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California Department of Fish and Game
Inland Fisheries Division

Evaluation of Salmonid Habitat Restoration Structures in Northwestern California Streams Conducted during 1993 and 1995.

Introduction

Fish habitat restoration activities and projects have been implemented by fisheries managers in California since the early 1930's. The Civilian Conservation Corps built 41 pool forming structures in the East Fork Kaweah River in 1935 (Ehlers 1956). Other Salmonid habitat restoration projects since the 1930's have consisted of pool enhancement structures, bank stabilization structures, log jam removal or modification, and fish passage improvement. Most of these projects, up to 1981, were funded by the Federal Aid in Sport Fishing Restoration Act (Dingell-Johnson Act). In the early 1980's California embarked on an aggressive program to improve anadromous Salmonid habitat. In 1980, the Energy and Resources Fund, administered through the California Department of Fish and Game (DFG), was used to contract with the California Conservation Corps to establish a $1 million-per-year cooperative fisheries project. In 1981, Assembly Bill 951 (Bosco-Keene) provided an additional $1 million per year for cooperative fish restoration projects. In succeeding years other funding sources for fisheries restoration work became available which included a self-imposed tax by commercial fishermen on salmon landings, the Environmental License Plate Fund, Proposition 70 Fund, Proposition 99 Fund, the State General Fund, and the Fish and Game Preservation Fund. Between 1980 through 1993, a total of $45 million specifically identified for fish habitat restoration, including cooperative rearing and outreach and education programs, was administered by DFG through its Fishery Restoration Grants program. This amount does not include additional matching money or in-kind donations as required by some funding proposal requests. In addition, other fishery restoration projects within California were funded and administered through other State and federal sources.

Fish restoration projects administered by the Fishery Restoration Grants Program were completed by private non-profit groups or public agencies under a contract with DFG. Contract information and brief project descriptions and objectives of restoration projects completed since 1981 were stored on a database maintained by DFG.

The purpose of this report is to evaluate the anadromous Salmonid habitat restoration projects funded through the Fishery Restoration Grants program during the period from fiscal year (FY) 1980-81 through FY 1993-94. The objective of the evaluation was to determine what structures or project elements were still intact, and how well they were meeting intended objectives.

Methods

The Fish Restoration Grants Program database was queried for all habitat restoration projects (exclusive of fish rearing and education projects) benefitting anadromous salmonids. The anadromous-project subset was then divided into six categories based on general project objectives as stated in each project narrative. A "project" consisted of work in a specific stream reach, and several projects or stream reaches could be covered by one contract. The database listed each "project" as an individual record. When projects included multiple objectives, the objective characterizing the most significant portion of the project was used. The six types of project categories were:

1. Instream habitat	These projects include instream scour structures to form or enhance pools, cover enhancing structures, and flow enhancement.
2. Spawning gravel	These projects included importation of spawning gravel.
3. Erosion control	Includes bank stabilization or protection, riparian planting, cattle exclusion fencing, sediment dams, grade control structures, slide stabilization projects and revegetation projects.
4. Fish passage - blasting	Includes rock barrier modification where blasting was required.
5. Fish passage-culverts	Includes modifications to culverts or culvert entrances.
6. Fish passage - ladders	Includes construction or modification to fish ladders or fishways.

The evaluation team consisted of one permanent and one seasonal employee with occasional assistance from other individuals when available. Since it was impossible to visit and evaluate each project site identified on the database, a sampling level of 25% was selected as representative of all work performed between 1980 and 1993. Projects in each project category were sequentially numbered and 25 percent were randomly selected with the aid of a random number generator.

Background information which described the project detail, location, inspection reports, along with any other pertinent material was gathered for each randomly selected project. In many cases very little project detail was available other than contract documents. Contract administrators were the best source of information, acting as guides to where the projects were located and providing descriptions of individual structure objectives.

Evaluation surveys consisted of locating the downstream portion of the project reach, and geographically referencing this position from a known reference point or by the use of a global positioning system device. Positioning from a known reference point entailed measuring up the stream thalweg from a stream confluence, bridge, or other prominent and permanent feature. Usually a hip-chain was used to measure distance. Each structure encountered was identified and the following information recorded (see Appendix A and B for field record forms):

1. Feet from reference point.
2. Construction method.
3. Structure objective.
4. Structure type.
5. Evaluation rating of how well structure meets objective.
6. Evaluation rating of physical integrity of structure.
7. Common structure problems.
8. Recommended maintenance or modification.
9. Habitat created by structure.
10. Primary pool (depth greater than 2 feet).
11. Spawning gravel associated with structure.
12. Maximum pool depth associated with structure.
13. Bankfull stream width at structure site.
14. Shelter rating.
15. Salmonids observed.
16. Description of revegetation projects.
17. Roll and frame number of photos taken.

Evaluation of individual structures involved considering physical features and habitat benefits as two separate items. The following criteria were used to evaluate how well each structure was meeting intended habitat restoration objectives:

Rating	Rating criteria - meeting objectives
1 (100%)	Excellent. Structure is providing the habitat conditions as expected. Examples include: formation of a primary pool, spawning gravel retained, complex cover provided, sediment controlled, vigorous riparian growth achieved, etc.
2 (75%)	Good. Structure is meeting objectives and providing habitat but maximum pool depth is between 2.0 to 2.5 feet, shelter complexity is less than 3, spawning gravel is available but not abundant, or riparian growth is moderate.

3 (50%)	Fair. Structure is providing some habitat benefit that was not present before construction but it is achieving only partial expected benefits. Or it may be providing some benefit but not the intended objective. Examples include: pool scour depth less than 2 feet, very little spawning gravel associated with structure, cover not complex, etc. Use Comments to explain.
4 (25%)	Poor. Very little habitat value exists as a result of the structure or prescription. Virtually no pool scour, shelter complexity less than 2, no gravel retained, etc. Use comments to explain.
5 (0%)	Failure. Not visible. No value. Structure is not meeting objective. Stranded out of stream channel with no possibility of providing low or high flow benefit. Use Comments to explain.

When evaluating structure physical condition the observer was instructed to consider structural integrity only, not how the structure was functioning. For example, the structure may be in excellent structural condition but not functioning (very low rating for meeting objective) because it is stranded out of channel. The evaluation of physical condition or structural integrity of each structure was rated based on the following criteria:

Rating	Rating criteria - structure physical condition
1 (100%)	Excellent. Structure is intact and structurally sound.
2 (75%)	Good. Structure is intact and generally sound but some wear is evident. Pieces may have shifted slightly, erosion cloth visible, wire fence material visible, one or two anchor pins or cables loose but structure still intact. Structure is generally as designed. Use Comments to explain.
3 (50%)	Fair. Structure has been altered significantly but is still meeting about 50 percent of design criteria. Boulders or logs may have shifted, log weirs undercut, cables loose, etc. Use Comments to explain.
4 (25%)	Poor. Structure is visible but in a condition that is only about 25 percent of original design. Significant structural damage. Use Comments to explain.
5 (0%)	Failed. Complete structural failure. Not visible or remnants not in any form of designed configuration. Use Comments to explain.

Information from field evaluation forms was entered into a database using a dBase program. Data were compiled for each stream individually and for all streams combined. Paired objective and condition rating scores assigned to each structure were entered into a 5x5 matrix table. From the matrix table, percentage of occurrence of each rating category, and mean and variance of ratings in each stream were calculated. Common structure problems were tabulated from those observed in each stream.

Results

1993 evaluation survey

In 1993, habitat restoration projects were evaluated on 53 streams in northwestern California (Table 1). A total of 1,433 individual structures designed to benefit instream habitat, and 172 individual structures designed for controlling erosion were evaluated (Table 1). In addition, 24 projects designed to improve fish passage were evaluated in 21 streams (Table 2).

During 1993, physical condition was rated excellent or good in 79.6 percent of all instream structures built prior to 1993. Only 4.4 percent of structures built prior to the 1993 survey physically failed. In contrast, 1993 ratings for how well structures were meeting intended objectives were 58.9 percent for excellent or good categories and 8.8 percent had failed to meet intended objectives (Figure 1).

Physical condition of erosion control structures was rated excellent or good in 85 percent of all streams surveyed in 1993 (Figure 2). A total of 6.9 percent had completely failed structurally. Erosion control devices were meeting objectives in the excellent or good categories in 75.9 percent of the cases surveyed. A total of 9.2 percent had failed completely to meet any intended objective.

Boulder clusters were some of the least complex structures and had the highest mean physical condition and mean objective ratings in 1993, 84.1 and 71.3, respectively. Of complex structures, weirs (log and boulder) had the highest mean physical condition and mean objective ratings in 1993, 75.7 and 68.2, respectively. Instream structures with the lowest mean physical condition ratings were log/boulder-combination constrictors: single 51.5, and opposing 58.3 (Table 3).

The most common structure problems noted during the 1993 survey were 1) movement of structural elements affecting structural integrity (boulder/log shifting), 2) use of inadequate size material (under built), and 3) poor choice of structure placement relative to stream hydraulics, stream substrate, or bank stability (poor placement) (Table 4).

Table 1 Summary of habitat restoration project evaluations conducted in 1993 and 1995.

Stream	R*	Drainage	1993 Feet surveyed	1993 No. of structures	1993 Mean objective/ condition scores	1995 Feet surveyed	1995 No. of structures	1995 mean objective/ condition scores
Bear Creek	y	Lower Eel River	8,510	42	48.2/ 56.0			
Bear Wallow Creek	y	Hollow Tree	5,935	20	72.6/ 75.0	5935	22	43.2/ 72.7
Big Creek		S.F. Trinity	11,890	54	65.7/ 75.5			
West Fork Blue Creek		Lower Klamath	1,900	7	71.4/ 85.7			
Bond Creek	y	Hollow Tree	6,870	59	63.1/ 77.5			
Bull Creek (Upper)		S.F. Eel River	2,840	10	70.0/ 72.5			
Butler Creek	y	Hollow Tree	6,700	34	69.1/ 88.3	6,700	39	52.6/ 68.6
Carson Creek		Eel River	2,100	8	65.6/ 56.3			
Cedar Creek	y	Trinity River	1,670	15	70.0/ 86.7			
Deadwood Creek		Trinity River	101	4	75.0/ 68.8			
China Creek		S.F. Eel River	410	6	66.7/ 75.0			
Dinner Creek		S.F. Eel River	950	6	79.2/ 87.5			
Elk River, SB, NF		Elk River	5,940	25	79.0/ 87.0			
Elk River, NF		Elk River	8,195	53	67.5/ 70.8			
Elk Creek		Klamath River	4,000	42	61.3/ 78.6			

Table 1 (continued). Summary of habitat restoration project evaluations conducted in 1993 and 1995.

Stream	R *	Drainage	1993 Feet surveyed	1993 No. of structures	1993 Mean objective/ condition scores	1995 Feet surveyed	1995 No. of structures	1995 Mean objective/ condition scores
Griffin Creek		Smith River	4,165	17	58.8/82.4			
Grizzly Creek	y	Van Duzen R.	5,165	24	new/new	5,165	24	22.9/34.4
Hayfork Creek		S.F. Trinity R.	500	4	18.8/75.0			
Hely Creek		Van Duzen R.	6,655	22	59.1/ 67.0			
Hollow Tree Cr. (2 reaches)	y	S.F. Eel River	16,240	78	60.4/ 68.0	6,160	29	56.0/ 62.9
Horse Linto Creek		Trinity River	13,875	128	81.1/ 87.9			
Huckleberry Creek	y	Hollow Tree	6,460	23	55.4/ 71.7	3,440	24	56.0/ 73.8
Hunter Creek	y	Klamath River	11,774	57	46.9/63.7			
Indian Creek		Klamath River	1,939	38	78.9/94.7			
Julias Creek			465	2	37.5/ 100			
Kiler Creek	y	Eel River	3,560	44	61.7/72.3	3,560	44	14.4/ 18.1
Knopki Creek		Smith River	2,230	27	72.2/ 73.1			
Low Gap Creek		S.F. Eel River	10,550	49	77.0/ 89.8			
Michaels Creek	y	Hollow Tree	4,470	22	new/ new	5,025	22	39.8/69.3
Monument Creek		Eel River	1,965	6	29.2/66.7			

Table 1 (continued). Summary of habitat restoration project evaluations conducted in 1993 and 1995.

Stream	R	Drainage	1993 Feet surveyed	1993 No. of structures	1993 Mean objective/ condition scores	1995 Feet surveyed	1995 No. of structures	1995 Mean objective/ condition scores
Olsen Creek		S.F. Trinity R.	2,080	14	96.4/ 87.5			
Patricks Creek		Smith River	100	5	75.0/ 85.0			
Potato Creek		S.F. Trinity R.	7,545	24	59.4/ 69.8			
Little Rattlesnake Creek		S.F. Trinity R.	3,000	14	98.2/ 94.6			
Rattlesnake Creek		S.F. Trinity R.	4,830	24	50.0/ 55.2			
Redwood Creek		Hollow Tree Cr.	2,660	9	new/ new			
Redwood Creek		S.F. Eel River	2,700	15				
Rowdy Creek		Smith River	15,785	53	62.3/ 67.0	15,785	53	67.0/ 72.2
Rusch Creek		S.F. Trinity R.	10,175	74	65.1/ 73.3			
Rush Creek		Trinity River	4,275	36	66.0/ 77.8			
Siskyou Fork		Smith River	12,545	44	47.7/ 59.7			
Sommerville Creek		S.F. Eel River	425	2	37.5/ 62.5			
Little Sproul Creek		S.F. Eel River	4,100	72	44.1/ 52.8			
Sproul Creek		S.F. Eel River	3,740	20	51.3/ 63.8			
Squaw Creek		S.F. Eel River	3,860	10	70.0/ 60.0			

Table 1 (continued). Summary of habitat restoration project evaluations conducted in 1993 and 1995.

Stream	R*	Drainage	1993 Feet surveyed	1993 No. of structures	1993 Mean objective/ condition scores	1995 Feet surveyed	1995 No. of structures	1995 Mean objective/ condition scores
Stevens Creek	y	Van Duzen R.	3,820	11	new/ new	3,820	11	56.8/ 65.9
Tarup Creek		Lower Klamath	12,385	65	48.1/ 70.4			
S.F. Trinity River		S.F.Trinity R.	12,225	23	38.0/ 38.0			
Tule Creek, East Fork	y	S.F. Trinity R.	9,820	61	61.1/ 70.5	9,820	64	49.5/ 60.5
Tule Creek, Main Stem	y	S.F. Trinity R.	5,495	50	72.5/ 75.5	5,495	50	52.0/ 66.5
Wildcat Creek		S.F. Eel River	2,905	5	70.0/ 70.0			
Winchuck River, S. Fork		Winchuck R	13,750	64	68.0/ 77.3			
Wolf-Jackass Creek		Pacific Ocean	2,145	17	72.1/ 76.5			

R*: "y" indicates an individual evaluation report has been completed.

Table 2. Fish passage improvement projects evaluated in 1993.

Stream	Basin	Project description	Rating scores Objective	Condition
		Region 1		
Wilson Creek	S.F. Trinity	Steep pass ladder	1	1
Packers Creek	S .F. Trinity	Steep pass ladder	1	1
Limestone Creek	S.F. Trinity	Culvert baffles, weir	1	1
Kingsberry Creek	S.F. Trinity	Culvert baffles, weir	dry	3
Kingsberry Creek	S.F. Trinity	Washington baffles	dry	1
Barker creek	S.F. Trinity	Culvert baffles, jump pool	1	1
Barker creek	S.F. Trinity	Gabions, log weir, water diver.	4	4
		Region 3		
Ackerman Creek	Russian	Denil ladder	1	1
Ackerman Creek	Russian	Boulder Necklace	2	2
Hensley Creek	Russian	Denil ladder	1	1
Orr Creek	Russian	Grade reduction weirs	2	2
Dark Gulch	Big Creek	Jump pool at culvert	1	2
Sheep Camp Creek	S.F. Eel R.	Boulder necklace	dry	
Steep Gulch	S.F. Eel R.	Steeppass and culvert baffles	dry	1
Rattlesnake Culvert	S.F. Eel R.	Step pool into culvert	1	2
Elk Creek (rest stop)	S.F. Eel R.	Step pool with steel ramp baffles	2	2
Wilson Creek	S.F. Eel R.	Denil ladder	dry	1
Bloody Run Creek	M.F. Eel R.	Rock barrier blasting	1	1
Burger Creek	M.F. Eel R.	Rock Barrier blasting	2	2
Turner Creek	M.F. Eel R.	Step pool into culvert	dry	2
Poorman's Creek	M.F. Eel R.	Culvert baffles	dry	2
Murphy Creek	M.F. Eel R.	Rock barrier blasting	2	2
Split Rock	N.F. Eel R.	Rock barrier blasting	2	2
Baker Creek	Russian	Culvert weirs	dry	2

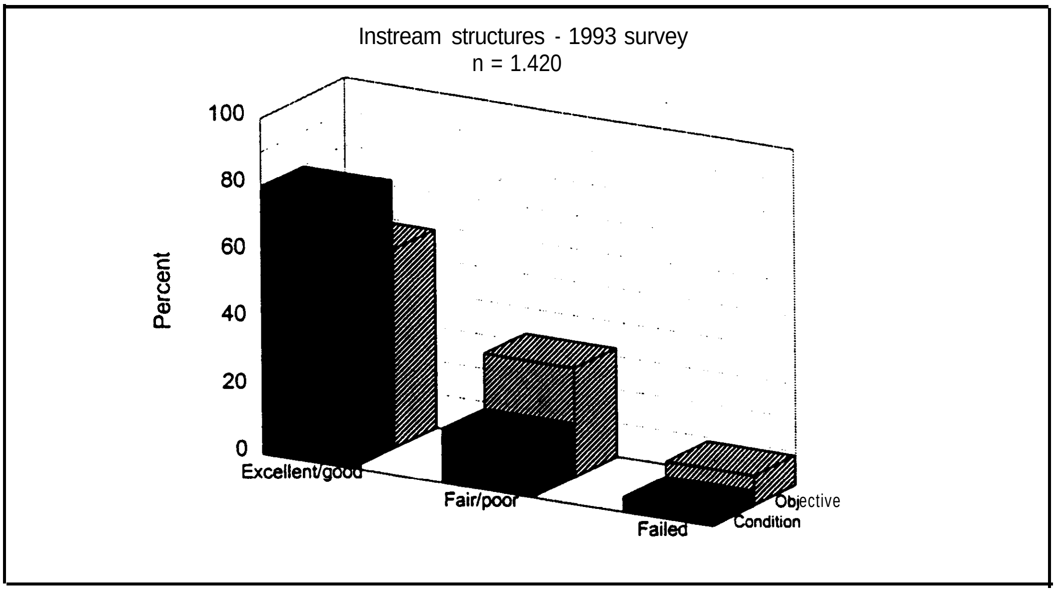

Figure 1. Evaluation ratings of 1,420 fish habitat improvement structures observed in northwestern California streams during 1993. Condition pertains to structural integrity and objective pertains to how well structure meets intended purpose of improving habitat.

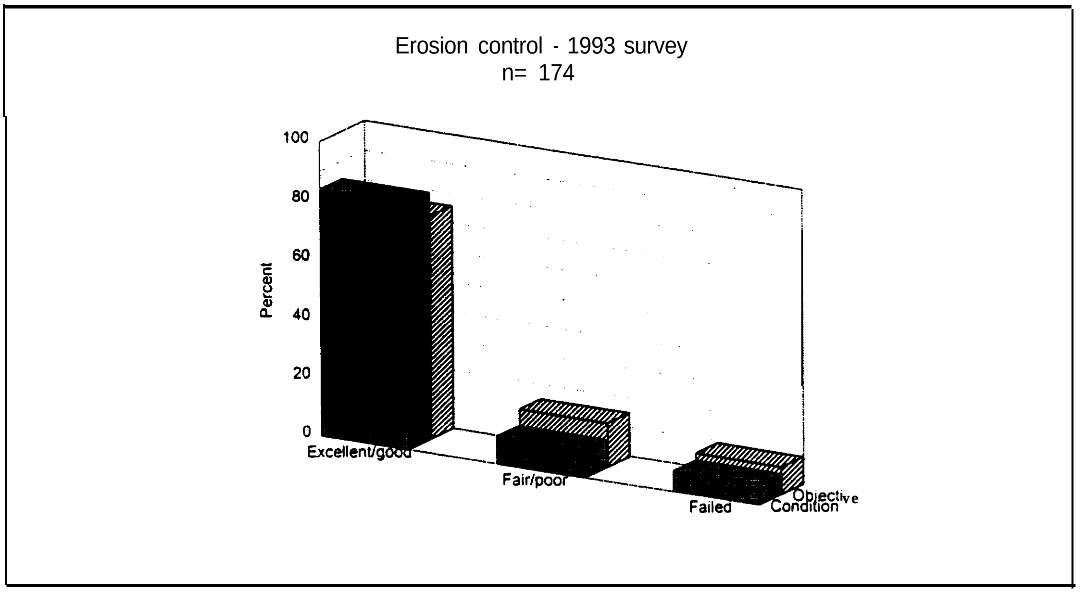

Figure 2. Evaluation ratings of 174 erosion control or bank stability structures observed in northwestern California streams during 1993. Condition pertains to structural integrity and objective pertains to how well structure meets intended purpose of preventing slope or bank erosion.

Table 3. Mean rating scores for structural condition factors and structure function that meets intended objectives for stream restoration structure types surveyed in northwestern California streams during **1993.**

Structure type	Mean Condition	Mean Objective	Individual Structures (n)
Instream Habitat Structures			
All boulder clusters	**84.1**	**71.3**	(172)
All weirs	**75.7**	**68.2**	(327)
boulder weirs	77.6	72.2	(98)
log weirs	74.9	66.5	(229)
All woody cover	**72.7**	**61.3**	(599
root wads	74.5	63.0	(52)
log cover	72.7	60.7	(358)
digger logs	71.2	61.0	(189)
All single constrictors	**69.6**	**58.2**	(200)
log constrictors	72.1	50.7	(69)
boulder constrictors	71.8	64.1	(101)
log/boulder combinations	51.7	51.7	(30)
All opposing constrictors	**67.1**	**60.0**	(135)
log constrictors	71.2	57.1	(39)
boulder constrictors	66.0	61.5	(72)
log/boulder combinations	58.3	55.2	(24)
Erosion Control Structures			
Bank armor	**74.9**	**72.7**	(140)
log bank armor	75.5	72.1	(111)
boulder rip rap	72.4	75.0	(29)
Deflectors - single wing	**67.2**	**59.4**	(32)
log deflectors	68.2	60.2	(22)
boulder deflectors	65.0	57.5	(10)

Table 4. Common problems noted during a 1993 survey from 1,671 structures designed to improve instream fish habitat or stream bank stability.

	Problem Type	Number of occurrences	Percent of total
1.	Anchor failure	133	8.0
2.	Cable failure	48	2.9
3.	Channel shift	52	3.1
4.	Boulder/log shift	223	13.3
5.	Undermined	38	2.3
6.	Buried by bedload	64	3.8
7.	Underbuilt	183	11.0
8.	Stranded out of channel	47	2.8
9.	Bank erosion at site	28	1.7
10.	Created sediment trap	55	3.3
11.	Poor design	112	6.7
12.	Poor or improper placement	151	9.0
13.	Other	23	1.4

1995 evaluation survey

In 1995, habitat restoration projects were evaluated on 11 streams in northwestern California. A total of 347 individual structures designed to benefit instream habitat, and 29 individual structures designed for controlling erosion were evaluated (Table 1).

During 1995, physical condition in combined rating categories of excellent or good was 67.3 percent of all instream structures built prior to 1993. Only 11 .O percent of structures built prior to the 1993 survey had physically failed entirely. Ratings for how well structures were meeting intended objectives in 1995 were 39.3 percent for combined excellent or good categories and 18.8 percent had failed to meet any degree of intended objectives (Figure 3).

Physical condition of erosion control structures was rated excellent or good in 37 percent of all streams surveyed in 1995 (Figure 4). A total of 18.5 percent had completely failed structurally. All erosion control devices were meeting objectives in the excellent or good categories in 48.1 percent of the cases surveyed. A total of 25.9 percent had failed completely to meet any intended objective.

Boulder clusters had the highest mean physical condition and mean objective ratings in 1995, 8 1.3 and 75.0, respectively. More complex structures such as boulder or log weirs, or woody cover elements had the highest mean physical condition ratings in 1995, 60.2 and 62.4, respectively. However, ratings of how well complex structures were meeting intended objectives were about the same for weir, cover, and constrictor categories, ranging from 43.1 to 55.6. Instream structures with the lowest mean physical condition ratings were log constrictors: single 36.8, and opposing 34.1 (Table 5)

The most common structure problems noted during the 1995 survey were 1) poor choice of structure placement relative to stream hydraulics, stream substrate, or bank stability (poor placement, 2) movement of structural elements affecting structural integrity (boulder/log shifting), and 3) poor design or ineffective use of a specific structural design (Table 6).

Discussion

The most difficult obstacle to overcome when investigating projects completed several years prior is the lack of project detail documentation. Poor documentation creates difficulty in locating the project site, and it does not allow the evaluator to determine if a specific structure is missing. Approximately half of the projects had detailed work plans or proposals from which to locate structures. However, none of the project documents contained “as built” diagrams of completed projects. Structure design or location was often modified from work plan or proposal specifications because of available on-site material or unexpected problems encountered at the actual site.

Mean scores for how well structures were meeting intended objectives were generally lower than mean physical condition scores. This phenomenon probably illustrates the real situation where field personnel generally have the skills to engineer and build sound structures but they are less able to predict how a specific structure will perform within stream hydraulic or sediment transport regimes.

For instream habitat structures observed in 1993, the percent of paired excellent or good scores for condition and objective categories was 55.7 percent. Objectives were being met, regardless of structure condition, in the excellent or good categories in 58.9 percent of the structures. In contrast, physical condition was judged to be excellent or good in 79.6 percent of the structures, regardless of how well objectives were being met (Figure 5). These data illustrate that structures are generally in better condition than their ability to meet intended objectives. However, how well a structure meets intended objectives correlates strongly with the physical condition of the structure (Figure 5).

The follow-up surveys conducted in 1995 indicated generally lower mean scores for each structure type in both condition and objective rating categories (Table 1). Although the follow-up surveys were not randomly selected and not statistically representative, they represent a general trend that stream flow conditions in 1994-95 caused structural damage and unfavorable hydraulic or sediment flow conditions within many project areas. Eleven projects evaluated in 1993 were re-evaluated in 1995. Four of these projects were newly completed in 1993 and the remainder were constructed between 1989 and 1992. Of the seven projects completed prior to 1993, four exhibited significantly lower mean rating scores in 1995 than in 1993 ($P<0.05$). Only two project reaches, Huckleberry Creek and Rowdy Creek, exhibited slightly higher scores in 1995 than in 1993, although these differences are not statistically significant ($P>0.05$) (Table 7).

Erosion control or bank stabilization structures exhibited higher failure rates in 1995 than instream structures. This may be a result of greater hydraulic forces and higher degree of potential erosion in critical stream bank areas than in stream thalweg areas. In other words, erosion control or stream bank stability prescriptions are located in areas of high potential erosion or existing bank failures. Structural problems that occur in these areas tend to be catastrophic.

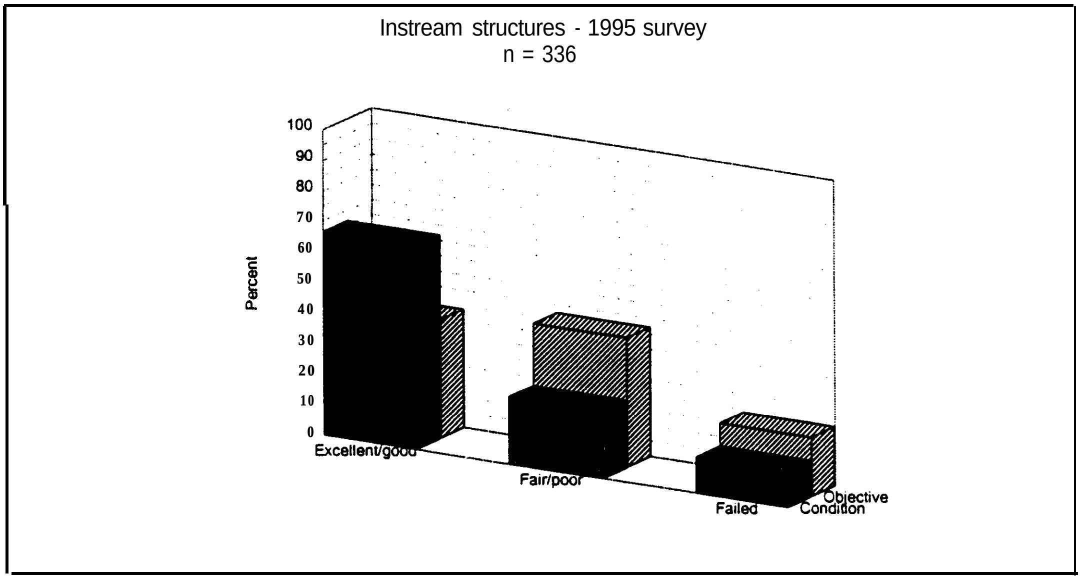

Figure 3. Evaluation ratings of 336 fish habitat improvement structures observed in northwestern California streams during 1995. Condition pertains to structural integrity and objective pertains to how well structure meets intended purpose of improving habitat.

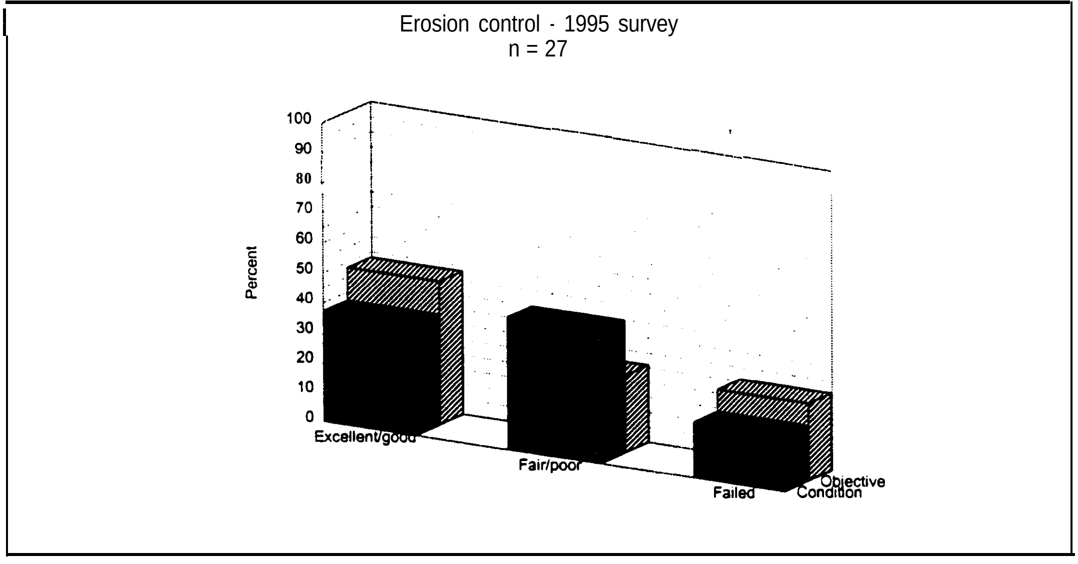

Figure 4. Evaluation ratings of 27 erosion control or bank stability structures observed in northwestern California streams during 1995. Condition pertains to structural integrity and objective pertains to how well structure meets intended purpose of preventing slope or bank erosion.

Table 5. Mean rating scores for structural condition factors and structure function that meets intended objectives for stream restoration structure types surveyed in northwestern California streams during **1995.**

Structure type	Mean Condition	Mean Objective	Individual Structures (n)
	Instream Habitat Structures		
All boulder clusters	**81.3**	**75.0**	(4)
All weirs	**60.2**	**43.1**	(54)
boulder weirs	59.1	**47.7**	(11)
log weirs	60.5	**41.9**	(43)
All woody cover	**62.4**	**44.7**	(189)
root wads	50.0	41.7	(3)
log cover	83.3	45.9	(149)
digger logs	5 9 . G	40.1	(40)
All single constrictors	**48.9**	**43.5**	(46)
log constrictors	36.8	**34.2**	(19)
Boulder constrictors	56.7	**49.0**	(26)
log/boulder combinations	75.0	**75.0**	(1)
All opposing constrictors	57.9	**55.6**	(54)
Erosion Control Structures			
bank armor log 44.4 33.3 70.8 25.0 70.8 (3) (6)			
Bank armor	**44.4**	38.9	(18)
Deflectors - single wing	**58.3**	55.5	(9)
bo			

Table 6. Common problems noted during a 1995 survey from 385 structures designed to improve instream fish habitat or stream bank stability.

	Problem Type	Number of occurrences	Percent of total
1.	Anchor failure	31	8.1
2.	Cable failure	15	3.9
3.	Channel shift	9	2.3
4.	Boulder/log shift	53	13.8
5.	Undermined	4	1.0
6.	Buried by bedload	16	4.2
7.	Underbuilt	20	5.2
8.	Stranded out of channel	13	3.4
9.	Bank erosion at site	7	1.8
10.	Created sediment trap	5	1.3
11.	Poor design	41	10.6
12.	Poor/improper placement	75	19.5
13.	Other	8	2.1

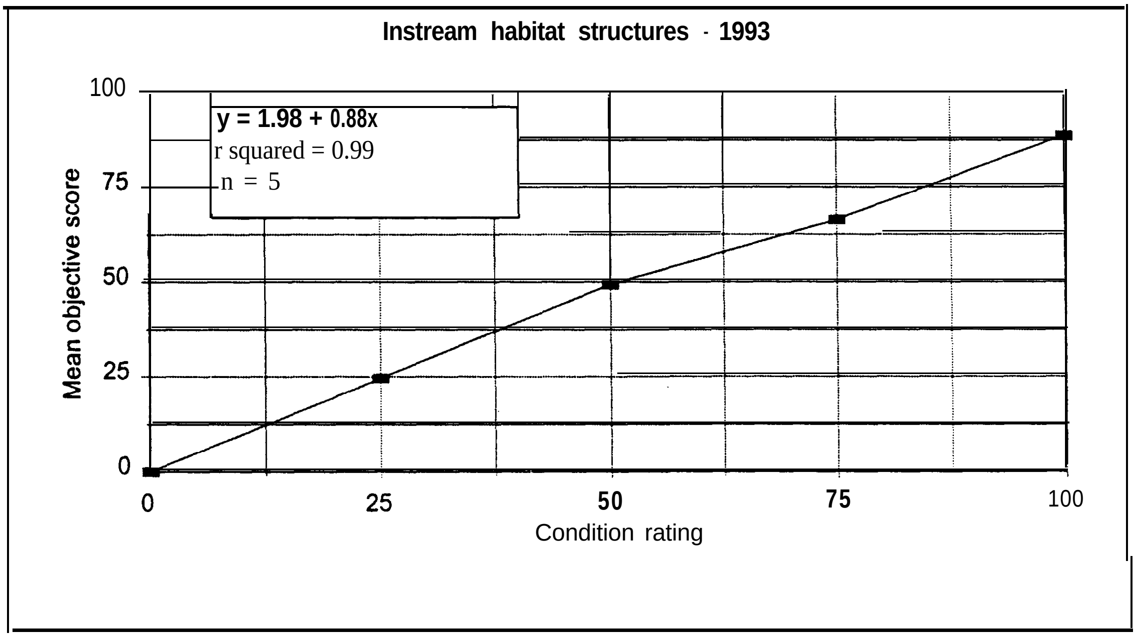
Instream habitat structures - 1993
y = 1.98 + 0.88x
r squared = 0.99
n = 5
Mean objective score
100
75
50
25
0
0
25
50
75
100
Condition rating

Table 7. Comparison of 1993 and 1995 mean evaluation scores for Salmonid habitat restoration projects completed prior to 1993.

	Structure Objective Ratings							Structure Condition Ratings						
	1993			1995				1993			1995			
Stream	Mean	Variance	n	Mean	Variance	n		Mean	Variance	n	Mean	Variance	n	
Butler Creek	69.1	701	34	52.6	666	39	(s)	88.3	413	34	68.6	279	39	(s)
Hollow Tree Creek	60.4	1275	78	56.0	718	29		68.0	1043	78	62.9	415	29	
Huckleberry Creek	55.4	976	23	56.0	411	24		71.7	288	23	73.8	88	24	
Kiler Creek	61.7	767	44	14.4	631	44	(s)	72.3	352	44	18.1	577	44	(s)
Rowdy Creek	62.3	463	53	67.0	773	53		67.0	301	53	72.2	534	53	
E. F. Tule Creek	61.1	850	61	49.5	742	64	(s)	70.5	605	61	60.5	504	64	(s)
Tule Creek	72.5	731	50	52.0	621	50	(s)	75.5	562	50	66.5	440	50	(s)

Note: (s): indicates that 1993 and 1995 means in each category are significantly different (t-test, $P<0.05$).

Bear Wallow, Grizzly, Michaels, and Stevens creeks were newly completed projects in 1993. Comparisons between survey results in 1993 and 1995 were not made for these projects.

The most common structure problems observed in 1993 were shifting of structure elements (logs and boulders) and use of too small materials (underbuilt). These two problems are related because logs and boulders not sized correctly to withstand stream forces will move. Movement often occurs even when elements are anchored if stream forces are great. The observed relative high incidence of anchor failure is also probably related to log and boulder movement. These failures illustrate and important point: if the correct size of material is not available, the project is likely to have a short life span and probably should not be constructed.

The age or life span of structures was not directly addressed in this survey. One problem with determining the age of a specific structure is that many structures were modified or repaired without being documented. However, degraded structure condition was not observed to be a result of log or boulder age (i.e., rotting logs or crumbling boulders). Poor anchoring technique, poor choice of anchoring substrate, log or boulder shift, or under size materials, and poor placement in the stream were usually the cause of structural failure. In a few cases old and deteriorating logs were used in new structures that probably limited their life span. In general, when sound material was used the life span of log structures probably exceeded 10 years. For example, several log structures placed in 1987, or before, exhibited little sign of deterioration (e.g., Horse Linto, Rush, Hunter, Deadwood creeks). Based on results of both 1993 and 1995 surveys, habitat improvement structures are in much more jeopardy from being damaged by stream flow events than suffering from old age.

Recommendations

1. Continue to monitor and evaluate a representative sample of fish habitat restoration projects for quality of construction techniques and habitat value. This should ensure that standard or proven designs, construction methods, and placement within the stream are being accomplished to produce or enhance fish habitat within intended objectives.

2. Results of this survey illustrates that most habitat improvement structures have remained in place, however, benefits to Salmonid production within streams have not been determined. One of the next evaluation steps should be to design a study to measure the response of Salmonid productivity resulting from fish habitat improvement projects.

3. Future contracts should require contractors to document “as built” structural detail and location within the stream channel for each project structure.

4. Require documentation of pre-project habitat detail for instream habitat improvement projects. The data should be adequate to enable measurement of changes resulting from habitat improvement projects.

Literature Cited

Ehlers, Robert. 1956. An evaluation of stream improvement devices constructed eighteen years ago. California Fish and Game, 42:203-217.

APPENDIX A

STREAM HABITAT ENHANCEMENT PROJECT EVALUATION
GENERAL PROJECT INFORMATION FORM

STREAM:________________________________ WATERSHED ______________________________

STREAM PNAME:____ PNAME CODE: __________________

EVALUATOR(s): ____ DATE:_____ ________I________

CHANNEL TYPE:_________ STREAM ORDER:________ DRAINAGE AREA (SQ MI)__________

USGS QUAD (7.5 MIN):____ ANADROMOUS MILES:_______

PROJECT LOCATION AT DOWNSTREAM END: LATITUDE:______________ LONGITUDE: ______________

CONTRACT NO.:____________FY:/____ ____ FUND SOURCE____________________________________

CONTRACT MANAGER:_________________________ CONTRACTOR:___________________________

DOES THIS CONTRACT INCLUDE PROJECTS IN OTHER STREAMS OR LOCATIONS: Y / N

AMOUNT SPENT ON EVALUATED PORTION OF CONTRACT: $_____________________
(May include total contract amount or a portion of contract)

PROPERTY OWNER:____

ACCESS DIRECTIONS:____

____

DATE PROJECT COMPLETED: MONTH________ YEAR_________

DATE OF MAINTENANCE OR MODIFICATION: MONTH___________ YEAR: ___________

DATE OF LAST EVALUATION: MONTH________ YEAR_________

PRE-PROJECT EVALUATION OR DATA AVAILABLE: Y_ N _ IF YES WHERE?________________________

____

AS-BUILT DATA OR PROPOSED DESIGNS AVAILABLE: Y / N
WHERE?______________________________

____

NO. OF STRUCTURES CONSTRUCTED _________ NO. OF STRUCTURES EVALUATED___________
COMMENTS:____

____

NUMBER OF EVALUATION PAGES ASSOCIATED WITH THIS FORM:________________

GENERAL PROJECT EVALUATION OR COMMENTS:____

____

____

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APPENDIX B
STREAM HABITAT ENHANCEMENT PROJECT EVALUATION
INDIVIDUAL STRUCTURE OR SITE FORM

STREAM:______________________ WATERSHED:______________ PAGE___of ____

DATE:____/____/____ STREAM PNAME:______________________ PNAME CODE:________

EVALUATOR(s) :______________________________ CONTRACT NO.:__________ FY:/____ ____

REFERENCE POINT:____________________ LAT: I_I_I.I_Im I_ Im I_ LONG:1 I I I.I _I _I _I _I
(DECIMAL DEGREES) (DECIMAL DEGREES)

FEET FROM REFERENCE POINT______________ **UP DN** CHANNEL TYPE ____________

RESTORATION OBJECTIVE: 1 2 3 (circle one) TYPE OF STRUCTURE: ______________

HOW WELL IS STRUCTURE MEETING HABITAT OBJECTIVE ? (circle number)

1 (100%) ________ 2 (75%)________ 3 (50%)________ 4 (25%)________ 5 (0)________

COMMENTS:____

CONDITION OF STRUCTURE consider structural integrity only (circle number):

1 (EXCELLENT)--------2 (GOOD) **3 (FAIR)** **-----4 (POOR)** **5** (NOT VISIBLE)

COMMENTS:____

STRUCTURE PROBLEMS (check appropriate items):

1. ANCHOR FAILURE__________,
2. CABLE FAILURE__________,
3. CHANNEL SHIFT____, _____
4. BOULDER/LOG SHIFT, ______
5. UNDERMINED_______, ______
6. BUILT BY BEDLOAD, ______
7. UNDERBUILT______________,
8. LOGS/BOULDERS STRANDED OUT OF CHANNEL, ______
9. BANK EROSION AT **SITE** AND/OR **DOWNSTREAM** , _____
10. CREATED SEDIMENT TRAP, ______
11. POOR DESIGN, ______
12. POOR PLACEMENT_______,
13. EX-FENCE FAILURE, ______
14. OTHER. ______

COMMENTS:____

Repair recommend:d: No Yes Enhancement to improve cover or effectiveness recommended: No Yes

HABITAT TYPE (associated with structure) ____________ BANKFUL STREAM WIDTH ________FT.

MAXIMUM POOL DEPTH__________FT. DEPTH OF POOL TAIL CREST__________FT.

SHELTER COMPLEXITY: 0 2 3 x SHELTER % COVER: = SHELTER RATING:________

OBSERVED SALMONIDS NO.: 0+__________, 1+__________, ADULTS__________, REDDS__________
COMMENTS:____

REVEGETATION :RIPARIAN____ UPSLOPE____ BOTH____ (Photo required for reveg.) DESCRIBE DENSITY:
____

PHOTO NO. PRINT: ROLL______ FRAME______, SLIDE: ROLL______ FRAME______
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