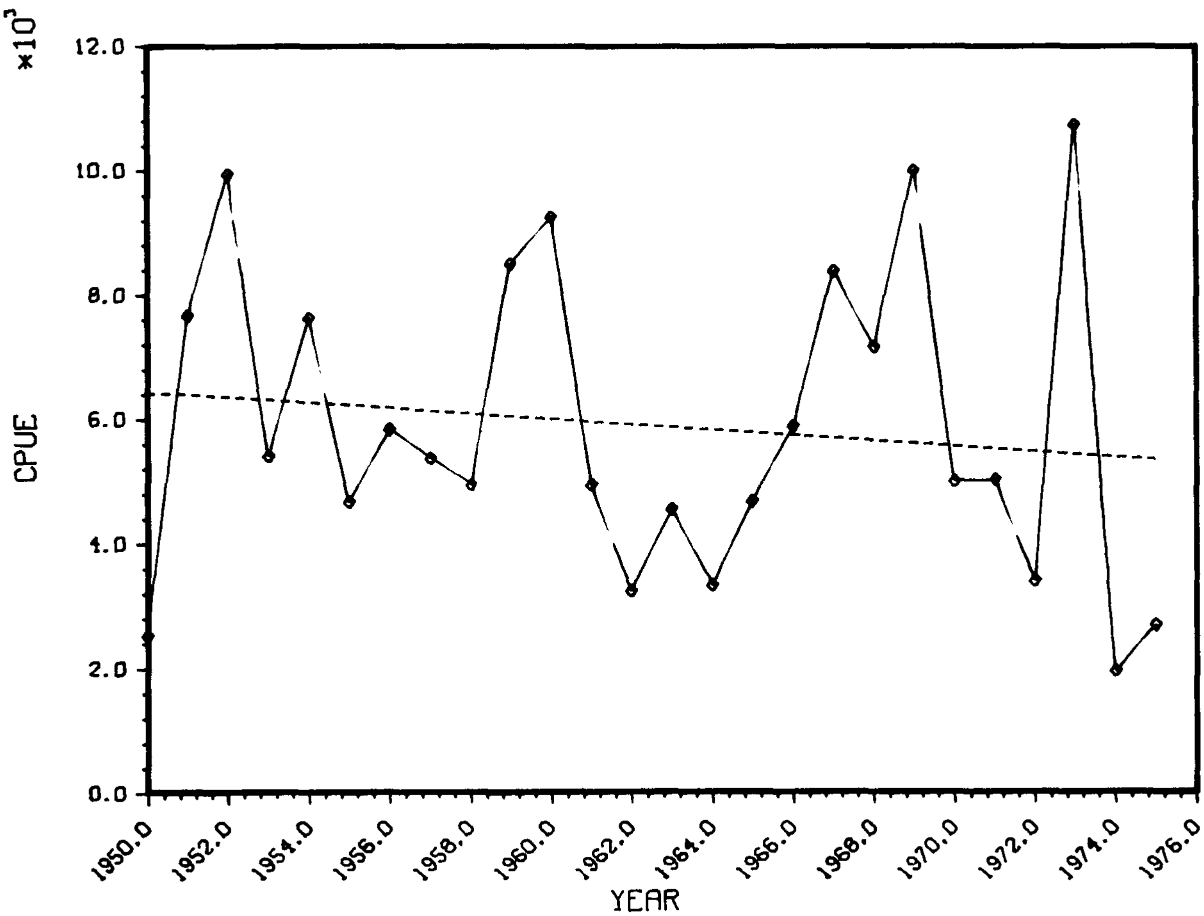

Figure B-1. Hudson River CPUE time series with linear trend.

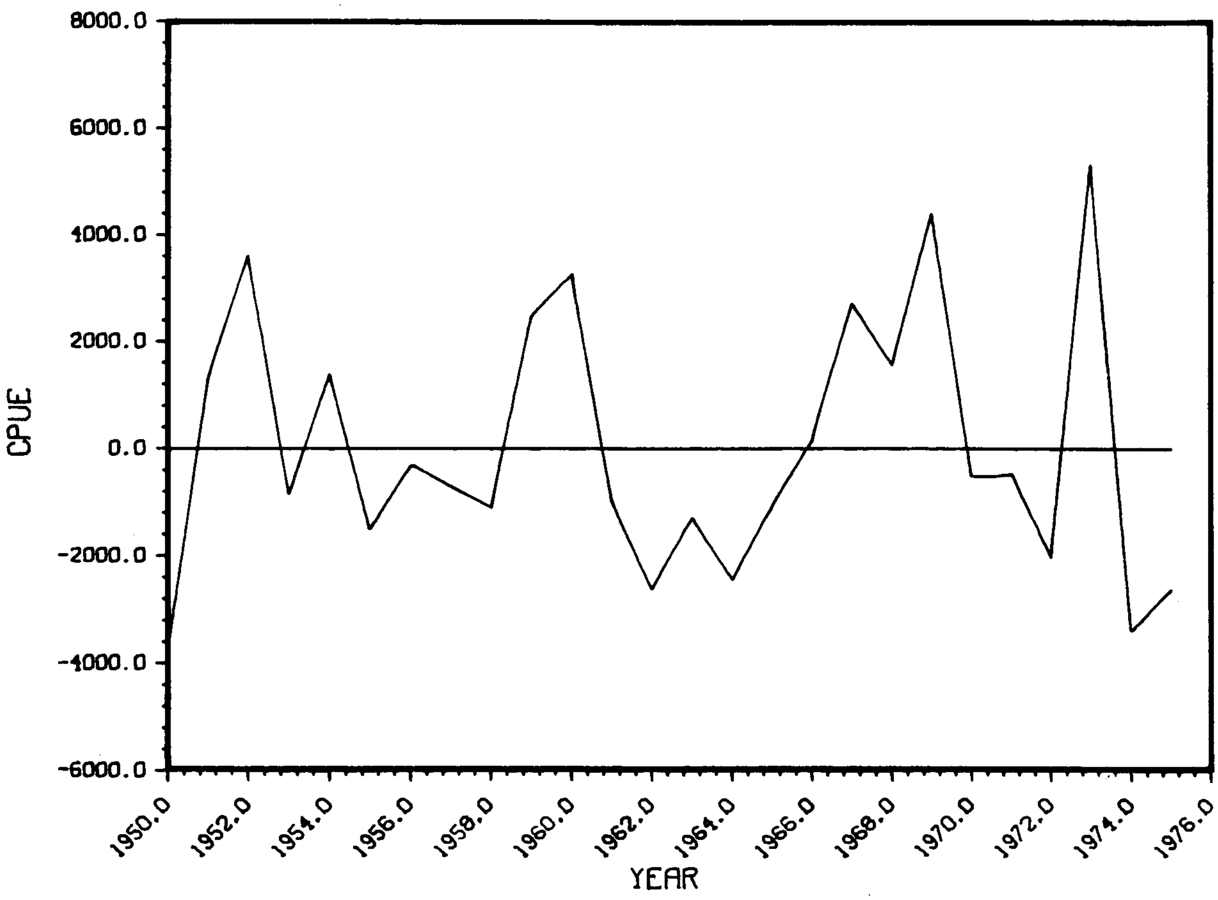

Figure B-2. Detrended Hudson River CPUE time series.

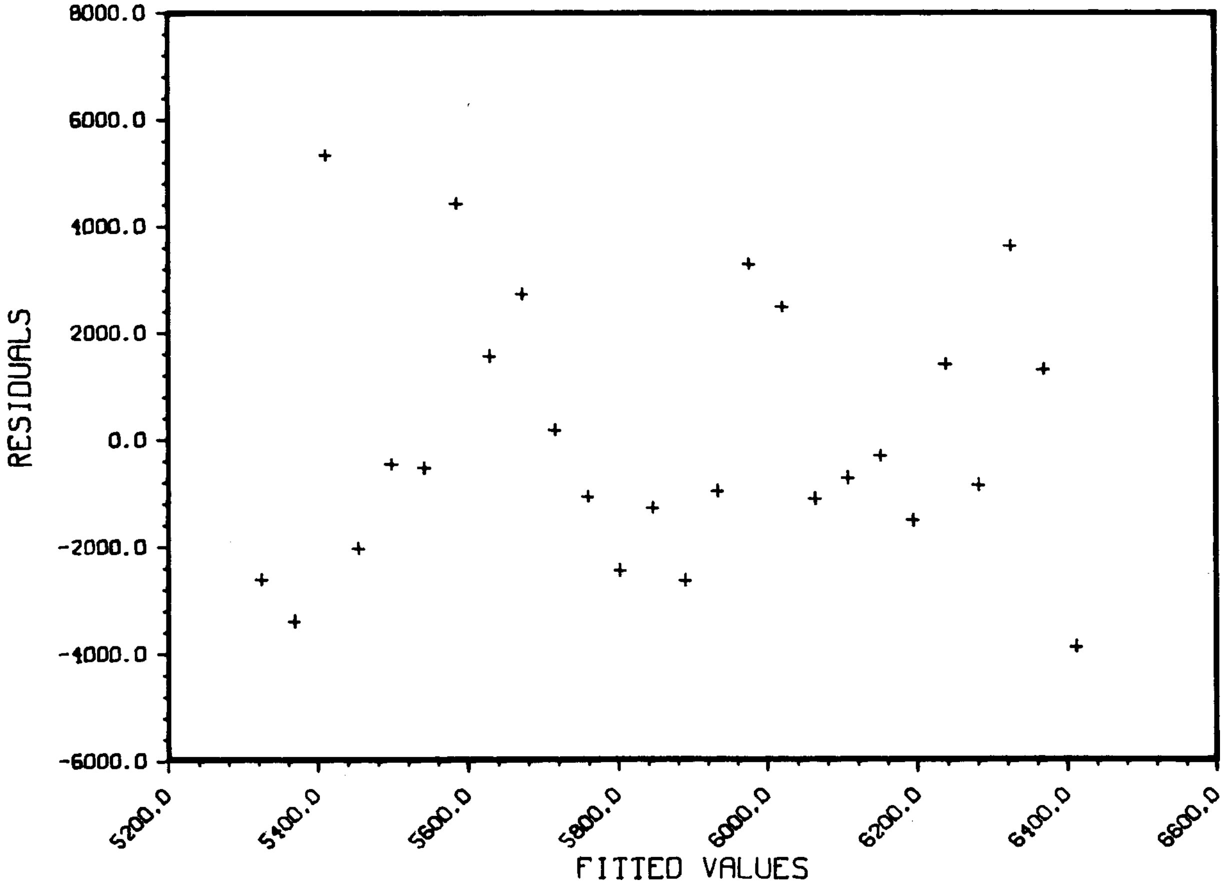

Figure B-3. Residuals of Hudson River CPUE time series plotted against fitted values.

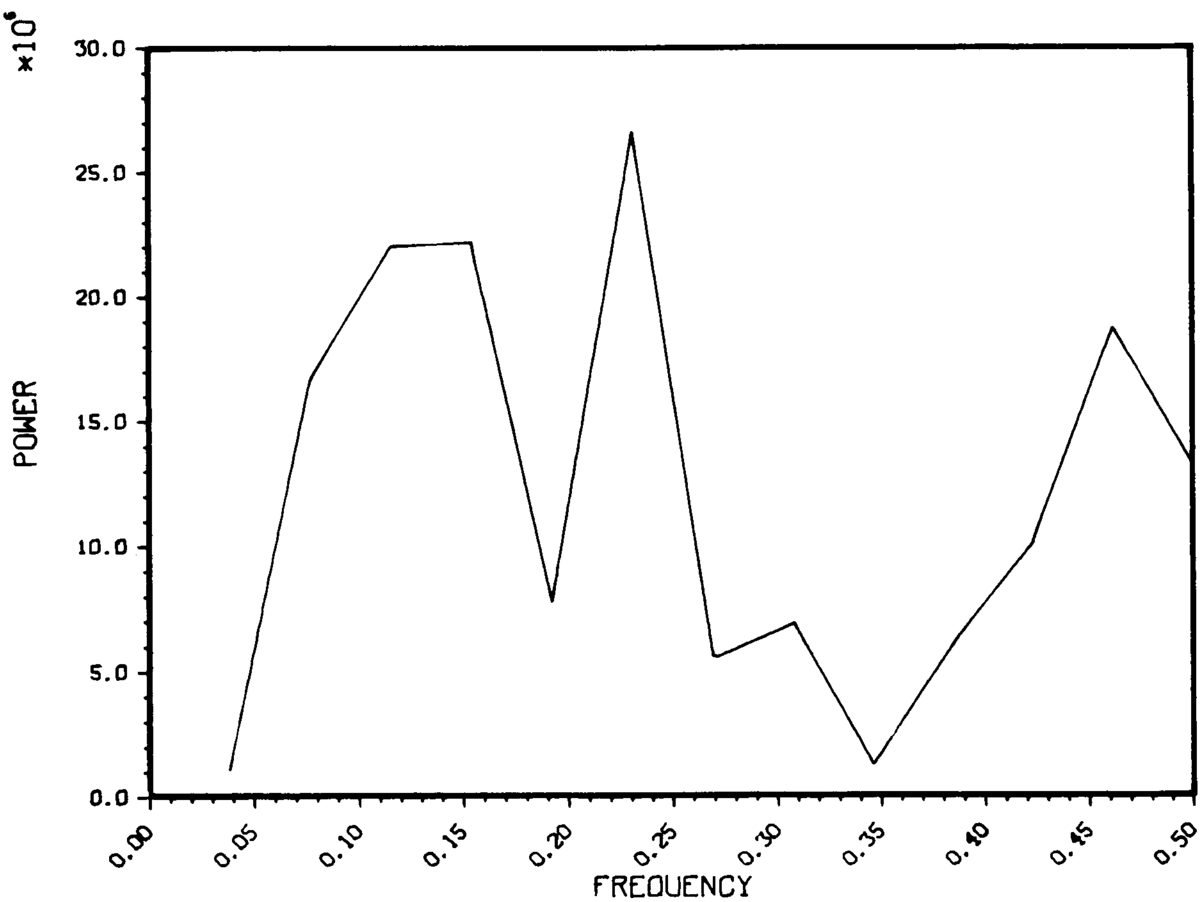

Figure B-4. Periodogram of detrended Hudson River CPUE time series.

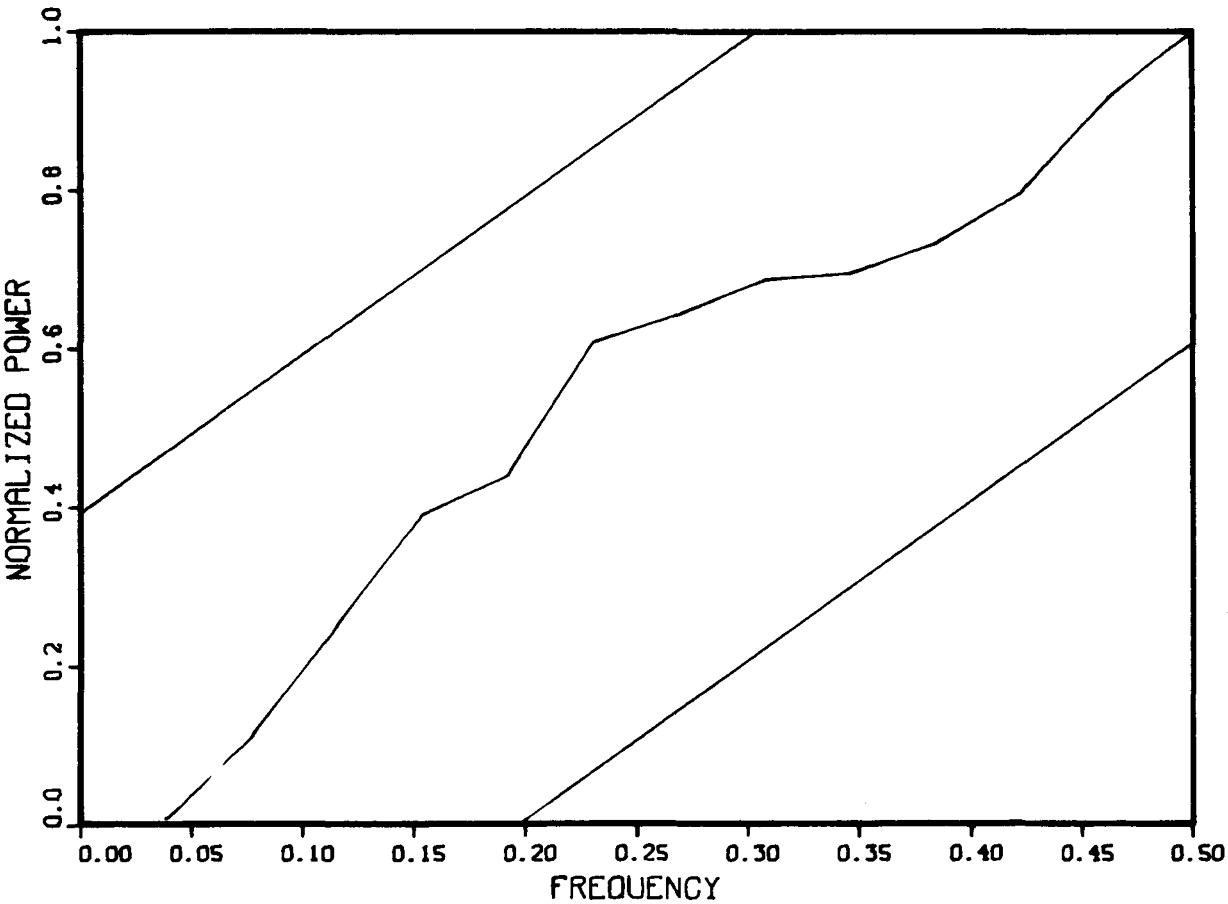

Figure B-5. Cumulative periodogram of detrended Hudson River CPUE time series.

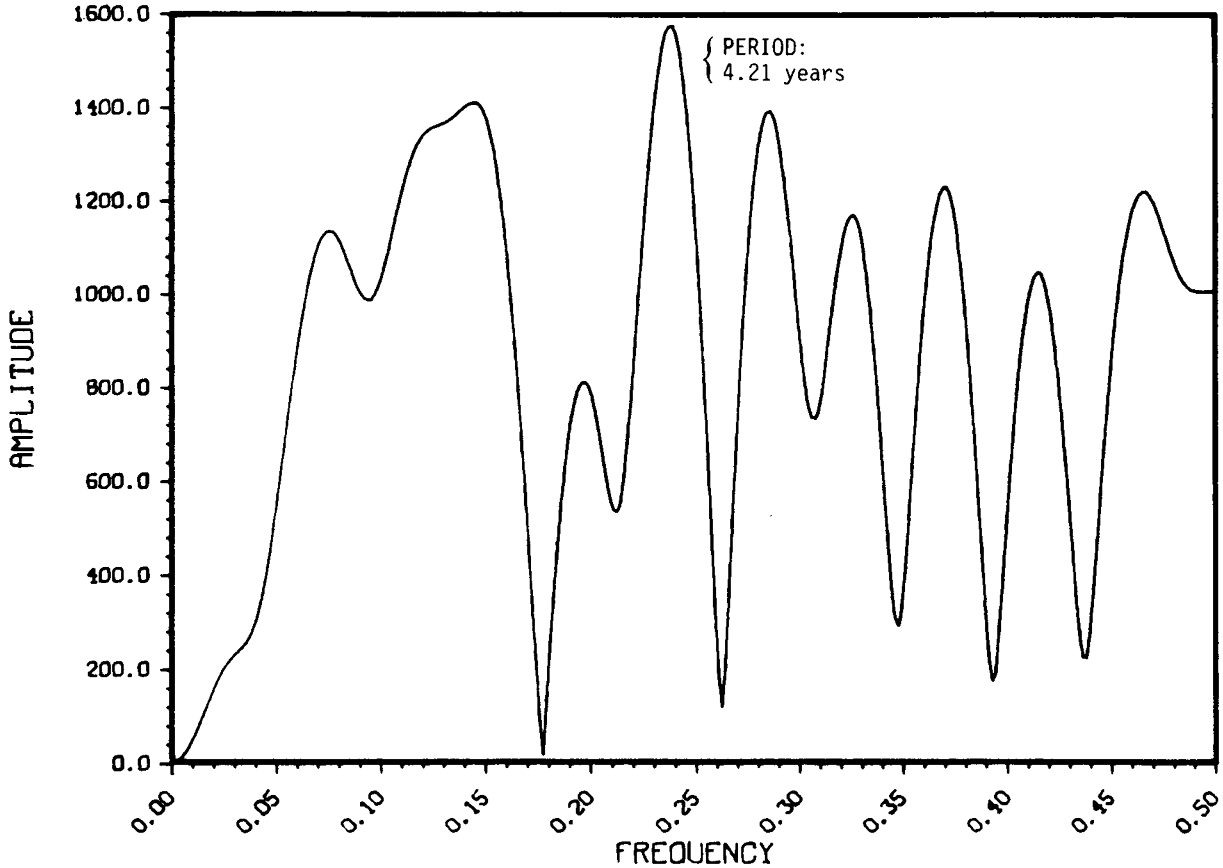

Figure B-6. Fourier amplitude spectrum of detrended Hudson River CPUE time series.

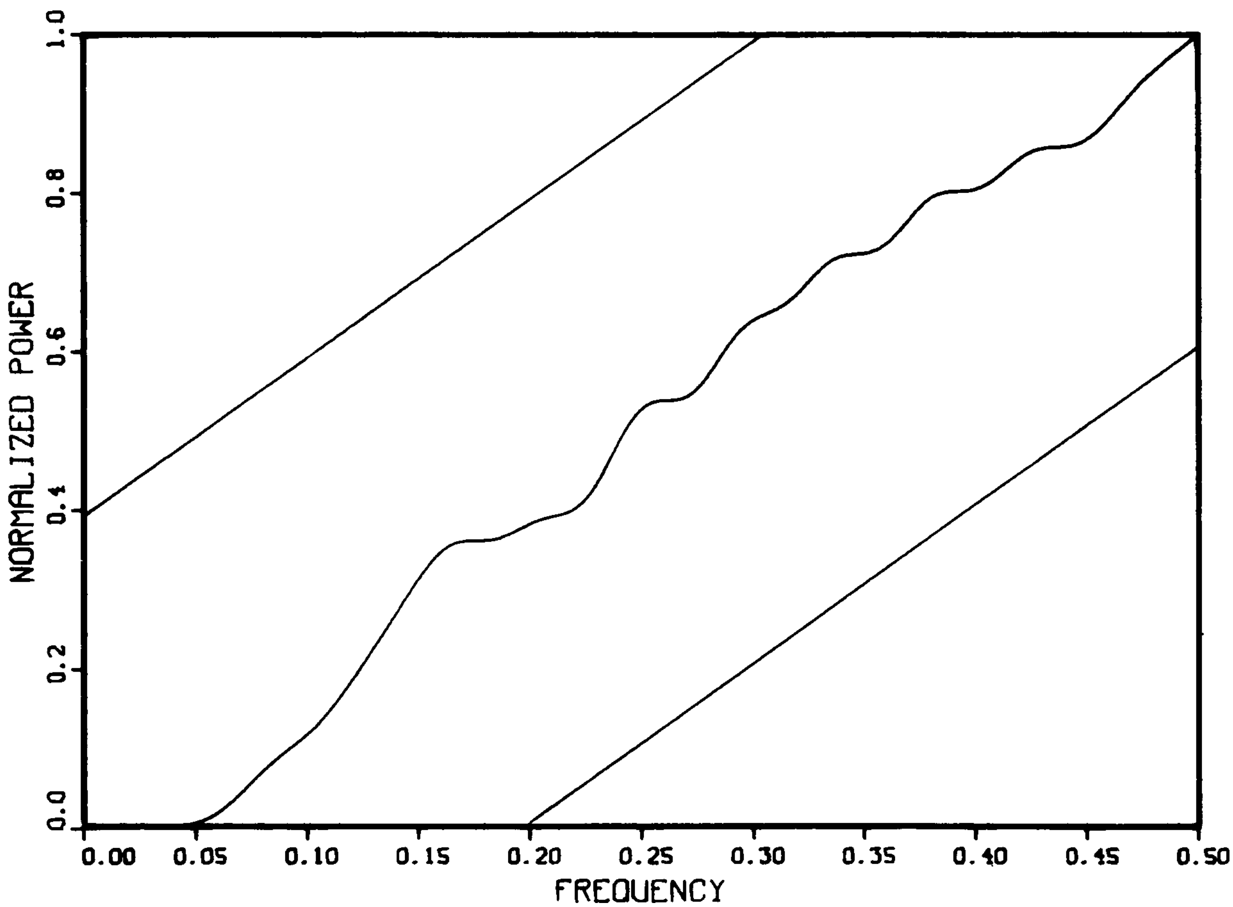

Figure B-7. Cumulative Fourier amplitude spectrum of detrended Hudson River CPUE time series.

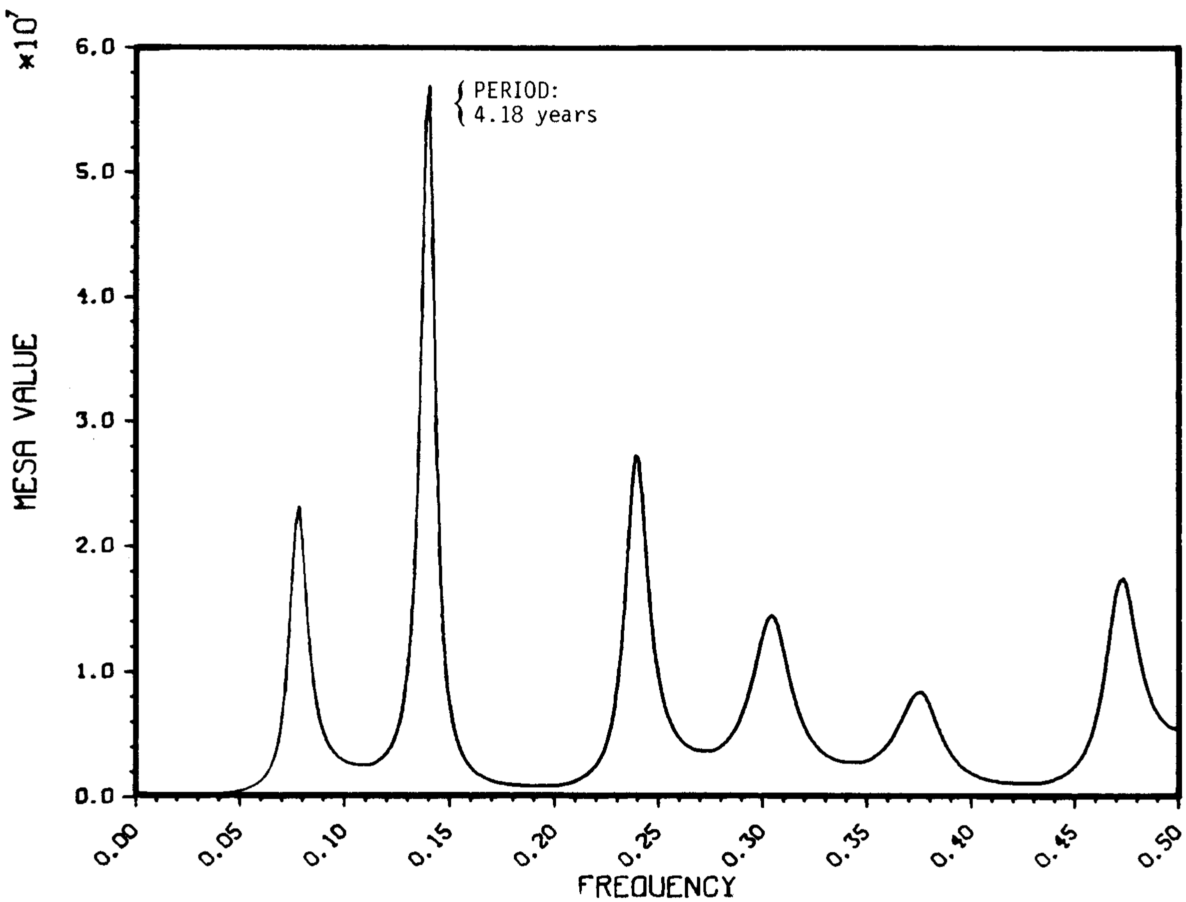

Figure B-8. Maximum entropy spectrum of detrended Hudson River CPUE time series.

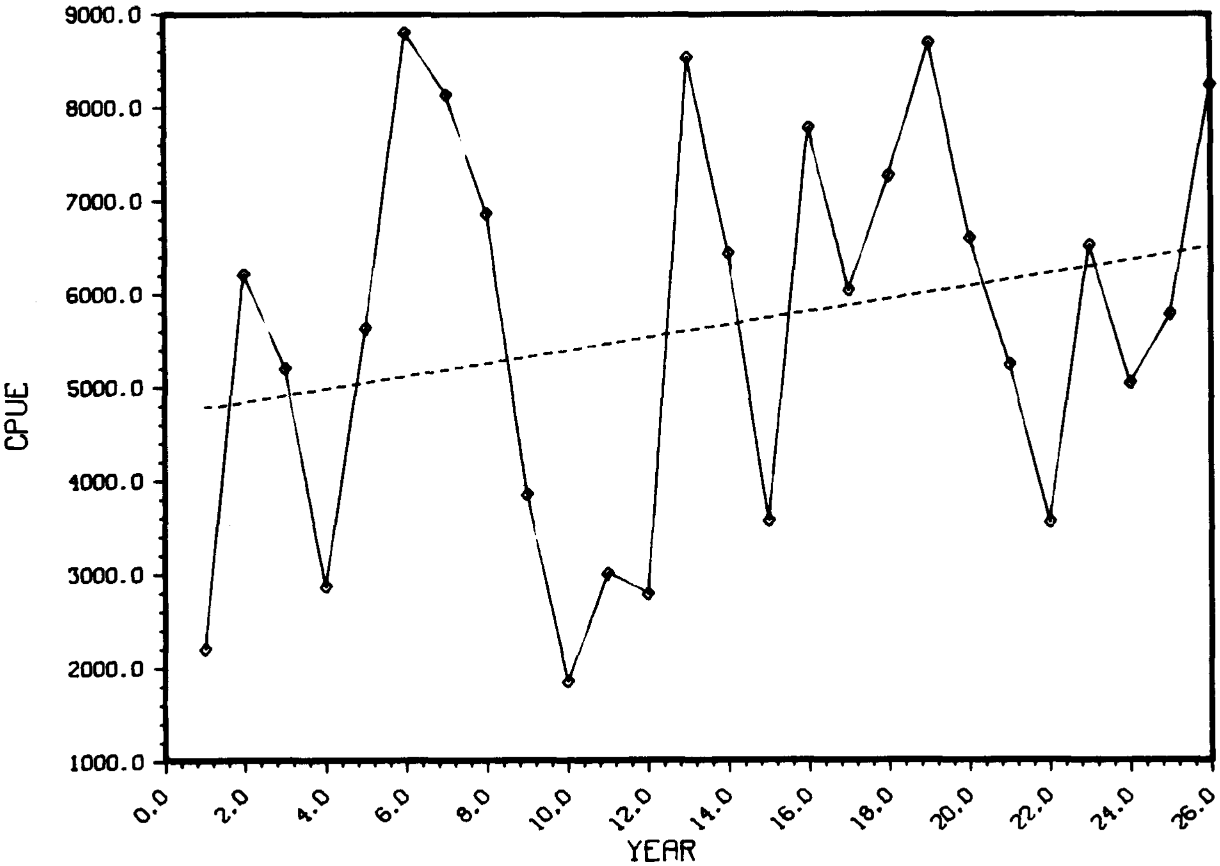

Figure B-9. Model-generated CPUE time series from Case 5, Run 46, Replicate 4, source alpha of 1.25, with linear trend.

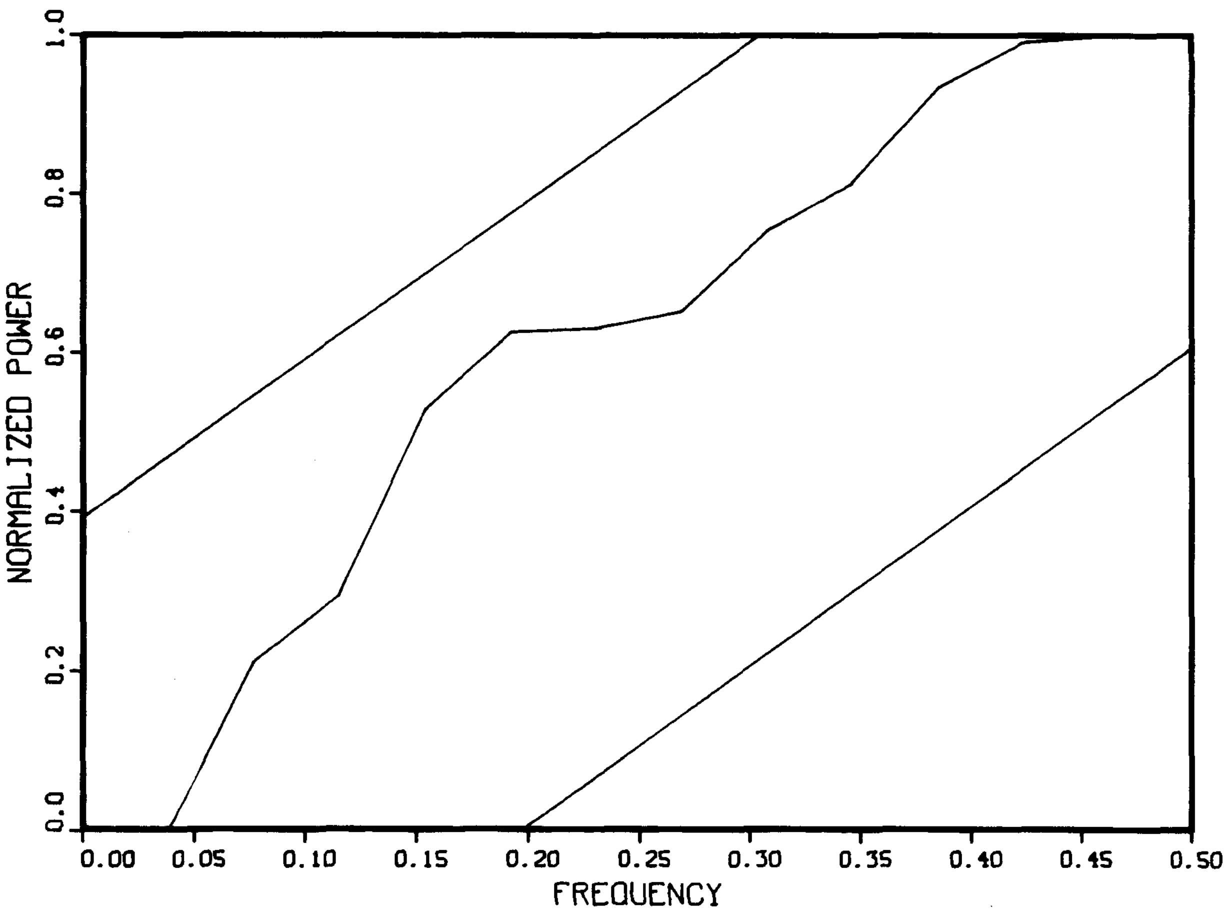

Figure B-10. Cumulative periodogram of detrended CPUE time series from Case 5, Run 46, Replicate 4, source alpha of 1.25.

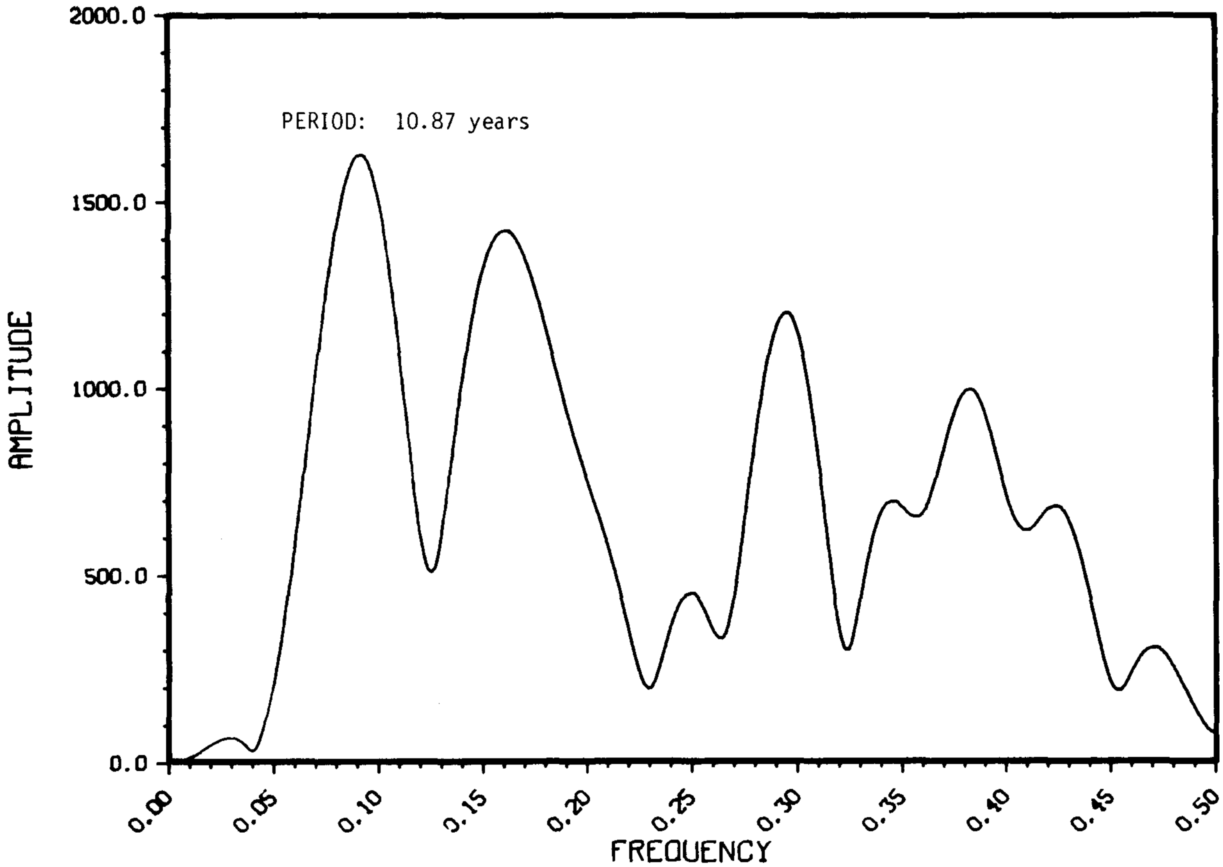

Figure B-11. Fourier amplitude spectrum of detrended CPUE time series from Case 5, Run 46, Replicate 4, source alpha of 1.25.

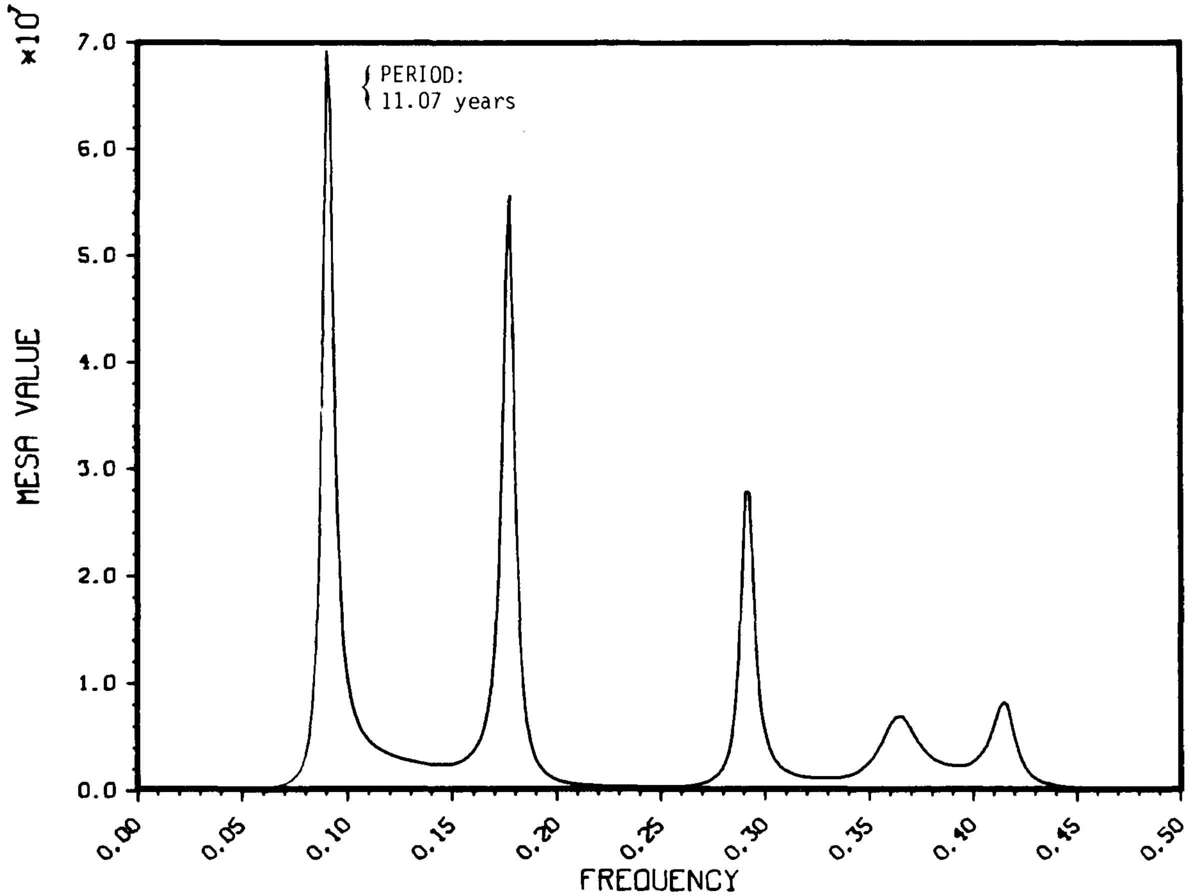

Figure B-12. Maximum entropy spectrum of detrended CPUE time series from Case 5, Run 46, Replicate 4, source alpha of 1.25.

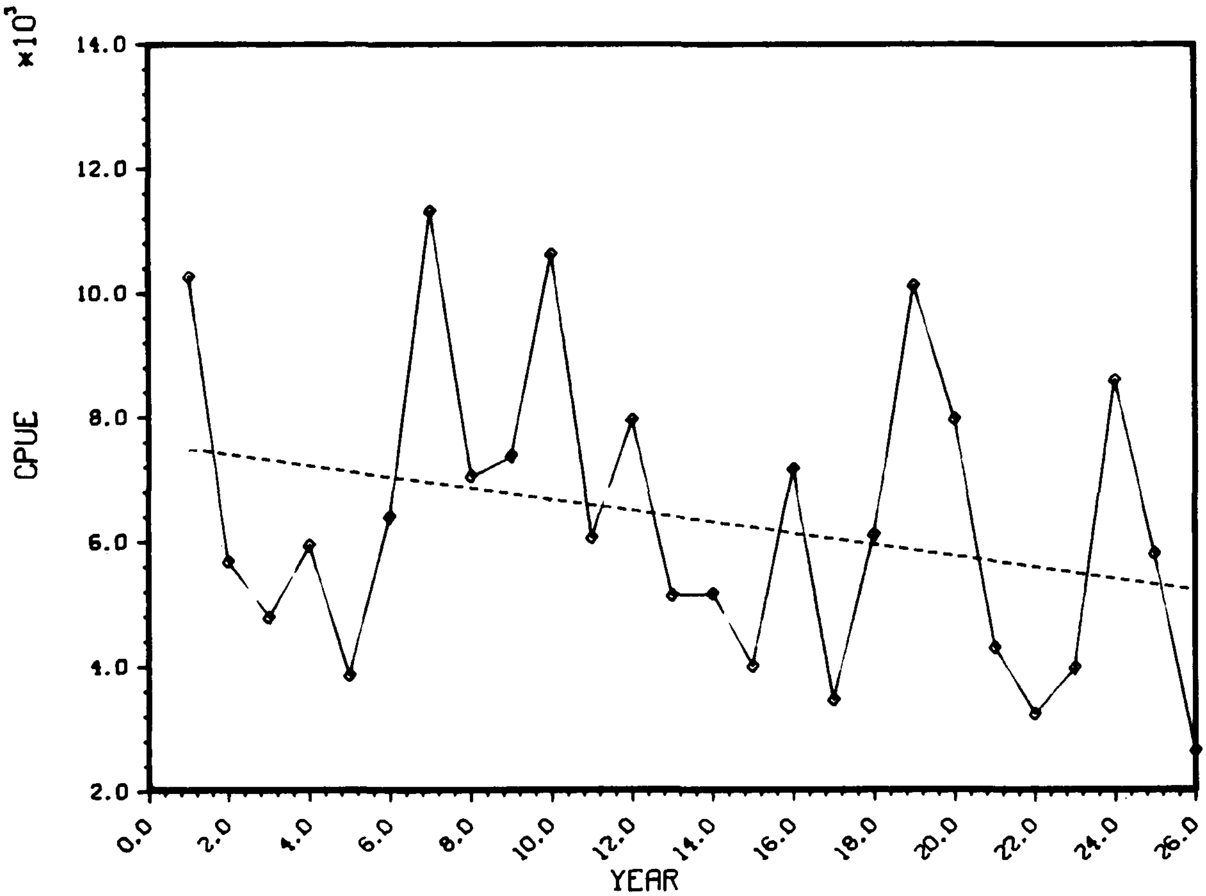

Figure B-13. Model-generated CPUE time series from Case 5, Run 46, Replicate 79, source alpha of 1.25, with linear trend.

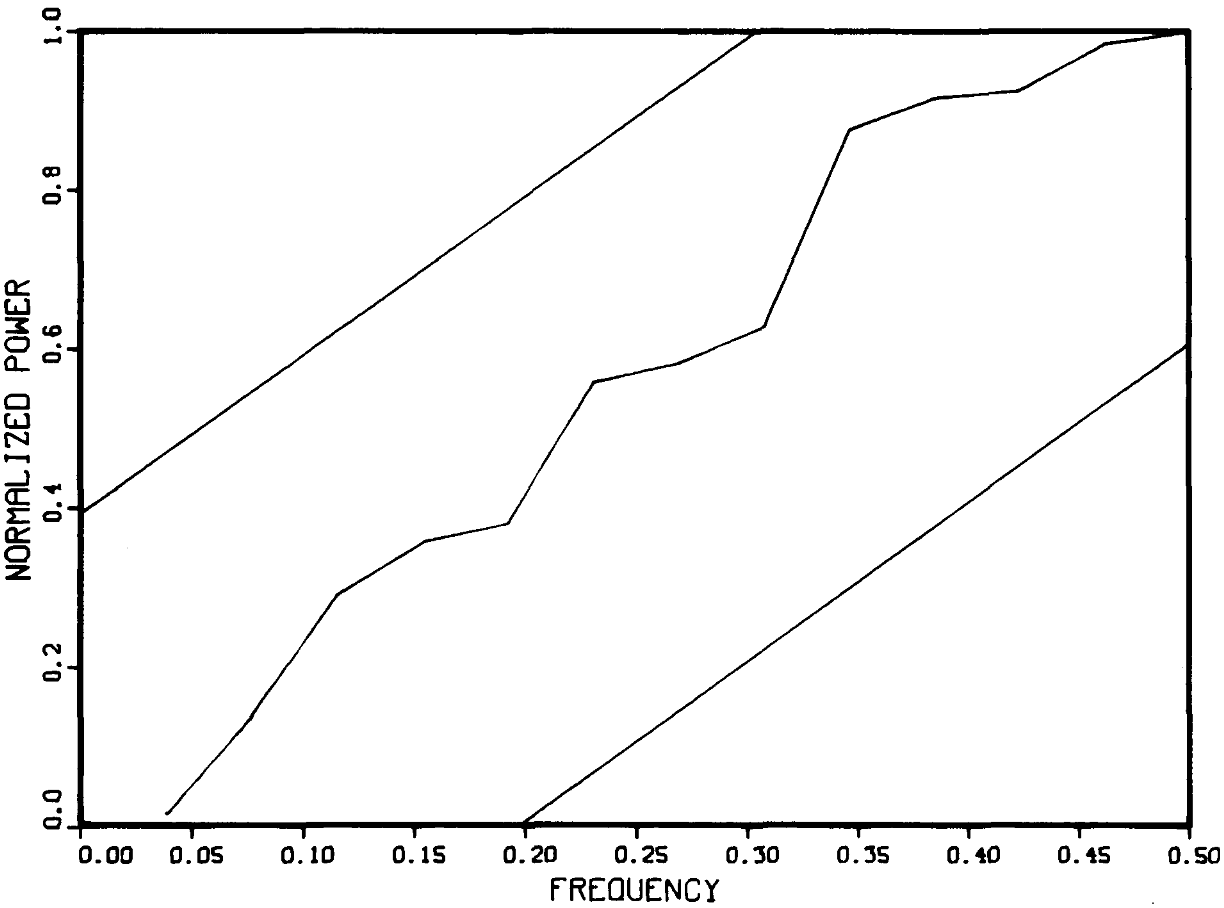

Figure B-14. Cumulative periodogram of detrended CPUE time series from Case 5, Run 46, Replicate 79, source alpha of 1.25.

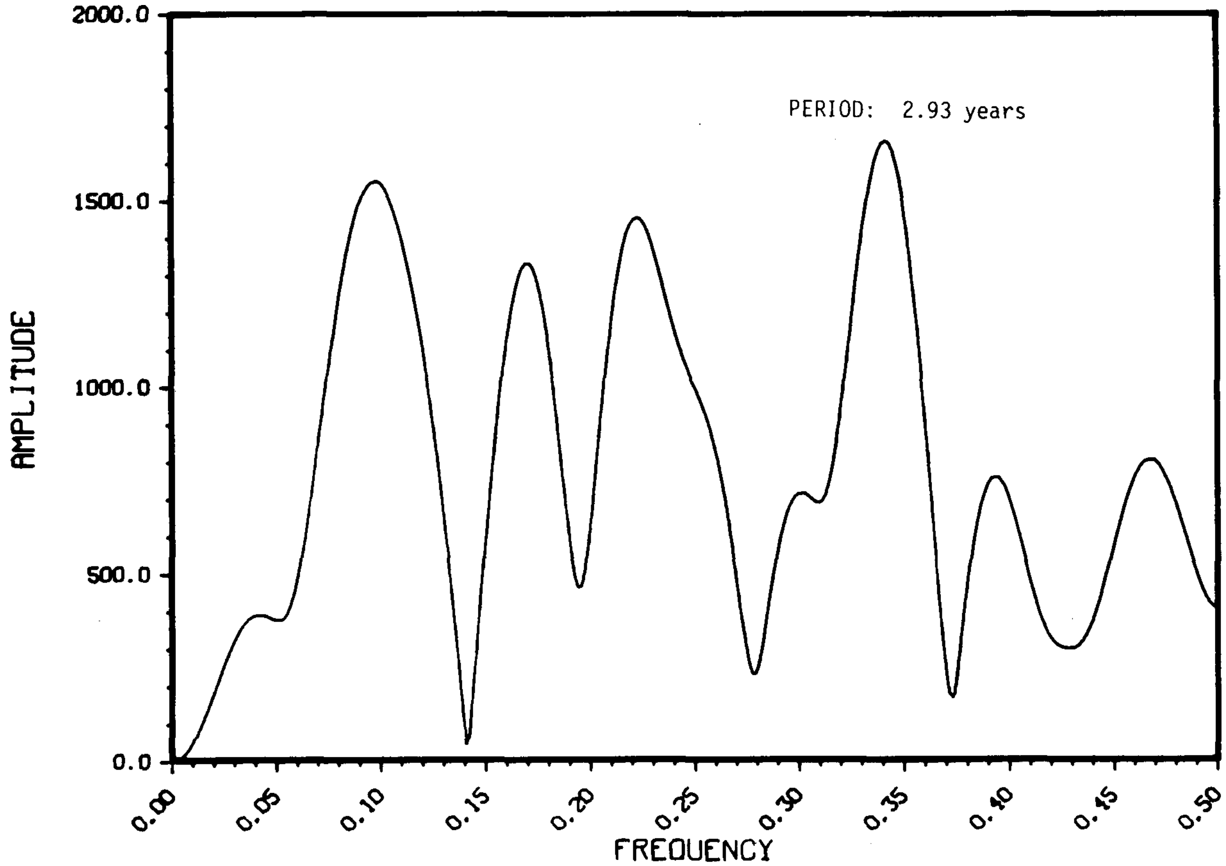

Figure B-15. Fourier amplitude spectrum of detrended CPUE time series from Case 5, Run 46, Replicate 79, source alpha of 1.25.

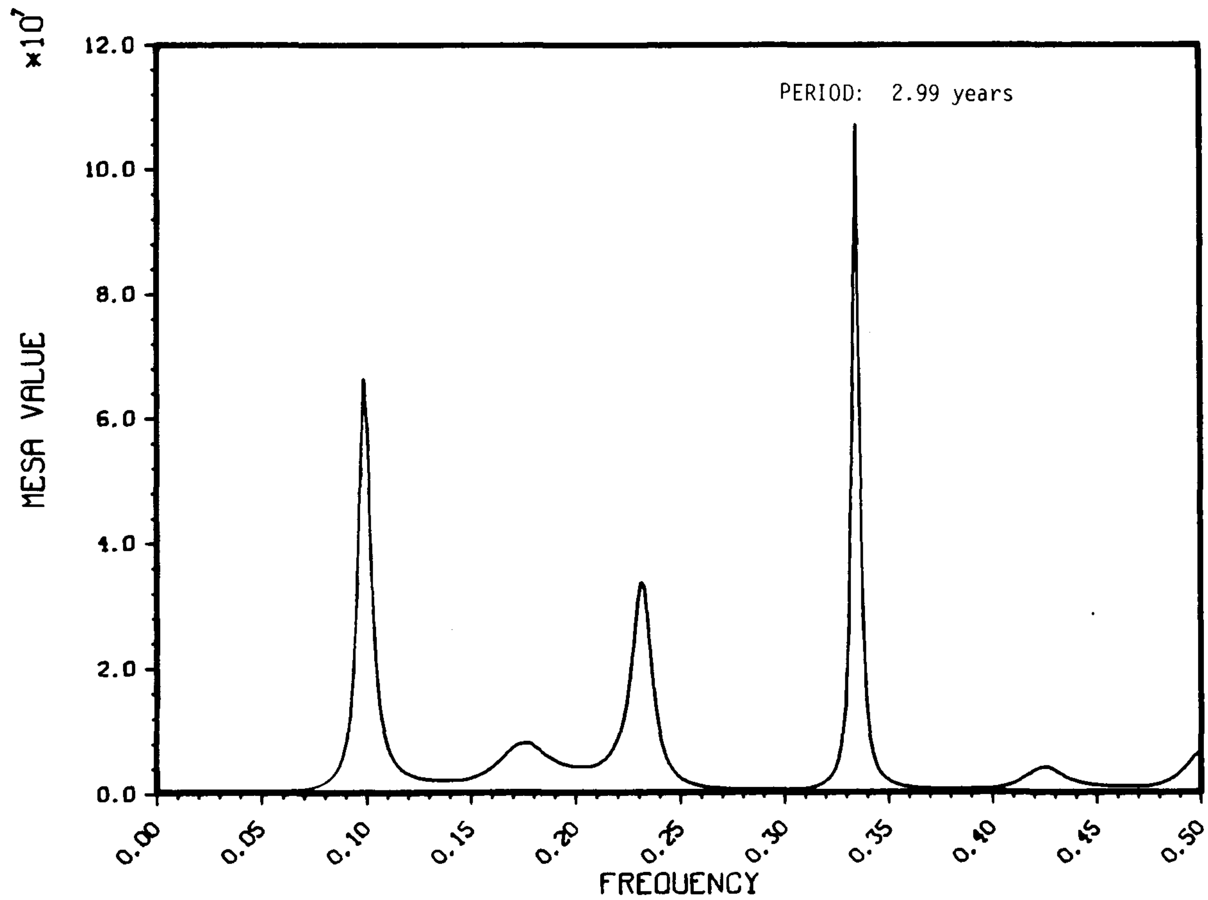

Figure B-16. Maximum entropy spectrum of detrended CPUE time series from Case 5, Run 46, Replicate 79, source alpha of 1.25.

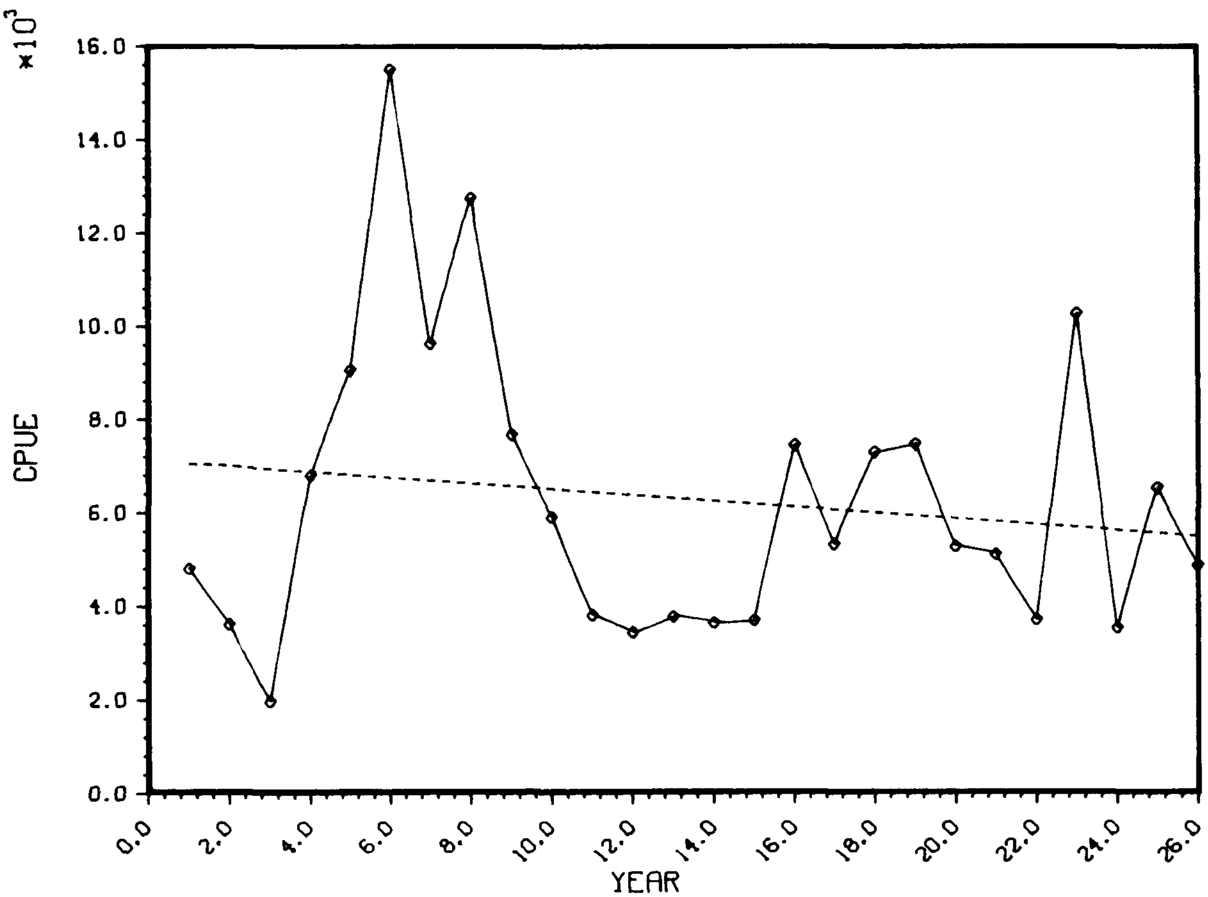

Figure B-17. Model-generated CPUE time series from Case 5, Run 48, Replicate 30, source alpha of 20.0, with linear trend.

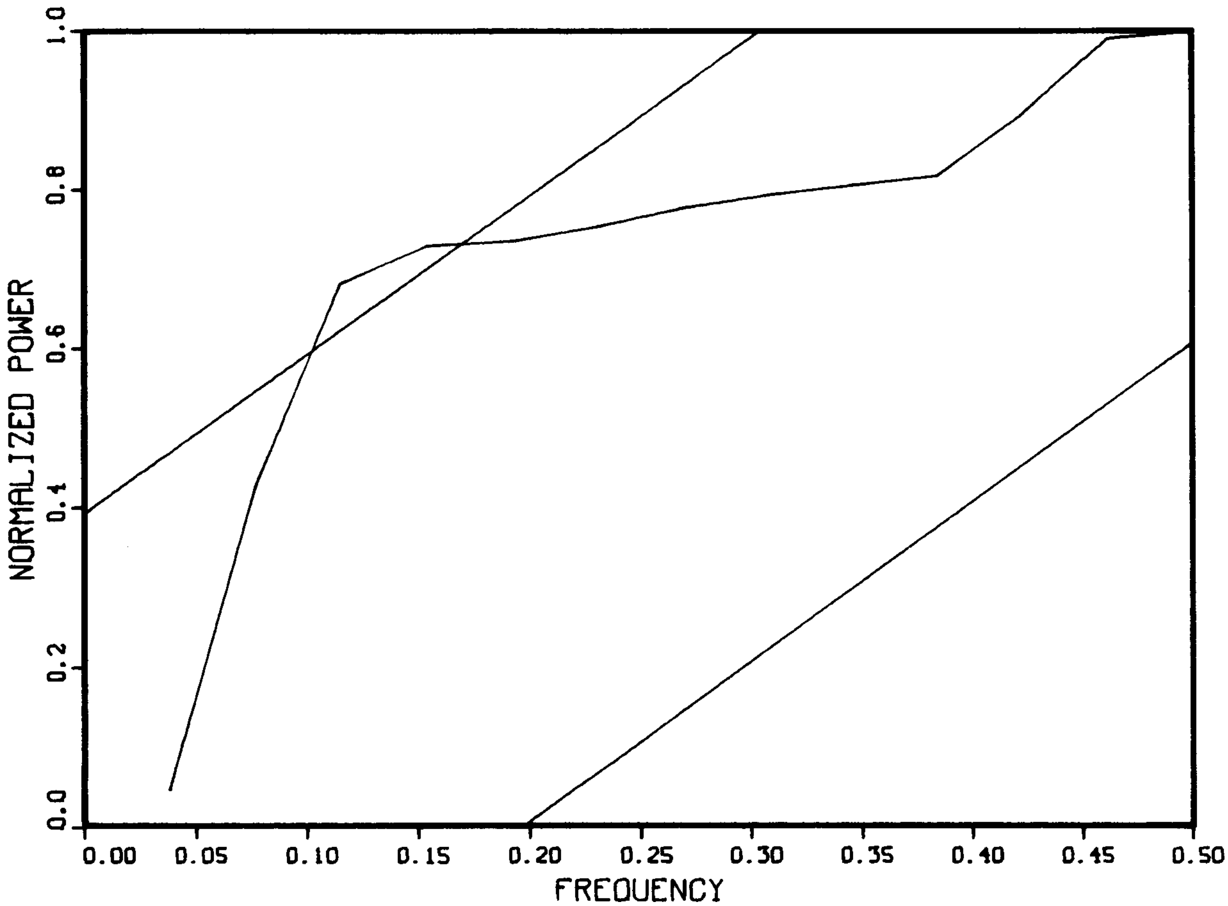

Figure B-18. Cumulative periodogram of detrended CPUE time series from Case 5, Run 48, Replicate 30, source alpha of 20.0.

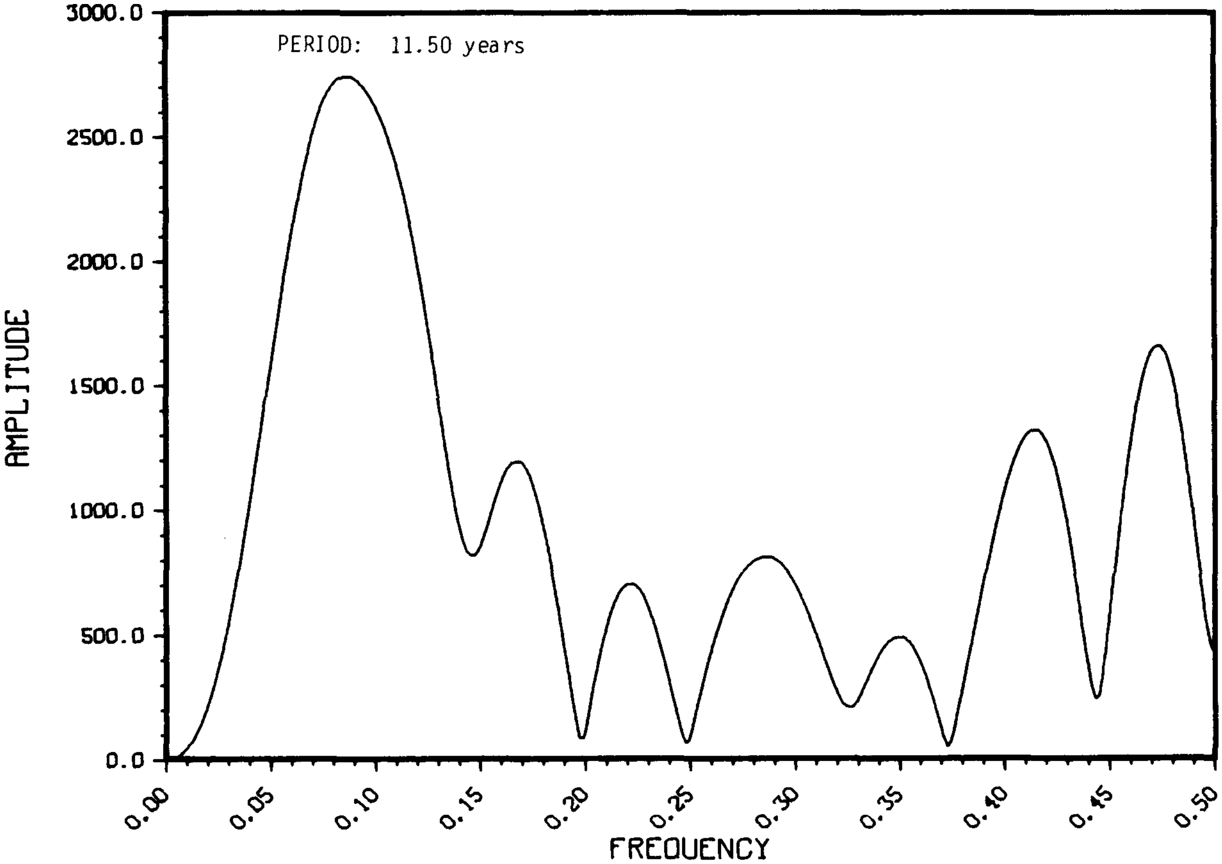

Figure B-19. Fourier amplitude spectrum of detrended CPUE time series from Case 5, Run 48, Replicate 30, source alpha of 20.0.

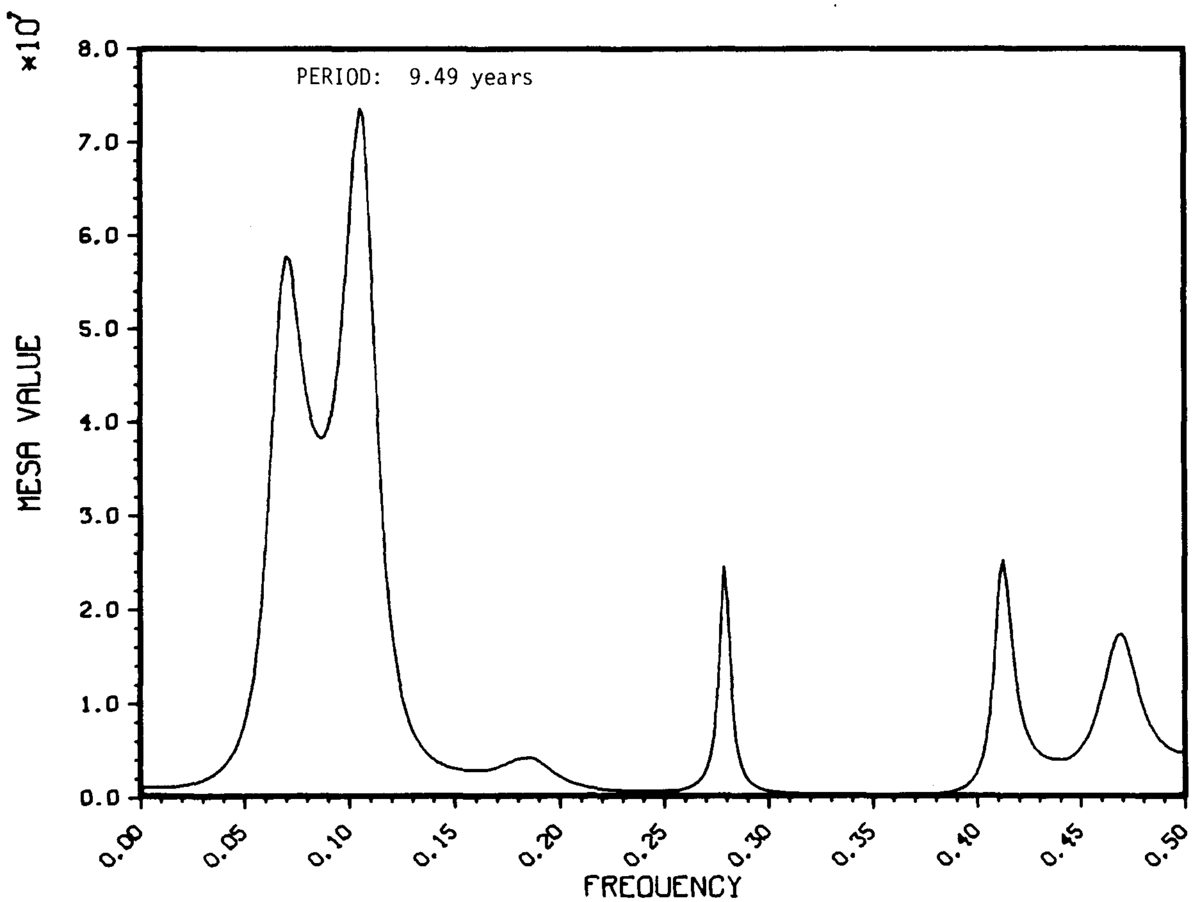

Figure B-20. Maximum entropy spectrum of detrended CPUE time series from Case 5, Run 48, Replicate 30, source alpha of 20.0.

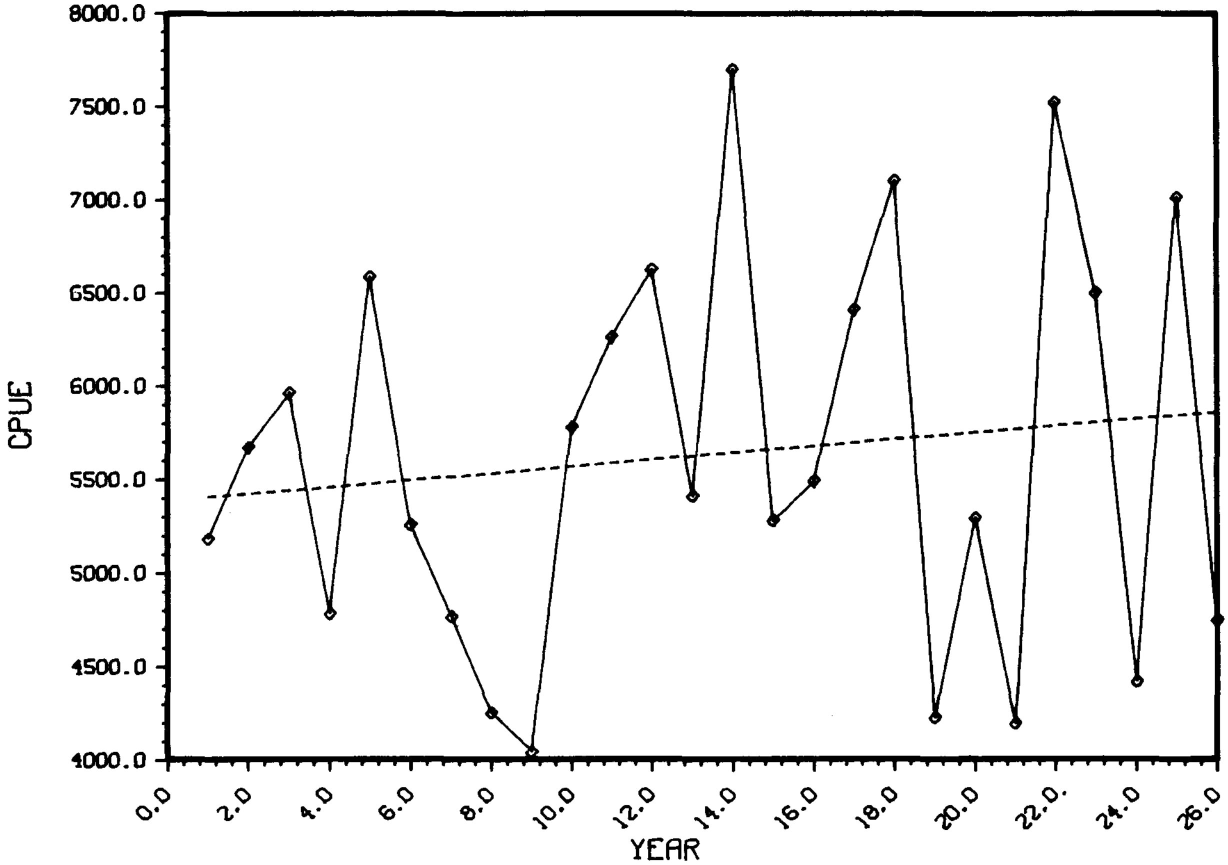

Figure B-21. Model-generated CPUE time series from Case 5, Run 48, Replicate 87, source alpha of 20.0.

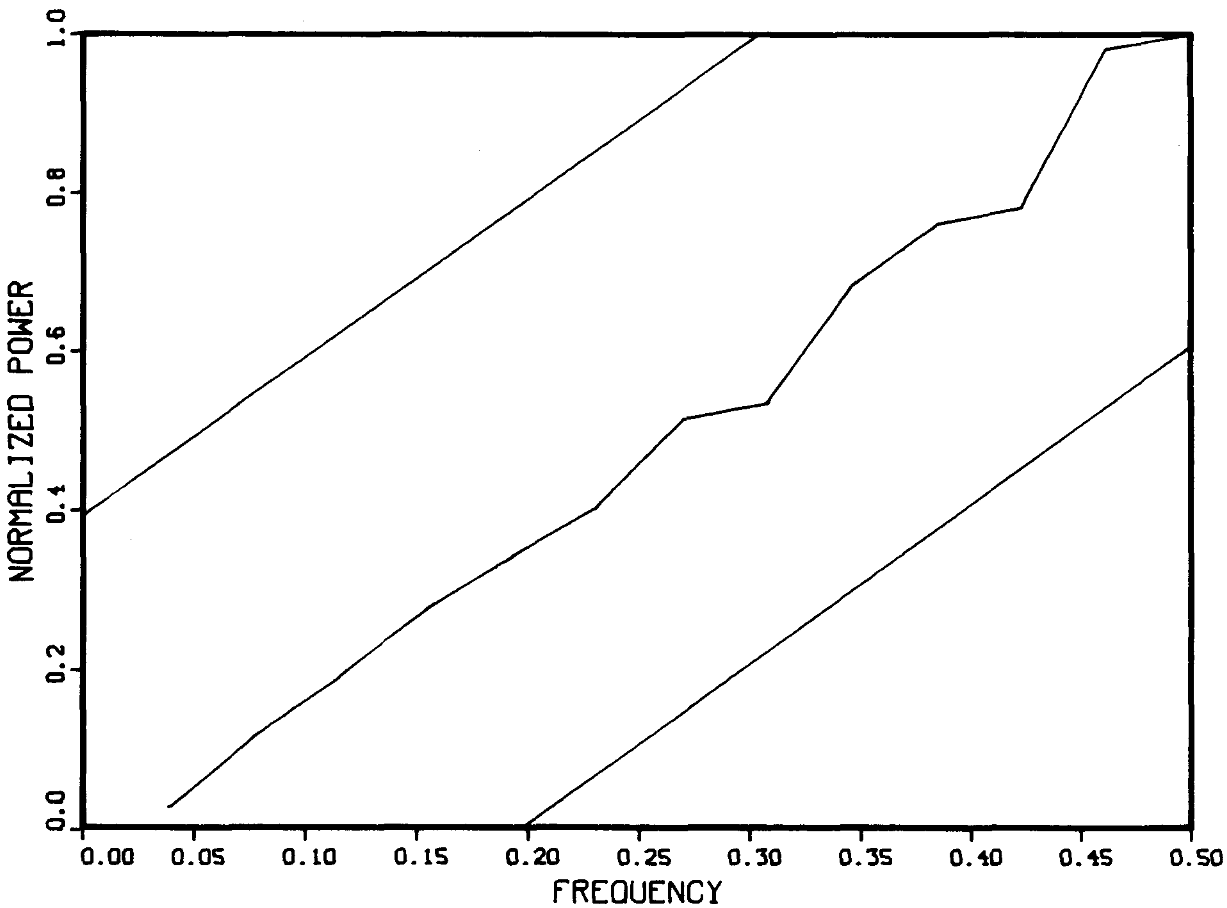

Figure B-22. Cumulative periodogram of detrended CPUE time series from Case 5, Run 48, Replicate 87, source alpha of 20.0.

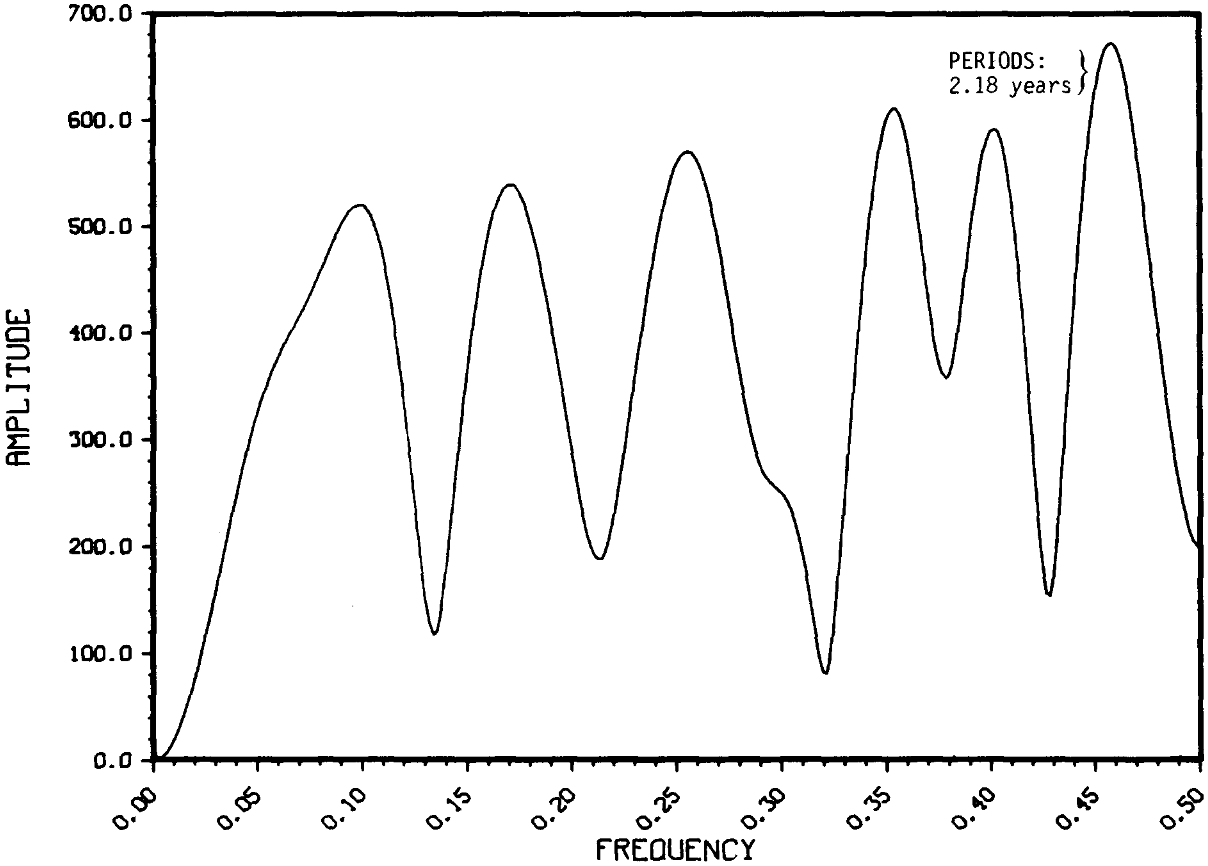

Figure B-23. Fourier amplitude spectrum of detrended CPUE time series from Case 5, Run 48, Replicate 87, source alpha of 20.0.

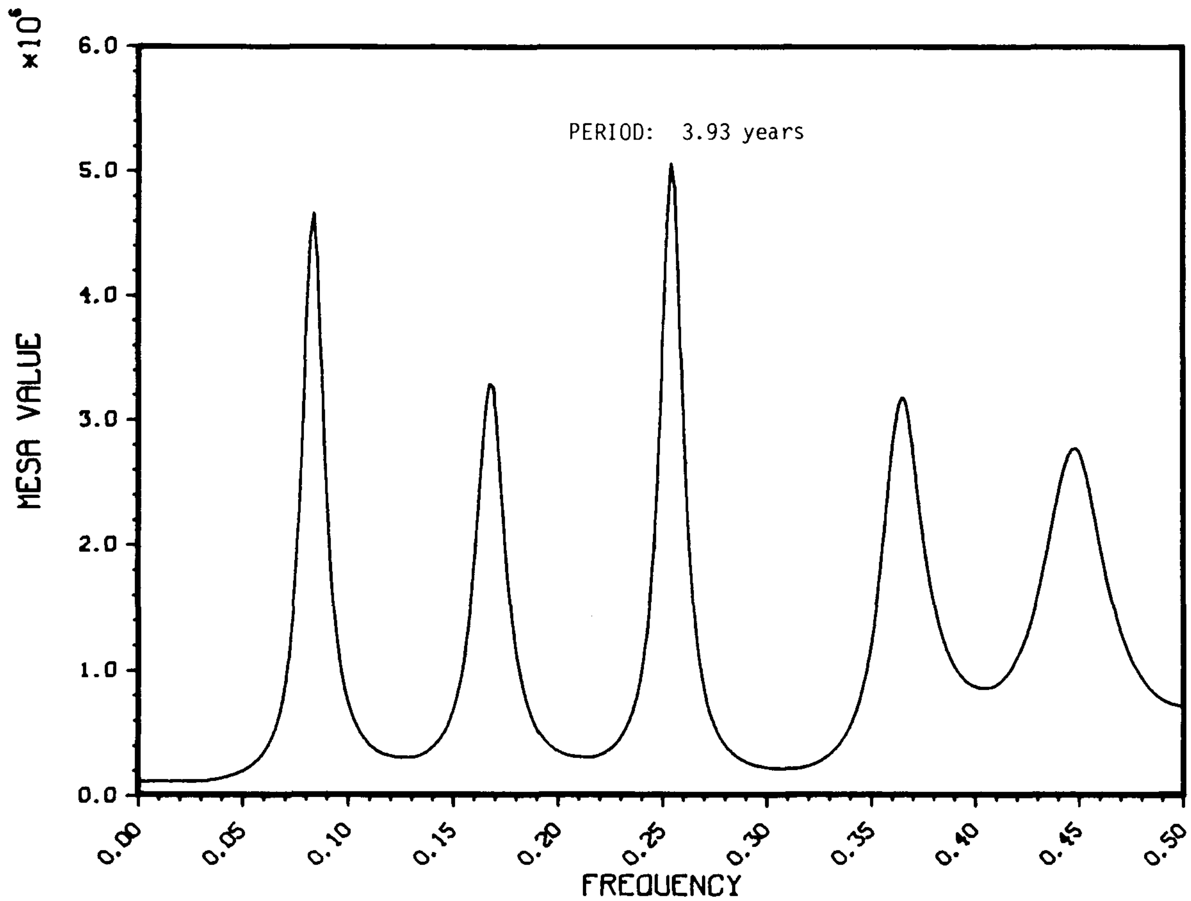

Figure B-24. Maximum entropy spectrum of detrended CPUE time series from Case 5, Run 48, Replicate 87, source alpha of 20.0.

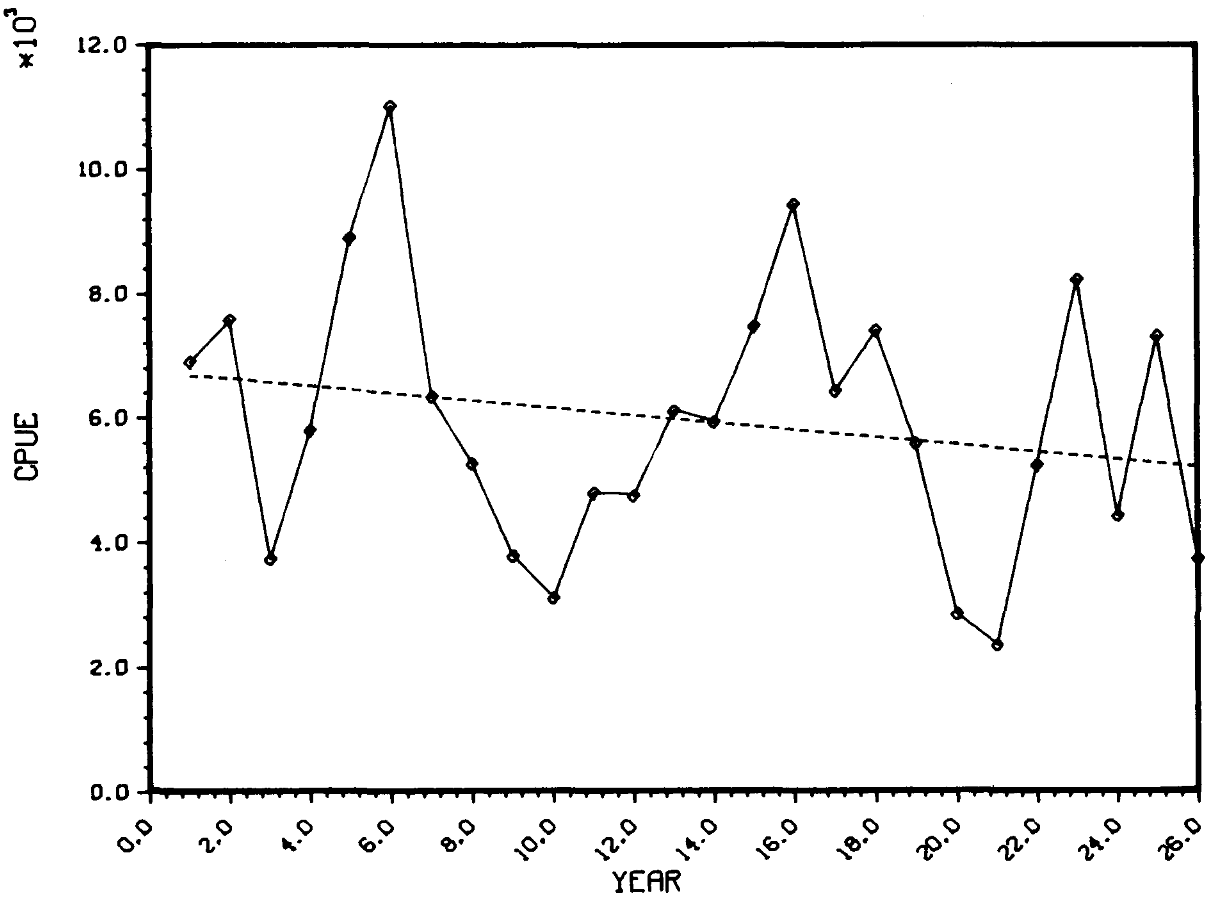

Figure B-25. Model-generated CPUE time series from Case 5, Run 48, Replicate 66, source alpha of 20.0, with linear trend.

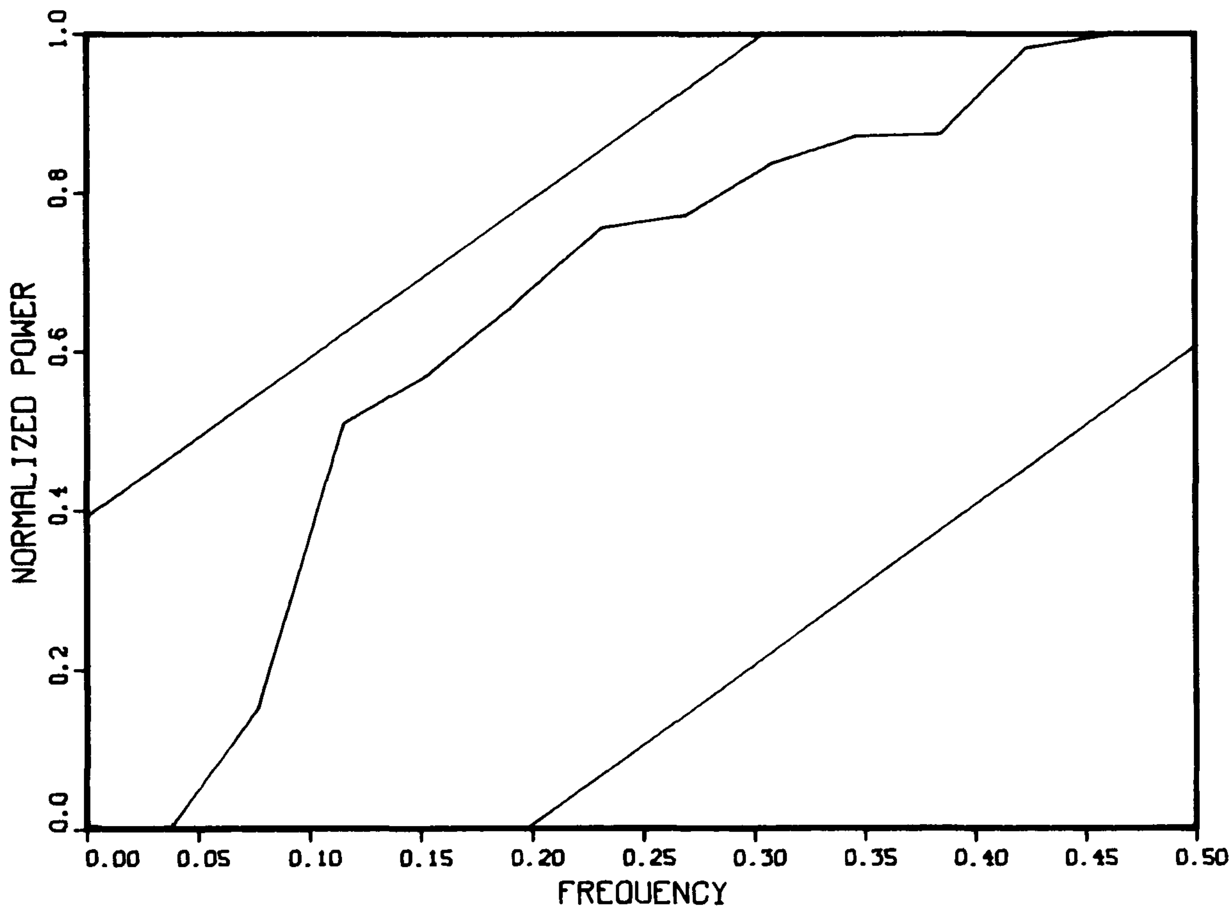

Figure B-26. Cumulative periodogram of detrended CPUE time series from Case 5, Run 48, Replicate 66, source alpha of 20.0.

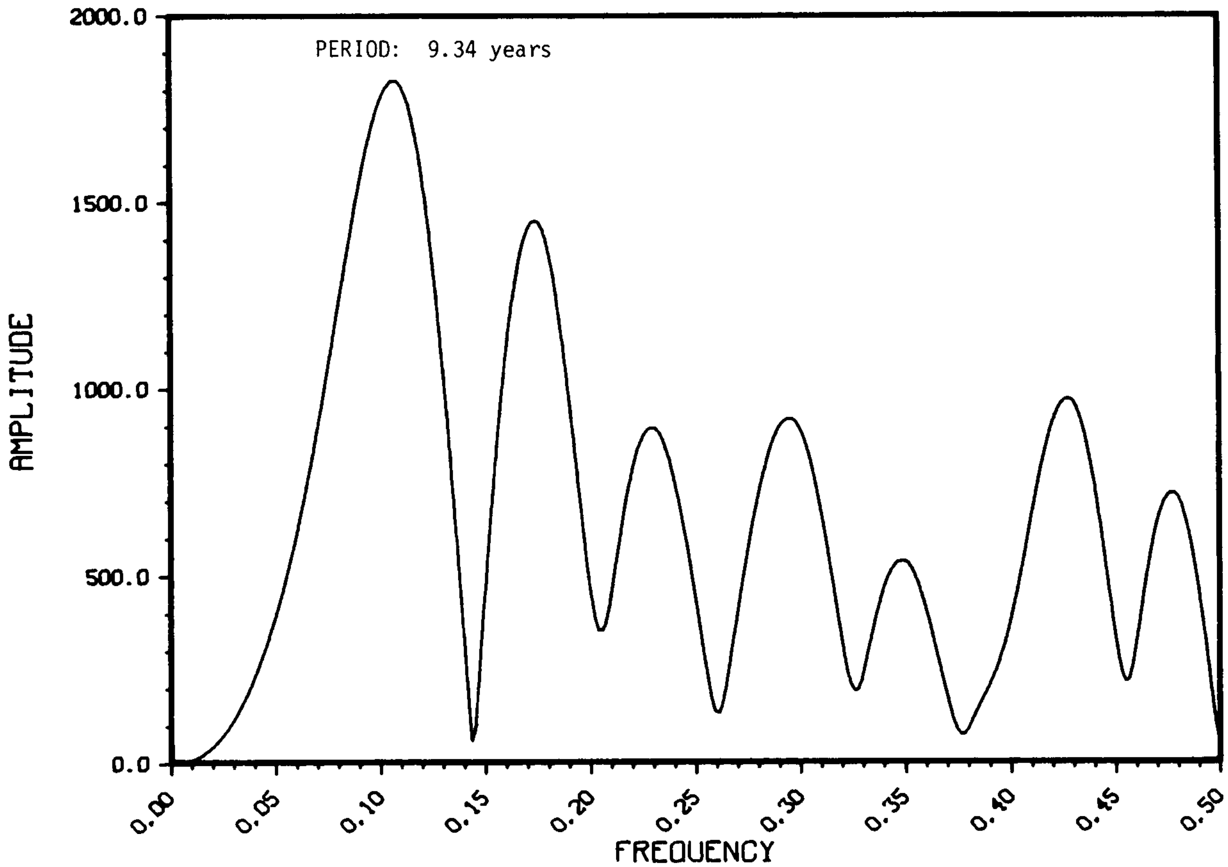

Figure B-27. Fourier amplitude spectrum of detrended CPUE time series from Case 5, Run 48, Replicate 66, source alpha of 20.0.

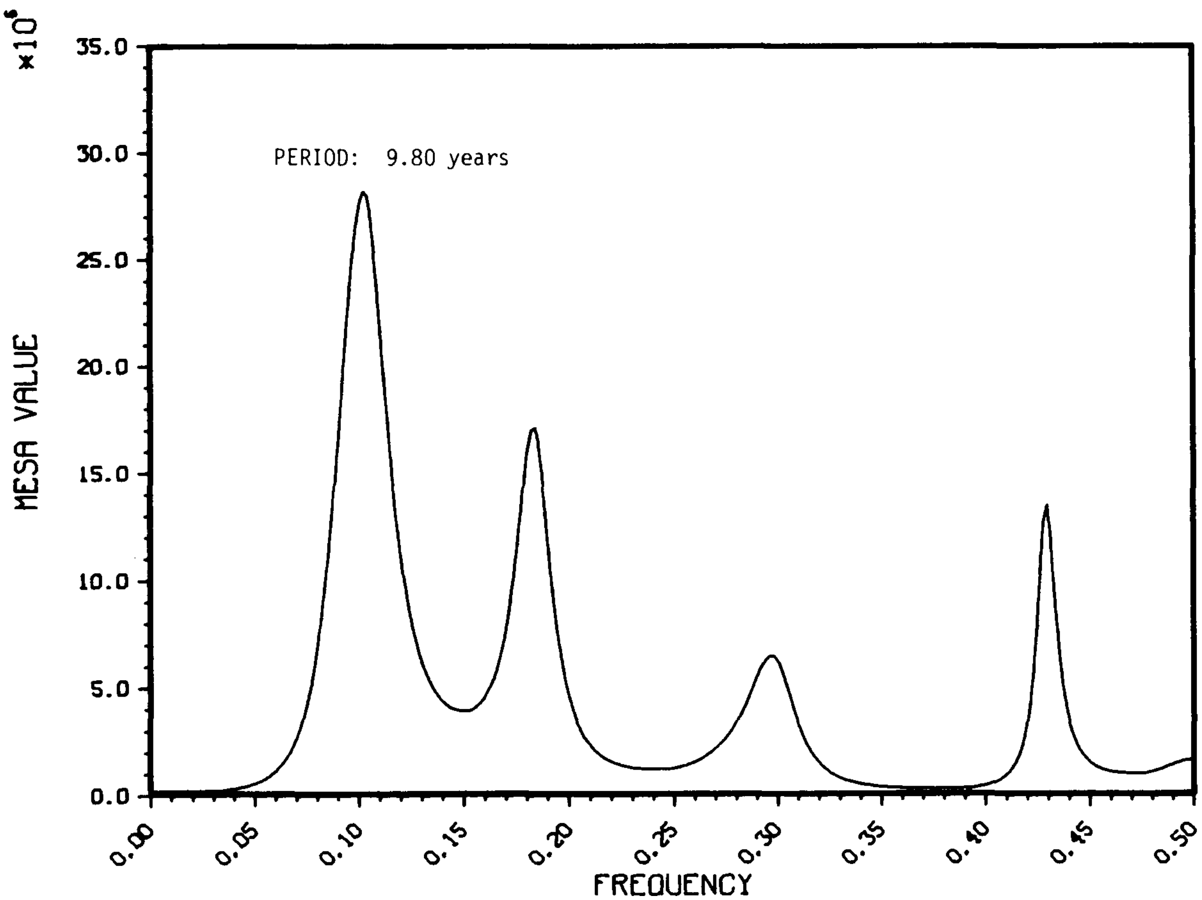

Figure B-28. Maximum entropy spectrum of detrended CPUE time series from Case 5, Run 48, Replicate 66, source alpha of 20.0.

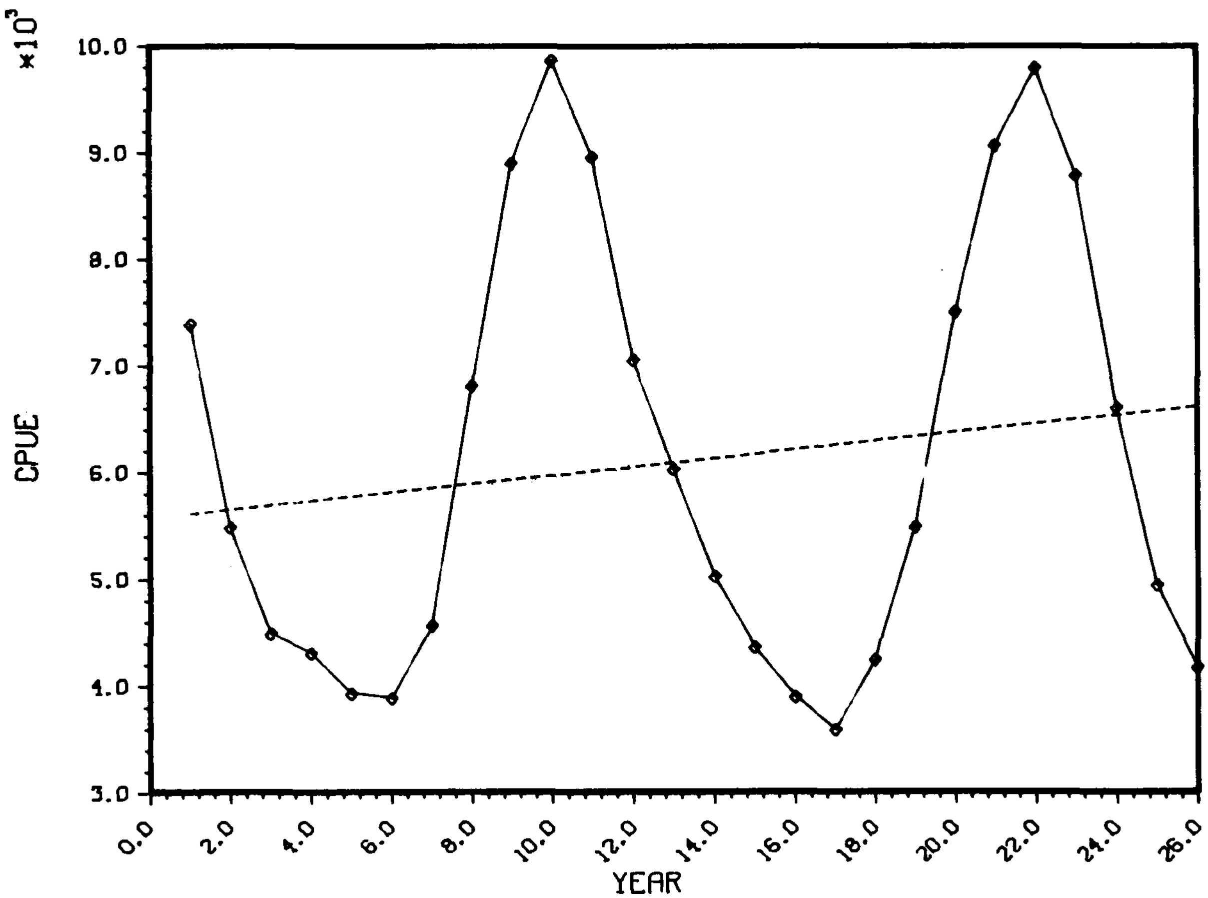

Figure B-29. Model-generated CPUE time series from Case 1, Run 32, Replicate 74, source alpha of 30.0, with linear trend.

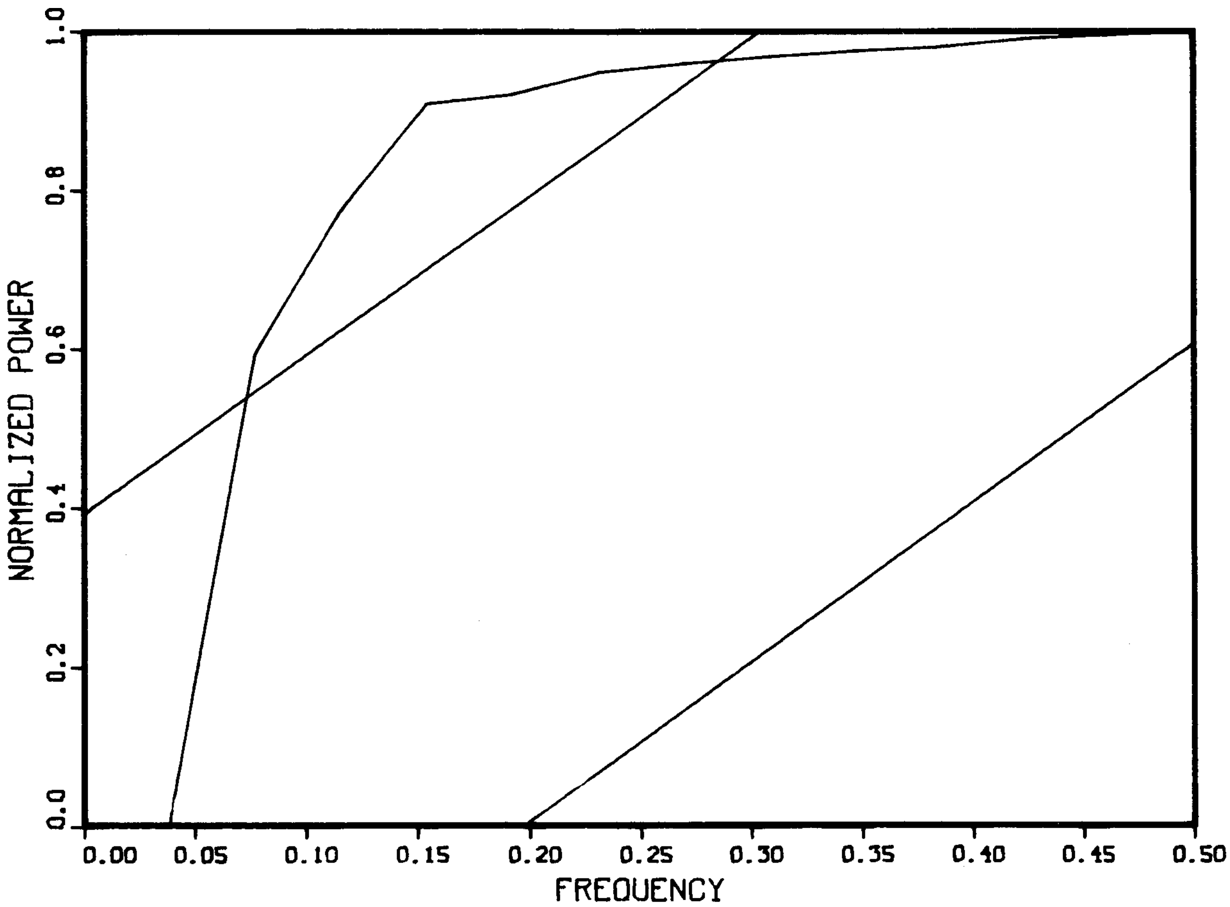

Figure B-30. Cumulative periodogram of detrended CPUE time series from Case 1, Run 32, Replicate 74, source alpha of 30.0.

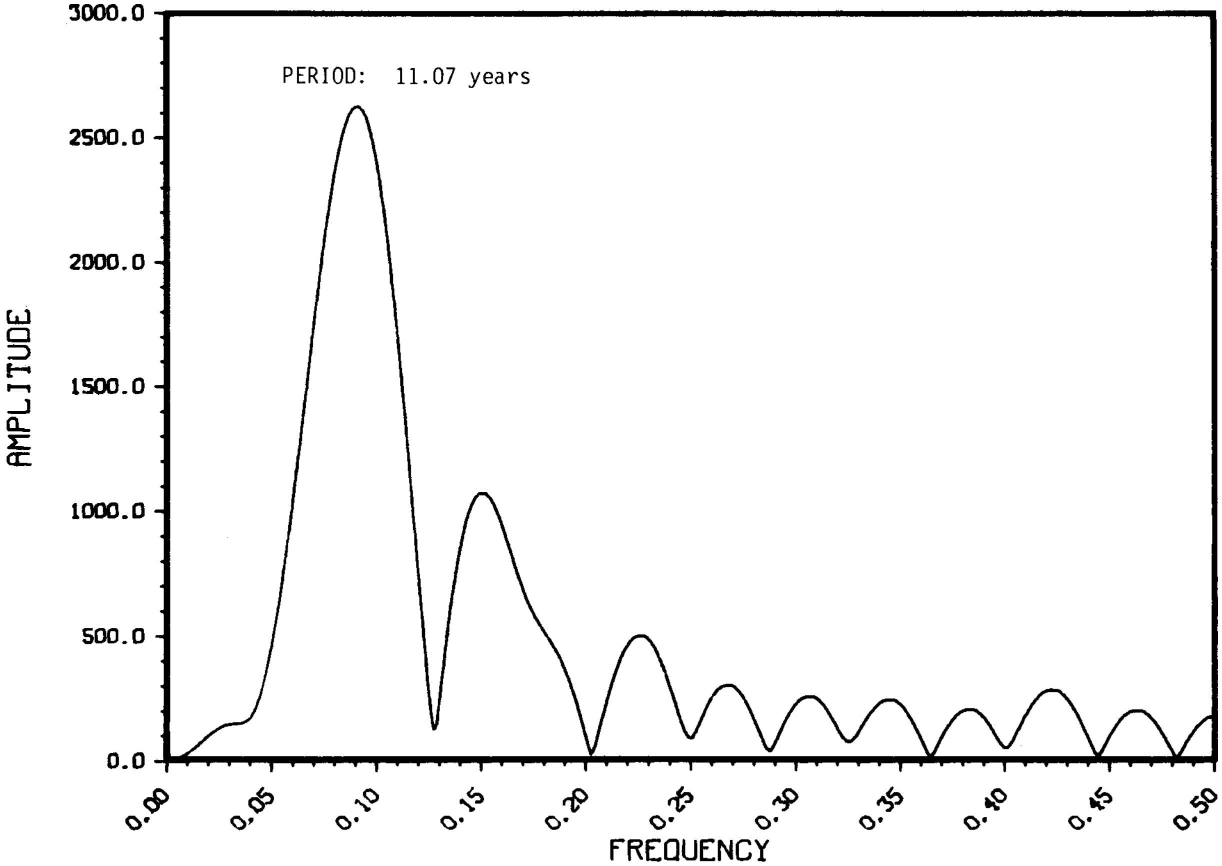

Figure B-31. Fourier amplitude spectrum of detrended CPUE time series from Case 1, Run 32, Replicate 74, source alpha of 30.0.

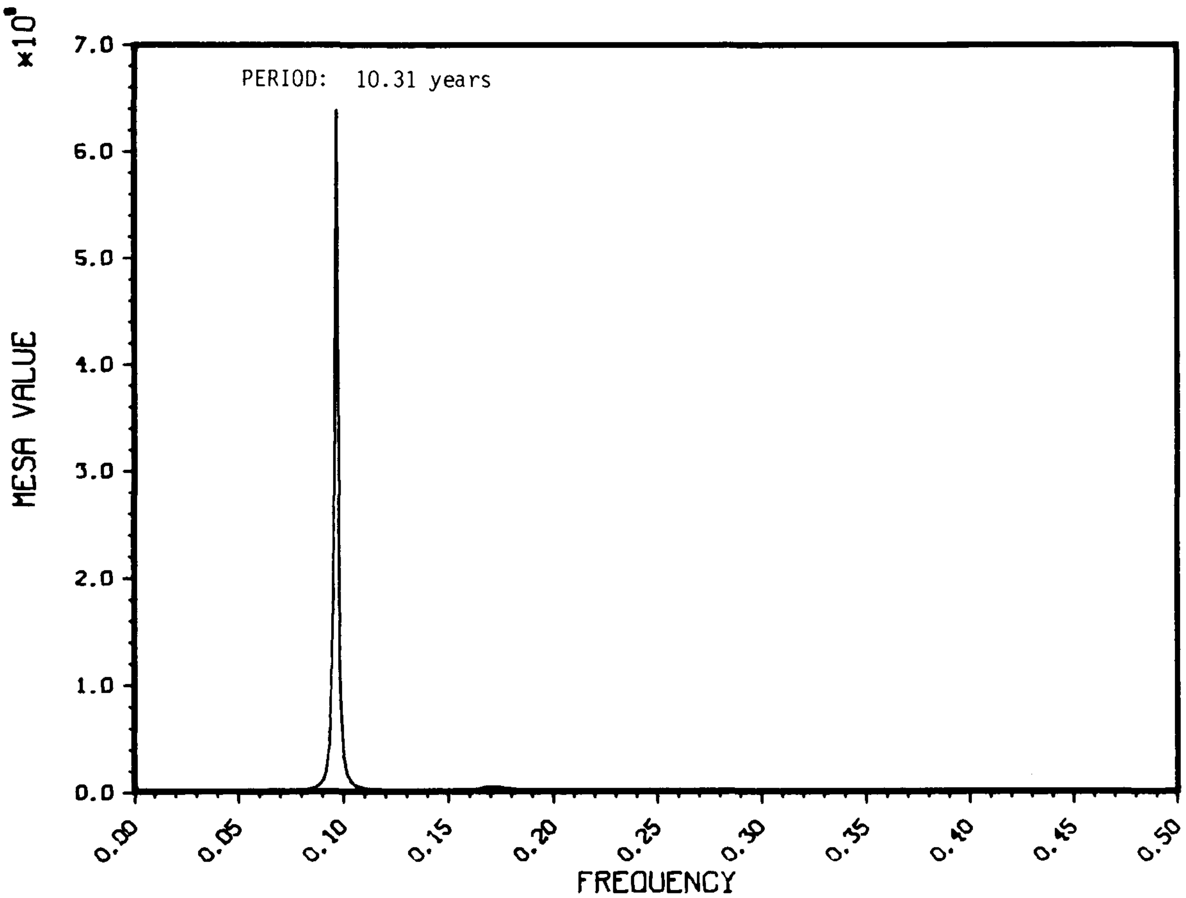

Figure B-32. Maximum entropy spectrum of detrended CPUE time series from Case 1, Run 32, Replicate 74, source alpha of 30.0.

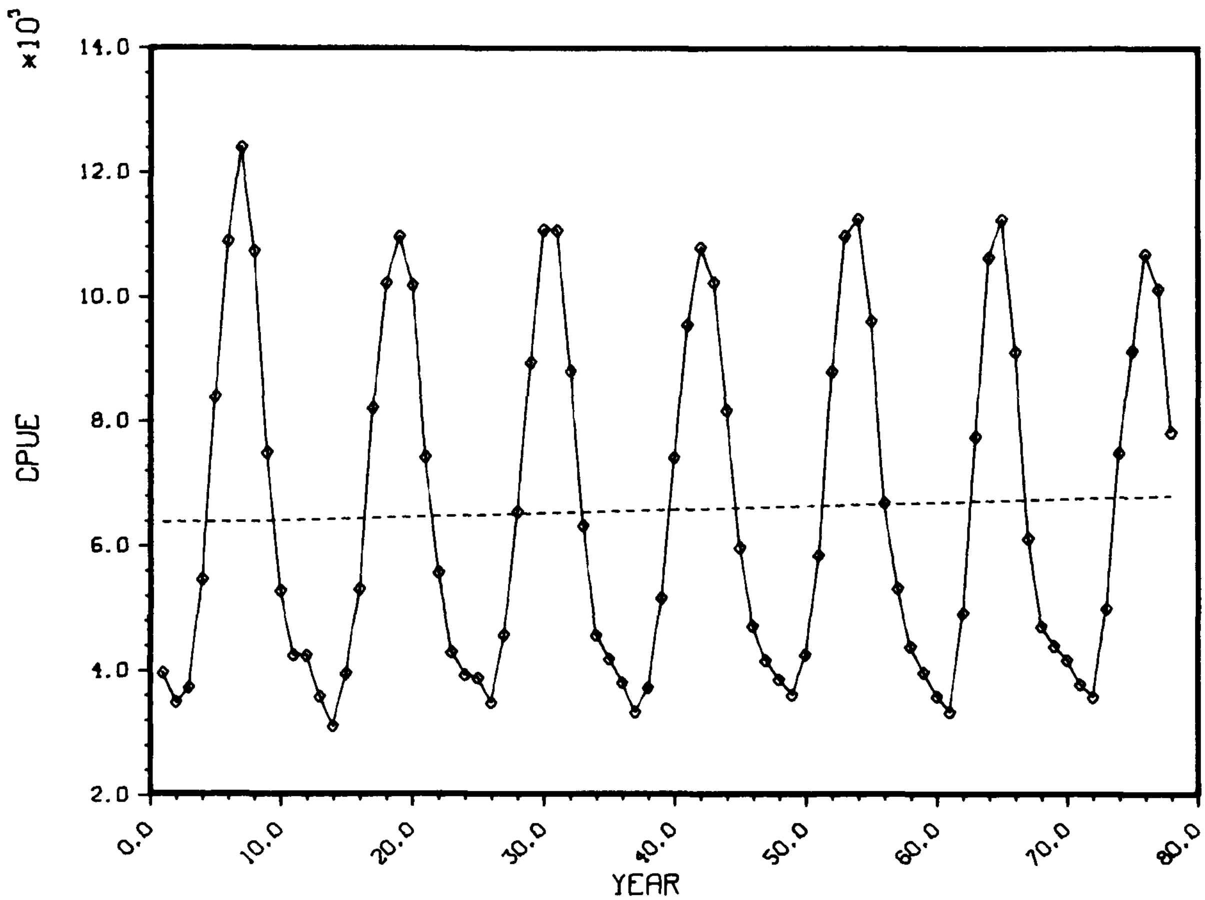

Figure B-33. Model-generated CPUE time series from Case 1, Run 32, Replicates 111-113, source alpha of 30.0.

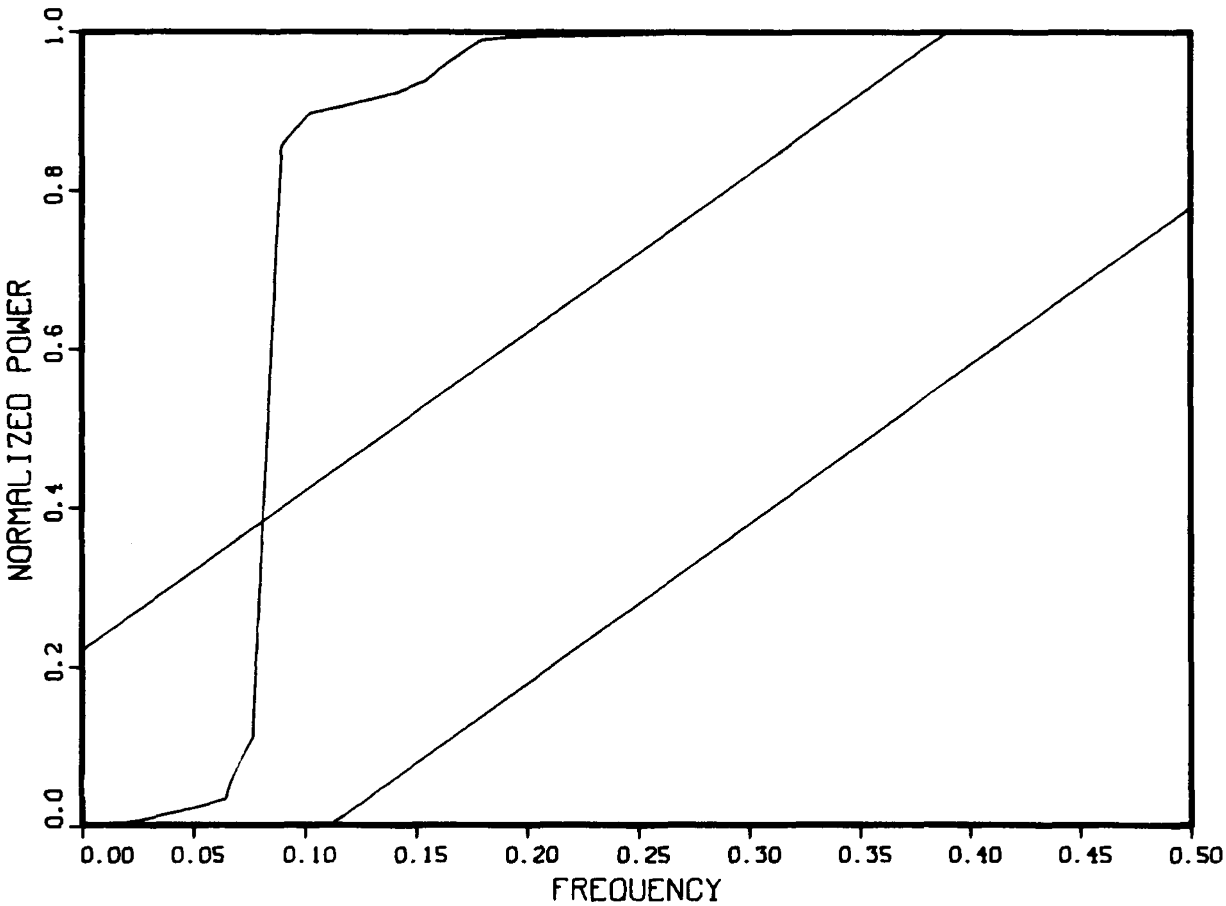

Figure B-34. Cumulative periodogram of detrended CPUE time series from Case 1, Run 32, Replicates 111-113, source alpha of 30.0.

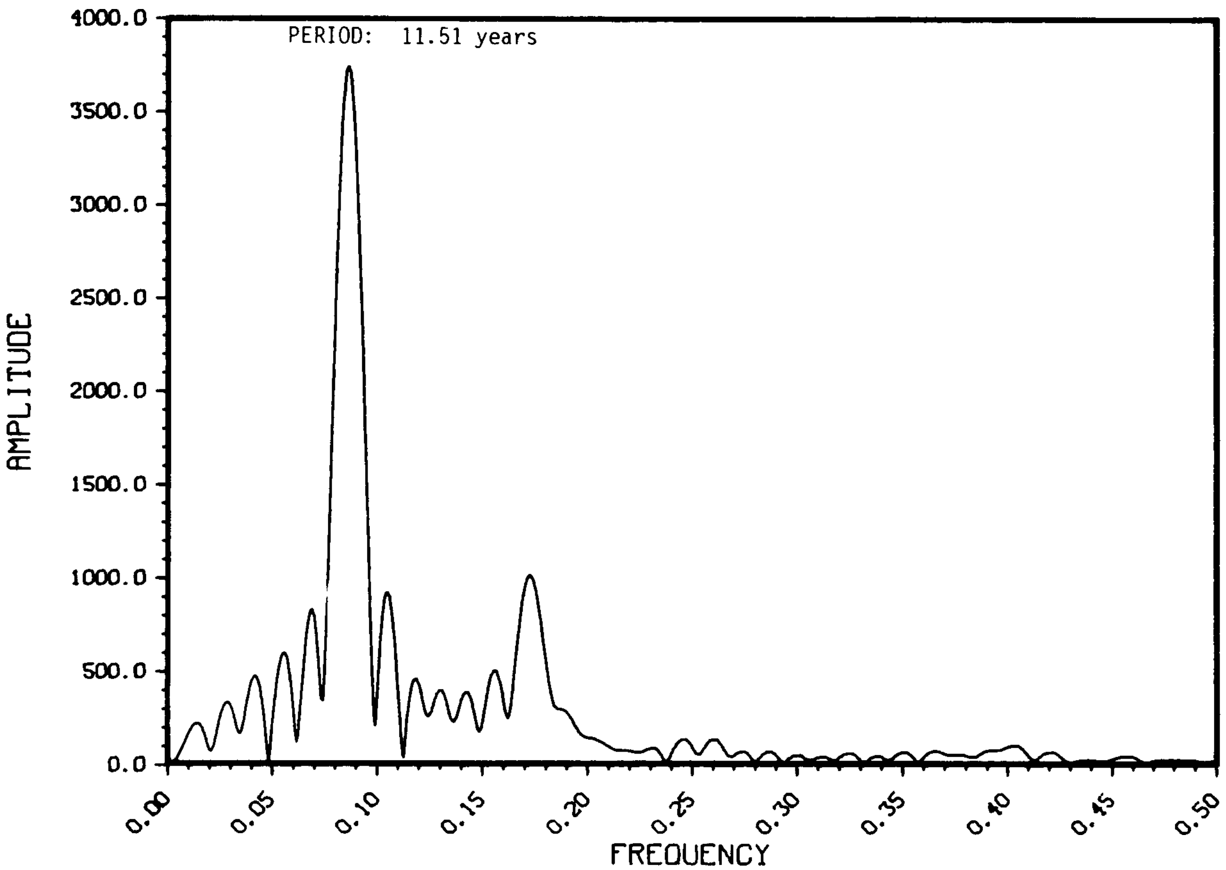

Figure B-35. Fourier amplitude spectrum of detrended CPUE time series from Case 1, Run 32, Replicates 111-113, source alpha of 30.0.

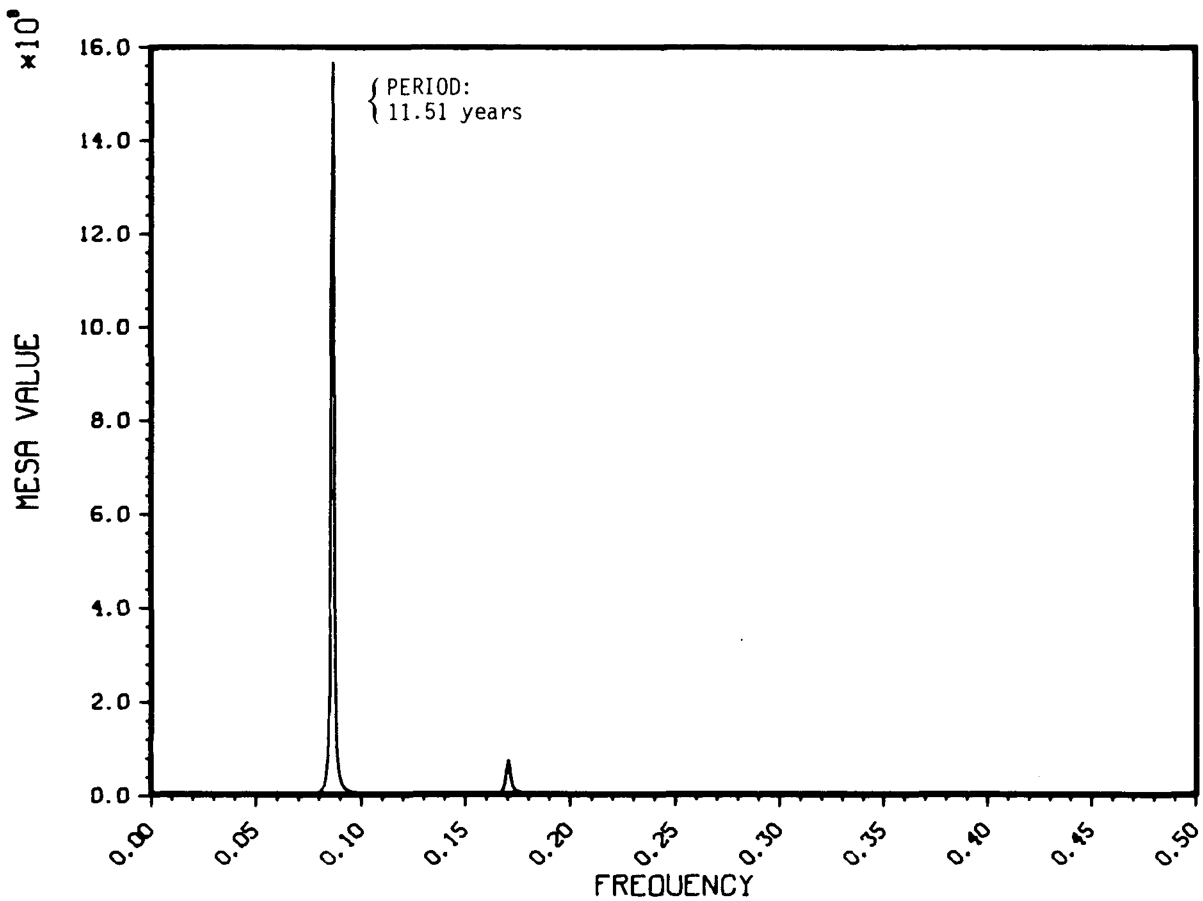

Figure B-36. Maximum entropy spectrum of detrended CPUE time series from Case 1, Run 32, Replicates 111-113, source alpha of 30.0.

APPENDIX C

PLOTS OF SELECTED CPUE TIME SERIES

Appendix C consists of graphs of the simulated CPUE time series from representative runs - in this case Run 46 and Run 48. Run 46 and Run 48 both come from Case 5. Run 46 has a source alpha of 1.25 and Run 48 a source alpha of 20. There are 120 Replicates for each Run. Each Replicate time series consists of 26 years of data There are 20 plots representing 20 Replicates per figure or page. The vertical origin for each plot starts at zero; however, the vertical scale varies from plot to plot.

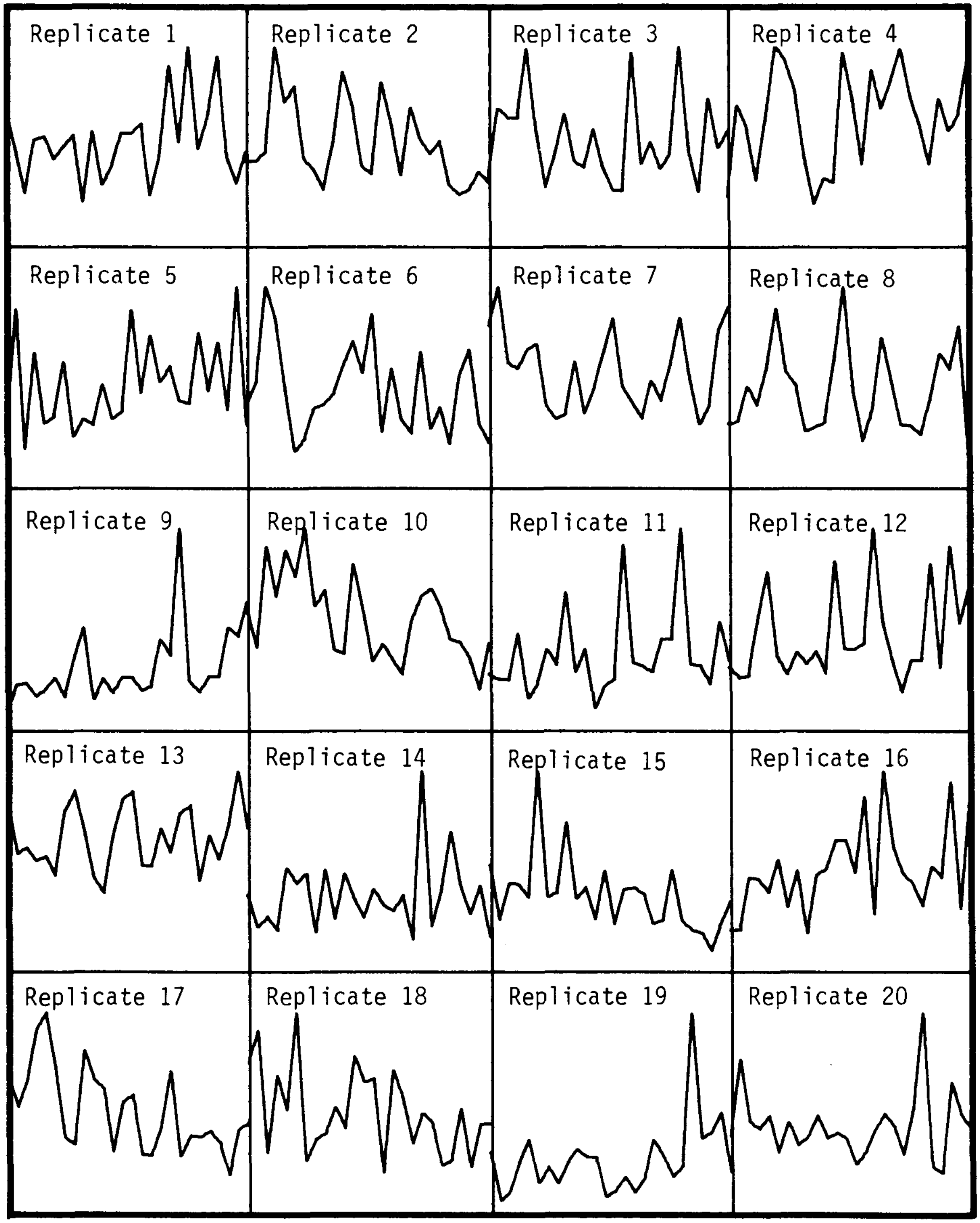

Figure C-1. Graphs of the simulated CPUE time series for Replicates 1-20 from Run 46, Case 5 (alpha of 1.25; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

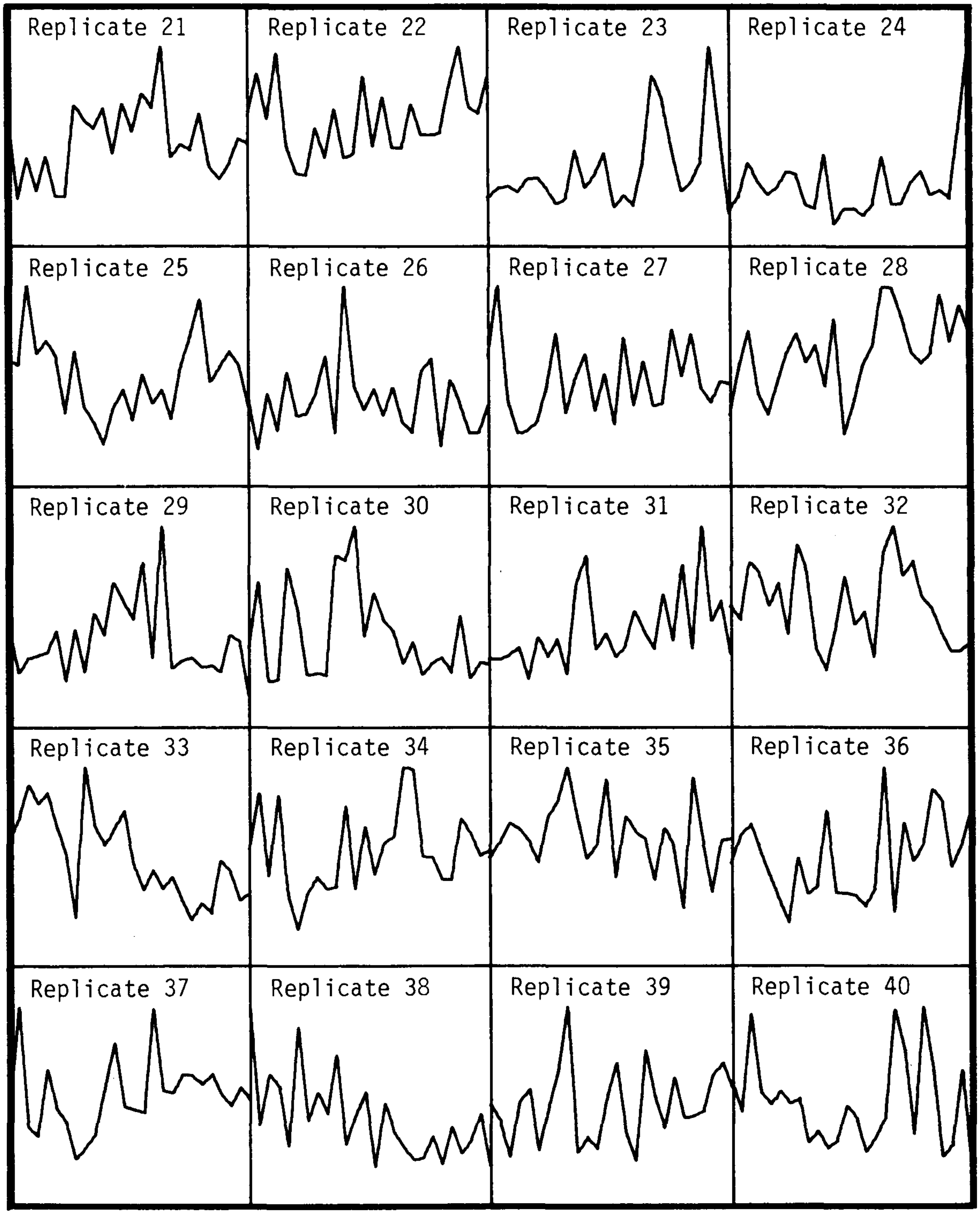

Figure C-2. Graphs of the simulated CPUE time series for Replicates 21-40 from Run 46, Case 5 (alpha of 1.25; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

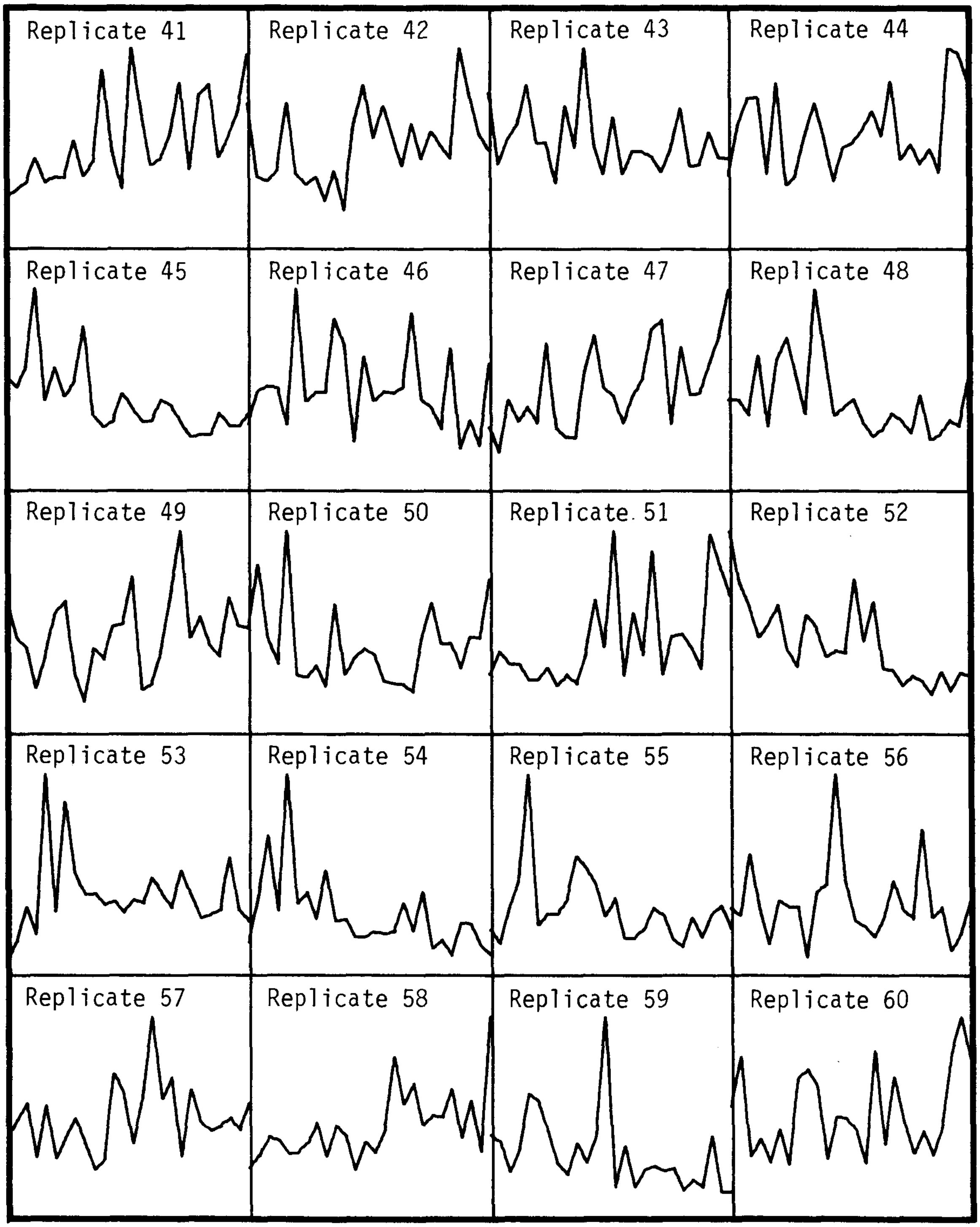

Figure C-3. Graphs of the simulated CPUE time series for Replicates 41-60 from Run 46, Case 5 (alpha of 1.25; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

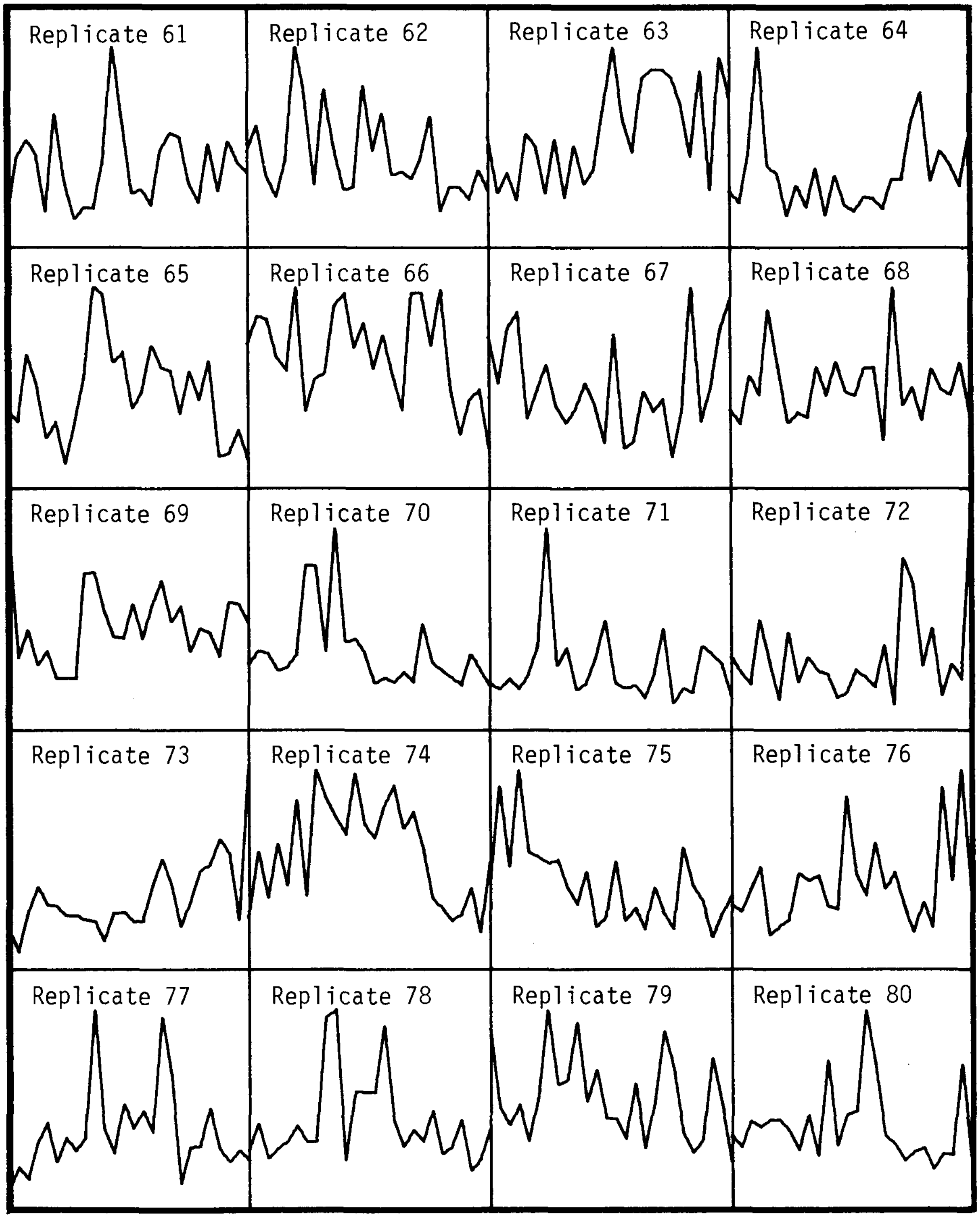

Figure C-4. Graphs of the simulated CPUE time series for Replicates 61-80 from Run 46, Case 5 (alpha of 1.25; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

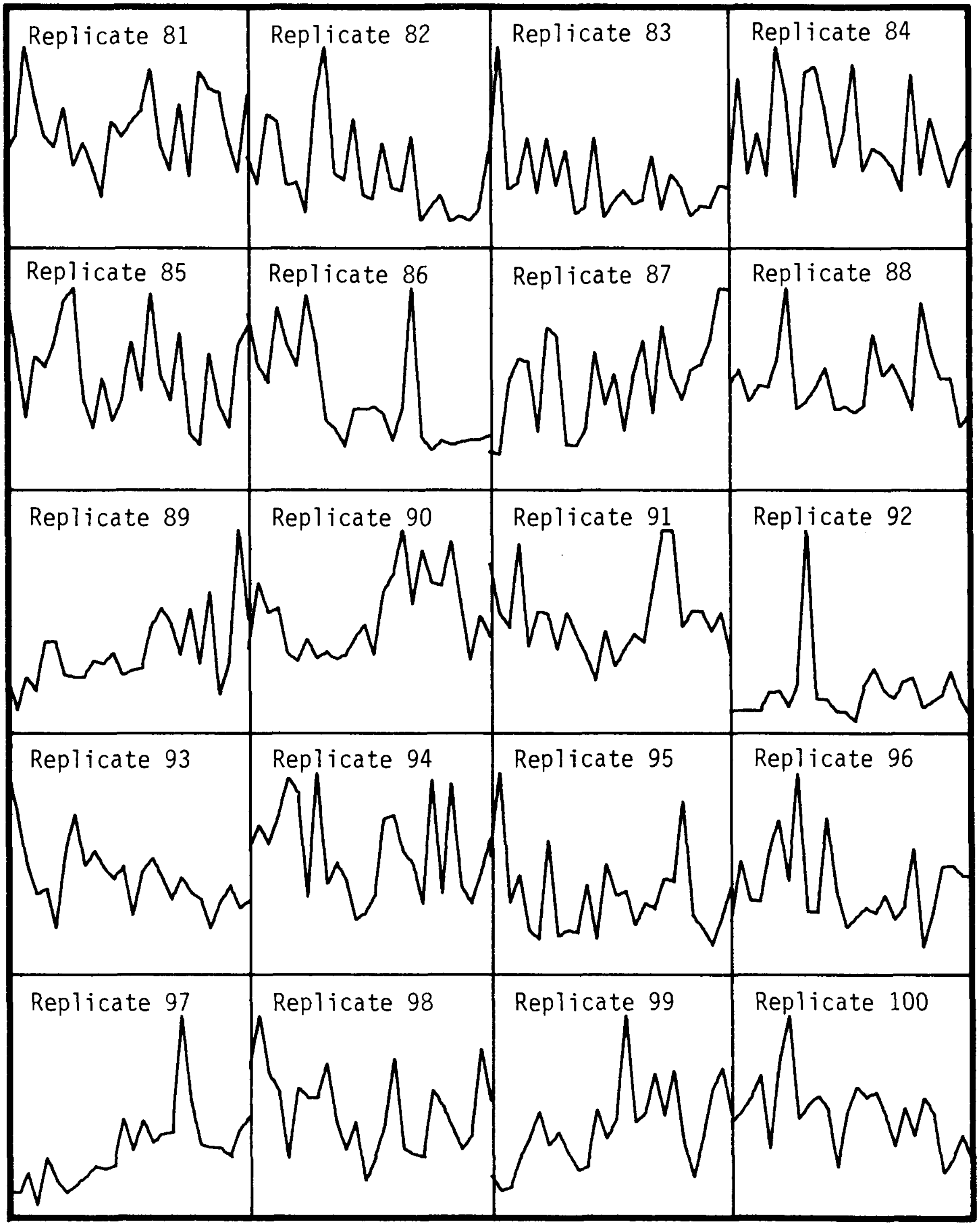

Figure C-5. Graphs of the simulated CPUE time series for Replicates 81-100 from Run 46, Case 5 (alpha of 1.25; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

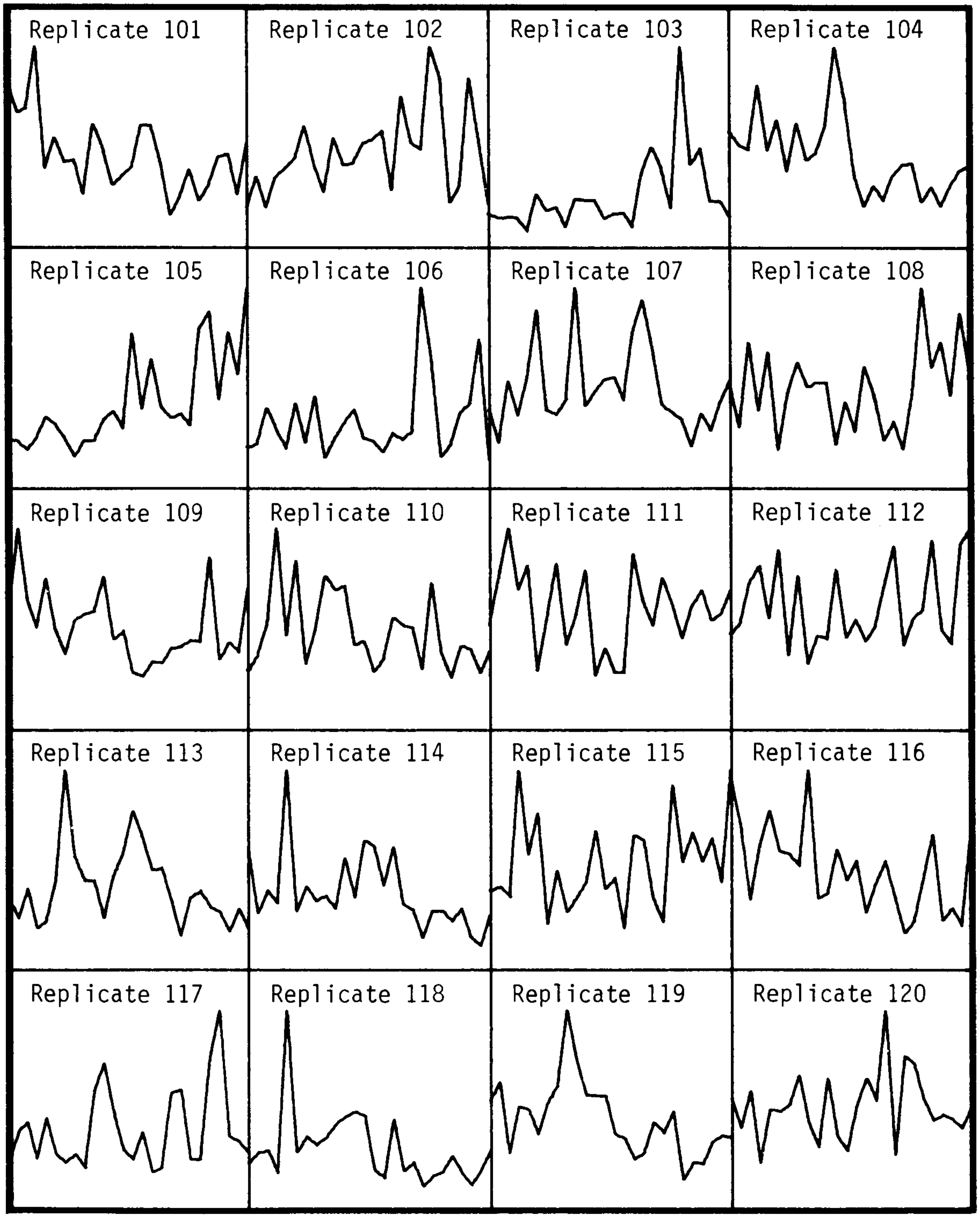

Figure C-6. Graphs of the simulated CPUE time series for Replicates 101-120 from Run 46, Case 5 (alpha of 1.25; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

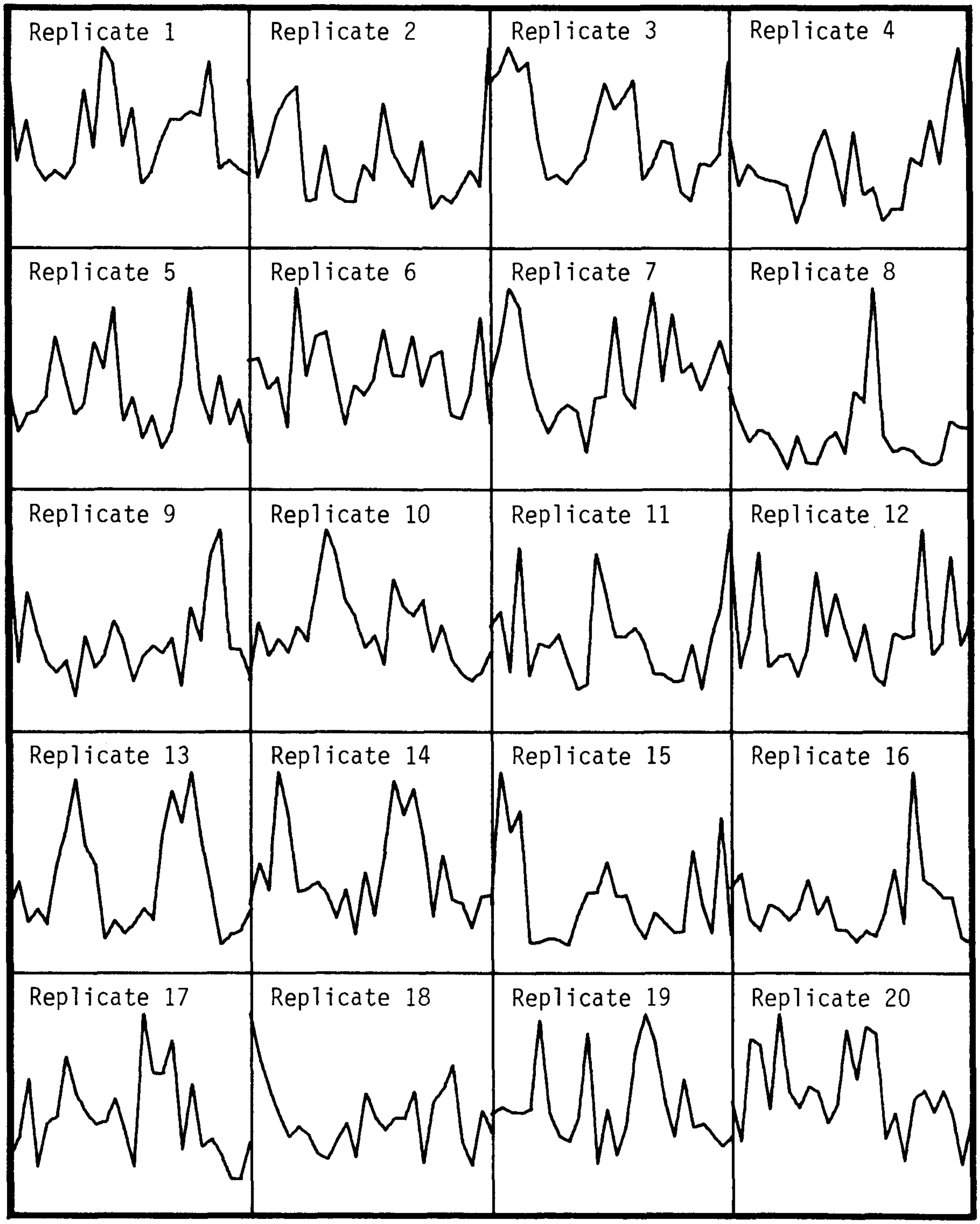

Figure C-7. Graphs of the simulated CPUE time series for Replicates 1-20 from Run 48, Case 5 (alpha of 20; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

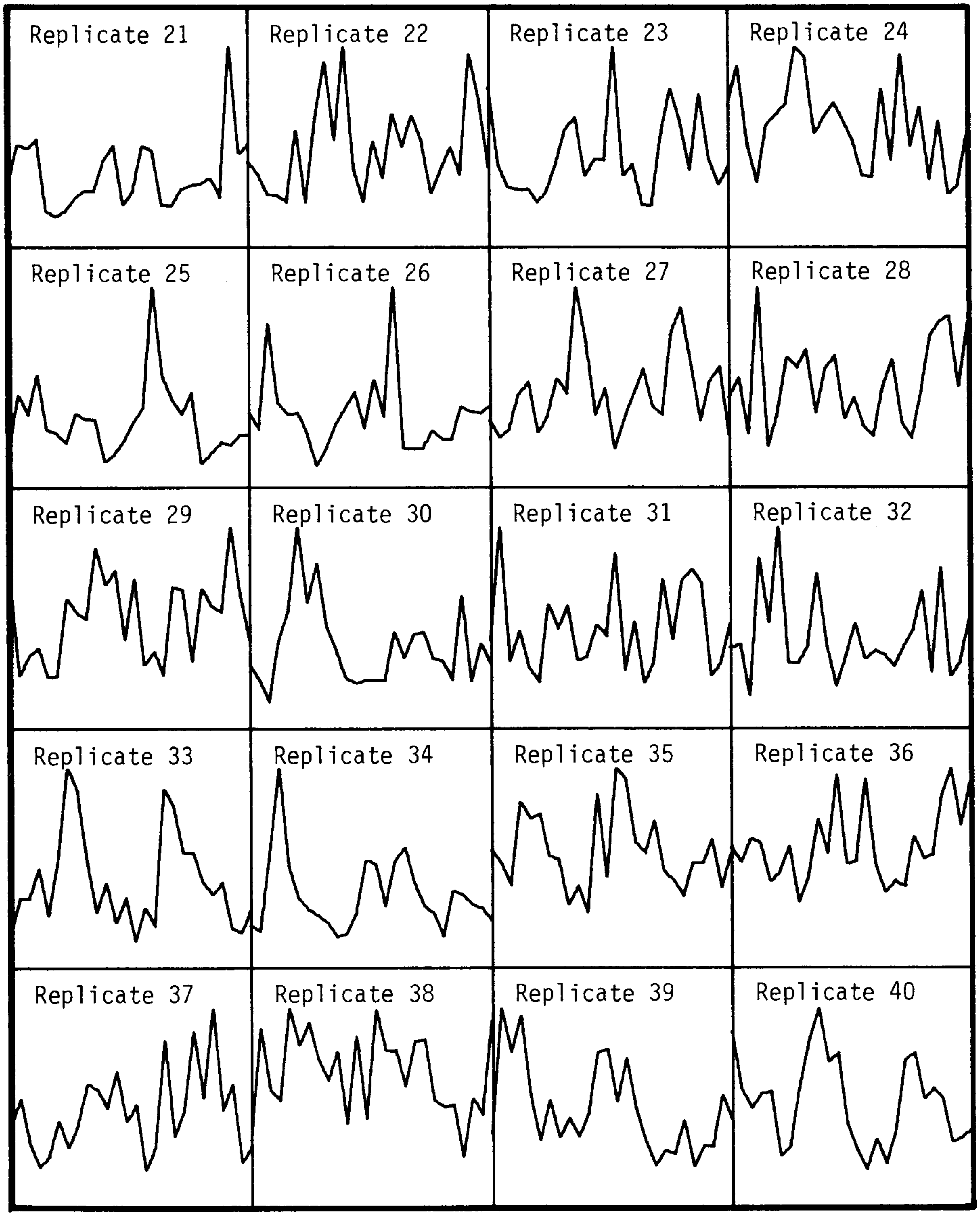

Figure C-8. Graphs of the simulated CPUE time series for Replicates 21-40 from Run 48, Case 5 (alpha of 20; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

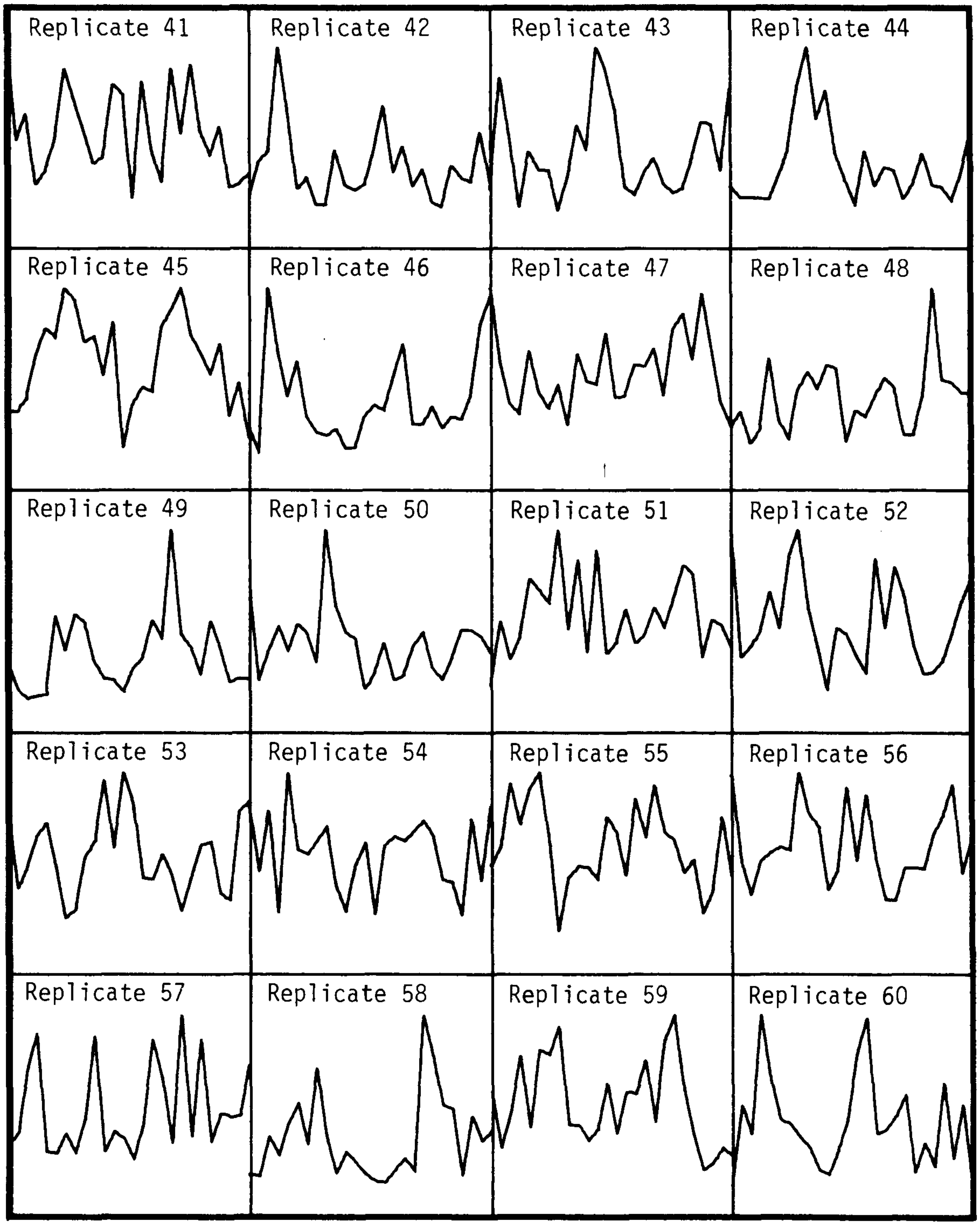

Figure C-9. Graphs of the simulated CPUE time series for Replicates 41-60 from Run 48, Case 5 (alpha of 20; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

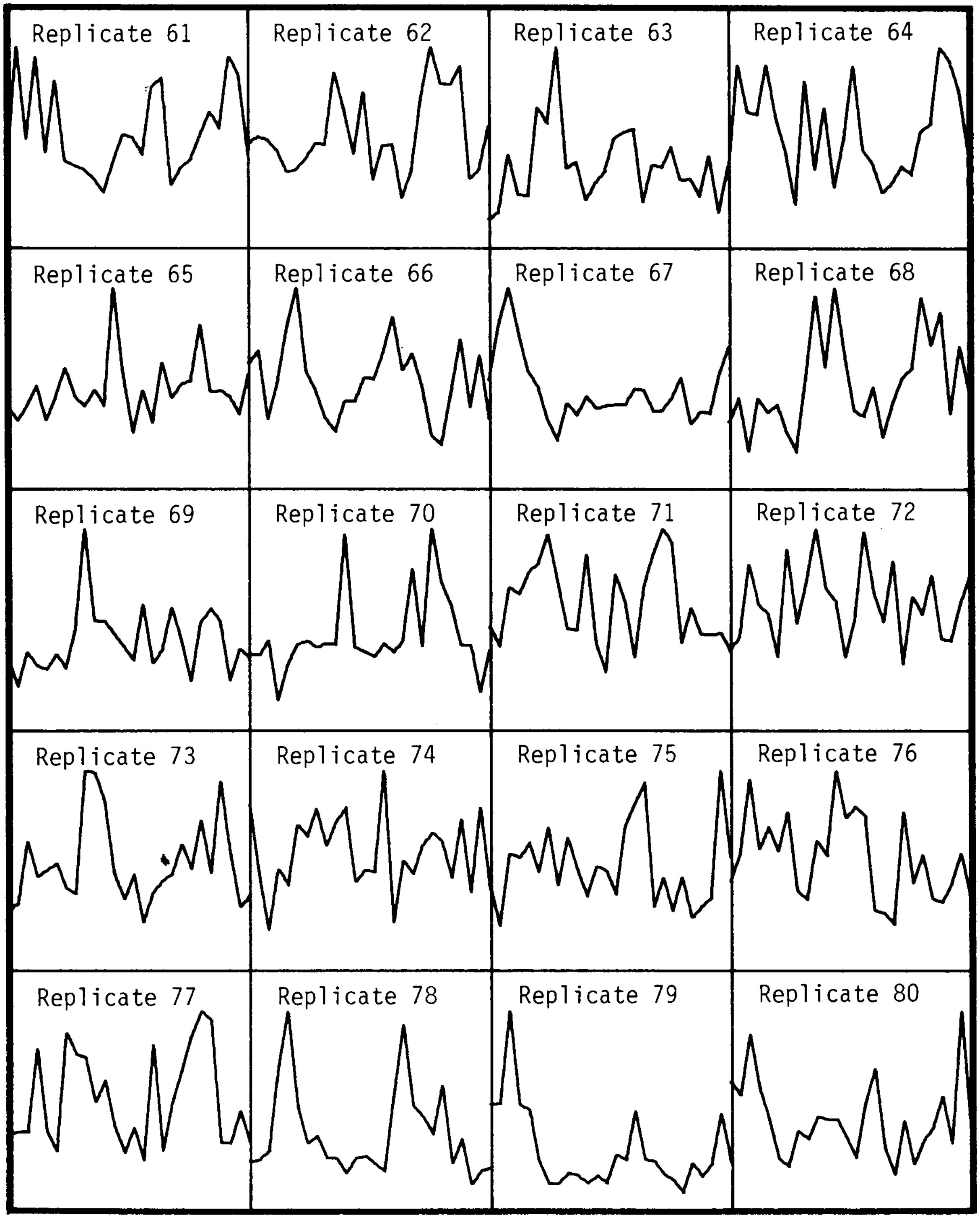

Figure C-10. Graphs of the simulated CPUE time series for Replicates 61-80 from Run 48, Case 5 (alpha of 20; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

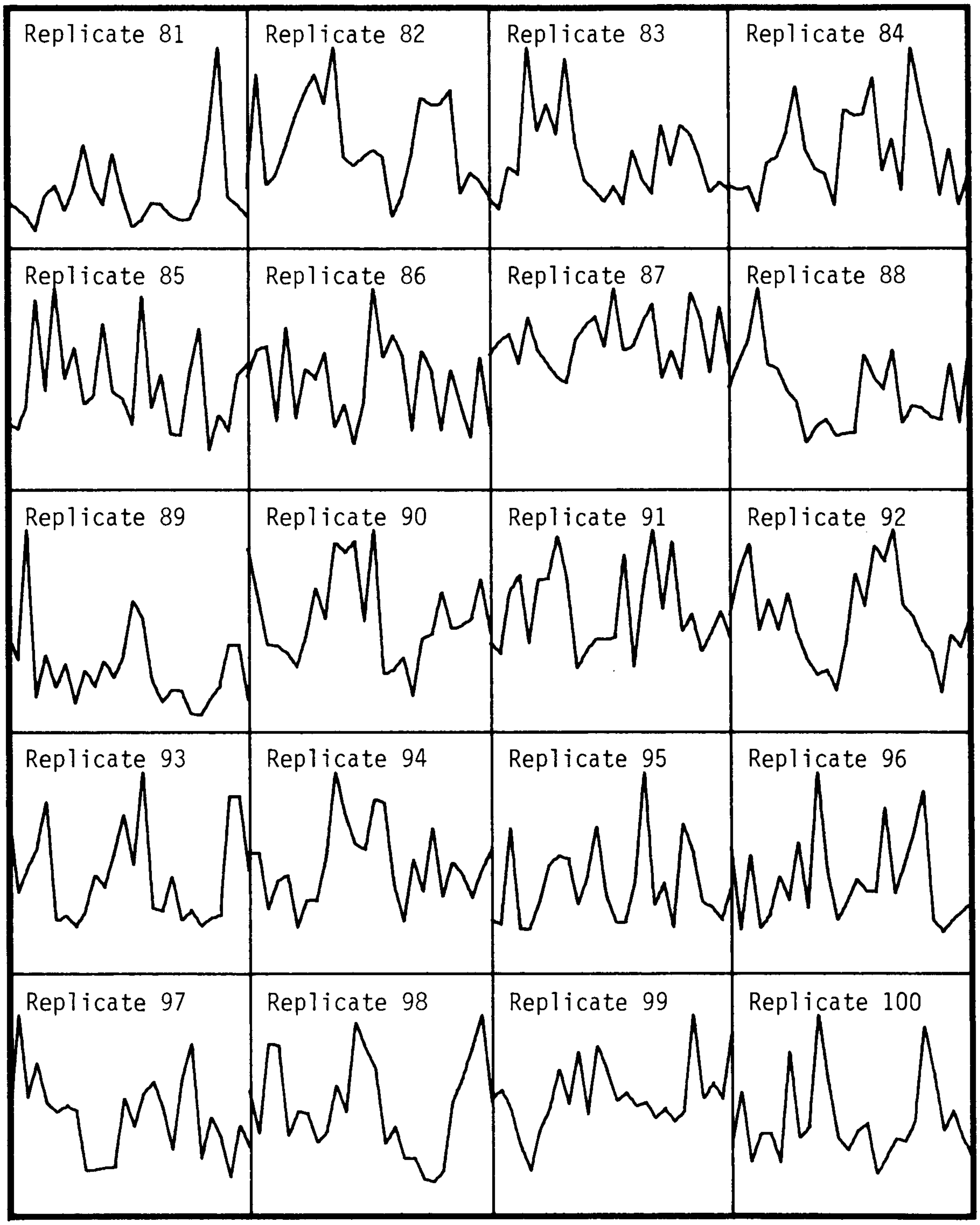

Figure C-11. Graphs of the simulated CPUE time series for Replicates 81-100 from Run 48, Case 5 (alpha of 20; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

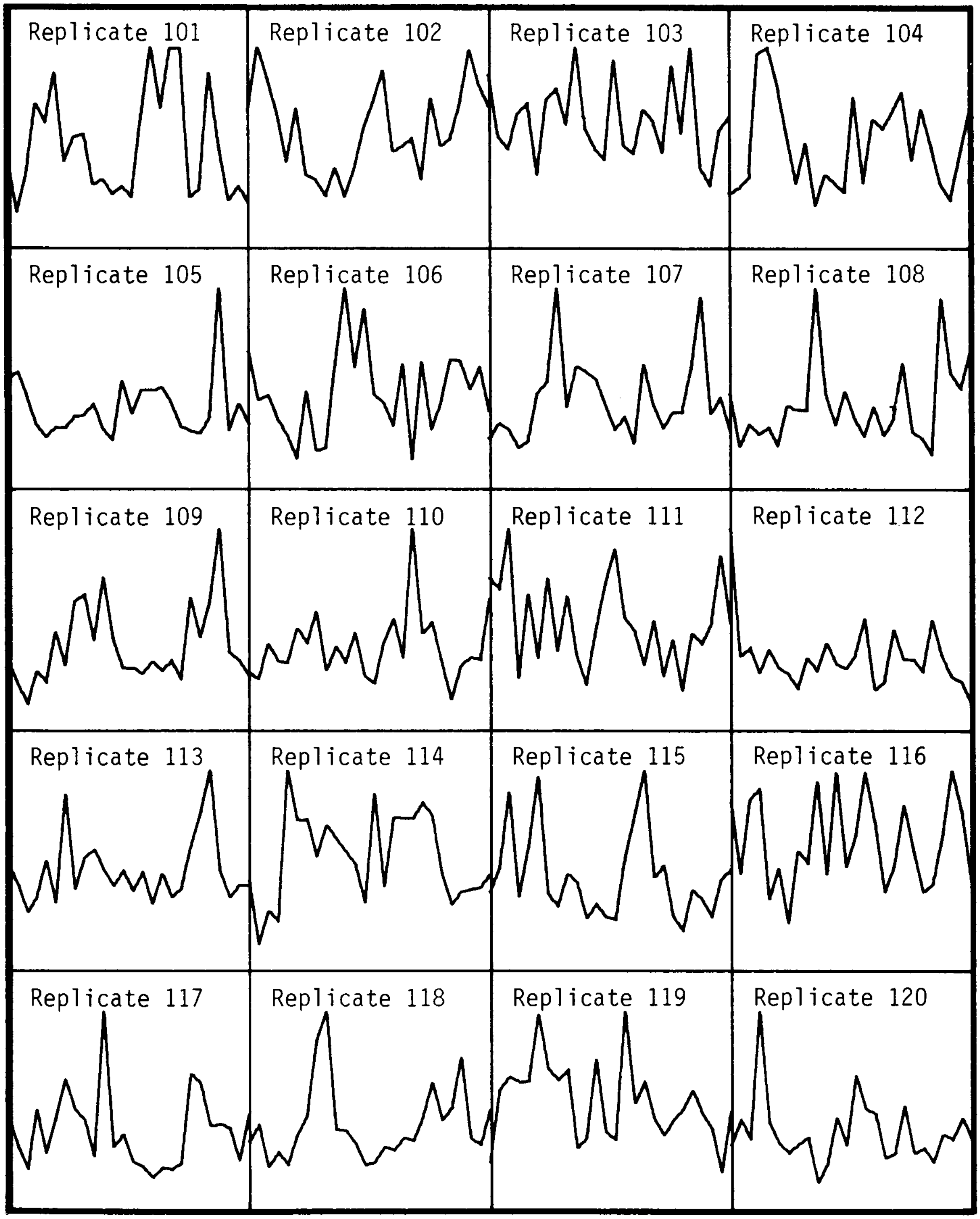

Figure C-12. Graphs of the simulated CPUE time series for Replicates 101-120 from Run 48, Case 5 (alpha of 20; stock-dependent mortality based on number of eggs; random variation in flow, YOY mortality, and CPUE with lognormal random coefficient).

APPENDIX D

RESULTS FROM THE VALIDATION ANALYSIS

This Appendix presents summary results from the application of the validation technique for Cases 1 through 7. The conditions governing these Cases are explained in a general way in Chapter 3, and are summarized in Table D-1, which also serves as an index to the remaining Tables in this Appendix.

Tables D-2 - D-141 are of the same general format as Tables 2-5 in the main text. This format is explained in some detail in Chapter 4. Tables here are grouped in order of Case so that all tables pertaining to Case 1 are grouped together. Within a Case, they are arranged by Run Number, within type of analysis. For example, the first type of analysis presented within Case 1 is alpha estimated without flow in the fit and without exclusions; Tables D-2 through D-8 present the results for this analysis from Runs 26-32. The next type of analysis is that for alpha estimated without flow in the fit and with exclusions; Tables D-9 through D-15 present these results. The remaining analyses for Case 1 are: alpha estimated with flow in the fit and without exclusions; alpha estimated with flow in the fit and with exclusions; and finally an analysis for gamma. This pattern is then repeated for Case 2, and so forth.

Table D-1. Summary of model Cases and Runs[a]

CASE 1:	Adult survival = 0.43, stock-dependent mortality based on eggs, random variation in young-of-the-year (Y-O-Y) survival only, Y-O-Y fluctuations not constrained. True model alphas of 1, 1.25, 2.5, 5, 10, 20, and 30 are used. Runs 26-32; Tables D-2 - D-36.
CASE 2:	As in Case 1, except that adult survival = 0.60, and true model alphas of 1, 1.25, 2.5, 5, 10, and 20 are used. Runs 33-38, Tables D-37 - D-66.
CASE 3:	As in Case 1, except that random variation (other than that attributed to flow) is in CPUE index only, and only alphas of 1.25, 5, and 20 are used. Runs 39-41; Tables D-67 - D-81.
CASE 4:	Adult survival = 0.43, stock-dependent mortality based on number of fish age 1 and older, random variation in both young-of-the-year survival and in CPUE index, median intra-replicate ratio of maximum:minimum yearlings constrained to approximately 10. True model alphas of 1.25, 5, and 20 are used. Runs 43-45; Tables D-82 - D-96.
CASE 5:	As in Case 4, except that stock-dependent mortality is based on eggs. Runs 46-48; Tables D-97 - D-111.
CASE 6:	As in Case 5, except that the distribution of the random coefficient of the CPUE index is normal rather than lognormal. Runs 55-57; Tables D-112 - D-126.
CASE 7:	As in Case 4, except that the distribution of the random coefficient of the CPUE index is normal rather than lognormal. Runs 58-60, Tables D-127 - D-141.

[a]A Case represents a set of choices for the biological characteristics of the modeled population and for the location and nature of the random variation. A Run (within a Case) involves the additional specification of the value for alpha. Each Run contains 120 Replicates, each consisting of 26 contiguous model-generated CPUE indices analogous to the Hudson River striped bass CPUE index.

TABLE D-2. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 26). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.34	1.34	1.17	3.20	0.49	2.21	8.24
B	120	2.17	1.17	1.03	2.43	0.35	2.11	7.91
C	120	2.26	1.26	1.02	2.63	0.33	2.22	6.08
D	120	2.30	1.30	1.11	2.95	0.26	2.17	6.03
E	120	2.37	1.37	1.11	3.13	0.33	2.35	6.43
F	120	2.50	1.50	1.43	4.29	0.22	2.39	11.07
N	120	2.03	1.03	1.68	3.90	0.26	1.75	12.25
P	120	2.35	1.35	1.04	2.92	0.42	2.41	5.48
Q	120	2.56	1.56	1.21	3.92	0.31	2.59	6.56
X	120	1.83	0.83	1.15	2.01	0.25	1.64	5.40
Y	120	5.09	4.09	15.38	253.53	0.17	2.38	160.90
Z	120	2.86	1.86	1.81	6.75	0.44	2.57	8.53

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-3. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 27). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.38	1.13	0.98	2.25	0.72	2.21	5.45
B	120	2.26	1.01	0.94	1.92	0.60	2.24	6.45
C	120	2.41	1.16	1.01	2.37	0.65	2.38	6.65
D	120	2.51	1.26	1.08	2.76	0.65	2.49	6.69
E	120	2.60	1.35	1.11	3.08	0.59	2.54	5.94
F	120	2.76	1.51	1.23	3.81	0.60	2.61	6.69
N	120	2.22	0.97	3.45	12.88	0.33	1.80	38.44
P	120	2.61	1.36	1.27	3.48	0.39	2.48	7.63
Q	120	2.88	1.63	1.42	4.69	0.39	2.72	8.39
X	120	1.86	0.61	0.88	1.15	0.31	1.82	5.42
Y	120	4.85	3.60	9.02	94.49	0.27	2.84	92.04
Z	120	3.05	1.80	1.63	5.90	0.58	2.75	8.37

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-4. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 28). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	1.00	1.01	0.95	2.39	6.51
B	120	2.43	-0.07	0.87	0.76	0.92	2.34	5.91
C	120	2.61	0.11	0.86	0.75	0.89	2.55	5.85
D	120	2.71	0.21	0.92	0.89	0.80	2.64	6.27
E	120	2.79	0.29	0.97	1.03	0.79	2.72	6.08
F	120	3.00	0.50	1.32	1.99	0.63	2.81	9.43
N	120	2.20	-0.30	1.13	1.37	0.43	2.05	7.22
P	120	2.76	0.26	1.13	1.34	0.99	2.60	7.72
Q	120	3.02	0.52	1.18	1.67	0.91	2.87	6.97
X	120	1.76	-0.74	0.75	1.12	0.33	1.67	4.16
Y	120	4.95	2.45	5.31	34.28	0.34	3.67	33.96
Z	120	3.02	0.52	1.52	2.58	0.63	2.75	8.54

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-5. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 29). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.78	-2.22	0.96	5.87	0.85	2.69	5.39
B	120	2.74	-2.26	1.09	6.35	0.64	2.53	7.20
C	120	2.96	-2.04	1.31	5.93	0.89	2.61	11.08
D	120	3.13	-1.87	1.64	6.22	0.98	2.75	14.53
E	120	3.13	-1.87	1.38	5.45	1.41	2.89	13.20
F	120	3.39	-1.61	1.96	6.45	1.09	3.04	19.17
N	120	2.48	-2.52	1.28	8.03	0.23	2.37	12.53
P	120	3.09	-1.91	1.00	4.68	1.18	2.98	6.35
Q	120	3.39	-1.61	1.17	3.97	1.46	3.27	8.93
X	120	1.77	-3.23	0.84	11.21	0.42	1.63	5.04
Y	120	7.94	2.94	27.11	743.78	0.33	4.76	298.40
Z	120	3.22	-1.78	1.80	6.44	0.89	2.83	11.88

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-6. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 30). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.10	-6.90	0.96	48.89	1.49	2.92	6.85
B	120	3.17	-6.83	1.16	48.44	1.34	2.92	7.90
C	120	3.41	-6.59	1.34	45.64	1.72	3.10	8.92
D	120	3.58	-6.42	1.46	43.65	1.76	3.28	9.88
E	120	3.53	-6.47	1.30	43.96	1.45	3.25	8.42
F	120	3.75	-6.25	1.35	41.25	1.50	3.48	8.25
N	120	3.00	-7.00	1.47	51.53	0.87	2.78	10.36
P	120	3.45	-6.55	1.33	45.02	1.26	3.25	7.97
Q	120	3.67	-6.33	1.25	41.93	1.70	3.44	8.36
X	120	1.95	-8.05	0.73	65.93	0.59	1.82	4.37
Y	120	10.45	0.45	27.47	754.55	0.57	6.19	298.70
Z	120	3.56	-6.42	1.50	43.80	1.21	3.07	9.57

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-7. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 31). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.56	-16.44	0.80	273.12	1.57	3.57	7.61
B	120	3.87	-16.13	0.95	263.15	1.46	3.91	6.37
C	120	4.21	-15.79	1.20	252.75	1.47	4.16	8.42
D	120	4.41	-15.59	1.35	246.77	1.56	4.31	8.55
E	120	4.35	-15.65	1.27	248.74	1.46	4.21	9.08
F	120	4.40	-15.60	1.46	247.48	1.26	4.38	9.18
N	120	3.56	-16.44	1.22	274.15	0.94	3.45	7.48
P	120	4.21	-15.79	1.31	253.25	1.41	4.04	9.02
Q	120	4.14	-15.86	1.15	254.82	1.47	4.00	7.99
X	120	1.95	-18.05	0.66	328.94	0.73	1.80	5.53
Y	120	11.01	-8.99	7.25	134.17	0.89	9.11	56.32
Z	120	3.84	-16.16	1.30	265.19	1.42	3.54	10.32

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-8. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 32). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 30.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	4.33	-25.67	0.39	664.52	3.38	4.35	5.53
B	120	5.70	-24.30	0.76	596.14	4.01	5.71	7.62
C	120	6.07	-23.93	0.85	578.11	4.09	6.14	8.20
D	120	6.30	-23.70	0.91	567.26	3.99	6.32	8.72
E	120	6.02	-23.98	0.83	580.36	4.01	5.98	8.23
F	120	5.60	-24.40	0.87	601.03	3.71	5.49	7.82
N	120	5.01	-24.99	0.52	630.10	3.66	5.02	6.30
P	120	5.74	-24.26	0.77	594.28	3.70	5.76	7.52
Q	120	5.10	-24.90	0.69	625.73	3.64	5.08	7.46
X	120	1.92	-28.08	0.39	795.26	1.26	1.88	2.70
Y	120	17.76	-12.24	3.54	163.72	9.06	17.73	33.46
Z	120	4.12	-25.88	0.69	675.97	2.88	4.03	5.77

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-9. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 26). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	117	2.38	1.38	1.16	3.28	0.72	2.22	8.24
B	114	2.24	1.24	1.00	2.55	0.66	2.16	7.91
C	114	2.34	1.34	0.98	2.76	0.63	2.32	6.08
D	115	2.37	1.37	1.08	3.07	0.60	2.20	6.03
E	116	2.43	1.43	1.08	3.23	0.59	2.38	6.43
F	116	2.56	1.56	1.41	4.43	0.54	2.42	11.07
N	100	2.29	1.29	1.72	4.64	0.70	1.91	12.25
P	114	2.41	1.41	1.02	3.05	0.63	2.49	5.48
Q	113	2.63	1.63	1.19	4.10	0.50	2.62	6.56
X	96	2.15	1.15	1.06	2.46	0.57	1.88	5.40
Y	102	5.91	4.91	16.56	298.65	0.57	2.73	160.90
Z	110	3.06	2.06	1.75	7.35	0.74	2.71	8.53

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-10. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 27). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	117	2.42	1.17	0.97	2.31	0.79	2.22	5.45
B	116	2.31	1.06	0.92	1.98	0.70	2.25	6.45
C	117	2.45	1.20	0.99	2.43	0.66	2.39	6.65
D	116	2.57	1.32	1.05	2.85	0.66	2.51	6.69
E	119	2.61	1.36	1.11	3.10	0.59	2.55	5.94
F	117	2.80	1.55	1.22	3.90	0.60	2.64	6.69
N	106	2.41	1.16	3.63	14.56	0.78	1.94	38.44
P	119	2.63	1.38	1.26	3.51	0.68	2.50	7.63
Q	119	2.90	1.65	1.41	4.73	0.69	2.74	8.39
X	102	2.05	0.80	0.80	1.29	0.68	1.88	5.42
Y	112	5.15	3.90	9.27	101.26	0.67	2.94	92.04
Z	117	3.10	1.85	1.61	6.05	0.79	2.80	8.37

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-11. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 28). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	1.00	1.01	0.95	2.39	6.51
B	120	2.43	-0.07	0.87	0.76	0.92	2.34	5.91
C	120	2.61	0.11	0.86	0.75	0.89	2.55	5.85
D	120	2.71	0.21	0.92	0.89	0.80	2.64	6.27
E	120	2.79	0.29	0.97	1.03	0.79	2.72	6.08
F	120	3.00	0.50	1.32	1.99	0.63	2.81	9.43
N	113	2.29	-0.21	1.10	1.26	0.91	2.11	7.22
P	120	2.76	0.26	1.13	1.34	0.99	2.60	7.72
Q	120	3.02	0.52	1.18	1.67	0.91	2.87	6.97
X	111	1.84	-0.66	0.72	0.95	0.65	1.72	4.16
Y	116	5.09	2.59	5.35	35.36	0.76	3.75	33.96
Z	117	3.08	0.58	1.50	2.58	1.06	2.77	8.54

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-12. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 29). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	119	2.80	-2.20	0.95	5.78	1.33	2.70	5.39
B	119	2.76	-2.24	1.08	6.24	1.31	2.53	7.20
C	119	2.97	-2.03	1.30	5.84	1.41	2.61	11.08
D	119	3.15	-1.85	1.64	6.13	1.50	2.76	14.53
E	120	3.13	-1.87	1.38	5.45	1.41	2.89	13.20
F	119	3.41	-1.59	1.96	6.37	1.37	3.05	19.17
N	114	2.57	-2.43	1.25	7.52	0.85	2.46	12.53
P	120	3.09	-1.91	1.00	4.68	1.18	2.98	6.35
Q	120	3.39	-1.61	1.17	3.97	1.46	3.27	8.93
X	109	1.86	-3.14	0.82	10.60	0.84	1.70	5.04
Y	116	8.19	3.19	27.54	768.99	0.92	4.89	298.40
Z	119	3.23	-1.77	1.79	6.35	0.89	2.85	11.88

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-13. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 30). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.10	-6.90	0.96	48.89	1.49	2.92	6.85
B	120	3.17	-6.83	1.16	48.44	1.34	2.92	7.90
C	120	3.41	-6.59	1.34	45.64	1.72	3.10	8.92
D	120	3.58	-6.42	1.46	43.65	1.76	3.28	9.88
E	120	3.53	-6.47	1.30	43.96	1.45	3.25	8.42
F	120	3.75	-6.25	1.35	41.25	1.50	3.48	8.25
N	118	3.04	-6.96	1.46	51.01	1.06	2.78	10.36
P	120	3.45	-6.55	1.33	45.02	1.26	3.25	7.97
Q	120	3.67	-6.33	1.25	41.93	1.70	3.44	8.36
X	116	1.98	-8.02	0.71	65.32	0.75	1.84	4.37
Y	118	10.62	0.62	27.67	765.96	1.31	6.33	298.70
Z	120	3.58	-6.42	1.50	43.80	1.21	3.07	9.57

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-14. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 31). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.56	-16.44	0.80	273.12	1.57	3.57	7.61
B	120	3.87	-16.13	0.95	263.15	1.46	3.91	6.37
C	120	4.21	-15.79	1.20	252.75	1.47	4.16	8.42
D	120	4.41	-15.59	1.35	246.77	1.56	4.31	8.55
E	120	4.35	-15.65	1.27	248.74	1.46	4.21	9.08
F	120	4.40	-15.60	1.46	247.48	1.26	4.38	9.18
N	119	3.58	-16.42	1.20	273.39	1.30	3.45	7.48
P	120	4.21	-15.79	1.31	253.25	1.41	4.04	9.02
Q	120	4.14	-15.86	1.15	254.82	1.47	4.00	7.99
X	119	1.96	-18.04	0.65	328.58	0.97	1.81	5.53
Y	119	11.09	-8.91	7.22	132.21	2.13	9.18	56.32
Z	120	3.84	-16.16	1.30	265.19	1.42	3.54	10.32

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-15. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 32). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 30.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	4.33	-25.67	0.39	664.52	3.38	4.35	5.53
B	120	5.70	-24.30	0.76	596.14	4.01	5.71	7.62
C	120	6.07	-23.93	0.85	578.11	4.09	6.14	8.20
D	120	6.30	-23.70	0.91	567.26	3.99	6.32	8.72
E	120	6.02	-23.98	0.83	580.36	4.01	5.98	8.23
F	120	5.60	-24.40	0.87	601.03	3.71	5.49	7.82
N	120	5.01	-24.99	0.52	630.10	3.66	5.02	6.30
P	120	5.74	-24.26	0.77	594.28	3.70	5.76	7.52
Q	120	5.10	-24.90	0.69	625.73	3.64	5.08	7.46
X	120	1.92	-28.08	0.39	795.26	1.26	1.88	2.70
Y	120	17.76	-12.24	3.54	163.72	9.06	17.73	33.46
Z	120	4.12	-25.88	0.69	675.97	2.88	4.03	5.77

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-16. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 26). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.33	1.33	1.12	3.02	0.50	2.13	6.38
B	120	2.15	1.15	1.00	2.32	0.36	2.11	7.28
C	120	2.23	1.23	0.99	2.51	0.34	2.23	5.90
D	120	2.27	1.27	1.06	2.74	0.27	2.18	5.53
E	120	2.32	1.32	1.03	2.84	0.34	2.29	5.32
F	120	2.44	1.44	1.31	3.80	0.23	2.36	9.35
P	120	2.31	1.31	1.00	2.73	0.42	2.35	5.27
Q	120	2.51	1.51	1.16	3.67	0.32	2.58	6.43
X	120	1.83	0.83	1.13	1.97	0.25	1.65	5.16
Y	120	5.39	4.39	19.87	414.41	0.16	2.37	213.10
Z	120	2.85	1.85	1.79	6.66	0.43	2.59	8.55

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-17. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 27). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.39	1.14	0.99	2.28	0.71	2.20	5.50
B	120	2.28	1.03	0.97	2.01	0.56	2.24	6.81
C	120	2.44	1.19	1.04	2.51	0.49	2.43	6.49
D	120	2.55	1.30	1.13	2.96	0.48	2.46	6.30
E	120	2.63	1.38	1.18	3.31	0.51	2.59	6.22
F	120	2.79	1.54	1.29	4.05	0.51	2.69	6.57
P	120	2.62	1.37	1.30	3.59	0.39	2.60	7.69
Q	120	2.88	1.63	1.44	4.74	0.39	2.70	8.41
X	120	1.87	0.62	0.91	1.21	0.30	1.73	5.27
Y	120	4.93	3.68	9.74	108.53	0.26	2.96	101.00
Z	120	3.07	1.82	1.67	6.16	0.55	2.74	8.52

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-18. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 28). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	1.03	1.07	0.96	2.38	7.03
B	120	2.44	-0.06	0.89	0.80	0.97	2.33	5.93
C	120	2.61	0.11	0.86	0.76	0.91	2.54	5.86
D	120	2.72	0.22	0.91	0.88	0.82	2.65	6.28
E	120	2.78	0.28	0.95	0.99	0.82	2.71	5.77
F	120	2.99	0.49	1.29	1.91	0.64	2.83	9.48
P	120	2.77	0.27	1.16	1.42	1.00	2.60	8.17
Q	120	3.02	0.52	1.19	1.69	0.92	2.88	6.94
X	120	1.77	-0.73	0.79	1.17	0.32	1.68	4.66
Y	120	4.98	2.48	5.63	37.90	0.35	3.66	41.02
Z	120	3.06	0.56	1.67	3.10	0.62	2.78	9.19

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-19. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 29). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MCDEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEI GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.77	-2.23	1.00	6.02	0.87	2.69	5.88
B	120	2.71	-2.29	1.08	6.44	0.62	2.46	6.83
C	120	2.92	-2.08	1.29	6.04	0.84	2.65	11.30
D	120	3.11	-1.89	1.61	6.20	0.92	2.73	14.79
E	120	3.11	-1.89	1.40	5.59	1.22	2.83	13.61
F	120	3.40	-1.60	2.00	6.58	0.91	3.08	19.64
P	120	3.06	-1.94	1.02	4.82	1.17	2.94	6.62
Q	120	3.39	-1.61	1.20	4.07	1.24	3.29	9.31
X	120	1.73	-3.27	0.78	11.37	0.44	1.61	5.09
Y	120	8.78	3.78	37.32	1407.11	0.33	4.66	411.80
Z	120	3.16	-1.84	1.72	6.39	0.90	2.84	12.07

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-20. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 30). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.09	-6.91	0.99	49.12	1.44	2.85	6.87
B	120	3.16	-6.84	1.16	48.57	1.29	2.91	7.85
C	120	3.40	-6.60	1.36	45.75	1.64	3.06	8.91
D	120	3.58	-6.42	1.50	43.75	1.31	3.26	9.88
E	120	3.51	-6.49	1.32	44.18	1.52	3.20	8.20
F	120	3.73	-6.27	1.39	41.55	1.34	3.46	8.06
P	120	3.42	-6.58	1.34	45.51	1.35	3.19	8.20
Q	120	3.64	-6.36	1.27	42.35	1.67	3.40	8.13
X	120	1.95	-8.05	0.83	66.04	0.63	1.85	5.70
Y	120	10.22	0.22	26.40	697.02	0.58	6.13	288.90
Z	120	3.60	-6.40	1.67	44.05	1.25	3.08	10.57

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-21. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 31). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.54	-16.46	0.79	273.78	1.57	3.53	6.38
B	120	3.87	-16.13	0.98	263.21	1.44	3.91	6.32
C	120	4.23	-15.77	1.21	252.25	1.47	4.13	8.38
D	120	4.45	-15.55	1.36	245.68	1.56	4.32	8.50
E	120	4.37	-15.63	1.29	248.01	1.45	4.24	9.00
F	120	4.43	-15.57	1.48	246.64	1.25	4.40	9.25
P	120	4.24	-15.76	1.36	252.41	1.39	4.08	9.78
Q	120	4.17	-15.83	1.16	253.98	1.44	4.10	7.99
X	120	1.96	-18.04	0.68	328.82	0.60	1.78	5.40
Y	120	11.15	-8.85	8.45	150.29	1.63	9.40	77.67
Z	120	3.85	-16.15	1.36	264.78	1.37	3.62	10.08

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-22. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 32). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 30.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	4.35	-25.65	0.44	663.58	3.28	4.33	5.60
B	120	5.72	-24.28	0.79	595.25	4.05	5.73	7.84
C	120	6.08	-23.92	0.89	577.73	4.12	6.12	8.23
D	120	6.29	-23.71	0.95	567.66	4.00	6.33	8.69
E	120	6.01	-23.99	0.86	581.03	4.01	5.95	8.13
F	120	5.59	-24.41	0.93	601.94	3.59	5.62	8.33
P	120	5.74	-24.26	0.83	594.27	3.82	5.70	7.92
Q	120	5.09	-24.91	0.74	626.45	3.57	5.09	7.51
X	120	1.95	-28.05	0.49	793.78	0.86	1.88	3.36
Y	120	17.89	-12.11	3.69	161.38	8.54	17.84	34.72
Z	120	4.15	-25.85	0.80	674.54	2.22	4.04	6.19

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-23. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 26). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	116	2.37	1.37	1.10	3.12	0.71	2.15	6.38
B	114	2.22	1.22	0.97	2.43	0.66	2.16	7.28
C	114	2.31	1.31	0.95	2.64	0.62	2.28	5.90
D	115	2.33	1.33	1.03	2.85	0.60	2.21	5.53
E	114	2.41	1.41	0.99	2.98	0.58	2.33	5.32
F	114	2.52	1.52	1.29	3.99	0.53	2.37	9.35
P	113	2.39	1.39	0.96	2.87	0.62	2.49	5.27
Q	111	2.62	1.62	1.12	3.90	0.50	2.62	6.43
X	95	2.15	1.15	1.04	2.42	0.59	1.82	5.16
Y	101	6.31	5.31	21.55	493.09	0.59	2.83	213.10
Z	109	3.07	2.07	1.73	7.32	0.76	2.75	8.55

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-24. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 27). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	116	2.43	1.18	0.97	2.35	0.78	2.23	5.50
B	116	2.32	1.07	0.95	2.07	0.64	2.26	6.81
C	116	2.49	1.24	1.02	2.59	0.62	2.45	6.49
D	116	2.61	1.36	1.09	3.06	0.62	2.48	6.30
E	118	2.66	1.41	1.16	3.36	0.55	2.63	6.22
F	116	2.85	1.60	1.27	4.18	0.55	2.73	6.57
P	118	2.66	1.41	1.28	3.64	0.69	2.64	7.69
Q	118	2.92	1.67	1.42	4.81	0.69	2.72	8.41
X	104	2.04	0.79	0.84	1.34	0.63	1.90	5.27
Y	111	5.27	4.02	10.05	117.37	0.66	3.14	101.00
Z	117	3.12	1.87	1.66	6.31	0.78	2.82	8.52

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-25. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 28). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	1.03	1.07	0.96	2.38	7.03
B	120	2.44	-0.06	0.89	0.80	0.97	2.33	5.93
C	120	2.61	0.11	0.86	0.76	0.91	2.54	5.86
D	120	2.72	0.22	0.91	0.88	0.82	2.65	6.28
E	120	2.78	0.28	0.95	0.99	0.82	2.71	5.77
F	120	2.99	0.49	1.29	1.91	0.64	2.83	9.48
P	120	2.77	0.27	1.16	1.42	1.00	2.60	8.17
Q	120	3.02	0.52	1.19	1.69	0.92	2.88	6.94
X	111	1.86	-0.64	0.76	0.99	0.67	1.72	4.66
Y	114	5.20	2.70	5.69	39.75	0.75	3.79	41.02
Z	117	3.12	0.62	1.65	3.11	0.96	2.82	9.19

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-26. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 29). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	118	2.80	-2.20	0.98	5.84	1.29	2.70	5.88
B	118	2.74	-2.26	1.06	6.26	1.22	2.49	6.83
C	119	2.94	-2.06	1.28	5.94	1.31	2.65	11.30
D	119	3.13	-1.87	1.60	6.11	1.43	2.75	14.79
E	119	3.12	-1.88	1.40	5.51	1.48	2.88	13.61
F	118	3.43	-1.57	1.99	6.44	1.43	3.09	19.64
P	120	3.06	-1.94	1.02	4.82	1.17	2.94	6.62
Q	119	3.40	-1.60	1.19	3.99	1.48	3.31	9.31
X	109	1.83	-3.17	0.75	10.71	0.80	1.67	5.09
Y	115	9.13	4.13	38.09	1468.02	0.89	4.73	411.80
Z	119	3.18	-1.82	1.72	6.30	0.90	2.86	12.07

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-27. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 30). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.09	-6.91	0.99	49.12	1.44	2.85	6.87
B	120	3.16	-6.84	1.16	48.57	1.29	2.91	7.85
C	120	3.40	-6.60	1.36	45.75	1.64	3.06	8.91
D	120	3.58	-6.42	1.50	43.75	1.31	3.26	9.88
E	120	3.51	-6.49	1.32	44.18	1.52	3.20	8.20
F	120	3.73	-6.27	1.39	41.55	1.34	3.46	8.06
P	120	3.42	-6.58	1.34	45.51	1.35	3.19	8.20
Q	120	3.64	-6.36	1.27	42.35	1.67	3.40	8.13
X	116	1.99	-8.01	0.81	65.44	0.76	1.89	5.70
Y	118	10.39	0.39	26.59	707.43	1.21	6.17	288.90
Z	120	3.60	-6.40	1.67	44.05	1.25	3.08	10.57

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-28. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 31). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.54	-16.46	0.79	273.78	1.57	3.53	6.38
B	120	3.87	-16.13	0.98	263.21	1.44	3.91	6.32
C	120	4.23	-15.77	1.21	252.25	1.47	4.13	8.38
D	120	4.45	-15.55	1.36	245.68	1.56	4.32	8.50
E	120	4.37	-15.63	1.29	248.01	1.45	4.24	9.00
F	120	4.43	-15.57	1.48	246.64	1.25	4.40	9.25
P	120	4.24	-15.76	1.36	252.41	1.39	4.08	9.78
Q	120	4.17	-15.83	1.16	253.98	1.44	4.10	7.99
X	118	1.98	-18.02	0.66	328.04	0.96	1.80	5.40
Y	120	11.15	-8.85	8.45	150.29	1.63	9.40	77.67
Z	120	3.85	-16.15	1.36	264.78	1.37	3.62	10.08

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-29. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 1 (RUN NUMBER 32). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 30.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	4.35	-25.65	0.44	663.58	3.28	4.33	5.60
B	120	5.72	-24.28	0.79	595.25	4.05	5.73	7.84
C	120	6.08	-23.92	0.89	577.73	4.12	6.12	8.23
D	120	6.29	-23.71	0.95	567.66	4.00	6.33	8.69
E	120	6.01	-23.99	0.86	581.03	4.01	5.95	8.13
F	120	5.59	-24.41	0.93	601.94	3.59	5.62	8.33
P	120	5.74	-24.26	0.83	594.27	3.82	5.70	7.92
Q	120	5.09	-24.91	0.74	626.45	3.57	5.09	7.51
X	120	1.95	-28.05	0.49	793.78	0.86	1.88	3.36
Y	120	17.89	-12.11	3.69	161.38	8.54	17.84	34.72
Z	120	4.15	-25.85	0.80	674.54	2.22	4.04	6.19

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-30. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 1 (RUN NUMBER 26). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.05	-3.65	2.72	20.83	-9.60	0.09	8.80
B	120	0.51	-3.09	2.93	18.17	-7.60	0.39	12.00
C	120	0.58	-3.02	2.90	17.62	-7.10	0.34	12.00
D	120	0.59	-3.01	3.02	18.29	-7.20	0.41	11.00
E	120	0.46	-3.14	2.61	16.78	-5.20	0.25	12.00
F	120	0.12	-3.48	2.71	19.56	-5.30	0.18	11.00
P	120	0.41	-3.19	2.48	16.46	-6.40	0.43	10.00
Q	120	0.24	-3.36	2.16	16.01	-3.90	-0.06	10.00
X	120	0.34	-3.26	3.43	22.49	-13.00	0.37	13.00
Y	120	0.45	-3.15	2.74	17.48	-6.70	0.46	12.00
Z	120	0.36	-3.24	2.95	19.27	-8.00	0.46	12.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-31. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 1 (RUN NUMBER 27). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.25

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.15	-3.75	2.97	22.98	-9.90	-0.07	11.00
B	120	0.34	-3.26	3.19	20.88	-9.90	0.25	12.00
C	120	0.49	-3.11	3.24	20.30	-11.00	0.58	10.00
D	120	0.65	-2.95	3.46	20.74	-11.00	0.47	9.60
E	120	0.53	-3.07	3.12	19.25	-12.00	0.30	8.40
F	120	0.62	-2.98	3.45	20.86	-10.00	0.55	9.90
P	120	0.51	-3.09	3.31	20.59	-13.00	0.58	9.80
Q	120	0.58	-3.02	3.03	18.41	-11.00	0.41	12.00
X	120	0.32	-3.28	3.52	23.24	-12.00	0.33	9.30
Y	120	0.26	-3.34	3.13	21.06	-10.00	0.04	9.30
Z	120	0.36	-3.24	3.17	20.67	-10.00	0.27	7.70

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-32 SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 1 (RUN NUMBER 28). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 2.50

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.21	-3.39	2.94	20.24	-12.00	0.19	7.30
B	120	0.24	-3.36	2.86	19.54	-8.20	0.07	10.00
C	120	0.34	-3.26	2.64	17.71	-5.90	0.38	9.80
D	120	0.43	-3.17	2.81	18.02	-5.70	0.21	10.00
E	120	0.19	-3.41	2.26	16.82	-4.80	0.01	8.40
F	120	0.03	-3.57	2.71	20.21	-8.00	0.07	6.60
P	120	0.22	-3.38	2.45	17.54	-6.80	0.27	12.00
Q	120	0.04	-3.56	2.07	17.02	-4.30	0.08	10.00
X	120	0.38	-3.22	3.86	25.38	-10.00	0.43	9.90
Y	120	0.46	-3.14	3.21	20.27	-8.10	0.46	8.90
Z	120	0.33	-3.27	3.27	21.49	-8.90	0.58	8.20

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-33. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 1 (RUN NUMBER 29). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 5.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.32	-3.28	3.56	23.51	-12.00	0.11	12.00
B	120	0.73	-2.87	3.65	21.59	-12.00	0.57	12.00
C	120	0.62	-2.98	3.20	19.20	-9.80	0.67	10.00
D	120	0.58	-3.02	3.13	19.01	-8.70	0.70	9.20
E	120	0.27	-3.33	3.37	22.56	-11.00	0.20	8.10
F	120	-0.06	-3.66	3.62	26.61	-12.00	-0.09	9.00
P	120	0.62	-2.98	3.73	22.86	-8.80	0.41	12.00
Q	120	0.35	-3.25	3.47	22.69	-11.00	0.31	10.00
X	120	0.34	-3.26	5.02	35.91	-15.00	0.37	21.00
Y	120	0.42	-3.18	3.67	23.66	-10.00	0.13	12.00
Z	120	0.35	-3.25	3.90	25.89	-9.90	0.32	16.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-34. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 1 (RUN NUMBER 30). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 10.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.10	-3.50	3.26	22.99	-7.70	0.07	8.70
B	120	0.50	-3.10	3.70	23.35	-9.10	0.49	18.00
C	120	0.58	-3.02	3.52	21.63	-8.00	0.44	21.00
D	120	0.68	-2.92	3.57	21.36	-7.30	0.58	23.00
E	120	0.44	-3.16	3.22	20.40	-8.60	0.58	20.00
F	120	0.21	-3.39	3.30	22.42	-6.80	0.32	19.00
P	120	0.57	-3.03	3.42	20.96	-9.10	0.43	19.00
Q	120	0.27	-3.33	2.82	19.13	-6.80	0.22	17.00
X	120	0.81	-2.79	6.78	53.84	-15.00	0.34	45.00
Y	120	0.79	-2.81	4.08	24.58	-7.80	0.70	28.00
Z	120	0.85	-2.75	5.29	35.61	-9.50	0.51	38.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-35. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 1 (RUN NUMBER 31). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 20.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.01	-3.61	3.10	22.69	-7.30	-0.11	8.80
B	120	0.90	-2.70	3.18	17.47	-7.60	0.69	10.00
C	120	0.94	-2.66	2.73	14.59	-5.90	0.72	8.90
D	120	0.97	-2.63	2.63	13.93	-4.50	0.70	8.40
E	120	0.80	-2.80	2.57	14.55	-5.60	0.52	9.30
F	120	0.50	-3.10	2.57	16.34	-4.50	0.16	9.20
P	120	0.73	-2.87	2.70	15.61	-5.60	0.66	8.80
Q	120	0.42	-3.18	2.09	14.57	-4.20	0.33	5.40
X	120	1.17	-2.43	4.40	25.31	-13.00	1.20	13.00
Y	120	0.70	-2.90	2.51	14.82	-6.20	0.49	9.70
Z	120	0.97	-2.63	3.34	18.15	-11.00	0.91	9.50

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-36. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 1 (RUN NUMBER 32). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 30.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.40	-3.20	2.82	18.27	-7.40	0.40	6.60
B	120	0.61	-2.99	2.41	14.81	-6.20	0.61	5.80
C	120	0.59	-3.01	2.03	13.23	-4.90	0.69	5.20
D	120	0.61	-2.99	1.98	12.94	-5.50	0.85	4.90
E	120	0.47	-3.13	1.66	12.64	-4.40	0.58	4.30
F	120	0.18	-3.42	2.33	17.23	-8.20	0.02	6.60
P	120	0.47	-3.13	1.76	12.98	-4.00	0.48	4.70
Q	120	0.25	-3.35	1.88	14.87	-5.80	0.17	5.30
X	120	0.79	-2.81	4.92	32.22	-15.00	0.61	14.00
Y	120	0.49	-3.11	1.07	10.91	-2.00	0.54	3.10
Z	120	0.66	-2.94	3.43	20.48	-11.00	0.55	8.90

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-37. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 33). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.52	1.52	1.08	3.49	0.78	2.33	7.05
B	120	2.26	1.26	0.98	2.56	0.54	2.15	6.57
C	120	2.37	1.37	0.94	2.77	0.49	2.34	5.88
D	120	2.37	1.37	0.97	2.84	0.43	2.41	6.19
E	120	2.53	1.53	1.05	3.46	0.47	2.52	6.58
F	120	2.60	1.60	1.25	4.12	0.37	2.44	8.23
N	120	1.97	0.97	1.08	2.10	0.17	1.75	7.28
P	120	2.55	1.55	1.03	3.49	0.77	2.47	6.16
Q	120	2.71	1.71	1.10	4.16	0.63	2.74	6.65
X	120	1.88	0.88	1.63	3.43	0.10	1.53	10.66
Y	120	6.27	5.27	16.86	312.35	0.01	2.54	109.10
Z	120	3.76	2.76	3.31	18.63	0.22	2.74	24.79

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-38. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 34). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.66	1.41	1.04	3.09	0.61	2.58	6.11
B	120	2.47	1.22	1.04	2.59	0.49	2.44	6.83
C	120	2.55	1.30	1.02	2.75	0.40	2.50	6.75
D	120	2.60	1.35	1.12	3.08	0.38	2.48	7.49
E	120	2.63	1.38	0.99	2.91	0.35	2.60	6.65
F	120	2.70	1.45	1.16	3.46	0.30	2.64	6.19
N	120	2.29	1.04	1.23	2.61	0.36	2.16	10.21
P	120	2.64	1.39	1.04	3.02	0.33	2.63	6.82
Q	120	2.84	1.59	1.21	4.03	0.27	2.79	8.79
X	120	2.34	1.09	1.66	3.95	0.13	2.10	8.37
Y	120	7.85	6.60	25.94	716.67	0.20	3.06	207.30
Z	120	4.49	3.24	3.74	24.63	0.35	3.32	23.09

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-39. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 35). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	0.95	0.91	1.08	2.36	6.20
B	120	2.53	0.03	1.13	1.29	0.95	2.34	8.92
C	120	2.77	0.27	1.53	2.40	0.99	2.47	13.80
D	120	2.89	0.39	1.77	3.29	0.96	2.46	16.03
E	120	2.98	0.48	1.74	3.26	1.03	2.60	15.54
F	120	3.29	0.79	2.90	9.07	1.02	2.89	28.68
N	120	2.47	-0.03	2.70	7.30	0.43	1.97	27.73
P	120	3.00	0.50	1.46	2.39	0.84	2.81	9.84
Q	120	3.36	0.86	2.05	4.96	0.94	2.99	13.70
X	120	1.96	-0.54	1.86	3.76	0.15	1.70	18.32
Y	120	25.28	22.78	177.58	32057.84	0.33	3.45	1893.00
Z	120	3.69	1.19	2.40	7.22	0.41	3.14	12.34

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-40. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 36). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.69	-2.31	0.85	6.10	1.42	2.45	6.68
B	120	2.66	-2.34	0.84	6.23	1.16	2.52	7.13
C	120	2.89	-2.11	0.89	5.28	1.31	2.77	6.78
D	120	3.09	-1.91	1.02	4.73	1.29	2.98	6.74
E	120	3.12	-1.88	0.96	4.49	1.40	3.09	5.85
F	120	3.50	-1.50	1.28	3.91	1.09	3.27	7.77
N	120	2.49	-2.51	1.14	7.64	0.54	2.28	8.19
P	120	3.03	-1.97	1.03	4.97	1.41	2.88	6.78
Q	120	3.46	-1.54	1.23	3.89	1.61	3.25	7.80
X	120	2.08	-2.92	2.33	14.02	0.27	1.65	24.46
Y	120	6.74	1.74	6.90	50.67	0.25	5.03	49.67
Z	120	4.32	-0.68	4.50	20.70	0.76	3.51	45.15

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-41. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 37).
FLOW IS NOT INCLUDED IN THE FITTED MODEL.
ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-7.18	0.86	52.75	1.65	2.63	7.39
B	120	3.24	-6.76	1.23	47.58	1.71	2.93	10.12
C	120	3.69	-6.31	1.51	42.39	1.54	3.31	11.48
D	120	4.10	-5.90	1.74	38.14	1.62	3.61	12.76
E	120	4.09	-5.91	1.69	38.05	1.73	3.76	12.42
F	120	4.83	-5.17	2.04	31.11	1.86	4.38	14.01
N	120	2.72	-7.28	1.30	55.20	1.02	2.48	9.70
P	120	3.76	-6.24	1.50	41.48	1.53	3.45	11.83
Q	120	4.42	-5.58	1.74	34.40	2.15	4.05	13.59
X	120	1.80	-8.20	0.91	68.72	0.46	1.60	5.57
Y	120	11.65	1.65	18.13	331.35	0.68	7.22	163.00
Z	120	3.45	-6.55	1.31	44.92	1.18	3.25	9.23

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-42. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 38). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.03	-16.97	0.64	290.81	1.72	3.00	4.79
B	120	3.90	-16.10	0.98	262.30	1.66	3.93	6.31
C	120	4.54	-15.46	1.16	242.22	1.89	4.53	7.52
D	120	5.22	-14.78	1.39	222.36	2.18	5.29	8.57
E	120	5.18	-14.82	1.32	223.33	2.33	5.12	8.56
F	120	6.43	-13.57	1.71	188.52	2.40	6.49	11.13
N	120	2.97	-17.03	0.74	292.89	0.96	2.88	5.60
P	120	4.88	-15.12	1.37	232.40	2.18	4.76	10.81
Q	120	5.86	-14.14	1.77	204.79	2.48	5.70	16.29
X	120	1.55	-18.45	0.80	343.90	0.77	1.38	8.76
Y	120	12.37	-7.63	5.72	91.50	1.65	11.56	37.86
Z	120	3.48	-16.52	1.08	276.33	1.73	3.30	9.85

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-43. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 33). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.52	1.52	1.08	3.49	0.78	2.33	7.05
B	119	2.28	1.28	0.97	2.58	0.75	2.16	6.57
C	119	2.39	1.39	0.92	2.79	0.75	2.34	5.88
D	118	2.40	1.40	0.95	2.88	0.75	2.42	6.19
E	119	2.55	1.55	1.03	3.49	0.76	2.53	6.58
F	115	2.68	1.68	1.21	4.30	0.67	2.48	8.23
N	103	2.17	1.17	1.02	2.43	0.79	2.03	7.28
P	119	2.57	1.57	1.02	3.52	0.77	2.47	6.16
Q	118	2.74	1.74	1.08	4.23	0.87	2.75	6.65
X	92	2.28	1.28	1.65	4.40	0.70	1.76	10.66
Y	93	7.91	6.91	18.86	403.93	0.57	3.52	109.10
Z	108	4.10	3.10	3.31	20.70	0.79	3.01	24.79

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-44. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 34). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	119	2.68	1.43	1.02	3.11	0.82	2.59	6.11
B	119	2.49	1.24	1.03	2.60	0.76	2.44	6.83
C	117	2.60	1.35	0.99	2.81	0.85	2.51	6.75
D	118	2.63	1.38	1.10	3.13	0.62	2.50	7.49
E	118	2.67	1.42	0.96	2.95	0.89	2.60	6.65
F	118	2.74	1.49	1.12	3.51	0.82	2.65	6.19
N	110	2.44	1.19	1.18	2.81	0.89	2.27	10.21
P	118	2.67	1.42	1.01	3.06	0.83	2.66	6.82
Q	118	2.88	1.63	1.18	4.08	0.87	2.80	8.79
X	91	2.89	1.64	1.53	5.07	0.85	2.53	8.37
Y	109	8.59	7.34	27.12	789.61	0.79	3.28	207.30
Z	113	4.74	3.49	3.73	26.14	0.75	3.60	23.09

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-45. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 35). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	0.95	0.91	1.08	2.36	6.20
B	120	2.53	0.03	1.13	1.29	0.95	2.34	8.92
C	120	2.77	0.27	1.53	2.40	0.99	2.47	13.80
D	120	2.89	0.39	1.77	3.29	0.96	2.46	16.03
E	120	2.98	0.48	1.74	3.26	1.03	2.60	15.54
F	120	3.29	0.79	2.90	9.07	1.02	2.89	28.68
N	112	2.59	0.09	2.76	7.61	0.78	2.14	27.73
P	120	3.00	0.50	1.46	2.39	0.84	2.81	9.84
Q	120	3.36	0.86	2.05	4.96	0.94	2.99	13.70
X	96	2.27	-0.23	1.96	3.88	0.62	1.83	18.32
Y	115	26.34	23.84	181.36	33463.75	0.66	3.72	1893.00
Z	117	3.77	1.27	2.39	7.32	0.74	3.19	12.34

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-46. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 36). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.69	-2.31	0.85	6.10	1.42	2.45	6.68
B	120	2.66	-2.34	0.84	6.23	1.16	2.52	7.13
C	120	2.89	-2.11	0.89	5.28	1.31	2.77	6.78
D	120	3.09	-1.91	1.02	4.73	1.29	2.98	6.74
E	120	3.12	-1.88	0.96	4.49	1.40	3.09	5.85
F	119	3.52	-1.48	1.27	3.81	1.50	3.29	7.77
N	118	2.52	-2.48	1.13	7.45	0.93	2.33	8.19
P	120	3.03	-1.97	1.03	4.97	1.41	2.88	6.78
Q	120	3.46	-1.54	1.23	3.89	1.61	3.25	7.80
X	101	2.33	-2.67	2.46	13.23	0.52	1.83	24.46
Y	116	6.94	1.94	6.93	51.86	1.14	5.11	49.67
Z	117	4.40	-0.60	4.53	20.85	0.76	3.54	45.15

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-47. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 37). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-7.18	0.86	52.75	1.65	2.63	7.39
B	120	3.24	-6.76	1.23	47.58	1.71	2.93	10.12
C	120	3.69	-6.31	1.51	42.39	1.54	3.31	11.48
D	120	4.10	-5.90	1.74	38.14	1.62	3.61	12.76
E	120	4.09	-5.91	1.69	38.05	1.73	3.76	12.42
F	120	4.83	-5.17	2.04	31.11	1.86	4.38	14.01
N	119	2.73	-7.27	1.29	54.98	1.14	2.49	9.70
P	120	3.76	-6.24	1.50	41.48	1.53	3.45	11.83
Q	120	4.42	-5.58	1.74	34.40	2.15	4.05	13.59
X	101	1.96	-8.04	0.90	66.12	0.72	1.68	5.57
Y	114	12.21	2.21	18.43	344.66	1.36	7.41	163.00
Z	120	3.45	-6.55	1.31	44.92	1.18	3.25	9.23

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-48. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 38). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.03	-16.97	0.64	290.81	1.72	3.00	4.79
B	120	3.90	-16.10	0.98	262.30	1.66	3.93	6.31
C	120	4.54	-15.46	1.16	242.22	1.89	4.53	7.52
D	120	5.22	-14.78	1.39	222.36	2.18	5.29	8.57
E	120	5.18	-14.82	1.32	223.33	2.33	5.12	8.56
F	120	6.43	-13.57	1.71	188.52	2.40	6.49	11.13
N	119	2.99	-17.01	0.72	292.30	1.31	2.89	5.60
P	120	4.88	-15.12	1.37	232.40	2.18	4.76	10.81
Q	120	5.86	-14.14	1.77	204.79	2.48	5.70	16.29
X	116	1.57	-18.43	0.81	343.22	0.77	1.40	8.76
Y	120	12.37	-7.63	5.72	91.50	1.65	11.56	37.86
Z	120	3.48	-16.52	1.08	276.33	1.73	3.30	9.85

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-49. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 33). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.53	1.53	1.13	3.64	0.79	2.33	7.26
B	120	2.28	1.28	1.04	2.73	0.54	2.16	7.82
C	120	2.39	1.39	0.97	2.90	0.49	2.32	6.59
D	120	2.39	1.39	1.00	2.95	0.43	2.35	6.54
E	120	2.56	1.56	1.10	3.66	0.47	2.51	7.89
F	120	2.62	1.62	1.30	4.31	0.37	2.44	9.20
P	120	2.56	1.56	1.06	3.60	0.79	2.46	6.94
Q	120	2.72	1.72	1.17	4.34	0.63	2.72	8.42
X	120	1.91	0.91	1.67	3.61	0.14	1.55	10.68
Y	120	6.01	5.01	15.70	271.88	0.01	2.51	117.00
Z	120	3.78	2.78	3.28	18.56	0.32	2.79	23.28

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-50. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 34). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.67	1.42	1.05	3.16	0.61	2.56	6.44
B	120	2.48	1.23	1.07	2.68	0.49	2.40	6.99
C	120	2.54	1.29	1.01	2.69	0.40	2.47	6.68
D	120	2.58	1.33	1.10	2.99	0.38	2.49	7.44
E	120	2.63	1.38	1.01	2.94	0.34	2.61	6.77
F	120	2.71	1.46	1.24	3.69	0.30	2.64	8.99
P	120	2.63	1.38	1.03	2.98	0.34	2.61	6.92
Q	120	2.83	1.58	1.18	3.90	0.28	2.78	8.43
X	120	2.36	1.11	1.74	4.29	0.17	2.12	9.61
Y	120	7.91	6.66	26.37	740.16	0.19	2.99	212.50
Z	120	4.51	3.26	3.82	25.30	0.40	3.35	22.94

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-51. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 35). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	0.95	0.92	0.95	2.38	6.19
B	120	2.54	0.04	1.19	1.41	0.89	2.34	8.55
C	120	2.79	0.29	1.67	2.88	0.94	2.44	15.97
D	120	2.93	0.43	1.95	3.98	0.94	2.46	18.42
E	120	3.02	0.52	1.89	3.83	0.95	2.62	17.16
F	120	3.35	0.85	3.29	11.55	1.01	2.92	33.32
P	120	3.04	0.54	1.69	3.13	0.74	2.80	13.50
Q	120	3.43	0.93	2.54	7.33	0.85	3.01	22.09
X	120	1.97	-0.53	1.86	3.74	0.13	1.68	17.66
Y	120	23.50	21.00	166.85	28284.28	0.33	3.64	1796.00
Z	120	3.75	1.25	2.67	8.72	0.35	3.08	15.74

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-52. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 36). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.68	-2.32	0.87	6.18	1.48	2.44	6.67
B	120	2.66	-2.34	0.83	6.21	1.22	2.50	6.84
C	120	2.90	-2.10	0.91	5.29	1.34	2.81	6.60
D	120	3.10	-1.90	1.06	4.77	1.31	2.98	6.54
E	120	3.13	-1.87	1.01	4.54	1.40	3.06	6.62
F	120	3.51	-1.49	1.35	4.06	1.09	3.24	8.46
P	120	3.06	-1.94	1.10	5.03	1.44	2.87	7.28
Q	120	3.48	-1.52	1.29	4.01	1.63	3.24	8.82
X	120	1.98	-3.02	1.53	11.55	0.27	1.65	13.58
Y	120	6.64	1.64	6.75	48.22	0.23	5.10	40.74
Z	120	4.18	-0.82	3.43	12.45	0.76	3.40	29.59

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-53. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 37). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.83	-7.17	0.86	52.58	1.63	2.65	7.23
B	120	3.25	-6.75	1.23	47.39	1.66	2.95	9.91
C	120	3.70	-6.30	1.51	42.35	1.44	3.31	11.27
D	120	4.10	-5.90	1.75	38.18	1.51	3.62	12.55
E	120	4.09	-5.91	1.71	38.20	1.62	3.74	12.25
F	120	4.83	-5.17	2.07	31.28	1.85	4.41	13.98
P	120	3.77	-6.23	1.53	41.53	1.39	3.45	11.64
Q	120	4.43	-5.57	1.79	34.48	2.15	3.99	13.56
X	120	1.82	-8.18	0.97	68.35	0.38	1.57	6.02
Y	120	12.09	2.09	18.82	358.53	0.64	7.12	157.30
Z	120	3.48	-6.52	1.33	44.68	1.21	3.40	8.91

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-54. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 38). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.03	-16.97	0.65	290.90	1.73	2.97	4.71
B	120	3.90	-16.10	0.99	262.29	1.58	3.92	6.42
C	120	4.55	-15.45	1.17	242.06	1.85	4.52	7.52
D	120	5.22	-14.78	1.39	222.16	2.13	5.27	8.58
E	120	5.16	-14.84	1.32	223.79	2.33	5.10	8.60
F	120	6.42	-13.58	1.70	188.88	2.31	6.47	11.04
P	120	4.86	-15.14	1.34	232.89	2.11	4.80	9.62
Q	120	5.84	-14.16	1.73	205.20	2.17	5.62	15.13
X	120	1.55	-18.45	0.89	343.91	0.65	1.36	8.67
Y	120	12.43	-7.57	5.69	90.19	1.59	11.65	37.28
Z	120	3.49	-16.51	1.12	276.20	1.72	3.28	8.86

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-55. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 33). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.53	1.53	1.13	3.64	0.79	2.33	7.26
B	119	2.29	1.29	1.03	2.75	0.74	2.18	7.82
C	119	2.41	1.41	0.96	2.92	0.75	2.32	6.59
D	118	2.42	1.42	0.98	3.00	0.70	2.37	6.54
E	119	2.57	1.57	1.09	3.69	0.73	2.51	7.89
F	115	2.70	1.70	1.26	4.49	0.64	2.48	9.20
P	119	2.58	1.58	1.06	3.63	0.79	2.47	6.94
Q	118	2.75	1.75	1.15	4.41	0.84	2.73	8.42
X	89	2.38	1.38	1.70	4.79	0.63	1.89	10.68
Y	95	7.43	6.43	17.39	344.10	0.55	3.37	117.00
Z	108	4.13	3.13	3.28	20.62	0.69	3.07	23.28

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-56. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 34). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	118	2.71	1.46	1.03	3.20	0.84	2.57	6.44
B	117	2.53	1.28	1.05	2.74	0.77	2.44	6.99
C	118	2.57	1.32	0.99	2.73	0.63	2.48	6.68
D	118	2.61	1.36	1.08	3.04	0.64	2.51	7.44
E	117	2.68	1.43	0.96	3.00	0.91	2.63	6.77
F	117	2.77	1.52	1.20	3.77	0.79	2.65	8.99
P	118	2.66	1.41	1.00	3.02	0.85	2.62	6.92
Q	118	2.87	1.62	1.14	3.95	0.84	2.80	8.43
X	91	2.92	1.67	1.64	5.51	0.78	2.62	9.61
Y	109	8.66	7.41	27.57	815.49	0.71	3.24	212.50
Z	114	4.71	3.46	3.81	26.62	0.67	3.52	22.94

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-57. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 35). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 2.50
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.57	0.07	0.95	0.92	0.95	2.38	6.19
B	120	2.54	0.04	1.19	1.41	0.89	2.34	8.55
C	120	2.79	0.29	1.67	2.88	0.94	2.44	15.97
D	120	2.93	0.43	1.95	3.98	0.94	2.46	18.42
E	120	3.02	0.52	1.89	3.83	0.95	2.62	17.16
F	120	3.35	0.85	3.29	11.55	1.01	2.92	33.32
P	120	3.04	0.54	1.69	3.13	0.74	2.80	13.50
Q	120	3.43	0.93	2.54	7.33	0.85	3.01	22.09
X	96	2.28	-0.22	1.95	3.86	0.57	1.89	17.66
Y	115	24.50	22.00	170.40	29524.67	0.66	3.89	1796.00
Z	117	3.83	1.33	2.66	8.86	0.70	3.14	15.74

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-58. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 36). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.68	-2.32	0.87	6.18	1.48	2.44	6.67
B	120	2.66	-2.34	0.83	6.21	1.22	2.50	6.84
C	120	2.90	-2.10	0.91	5.29	1.34	2.81	6.60
D	120	3.10	-1.90	1.06	4.77	1.31	2.98	6.54
E	120	3.13	-1.87	1.01	4.54	1.40	3.06	6.62
F	119	3.53	-1.47	1.34	3.97	1.48	3.25	8.46
P	120	3.06	-1.94	1.10	5.03	1.44	2.87	7.28
Q	120	3.48	-1.52	1.29	4.01	1.63	3.24	8.82
X	98	2.26	-2.74	1.56	10.01	0.72	2.01	13.58
Y	117	6.79	1.79	6.77	49.02	1.01	5.24	40.74
Z	116	4.29	-0.71	3.44	12.36	0.76	3.54	29.59

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-59. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 37). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 10.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.83	-7.17	0.86	52.58	1.63	2.65	7.23
B	120	3.25	-6.75	1.23	47.39	1.66	2.95	9.91
C	120	3.70	-6.30	1.51	42.35	1.44	3.31	11.27
D	120	4.10	-5.90	1.75	38.18	1.51	3.62	12.55
E	120	4.09	-5.91	1.71	38.20	1.62	3.74	12.25
F	120	4.83	-5.17	2.07	31.28	1.85	4.41	13.98
P	120	3.77	-6.23	1.53	41.53	1.39	3.45	11.64
Q	120	4.43	-5.57	1.79	34.48	2.15	3.99	13.56
X	99	2.02	-7.98	0.96	65.23	0.74	1.71	6.02
Y	114	12.67	2.67	19.13	373.26	1.60	7.25	157.30
Z	120	3.48	-6.52	1.33	44.68	1.21	3.40	8.91

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-60. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 2 (RUN NUMBER 38). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.03	-16.97	0.65	290.90	1.73	2.97	4.71
B	120	3.90	-16.10	0.99	262.29	1.58	3.92	6.42
C	120	4.55	-15.45	1.17	242.06	1.85	4.52	7.52
D	120	5.22	-14.78	1.39	222.16	2.13	5.27	8.58
E	120	5.16	-14.84	1.32	223.79	2.33	5.10	8.60
F	120	6.42	-13.58	1.70	188.88	2.31	6.47	11.04
P	120	4.86	-15.14	1.34	232.89	2.11	4.80	9.62
Q	120	5.84	-14.16	1.73	205.20	2.17	5.62	15.13
X	111	1.61	-18.39	0.90	342.15	0.84	1.40	8.67
Y	120	12.43	-7.57	5.69	90.19	1.59	11.65	37.28
Z	120	3.49	-16.51	1.12	276.20	1.72	3.28	8.86

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-61. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 2 (RUN NUMBER 36). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 5.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.00	-3.60	3.35	24.31	-9.30	0.39	8.70
B	120	0.59	-3.01	3.61	22.17	-11.00	0.24	12.00
C	120	0.68	-2.92	3.73	22.54	-10.00	0.35	14.00
D	120	0.84	-2.76	3.91	22.99	-9.30	0.21	17.00
E	120	0.53	-3.07	3.58	22.32	-11.00	0.25	14.00
F	120	0.26	-3.34	3.67	24.66	-9.10	0.04	15.00
P	120	0.52	-3.08	3.67	23.06	-11.00	0.36	13.00
Q	120	0.42	-3.18	3.20	20.46	-8.40	0.31	12.00
X	120	0.24	-3.36	6.07	48.18	-32.00	-0.01	24.00
Y	120	0.44	-3.16	2.87	18.31	-6.60	0.19	9.90
Z	120	0.39	-3.21	4.16	27.69	-21.00	0.07	14.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-62. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 2 (RUN NUMBER 37). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 10.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.57	-3.03	3.27	19.92	-6.10	0.47	13.00
B	120	0.87	-2.73	3.13	17.33	-7.40	0.75	9.20
C	120	0.78	-2.82	3.08	17.55	-8.00	1.15	9.60
D	120	0.87	-2.73	3.16	17.47	-7.90	1.30	10.00
E	120	0.50	-3.10	2.91	18.15	-7.40	0.76	9.20
F	120	0.18	-3.42	3.10	21.39	-7.70	0.16	7.70
P	120	0.46	-3.14	3.33	21.07	-11.00	0.50	10.00
Q	120	0.23	-3.37	3.11	21.17	-12.00	0.59	9.00
X	120	1.01	-2.59	5.46	36.62	-19.00	0.91	19.00
Y	120	0.31	-3.29	2.32	16.30	-6.20	0.11	6.50
Z	120	0.87	-2.73	3.65	20.85	-14.00	0.97	13.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-63. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 2 (RUN NUMBER 38). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 20.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.13	-3.73	3.37	25.37	-12.00	-0.14	8.90
B	120	0.26	-3.34	3.60	24.25	-18.00	0.34	9.10
C	120	0.27	-3.33	3.64	24.41	-18.00	0.37	11.00
D	120	0.34	-3.26	3.57	23.50	-17.00	0.72	12.00
E	120	0.20	-3.40	3.38	23.04	-17.00	0.54	11.00
F	120	-0.06	-3.66	2.94	22.17	-15.00	0.07	11.00
P	120	0.18	-3.42	3.55	24.40	-17.00	0.41	10.00
Q	120	0.04	-3.56	2.84	20.89	-13.00	0.29	9.60
X	120	0.30	-3.30	6.49	53.07	-17.00	0.32	15.00
Y	120	0.30	-3.30	1.93	14.72	-6.80	0.30	5.30
Z	120	0.29	-3.31	4.39	30.28	-13.00	0.65	10.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-64. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 2 (RUN NUMBER 35). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 2.50

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.03	-3.57	3.62	25.95	-19.00	0.37	8.90
B	120	0.65	-2.95	3.91	24.00	-24.00	0.74	8.80
C	120	0.84	-2.76	3.71	21.42	-22.00	0.83	9.50
D	120	1.13	-2.47	3.50	18.40	-15.00	1.35	9.80
E	120	0.76	-2.84	3.42	19.83	-14.00	1.10	9.20
F	120	0.65	-2.95	3.41	20.43	-13.00	0.77	10.00
P	120	0.70	-2.90	3.42	20.18	-11.00	0.66	8.60
Q	120	0.55	-3.05	3.07	18.76	-12.00	0.51	10.00
X	120	0.79	-2.81	4.82	31.20	-27.00	0.77	12.00
Y	120	0.52	-3.08	2.96	18.31	-12.00	0.58	7.70
Z	120	0.75	-2.85	3.71	21.94	-23.00	0.86	9.70

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-65. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 2 (RUN NUMBER 34). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.25

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.57	-3.03	2.58	15.93	-5.40	0.57	7.60
B	120	0.91	-2.69	2.72	14.69	-6.90	0.87	8.80
C	120	0.94	-2.66	2.55	13.63	-5.10	0.76	9.30
D	120	0.96	-2.64	2.75	14.61	-4.90	0.53	11.00
E	120	0.74	-2.86	2.30	13.55	-3.50	0.52	7.70
F	120	0.41	-3.19	2.62	17.13	-5.80	0.38	9.00
P	120	0.74	-2.86	2.52	14.55	-5.80	0.56	10.00
Q	120	0.51	-3.09	2.19	14.43	-4.70	0.33	8.70
X	120	0.63	-2.97	3.35	20.12	-8.80	0.54	8.70
Y	120	0.63	-2.97	3.00	17.93	-9.20	0.43	8.30
Z	120	0.50	-3.10	2.90	18.15	-6.80	0.30	7.80

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-66. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 2 (RUN NUMBER 33). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.07	-3.67	2.78	21.35	-9.40	-0.21	7.30
B	120	0.49	-3.11	3.08	19.26	-7.80	0.41	8.10
C	120	0.28	-3.32	2.84	19.17	-7.70	0.37	10.00
D	120	0.34	-3.26	3.06	20.05	-8.10	0.22	13.00
E	120	0.13	-3.47	2.73	19.56	-6.40	0.10	10.00
F	120	0.03	-3.57	3.29	23.67	-7.10	-0.09	14.00
P	120	-0.07	-3.67	2.98	22.51	-12.00	0.20	9.70
Q	120	-0.21	-3.81	2.95	23.35	-11.00	0.00	8.20
X	120	0.68	-2.92	3.63	21.77	-7.80	0.26	13.00
Y	120	0.60	-3.00	3.56	21.78	-7.50	0.34	17.00
Z	120	0.63	-2.97	3.36	20.20	-11.00	0.62	11.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-67. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 39). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.66	1.41	0.60	2.35	1.25	2.64	3.88
B	120	2.76	1.51	0.73	2.82	1.52	2.62	4.95
C	120	2.86	1.61	0.53	2.89	1.58	2.87	4.21
D	120	2.79	1.54	0.73	2.92	1.21	2.70	4.73
E	120	2.89	1.64	0.48	2.95	1.36	2.87	4.17
F	120	2.78	1.53	0.73	2.89	1.15	2.73	4.80
N	120	2.46	1.21	0.94	2.35	0.60	2.35	6.42
P	120	2.88	1.63	0.52	2.94	1.47	2.83	4.29
Q	120	2.95	1.70	0.47	3.12	1.50	2.92	4.36
X	120	1.51	0.26	0.57	0.40	0.49	1.46	3.97
Y	120	5.92	4.67	9.97	121.35	0.30	3.54	102.90
Z	120	2.99	1.74	1.20	4.49	0.89	2.75	7.57

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-68. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 40). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.88	-2.12	0.61	4.91	1.58	2.78	4.77
B	120	2.68	-2.32	0.63	5.80	1.35	2.57	4.33
C	120	2.84	-2.16	0.58	5.03	1.82	2.76	4.82
D	120	2.80	-2.20	0.70	5.38	1.41	2.64	5.21
E	120	2.89	-2.11	0.56	4.78	1.73	2.86	4.98
F	120	2.81	-2.19	0.78	5.46	1.35	2.70	5.90
N	120	2.67	-2.33	0.87	6.24	0.72	2.64	5.15
P	120	2.85	-2.15	0.56	4.98	1.78	2.78	4.73
Q	120	2.93	-2.07	0.51	4.59	1.78	2.86	4.71
X	120	1.53	-3.47	0.54	12.46	0.48	1.49	3.33
Y	120	6.17	1.17	5.34	29.87	0.27	4.76	35.14
Z	120	3.13	-1.87	1.21	5.01	1.03	2.88	7.05

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-69. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 41). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.90	-17.10	0.62	295.30	1.68	2.87	5.23
B	120	2.96	-17.04	0.72	293.32	1.66	2.93	4.86
C	120	3.10	-16.90	0.65	288.52	1.74	3.04	5.06
D	120	3.01	-16.99	0.78	291.54	1.69	2.96	5.59
E	120	3.09	-16.91	0.61	288.88	1.78	3.06	4.92
F	120	2.88	-17.12	0.78	296.20	1.34	2.80	4.88
N	120	2.82	-17.18	0.92	298.48	0.79	2.80	5.05
P	120	3.10	-16.90	0.63	288.57	1.67	3.01	4.88
Q	120	3.08	-16.92	0.53	289.13	2.07	2.98	4.42
X	120	1.65	-18.35	0.59	339.92	0.60	1.63	4.13
Y	120	7.08	-12.92	6.73	213.65	0.38	5.17	42.78
Z	120	3.35	-16.65	1.23	280.97	1.30	3.08	7.25

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-70. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 39). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.66	1.41	0.60	2.35	1.25	2.64	3.88
B	120	2.76	1.51	0.73	2.82	1.52	2.62	4.95
C	120	2.86	1.61	0.53	2.89	1.58	2.87	4.21
D	120	2.79	1.54	0.73	2.92	1.21	2.70	4.73
E	120	2.89	1.64	0.48	2.95	1.36	2.87	4.17
F	120	2.78	1.53	0.73	2.89	1.15	2.73	4.80
N	116	2.51	1.26	0.91	2.43	1.02	2.41	6.42
P	120	2.88	1.63	0.52	2.94	1.47	2.83	4.29
Q	120	2.95	1.70	0.47	3.12	1.50	2.92	4.36
X	105	1.62	0.37	0.52	0.41	0.87	1.51	3.97
Y	114	6.20	4.95	10.15	127.78	0.83	3.77	102.90
Z	118	3.02	1.77	1.18	4.56	1.30	2.78	7.57

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-71. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 40). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.88	-2.12	0.61	4.91	1.58	2.78	4.77
B	120	2.68	-2.32	0.63	5.80	1.35	2.57	4.33
C	120	2.84	-2.16	0.58	5.03	1.82	2.76	4.82
D	120	2.80	-2.20	0.70	5.38	1.41	2.64	5.21
E	120	2.89	-2.11	0.56	4.78	1.73	2.86	4.98
F	120	2.81	-2.19	0.78	5.46	1.35	2.70	5.90
N	119	2.68	-2.32	0.85	6.14	0.98	2.65	5.15
P	120	2.85	-2.15	0.56	4.98	1.78	2.78	4.73
Q	120	2.93	-2.07	0.51	4.59	1.78	2.86	4.71
X	105	1.64	-3.36	0.49	11.67	0.72	1.53	3.33
Y	113	6.51	1.51	5.31	30.54	0.87	5.08	35.14
Z	120	3.13	-1.87	1.21	5.01	1.03	2.88	7.05

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-72. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 41). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.90	-17.10	0.62	295.30	1.68	2.87	5.23
B	120	2.96	-17.04	0.72	293.32	1.66	2.93	4.86
C	120	3.10	-16.90	0.65	288.52	1.74	3.04	5.06
D	120	3.01	-16.99	0.78	291.54	1.69	2.96	5.59
E	120	3.09	-16.91	0.61	288.88	1.78	3.06	4.92
F	120	2.88	-17.12	0.78	296.20	1.34	2.80	4.88
N	118	2.85	-17.15	0.89	297.30	0.93	2.81	5.05
P	120	3.10	-16.90	0.63	288.57	1.67	3.01	4.88
Q	120	3.08	-16.92	0.53	289.13	2.07	2.98	4.42
X	111	1.72	-18.28	0.56	337.54	0.91	1.67	4.13
Y	118	7.19	-12.81	6.73	210.84	1.00	5.21	42.78
Z	120	3.35	-16.65	1.23	280.97	1.30	3.08	7.25

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-73. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 39). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.66	1.41	0.58	2.35	1.20	2.64	3.84
B	120	2.76	1.51	0.76	2.89	1.39	2.62	4.92
C	120	2.86	1.61	0.55	2.92	1.57	2.87	4.19
D	120	2.79	1.54	0.75	2.96	1.24	2.68	4.94
E	120	2.89	1.64	0.50	2.96	1.36	2.84	4.28
F	120	2.77	1.52	0.75	2.90	1.15	2.69	5.38
P	120	2.87	1.62	0.52	2.93	1.47	2.84	4.35
Q	120	2.95	1.70	0.47	3.14	1.50	2.94	4.40
X	120	1.50	0.25	0.52	0.33	0.47	1.45	3.09
Y	120	6.04	4.79	9.39	111.37	0.06	3.47	93.17
Z	120	2.97	1.72	1.11	4.22	0.89	2.77	5.83

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-74. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 40). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.91	-2.09	0.64	4.84	1.57	2.82	5.08
B	120	2.70	-2.30	0.66	5.78	1.36	2.63	4.39
C	120	2.84	-2.16	0.61	5.08	1.76	2.76	4.76
D	120	2.79	-2.21	0.72	5.43	1.57	2.66	5.09
E	120	2.90	-2.10	0.59	4.78	1.70	2.89	4.96
F	120	2.83	-2.17	0.85	5.45	1.31	2.72	6.13
P	120	2.85	-2.15	0.61	5.02	1.75	2.82	4.70
Q	120	2.94	-2.06	0.56	4.60	1.74	2.92	4.84
X	120	1.55	-3.45	0.62	12.42	0.42	1.49	4.58
Y	120	6.77	1.77	5.86	37.46	0.26	5.12	27.59
Z	120	3.16	-1.84	1.34	5.22	0.88	2.95	9.19

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-75. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 41). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.90	-17.10	0.62	295.34	1.70	2.85	5.26
B	120	2.96	-17.04	0.72	293.32	1.41	2.95	4.85
C	120	3.11	-16.89	0.66	288.25	1.79	3.04	5.18
D	120	3.02	-16.98	0.80	291.23	1.66	2.87	5.65
E	120	3.09	-16.91	0.62	288.79	1.88	3.06	4.92
F	120	2.87	-17.13	0.79	296.64	1.33	2.82	4.88
P	120	3.11	-16.89	0.65	288.26	1.74	3.02	4.89
Q	120	3.08	-16.92	0.55	289.15	1.98	2.97	4.45
X	120	1.67	-18.33	0.67	339.12	0.50	1.61	4.22
Y	120	7.27	-12.73	8.29	232.19	0.56	5.16	64.92
Z	120	3.39	-16.61	1.38	280.15	1.09	3.11	8.86

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-76. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 39). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.66	1.41	0.58	2.35	1.20	2.64	3.84
B	120	2.76	1.51	0.76	2.89	1.39	2.62	4.92
C	120	2.86	1.61	0.55	2.92	1.57	2.87	4.19
D	120	2.79	1.54	0.75	2.96	1.24	2.68	4.94
E	120	2.89	1.64	0.50	2.96	1.36	2.84	4.28
F	120	2.77	1.52	0.75	2.90	1.15	2.69	5.38
P	120	2.87	1.62	0.52	2.93	1.47	2.84	4.35
Q	120	2.95	1.70	0.47	3.14	1.50	2.94	4.40
X	104	1.62	0.37	0.45	0.34	0.91	1.52	3.09
Y	115	6.29	5.04	9.52	116.23	0.84	3.52	93.17
Z	118	3.01	1.76	1.08	4.29	1.01	2.78	5.83

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-77. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 40). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.91	-2.09	0.64	4.84	1.57	2.82	5.08
B	120	2.70	-2.30	0.66	5.78	1.36	2.63	4.39
C	120	2.84	-2.16	0.61	5.08	1.76	2.76	4.76
D	120	2.79	-2.21	0.72	5.43	1.57	2.66	5.09
E	120	2.90	-2.10	0.59	4.78	1.70	2.89	4.96
F	120	2.83	-2.17	0.85	5.45	1.31	2.72	6.13
P	120	2.85	-2.15	0.61	5.02	1.75	2.82	4.70
Q	120	2.94	-2.06	0.56	4.60	1.74	2.92	4.84
X	103	1.68	-3.32	0.57	11.49	0.71	1.58	4.58
Y	114	7.10	2.10	5.83	38.39	0.87	5.39	27.59
Z	119	3.18	-1.82	1.33	5.12	1.17	2.95	9.19

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-78. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 3 (RUN NUMBER 41). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.90	-17.10	0.62	295.34	1.70	2.85	5.26
B	120	2.96	-17.04	0.72	293.32	1.41	2.95	4.85
C	120	3.11	-16.89	0.66	288.25	1.79	3.04	5.18
D	120	3.02	-16.98	0.80	291.23	1.66	2.87	5.65
E	120	3.09	-16.91	0.62	288.79	1.88	3.06	4.92
F	120	2.87	-17.13	0.79	296.64	1.33	2.82	4.88
P	120	3.11	-16.89	0.65	288.26	1.74	3.02	4.89
Q	120	3.08	-16.92	0.55	289.15	1.98	2.97	4.45
X	110	1.75	-18.25	0.64	336.34	0.91	1.64	4.22
Y	118	7.38	-12.62	8.31	229.73	1.05	5.17	64.92
Z	120	3.39	-16.61	1.38	280.15	1.09	3.11	8.86

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-79. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 3 (RUN NUMBER 39). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.25

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.15	-3.75	2.97	23.02	-8.60	-0.24	5.90
B	120	0.11	-3.49	2.75	19.83	-7.80	0.09	6.60
C	120	0.68	-2.92	2.20	13.46	-5.30	0.75	5.90
D	120	1.25	-2.35	3.11	15.23	-6.30	1.30	11.00
E	120	0.51	-3.09	2.05	13.79	-5.80	0.70	7.90
F	120	0.12	-3.48	3.61	25.24	-10.00	0.25	12.00
P	120	0.55	-3.05	2.08	13.70	-5.00	0.61	6.80
Q	120	0.45	-3.15	1.88	13.55	-5.10	0.35	8.70
X	120	-0.07	-3.67	3.55	26.21	-9.00	-0.40	9.70
Y	120	-0.16	-3.76	3.59	27.11	-8.60	-0.33	11.00
Z	120	-0.14	-3.74	3.37	25.44	-8.10	-0.21	8.70

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-80. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 3 (RUN NUMBER 40). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 5.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.38	-3.22	2.89	18.83	-8.60	0.43	9.10
B	120	0.46	-3.14	3.23	20.37	-8.30	0.57	8.30
C	120	1.01	-2.59	2.40	12.52	-5.00	1.05	7.00
D	120	1.49	-2.11	3.21	14.79	-6.70	1.30	10.00
E	120	0.85	-2.75	1.98	11.53	-3.80	0.78	5.70
F	120	0.46	-3.14	3.04	19.14	-8.00	0.39	11.00
P	120	0.95	-2.65	2.21	11.96	-4.30	0.93	6.00
Q	120	0.65	-2.95	1.65	11.49	-3.20	0.63	5.70
X	120	0.76	-2.84	3.78	22.47	-9.30	0.90	9.30
Y	120	0.37	-3.23	3.71	24.30	-10.00	0.58	9.70
Z	120	0.57	-3.03	3.73	23.22	-11.00	1.03	8.60

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-81. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 3 (RUN NUMBER 41). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 20.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.08	-3.52	2.93	21.11	-8.50	0.00	8.70
B	120	1.03	-2.57	3.26	17.29	-12.00	0.79	8.40
C	120	0.89	-2.71	2.49	13.61	-7.90	0.95	7.20
D	120	0.75	-2.85	3.33	19.25	-8.10	0.56	8.40
E	120	0.46	-3.14	2.06	14.18	-7.10	0.40	5.90
F	120	-0.25	-3.85	3.38	26.44	-9.90	-0.28	12.00
P	120	0.57	-3.03	2.24	14.32	-7.60	0.71	6.90
Q	120	0.05	-3.55	1.76	15.79	-5.00	0.15	5.50
X	120	0.93	-2.67	4.22	24.96	-16.00	0.67	12.00
Y	120	1.15	-2.45	3.44	17.86	-7.80	1.35	11.00
Z	120	1.12	-2.48	3.78	20.54	-12.00	1.15	12.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-82. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 43). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.77	1.52	0.66	2.76	1.57	2.67	5.45
B	120	2.73	1.48	0.71	2.71	1.51	2.59	5.83
C	120	2.76	1.51	0.56	2.62	1.71	2.71	4.21
D	120	2.66	1.41	0.66	2.43	1.42	2.56	4.22
E	120	2.84	1.59	0.54	2.83	1.63	2.82	4.51
F	120	2.79	1.54	0.83	3.09	1.52	2.67	5.22
N	120	2.40	1.15	0.89	2.11	0.70	2.33	4.67
P	120	2.82	1.57	0.57	2.80	1.29	2.80	4.51
Q	120	2.88	1.63	0.52	2.95	1.52	2.87	4.22
X	120	1.74	0.49	0.77	0.83	0.49	1.66	5.74
Y	120	5.64	4.39	6.84	66.20	0.32	3.28	46.62
Z	120	3.50	2.25	1.69	7.97	1.12	3.14	13.28

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-83. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 44). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.70	-2.30	0.74	5.87	1.41	2.61	5.07
B	120	2.72	-2.28	0.70	5.72	1.58	2.62	5.30
C	120	2.80	-2.20	0.53	5.15	1.81	2.80	4.59
D	120	2.68	-2.32	0.69	5.90	1.45	2.57	4.71
E	120	2.86	-2.14	0.54	4.90	1.81	2.83	5.10
F	120	2.80	-2.20	0.92	5.74	1.34	2.61	7.30
N	120	2.56	-2.44	0.96	6.91	0.71	2.51	6.21
P	120	2.86	-2.14	0.54	4.91	1.77	2.81	4.54
Q	120	2.94	-2.06	0.54	4.58	1.72	2.91	5.00
X	120	1.47	-3.53	0.58	12.87	0.15	1.44	3.14
Y	120	5.23	0.23	6.47	41.87	0.29	3.49	43.42
Z	120	2.99	-2.01	1.28	5.73	0.35	2.74	7.55

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-84. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 45). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-17.18	0.82	298.43	1.52	2.66	6.09
B	120	2.85	-17.15	0.80	297.35	1.58	2.69	5.70
C	120	2.86	-17.14	0.62	296.75	1.57	2.79	5.55
D	120	2.69	-17.31	0.67	302.68	1.46	2.65	4.96
E	120	2.84	-17.16	0.52	297.35	1.65	2.80	3.98
F	120	2.66	-17.34	0.70	303.78	1.54	2.56	5.14
N	120	2.68	-17.32	0.97	303.35	0.86	2.63	6.44
P	120	2.83	-17.17	0.59	297.54	1.53	2.80	4.76
Q	120	2.85	-17.15	0.48	296.78	1.57	2.81	4.10
X	120	1.56	-18.44	0.59	343.07	0.63	1.48	3.62
Y	120	5.48	-14.52	5.30	240.68	0.47	3.96	36.71
Z	120	3.19	-16.81	1.39	286.96	1.24	2.95	8.74

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-85. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 43). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.77	1.52	0.66	2.76	1.57	2.67	5.45
B	120	2.73	1.48	0.71	2.71	1.51	2.59	5.83
C	120	2.76	1.51	0.56	2.62	1.71	2.71	4.21
D	120	2.66	1.41	0.66	2.43	1.42	2.56	4.22
E	120	2.84	1.59	0.54	2.83	1.63	2.82	4.51
F	120	2.79	1.54	0.83	3.09	1.52	2.67	5.22
N	118	2.42	1.17	0.87	2.14	0.94	2.34	4.67
P	120	2.82	1.57	0.57	2.80	1.29	2.80	4.51
Q	120	2.88	1.63	0.52	2.95	1.52	2.87	4.22
X	113	1.80	0.55	0.75	0.87	0.82	1.71	5.74
Y	117	5.77	4.52	6.88	67.89	0.83	3.47	46.62
Z	120	3.50	2.25	1.69	7.97	1.12	3.14	13.28

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-86. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 44). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.70	-2.30	0.74	5.87	1.41	2.61	5.07
B	120	2.72	-2.28	0.70	5.72	1.58	2.62	5.30
C	120	2.80	-2.20	0.53	5.15	1.81	2.80	4.59
D	120	2.68	-2.32	0.69	5.90	1.45	2.57	4.71
E	120	2.86	-2.14	0.54	4.90	1.81	2.83	5.10
F	120	2.80	-2.20	0.92	5.74	1.34	2.61	7.30
N	118	2.60	-2.40	0.94	6.71	0.99	2.54	6.21
P	120	2.86	-2.14	0.54	4.91	1.77	2.81	4.54
Q	120	2.94	-2.06	0.54	4.58	1.72	2.91	5.00
X	100	1.62	-3.38	0.51	11.77	0.79	1.53	3.14
Y	112	5.55	0.55	6.58	43.55	0.91	3.61	43.42
Z	119	3.01	-1.99	1.26	5.60	1.11	2.74	7.55

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-87. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 45). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-17.18	0.82	298.43	1.52	2.66	6.09
B	120	2.85	-17.15	0.80	297.35	1.58	2.69	5.70
C	120	2.86	-17.14	0.62	296.75	1.57	2.79	5.55
D	120	2.69	-17.31	0.67	302.68	1.46	2.65	4.96
E	120	2.84	-17.16	0.52	297.35	1.65	2.80	3.98
F	120	2.66	-17.34	0.70	303.78	1.54	2.56	5.14
N	119	2.70	-17.30	0.96	302.89	0.86	2.63	6.44
P	120	2.83	-17.17	0.59	297.54	1.53	2.80	4.76
Q	120	2.85	-17.15	0.48	296.78	1.57	2.81	4.10
X	106	1.66	-18.34	0.55	339.83	0.92	1.54	3.62
Y	115	5.69	-14.31	5.31	234.83	0.92	4.25	36.71
Z	120	3.19*	-16.81	1.39	286.96	1.24	2.95	8.74

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-88. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 43). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.77	1.52	0.67	2.80	1.59	2.67	5.37
B	120	2.71	1.46	0.72	2.68	1.49	2.62	6.07
C	120	2.77	1.52	0.57	2.64	1.68	2.71	4.22
D	120	2.67	1.42	0.69	2.50	1.44	2.53	4.67
E	120	2.84	1.59	0.55	2.85	1.63	2.81	4.49
F	120	2.80	1.55	0.84	3.13	1.54	2.60	5.26
P	120	2.81	1.56	0.57	2.78	1.29	2.79	4.48
Q	120	2.88	1.63	0.52	2.94	1.53	2.87	4.20
X	120	1.74	0.49	0.80	0.89	0.48	1.60	6.63
Y	120	5.85	4.60	8.01	85.52	0.25	3.43	59.63
Z	120	3.50	2.25	1.80	8.35	1.10	3.25	15.40

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-89. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 44). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.70	-2.30	0.76	5.93	1.38	2.54	5.41
B	120	2.74	-2.26	0.76	5.72	1.50	2.65	5.26
C	120	2.81	-2.19	0.56	5.15	1.59	2.81	4.42
D	120	2.67	-2.33	0.68	5.92	1.24	2.55	4.72
E	120	2.87	-2.13	0.55	4.88	1.65	2.83	5.09
F	120	2.81	-2.19	0.97	5.77	1.29	2.66	7.08
P	120	2.88	-2.12	0.57	4.84	1.67	2.88	4.67
Q	120	2.95	-2.05	0.56	4.56	1.76	2.96	4.98
X	120	1.50	-3.50	0.65	12.78	0.15	1.44	4.53
Y	120	5.99	0.99	10.96	121.21	0.15	3.49	106.30
Z	120	3.02	-1.98	1.36	5.82	0.35	2.73	8.64

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-90. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 45). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-17.18	0.85	298.24	1.42	2.66	6.64
B	120	2.88	-17.12	0.82	296.29	1.55	2.75	5.97
C	120	2.86	-17.14	0.63	296.54	1.53	2.82	5.62
D	120	2.68	-17.32	0.67	303.03	1.45	2.63	4.93
E	120	2.85	-17.15	0.52	296.83	1.62	2.79	4.01
F	120	2.69	-17.31	0.74	302.65	1.53	2.54	5.19
P	120	2.85	-17.15	0.59	296.92	1.46	2.82	4.75
Q	120	2.86	-17.14	0.49	296.35	1.53	2.82	4.13
X	120	1.58	-18.42	0.63	342.44	0.53	1.47	3.59
Y	120	5.92	-14.08	6.12	237.27	0.39	3.90	35.21
Z	120	3.21	-16.79	1.45	286.49	1.11	2.90	8.61

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-91. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 43). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.77	1.52	0.67	2.80	1.59	2.67	5.37
B	120	2.71	1.46	0.72	2.68	1.49	2.62	6.07
C	120	2.77	1.52	0.57	2.64	1.68	2.71	4.22
D	120	2.67	1.42	0.69	2.50	1.44	2.53	4.67
E	120	2.84	1.59	0.55	2.85	1.63	2.81	4.49
F	120	2.80	1.55	0.84	3.13	1.54	2.60	5.26
P	120	2.81	1.56	0.57	2.78	1.29	2.79	4.48
Q	120	2.88	1.63	0.52	2.94	1.53	2.87	4.20
X	110	1.83	0.58	0.78	0.95	0.88	1.71	6.63
Y	114	6.13	4.88	8.12	90.03	0.85	3.56	59.63
Z	120	3.50	2.25	1.80	8.35	1.10	3.25	15.40

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-92. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 44). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.70	-2.30	0.76	5.93	1.38	2.54	5.41
B	120	2.74	-2.26	0.76	5.72	1.50	2.65	5.26
C	120	2.81	-2.19	0.56	5.15	1.59	2.81	4.42
D	120	2.67	-2.33	0.68	5.92	1.24	2.55	4.72
E	120	2.87	-2.13	0.55	4.88	1.65	2.83	5.09
F	120	2.81	-2.19	0.97	5.77	1.29	2.66	7.08
P	120	2.88	-2.12	0.57	4.84	1.67	2.88	4.67
Q	120	2.95	-2.05	0.56	4.56	1.76	2.96	4.98
X	98	1.67	-3.33	0.58	11.52	0.87	1.52	4.53
Y	108	6.58	1.58	11.41	132.73	0.84	4.00	106.30
Z	119	3.04	-1.96	1.35	5.69	1.05	2.73	8.64

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-93. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 4 (RUN NUMBER 45). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-17.18	0.85	298.24	1.42	2.66	6.64
B	120	2.88	-17.12	0.82	296.29	1.55	2.75	5.97
C	120	2.86	-17.14	0.63	296.54	1.53	2.82	5.62
D	120	2.68	-17.32	0.67	303.03	1.45	2.63	4.93
E	120	2.85	-17.15	0.52	296.83	1.62	2.79	4.01
F	120	2.69	-17.31	0.74	302.65	1.53	2.54	5.19
P	120	2.85	-17.15	0.59	296.92	1.46	2.82	4.75
Q	120	2.86	-17.14	0.49	296.35	1.53	2.82	4.13
X	109	1.67	-18.33	0.60	339.64	0.85	1.50	3.59
Y	115	6.15	-13.85	6.15	231.24	0.88	3.95	35.21
Z	120	3.21	-16.79	1.45	286.49	1.11	2.90	8.61

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-94. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 4 (RUN NUMBER 43). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.25

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.10	-3.70	2.80	21.67	-7.70	-0.29	7.40
B	120	0.63	-2.97	3.25	19.50	-9.60	0.72	8.50
C	120	0.61	-2.99	2.41	14.85	-5.00	0.58	7.00
D	120	0.64	-2.96	3.24	19.34	-6.90	0.51	9.00
E	120	0.39	-3.21	1.93	14.11	-4.00	0.46	6.30
F	120	-0.17	-3.77	3.04	23.56	-5.90	-0.54	7.70
P	120	0.45	-3.15	2.12	14.45	-6.20	0.46	6.00
Q	120	0.16	-3.44	1.56	14.38	-3.90	0.01	4.70
X	120	0.46	-3.14	3.78	24.21	-7.30	0.43	11.00
Y	120	0.64	-2.96	3.63	22.01	-7.10	0.83	10.00
Z	120	0.56	-3.04	3.57	22.09	-6.60	0.65	11.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-95. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 4 (RUN NUMBER 44). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 5.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.32	-3.28	2.89	19.22	-7.00	0.47	8.10
B	120	0.61	-2.99	3.03	18.22	-8.30	0.73	8.20
C	120	0.47	-3.13	2.39	15.57	-7.90	0.34	6.90
D	120	0.31	-3.29	3.66	24.37	-7.40	0.12	11.00
E	120	0.34	-3.26	2.14	15.28	-6.00	0.26	5.90
F	120	0.07	-3.53	3.20	22.81	-8.00	0.09	8.50
P	120	0.41	-3.19	2.07	14.55	-6.30	0.13	5.40
Q	120	0.22	-3.38	1.82	14.84	-3.90	0.11	5.10
X	120	0.84	-2.76	3.88	22.72	-10.00	0.60	11.00
Y	120	0.69	-2.91	3.69	22.15	-10.00	0.94	9.40
Z	120	0.75	-2.85	3.54	20.72	-9.30	0.58	8.50

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-96. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 4 (RUN NUMBER 45). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 20.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.16	-3.76	3.42	25.90	-8.10	-0.14	7.90
B	120	0.42	-3.18	2.96	18.95	-7.80	0.51	7.80
C	120	0.16	-3.44	2.36	17.49	-6.90	0.08	6.80
D	120	-0.09	-3.69	3.28	24.45	-8.40	0.13	12.00
E	120	-0.02	-3.62	1.95	17.05	-5.70	0.05	4.80
F	120	-0.31	-3.91	3.15	25.34	-9.00	-0.27	7.70
P	120	0.11	-3.49	2.12	16.79	-7.40	0.21	6.00
Q	120	-0.01	-3.61	1.80	16.37	-6.20	-0.11	5.20
X	120	0.57	-3.03	3.92	24.61	-11.00	0.83	9.80
Y	120	0.61	-2.99	3.84	23.76	-16.00	0.66	9.30
Z	120	0.63	-2.97	3.75	22.97	-11.00	0.72	10.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-97. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 46). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.52	1.27	0.66	2.07	1.34	2.36	5.44
B	120	2.54	1.29	0.67	2.12	1.25	2.47	4.72
C	120	2.64	1.39	0.61	2.31	1.38	2.62	4.30
D	120	2.58	1.33	0.75	2.34	1.34	2.46	4.59
E	120	2.69	1.44	0.63	2.48	1.45	2.74	4.42
F	120	2.63	1.38	0.85	2.65	1.20	2.58	5.41
N	120	2.01	0.76	0.87	1.34	0.62	1.92	4.79
P	120	2.74	1.49	0.65	2.66	1.30	2.76	5.15
Q	120	2.83	1.58	0.71	3.01	1.50	2.87	5.92
X	120	1.50	0.25	0.65	0.48	0.41	1.41	3.43
Y	120	3.82	2.57	4.68	28.57	0.18	2.57	39.77
Z	120	2.78	1.53	1.33	4.12	0.96	2.44	7.39

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-98. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 47). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.79	-2.21	0.70	5.40	1.41	2.62	5.04
B	120	2.81	-2.19	0.73	5.37	1.38	2.66	5.44
C	120	2.92	-2.08	0.63	4.76	1.74	2.85	5.23
D	120	2.88	-2.12	0.72	5.07	1.66	2.80	4.86
E	120	2.98	-2.02	0.62	4.50	1.86	2.92	4.92
F	120	2.97	-2.03	0.78	4.77	1.67	2.96	5.86
N	120	2.66	-2.34	0.88	6.31	0.85	2.73	4.97
P	120	2.91	-2.09	0.63	4.78	1.59	2.84	5.24
Q	120	3.00	-2.00	0.57	4.34	1.94	3.01	5.12
X	120	1.61	-3.39	0.52	11.87	0.63	1.63	3.54
Y	120	6.00	1.00	5.10	26.99	0.48	4.61	29.88
Z	120	3.08	-1.92	1.09	4.88	1.29	2.88	7.67

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-99. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 48). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.18	-16.82	0.65	285.66	1.72	3.09	5.02
B	120	3.49	-16.51	0.90	275.73	1.87	3.34	6.56
C	120	3.58	-16.42	0.84	272.66	2.28	3.42	6.35
D	120	3.50	-16.50	0.93	275.45	1.80	3.38	7.21
E	120	3.59	-16.41	0.83	272.12	2.22	3.45	6.31
F	120	3.40	-16.60	0.93	278.86	1.71	3.25	7.15
N	120	3.50	-16.50	1.10	275.68	1.17	3.53	7.28
P	120	3.57	-16.43	0.86	272.82	2.10	3.47	6.35
Q	120	3.46	-16.54	0.74	276.53	2.16	3.37	5.63
X	120	1.65	-18.35	0.44	339.73	0.66	1.58	2.88
Y	120	9.92	-10.08	7.82	163.61	1.16	8.48	56.16
Z	120	3.47	-16.53	0.93	276.53	1.52	3.32	6.61

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-100. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 46). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.52	1.27	0.66	2.07	1.34	2.36	5.44
B	120	2.54	1.29	0.67	2.12	1.25	2.47	4.72
C	120	2.64	1.39	0.61	2.31	1.38	2.62	4.30
D	120	2.58	1.33	0.75	2.34	1.34	2.46	4.59
E	120	2.69	1.44	0.63	2.48	1.45	2.74	4.42
F	120	2.63	1.38	0.85	2.65	1.20	2.58	5.41
N	111	2.11	0.86	0.82	1.42	0.88	2.02	4.79
P	120	2.74	1.49	0.65	2.66	1.30	2.76	5.15
Q	120	2.83	1.58	0.71	3.01	1.50	2.87	5.92
X	103	1.63	0.38	0.61	0.51	0.79	1.50	3.43
Y	111	4.08	2.83	4.77	30.87	0.83	2.76	39.77
Z	119	2.80	1.55	1.32	4.16	0.96	2.51	7.39

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-101. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 47). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.79	-2.21	0.70	5.40	1.41	2.62	5.04
B	120	2.81	-2.19	0.73	5.37	1.38	2.66	5.44
C	120	2.92	-2.08	0.63	4.76	1.74	2.85	5.23
D	120	2.88	-2.12	0.72	5.07	1.66	2.80	4.86
E	120	2.98	-2.02	0.62	4.50	1.86	2.92	4.92
F	120	2.97	-2.03	0.78	4.77	1.67	2.96	5.86
N	116	2.71	-2.29	0.84	5.98	1.15	2.77	4.97
P	120	2.91	-2.09	0.63	4.78	1.59	2.84	5.24
Q	120	3.00	-2.00	0.57	4.34	1.94	3.01	5.12
X	111	1.67	-3.33	0.50	11.45	0.83	1.64	3.54
Y	117	6.14	1.14	5.09	27.20	0.86	4.72	29.88
Z	120	3.08	-1.92	1.09	4.88	1.29	2.88	7.67

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-102. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 48). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.18	-16.82	0.65	285.66	1.72	3.09	5.02
B	120	3.49	-16.51	0.90	275.73	1.87	3.34	6.56
C	120	3.58	-16.42	0.84	272.66	2.28	3.42	6.35
D	120	3.50	-16.50	0.93	275.45	1.80	3.38	7.21
E	120	3.59	-16.41	0.83	272.12	2.22	3.45	6.31
F	120	3.40	-16.60	0.93	278.86	1.71	3.25	7.15
N	120	3.50	-16.50	1.10	275.68	1.17	3.53	7.28
P	120	3.57	-16.43	0.86	272.82	2.10	3.47	6.35
Q	120	3.46	-16.54	0.74	276.53	2.16	3.37	5.63
X	116	1.68	-18.32	0.41	338.72	0.78	1.60	2.88
Y	120	9.92	-10.08	7.82	163.61	1.16	8.48	56.16
Z	120	3.47	-16.53	0.93	276.53	1.52	3.32	6.61

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-103. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 46). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.52	1.27	0.70	2.13	1.26	2.41	5.86
B	120	2.53	1.28	0.66	2.09	1.26	2.50	4.64
C	120	2.62	1.37	0.59	2.24	1.44	2.64	4.36
D	120	2.56	1.31	0.73	2.25	1.33	2.46	4.68
E	120	2.67	1.42	0.62	2.40	1.50	2.67	4.39
F	120	2.60	1.35	0.84	2.55	1.16	2.50	5.07
P	120	2.74	1.49	0.65	2.65	1.36	2.75	5.19
Q	120	2.82	1.57	0.72	3.00	1.51	2.84	5.95
X	120	1.52	0.27	0.67	0.53	0.48	1.39	3.47
Y	120	4.01	2.76	4.59	28.75	0.19	2.53	34.27
Z	120	2.81	1.56	1.38	4.33	1.00	2.42	7.15

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-104. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 47). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-2.18	0.70	5.27	1.39	2.64	4.83
B	120	2.82	-2.18	0.76	5.36	1.38	2.64	5.58
C	120	2.93	-2.07	0.65	4.72	1.70	2.88	5.16
D	120	2.89	-2.11	0.74	5.03	1.64	2.79	4.86
E	120	2.99	-2.01	0.63	4.45	1.86	2.96	4.93
F	120	3.00	-2.00	0.82	4.72	1.63	2.99	5.88
P	120	2.93	-2.07	0.63	4.71	1.70	2.85	5.14
Q	120	3.02	-1.98	0.58	4.29	1.91	3.03	5.15
X	120	1.62	-3.38	0.56	11.83	0.57	1.54	3.87
Y	120	6.49	1.49	7.90	64.61	0.44	4.60	73.15
Z	120	3.09	-1.91	1.12	4.94	1.04	2.84	8.52

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-105. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 48). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.16	-16.84	0.67	286.33	1.54	3.08	5.20
B	120	3.49	-16.51	0.89	275.57	1.97	3.38	6.30
C	120	3.57	-16.43	0.80	272.80	2.25	3.46	5.98
D	120	3.49	-16.51	0.93	275.91	1.67	3.32	7.47
E	120	3.59	-16.41	0.79	272.28	2.28	3.47	6.31
F	120	3.40	-16.60	0.93	278.75	1.79	3.21	6.23
P	120	3.58	-16.42	0.86	272.55	2.17	3.48	6.81
Q	120	3.46	-16.54	0.75	276.30	2.17	3.32	5.63
X	120	1.67	-18.33	0.48	339.00	0.67	1.62	3.57
Y	120	9.84	-10.16	7.02	153.26	1.18	8.69	45.62
Z	120	3.52	-16.48	1.00	274.98	1.58	3.34	6.60

(1) KEY TC PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-106. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 46). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.52	1.27	0.70	2.13	1.26	2.41	5.86
B	120	2.53	1.28	0.66	2.09	1.26	2.50	4.64
C	120	2.62	1.37	0.59	2.24	1.44	2.64	4.36
D	120	2.56	1.31	0.73	2.25	1.33	2.46	4.68
E	120	2.67	1.42	0.62	2.40	1.50	2.67	4.39
F	120	2.60	1.35	0.84	2.55	1.16	2.50	5.07
P	120	2.74	1.49	0.65	2.65	1.36	2.75	5.19
Q	120	2.82	1.57	0.72	3.00	1.51	2.84	5.95
X	104	1.64	0.39	0.63	0.56	0.82	1.48	3.47
Y	112	4.25	3.00	4.66	30.79	0.80	2.74	34.27
Z	119	2.82	1.57	1.37	4.37	1.00	2.47	7.15

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-107. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 47). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.82	-2.18	0.70	5.27	1.39	2.64	4.83
B	120	2.82	-2.18	0.76	5.36	1.38	2.64	5.58
C	120	2.93	-2.07	0.65	4.72	1.70	2.88	5.16
D	120	2.89	-2.11	0.74	5.03	1.64	2.79	4.86
E	120	2.99	-2.01	0.63	4.45	1.86	2.96	4.93
F	120	3.00	-2.00	0.82	4.72	1.63	2.99	5.88
P	120	2.93	-2.07	0.63	4.71	1.70	2.85	5.14
Q	120	3.02	-1.98	0.58	4.29	1.91	3.03	5.15
X	113	1.67	-3.33	0.53	11.46	0.93	1.58	3.87
Y	117	6.64	1.64	7.94	65.78	0.97	4.75	73.15
Z	120	3.09	-1.91	1.12	4.94	1.04	2.84	8.52

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-108. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 5 (RUN NUMBER 48). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.16	-16.84	0.67	286.33	1.54	3.08	5.20
B	120	3.49	-16.51	0.89	275.57	1.97	3.38	6.30
C	120	3.57	-16.43	0.80	272.80	2.25	3.46	5.98
D	120	3.49	-16.51	0.93	275.91	1.67	3.32	7.47
E	120	3.59	-16.41	0.79	272.28	2.28	3.47	6.31
F	120	3.40	-16.60	0.93	278.75	1.79	3.21	6.23
P	120	3.58	-16.42	0.86	272.55	2.17	3.48	6.81
Q	120	3.46	-16.54	0.75	276.30	2.17	3.32	5.63
X	113	1.72	-18.28	0.44	337.17	0.79	1.66	3.57
Y	120	9.84	-10.16	7.02	153.26	1.18	8.69	45.62
Z	120	3.52	-16.48	1.00	274.98	1.58	3.34	6.60

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-109. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 5 (RUN NUMBER 46). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.25

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.38	-3.22	3.44	22.27	-7.10	0.19	20.00
B	120	0.70	-2.90	2.91	16.95	-10.00	0.58	10.00
C	120	0.94	-2.66	2.46	13.19	-7.30	0.97	8.10
D	120	1.02	-2.58	3.23	17.10	-8.50	1.20	10.00
E	120	0.84	-2.76	2.45	13.73	-4.70	0.71	8.80
F	120	0.59	-3.01	3.50	21.39	-6.50	0.59	14.00
P	120	0.81	-2.79	2.51	14.16	-6.20	0.63	7.60
Q	120	0.66	-2.94	2.14	13.29	-5.00	0.68	6.70
X	120	0.59	-3.01	3.65	22.49	-7.00	0.61	17.00
Y	120	0.53	-3.07	3.44	21.35	-8.80	0.38	13.00
Z	120	0.58	-3.02	3.49	21.35	-8.80	0.56	16.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-110. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 5 (RUN NUMBER 47). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 5.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.37	-3.97	2.58	22.51	-6.40	-0.17	5.70
B	120	0.48	-3.12	2.72	17.23	-6.40	0.42	6.40
C	120	0.53	-3.07	2.52	15.82	-8.60	0.77	6.10
D	120	0.67	-2.93	3.20	18.84	-7.80	0.32	9.60
E	120	0.69	-2.91	2.14	13.14	-7.00	0.53	5.90
F	120	1.00	-2.60	2.96	15.57	-7.00	0.91	8.20
P	120	0.50	-3.10	2.45	15.72	-9.10	0.74	5.90
Q	120	0.57	-3.03	2.05	13.45	-5.60	0.53	5.30
X	120	0.55	-3.05	3.36	20.66	-8.00	0.48	7.20
Y	120	0.53	-3.07	2.88	17.76	-6.80	0.40	7.00
Z	120	0.59	-3.01	2.93	17.73	-6.20	0.51	6.70

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-111. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 5 (RUN NUMBER 48). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 20.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.02	-3.58	2.95	21.61	-6.90	-0.12	7.10
B	120	0.84	-2.76	2.93	16.30	-10.00	0.83	9.20
C	120	0.78	-2.82	2.32	13.41	-7.10	0.79	7.20
D	120	0.62	-2.98	3.06	18.33	-5.80	0.31	9.70
E	120	0.61	-2.99	2.14	13.56	-4.80	0.41	10.00
F	120	0.31	-3.29	3.11	20.61	-6.80	-0.04	15.00
P	120	0.52	-3.08	2.20	14.39	-5.10	0.62	9.20
Q	120	0.10	-3.50	1.91	16.04	-4.50	-0.09	9.90
X	120	1.24	-2.36	4.77	28.37	-14.00	0.55	17.00
Y	120	1.02	-2.58	3.22	17.09	-8.60	1.30	8.90
Z	120	1.11	-2.49	3.83	20.97	-12.00	0.74	12.00

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-112. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 55). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.96	1.71	1.11	4.18	1.36	2.70	7.86
B	120	2.99	1.74	1.13	4.35	1.15	2.87	9.36
C	120	3.11	1.86	1.07	4.62	1.37	2.99	8.28
D	120	3.04	1.79	1.27	4.84	1.21	2.74	9.30
E	120	3.19	1.94	1.16	5.14	1.16	3.03	9.79
F	120	3.17	1.92	1.64	6.38	1.23	2.86	14.21
N	120	2.00	0.75	0.89	1.35	0.57	1.85	5.00
P	120	3.23	1.98	1.14	5.25	0.92	3.09	8.39
Q	120	3.34	2.09	1.26	5.96	1.15	3.17	10.08
X	120	1.55	0.30	0.73	0.62	0.31	1.45	3.99
Y	120	3.96	2.71	4.75	29.96	0.22	2.54	30.02
Z	120	2.97	1.72	1.49	5.20	0.74	2.71	7.08

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-113. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 56). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.27	-1.73	1.27	4.63	0.84	2.93	12.63
B	120	3.32	-1.68	1.05	3.93	1.61	3.16	6.07
C	120	3.45	-1.55	0.92	3.28	1.86	3.29	6.73
D	120	3.32	-1.68	0.99	3.83	1.51	3.20	6.03
E	120	3.54	-1.46	1.00	3.15	2.02	3.32	8.09
F	120	3.52	-1.48	1.24	3.74	1.72	3.19	7.54
N	120	2.67	-2.33	0.93	6.36	0.79	2.75	5.50
P	120	3.44	-1.56	0.94	3.34	1.53	3.25	7.67
Q	120	3.54	-1.46	0.96	3.07	2.10	3.46	9.13
X	120	1.61	-3.39	0.61	11.96	0.19	1.56	3.79
Y	120	7.17	2.17	9.71	99.07	0.07	4.74	84.37
Z	120	3.18	-1.82	1.30	5.00	0.35	2.85	9.22

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-114. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 57). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.54	-16.46	0.87	274.03	2.18	3.33	7.09
B	120	3.92	-16.08	1.49	262.93	2.10	3.67	14.66
C	120	3.99	-16.01	1.15	259.83	2.41	3.83	10.50
D	120	3.84	-16.16	1.13	264.71	1.58	3.68	8.32
E	120	4.00	-16.00	1.05	259.25	2.37	3.87	8.56
F	120	3.75	-16.25	1.13	267.50	1.82	3.63	7.95
N	120	3.54	-16.46	1.14	274.65	0.93	3.54	7.13
P	120	3.98	-16.02	1.11	260.05	2.28	3.82	9.90
Q	120	3.83	-16.17	0.95	264.59	2.32	3.64	8.19
X	120	1.67	-18.33	0.48	339.10	0.56	1.59	3.09
Y	120	10.59	-9.41	8.43	160.30	0.38	8.62	55.97
Z	120	3.58	-16.42	1.03	272.82	1.35	3.28	6.21

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-115. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 55). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.96	1.71	1.11	4.18	1.36	2.70	7.86
B	120	2.99	1.74	1.13	4.35	1.15	2.87	9.36
C	120	3.11	1.86	1.07	4.62	1.37	2.99	8.28
D	120	3.04	1.79	1.27	4.84	1.21	2.74	9.30
E	120	3.19	1.94	1.16	5.14	1.16	3.03	9.79
F	120	3.17	1.92	1.64	6.38	1.23	2.86	14.21
N	113	2.08	0.83	0.85	1.42	0.84	1.93	5.00
P	120	3.23	1.98	1.14	5.25	0.92	3.09	8.39
Q	120	3.34	2.09	1.26	5.96	1.15	3.17	10.08
X	105	1.69	0.44	0.68	0.65	0.74	1.51	3.99
Y	108	4.33	3.08	4.87	33.27	0.70	2.91	30.02
Z	117	3.02	1.77	1.47	5.33	0.83	2.72	7.08

(1) KEY TO PROCESSING CODES:

- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-116. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 56). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.27	-1.73	1.27	4.63	0.84	2.93	12.63
B	120	3.32	-1.68	1.05	3.93	1.61	3.16	6.07
C	120	3.45	-1.55	0.92	3.28	1.86	3.29	6.73
D	120	3.32	-1.68	0.99	3.83	1.51	3.20	6.03
E	120	3.54	-1.46	1.00	3.15	2.02	3.32	8.09
F	120	3.52	-1.48	1.24	3.74	1.72	3.19	7.54
N	116	2.72	-2.28	0.89	6.02	1.14	2.77	5.50
P	120	3.44	-1.56	0.94	3.34	1.53	3.25	7.67
Q	120	3.54	-1.46	0.96	3.07	2.10	3.46	9.13
X	110	1.69	-3.31	0.57	11.42	0.76	1.61	3.79
Y	115	7.46	2.46	9.82	102.48	0.93	4.86	84.37
Z	119	3.21	-1.79	1.27	4.86	1.44	2.86	9.22

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-117. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 57). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.54	-16.46	0.87	274.03	2.18	3.33	7.09
B	120	3.92	-16.08	1.49	262.93	2.10	3.67	14.66
C	120	3.99	-16.01	1.15	259.83	2.41	3.83	10.50
D	120	3.84	-16.16	1.13	264.71	1.58	3.68	8.32
E	120	4.00	-16.00	1.05	259.25	2.37	3.87	8.56
F	120	3.75	-16.25	1.13	267.50	1.82	3.63	7.95
N	120	3.54	-16.46	1.14	274.65	0.93	3.54	7.13
P	120	3.98	-16.02	1.11	260.05	2.28	3.82	9.90
Q	120	3.83	-16.17	0.95	264.59	2.32	3.64	8.19
X	114	1.71	-18.29	0.45	337.52	0.96	1.63	3.09
Y	118	10.76	-9.24	8.39	156.46	1.15	8.76	55.97
Z	120	3.58	-16.42	1.03	272.82	1.35	3.28	6.21

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-118. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 55). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.97	1.72	1.17	4.36	1.23	2.76	8.16
B	120	2.99	1.74	1.18	4.44	1.16	2.88	10.44
C	120	3.09	1.84	1.05	4.50	1.46	3.00	8.36
D	120	3.01	1.76	1.27	4.74	1.10	2.74	9.57
E	120	3.16	1.91	1.15	5.02	1.29	2.97	9.54
F	120	3.13	1.88	1.55	5.94	1.24	2.85	12.67
P	120	3.22	1.97	1.15	5.24	0.95	3.10	8.41
Q	120	3.33	2.08	1.28	6.02	1.33	3.14	10.26
X	120	1.57	0.32	0.76	0.68	0.32	1.45	4.07
Y	120	4.16	2.91	5.62	40.16	0.24	2.62	35.81
Z	120	3.00	1.75	1.61	5.67	0.66	2.71	9.30

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-119. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 56). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.33	-1.67	1.32	4.55	0.93	3.05	12.25
B	120	3.35	-1.65	1.08	3.92	1.60	3.15	6.26
C	120	3.49	-1.51	1.02	3.33	1.81	3.27	8.80
D	120	3.36	-1.64	1.09	3.88	1.42	3.16	7.69
E	120	3.58	-1.42	1.11	3.27	2.01	3.37	10.50
F	120	3.59	-1.41	1.39	3.93	1.83	3.22	11.09
P	120	3.47	-1.53	1.03	3.41	1.64	3.31	9.68
Q	120	3.57	-1.43	1.10	3.28	2.03	3.45	11.65
X	120	1.61	-3.39	0.64	11.97	0.22	1.55	4.27
Y	120	8.27	3.27	15.13	239.57	0.15	4.90	123.90
Z	120	3.18	-1.82	1.32	5.11	0.47	2.96	9.76

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-120. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 57). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.51	-16.49	0.88	274.92	1.99	3.36	7.10
B	120	3.92	-16.08	1.50	263.07	1.98	3.68	14.87
C	120	3.98	-16.02	1.11	260.12	2.34	3.84	10.43
D	120	3.82	-16.18	1.15	265.40	1.53	3.59	8.74
E	120	3.99	-16.01	1.01	259.45	2.44	3.84	8.53
F	120	3.76	-16.24	1.17	267.24	1.88	3.55	8.07
P	120	3.98	-16.02	1.09	259.98	2.37	3.79	9.79
Q	120	3.83	-16.17	0.96	264.52	2.32	3.63	8.21
X	120	1.70	-18.30	0.54	338.01	0.59	1.66	3.83
Y	120	10.35	-9.65	7.17	145.34	0.38	8.82	46.07
Z	120	3.66	-16.34	1.13	270.67	1.42	3.42	7.99

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-121. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 55). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	2.97	1.72	1.17	4.36	1.23	2.76	8.16
B	120	2.99	1.74	1.18	4.44	1.16	2.88	10.44
C	120	3.09	1.84	1.05	4.50	1.46	3.00	8.36
D	120	3.01	1.76	1.27	4.74	1.10	2.74	9.57
E	120	3.16	1.91	1.15	5.02	1.29	2.97	9.54
F	120	3.13	1.88	1.55	5.94	1.24	2.85	12.67
P	120	3.22	1.97	1.15	5.24	0.95	3.10	8.41
Q	120	3.33	2.08	1.28	6.02	1.33	3.14	10.26
X	100	1.75	0.50	0.69	0.73	0.83	1.53	4.07
Y	108	4.56	3.31	5.79	44.61	0.82	2.85	35.81
Z	118	3.04	1.79	1.59	5.76	0.83	2.72	9.30

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-122. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 56). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.33	-1.67	1.32	4.55	0.93	3.05	12.25
B	120	3.35	-1.65	1.08	3.92	1.60	3.15	6.26
C	120	3.49	-1.51	1.02	3.33	1.81	3.27	8.80
D	120	3.36	-1.64	1.09	3.88	1.42	3.16	7.69
E	120	3.58	-1.42	1.11	3.27	2.01	3.37	10.50
F	120	3.59	-1.41	1.39	3.93	1.83	3.22	11.09
P	120	3.47	-1.53	1.03	3.41	1.64	3.31	9.68
Q	120	3.57	-1.43	1.10	3.28	2.03	3.45	11.65
X	111	1.69	-3.31	0.61	11.45	0.79	1.59	4.27
Y	116	8.54	3.54	15.31	247.12	0.93	5.07	123.90
Z	118	3.22	-1.78	1.29	4.87	1.20	2.98	9.76

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-123. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 6 (RUN NUMBER 57). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN- IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.51	-16.49	0.88	274.92	1.99	3.36	7.10
B	120	3.92	-16.08	1.50	263.07	1.98	3.68	14.87
C	120	3.98	-16.02	1.11	260.12	2.34	3.84	10.43
D	120	3.82	-16.18	1.15	265.40	1.53	3.59	8.74
E	120	3.99	-16.01	1.01	259.45	2.44	3.84	8.53
F	120	3.76	-16.24	1.17	267.24	1.88	3.55	8.07
P	120	3.98	-16.02	1.09	259.98	2.37	3.79	9.79
Q	120	3.83	-16.17	0.96	264.52	2.32	3.63	8.21
X	112	1.76	-18.24	0.50	335.79	0.93	1.68	3.83
Y	118	10.52	-9.48	7.11	141.25	1.16	9.05	46.07
Z	120	3.66	-16.34	1.13	270.67	1.42	3.42	7.99

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-124. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 6 (RUN NUMBER 55). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.25

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.36	-3.24	3.72	24.47	-7.70	-0.08	14.00
B	120	0.37	-3.23	3.45	22.40	-13.00	0.41	9.00
C	120	0.75	-2.85	2.55	14.68	-8.20	0.84	7.50
D	120	0.77	-2.83	3.89	23.27	-11.00	1.20	12.00
E	120	0.70	-2.90	2.59	15.21	-7.10	1.00	8.40
F	120	0.60	-3.00	4.12	26.00	-9.10	-0.08	13.00
P	120	0.59	-3.01	2.68	16.30	-9.10	0.54	8.00
Q	120	0.50	-3.10	2.31	15.05	-9.00	0.74	6.40
X	120	0.46	-3.14	4.35	28.86	-9.70	0.83	23.00
Y	120	0.38	-3.22	3.99	26.38	-7.80	0.47	18.00
Z	120	0.44	-3.16	4.16	27.36	-9.90	0.66	22.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-125. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 6 (RUN NUMBER 56). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 5.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.41	-4.01	3.32	27.28	-9.70	-0.29	8.10
B	120	0.41	-3.19	3.28	21.02	-7.70	0.48	11.00
C	120	0.49	-3.11	2.70	17.01	-8.70	0.54	6.40
D	120	0.67	-2.93	3.91	23.96	-8.20	0.15	13.00
E	120	0.62	-2.98	2.25	14.01	-7.00	0.61	6.20
F	120	1.04	-2.56	3.40	18.19	-7.80	0.68	9.20
P	120	0.48	-3.12	2.73	17.31	-9.20	0.55	8.90
Q	120	0.54	-3.06	2.26	14.57	-5.80	0.64	8.80
X	120	0.47	-3.13	4.10	26.74	-14.00	0.27	9.60
Y	120	0.42	-3.18	3.67	23.71	-12.00	0.54	10.00
Z	120	0.53	-3.07	3.69	23.13	-13.00	0.39	9.40

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-126. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 6 (RUN NUMBER 57). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 20.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.10	-3.70	3.08	23.31	-6.80	-0.22	9.00
B	120	0.76	-2.84	3.28	18.92	-11.00	0.88	9.40
C	120	0.71	-2.89	2.54	14.86	-6.70	0.75	8.40
D	120	0.50	-3.10	3.81	24.22	-11.00	0.30	14.00
E	120	0.59	-3.01	2.34	14.59	-4.90	0.41	11.00
F	120	0.31	-3.29	3.66	24.26	-14.00	0.16	18.00
P	120	0.50	-3.10	2.40	15.44	-5.40	0.58	9.50
Q	120	0.07	-3.53	2.04	16.72	-4.40	-0.16	10.00
X	120	1.21	-2.39	5.12	32.01	-19.00	0.71	17.00
Y	120	1.02	-2.58	3.66	20.11	-14.00	1.40	10.00
Z	120	1.10	-2.50	4.29	24.69	-17.00	0.97	13.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-127. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 58). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.40	2.15	1.22	6.17	1.82	3.11	7.91
B	120	3.37	2.12	1.56	6.97	1.14	2.93	12.05
C	120	3.37	2.12	1.19	5.92	1.70	3.13	7.02
D	120	3.22	1.97	1.41	5.90	1.45	2.91	10.47
E	120	3.48	2.23	1.24	6.54	1.69	3.13	8.62
F	120	3.53	2.28	2.01	9.26	1.46	3.09	16.92
N	120	2.35	1.10	0.88	2.00	0.64	2.37	5.30
P	120	3.50	2.25	1.28	6.72	1.56	3.21	7.91
Q	120	3.58	2.33	1.27	7.06	1.83	3.29	9.14
X	120	1.80	0.55	0.83	1.00	0.40	1.67	5.65
Y	120	7.89	6.64	18.40	383.10	0.72	3.38	150.10
Z	120	3.75	2.50	1.90	9.93	0.97	3.37	11.23

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-128. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 59). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.55	-1.45	1.44	4.19	1.55	3.47	10.56
B	120	3.65	-1.35	1.98	5.76	1.23	3.35	20.19
C	120	3.74	-1.26	1.28	3.25	1.81	3.51	11.13
D	120	3.62	-1.38	1.95	5.72	0.86	3.19	17.78
E	120	3.83	-1.17	1.34	3.19	1.97	3.52	11.32
F	120	3.76	-1.24	1.80	4.80	0.92	3.30	14.11
N	120	2.58	-2.42	0.89	6.69	0.72	2.50	6.53
P	120	3.81	-1.19	1.40	3.39	1.76	3.56	12.01
Q	120	3.93	-1.07	1.42	3.16	1.80	3.58	11.10
X	120	1.59	-3.41	1.25	13.28	0.37	1.42	12.99
Y	120	10.59	5.59	30.73	975.61	0.24	3.83	286.90
Z	120	3.49	-1.51	3.12	12.06	0.73	2.83	32.18

(1) KEY TO PROCESSING CODES:

A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-129. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 60). FLOW IS NOT INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.73	-16.27	1.82	270.41	1.53	3.42	16.86
B	120	3.79	-16.21	1.74	267.91	1.43	3.33	15.08
C	120	3.81	-16.19	1.30	266.01	1.94	3.61	10.80
D	120	3.57	-16.43	1.31	273.90	1.28	3.38	9.64
E	120	3.82	-16.18	1.35	265.86	2.09	3.57	10.62
F	120	3.51	-16.49	1.70	277.08	1.56	3.07	11.89
N	120	2.64	-17.36	1.00	304.75	0.65	2.61	7.17
P	120	3.81	-16.19	1.63	267.12	1.50	3.54	15.55
Q	120	3.84	-16.16	1.57	265.70	1.95	3.53	14.31
X	120	1.66	-18.34	0.87	340.02	0.25	1.51	5.41
Y	120	7.79	-12.21	14.70	366.39	0.21	4.27	132.90
Z	120	3.60	-16.40	2.00	275.22	0.41	3.11	10.96

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-130. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 58). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.40	2.15	1.22	6.17	1.82	3.11	7.91
B	120	3.37	2.12	1.56	6.97	1.14	2.93	12.05
C	120	3.37	2.12	1.19	5.92	1.70	3.13	7.02
D	120	3.22	1.97	1.41	5.90	1.45	2.91	10.47
E	120	3.48	2.23	1.24	6.54	1.69	3.13	8.62
F	120	3.53	2.28	2.01	9.26	1.46	3.09	16.92
N	116	2.41	1.16	0.84	2.06	0.97	2.44	5.30
P	120	3.50	2.25	1.28	6.72	1.56	3.21	7.91
Q	120	3.58	2.33	1.27	7.06	1.83	3.29	9.14
X	114	1.86	0.61	0.81	1.03	0.83	1.72	5.65
Y	118	8.01	6.76	18.54	389.65	0.84	3.43	150.10
Z	120	3.75	2.50	1.90	9.93	0.97	3.37	11.23

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-131. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 59). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.55	-1.45	1.44	4.19	1.55	3.47	10.56
B	120	3.65	-1.35	1.98	5.76	1.23	3.35	20.19
C	120	3.74	-1.26	1.28	3.25	1.81	3.51	11.13
D	120	3.62	-1.38	1.95	5.72	0.86	3.19	17.78
E	120	3.83	-1.17	1.34	3.19	1.97	3.52	11.32
F	120	3.76	-1.24	1.80	4.80	0.92	3.30	14.11
N	118	2.61	-2.39	0.87	6.50	0.96	2.51	6.53
P	120	3.81	-1.19	1.40	3.39	1.76	3.56	12.01
Q	120	3.93	-1.07	1.42	3.16	1.80	3.58	11.10
X	94	1.83	-3.17	1.31	11.85	0.85	1.61	12.99
Y	111	11.40	6.40	31.82	1053.84	0.69	4.46	286.90
Z	119	3.51	-1.49	3.13	12.01	0.96	2.85	32.18

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-132. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 60). FLOW IS NOT INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.73	-16.27	1.82	270.41	1.53	3.42	16.86
B	120	3.79	-16.21	1.74	267.91	1.43	3.33	15.08
C	120	3.81	-16.19	1.30	266.01	1.94	3.61	10.80
D	120	3.57	-16.43	1.31	273.90	1.28	3.38	9.64
E	120	3.82	-16.18	1.35	265.86	2.09	3.57	10.62
F	120	3.51	-16.49	1.70	277.08	1.56	3.07	11.89
N	117	2.69	-17.31	0.97	303.07	0.90	2.63	7.17
P	120	3.81	-16.19	1.63	267.12	1.50	3.54	15.55
Q	120	3.84	-16.16	1.57	265.70	1.95	3.53	14.31
X	103	1.82	-18.18	0.83	334.57	0.83	1.64	5.41
Y	115	8.11	-11.89	14.93	365.46	0.95	4.51	132.90
Z	119	3.63	-16.37	1.99	274.29	0.95	3.13	10.96

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- N: EQUATION 15U: PARENTS AND RECRUITS EACH OBTAINED BY SUMMING OVER 7 YEARS, WITH A 4 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-133. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 58). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.43	2.18	1.41	6.76	1.61	3.12	11.79
B	120	3.38	2.13	1.62	7.17	1.14	2.93	12.01
C	120	3.38	2.13	1.23	6.09	1.67	3.16	7.82
D	120	3.24	1.99	1.42	6.02	1.48	2.90	9.90
E	120	3.50	2.25	1.28	6.73	1.67	3.16	8.50
F	120	3.54	2.29	1.97	9.19	1.31	3.01	15.01
P	120	3.50	2.25	1.31	6.82	1.56	3.15	7.90
Q	120	3.58	2.33	1.29	7.14	1.82	3.30	8.86
X	120	1.80	0.55	0.87	1.07	0.38	1.65	4.84
Y	120	7.87	6.62	18.93	402.71	0.38	3.62	180.00
Z	120	3.76	2.51	2.00	10.33	0.91	3.43	10.21

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-134. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 59). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.54	-1.46	1.51	4.45	1.53	3.36	10.22
B	120	3.62	-1.38	1.62	4.56	1.09	3.36	13.04
C	120	3.73	-1.27	1.30	3.31	1.49	3.53	10.34
D	120	3.61	-1.39	1.90	5.56	0.68	3.18	16.32
E	120	3.83	-1.17	1.37	3.24	1.51	3.52	10.91
F	120	3.78	-1.22	1.94	5.26	0.62	3.37	14.42
P	120	3.83	-1.17	1.41	3.38	1.68	3.60	11.34
Q	120	3.93	-1.07	1.45	3.25	1.84	3.59	11.17
X	120	1.57	-3.43	0.88	12.61	0.27	1.42	7.00
Y	120	10.63	5.63	28.56	847.39	0.16	4.11	221.70
Z	120	3.40	-1.60	2.11	7.03	0.69	2.91	16.90

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-135. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 60). FLOW IS INCLUDED IN THE FITTED MODEL. ALL MODEL ESTIMATES ARE INCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.70	-16.30	1.85	271.30	1.49	3.29	17.15
B	120	3.84	-16.16	1.80	266.65	1.60	3.40	16.50
C	120	3.83	-16.17	1.31	265.51	1.94	3.59	11.56
D	120	3.56	-16.44	1.28	274.16	1.02	3.39	9.69
E	120	3.85	-16.15	1.34	264.80	2.15	3.61	10.92
F	120	3.59	-16.41	1.78	274.62	1.57	3.14	13.26
P	120	3.83	-16.17	1.66	266.31	1.60	3.58	16.28
Q	120	3.86	-16.14	1.56	265.13	1.86	3.52	14.44
X	120	1.71	-18.29	1.05	338.50	0.25	1.52	7.24
Y	120	9.41	-10.59	18.53	456.58	0.13	4.51	139.40
Z	120	3.68	-16.32	2.27	273.71	0.41	3.14	12.14

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-136. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 58). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 1.25
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.43	2.18	1.41	6.76	1.61	3.12	11.79
B	120	3.38	2.13	1.62	7.17	1.14	2.93	12.01
C	120	3.38	2.13	1.23	6.09	1.67	3.16	7.82
D	120	3.24	1.99	1.42	6.02	1.48	2.90	9.90
E	120	3.50	2.25	1.28	6.73	1.67	3.16	8.50
F	120	3.54	2.29	1.97	9.19	1.31	3.01	15.01
P	120	3.50	2.25	1.31	6.82	1.56	3.15	7.90
Q	120	3.58	2.33	1.29	7.14	1.82	3.30	8.86
X	110	1.90	0.65	0.84	1.14	0.72	1.75	4.84
Y	114	8.25	7.00	19.36	424.07	0.77	3.85	180.00
Z	120	3.76	2.51	2.00	10.33	0.91	3.43	10.21

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-137. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 59). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 5.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.54	-1.46	1.51	4.45	1.53	3.36	10.22
B	120	3.62	-1.38	1.62	4.56	1.09	3.36	13.04
C	120	3.73	-1.27	1.30	3.31	1.49	3.53	10.34
D	119	3.63	-1.37	1.89	5.45	0.88	3.19	16.32
E	120	3.83	-1.17	1.37	3.24	1.51	3.52	10.91
F	119	3.81	-1.19	1.92	5.14	0.90	3.37	14.42
P	120	3.83	-1.17	1.41	3.38	1.68	3.60	11.34
Q	120	3.93	-1.07	1.45	3.25	1.84	3.59	11.17
X	94	1.82	-3.18	0.84	10.94	0.74	1.62	7.00
Y	106	11.96	6.96	30.15	957.72	0.67	4.65	221.70
Z	118	3.45	-1.55	2.10	6.84	0.97	2.95	16.90

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-138. SUMMARY STATISTICS FOR MODEL ESTIMATES OF ALPHA, A PARAMETER IN THE RICKER MODEL, FOR CASE NUMBER 7 (RUN NUMBER 60). FLOW IS INCLUDED IN THE FITTED MODEL. MODEL ESTIMATES OF ALPHA WHICH ARE ASSOCIATED WITH NEGATIVE ESTIMATES OF BETA ARE EXCLUDED.

TRUE MODEL ALPHA = 20.00
TRUE MODEL GAMMA = 0.000036

PROC. CODE (1)	NO. OF OBS.	MEAN EST. ALPHA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM ALPHA	MEDIAN ALPHA	MAXIMUM ALPHA
A	120	3.70	-16.30	1.85	271.30	1.49	3.29	17.15
B	120	3.84	-16.16	1.80	266.65	1.60	3.40	16.50
C	120	3.83	-16.17	1.31	265.51	1.94	3.59	11.56
D	120	3.56	-16.44	1.28	274.16	1.02	3.39	9.69
E	120	3.85	-16.15	1.34	264.80	2.15	3.61	10.92
F	120	3.59	-16.41	1.78	274.62	1.57	3.14	13.26
P	120	3.83	-16.17	1.66	266.31	1.60	3.58	16.28
Q	120	3.86	-16.14	1.56	265.13	1.86	3.52	14.44
X	103	1.88	-18.12	1.03	332.52	0.81	1.58	7.24
Y	112	10.05	-9.95	19.03	461.81	0.82	4.63	139.40
Z	119	3.71	-16.29	2.26	272.77	0.76	3.15	12.14

(1) KEY TO PROCESSING CODES:
A: 4 YEAR LAG.
B: 5 YEAR LAG.
C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
D: 6 YEAR LAG.
E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
F: 7 YEAR LAG.
P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-139. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 7 (RUN NUMBER 58). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 1.25

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.19	-3.79	3.47	26.53	-14.00	-0.41	8.50
B	120	0.40	-3.20	3.99	26.22	-12.00	0.59	14.00
C	120	0.42	-3.18	2.66	17.22	-5.70	0.40	8.30
D	120	0.56	-3.04	3.85	24.14	-7.10	0.33	9.90
E	120	0.15	-3.45	2.25	17.06	-7.80	0.32	5.30
F	120	-0.65	-4.25	4.24	36.22	-18.00	-0.28	8.40
P	120	0.23	-3.37	2.44	17.41	-8.00	0.43	5.70
Q	120	-0.05	-3.65	1.93	17.20	-7.30	0.01	4.70
X	120	0.53	-3.07	4.29	27.91	-8.90	0.39	15.00
Y	120	0.75	-2.85	4.05	24.60	-8.00	0.79	15.00
Z	120	0.62	-2.98	4.09	25.67	-7.70	0.84	15.00

(1) KEY TO PROCESSING CODES:
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- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-140. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 7 (RUN NUMBER 59). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 5.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	0.38	-3.22	4.05	26.90	-14.00	0.80	12.00
B	120	0.93	-2.67	4.41	26.64	-13.00	0.57	16.00
C	120	0.56	-3.04	2.93	17.90	-12.00	0.33	7.30
D	120	0.39	-3.21	5.10	36.43	-21.00	0.20	12.00
E	120	0.36	-3.24	2.54	17.04	-12.00	0.34	7.70
F	120	0.39	-3.21	4.72	32.67	-13.00	0.44	21.00
P	120	0.39	-3.21	2.70	17.68	-12.00	0.39	9.10
Q	120	0.18	-3.42	2.31	17.11	-11.00	0.11	8.40
X	120	1.16	-2.44	5.12	32.19	-13.00	0.95	20.00
Y	120	1.09	-2.51	4.97	31.02	-12.00	0.77	18.00
Z	120	1.08	-2.52	4.81	29.59	-12.00	0.61	18.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).

TABLE D-141. SUMMARY STATISTICS FOR MODEL ESTIMATES OF GAMMA, THE COEFFICIENT RELATING RIVER FLOW TO SURVIVAL, FOR CASE NUMBER 7 (RUN NUMBER 60). ALL GAMMA VALUES HAVE BEEN SCALED BY MULTIPLYING BY 100,000 PRIOR TO ANALYSIS.

TRUE MODEL GAMMA = 3.60
TRUE MODEL ALPHA = 20.00

PROC. CODE (1)	NO. OF OBS.	MEAN EST. GAMMA	BIAS	STANDARD DEVIATION	MEAN SQUARE ERROR	MIN-IMUM GAMMA	MEDIAN GAMMA	MAXIMUM GAMMA
A	120	-0.28	-3.88	4.40	34.53	-13.00	-0.12	13.00
B	120	0.33	-3.27	4.12	27.74	-10.00	0.87	12.00
C	120	0.12	-3.48	2.97	21.06	-16.00	0.13	6.70
D	120	-0.23	-3.83	4.65	36.37	-29.00	0.24	12.00
E	120	-0.13	-3.73	2.80	21.84	-18.00	0.11	7.40
F	120	-0.53	-4.13	4.82	40.40	-22.00	-0.12	12.00
P	120	0.02	-3.58	2.86	21.12	-17.00	0.10	7.60
Q	120	-0.13	-3.73	2.49	20.21	-16.00	-0.23	6.60
X	120	0.74	-2.86	5.00	33.21	-15.00	0.78	17.00
Y	120	0.75	-2.85	5.18	34.97	-21.00	1.25	16.00
Z	120	0.79	-2.81	4.92	32.19	-15.00	1.10	17.00

(1) KEY TO PROCESSING CODES:
- A: 4 YEAR LAG.
- B: 5 YEAR LAG.
- C: RECRUITS OBTAINED BY AVERAGING 5 AND 6 YEAR LAGS.
- D: 6 YEAR LAG.
- E: RECRUITS OBTAINED BY AVERAGING 5, 6, AND 7 YEAR LAGS.
- F: 7 YEAR LAG.
- P: "MULTIPLE AGE" MODEL, EXHIBIT UT-58.
- Q: "EGGS ON EGGS" MODEL, EXHIBIT UT-58.
- X: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * P) (EQUATION 8U).
- Y: MATRIX MODEL REP = ALPHA * PEP * EXP (-BETA * PEP) (EQUATION 13U).
- Z: MATRIX MODEL R = ALPHA * P * EXP (-BETA * P) (EQUATION 14U).