Annotated Bibliography for the Sacramento San-Joaquin Bay Estuary in Reference to Economic Value, Escapement, Restoration, and Salmon Populations

U.S. Fish and Wildlife Service

5-19-05

Introduction

This bibliography summarizes a broad range of literature relevant to salmon with emphasis on 1) the economic value of the fishery, 2) escapement, 3) restoration, and 4) salmon populations. An asterisk (*) in front of the first author's name denotes that such reference was not available in electronic format or PDF file.

a. Age composition, decline, distribution, genetics, management

***Davis, SF; Unwin, MJ. 1989. Freshwater life history of chinook salmon (Oncorhynchus tshawytscha) in the Rangitata River catchment, New Zealand. New Zealand Journal of Marine and Freshwater Research [N.Z. J. MAR. FRESHWAT. RES.], vol. 23, no. 3, pp. 311-319, 1989**

Abstract

"Migration and residence of chinook salmon (Oncorhynchus tshawytscha) in the Rangitata River and 1 of its tributaries (Deep Stream) were investigated during 1983-85, and compared with findings from similar studies undertaken in the nearby Rakaia River catchment during 1972-84. The estimated spawning population in Deep Stream was 748 plus or minus 161 in 1983, and 1071 plus or minus 147 in 1984. The seasonal timing of adult and juvenile movements in and out of Deep Stream was similar to that in Glenariffe Stream, a Rakaia River tributary, as was the development of a population of resident juveniles in spring and early summer. Juvenile salmon migration from Deep Stream appears to be less influenced by competition for rearing habitat than in Glenariffe Stream, suggesting that differences may exist between the egg to fry survival and/or rearing capacity in the 2 streams."

***Fisher, FW. 1994. Past and present status of Central Valley chinook salmon. Conservation Biology [CONSERV. BIOL.], vol. 8, no. 3, pp. 870-873, 1994.**

Abstract

"California's Central Valley chinook salmon populations are a fragment of their former abundance. Water development for hydroelectric production, irrigation, domestic water supplies, and flood control has restricted or eliminated much of the natural habitat formerly occupied by Central Valley salmon. Much of the species historical habitat has been replaced by hatcheries. Where certain runs are difficult to domesticate for hatchery culture, only isolated population remnants remain."

Greenwald, G.M.; Campton, D.E. 2005. Genetic Influence of Hatchery-Origin Fish to Natural Populations of Rainbow Trout in the Santa Ynez River, California. February 21, 2005. Submitted to U.S. Fish and Wildlife Service, Sacramento and Ventura, California, U.S. Geological Survey, Anchorage, Alaska.

Introduction

"Nielsen et al. (2003) used multi-locus genotypes at microsatellite, nuclear DNA (nDNA) loci and mitochondrial DNA (mtDNA) to examine the genetic structure of rainbow trout (*Oncorhynchus mykiss*) populations in the upper Santa Ynez River near Santa Barbara, California. They also compared mtDNA haplotype frequencies of those populations to those of hatchery populations and other naturally spawning populations in southern California. This synopsis summarizes those results and provides additional interpretations regarding the potential genetic contributions of introduced rainbow trout from hatchery populations to natural populations currently residing in the Santa Ynez watershed. This synopsis is intended primarily for non-geneticists and individuals responsible for water resource and land use planning in the Santa Ynez River basin."

***Healey, MC. 1994. Variation in the life history characteristics of chinook salmon and its relevance to conservation of the Sacramento winter run of Chinook salmon. Conservation Biology [CONSERV. BIOL.], vol. 8, no. 3, pp. 876-877, 1994.**

Abstract

"The highly variable life history of chinook salmon contributes to both the species' resilience and its apparent sensitivity to disturbance. Variation in chinook can be characterized on scales ranging from the geographic range of the species to variation within populations. Over its geographic range chinook are found in two primary forms, stream-type and ocean-type. Each form is widely distributed and is characterized by a different suite of life history characteristics including smolt age, oceanic distribution, run timing, spawning location, age at maturity, and fecundity. Winter run chinook in the Sacramento River appear to have characteristics intermediate between the two widely distributed forms and may represent a third successful suite of life history characteristics, albeit confined to a single river system. Within and among populations of each of these individual forms there is variation in adult and juvenile habitat use, migratory behavior, fecundity, and age at maturity."

***Heath, DD; Rankin, L; Bryden, CA; Heath, JW; Shrimpton, JM. 2002. Heritability and Y-chromosome influence in the jack male life history of chinook salmon (Oncorhynchus tshawytscha). Heredity [Heredity]. Vol. 89, no. 4, pp. 311-317. Oct 2002.**

Abstract

"Jacking in chinook salmon (Oncorhynchus tshawytscha) is an alternative reproductive strategy in which males sexually mature at least 1 year before other members of their year class. We characterize the genetic component of this reproductive strategy using two approaches; hormonal phenotypic sex manipulation, and a half-sib breeding experiment. We `masculinized' chinook salmon larvae with testosterone, reared them to first maturation, identified jacks and immature males based on phenotype, and genotyped all fish as male (`XY') or female (`XX' using PCR-based Y-chromosome markers. The XY males had a much higher incidence of jacking than the XX males (30.8% vs 9.9%). There was no difference in body weight, gonad weight, and plasma concentrations of testosterone and 17 beta -estradiol between the two jack genotypes, although XY jacks did have a higher gonadosomatic index (GSI) than XX jacks. In the second experiment, we bred chinook salmon in two modified half-sib mating designs, and scored the number of jacks and immature fish at first maturation. Heritability of jacking was estimated using two ANOVA models: dams nested within sires, and sires nested within dams with one-half of the half-sib families common to the two models. The sire component of the additive genetic variance yielded a high heritability estimate and was significantly higher than the dam component (h super(2) sub(sire) = 0.62 plus or minus 0.21; h super(2) sub(dam) = -0.14 plus or minus 0.12). Our experiments both indicated a strong sex-linked component (Y-chromosome) to jacking in chinook salmon, although evidence for at least some autosomal contribution was also observed."

***Kinnison, MT; Hendry, AP; Quinn, TP; Unwin, MJ. 2001. Migratory costs and the evolution of egg size and number in introduced and indigenous salmon populations. Evolution [Evolution]. Vol. 55, no. 8, pp. 1656-1667. 2001.**

Abstract

"The trade-off between reproductive investment and migration should be an important factor shaping the evolution of life-history traits among populations following their radiation into habitats with different migratory costs and benefits. An experimentally induced difference in migratory rigor for families of chinook salmon (Oncorhynchus tshawytscha), of approximately 86 km and 413 m elevation, exacted a cost to somatic energy reserves (similar to 17% reduction in metabolizable mass) and ovarian investment (13.7% reduction in ovarian mass). This cost was associated with a reduction in egg size and paralleled the phenotypic pattern of divergence between two introduced New Zealand populations of common origin, presently breeding at sites with different migration distances. The genetic pattern of divergence of these same populations, detected under common rearing, was consistent with compensation for migratory costs (the population that migrates farther invested more in ovarian mass), but egg number more than egg size was associated with this evolution. These evolutionary patterns are consistent with what is known of the inheritance of these traits and with trade-offs and constraints favoring initial evolution in offspring number over offspring size. Analysis of egg number-size patterns of other Pacific salmon populations in their native range supported the hypothesis that migration strongly influences patterns of reproductive allocation, favoring a higher ratio of egg number to egg size with greater migration distance."

***Kope, RG. 1988. Analysis of factors influencing the population dynamics of Chinook salmon, Oncorhynchus tshawytscha, in central California. DISS. ABST. INT. PT. B - SCI. & ENG. Vol. 49, no. 4, 122 pp. Oct 1988.**

Abstract

"The work presented here is organized into three papers. The first of these adapts the techniques of separable virtual population analysis to the complex life-history of chinook salmon. The model is then used to estimate historic realized fishing effort, and age-specific vulnerabilities for the commercial and sport fisheries in the ocean, and the age-specific probabilities of spawning from estimated recoveries of marked salmon reared in hatcheries. The second paper develops a theory for obtaining estimates of recruitment, or year-class strength, by deconvolution of abundance data. The theory is applied to commercial catch, sport catch and spawning escapement data from the period 1962 through 1986 to obtain recruitment estimates for the central California stock of chinook salmon. The accuracy of these estimates is then evaluated through Monte Carlo simulations. The third paper uses recruitment estimates obtained by deconvolution of the commercial and sport catches, total spawning escapement, and spawning escapement for individual streams for correlation analysis of environmental effects on recruitment. Correlations are calculated between abundance indices and the recruitment estimates, and environmental variables that could potentially affect both the freshwater and marine phases of salmon life-history, and the resulting patterns of correlations are compared with the results reported in previous studies. (DBO)"

Kutkuhn, J.H. 1963. Estimating Absolute Age composition of California salmon Landings. Fish Bulletin No. 120. California Department of Fish and Game.

Discusses the following; limitations of the processed data, the drawing of the sample, distribution of landings and sampling effort, access to individual catches: choice of vessel, consolidating raw data, age determination, definition of the parent population, age structure estimates: port-month landings, two-phase sampling for stratification, age sample size for a fixed length sample, two-phase vesus simple random sampling with varying age, sample costs, and estimating over-all age composition.

National Marine Fisheries Service. 1998. factors Contributing to the Decline of Chinook Salmon: an Addendum to the 1996 West Coast Steelhead Factors for Decline Report. National Marine Fisheries Service. Portland OR. June 1998.

Quote from the Purpose of the Report

"The purpose of this report is to compile and present available scientific information with respect to the factors of decline for west coast chinook salmon. The information contained in this report was presented to NMFS in response to requests for information relevant to completing the status review for chinook salmon, and has been sorted and reorganized in order to combine information on the factors for decline for west coast chinook salmon."

Nielsen, J.L.; Zimmerman, C.E.; Olsen, J.B.; Wiacek, T.C.; Kretschmer, E.J.; Greenwald,G.M.; Wenburg, J.K. 2001. Population Genetic Structure of Santa Ynez Rainbow Trout - Based on Microsatellite and mtDMA Analyses. Submitted to U.S. Fish and Wildlife Service, Sacramento, California.

Introduction

"Anadromous *O. mykiss* (steelhead) at the southern extent of their range occurred historically in streams flowing from San Francisco Bay (Gall et al. 1990) to the Baja California peninsula (Behnke 2002). Urban development and habitat modifications due to high freshwater demands for human consumption have greatly limited the distribution of anadromous steelhead throughout this area. Central and southern California *O. mykiss* are characterized by highly flexible life history strategies (Shapovalov and Taft 1954), and previous genetic studies (Gall et al. 1990; Nielsen et al. 1997a) suggest that isolated freshwater habitats may contain relic, nonanadromous components of the *O. mykiss* gene pool found in geographically proximate anadromous populations.

There has been considerable manipulation of *O. mykiss* in California hatcheries since the early 1800's (Busack and Gall 1980). Impacts of hatchery supplementation of *O. mykiss* on wild stocks in streams and reservoirs throughout North America over the last 200 years has been the subject of many studies (see reviews in Reisenbichler and McIntyre 1977, Waples and Do 1994, Campton 1995, and Nielsen 1999). The early findings of Gall et al. (1990) suggest that anadromous *O. mykiss* populations have residualized as freshwater fish behind man-made structures and dams throughout California. This study argues that residual freshwater populations of *O. mykiss* reflect genetic population structure similar to their putative anadromous progenitors.

There is significant public and scientific concern over what fragments of the freshwater component of this species are part of the evolutionary legacy of the species. This issue has previously been examined in other *O. mykiss* populations isolated by dams in California. For example, land-locked populations of *O. mykiss* on Alameda Creek were most closely related genetically to putative anadromous fish collected below the dam and known steelhead found in Lagunitas Creek, Marin County (Nielsen and Fountain 1999b; Nielsen 2003). Similar studies demonstrated genetic associations between freshwater resident and anadromous *O. mykiss* above and below man-made barriers on Pinole Creek (Nielsen and Fountain 1999a), San Francisquito Creek (Nielsen 2000), and San Mateo Creek (Nielsen and Sage 2002).

Three dams divide the Santa Ynez River – Gilbraltar Dam and Reservoir (completed in 1920), Juncal Dam and Jameson Reservoir (1930), and Bradbury Dam and Cachuma Reservoir (1953). This study represents genetic analyses of samples of land-locked populations from the upper Santa Ynez River drainage, collected in 2001, and analyzed in 2002. Samples were analyzed for microsatellite allelic diversity at the USGS Alaska Science Center's Molecular Conservation Genetics Laboratory, and for mtDNA diversity at the USFWS Conservation Genetics Laboratory, Anchorage, Alaska. We compared Santa Ynez River mtDNA haplotype frequencies to data from hatchery and wild southern California *O. mykiss*, both anadromous and resident life histories, available from previous studies in the Nielsen laboratory."

Pacific Fishery Management Council. 2003. Pacific Coast Salmon Plan: Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon and California as Revised Through Amendment 14 (Adopted march 1999). Pacific Fishery Management Council. September 2003.

Introduction

"This document is the *Pacific Coast Salmon Plan* of the Pacific Fishery Management Council (Council or PFMC) as revised and updated in 1998 for implementation in 1999. It guides management of commercial and recreational salmon fisheries off the coasts of Washington, Oregon, and California. Since 1977, salmon fisheries in the exclusive economic zone (EEZ) (three to 200 miles offshore) off Washington, Oregon, and California have been managed under salmon fishery management plans (FMP) of the Council. Creation of the Council and the subsequent development and implementation of these plans were initially authorized under the Fishery Conservation and Management Act of 1976. This act, now known as the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), was most recently amended by the Sustainable Fisheries Act (SFA) in 1996. The plan presented in this document contains or references all the elements required for an FMP under the Magnuson-Stevens Act. It completely replaces the 1997 version of the *Pacific Coast Salmon Plan*.

The Council's first salmon FMP and its environmental impact statement (EIS) were issued to govern the 1977 salmon season. A new salmon management plan and EIS were issued in 1978 to replace the 1977 documents. To establish management measures from 1979 through 1983, the 1978 FMP was amended annually and published along with a supplemental EIS (SEIS) and Regulatory Impact Review/Regulatory Flexibility Analysis (RIR/RFA). This annual process was lengthy, complex and costly. It lacked a long-range perspective and was too cumbersome to allow for timely implementation of the annual regulations and efficient fishery management. Therefore, in 1984, the Council adopted a comprehensive framework amendment that was designed to end the need for annual plan amendments and supplemental EISs (PFMC 1984).

The comprehensive framework plan amendment of 1984 (Amendment 6) replaced the 1978 plan as the base FMP document and established a framework of fixed management objectives with flexible elements to allow annual management measures to be varied to reflect changes in stock abundance and other critical factors. Subsequently, at irregular intervals, the Council has developed various amendments to portions of the framework plan to address specific management issues raised by participants in the salmon management process or as necessary to respond to reauthorization of the original Fishery Conservation and Management Act of 1976. The next seven amendments adopted since implementation of the framework FMP in 1984 were accompanied by an environmental assessment. The most recent, Amendment 14, was accompanied by and SEIS.

The primary amendment issues since 1984 have included specific spawner escapement goals for Oregon coastal natural (OCN) coho and Klamath River fall chinook (Amendments 7, 9, 11, and 13), non-Indian harvest allocation (Amendments 7, 9, 10, and 14), inseason management criteria (Amendment 7), habitat and essential fish habitat (EFH) definition (Amendments 8 and 14), safety (Amendment 8), a definition of overfishing (Amendments 10 and 14), management objectives for stocks listed under the Endangered Species Act (ESA) (Amendments 12 and 14), bycatch reporting and priorities for avoiding bycatch (Amendment 14), and selective fisheries (Amendment 14).

In 1996, as part of Amendment 12, the Council made an editorial update to the framework FMP that included incorporating all of the amendments after 1984 into the *Pacific Coast Salmon Plan* (PFMC 1997b). Subsequently, the Council modified the OCN coho management goals under Amendment 13 in 1999 (PFMC 1999). The current salmon FMP includes changes through Amendment 14 (PFMC 2000a), an extensive revision of the FMP primarily to respond to the SFA and to improve the readability and organization of the plan. Table 1 contains a complete listing of the issues in each amendment through Amendment 14.

This document is the current salmon FMP. Appendix A contains the complete description of essential fish habitat, Appendix B provides a description of the fishery, and Appendix C , which will always be the Council's most current annual review of the ocean fisheries, provides an annual updating of the fishery information. The reader may wish to refer to the original salmon FMP and individual amendment documents for more background and explanatory information, including the environmental impact assessments, EISs, and examples of management options not adopted by the Council."

***Utter, FM; Chapman, DW; Marshall, AR. 1995. Genetic population structure and history of chinook salmon of the upper Columbia River. EVOLUTION AND THE AQUATIC ECOSYSTEM: DEFINING UNIQUE UNITS IN POPULATION CONSERVATION., 1995, pp. 149-165, American Fisheries Society Symposium [AM. FISH. SOC. SYMP.], vol. 17**

Abstract

"Chinook salmon Oncorhynchus tshawytscha that return to the upper Columbia River (upstream from the confluence of the Yakima River) are considered from the perspectives of allelic variation at 32 polymorphic loci, historical activities within this region, and ancestral affinities to downstream populations. Collections of summer-fall-run fish are distinguished from spring-run fish by an eightfold greater genetic distance between groups than exists within either group. Each group was related to but remained distinct from adjacent downstream groups within different major ancestral units, previously identified throughout the Columbia River. Summer-fall-run fish are most closely related to fall-run fish of the mid-Columbia and Snake rivers, and spring-run fish to the spring-summer-run fish of the Snake River. In both groups, the present geographic distributions and genetic population structures within the upper Columbia River reflect translocations, confinements, and cultural activities between 1939 and 1943 under the Grand Coulee Fish Maintenance Project, and subsequent introductions and fish culture. The considerable genetic homogeneity within the summer-fall-run group appears to have been maintained through past and present interbreedings and strayings over a single continuous run. Some degree of genetic distinction persists between cultured and wild spring-run fish; the cultured fish are genetically indistinguishable from their ancestral source of the downstream Carson Hatchery, derived during the 1950s from fish returning to the upper Columbia and Snake rivers. The entire summer-fall-run group and the wild component of the spring-run group qualify for consideration as different evolutionarily significant units. Suggestions to conserve the genetic variation within these groups focus on measures that restrict excessive gene flow and permit maintenance and development of local adaptations."

***Waples, RS; Teel, DJ; Myers, JM; Marshall, AR. 2004. Life-History Divergence In Chinook Salmon: Historic Contingency And Parallel Evolution. Evolution [Evolution]. Vol. 58, no. 2, pp. 386-403. Feb 2004.**

Abstract

"By jointly considering patterns of genetic and life-history diversity in over 100 populations of Chinook salmon from California to British Columbia, we demonstrate the importance of two different mechanisms for life-history evolution. Mapping adult run timing (the life-history trait most commonly used to characterize salmon populations) onto a tree based on the genetic data shows that the same run-time phenotypes exist in many different genetic lineages. In a hierarchical gene diversity analysis, differences among major geographic and ecological provinces explained the majority (62%) of the overall G ST, whereas run-time differences explained only 10%. Collectively, these results indicate that run-timing diversity has developed independently by a process of parallel evolution in many different coastal areas. However, genetic differences between coastal populations with different run timing from the same basin are very modest (G ST < 0.02), indicating that evolutionary divergence of this trait linked to reproductive isolation has not led to parallel speciation, probably because of ongoing gene flow. A strikingly different pattern is seen in the interior Columbia River Basin, where run timing and other correlated life-history traits map cleanly onto two divergent genetic lineages (G ST similar to 0.15), indicating that some patterns of life-history diversity have a much older origin. Indeed, genetic data indicate that in the interior Columbia Basin, the two divergent lineages behave essentially as separate biological species, showing little evidence of genetic contact in spite of the fact that they comigrate through large areas of the river and ocean and in some locations spawn in nearly adjacent areas."

***Yoshiyama, R.M. 1999. A History of Salmon and People in the Central Valley Region of California. Reviews in Fisheries Science [Rev. Fish. Sci.]. Vol. 7, no. 3-4, pp. 197-239. Jul 1999.**

Abstract

"Chinook salmon (Oncorhynchus tshawytscha) formerly occurred in great abundance within the California Central Valley drainage and were a correspondingly important part of the subsistence economics and cultures of the indigenous peoples of that region. Salmon and other fishery resources on the Central Valley floor were part of a resource base that enabled resident Native American groups to attain some of the highest population densities to occur among the non-agricultural native societies of North America. Indirect estimates of aboriginal harvests prior to Euro-American settlement of the region indicate that the native fishers may have exploited the Central Valley salmon resource on a level comparable to that later attained by the immigrant Euro-American fishers of the late ninteenth century commercial fishery. The salmon resource also figured, to varying degrees, in native group interactions-- from trade item to causa belli. Among the last intact native groups in California reliant on a salmon-based subsistence economy were the McCloud River Wintua people who were instrumental in the successful operation of the U.S. Fish Commission egg-collecting station on the lower McCloud River that supplied salmon eggs for shipments to U.S. Eastern states and overseas countries. Prior to 1850, mention of salmon was made perodically by Spanish chroniclers and by European and (U.S.) American observers who traveled through the region."

Yoshiyama, R.M. Gerstung, E.R.; Fisher, F.W.; Moyle, P.B. 2001. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. Fish Bulletin No. 179. Volume 1. California Department of Fish and Game. Page 71 - 176.

Abstract

"Chinook salmon (*Oncorhynchus tshawytscha*) formerly were highly abundant and widely distributed in virtually all the major streams of California's Central Valley drainage—encompassing the Sacramento River basin in the north and San Joaquin River basin in the south. We used information from historical narratives and ethnographic accounts, fishery records and locations of in-stream natural barriers to determine the historical distributional limits and, secondarily, to describe at least qualitatively the abundances of chinook salmon within the major salmon-producing Central Valley watersheds. Individual synopses are given for each of the larger streams that historically supported or currently support salmon runs. In the concluding section, we compare the historical distributional limits of chinook salmon in Central Valley streams with present-day distributions to estimate the reduction of in-stream salmon habitat that has resulted from human activities—namely, primarily the construction of dams and other barriers and dewatering of stream reaches. We estimated that at least 1,057 mi (or 48%) of the stream lengths historically available to salmon have been lost from the original total of 2,183 mi in the Central Valley drainage. We included in these assessments all lengths of stream that were occupied by salmon, whether for spawning and holding or only as migration corridors. In considering only spawning and holding habitat (in other words, excluding migration corridors in the lower rivers), the proportionate reduction of the historical habitat range was far more than 48% and probably exceeded 72% because most of the former spawning and holding habitat was located in upstream reaches that are now inaccessible for salmon. Individual stream assessments revealed substantial differences among streams in the extent of salmon habitat lost. Some streams experienced little or no reduction (for example, Bear River, Mill Creek) while others were entirely eliminated from salmon production (for example, McCloud, Upper Sacramento, and Upper San Joaquin rivers.)

<u>b. Annual reports_DO_flow_limiting factors_restoration_spawning habitat_summer dams_X2</u>

California Department of Fish and Game. 2000. Spring-run Chinook Salmon, Annual Report Prepared for the Fish and Game Commission. Habitat conservation Division. Native Anadromous Fish and Watershed Branch. California Department of Fish and Game. March 2001.

Introduction

"This is the second annual report to the Fish and Game Commission for spring-run Chinook salmon since its listing as a threatened species on February 5, 1999. It builds on the following Department of Fish and Game (DFG) reports:

Status of Actions to Restore Central Valley Spring-run Chinook Salmon; February 1996

The Status of the Sacramento River Spring-run Chinook Salmon; December 1996

Central Valley Spring-run Chinook Salmon, A Status Report to the Fish and Game Commission, January-June 1997; June 1997

Status of Actions to Restore Central Valley Spring-run Chinook Salmon; December 1997

A Status Review of the Spring-run Chinook Salmon (*Oncorhyncus tshawytscha*) in the Sacramento River Drainage, Candidate Species Status Report 98-01; June 1998

Spring-run Chinook Salmon, Annual Report Prepared for the Fish and Game Commission; June 2000

This report includes spring-run chinook salmon adult counts for selected tributaries, monitoring activities, status of restoration and management activities, an update on Watershed Conservancy activities for selected tributaries, and updates on the Spring-run Salmon Protection Plan and the Juvenile Chinook Salmon Protection Decision Process. The numbers in this report for adult fish are based primarily on snorkel surveys where the actual fish were counted with the exception of Battle and Mill Creeks. Therefore, the term "spawning escapement estimate" is not used. Escapement estimates are usually derived by extrapolating the data into population estimates using a numerical formula. We have not done this, but presented the counts of fish actually seen. For Mill Creek, the estimate was calculated by expanding salmon redd counts within the spring run chinook spawning habitat. Battle Creek numbers were derived by combining the passage information gathered from both live trapping and underwater videography. The 2000 adult spring-run counts for the Sacramento River tributaries are visually represented in graph form in Appendix A. Contributors to this manuscript are listed in Appendix B."

California Department of Fish and Game. 2001. Spring-run Chinook Salmon, Annual Report Prepared for the Fish and Game Commission. Habitat conservation Division. Native Anadromous Fish and Watershed Branch. California Department of Fish and Game. October 2002.

Introduction

"The status of Sacramento River spring-run Chinook Salmon (*Oncorhynchus tshawystcha*) and previous monitoring, restoration, and management activities have been documented by the Candidate Species Status Report (CDFG 1998) and Annual Reports to the Fish and Game Commission (Commission) (CDFG 200, 2001). Scientific information related to spring-run Chinook salmon distribution, life history, and current issues has been reviewed by Moyle (2002). Conservation efforts of spring-run Chinook salmon stakeholders have also been reported (Bingham and Harthorn 2000). This document is the third annual Sacramento River spring-run Chinook salmon report to the Commission since its listing as a threatened species on February 5, 1999. This report describes population status, research and monitoring activities, and status of restoration and management. The report also provides an update on watershed conservancy activities on selected Sacramento River tributaries. Current issues, science, and research regarding spring-run Chinook salmon conservation are also discussed in this report."

California Department of Fish and Game. 2002. Sacramento River Winter-run Chinook Salmon 2000-2001 Biennial Report. Prepared for the Fish and Game Commission. California Department of Fish and Game. Habitat conservation Division. Native Anadromous Fish and Watershed Branch. California Department of Fish and Game. March 2002.

Introduction

"The Sacramento River winter-run chinook salmon was listed as endangered under the California Endangered Species Act on September 22, 1989. Since that time, the Department of Fish and Game (Department) has submitted annual reports to the Fish and Game Commission, summarizing the population status and management and recovery actions taken each year. Beginning in 2000, the reporting frequency was changed to a biennial basis. The Department remains strongly committed to the protection and recovery of the Sacramento River winter-run chinook. In the summer of 2001, the Department formed an internal Winter run Technical Team to improve winter-run science and management. The mission of the team includes identification of winter-run monitoring, research, and management needs, exchange of technical information, and development of sound technical recommendations for winter-run management. Team members include staff from the Native Anadromous Fish and Watershed Branch, Habitat Conservation Division, Marine Region, Northern California - North Coast Region, and Sacramento Valley - Central Sierra Region. The Department plans to develop a technically based management approach that includes appropriate monitoring and analysis to support a progressive adaptive management program for the entire life cycle of winter-runchinook.

This report summarizes winter-run population status, harvest management conservation measures, research, Central Valley-wide restoration programs, and restoration and management actions for 2000 and 2001."

California Department of Fish and Game. 2004a. Sacramento River Spring-run Chinook Salmon 2002-2003 Biennial Report. Prepared for the Fish and Game Commission. California Department of Fish and Game. Habitat conservation Division. Native Anadromous Fish and Watershed Branch. California Department of Fish and Game. June 2004.

Introduction

"The Sacramento River spring-run Chinook salmon (*Oncorhyncus tshawytscha*) was listed as a threatened species in February 1999 by the California Fish and Game Commission. Scientific information related to spring-run Chinook distribution, life history, and current issues has been reviewed by Moyle (2002). Conservation efforts of the spring-run Chinook stakeholders have also been reported by Bingham and Harthorn (2000). Spring-run Chinook population status and previous monitoring, restoration, and management activities have been documented by the Candidate Species Status Report (CDFG 1998), and following its listing, by annual reports to the Fish and Game Commission (Commission) (CDFG 2000, 2001, 2002). In 2002, the reporting frequency to the Commission was changed from an annual to a biennial basis. This document, therefore, describes spring-run Chinook population status, research and monitoring activities; status of restoration and management; and watershed conservancy activities in 2002 and 2003.

The Department's previous status review documented the reduction in range and distribution of Central Valley spring-run Chinook from historical conditions (CDFG 1998; Figures 1 and 2). Deer, Mill, and Butte creeks are now the principal streams still supporting spawning and rearing habitat for spring-run Chinook (Moyle 2002)."

California Department of Fish and Game. 2004b. Sacramento River Winter-run Chinook Salmon 2002-2003 Biennial Report. Prepared for the Fish and Game Commission. California Department of Fish and Game. Habitat conservation Division. Native Anadromous Fish and Watershed Branch. California Department of Fish and Game. June 2004.

Introduction

"The Sacramento River winter-run Chinook salmon was listed as endangered under the California Endangered Species Act on September 22, 1989. Since that time, the Department of Fish and Game (Department) has submitted annual reports to the Fish and Game Commission, summarizing the population status and management and recovery actions taken each year. Beginning in 2000, the reporting frequency was changed to a biennial basis. This report summarizes winter-run population status, harvest management conservation measures, research, Central Valley-wide restoration programs, and restoration and management actions for 2002 and 2003.

The Department remains strongly committed to the protection and recovery of the Sacramento River winter-run Chinook. In the summer of 2001, the Department formed an internal Winter-run Technical Team to improve winter-run science and management. The mission of the team includes identification of winter-run monitoring, research, and management needs; exchange of technical information; and development of scientifically-based recommendations for winter-run management. The Department plans to develop a technically based management approach that includes appropriate monitoring and analysis to support a progressive adaptive management program for the entire life cycle of winter-run Chinook.

The Department is also participating in the NOAA Fisheries recovery planning process for the Central Valley domain, which was initiated in 2003. Over the next two years, DFG will participate on the Technical Recovery Team that will identify population delisting criteria, factors for decline, limiting factors, early actions for recovery, and research, monitoring, and evaluation needs for winter-run Chinook, as well as spring-run Chinook and steelhead."

***Fisher, AC; Hanemann, WM; Keeler, AG. 1991. Integrating fishery and water resource management: A biological model of a California salmon fishery. Journal of Environmental Economics and Management [J. ENVIRON. ECON. MANAGE.], vol. 20, no. 3, pp. 234-261, 1991**

Abstract

"In this paper we develop a model to simulate the impacts of changes in freshwater flows into and out of the San Francisco Bay/Delta on the California Central Valley salmon fishery. The model also describes interactions among these water flow controls, hatchery operations, and harvest regulation. Traditionally, the management of California's freshwater resources and anadromous fisheries has been undertaken separately, in the literature and in practice. We demonstrate the potential gains from a coordinated management approach."

Hayes, S.P.; Lee, J.S. 1998. 1998 Fall Disolved Oxygen Conditions in the Stockton Ship Channel. California Department of Water Resources.

"Dissolved oxygen concentrations in the Stockton Ship Channel are closely monitored during the late summer and early fall of each year because levels can drop below 5.0 mg/L, especially in the eastern portion of the channel. The dissolved oxygen decrease in this area is apparently due to low San Joaquin River inflows, warm water temperatures, high biochemical oxygen demand (BOD), reduced tidal circulation, and intermittent reverse flow conditions in the San Joaquin River past Stockton. Low dissolved oxygen levels can cause physiological stress to fish and can block upstream migration of salmon."

Merz, J.E.; Setka, J.D. 2004. Evaluation of a Spawning Habitat Enhancement Site for Chinook Salmon in a Regulated California River. Reveived February 19, 2003; accepted June 16, 2003. North American Journal of Fisheries Management 24:397-407.

Abstract

"An evaluation of the effectiveness of a project to enhance spawning habitat for Chinook salmon *Oncorhynchus tshawytscha* was conducted in the Mokelumne River, a regulated stream in California's Central Valley. Approximately 976 m3 of clean river gravel (25–150 mm) was placed in berm and gravel bar configurations along the 45-m enhancement site. Physical measurements taken before and after gravel placement indicate that the project significantly increased channel water velocities, intergravel permeability, and dissolved oxygen; reduced channel depths; and equilibrated intergravel and ambient river temperatures. These positive benefits remained throughout the 30-month monitoring period. Adult Chinook salmon began spawning at the previously unused site within 2 months after gravel placement and continued to use the site during the three spawning seasons encompassed by the study. Bed material movement was documented by channel bathymetry surveys over two water years. Topographical channel surveys provide a useful tool for monitoring bed material transport and layering redd locations on contour maps. Although its usefulness in restoring salmon populations is poorly understood, gravel enhancement can be an effective means for improving salmon spawning habitat in rivers where upstream dams have effected low gravel recruitment."

Monismith, S. 1998. X2 Workshop Notes. Fall 1998. Interagency Ecological Program Newsletter. p. 6-13. Sacramento, CA.

Objectives of the Meeting from the Introduction Section

" 1. Refine our knowledge of X2 and its hydrodynamic and biological implications.

2. Provide stakeholders with a consensus statement about the value (or lack thereof) of X2 and the relevance and biological significance of the relationships of abundance to X2.

3. Clarify points of misunderstanding or technical disagreement.

4. Build on the Estuarine Ecology Team's discussion of probable mechanisms underlying the X2 relationships."

National Marine Fisheries Service. 2001a The Effects of Summer Dams on Salmon and Steelhead in California coastal Watersheds and Recommendations for Mitigating Their Impacts. Southwest Region, National Marine Fisheries Service. Santa Rosa, CA. July 23, 2001.

From the Problem Statement:

"The purpose of this paper is to examine the potential site-specific and cumulative effects of "summer dams" on anadromous salmonid species in California coastal streams. These species include coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawystcha*), and steelhead trout (*O. mykiss*). Specific objectives of this paper are to: (1) identify the likely effects of summer dams on these species; (2) review scientific literature pertaining to stream ecology and the ecology of anadromous salmonids as they relate to possible effects of summer dams on salmonid populations; and (3) propose scientifically-sound recommendations that would facilitate environmental regulatory review of summer dams in California."

National Marine Fisheries Service. 2001b. Instream Flow Needs for Steelhead in the Carmel River: Bypass Flow Recommendations for Water Supply Projects Using Carmel River Waters. National Marine Fisheries Service. Santa Rosa, CA. June 3, 2002

Quote from the Executive Summary

"Diversions of water from the Carmel Valley Aquifer have had a significant direct effect on surface flow in the Carmel River. During most years, the Carmel River goes dry downstream from approximately river-mile (RM) 6 or 7 by July. These reductions of flow and dewatering of the lower river have substantially reduced available steelhead habitat in the lower river. This report draws upon the extensive Carmel River fisheries and hydrologic data and other existing information to develop minimum flow guidelines and maximum rates of diversion for new off-stream storage projects for Carmel River water. The intent of this report is to provide information for developing long-term solutions for resolving ongoing impacts to steelhead an ater supply needs for the Carmel River Valley."

Pacific Fishery Management Council. 2004. Preseason Report III: Analysis of Council Adopted Management measures for 2004 Ocean Salmon fisheries. Pacific Fishery Management Council. Portland, OR. April 2004.

Introduction

"This is the last in a series of three preseason reports prepared by the Pacific Fishery Management Council's (Council) Salmon Technical Team (STT) and staff. The reports document and help guide salmon fishery management in the exclusive economic zone (EEZ) from three to 200 nautical miles off the coasts of Washington, Oregon, and California, and within state territorial waters. This report summarizes the STT analysis of the 2004 ocean salmon fishery management measures adopted by the Council for submission to the U.S. Secretary of Commerce, and serves as the basis for the Preferred alternative included in the National Environmental Policy Act (NEPA) analysis of proposed management measures. A biological evaluation of expected impacts on stocks listed under the Endangered Species Act (ESA) is included in Appendix A."

Pacific States Marine Fisheries Commission. U.S. Fish and Wildlife Service. 2004. Summary of the Ninth Pacific coast Steelhead Management Meeting. March 9 - 11, 2004. Port Townsend, WA.

Introduction

"From March 9-11, 2004, the Pacific States Marine Fisheries Commission, with partial support from the U.S. Fish and Wildlife Service – Sport Fish Restoration Program, sponsored the ninth in a series of workshops on steelhead (*Oncorhynchus mykiss*) management. The meeting, held in Port Townsend, Washington, was attended by approximately 60 Pacific Coast fisheries managers, researchers and other interested parties from the states of Alaska, Washington, Idaho, Oregon, and the province of British Columbia. Topics for this workshop included:

- an update on the status of steelhead in each management jurisdiction;
- updates on continuing steelhead life history research;
- steelhead escapement considerations and research;
- integrated vs. segregated steelhead management in Washington; and,
- contributed reports on current steelhead research projects.

An evening session was held featuring SalmonScape, a website of interactive maps featuring information on Washington salmon populations, created by WDFW.

The workshop was structured as a series of individual presentations by topic area, followed by a panel discussion and/or questions from the audience. The meeting allowed steelhead managers and researchers on a coastwide basis to discuss common problems and to share insights into possible solutions. The following abstracts prepared by the speakers summarize their presentations."

Pasternack, G.B.; Wang, C.L., Merz, J.E. 2002. Application of a 2D Hydrodynamic Model to Design of Reach-scale Spawning Gravel Replenishment on the Mokelumne River, California. River Research and Applications. River Res. Applic. 20: 205-225 (2004). February 12, 2004.

Abstract

"In-stream chinook salmon (Oncorhynchus tschawytscha) spawning habitat in California's Central Valley has been degraded by minimal gravel recruitment due to river impoundment and historic gravel extraction. In a recent project marking a new direction for spawning habitat rehabilitation, 2450m3 of gravel and several boulders were used to craft bars and chutes. To improve the design of future projects, a test was carried out in which a commercial modelling package was used to design and evaluate alternative gravel configurations in relation to the actual pre- and post-project configurations. Tested scenarios included alternate bars, central braid, a combination of alternate bars and a braid, and a flat riffle with uniformly spaced boulders. All runs were compared for their spawning habitat value and for susceptibility to erosion. The flat riffle scenario produced the most total, high, and medium quality habitat, but would yield little habitat under flows deviating from the design discharge. Bar and braid scenarios were highly gravel efficient, with nearly 1m2 of habitat per

1m3 of gravel added, and yielded large contiguous high quality habitat patches that were superior to the actual design. At near bankfull flow, negligible sediment entrainment was predicted for any scenario.

Reynolds, F.L.; Mills, T.J.; Benthin, R.; Low, A. 1993. Restoring Central Valley Streams: a Plan for Action. California Department of Fish and Game. Inland Fisheries Division. November 1993.

Quote from the Executive Summary

"The specific goals of this plan, as presented in Governor Pete Wilson's April 1992 water policy statement, are to restore and protect California's aquatic ecosystems that support fish and wildlife, and to protect threatened and endangered species. The goals of this plan also incorporate the State-legislated mandate and policy to double populations of anadromous fish in California."

Stillwater Sciences, Dietrich, W. 2002. Napa River Basin Limiting Factors Analysis: Final Technical Report. Prepared for San Francisco Bay Water Quality control Board and California State Coastal Conservancy. Stillwater Sciences and Professor William Dietrich. Berkeley, CA. June 14, 2002.

Abstract

"Although the abundance and distribution of salmon, steelhead, and other native aquatic species are believed to have declined substantially during the historical period, the Napa River and its tributaries continue to support an exceptionally diverse and almost entirely intact assemblage of native fishes including runs of steelhead, with habitat primarily in the tributaries, and fall-run Chinook salmon in the mainstem channel. In 1990, based on evidence of widespread erosion and concerns regarding adverse impacts to fisheries habitat, the Regional Board listed Napa River and its tributaries as impaired by too much sediment under Section 303(d) of the federal Clean Water Act. As such, the Regional Board is legally required to examine whether sediment is impairing habitat, and if so, to prepare a plan to reduce sediment supply as needed to facilitate self-sustaining populations of native aquatic species. The California State Coastal Conservancy (Coastal Conservancy) is a non-regulatory agency that is actively involved in restoration planning and project implementation in the Napa River watershed. It has a strong interest in funding additional projects in the Napa River watershed to restore and enhance natural habitats and processes throughout the watershed.

To serve the public trust, and to fulfill the responsibilities of our agencies, Regional Board and Coastal Conservancy funded a two-year study by the University of California, in collaboration with Stillwater Sciences, to evaluate factors limiting populations of three asterisk native species: 1) steelhead, which are federally listed as threatened in central California; 2) Chinook salmon, which are rare in Bay Area streams; and 3) California freshwater shrimp, which are federally listed as endangered. We conducted the study to evaluate the Regional Board's sediment listing and facilitate the Coastal Conservancy's restoration planning and project implementation, by addressing the following questions: 1) What are the primary factors currently limiting populations of steelhead, Chinook salmon, and California freshwater shrimp? 2) How important is sediment relative to other potential limiting factors? 3) What actions are needed to conserve or restore selfsustaining populations of these species?

The limiting factors study involved five sequential steps:

1) Review of available information and interview of local experts regarding the biological and physical attributes of the Napa River watershed to characterize the watershed and select initial sites for fieldwork;
2) The selection of three at-risk, analysis species for more in-depth study, the development of initial hypotheses regarding current habitat conditions and limiting factors, and reconnaissance field surveys to refine hypotheses and identify priorities for focused field studies;
3) Focused field studies to begin testing the most likely hypotheses about how current habitat conditions might limit analysis species;
4) Review and synthesis to identify significant limiting factors; and
5) Development of recommendations for future studies, to reduce uncertainty regarding limiting factors and determine cause-effect relationships, and to establish interim priorities to facilitate the conservation or recovery of native aquatic species, including steelhead, salmon, and freshwater shrimp.

In our focused studies (step 3), we developed a large amount of original data to describe physical habitat attributes in the mainstem of the Napa River and its tributaries including:
1) Pool filling with fine sediment measured at 136 sites in 29 reaches of 18 tributaries;

2) Permeability, the flow rate of water through streambed gravels, was measured at
59 potential spawning sites in 28 reaches of 17 tributaries, and 5 sites in 3 reaches of the mainstem channel;
3) The duration of elevated turbidity following storms was measured at 18 sites in 16 tributaries following 4-to-5 storm events, and 6 mainstem sites following 5 storms;
4) Stream temperature was continuously monitored at 22 sites in 13 tributaries, and 6 mainstem sites over two dry seasons and one wet season; and
5) Late dry-season surface flow was described at 148 sites throughout the watershed.

We also compiled and extended previously collected fish passage barrier data, conducted a pilot study to examine juvenile steelhead growth during the summer months, interpreted historical and recent aerial photos, and conducted extensive field surveys of the mainstem channel (about 10 miles) and to describe current habitat (for salmon, freshwater shrimp, and steelhead) and geomorphic conditions, and changes in channel form between 1940's and present.

We found that pool filling with fine sediment is typically quite low with values less than 10 percent at 25 of 29 sites sampled. We also measured turbidity following storm runoff events and found that turbidity typically dropped to very low levels (less than 20 NTU) within 1-to-2 days to following peak runoff events. Therefore we concluded that pool filling and chronic turbidity do not appear to be significant limiting factors for the analysis species under present-day conditions. In contrast, measured values of permeability at potential spawning sites for steelhead and Chinook salmon were typically quite low as a result of fine sediment deposition in the streambed. Based on examination of data relating permeability to survival of incubating salmon eggs and larvae we predicted that mortality of incubating eggs and larvae in Napa River and its tributaries may often exceed 50 % between spawning and emergence. To help evaluate the effect of this level of mortality during incubation on steelhead run size, we performed a quantitative population dynamics modeling exercise using data from one tributary: Ritchie Creek. Based on this analysis, we concluded that current permeability values, although low, might only depress steelhead population by a small amount because it appears that available juvenile rearing habitat can be well seeded even with only 50 % survival during incubation. Our analysis also indicates however, that further reductions in permeability or spawning gravel quantity might cause a substantial decline in steelhead smolt production. Taking these findings into account, the Regional Board has concluded that the Clean Water Act sediment listing should be maintained. Additional studies are needed to determine whether the fine sediments causing low permeability are from natural or anthropogenic sources.

We also identified several other significant factors, in addition to low permeability, that appear to be limiting steelhead trout population size including: 1) the common occurrence of potentially stressful stream temperatures, with typical average daily summer temperatures in tributaries ranging from 15 to 20 °C, and a lack of dry season flow persistence over most riffles act in a synergistic fashion, and appear to severely limit growth of juvenile steelhead during summer months; 2) a large number of potential impediments and/or barriers in tributaries which may block or impede access to a large amount of otherwise suitable habitat; and 3) the amount of large wood in streams draining mixed evergreen forests, primarily the west side and Howell Mountain, appears to be much lower than would be expected for streams in unmanaged mixed evergreen forests (higher amounts of large wood would promote the retention of spawning gravels and an increase the frequency and quality of pools in tributaries).

Although large amounts of fine sediment are deposited throughout the mainstem channel, we do not conclude that this is a primary factor limiting the Chinook salmon population. Based on comparison of 1940 and 1998 aerial photographs of the mainstem channel, extensive channel surveys, and review of existing information, we conclude the mainstem channel has typically incised 4-6 ft (1-2 m), or more, between its mouth and a point upstream of Calistoga since the 1940s, and as a result the channel form has greatly simplified. Pervasive channel incision and habitat simplification have greatly reduced the quantity of habitat for spawning (gravel bars) and early juvenile rearing (riffle margins, side channels and sloughs), and greatly expanded habitat favored by introduced predator fish species (long deep pool-run habitat complexes). Channel incision and simplification appears to be the primary factor limiting salmon population. Considering the spatial extent, nature, and magnitude of the changes in channel form, we hypothesize that little increase in salmon population would occur as a result of a substantial reduction in total and/or fine bed material supply to the mainstem channel. Complex habitat structure must first be restored on a large scale before habitat quality as affected by sediment (e.g., redd scour and permeability, and pool depth and cover) would begin to influence Chinook salmon population size. California freshwater shrimp (CFWS) are found in the mainstem and lower reaches of some tributaries. The details of the ecology and life history of CFWS are not well documented, however it is known that they require undercut bank habitat, in low velocity, moderately deep (1-3 feet [0.3-0.9 m]) stream reaches with overhanging riparian vegetation, aquatic vegetation, structurally complex streambanks with exposed roots, and submerged woody debris or live vegetation. CFWS are tolerant of warm stream temperatures and low flow, however they do not tolerate brackish water. We surveyed about 10 miles (16 km) of the mainstem channel, primarily between St. Helena and Calistoga, and found that on average about 3 percent by length of the stream surveyed possessed suitable habitat for CFWS. More information is needed to determine how the current distribution, abundance, and quality of habitat compares with historical conditions, together with more detailed understanding of the ecology and life history of CFWS.

Based on the above findings, we developed several recommendations for interim priorities for management actions and additional research to reduce uncertainty regarding limiting factors and determine cause-effect relationships between limiting factors, natural disturbances, and human activities. Recommendations include:

1) The development of detailed sediment budget to quantify relationships between land use and delivery of fine sediment to channels, and additional vigilance to prevent increased delivery, or preferably to reduce the delivery, of sediment to channels;

2) Conducting tributary surveys to identify potential barriers (and the amount of potential habitat affected) and quantify the amount and functions of large woody debris, coupled with studies to assess how various land and water use activities influence stream habitat quantity and quality, and actions to add large woody debris and increase woody riparian vegetation when opportunities arise;

3) Conducting more intensive historical analysis of mainstem, tributary, and estuary conditions and processes, and changes associated with human land and water uses to explore the potential costs and benefits associated with restoration actions designed to enhance the current runs of Chinook salmon or steelhead;

4) Conducting additional studies of the influence of flow, temperature, and food levels on juvenile steelhead growth rates and exploring opportunities to reduce water temperature by enhancing riparian vegetation to increase stream shading, reduce unnecessary or inefficient water use and thus increase summer baseflow in tributaries, and ensure that potential sources of turbidity are not increased or exacerbated; and

5) Conducting more studies on the distribution, abundance, and habitat needs of the California freshwater shrimp, investigate the geomorphic and ecological processes that create and maintain California freshwater shrimp habitat, and strongly encourage efforts to protect undercut bank habitat and associated riparian vegetation."

Tompkins, M.R.; Kondolf, G.M.; 2001. Integrating Geomorphic Process Approach in Riparian and Stream Restoration: Past Experience and Future Opportunities. In Farber, P.M. (ed.). 2003. California riparian systems: Processes and Floodplains Management, Ecology, and restoration. 2001. Riparian Habitat and Floodplains Conference Proceedings, riparian Habitat Joint Venture, Sacramento, CA.

Abstract

"Riparian and stream restoration efforts frequently focus on the restoration of desired channel forms within a stream corridor, often without consideration of the geomorphic processes that drive the development of those channel forms. As noted by the National Research Council (1992), many river channel and riparian restoration projects have failed because the underlying processes were not sufficiently well understood - rather they involved physical reconstruction of desired habitats, which were not sustainable without the processes to maintain them. Here we consider some distinct characteristics of process-based riparian and channel restoration projects, and review recent and ongoing restoration efforts emphasizing preservation or restoration of natural processes. Three case studies: the Sacramento River SB1086 program, the Clear Creek restoration program, and the realignment and restoration of Best Slough, illustrate the influence of factors such as watershed land use changes, water resource development, and urbanization on opportunities and constraints on process-based restoration."

West Coast Chinook Salmon Biological Review Team. 1999. Status Review Update for Four Deferred ESUs of Chinook Salmon: Central Valley Spring Run, Central Valley Fall and Late-Fall Run, South Oregon and California Coastal, and Snake River Fall Run. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. Seattle, WA. July 16, 1999.

Summary

"The Biological Review Team (BRT) for the updated west coast Chinook salmon status review met in Seattle, 22-24 June 1999 to discuss new information received regarding the status of four evolutionarily significant units (ESUs) under the Endangered Species Act (ESA) and reevaluate the ESU designations and risk determinations.

All four of the ESUs considered were proposed for listings under the ESA by NMFS (1998a) in early 1998. Two of the ESUs were proposed for threatened listings (Central Valley Fall- and Late-Fann Run and southern Oregon and California Coastal Chinook SalmonESUs), one was the modificzation of an ESU already listed as threatened (Snake River Rall-Run Chinook Salmon ESU), and one was proposed as endangered (Central Valley Spring-Run Chinook Salmon ESU). The final conclusions of the BRT are summarized below."

c. Juvenile abundance_adult catch and escapement_migration_environmental assessment

Brown, R.; Chapell, E. 1999. Chinook Salmon Catch and Escapement. Spring 1999. Interagency Ecological Program Newsletter. p. 38 - 41. Sacramento, CA.

Discusses PFMC actions, Central Valley Chinook salmon annual abundance index, ocean commercial and recreational catches, Sacramento Valley escapements, American, Feather, and Yuba River escapements, San Joaquin system escapements, and spring and winter run escapements.

Brown, R.; Chapell, E. 2000. Chinook Salmon Catch and Escapement. Spring 2000. Interagency Ecological Program Newsletter. p. 38 - 41. Sacramento, CA.

Discusses PFMC actions, Central Valley Chinook salmon annual abundance index, ocean commercial and recreational catches, Sacramento Valley escapements, American, Feather, and Yuba River escapements, San Joaquin system escapements, and spring and winter run escapements.

Hallock, R.J.; Elwell, R.F.; Fry, D.H. jr. 1970. Migrations of Adult King Salmon Oncorhynchus tshawytscha in the San Joaquin Delta as Demonstrated by the use of Sonic Tags. Fish Bulletin No. 151. California Department of Fish and Game.

Abstract

"Each fall, king salmon, Oncorhynchus tshawytscha, bound for the Sacramento and San Joaquin River systems, pass through the Sacramento-San Joaquin Delta. Starting in 1961, salmon runs of the San Joaquin, but not of the Sacramento, suffered a disastrous collapse, probably due to water conditions in the San Joaquin part of the Delta. A partial recovery started in 1964. An annually recurring oxygen block caused by pollution in the south-eastern part of the Delta, plus reversal of direction of flow in all three major north-south channels of the San Joaquin (southern) part of the Delta, were believed responsible for the collapse. In the eastern channel, flow reversal which lasts into the salmon migration period occurs only in exceptionally dry falls such as 1961; in the other channels it occurs annually. Reversal is caused by operation of a 4,600 cfs capacity pumping plant which pulls Sacramento River water south through channels that normally carry San Joaquin water north. From 1964 through 1967, salmon tagged with sonic tags were released in the central part of the Delta to determine their reaction to low oxygen levels and reversed flows. Electronic equipment enabled us to follow tags by boat and to record their movement past fixed points. Salmon avoided water with less than 5 ppm dissolved oxygen by staying farther downstream until the oxygen block cleared. Temperatures over 66° F. had a similar but less sharply defined effect. In 1964, pumped water and partial closure of one major west-flowing channel were used to force extra water through the polluted area and break up the oxygen block. At present pumping rates, this method is practical in dry years, but is not needed in normal or wet years. Relatively few fish used either of two western channels which had reversed flows but would have led them to their destination. The pattern of salmon movement is complicated by a large flow of Sacramento River water which diverts through the Delta Cross Channel and Georgiana Slough and flows successively through the Mokelumne and San Joaquin Rivers and back into the Sacramento. Some Sacramento salmon go upstream by this route. A second large pumping plant (10,000 cfs capacity) has recently been completed, and will greatly increase flow reversal problems until a closed canal system (such as the proposed Peripheral Canal) is used to conduct Sacramento River water to the two large pumping plants."

McLain, J. 2000. Juvenile Chinook Salmon Relative Abundance and Real Time Protection. Spring 2000. Interagency Ecological Program Newsletter. p. 31 - 34. Sacramento, CA.

Introduction

"The U.S. Fish and Wildlife Service (USFWS) monitors the abundance and distribution of juvenile chinook salmon (Oncorhynchus tshawytscha) in the lower Sacramento and San Joaquin rivers, Delta, and San Francisco and San Pablo bays using the beach seine. In addition, trawling is conducted at Sacramento and Mossdale to document the movement of juveniles into the Delta (from the Sacramento and San Joaquin basins respectively) and at Chipps Island to document the relative density of juveniles leaving the Delta.

Following is a discussion of relative abundance during the 1999 field season as well as a brief discussion of winter run and spring-run yearling protection efforts between October and March of the 1999 field season."

McLain, J.; Burmester R. 1999. Juvenile Chinook Salmon Relative Abundance and Real Time Protection. Spring 1999. Interagency Ecological Program Newsletter. p. 31 - 34. Sacramento, CA.

Introduction

"Juvenile chinook salmon abundance and distribution is monitored by beach seine in the lower Sacramento and San Joaquin rivers, the Sacramento-San Joaquin Delta, and San Francisco Bay. In addition, trawling at Sacramento and Mossdale is conducted to document the movement of juveniles into the delta. Trawling at Chipps Island is conducted to document the relative density of juveniles leaving the delta."

Snider, B.; Reavis, B.; Hill, S. 2001. 2000 Upper Sacramento River Winter-run Chinook Salmon Escapement Survey; May - August 2000. Stream Evaluation Program, Technical Report No. 01-11. April 2000. California Department of Fish and Game. Environmental Services Division.

Summary

"The California Department of Fish and Game's Stream Evaluation Program and the U.S. Fish and Wildlife Service's Red Bluff Fish and Wildlife Office jointly conducted a winter-run chinook salmon Oncorhynchus tshawystcha escapement survey in the upper Sacramento River during spring-summer 2000 to acquire data on abundance, age and sex composition of the spawner population, pre-spawning mortality, and temporal and spatial distribution of spawning activity. This was the fifth consecutive year that a winter-run escapement survey was conducted as part of a multi-year investigation to determine salmon habitat requirements in the Sacramento River system. The survey was conducted from 3 May through 29 August 2000. It covered the uppermost 14 miles of the Sacramento River accessible to migrating salmon, from river mile 288 (RM 288) upstream to Keswick Dam (RM 302).

Flows ranged from 8,400 cubic feet per second (cfs) on 12-13 May to 15,700 cfs on 26-27 July. Secchi disk depths (water transparency) ranged from 8.7 ft on 3-4 May to 20.0 ft on 10-11 August. Water transparency was much greater than during previous surveys providing more favorable survey conditions. Water temperature fluctuated from 51°F to 54°F during the survey. The peak in fresh carcasses observations occurred between 11 and 30 June 2000 indicating that spawning activity peaked during the first two weeks of June (2 weeks prior).

A total 2,482 carcasses (1,091 fresh and 1,391 decayed) was collected. Based on data from measured fresh carcasses (n=1,048), 97.3% of the population were adults and 2.7% were grilse. Overall, 18.2% of measured fresh carcasses were male and 81.8% were female; 16.6% of the adults were male and 83.4% were female. All of the 854 females checked for egg retention had completely spawned. Four adipose-tin-marked carcasses were collected; only one coded-wire tag (CWT) was recovered. The CWT was taken from a 1995 brood year late-fall run released from Coleman National Fish Hatchery.

A carcasses tag-and-recapture survey was used to estimate spawner escapement. A total of 1,053 fresh adult carcasses was tagged and 469 were subsequently recovered (45%). Three mark-and-recapture models were applied to the survey results and compared. The Petersen model was applied using the tag-and-recovery data for adult-sized, fresh carcasses to estimate the adult, winter-run escapement. Total escapement (adult and grilse) was estimated by expanding the adult estimate in proportion to the adult carcass composition in the fresh carcass sample (97.3%). The total population estimate was 6,670 including 6,492 adults and 178 grilse. Similar application of the Schaefer model yielded a total escapement population estimate of 5,707 (5,555 adult and 152 grilse). Application of the Jolly-Seber model and both fresh and decayed carcass data yielded a total escapement estimate of 4,343 (4,227 adult and 116 grilse).

The effective spawner population (e.g., total number of females that spawned) was estimated by applying the total composition of females (81.8%) and the percentage of completely spawned females (100%) to the three escapement estimates. Total effective spawner population estimates were 5,454 (Petersen estimate), 4,667 (Schaefer estimate), and 3,551 (Jolly-Seber estimate). In comparison, the effective spawner population estimate using winter-run count data collected at Red Bluff Diversion Dam was 517 (43% of the estimated escapement of 1,206 unmarked salmon)."

United States Department of Commerce. 2004. Environmental Assessment for the Annual Management Measures for the 2004 West Coast ocean Salmon Fisheries. April 29, 2004. National Oceanic and Atmospheric Administration. Silver Spring, Maryland.

Summary

"This action implements the Pacific Fishery Management Council's recommendations for 2004 ocean salmon management measures. Specific fishery management measures vary by fishery and by area. The measures establish fishing areas, seasons, quotas, legal gear, recreational fishing days and catch limits, possession and landing restrictions, and minimum lengths for salmon taken in the U.S. exclusive economic sone (3-200 nm) off Washington, Oregon, and California. The management measures are intended to prevent overfishing and to apportion the ocean harvest equitably among treaty Indian, non-treaty commercial, and recreational fisheries. The measures are also intended to allow a portion of the salmon runs to escape the ocean fisheries in order to provide for spawning escapement and for inside fisheries (fisheries occurring in state internal waters)."

d. Natural production_escapement_flow

Doubling goal graphs showing natural production, escapement, and flow.

e. Value of commercial and sport landings

California Department of Fish and Game. 2003a. Annual Report of Statewide Fish Landings by the Commercial Passenger Fishing Vessel (CPFV) Fleet. 2003. California Department of Fish and Game. Los Alamitos, CA.

The table contains statewide marine landing information for all species taken abord commercial passenger fish vessels.

California Department of Fish and Game. 2003b. Poundage and Value of Landings of Commercial Fish into California by Area - 2003. California Department of Fish and Game.

The table contains statewide marine landings by poundage and value of commercially caught fish.

California Department of Fish and Game. 2003c. Poundage and Value of Landings by Port, Monterey Area During 2003. California Department of Fish and Game.

The table contains marine landings by poundage and value of commercially caught fish in the Monterey area.

California Department of Fish and Game. 2003d. Poundage and Value of Landings by Port, San Francisco Area During 2003. California Department of Fish and Game.

The table contains marine landings by poundage and value of commercially caught fish in the San Francisco area.

Gallo, D.E.; Evans, K. 2003. The economic Benefits to Freshwater Anglers of Achieving the Anadromous Fish Restoration Program Fish Population goals for the Sacramento River System. April 25, 2003. Chico State University Symposium. Chico State University. Chico, CA.
The Sacramento River Sport Fishing Valuation study assessed the 1999 value of the Sacramento River sport fishery, and estimated the increase in value of the fishery as a result of achieving the AFRP doubling goals.

***Gillen, DW; McGaw, R. 1984. Economic value of salmon angling: Estimates of willingness to pay from hedonic price functions. Canadian journal of regional science/Revue canadienne des sciences regionales. Halifax NS [CAN. J. REG. SCI./REV. CAN. SCI. REG.], vol. 7, no. 2, pp. 181-193, 1984.**
Abstract
"Economic Value of Salmon Angling: Estimates of Willingness to Pay from Hedonic Price Functions": This paper utilizes an extension of hedonic price functions to examine the value of salmon leases auctioned by the New Brunswick government in 1979. The bid variations according to characteristics are determined, and this information is used to estimate the marginal value of salmon. The model yield estimates of the marginal willingness to pay for salmon per rod-day and thus provides useful information for evaluating salmonid enhancement programs or public access pricing."

***Laird, LM. 1988. The value of salmon to tourism is Scotland. INTERNATIONAL CONFERENCE: WILD SALMON -- PRESENT AND FUTURE. FRIDAY16th SEPTEMBER AND SATURDAY 17th SEPTEMBER 1988. SHERKIN ISLAND MARINE STATION, SHERKIN ISLAND, CO. CORK, IRELAND., (nd), pp. 82-87**
Abstract
"An examination is made of the relationship between tourism and salmon in Scotland from the point of view of angling, but also taking into account salmon farming and general tourist interest in salmon. Details are given of the structure of the salmon angling industry. The findings of a survey conducted to evaluate the economic value of salmon fishing in 3 selected areas of Scotland are also outlined. It is concluded that salmon play an important role in Scottish tourism; much of their importance relates to angling. However opportunities exist for the development of information centers concerning wild salmon to heighten public awareness of the life cycle of the fish, the hazards which they face, and also methods used to improve their survival."

National Marine Fisheries Service. 2004. NMFS Landings Query Results; 1967-2003.
The table contains marine landings by poundage and value of commercially caught Chinook and coho salmon for the State, frm 1967 through 2003.

Pacific Fisheries Management Council. 2004. Chapter IV; Socioeconomic Assessment of the 2004 Ocean Salmon Fisheries. 2004. Pacific Fisheries Management Council. Portland, OR.
Sections include the allocation of the salmon resource, commercial salmon fisheries, the west coast non-Indian commercial ocean fishery, ocean commercial salmon harvesters, west coast treaty Indian commercial ocean fishery, Columbia River commercial fishery, other inside commercial fisheries, ceremonial and subsistence salmon fisheries, recreational salmon fisheries, and salmon fishery income impacts and community dependence.

Pacific Fisheries Management Council. 2005. Review of 2004 Ocean Salmon Fisheries; Appendix A, B, C, D. Pacific Fisheries Management Council. Portland, OR. February 2005.
Appendix A - historical record of ocean salmon fishery effort and landings.
Appendix B - historical record of escapements to inland fisheries and spawning areas.
Appendix C - historical record of ocean salmon fishery regulations and a chronology of 2004 events.
Appendix D - historical economic data.