

Scientific Foundation for Endangered Species Act Listing And Recovery Decisions-The Need for Good Science

**Charles H. Hanson, Ph.D.
Hanson Environmental, Inc.
132 Cottage Lane
Walnut Creek, CA 94595
(925) 937-4606 (office)
(925) 937-4608 (fax)**

Sound, objective scientific information forms the cornerstone for making objective decisions regarding the listing of a species for protection under the Endangered Species Act (ESA), identifying prudent protection measures, and evaluating recovery of a species. In essence, “good science leads to good decisions”. The quality of scientific information available and used in making ESA decisions, however, can be highly variable. The quality and reliability of scientific information ranges from very poor (e.g., sometimes referred to as voodoo biology, black-box analyses, SWAG-scientific wild-ass guess), intermediate (e.g., unpublished gray literature, anecdotal observations), and high quality sources of scientific information (e.g., rigorous sampling programs that are well documented, provide thorough statistical analysis, and have been subject to independent expert peer review). It needs to be recognized that the collection and analysis of information on the geographic distribution, trends in abundance, population dynamics, and other attributes of a species that are important in making informed decisions under the ESA are frequently difficult to achieve under real-life field conditions, are subject to substantial interannual variability in many cases which makes long-term studies necessary, and are rarely comprehensive and/or definitive in their conclusions. The variability inherent in these scientific investigations frequently leads to differing expert opinions, analyses, and interpretations of the scientific data underlying ESA decisions. As a result, the scientific foundation underlying many ESA decisions has been critically scrutinized and frequently challenged. Many of these challenges focus on the accuracy of the underlying biological information used to make ESA related decisions, inadequacy in the geographic or temporal distribution of surveys, disagreements regarding the reliability and approach to statistical analyses of the available data, the selective exclusion of certain data points or observations, questions regarding cause-and-effect relationships, the relative importance of various sources of mortality or other factors effecting population abundance, the appropriate length of the historic record for establishing and evaluating trends in population abundance, and a variety of other issues. Compounding these fundamental scientific issues and the associated uncertainty are the additional problems that arise from having poorly documented scientific reports and analyses, a potential for biased interpretations, misleading and/or incomplete reports, and other problems with the quality of the available scientific record. In response to the critical review and challenges to a number of scientific investigations used to support ESA related decisions, the quality of scientific investigations used to assess the status

of populations and the need for additional protections offered by the ESA has shown a general trend of improvement over the last decade.

In general, the characteristics of a well designed, robust, reliable, and scientifically defensible investigation used to support ESA related decisions would include:

- Clearly defined scientific objectives and/or testable hypotheses;
- Development of a study plan, circulated in advance of conducting the investigation to solicit peer and stakeholder review, based on a sampling design which is statistically reliable and robust;
- Detailed documentation of the scientific methods used in the investigation;
- Documentation of the resulting data and the associated quality assurance/quality control of the database;
- Application of the best available scientific methods for data collection and analysis;
- Documentation of the assumptions and data analyses;
- Documentation of the results of the surveys and/or experimental investigations;
- Documentation of all the data and analyses (typically in technical appendices) which would then be available for independent review;
- Disclosure and discussion of the strengths and weaknesses inherent in the underlying biological surveys and available data, identification of alternative hypotheses, identification of alternative conclusions and interpretations of the available data, and a clear and concise discussion of the linkage between specific analyses and findings and conclusions of the assessment; and
- Subjection of results of the analyses and all supporting information to an objective scientific peer review by experts knowledgeable in the field, in addition to providing review and comment opportunities for the public, interested stakeholders, resource and regulatory agencies, and other parties willing to participate in the scientific process of developing and evaluating an appropriate scientific foundation for ESA decisions.

Key elements of developing a good scientific foundation and record revolve around (1) a strong and rigorous scientifically based data collection effort to compile and synthesize relevant information regarding the specific ESA issues to be addressed, (2) adequate disclosure and documentation of the methods, results, analyses, and interpretation, and (3) objective scientific peer review and participation in the review process by other interested stakeholders and parties. Through this process, a scientifically defensible and objective foundation for making informed ESA decisions can be achieved.

A significant fraction of the available scientific information, compiled over a number of years, fails to meet the criteria outlined above. Much of the available information is published in gray literature which has not been subject to rigorous scientific peer review and quality control checks. Many of the available reports provide only partial and incomplete documentation of the experimental design and sampling methods, in many cases do not provide detailed documentation of results of analyses and the supporting data that would allow for independent reanalysis, and provide only limited geographic or temporal coverage. In addition, many of the previous studies were not conducted to meet the specific objectives of supporting ESA related decisions, but rather were performed as part of baseline monitoring efforts, resource inventories, management studies, academic investigations, or for other purposes and hence the sampling methods, experimental design, and study results may be only partially applicable to relevant ESA decisions. In the absence of more rigorous and definitive investigations, these previous studies represent the “best available science” despite their weaknesses and limitations. Under these circumstances, it is important that the available information be critically reviewed. Detailed documentation and disclosure should be provided on the strengths and weaknesses of the available information. The specific data and analyses used to derive scientific interpretation and findings should be presented. A disclosure and discussion of the uncertainty regarding the scientific underpinning should be described. Finally, a discussion should be included in the application of the results from one or more of these investigations within the overall decision making framework. The results of such a synthesis and analysis of studies should be documented, including complete documentation of the supporting data and studies, which would then be made available for critical scientific peer review by an objective independent panel of experts, in addition to review and comment by stakeholders and other interested parties.

Examples of the Type of Studies and Approach for Addressing ESA Fishery Issues

The scientific foundation for assessing the status of an aquatic (fish) species under the ESA, identification of appropriate protections (e.g., reduce sources of mortality, enhance and protect habitat, etc.) and for documenting recovery of a species would include scientific information on the following:

- Life history/life cycle of the species;
- Seasonal distribution of various lifestages of the species within different habitats;
- Geographic distribution of the species and changes in distribution within and between years and as a trend over time; (e.g. geographic distribution expansion, contraction, fragmentation)
- Habitat requirements for various lifestages of the species;
- Assessment of the quality and availability of the habitat suitable for various lifestages and changes in habitat conditions that have occurred historically;

- Results of a limiting factor analysis which identifies opportunities and constraints for factors affecting population dynamics of the species including reproductive success, survival, growth, successful migration and access to suitable habitat, and seasonal and interannual variability in environmental conditions;
- Linkages between physical habitat conditions and the carrying capacity and suitability of habitats for various lifestages of the target species; and
- Status of the population: population dynamics/fluctuations which may include trends in abundance, age-class distribution, age-specific mortality, resiliency of the population to recover from adverse environmental conditions, susceptibility of the population to a variety of sources of mortality, genetic structure and integrity of the population, and results of a probability of extinction analysis.

These and other fundamental scientific investigations serve as the foundation for evaluating the status of a species and the risk of extinction and/or recovery within the framework provided by the ESA.

In developing the scientific foundation for assessing and evaluating the status of a species or population, knowledge of the complete life cycle of the species and factors affecting survival of the species at various lifestages is fundamental. For example, for steelhead trout (Figure 1) the life cycle includes an ocean rearing stage, followed by the migration of adults in preparation for spawning as they move from the marine environment upstream into freshwater stream and river systems. Information on the migration of adults, not only in terms of physical habitat requirements (e.g., suitable water depths and temperatures for migration), but also the seasonal timing of adult migration and the environmental factors affecting migration timing are all important attributes of the life cycle to be taken into account. Information on the geographic distribution of spawning and the physical habitat requirements for successful spawning and egg incubation are also important factors to be taken into account when developing a sufficient scientific basis for evaluating population status and the factors affecting the population. Juvenile rearing habitat and factors such as predation mortality, availability of suitable habitat cover, availability of suitable prey, the effects of seasonal water temperature conditions and other water quality parameters, seasonal instream flows, vulnerability at water diversions, and a variety of other factors are taken into account when evaluating juvenile rearing. Factors affecting juvenile survival as they migrate downstream from the freshwater environment to the ocean are also important to take into account when developing an appropriate scientific foundation for evaluating factors affecting the species. A fundamental consideration in developing appropriate scientific investigations is a recognition that none of the individual lifestages of a species should be taken out of context with the entire life cycle. Information should be developed as part of rigorous scientific investigations for examining the factors affecting each of the individual lifestages of the species rather than focusing on only a narrow portion of the life history and/or geographic distribution of the species of interest.

There is a substantial body of scientific information (Table 1) available from the scientific literature that can be compiled and synthesized for use as part of the foundation for evaluating

habitat quality and availability and the factors affecting each of the various lifestages of the species. Information developed through scientific investigations on the life history cycle, habitat requirements, population dynamics, and factors affecting the species can then be used within the framework of a limiting factors analysis (Figure 2) to identify opportunities and constraints for species conservation.

Population Abundance Monitoring

Monitoring and interpreting information on trends in abundance of a species is one of the key scientific issues to be addressed as part of the foundation for ESA related decisions. Population abundance monitoring is critical for determining the number of individuals within the reproducing population which has a bearing on genetic integrity (e.g., minimum population size), the risk of extinction, and the resiliency of the population to rebound from adverse environmental conditions. For many species, however, determining the abundance of the population at any point in time is extremely difficult to accomplish. There is a high degree of uncertainty regarding population estimates for many species and, hence, there is no answer to the question raised in many ESA listing decisions as to “how many individuals of the species are there?”

In the absence of detailed information on the absolute abundance of individuals within a population, many ESA decisions are based on indices of abundance collected from various surveys over time to determine whether the population appears to be increasing or decreasing in abundance. Many listing decisions are based on results of monitoring studies showing that indices of abundance have decreased over some period of record. The interpretation of data on trends in abundance, however, can be extremely difficult and potentially misleading. For example, consider monitoring data on the number of adult fall-run Chinook salmon returning to the San Joaquin River tributaries to spawn. Had the monitoring been conducted over the period from 1985-1992 (Figure 3), the results would have shown a substantial decline in abundance which could have served as the basis for a petition and potential decisions to list the species for protection under the ESA, particularly given the low numbers of adults returning to the river during 1990, 1991, and 1992. In contrast, had the monitoring been conducted between 1977 and 1985 (Figure 4), the data would support a finding that the San Joaquin River fall-run Chinook salmon population is rapidly expanding, appears to be robust, and shows a high degree of resiliency. Both of these conclusions, drawn from actual monitoring data of trends in population abundance, do not provide a true and accurate depiction of the population dynamics of the species. When examining results of monitoring over a longer period of time (1961-1996), it becomes apparent that the San Joaquin River fall-run Chinook salmon population is characterized by high fluctuation and cyclic patterns in abundance which vary substantially among years (Figure 5) reflecting patterns of both increasing and decreasing abundance over time. Results of this simple example are intended to illustrate the potential for misinterpretation of monitoring results within the context of ESA decision making, and the critical need for scientifically valid, carefully reviewed, information for use in making informed decisions on resource status, conservation strategies, and the need for protection of the species under the ESA.

Concluding Remarks

Objective, quantitative, scientific data provide a strong foundation and cornerstone for informed decision making as part of the ESA. Collectively, the scientific community should continue to strive to provide the best information possible for use in making decisions regarding the protection of species, identification of conservation measures, monitoring recovery of populations, and evaluating the effectiveness of management actions implemented as part of ESA related actions. Unfortunately, much of the available scientific information does not meet these criteria for rigor including the basic experimental and sampling design, survey and experimental methods, data documentation, and critical scientific peer review. In light of these constraints, listing decisions are a balancing between the needs to provide legitimate protection for species truly threatened with extinction while avoiding needless listings of species on the basis of fragmented, incomplete, or in some instances misleading scientific information. Conflicts emerge between individuals wanting to provide protection for a species under the ESA based on an extremely conservative review of weak scientific information and, in many instances, a worst case approach to risk analysis and those individuals that require a high level of scientific rigor and confidence in the available scientific record before a listing decision is made. Given the uncertainties in scientific information and the inherent variability characterizing the population dynamics of many species, the burden of producing strong, objective, and scientifically credible information for use in ESA decision making is critical. Good science should support and lead to good management decisions within the framework provided by the ESA, and should set the standard for future decisions regarding listing of species as threatened or endangered, development of conservation strategies, and determining the performance of species recovery.

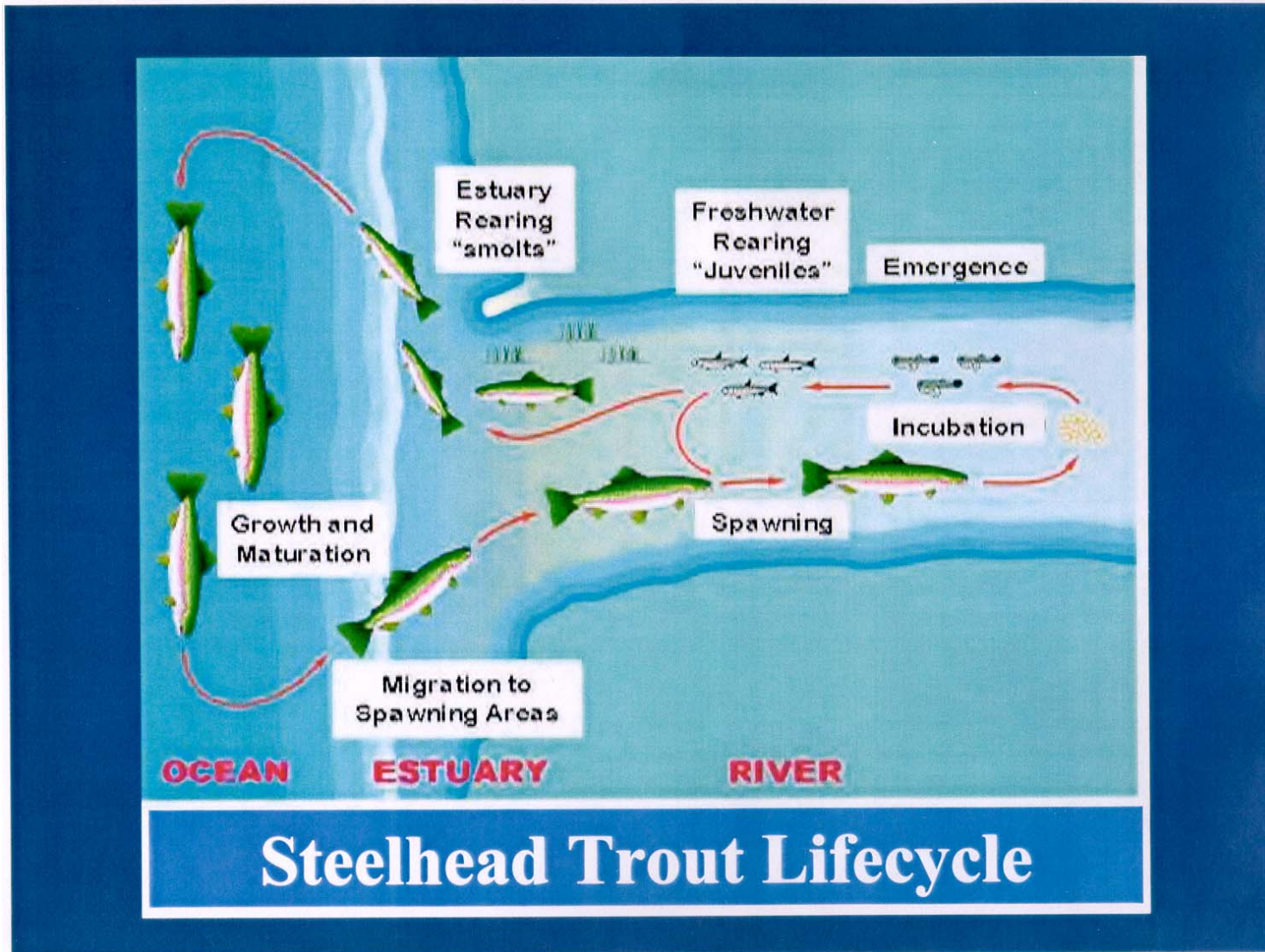


Figure 1. Steelhead trout lifecycle.

Table 1. Example of Chinook salmon habitat requirements.

CHINOOK SALMON life-history limiting factors

Life Stage	Parameter	Seasonal Period	Suitable/Optimal	Suboptimal/Stressful	Unsuitable	Citations
Species Requirements	Maximum/Minimum pH	Annual	7.5 - 8.0	5.5 - 7.5 8.0 - 9.0	< 5.5 > 9.0	Raleigh <i>et al.</i> , 1986
	Minimum dissolved oxygen (mg/l)	Temp 5 - 10 C Temp > 10 C	> 9 > 13	4.5 - 9 4.5 - 13	< 4.5 < 4.5	Raleigh <i>et al.</i> , 1986
	Nitrate-nitrogen (µg/l)	Late summer	0.15 - 0.25	0 - 0.15	0 or > 2.0	Raleigh <i>et al.</i> , 1986
Adult upstream migration/ passage requirements	Passage Depth (cm)	September-December	>12.5	9.5 - 12.5	< 9.5	Raleigh <i>et al.</i> , 1986
	Velocities					
	Water Temperature (C)	September-December	8 - 12 4.5 - 13 7 - 13 < 13.9	12 - 24 13 - 16 13 - 16 13.9 - 15.6	> 24 > 16 > 16 > 15.6	Raleigh <i>et al.</i> , 1986 Raleigh <i>et al.</i> , 1986 Raleigh <i>et al.</i> , 1986 Tetra Tech (Coyote Creek) 1999
Spawning Requirements	Redd sizes (m ²)	October-December	0.3 - 1.0			Bjornn & Reiser 1991
	Territory sizes (m ²)		1.3 - 2.0			Burner 1951
	Percent Fines in Spawning Gravels silt (<0.8 mm)	October-December	< 5	5 - 30	> 30	Raleigh <i>et al.</i> , 1986
	sand (0.8 - 30 mm)		< 5	5 - 40	> 40	Raleigh <i>et al.</i> , 1986
	Average substrate size (cm)	October-December	2-11 1.3 - 10.2	0.5 - 2	< 0.5	Raleigh <i>et al.</i> , 1986 Bjornn & Reiser 1991
	Velocities (cm/sec)	October-December				Healey 1991 Bjornn & Reiser 1991
	Average Column Velocity (cm/sec)	October-December	30 - 80 45 - 70	20 - 30 80 - 120 0 - 45 70 - 90	< 20 >120 0 > 90	Raleigh <i>et al.</i> , 1986 Sams and Pearson 1963
	Percent average annual low flow base*	October-December	> 50	0 - 50	0	Raleigh <i>et al.</i> , 1986
	Average annual peak flow as a multiple of average annual daily during egg incubation	October-December	2 - 2.9	1 - 2 2.9 - 6	>6	Raleigh <i>et al.</i> , 1986
	Depth (cm)	October-December	5 - 700 + >24 20 - 30	0 - 20 > 30	0	Healey 1991 Bjornn & Reiser 1991 Raleigh <i>et al.</i> , 1986
Eggs buried to Depths (cm)	October-December	18 - 61 20 - 43			Healey 1991 Bjornn & Reiser 1991	
Maximum temperature (eggs) spawning/egg incubation (C)	October-February	< 13.9 < 14	13.9 - 15.6 14 - 18	> 15.6 > 18	Tetra Tech (Coyote Creek) 1999 Raleigh <i>et al.</i> , 1986	

Framework for Evaluating Limiting Factors

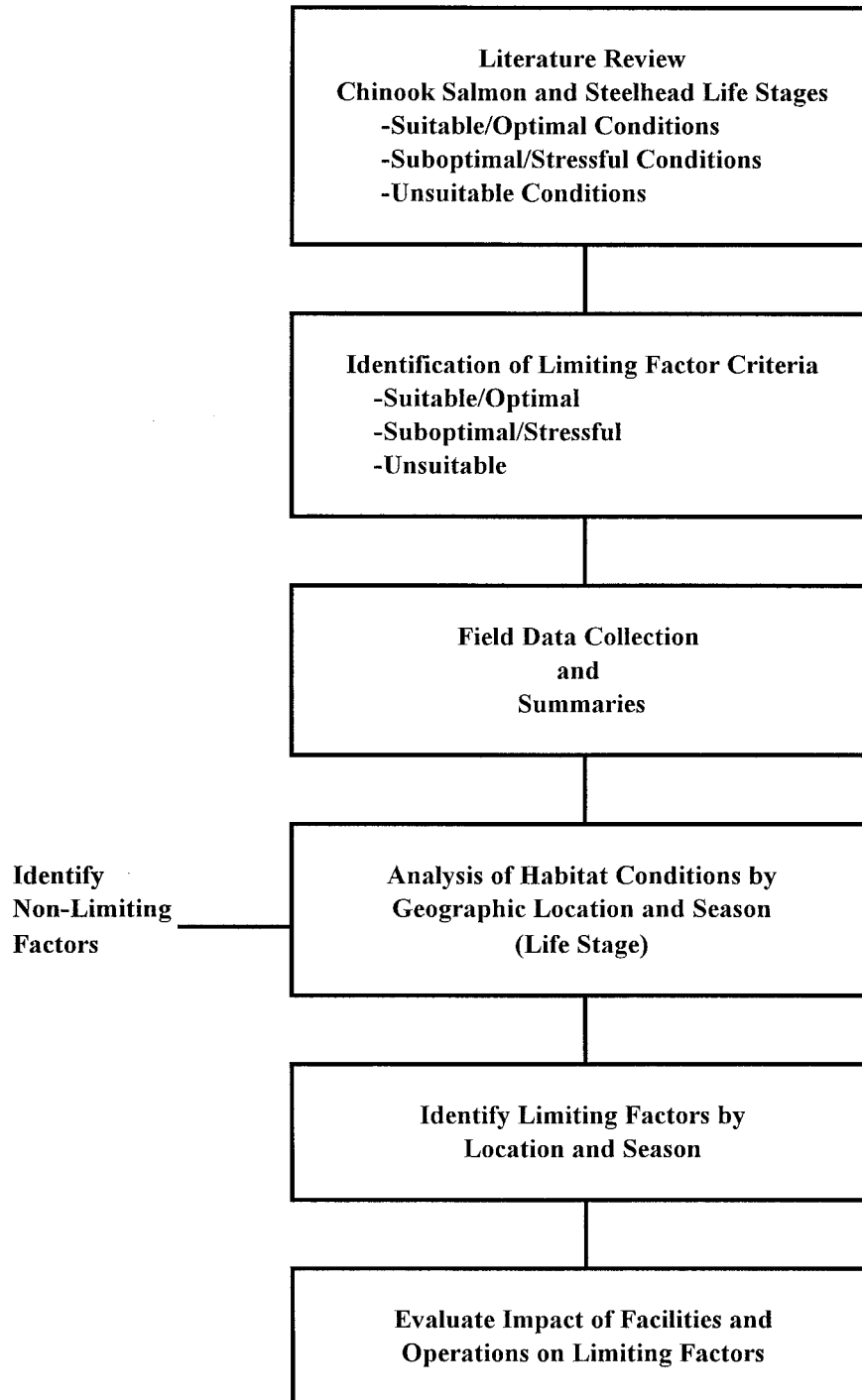


Figure 2. Framework for evaluating limiting factors.

**Fall-Run Salmon Escapement
1985-1992**

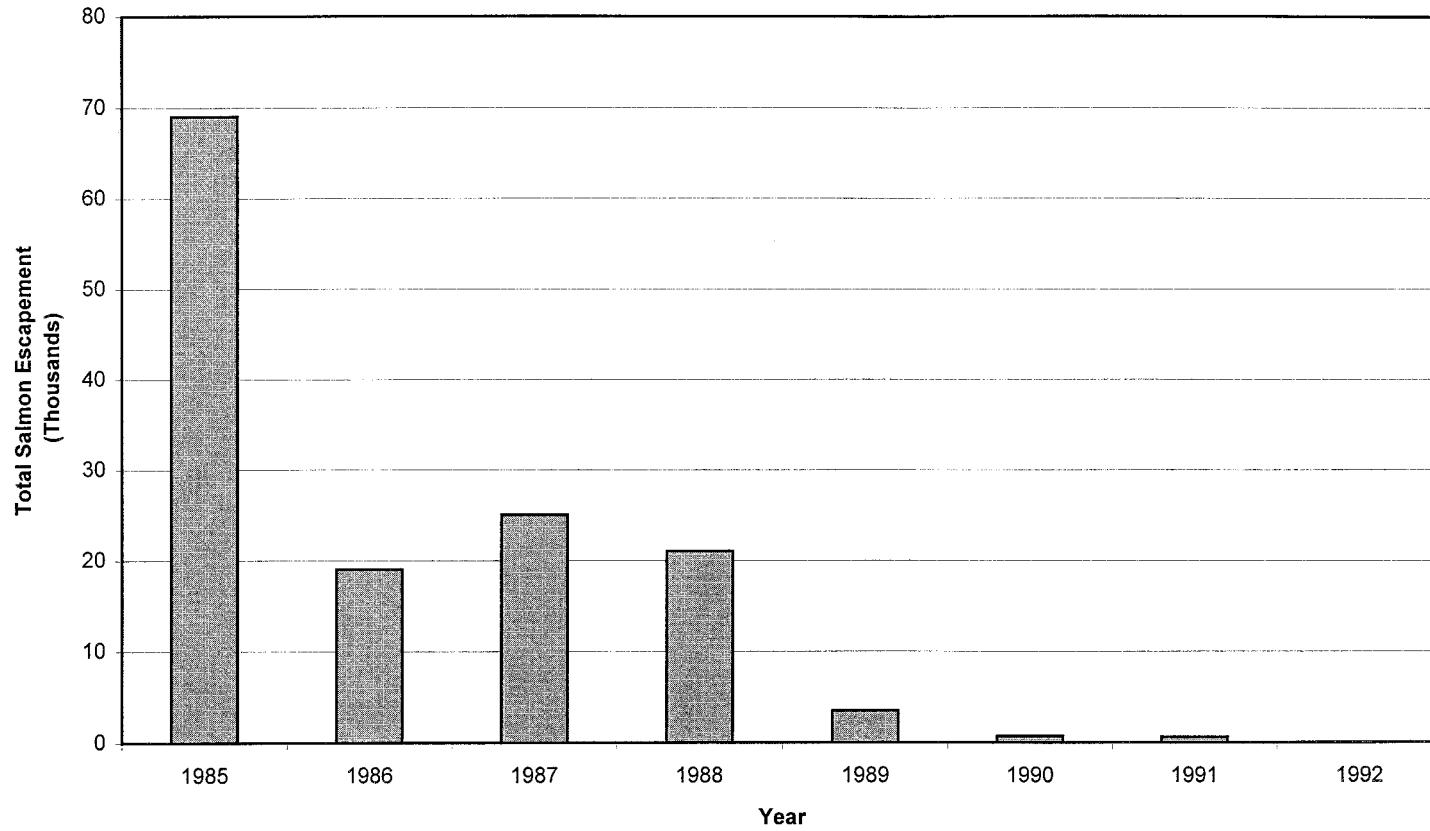


Figure 3. Results of adult Chinook salmon returns to the San Joaquin River: 1985-1992.

**Fall-Run Salmon Escapement
1977-1985**

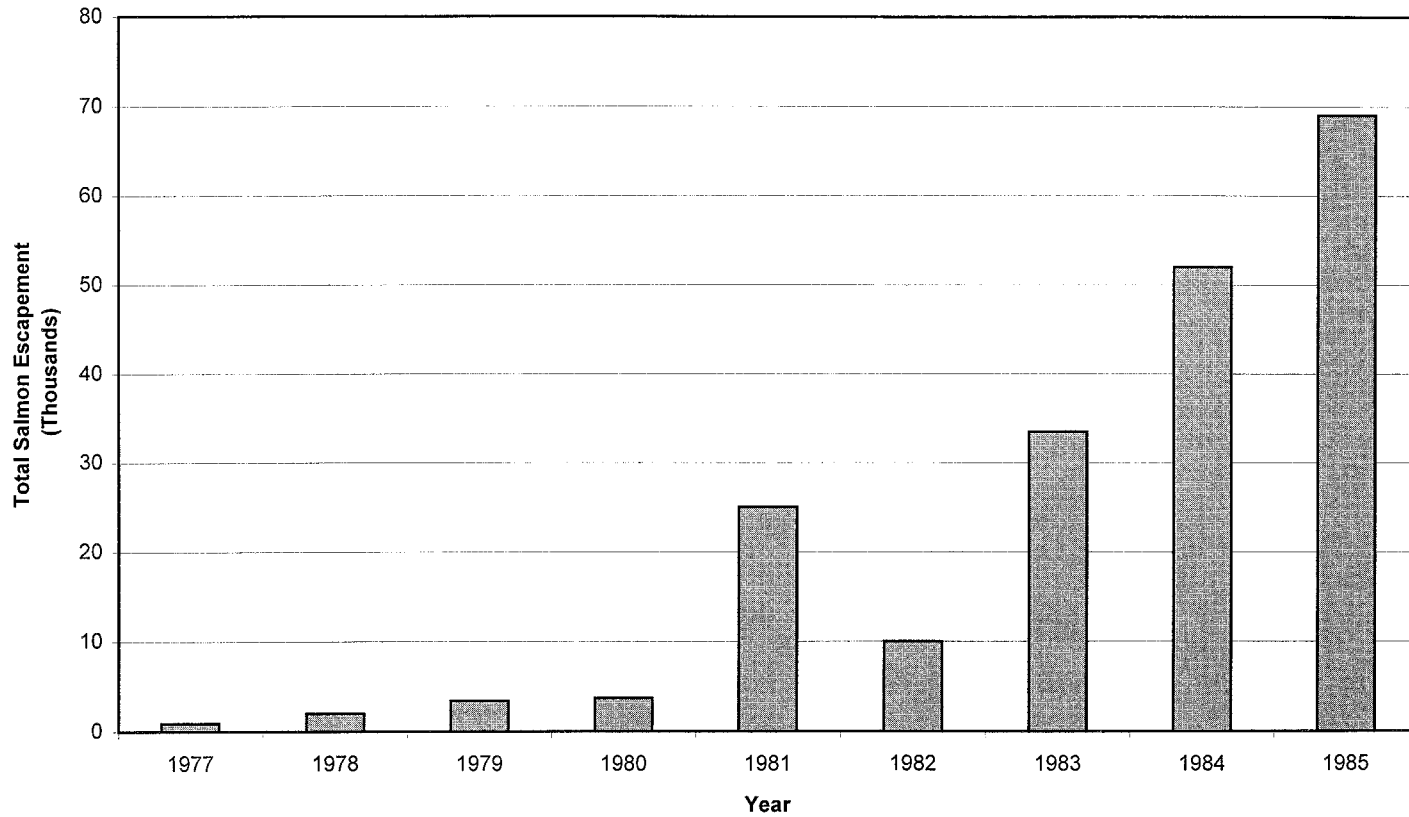


Figure 4. Results of adult Chinook salmon returns to the San Joaquin River: 1977-1985.

**Fall-Run Salmon Escapement
1961 - 1996**

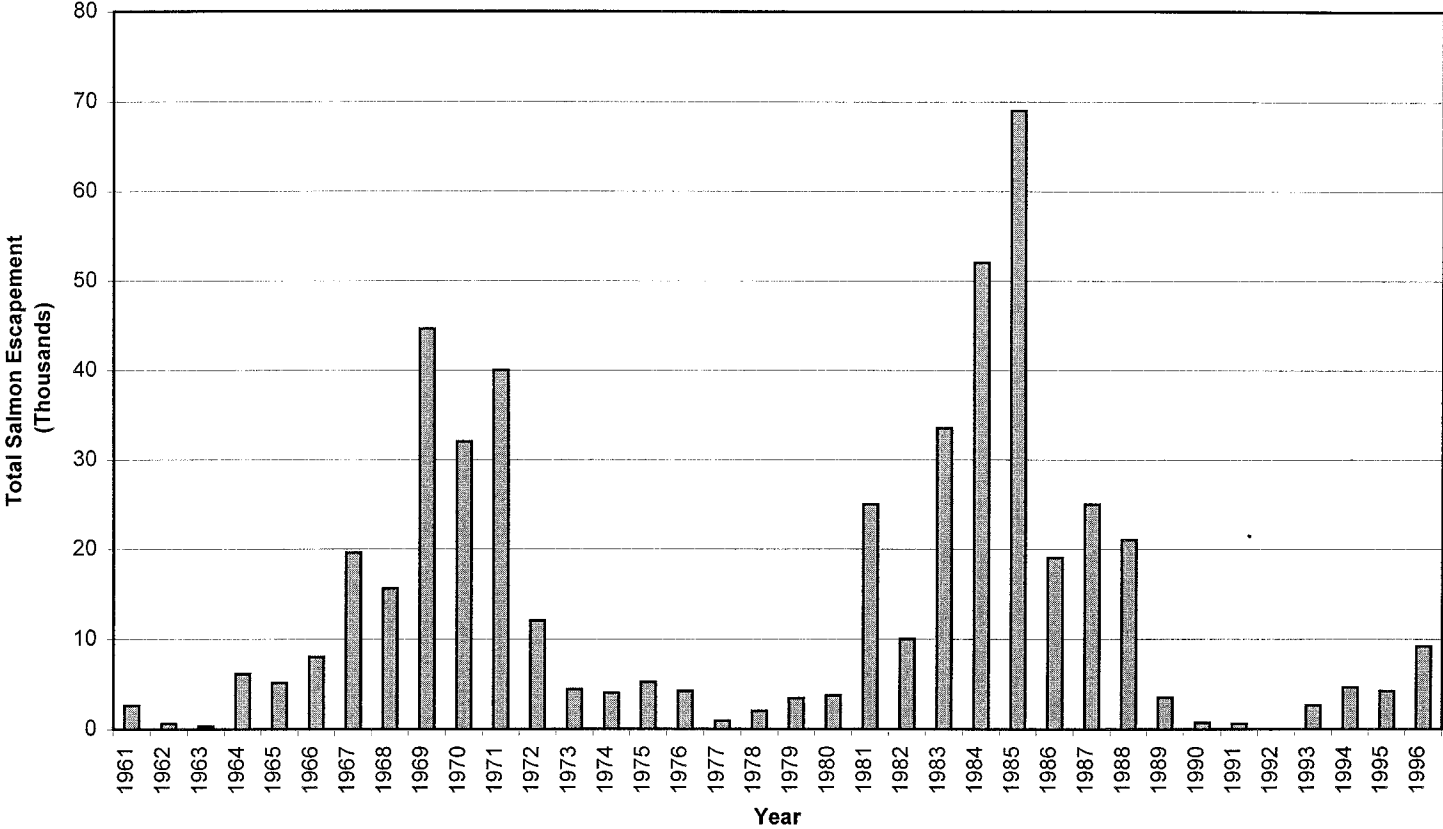


Figure 5. Results of adult Chinook salmon returns to the San Joaquin River: 1961-1996.