

UPPER SACRAMENTO RIVER
SALMON AND STEELHEAD ADVISORY COMMITTEE

Report No. 1
Red Bluff Diversion Dam
and
Tehama-Colusa Fish Facility

July 1983

UPPER SACRAMENTO RIVER SALMON AND STEELHEAD ADVISORY COMMITTEE

Appointed by the Director of the California
Department of Fish and Game
in December 1982

<u>Member</u>	<u>Representing</u>
Dan Frost, Chairman	Self (Attorney)
George Warner, Vice-Chairman	Tehama Fly Fishers
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Tom Maloney	Glenn County Fish, Game and Recreation Commission
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Dave Miller	Salmon Unlimited
Scott Ferris	Northern California Salmon and Steelhead Assn.
Chet Cordis	California Kamloops
Charlie Moss	Self (Businessman)
Joe Patten	Self (Engineer)
C. A. Stromsness	Self (Attorney)
Barry Hecht	Self (Hydrologist)

1/ Mr. Smith withdrew from an active role on the committee due to health reasons and Mr. Miller then represented Salmon Unlimited.

INTRODUCTION

Salmon and steelhead runs in the upper Sacramento River have experienced severe declines during the last thirty years. Above the confluence of the Sacramento and Feather rivers, the Sacramento's salmon numbers have fallen from spawning runs of about 400,000 fish per year that were common in the 1950s to less than 100,000 today. The average steelhead run thirty years ago was 20,000, but in recent years it has been less than half that number. This precipitous decline must be reversed and the fishery restored.

The deteriorating condition of the fishery is of major concern to the commercial fishing industry, sports fishermen, the tourist industry, and a wide range of economic and public interests that benefit from and who share in the responsibility for the perpetuation of this unique and irreplaceable resource.

The annual value of the commercial king salmon ocean catch off California is approximately \$40 million, of which 35% comes from the upper Sacramento. The salmon and steelhead sport fishing industry contributes additional tens of millions of dollars to the California economy each year, including many millions to hard-pressed local economies. The United States Bureau of Reclamation recently estimated that the combined sport and commercial value of the upper Sacramento River salmon fishery may be as high as \$86 million annually. In short, the upper Sacramento fishery is a major economic resource.

At the same time, the value of salmon and steelhead in California goes beyond its contribution to the economy. The fighting qualities of these fish are so great that fishermen often will travel hundreds, and sometimes thousands, of miles just for the chance to catch one. The fishery thus provides much needed enjoyment and recreation for thousands, the additional value of which cannot be measured in dollars alone. Perhaps because of their heroic life cycle that impels them to travel thousands of miles in the ocean and then return to the rivers of their birth, salmon and steelhead inspire wonder, and even awe, in fishermen and non-fishermen alike. We in California will be poorer in much more than economic terms if we allow this source of inspiration and enjoyment to dwindle and eventually perish.

Some of the causes of the decline of the fishery in the upper Sacramento, such as Delta diversions and an intensive ocean harvest, lie outside the upper river. But in the last two decades the fishery has declined dramatically in the upper Sacramento while it has remained relatively constant in the Feather River and has improved in the American River. This provides strong evidence that many of the causes of decline of the upper river fishery are to be found in the upper Sacramento itself. This advisory committee was appointed by the Director of the California Department of Fish and Game to identify those causes and to make recommendations for the restoration of the fishery.

There is little question but that one of the major causes, and perhaps the single most important cause, of the decline of salmon and steelhead in the upper Sacramento has been the Red Bluff Diversion Dam, which adversely affects both adult and juvenile fish. Our first report therefore deals primarily with the Diversion Dam and its related facilities. Subsequent reports will consider other causes of the decline and will include further recommendations for improving the fishery.

RED BLUFF DIVERSION DAM

Diversion Dam Facilities

The Red Bluff Diversion Dam diverts water from the Sacramento River at Red Bluff into the Tehama-Colusa Canal and into the Corning Canal Pumping Plant. In 1952, when the project was in the planning stage, the California Department of Fish and Game in its comments to the Secretary of the Interior, warned that the project could block upstream migrants, could cause the loss of downstream migrants into the canals, and would result in the loss of spawning ground both above and below the project. The United States Fish and Wildlife Service, however, concluded that the project would have a negligible effect on the fishery. Construction of the project was completed by the United States Bureau of Reclamation in 1964 and operation of the project began in 1966.

The Diversion Dam is a gravity dam with a length of 752 feet and a height of 78 feet. Water is controlled by eleven gates, each 60 feet wide and 18 feet high, which can be raised from the top to permit water to flow underneath. Each gate can be operated independently from the others. Gate 11 at the west end of the dam is operated automatically to carry debris away from the headworks.

A fishway with fish counting equipment (closed circuit television) is located on each of the dam abutments and a fish trapping device is incorporated in the east fishway. The headworks of the Tehama-Colusa Canal, situated near the west abutment, is affixed with a louver-type fish screen. Except during flood periods, downstream releases from the dam are made by partially raising one or more gates so that flows pass underneath. Some additional flow past the dam is provided by the operation of the fishways.

Public facilities include a salmon viewing plaza, an information center overlooking the east fishway, and boat launching ramps above and below the dam. Campgrounds and a picnic area also are provided.

Upstream Migration Problems

Four runs or races of chinook (king) salmon migrate past the Red Bluff Diversion Dam each year: fall, late-fall, winter, and spring. Fall-run salmon migrate past Red Bluff from July through December and spawn from early September through December. Late-fall-run salmon pass Red Bluff from late October or November through early April and spawn from early January through early April. Winter-run salmon pass Red Bluff from late December or early January through mid-July and spawn from mid-April through mid-July. Spring-run salmon migrate past Red Bluff from early April through early October and spawn from mid-August through early October. Since the construction of the diversion dam the size of all these runs has decreased. It also is apparent there has been a significant change in the distribution of fall-run salmon above and below the dam. Between 1966 and 1978, average annual populations of fall-run salmon utilizing the Sacramento River system upstream from Red Bluff declined by 80,400 fish, while the number spawning between Red Bluff and the mouth of Big Chico Creek downstream increased by 44,000 - a net decrease of 36,400 above Red Bluff.

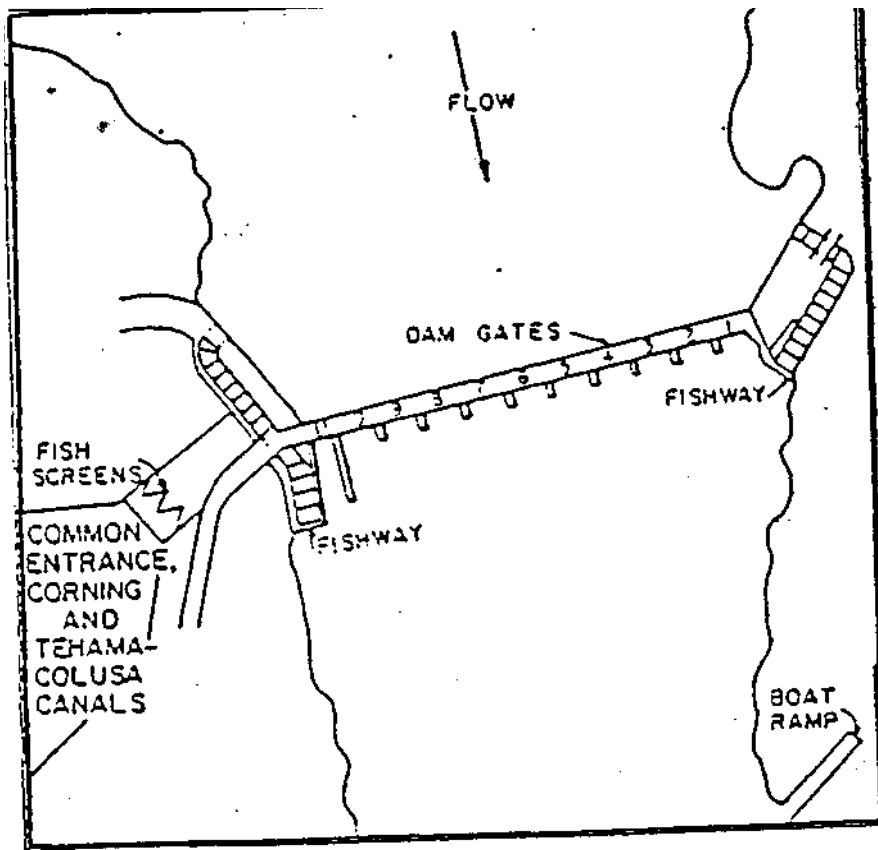
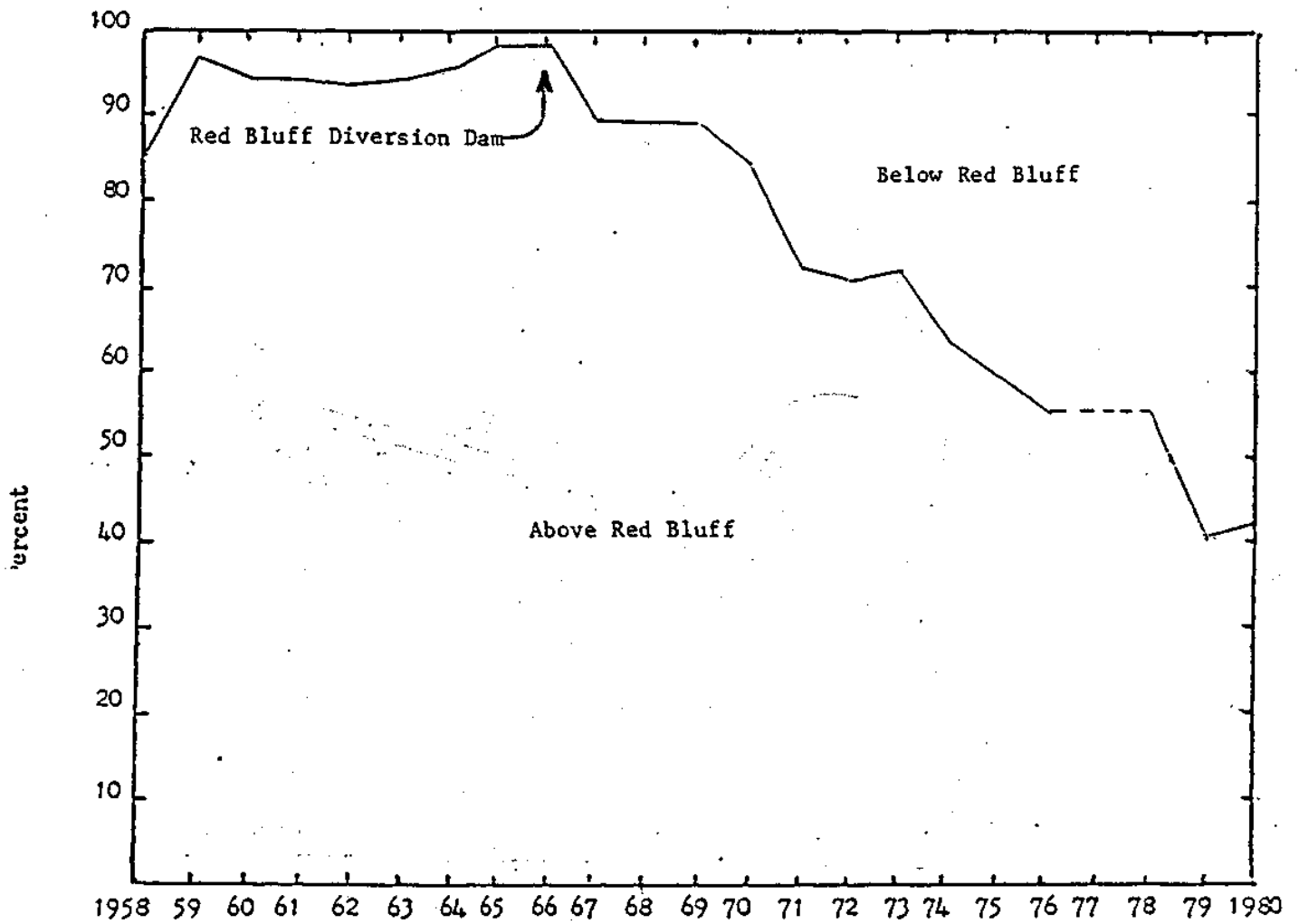


Figure 1. Red Bluff Diversion Dam.



Percent of fall-run king salmon, utilizing the Sacramento River above the Feather River that spawned above and below Red Bluff.

Evidence supporting the premise that salmon are delayed at the dam and that some drift back downstream was provided by a study conducted by the Department of Fish and Game and the Bureau of Reclamation. The use of radio tagged salmon demonstrated that delay below the dam ranged from 1 to 40 days and that over 26% of the fish never ascended the fishways and backed off downstream. The study also indicated that delay time increased with flow increases and suggested this may be related to the way the dam is operated at higher flows. Remaining downstream from the dam is highly detrimental to winter-run and spring-run salmon since they spawn during periods when water temperatures in this reach of the river are often lethal to incubating eggs.

Because timing is important to successful salmon spawning, fish whose passage upstream is delayed but not blocked may not spawn successfully.

There have been no studies to determine if adult steelhead are delayed or blocked by the dam, but these salmonids also appear to be seriously affected. Fish ladder counts show a continued decline in the size of the runs from 17,000 in 1967 to 2,300 in 1981.

The ability of the fish to find and use the fishways is greatly diminished by the manner in which the gates at the dam are operated. This situation is especially harmful at the west fishway where gate 11 is used to flush trash from the Tehama-Colusa Canal headworks. The large flow through this gate obscures the fishway flow and hinders fish passage. Reverse flows often result from the high velocity and turbulence of water flowing under the gates. Confused, disoriented salmon are commonly observed immediately below the dam.

An additional hazard to upstream migrants was discovered recently by divers inspecting the fish screen bypass outlet. They found the carcasses of several salmon which had become trapped in the bypass terminal box. While losses here appear to be small they are cause for concern.

Downstream Migration Problems

In 1975, the California Department of Fish and Game initiated a study to find out if losses were occurring among fingerling salmon migrating downstream past the diversion dam, and specifically if passing under a dam gate was harmful to fingerlings. It was a cooperative study involving the U.S. Fish and Wildlife Service, through Coleman National Fish Hatchery, and the U.S. Bureau of Reclamation. The project involved releasing groups of marked fingerling salmon over a three-year period at sites two miles above and one-quarter mile below the dam, and above and below gates 10 and 11. Recoveries of marked fingerlings in the lower Sacramento River and marked adults in the ocean sport and commercial fisheries as well as in the spawning stock surveys were used to measure the relative survival of salmon released at different locations. Based on limited data, the Department of Fish and Game estimates that the diversion dam has caused mortalities of from 12 million to 32 million fingerlings per year.

Although data from some elements of the study lend themselves to differing interpretations, there is undisputed evidence that survival of hatchery produced fingerling salmon is enhanced by releasing these fish below the dam.

Squawfish predation in Red Bluff Lake and immediately below the dam appears to be one of the reasons for poorer survival of fingerlings released upstream from the dam. Likewise, these predators probably take a significant toll of naturally produced fingerlings from upstream spawning areas. Other conditions which may adversely influence downstream migrants are the physical effects upon fish passing under the dam gates, leakage of fish through the louver fish screens and passage of fish through the bypass system. It also is theorized that lighting at the dam increases nocturnal predation.

Little is known about the effect of the dam on downstream migrant yearling steelhead released at Coleman Hatchery. However, between 1973 and 1977 the Department of Fish and Game, in cooperation with California Kamloops, Inc., and the U.S. Fish and Wildlife Service, conducted a study to find out if losses were occurring among Coleman Hatchery-reared yearling steelhead migrating downstream past the diversion dam. Yearling steelhead from three consecutive brood years were marked and released in equal numbers in Battle Creek at Coleman Hatchery and in the Sacramento River one-quarter mile downstream from Red Bluff Diversion Dam. Conclusions: 36% more adult steelhead returned to the hatchery and 42% more to Red Bluff Diversion Dam from the yearlings released one-quarter mile below the dam. The Department of Fish and Game and the U.S. Fish and Wildlife Service are not in complete agreement as to the significance of these results, because the same fin mark had to be used on all three brood years. Other evidence of adverse effects of the diversion dam on steelhead runs is that prior to the construction of the dam, releases of marked yearling steelhead at Princeton, 60 miles downstream from Red Bluff, produced excellent returns to the river as well as to the hatchery.

FISH FACILITIES

Mitigation Facilities - Single Purpose Channel

Red Bluff Diversion Dam impounds a lake approximately 3 miles long inundating Sacramento River gravel riffles which supported some 3,000 spawning salmon annually before the dam was constructed. To try to mitigate this loss, a man-made spawning channel concept was selected in lieu of a hatchery by representatives of the U.S. Fish and Wildlife Service, Department of Fish and Game and U.S. Bureau of Reclamation. The rationale for this decision was the reported success of channels elsewhere on the Pacific Coast, a preference for natural spawning over hatchery production and the possibility of avoiding the Sacramento River Chinook Disease which was rampant at nearby Coleman Hatchery.

The mitigation facility, known as the Single Purpose Channels, was first operated in 1971-72. It consists of two connecting parallel channels, each one mile long containing gravel thought to be of preferred quality and depth for salmon spawning (Figure 2). Suitable water velocity for spawning also is provided. Downstream from the spawning area, flows pass through a fish conveyance channel into Coyote Creek and thence into the Sacramento River. An electronic counting facility at the lower end of the two channels permits an evaluation of production. Equipment also is provided for selecting adults to be used in the facility. The original plan, later modified, was to introduce adult salmon into the spawning area for a period of four years by trapping and transporting fish from Red Bluff Diversion Dam. After that it was expected that fish homing to the facility via Coyote Creek would populate the channel annually.

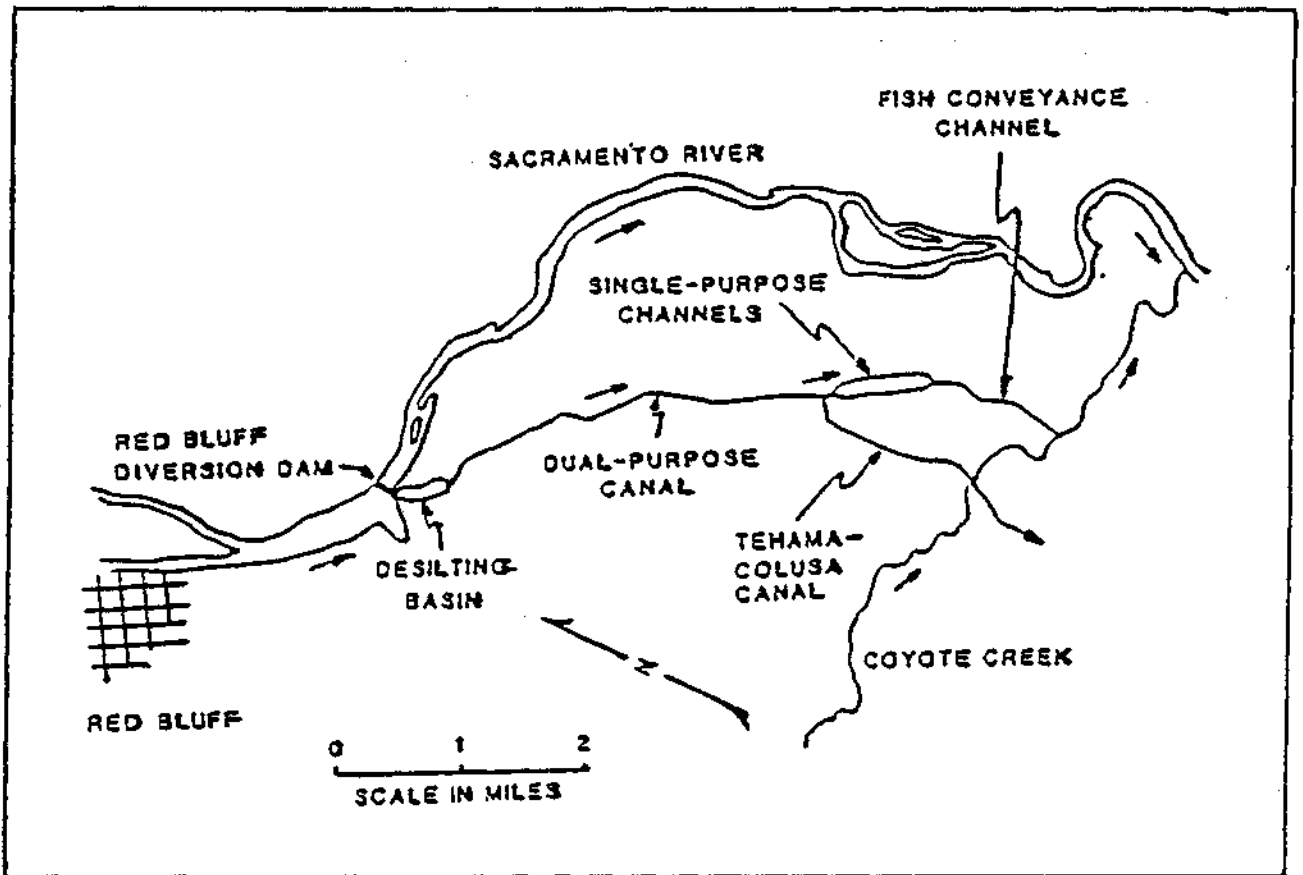


Figure 2. Location of the Tehama-Colusa Fish Facilities.

Single Purpose Channel Operation and Problems

The U.S. Fish and Wildlife Service states that in the ten years the Single Purpose Channel System has been in operation, the goal of mitigating the loss of spawning area in the river has been met. While it is true that the channels provide spawning habitat equivalent to that inundated by the reservoir, it is now obvious that the original goal of mitigating only the loss of that spawning habitat is grossly inadequate to compensate for all of the losses caused by the project.

The two channels also have suffered from operational problems, the most serious of which is that the spawning gravel has become heavily blanketed with sediment. Because of this, the channels were not utilized in 1982 and salmon entering Coyote Creek were allowed to move on into the Dual Purpose Canal that links the Single Purpose Channels with the Sacramento River. Cleaning the two Single Purpose Channels by loosening the gravel and flushing the fine sediment into Coyote Creek and the Sacramento River is presently prohibited by the Regional Water Quality Control Board. A cleaning project in the "dry" with special equipment is planned prior to the 1983 spawning season. Problems with the two spawning channels include high turbidity which causes premature out-migration of fingerlings and makes it extremely difficult to estimate the number of fingerlings produced in the channel. Several spawning channels in California and elsewhere have been abandoned because of similar operational problems.

The Department of Fish and Game takes the position that the channels or a portion of the channels would be better utilized if converted to rearing ponds to raise surplus fingerlings from Coleman Hatchery to a larger size and to hold what would otherwise be premature out-migrants. Plans prepared by the Department for construction of holding and rearing facilities at the Single Purpose Channels have not been implemented because of lack of funds.

Enhancement Facilities - Dual Purpose Canal

Funds for salmon enhancement in connection with the Tehama-Colusa Canal project were provided by Congressional appropriation. Facilities to achieve this enhancement are incorporated in a 3.25-mile-long section of the facility known as the Dual Purpose Canal. After studies indicated that expected water velocity and depth would be in a range acceptable to spawning salmon, the bottom of the canal was lined with 30 inches of spawning gravel. This provided 1.6 million square feet of spawning habitat expected to accommodate about 26,000 salmon.

The facilities include a gravel cleaner to flush fine sediment from the spawning beds during a time when salmon or incubating eggs would not be affected and drum screens at the lower end of the spawning area. These screens are designed to direct salmon fingerlings into the Single Purpose Channels system enroute to the Sacramento River. A yet to be completed electronic counting facility was planned to evaluate production in the Dual Purpose Canal. As with the Single Purpose Channel, fish trapped at the Red Bluff Diversion Dam were to be introduced into the Dual Purpose Canal for a limited number of years to develop a run that returned to the spawning channel via Coyote Creek.

Dual Purpose Canal Operations and Problems

The anticipated enhancement provided by the Dual Purpose Canal has never been achieved. To date the canal has been used experimentally with small numbers of salmon to identify problems and seek solutions. Due to hydraulic design deficiencies, the most critical problem is that water velocities are too low for salmon spawning. During the non-irrigation season the physical limitation of returning the canal flow to the Sacramento River prevents increasing the water velocity by increasing the flow. In addition, irregularities in the gravel bed reduce the area available for spawning, while the accumulation of algae presents a maintenance problem. Another difficulty is the leakage of salmon fingerlings through the louver screen at the canal headworks, which makes it impossible to determine which fish were produced in the Dual Purpose Canal and which come in from the river. Also of significance is the fact that the Bureau of Reclamation has not committed sufficient water for the fish facilities. While this has caused no difficulty to date, it is cause for concern in future operations.

The Fish and Wildlife Service and the Bureau of Reclamation have an ongoing program to estimate the number of fingerlings entering the canal through the louvers. It has also been determined that the gravel cleaner can be used to create berms in the canal bed spawning gravels at certain intervals to raise near-bed velocities to the satisfactory and sometime optimum range for spawning salmon. The 2,311 salmon which utilized the canal in the fall of 1982 (1,225 that entered via Coyote Creek and 1,086 hauled from the diversion dam) were observed spawning on the berms; however, no data are yet available relative to the success of this spawning.

Unfortunately the Bureau of Reclamation has been using magnacide to control algae in the Dual Purpose Canal. This substance is extremely toxic to fish and any fingerlings lingering in the canal are adversely affected when it is used. For example, in July, 1982, an estimated 20,000 to 40,000 juvenile salmon were killed in the canal during the algae treatment program. The Bureau since has obtained an algae control product for testing which is claimed to be non-toxic to fish life.

PROPOSED CITY OF REDDING-RED BLUFF POWER DAM PROJECT

The City of Redding proposes to construct a hydroelectric power plant at the site of the Red Bluff Diversion Dam. The proposed facility would divert water from the river through a powerhouse utilizing the existing head of approximately 13' at the dam. The intake channel would begin on the east bank of the river approximately 700' upstream from the diversion dam and would discharge approximately 100' downstream from the diversion dam. During certain periods of the year the project would divert as much as 80% of the total flow of the river. The proposed project includes the construction of a trash rack/bridge/fish bypass structure and a separate louver fish screen and fish conduit bypass upstream from the turbines.

Several studies of the project have been completed and a license application with the Federal Energy Regulatory Commission is now on file. In its license application, the City has expressed the opinion that the project will have no "net adverse impacts" on existing anadromous fish populations. After reviewing the studies supporting the application, and after hearing testimony from the City's consultant, the committee has concluded that the project has considerable potential for adversely affecting the fishery. The committee's concerns with the project include the following:

- a) It appears that the project would result in significantly increased squawfish predation of juvenile salmon and steelhead in the intake channel, at the bypass outlets and at the point where the channel discharges to the river.
- b) The project would divert excessive amounts of river flow during certain times of the year and expose the spawning riffle immediately below the dam.
- c) Because the project would not be economically feasible if not operated year around, the installation of the project would effectively prevent the raising of the gates at the diversion dam during the non-irrigation season.
- d) The project would make more difficult the identification of the reasons for the decline of the fishery and the assignment of responsibilities for that decline.
- e) Without positive fish screens, there is a significant chance of juvenile salmon and steelhead mortality at the turbines.

The committee opposes the construction of the project unless it can be conclusively proved that it will not adversely affect the anadromous fishery. That proof has not yet been provided.

If the project is constructed, it should include positive fish screens. Additionally, the project should not be constructed unless a fund is established with a substantial initial contribution by the City, and with the City's written agreement to pay over the life of the project a portion of the project revenues deemed sufficient by the Department of Fish and Game to analyze all aspects of the project and to mitigate its adverse effects. The Department of Fish and Game should administer the fund, and should have sole and exclusive authority to use the fund to conduct all necessary studies and to carry out all necessary or appropriate mitigation measures.

POLITICAL AND ADMINISTRATIVE PROBLEMS

The declining anadromous fishery resources of the upper Sacramento River and the lack of clear-cut administrative and financial responsibility for the decline are similar in many respects to the problems of the Columbia River. In both cases large federal water storage projects have been built without fishery enhancement or mitigation as a specifically expressed authorized function of the projects and with no agency functionally responsible for the fishery resources.

The Congressional authorization of the initial features of the Central Valley Project (CVP) and the authorization for the Sacramento Valley Canals Units of the CVP (Act of September 26, 1950, Ch. 1047, Stat. 1036) contain no express recognition of the fishery resources, nor do they assign any specific responsibilities for the protection of that resource or the mitigation of adverse impacts of the project. The legislative history of these acts clearly indicates that Congress did not intend to relegate fisheries incidental to water development, but the lack of specific direction as to the funding and administrative responsibilities for mitigation has left both funding and administration to interagency agreements. The Bureau of Reclamation retains jurisdiction over all CVP operations but has shunted off to the United States Fish and Wildlife Service the burden of funding the mitigation of losses caused by the CVP and its various components, including the Red Bluff Diversion Dam. Under the present system, badly needed mitigation projects at the diversion dam must compete with other worthwhile projects across the country for scarce U.S. Fish and Wildlife Service funds, while the Bureau of Reclamation, which is responsible for the fish losses, escapes financial responsibility. The result has been a lack of funding, which in turn has prevented the timely identification and execution of necessary mitigation measures. This must change. Mitigation fundings should be an integral part of the CVP's operation and maintenance budgets.

The painfully slow response to fish losses caused by Red Bluff Diversion Dam has in some instances been aggravated by the lack of clear administrative responsibility for determining the cause of the fish losses and the identification and funding of necessary mitigation measures. There are often strong differences of opinion between federal and state agencies as to the cause of fishery declines in the upper Sacramento and the proper role of the Tehama-Colusa Fish Facility.

These philosophical differences tend to mask the highly technical considerations necessary for rational solutions. They also have contributed in some cases to what appears to be a serious lack of cooperation between agencies at some levels. This is a problem in itself which must be resolved in a timely manner. Either the U.S. Fish and Wildlife Service or the California Department of Fish and Game should be assigned final authority of the identification and execution of necessary mitigation measures. This committee, however, makes no recommendation as to which agency should be assigned that responsibility. It is apparent, however, that if matters are addressed in the same manner as they have been for the past 40 years (20 years at Red Bluff), the fishery resource will continue to decline.

Two approaches appear to be available to assist in resolving the issues of funding responsibility and administrative responsibility for mitigation, although these two approaches are not necessarily the only ones. The first approach would be special legislation addressing the responsibility for the deficiencies and giving direction to specific agencies, using the Pacific Northwest Power Act as a model. A second approach would be a panel appointed to address these deficiencies and to make specific recommendations. Such a panel should not be large, but should represent the key agencies involved, including the California Department of Fish and Game.

Although action to address both the funding and the administrative responsibility issues is critical and should be addressed without delay, initiation of the specific measures at the Red Bluff Diversion Dam recommended by this committee should not await resolution of those issues. Since time is running out and the fishery continues to decline, it is imperative that all problems, both physical and administrative, be attacked simultaneously, and that the shortest possible route to the resolution of each issue be taken.

RECOMMENDATIONS

The following recommendations are a result of the testimony and scientific reports presented to the Upper Sacramento River Salmon and Steelhead Advisory Committee during a five-month period of meeting and deliberations. Implementation of the recommendations will involve cooperation and participation by federal and state agencies and, in some cases, may require action by the State Legislature and Congress.

1) Problem

The upstream migration of adult salmon and steelhead is delayed or blocked by the operation of the Red Bluff Diversion Dam.

Recommendations

- a) Raise the diversion dam gates full-time during the non-irrigation season of October through March.
- b) Immediately install two or more steepass fishways on the gates of the dam.
- c) Modify the dam gates operation to make fishway entrances more attractive to migrating fish.
- d) Conduct further studies and completely redesign the fishway.
- e) Rebuild the trash rack and eliminate the use of gate 11 as trash sluiceway.

Discussion

The adverse effects of the dam on adult salmon and steelhead upstream migration would be eliminated during October through March if all of the gates were raised during that season to permit unrestricted upstream fish passage. Information recently supplied by the Bureau of Reclamation to the California Department of Water Resources projects no demand for irrigation water from the diversion dam through the year 2000 for the months of November through March, and very little demand in October. Other sources should be able to meet any relatively small demand which may develop during the months of October through March.

Opening the gates during the non-irrigation season would require the installation of a 230 cubic-feet-per-second (cfs) capacity pump to supply flows of adequate velocity to the Single Purpose Channels. Pumping would not, however, provide a practical means of supplying water for year-round maintenance of the Dual Purpose Canal. Therefore, a choice must be made between abandoning the Dual Purpose Canal or continuing to keep the gates down during the non-irrigation season. The committee recommends the former alternative.

Spawning success in the Dual Purpose Canal has been limited, at best, and the canal has consumed an inordinate proportion of the resources devoted to mitigating fishery losses caused by the diversion dam. Abandoning the Dual Purpose Canal would: (a) permit the gates to be opened full-time during the non-irrigation season; (b) free manpower and financial resources to be used for more productive mitigation ventures; (c) eliminate problems caused by the reduction of flows in the 10-mile stretch below the diversion dam; (d) prevent the attraction of salmon into excess water fishways; and, (e) reduce undesirable fluctuation in the river near Redding that now occurs to accommodate the canal.

The committee believes that raising the gates at the diversion dam during the non-irrigation season is a practical and achievable measure which should be accomplished without delay.

In addition, at least two steepass fishways should be immediately installed at the diversion dam. Steepass fishways are portable, prefabricated flumes which can be located at dams or other barriers for the passage of adult salmon and steelhead. Baffles in a steepass fishway control water velocity so that swim-through conditions are provided even though there is a sharp rise in elevation between the entrance of the fishway below the barrier and the exit above. These fishways could be installed relatively quickly and at a comparatively modest cost. The committee believes they are worth trying.

The Department of Fish and Game should immediately assume the responsibility for studies of the distribution of salmon and steelhead runs in the river and all studies necessary to modify the dam structures and fishways to facilitate fish passage during the irrigation season.

2) Problem

The passage of juvenile salmon and steelhead under the dam gates adversely affects juvenile survival.

Recommendations

- a) Raise the gates full-time during the non-irrigation season of October through March.
- b) Modify the dam gates with overflow gates, steepass fishways, or other suitable devices.
- c) Release juveniles below the dam.

Discussion

The effect of passage under the dam gates on downstream juvenile migrants is not clearly understood, but studies generally indicate that passage under the gates does cause significant juvenile mortality. The Department of Fish and Game studies indicate the mortality is of a magnitude of between 12 million and 32 million juveniles per year. While studies on the effect of the operation of the dam on downstream migrants should be continued, the measures recommended above should be implemented without delay.

3) Problem

The Red Bluff Diversion Dam subjects juvenile salmon and steelhead to increased predation, primarily from squawfish.

Recommendations

- a) Raise the gates full-time during the non-irrigation season of October through March.
- b) Lessen possible disorientation of down-migrant salmon and steelhead by steep pass fishways.
- c) Reduce the dam illumination at night.
- d) Release juvenile salmon and steelhead below the dam.
- e) Encourage sport catch of squawfish.
- f) Trap all upstream migrant squawfish in fishways.
- g) Add more by-pass outlets.

Discussion

Large populations of squawfish and other predators which reside in the reservoir above the diversion dam and below the dam are known to prey heavily on juvenile salmon and steelhead. Opening the dam gates during the non-irrigation season would reduce squawfish predation above and below the dam. Predation below the dam also would be reduced for hatchery juveniles if those juveniles were released below rather than above the dam.

4) Problem

The lower portion of the Single Purpose Channels is only slightly used by spawning salmon, while Coleman Hatchery lacks facilities to rear large numbers of salmon fingerlings for late fall release.

Recommendation

Convert the lower 1,000 feet of each Single Purpose Channel into rearing ponds.

Discussion

The recommendation to convert the lower 1,000 -feet of the Single Purpose Channels to rearing ponds is really a recommendation to capitalize on an opportunity rather than respond to a problem at the Red Bluff facility. The proposed conversion offers the opportunity to raise up to 600,000 surplus juvenile salmon from Coleman to a larger size for release in the late fall when losses of juvenile salmon to irrigation diversions are minimal. Both the Department of Fish and Game and the U.S. Fish and Wildlife Services have expressed interest in moving forward with the proposed conversion. The committee recommends that action be taken at the earliest possible moment.

5) Problem

Large numbers of downstream migrant salmon and some steelhead enter the Dual Purpose Canal through an inefficient louver screen at the canal headworks.

Recommendation

Replace the louver screen with a positive fish screen.

Discussion

It is undesirable to divert downstream migrant salmon from a direct route to the sea. Leakage through the louvers of salmon produced both in the river and at Coleman Hatchery also complicates any attempted evaluation of salmon production in the Dual Purpose Canal. The need for an effective screen has been recognized for many years and additional data on fish losses are not required. Design and construction of a positive fish screen should begin immediately.

6) Problem

Cleaning of the Single Purpose Channels causes violations of water quality standards and sedimentation of the channels makes them unusable.

Recommendation

Clean the channels "in the dry" by using a recirculating water system so no sediments are released to the river.

Discussion

Release of freed sediments back into the stream contaminates downstream areas, but the gravel must be clean in order to provide conditions necessary for egg incubation and alevin survival.

7) Problem

Sedimentation and algae growth in the Dual Purpose Canal seriously impair spawning success in the canal.

Recommendations

- a) Abandon the Dual Purpose Canal when the gates at the diversion dam are raised during the non-irrigation season.
- b) When the canal is in use, any treatment for algae growth should be done with herbicides that are non-toxic to fish.

Discussion

The rationale for abandoning the Dual Purpose Canal for spawning purposes was discussed earlier. So far as the treatment of algae in the Dual Purpose Canal is concerned, strict requirements for the use of non-toxic herbicides would be far less necessary if the headworks included a positive fish screen and if a separate water supply were found for the Single Purpose Channels.

8) Problem

Adult salmon become trapped behind the grating covering the fish screen by-pass terminal structure.

Recommendation

Modify the grating to exclude adult salmon.

Discussion

The purpose of the by-pass grating is to prevent upstream migrant salmon from entering the fish screen by-pass outlet. The grating can be easily modified to exclude all adult fish and still allow unrestricted passage of downstream migrants.

9) Problem

Locations for the planting of salmon and steelhead reared at Coleman Hatchery have not been firmly established.

Recommendations

- a) Complete and analyze ongoing studies involving releases of marked salmon and steelhead at various locations.
- b) If gates at the diversion dam are opened during the non-irrigation season, juveniles released upstream from Red Bluff during that period would be unaffected by the dam. Releases of salmon from Coleman Hatchery during the period from April 1 through September 30 should be made according to item d) below.
- c) At least 50% of the yearling steelhead produced at Coleman each year should be released below Red Bluff; at least 50,000 of which should be marked smolts which would be barged downstream for release below the Delta. The barging program should be carried on for at least four years and the results compared with returns from other release sites.

d) If the gates are closed all year, the following interim schedule for salmon planting should be followed, pending results of studies:

1. Release late-fall salmon below Red Bluff Diversion Dam.
2. Release winter-run salmon below the dam.
3. Release marked fall-run salmon according to design of ongoing study. Plant portion of remainder below the dam.

Discussion

It is anticipated that most of the studies related to the survival of hatchery-produced salmon and steelhead will be completed by the time a plan for opening the diversion dam gates can be put into operation. With the gates open from October 1 to April 1, the dam would pose no obstacle to downstream migrants passing Red Bluff during this period and squawfish predation would be minimized. The gates could be closed temporarily for short-term mortality studies or other work related to fish passage studies. Recommendation d) is an interim schedule. Study results may indicate changes in planting locations. Recommendation c) reflects the need for an innovative approach to rebuilding the steelhead run. Long before construction of the Red Bluff Diversion Dam, releasing Coleman Hatchery steelhead at Princeton, 60 miles below Red Bluff, produced outstanding returns to the hatchery and the fishery. The merits of transporting steelhead smolts by barge to downstream release sites has been demonstrated by studies on the Columbia River. A similar project on the Sacramento River is long overdue.

CONCLUSION

The problems at the Red Bluff Diversion Dam have contributed significantly to the alarming decline of the salmon and steelhead resources of the upper Sacramento River. It is the hope of this committee that the problems at the Red Bluff Diversion Dam will receive not only immediate attention, but also immediate action.

But, while the Red Bluff Diversion Dam has been a major cause of the decline of the fishery in the upper river, it is not the only cause. Therefore, this committee will issue further reports in the future, examining other causes of the decline and making further recommendations to rebuild the salmon and steelhead populations of the upper river.