Recommendations to the Trinity River Hatchery
Ad Hoc Review Committee for management of coho salmon

November 2009

Contributing Technical Action Group Members

Seth W. Naman, National Marine Fisheries Service
Larry Preston, California Department of Fish and Game
Nina Hemphill, Trinity River Restoration Program
Wade Sinnen, California Department of Fish and Game
Joe Polos, U.S. Fish and Wildlife Service

Introduction

In recent years there have been large adult returns of hatchery fish to the Trinity River, particularly steelhead and coho salmon. The substantial numbers of adult hatchery fish, the majority of which were not harvested by recreational anglers or tribes, prompted concern from several stakeholders on the effects of hatchery stocks on naturally produced stocks. Additionally, there has been no adjustment to coho salmon production at Trinity River Hatchery (TRH) since the closure of recreational and commercial coho salmon fisheries in California, which may also have contributed to the high adult returns in recent years. In the summer of 2009, the Ad Hoc Trinity River Hatchery review committee was formed to examine TRH operations in relation to mitigation goals and objectives within the Trinity River basin. The Ad Hoc committee will discuss issues related to hatchery operations and develop best management practices for the hatchery. The Committee's recommendations will be presented to stakeholders for their consideration. The Technical Action Group (TAG) was formed at the same time to make technical recommendations to the Ad Hoc committee. This paper summarizes the TAG review of coho salmon production at TRH and recommendations for modifications to the coho salmon production program. Subsequent analysis will be made for steelhead and Chinook salmon.

Hatchery fish are known to cause impacts to naturally produced fish through genetic and ecological interactions (HSRG 2009). Hatchery fish may be less fit than naturally produced fish and suffer from domestication (Arakai et al 2008; Reisenbicler and Rubin 1999), causing a reduction in the viability of the overall hatchery and naturally produced population (Williams et al. 2008). Ecological interactions between hatchery and naturally produced fish, like competition for habitat, have also been linked to population declines in naturally produced stocks (Kostow and Zhou 2006). Throughout the Pacific Northwest, management of hatchery fish has undergone significant change in the last decade. The Hatchery Scientific Review Group (HSRG) was formed in order to reexamine hatchery policies in Puget Sound and the Columbia River Basin, and recommend hatchery reform policies to reduce impacts to naturally produced fish, and increase the fitness of the overall hatchery and wild populations.

Hatchery reforms that improve fitness of the natural populations from the current condition (for example, by promoting local adaptation) also increase the benefit of current and future habitat improvements (HSRG 2009). Conversely, when habitat improvements are made without hatchery reforms, the resulting benefits will be less than with hatchery reform. Improvements in population fitness and productivity from hatchery reform are likely to occur on a shorter time scale than improvements from habitat actions (HSRG 2009). Given that hatchery reforms enhance habitat potential, there is no reason for these reforms to wait for future habitat improvements (HSRG 2009).

Presently, the production goal at TRH is 500,000 juveniles. The current adult coho salmon return goal for TRH is 2,100. With an average of about 2,500 eggs per female, hatchery personnel need no less than 400 adult females for broodstock due to fertility rates between 60 and 80 %, and also to provide a hedge against unforeseen losses in the hatchery. It should be noted that this review of the TRH coho salmon program should not be taken as a referendum on

current hatchery management. TRH has been extremely successful in terms of adult returns and the amount of salmon and steelhead available for harvest.

Historical Run Size Information

Coho salmon historical run estimates for the Trinity River are not available. Moffet and Smith (1950) wrote that coho salmon "are not known to migrate above the mouth of the South Fork at the present time, and there are no definite indications that they have ever migrated upriver as far as Lewiston." USFWS and CDFG (1956) wrote that based on meager information available, "it is estimated that 5,000 may ascend the Trinity River upstream of Lewiston, CA." They also stated that juvenile coho salmon had been rescued in three separate years in the early 1950s in a Ramshorn Creek diversion and a Stuart Fork of the Trinity River diversion. Given the little information available, the TAG concluded that it was unlikely that the average run size upstream of Lewiston (some years may have been greater, others less) eclipsed 5,000 adult coho salmon.

Recruits per Spawner

The first year that coho salmon juveniles were consistently marked at TRH was the spring of 1996, with jacks returning in the fall of 1996 and adults returning in 1997. Therefore, the bulk of our analyses are based on the years 1997-2008, the time period that hatchery and naturally produced coho salmon could be differentiated. Coho salmon adult returns are estimated, and the estimates have measurement error and may have sampling error. Nearly all of the data utilized for our analyses below were collected by the California Department of Fish and Game (CDFG) Trinity River Basin Salmon and Steelhead Monitoring Project. These data have been summarized in annual reports available from the CDFG Redding, California office.

In order to examine how the number of hatchery and naturally produced coho salmon spawning in the wild relates to the amount that return three years later, the TAG examined the recruit to spawner relationships from 1997-2008 (Figures 1 and 2; Table 5). Spawners were calculated by adding the estimated number of hatchery and naturally produced (unmarked) adult coho salmon on the spawning grounds in any given year, multiplying by the proportion of females, and then multiplying by one minus the proportion of pre-spawned mortality for that year. Recruits were calculated as the number of unmarked adults (males and females) returning to the CDFG Willow Creek weir three years later, plus the number of adults harvested by the Yurok and Hoopa tribes, multiplied by one plus the pre-season projected ocean incidental exploitation rate obtained from the Pacific Fishery Management Council (PFMC 2009). Hoopa Tribe harvest of unmarked coho salmon was provided by the Hoopa Tribal Fisheries Program. Yurok Tribe harvest of unmarked coho salmon was calculated by dividing the estimated harvest of marked TRH fish (Provided by the Yurok Tribal Fisheries Program) by the percentage of hatchery fish at the Willow Creek weir minus the estimated harvest of marked TRH fish. The TAG acknowledges that poorly marked yearlings and escapees are a potential source of bias, although the percentage of poorly marked coho salmon is low. Jacks were excluded from this analysis.

The estimated recruits per spawner values are very low, less than the replacement value of two (Figure 1). The reason is not known, but possible explanations include low reproductive success of naturally spawning marked and unmarked fish, poor or limited habitat conditions, or low survival rates at one or more life stages. Poor reproductive success is predicted when few naturally produced fish are used for broodstock and a high percentage of hatchery fish dominate the spawning grounds (HSRG 2004; HSRG 2009). The data indicate that the recruit to spawner ratio declines when the number of female spawners is greater than approximately 4,000 (Figures 1 and 2). There is only one exception (spawners in 2001, recruits in 2004) which indicates that any more than about 4,000 female spawners leads to more recruits (Figures 1 and 2; Table 5). It is noteworthy that the 2001 and 2004 coho salmon brood years were strong year classes in other streams in California and southern Oregon (Good et al 2005; Reichmuth 2008). The TAG concluded that in years of large hatchery returns, excessive numbers of fish probably exceeded the carrying capacity of the river, possibly triggering density dependent mechanisms leading to reduced productivity. Additionally, high returns of hatchery coho salmon using the spawning grounds will reduce productivity of Chinook salmon through redd superimposition (Fukushima et al. 1998; Essington et al. 2000), particularly in the uppermost reaches of the river. Regardless of the mechanism, the recruits per female spawner value is substantially less than two, meaning the population is failing to replace itself and relies on hatchery fish spawning in the river (Table 5; Figure 1).

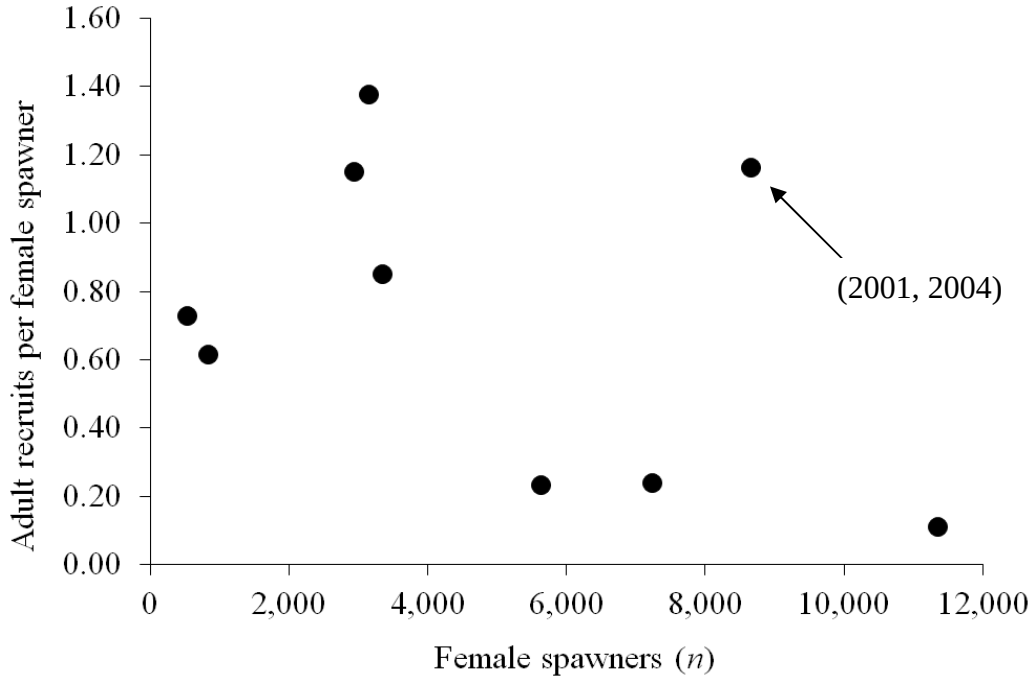

Figure 1. Recruit per spawner ratios and the number of naturally spawning marked and unmarked adult females in the Trinity River from 1997 to 2008. Recruits were defined as male and female unmarked adults. Estimates of adult returns were made by CDFG at the Willow Creek, California weir site.

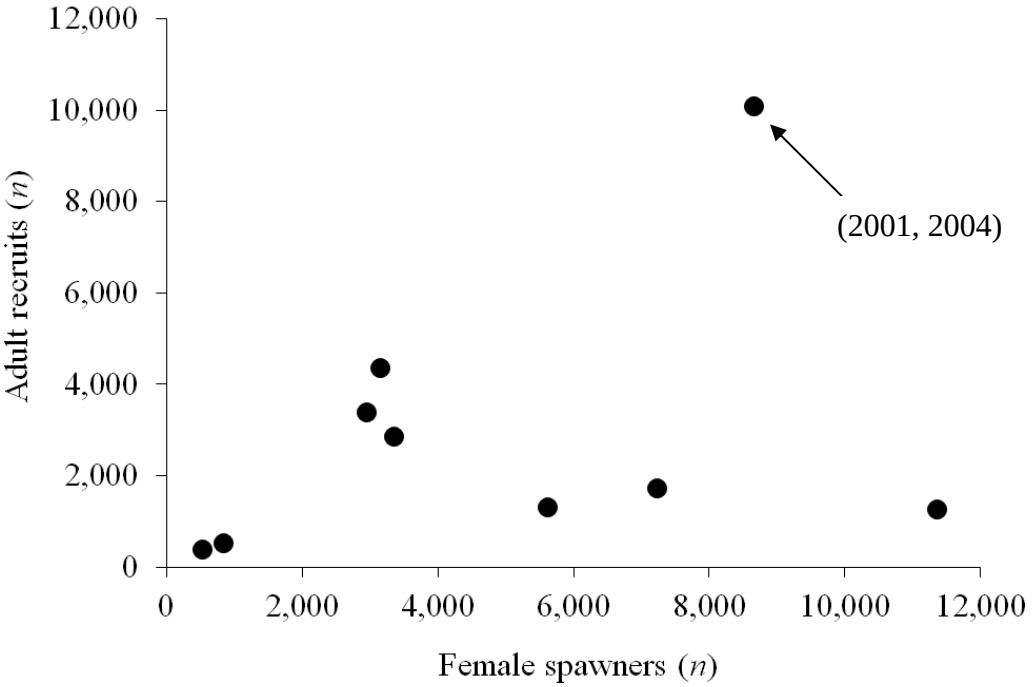

Figure 2. Number of unmarked adult coho salmon recruits produced by naturally spawning marked and unmarked adult coho salmon females in the Trinity River from 1997 to 2008. Estimates of adult returns were made by CDFG at the Willow Creek, California weir site.

Smolt-to Adult Survival

In order to examine how changes in the release goals for TRH would impact hatchery adult and jack coho salmon returns, we used smolt-to-adult (SAR) ratios from 1997 to 2008 to calculate hypothetical returns based on releases of 250,000, 200,000 and 150,000 juveniles (Table 1). In Table 1, estimated returns were calculated as the number of marked adult coho salmon returning in the fall one calendar year after release. The data do not include jacks. Incidental mortality in Chinook salmon directed ocean fisheries and harvest by the Yurok and Hoopa tribes were added to the CDFG estimated adult returns.

The average adult hatchery coho salmon return from 1997 to 2008 was 14,949, nearly three times the TRH coho salmon mitigation goal of 5,000 (Table 1). The average SAR over the same time period was 3.2%. The average percentage of hatchery coho salmon returning to the hatchery itself was 45% (Table 2; range 24%-61%). Including jacks in the SAR calculations raises the average return to the Trinity River to 16,469 with a SAR of 3.73%. The release of 200,000 juveniles would result in an average return to the Trinity River of 6,341 adult coho salmon (not including jacks) assuming an average SAR of 3.2% (Table 1). This amount of fish is similar to that hypothesized by USFWS and CDFG (1956) to have returned to the Trinity River upstream of Lewiston, CA. Using the release of 200,000 juveniles and the average percentage of hatchery fish entering the hatchery, the lowest number of adult coho salmon entering the hatchery would have been in 2006, when 910 fish (1,625 × 0.56) would have ascended the hatchery ladder. This would be an adequate amount of fish for broodstock. Additionally, unmarked fish and jacks would also be utilized for broodstock in the future, reducing the amount of marked adults needed for broodstock.

Table 1. Number of juvenile hatchery coho salmon released from Trinity River Hatchery, estimated adult coho salmon returns, smolt-to-adult returns (SAR), and the number of adults returning using three different hypothetical juvenile release levels multiplied by the SAR.

Release year	Release number	Estimated adult returns	SAR	Hypothetical returns		
				250,000	200,000	150,000
1996	71,993	1,885	2.6%	6,546	5,237	3,927
1997	584,970	10,285	1.8%	4,395	3,516	2,637
1998	516,192	4,781	0.9%	2,316	1,852	1,389
1999	519,273	10,586	2.0%	5,096	4,077	3,058
2000	493,727	28,122	5.7%	14,239	11,392	8,544
2001	513,400	15,617	3.0%	7,605	6,084	4,563
2002	530,285	22,936	4.3%	10,813	8,650	6,488
2003	418,139	27,163	6.5%	16,240	12,992	9,744
2004	517,774	27,941	5.4%	13,491	10,793	8,095
2005	520,563	18,774	3.6%	9,016	7,213	5,410
2006	545,851	4,436	0.8%	2,032	1,625	1,219
2007	514,592	6,858	1.3%	3,332	2,666	1,999
Averages	478,897*	14,949	3.2%	7,927	6,341	4,756

* It should be noted that the average number of hatchery coho salmon released was 515,888 if the average is calculated without 1996.

Table 2. Percentage of marked coho salmon (adults and jacks) returning to the Trinity River that enter Trinity River Hatchery.

Run Year	Total marked into hatchery	Total marked on spawning grounds	Total marked	Percent returning to hatchery
1997	1,725	5,520	7,245	24%
1998	4,868	6,480	11,348	43%
1999	3,396	1,477	4,873	70%
2000	4,323	10,670	14,993	29%
2001	10,649	18,119	28,768	37%
2002	7,097	8,323	15,420	46%
2003	11,179	12,880	24,059	46%
2004	9,903	19,884	29,787	33%
2005	17,425	11,233	28,658	61%
2006	10,326	8,128	18,454	56%
2007	2,706	1,845	4,551	59%
2008	4,820	3,851	8,671	56%
Average	7,368	9,034	16,402	45%

All H Analyzer Modeling Results

In 2004, the Hatchery Scientific Review Group (HSRG 2004) for the Pacific Northwest proposed three parameters to access the risk of hatchery programs on natural stock genetics, as follows:

- proportion of wild adults relative to the total hatchery brood stock (pNOB)
- proportion of hatchery-origin spawners that spawn in the wild (pHOS)
- proportion of natural influence (PNI) = pNOB/(pNOB + pHOS)

The PNI is a measure of gene flow between hatchery and wild fish. Diversity within a population decreases with a lower PNI because the uniform hatchery environment is driving population diversity compared to the more diverse natural environment. When PNI is 0.5, the natural and hatchery environment exert equal influence on the population. Thus, PNI must exceed 0.5 if the natural environment is to dominate the selection process. Based on adult returns and hatchery broodstock information, the average PNI for the Upper Trinity River from 1997-2008 is about 0.05, one order of magnitude lower than the HSRG threshold of 0.67 (Table 3) with an average of 89% hatchery fish (Table 4). This indicates that the hatchery has a much greater influence than the natural environment on the selection process for the overall hatchery and naturally produced coho salmon population (HSRG 2004).

The HSRG (HSRG 2004; HSRG 2009) developed the All H Analyzer (AHA) model (habitat, hatcheries, harvest, and hydropower) as a way to examine how changes to the various “H’s” will impact returns of hatchery and wild fish and the relative fitness of the overall population. One of

the outputs of the AHA model is an estimate of the PNI, as well as a "fitness factor," calculated after running a particular model scenario for 100 generations. The fitness computations are derived from concepts developed by Ford (2002), Lynch and O'Hely (2001), and others. It is essentially a scale of the performance of hatchery origin fish relative to that of natural origin fish. The AHA model does not measure the ecological consequences (competition, predation, behavior or disease transmittal) of releasing hatchery fish.

The TAG used the AHA model to evaluate the possible effects of hatchery, harvest, and habitat on natural coho salmon production. Because there are no hydroelectric facilities that coho salmon must pass on the Trinity River, this portion of the model was not utilized. We sought to balance the TRH smolt production with harvest, and habitat restoration to achieve a predicted PNI value greater than 0.67.

The model was first parameterized for the Trinity River using an estimate for productivity from a Beverton-Holt regression (Mobrand, Jones & Stokes 2005), the number of eggs per female, average hatchery releases, and several other factors. The model did a reasonable job of predicting current conditions. For example, the model calculated that about 2,411 naturally produced adults would return on average, while the actual value from 1997-2008 was 2,250 (Figure 4). In the current scenario, hatchery fish dominate on the spawning grounds called "Habitat" in Figure 3 below. This results in a PNI of less than 0.5 and a fitness factor of 0.5 (the floor established in the model) after 100 generations. In this model harvest was kept at a rate of 0.062 in marine, and roughly 0.015 in two hypothetical river reaches (upper and lower) for an overall exploitation rate of 0.088 for naturally produced fish and 0.093 for wild stocks. These harvest rates were based on data collected from the Tribes and the Pacific Fishery Management Council for 1997 to 2008.

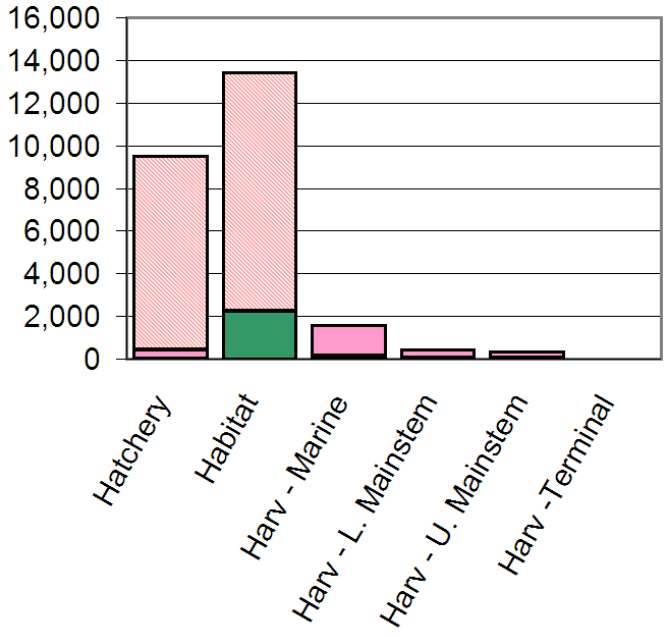

Figure 3. Output of the AHA model for coho salmon returns to various areas using the "current" conditions. The green indicates "naturally produced" fish, the hatched pink indicates hatchery

fish spawning in the river (habitat) or excess hatchery fish returning to the hatchery. The solid pink indicates either hatchery broodstock or harvested hatchery fish.

The TAG ran a model combining several changes to the current conditions, most notably, a reduction in the number of juveniles released from the hatchery from 500,000 to 200,000. Another large change to the current conditions in the model run was to remove 90% of hatchery fish from the river (they entered the hatchery in the model). As mentioned above, the current proportion of hatchery coho salmon returning to the hatchery is about 46%. Harvest rates of hatchery and naturally produced fish were kept static in the ocean and two river reaches. These changes resulted in a predicted PNI of 0.67 (up from 0.05 from 1997 to 2008) and a fitness factor of 0.81 after 100 generations. The biggest change to the model output of adult returns was a large reduction in the amount of hatchery adult spawning in the river (Figure 4). On average, the hatchery would still be receiving about 7,000 adults annually (Figure 4). This model run assumes that the rate of hatchery fish spawning in the wild will be reduced to 35% of the total number of coho spawning in natural areas. Modeling results using a juvenile release level of 250,000, with all other factors kept static, resulted in a PNI of 0.62, a fitness factor after 100 generation of 0.77 and average hatchery returns of around 10,000 fish. In order to achieve a similar PNI and fitness factor as the release of 200,000 juveniles, a higher percentage of naturally produced broodstock would have to be utilized and a higher percentage of hatchery fish would have to be removed from the river.

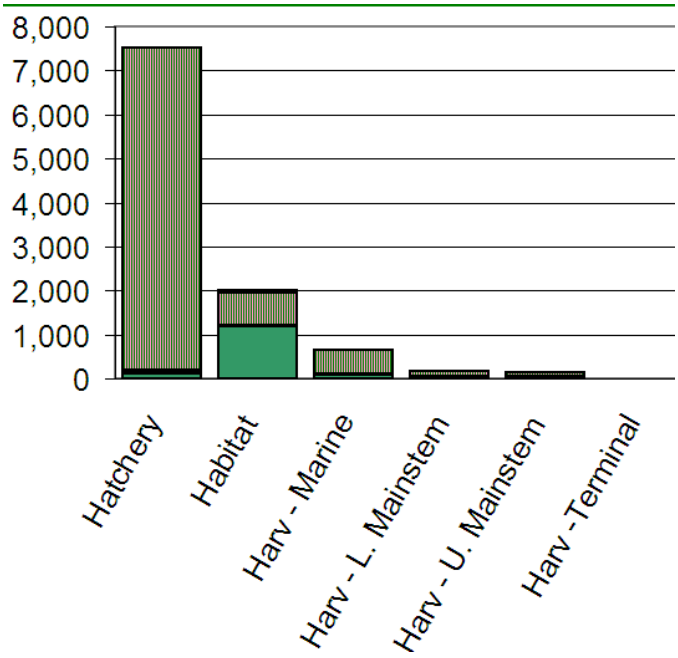

Figure 4. Coho salmon returns to various areas based on the TAG reccomendations using the AHA model. The solid green indicates naturally produced fish, while the olive indicates hatchery fish. Note the relatively low percentage of hatchery fish spawning in the river (habitat), compared with the "current" model scenario..

It is critical that surplus hatchery fish are removed to reduce pHOS and maintain a PNI greater than 0.67. The modeling performed by this group assumes that 90% of the hatchery fish returning to the river will not spawn in the river. Because only 46% of hatchery coho salmon return to TRH on average, hatchery coho salmon would have to be removed from the river by

other means, such as culling at a weir, to achieve the appropriate level for metrics like the fitness factor and the PNI, developed by the HSRG (HSRG 2004; HSRG 2009).

Recommendations

The following are proposed interim recommendations. The TAG will develop more concise guidelines upon approval of the AD HOC Review committee.

Hatchery Broodstock and Spawning Protocol

1. Reduce coho salmon release to 200,000.
2. Adopt 1:1 mating protocol
3. With a target of 70% naturally produced fish, integrate the maximum number of natural coho salmon into TRH broodstock
4. Incorporate jacks at a rate of 10% into the broodstock
5. When adequate numbers of natural coho salmon are available during a spawning session, prioritize mating as 1) naturally produced x naturally produced 2) naturally produced x hatchery and 3) hatchery x hatchery
6. Continue to trap and cull (in excess of broodstock needs) hatchery adult coho
7. Archive tissue samples from all coho salmon broodstock

Harvest

1. Adopt a terminal (upstream of the North Fork Trinity, or possibly upstream of Lewiston) recreational fishery for hatchery coho salmon
2. Evaluate lower production goals on harvest rates by Tribal fisheries

Habitat

1. Continue Trinity River Restoration Program habitat improvements as adopted in the Trinity River Record of Decision
2. Monitor coho salmon returns and monitor response of natural/hatchery ratios based on new production goals

Logistical Constraints

Policy concerns

1. Hatchery coho salmon non retention in California
2. Tribal concerns

Hatchery needs

1. Adult holding tanks to hold non-ripe naturally produced broodstock
2. Additional staff and resources to assist in development of new spawning protocols

Monitoring, research and implementation needs

1. Potential culling weir near Lewiston, CA
2. Coho salmon genetic evaluation
3. Straying research

References

Araki, H., B. A. Berejikian, M. J. Ford and M. S. Blouin. 2008. "Fitness of hatchery-reared salmonids in the wild." Journal compilation, Blackwell Publishing Ltd 1: 342–355.

Essington T.E., J.R. Hodgson, J.F. Kitchell. 2000. Role of satiation in the functional response of a piscivore, largemouth bass (Micropterus salmoides). Can J Fish Aquat Sci 57:548–556

Ford, M.J. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. Conserv. Biol. 16:815-625

Fukushima, M., T.J. Quinn, II, and W.W. Smoker. 1998. Estimation of egg loss from the spawning ground of pink salmon. Can. J. Fish. Aqu. Sci. 55: 618-625.

Good, T. P., R. S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-66. 597 p.

HSRG (Hatchery Scientific Review Group). 2004. "Hatchery Reform; Principles and Recommendations of the Hatchery Scientific Review Group." Hatchery Scientific Review Group (HSRG). Available online:http://www.longlivethekings.org/pages/hatchery_reform_project/HRP_Publications_HSRG_Recs.html

HSRG (Hatchery Scientific Review Group). 2009. Columbia River Hatchery Reform System-Wide Report. Final Systemwide Report. February 2009. Available Online at:http://www.hatcheryreform.us/hrp/reports/system/welcome_show.action.

Kostow, K. and S. Zhou. 2006. "The Effect of an Introduced Summer Steelhead Hatchery Stock on the Productivity of a Wild Winter Steelhead Population." Transactions of the American Fisheries Society 135: 825–841.

Lynch, M., and M. O'Hely. 2001. Supplementation and the genetic fitness of natural populations. Conservation Genetics 2: 363-378.

Mobrand, Jones & Stokes Associates. 2005. All H Analyzer (AHA) User Guide; June 7, 2005 draft. Available online at http://www.fws.gov/pacific/Fisheries/Hatcheryreview/documents/All-HAnalyzerDraftUsersGuideAug05.pdf. Accessed November 2009.

Moffett, J. W. and S. H. Smith. 1950. Biological investigations of the fishery resources of the Trinity River, California. Special Scientific Report No. 12. U.S. Fish and Wildlife Service. 71 pp. Available from the USFWS Arcata, CA office.

Pacific Fishery Management Council (PFMC). 2009. Salmon preseason reports. Available online at http://www.pcouncil.org/salmon/salpre.html. Accessed November 2009.

Reichmuth, M. 2008. 2007-2008 Redwood Creek coho salmon briefing. Unpublished report of the National Park Service. Available online at http://science.nature.nps.gov/im/units/sfan/vital_signs/fish/docs/Redwood%20Creek%20Briefing%202008%20v.2.pdf. Accessed November 2009.

Reisenbichler, R. R. and S. P. Rubin. 1999. "Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations." ICES J. Mar. Sci 56(459-466).

USFWS and CDFG (U.S Fish and Wildlife Service and California Department of Fish and Game). 1956. A plan for the protection of fish and wildlife resources affected by the Trinity River Division, Central Valley Project. Prepared jointly by the California Department of Fish and Game and the U.S. Fish and Wildlife Service. 76. pp. Available from the USFWS Arcata, CA office.

Appendix Tables

Table 3. Estimated returns of unmarked coho salmon to the Trinity River from 1997 to 2008 with calculations of the PNI.

Run Year	Unmarked adults spawned at hatchery	Unmarked adults and jacks not spawned at hatchery (returned to river)	Total unmarked jacks	Total unmarked adults and jacks into hatchery	Unmarked Adults and jacks not into hatchery on spawning grounds	Total unmarked adults and jacks on spawning grounds	Angler harvest (natural)	Unmarked adults and jacks total	Phos	Pnob	PNI	Total Marked and unmarked adults and jacks on spawning grounds
1997	16	17	399	33	615	632	3	651	0.90	0.02	0.02	6,152
1998	43	180	131	223	1,009	1,189	0	1,232	0.84	0.03	0.03	7,669
1999	50	61	31	111	463	524	12	586	0.74	0.04	0.05	2,001
2000	11	53	197	64	475	528	0	539	0.95	0.01	0.01	11,198
2001	13	119	298	132	3,241	3,360	0	3,373	0.84	0.01	0.01	21,479
2002	32	69	138	101	495	564	0	596	0.94	0.02	0.02	8,887
2003	186	494	163	680	3,413	3,907	0	4,093	0.77	0.08	0.09	16,787
2004	74	1,006	154	1,080	7,975	8,981	0	9,055	0.69	0.06	0.08	28,865
2005	97	833	81	930	1,810	2,643	0	2,740	0.81	0.06	0.06	13,876
2006	77	97	38	174	1,450	1,547	0	1,624	0.84	0.04	0.04	9,675
2007	90	132	42	222	977	1,109	0	1,199	0.62	0.07	0.10	2,954
2008	82	286	89	368	944	1,230	0	1,312	0.76	0.07	0.08	5,081

Table 4. Estimated returns of marked coho salmon to the Trinity River from 1997 to 2008.

Run Year	Marked adults and jacks spawned at hatchery	Marked adults and jacks not spawned at hatchery (culled)	Total marked jacks	Total marked adults and jacks into hatchery	Total marked adults and jacks on spawning grounds	Angler harvest (marked)	Marked adult and jacks total	Percent Hatchery	Total adult and jack returns to the hatchery (marked and unmarked)
1997	738	987	5,552	1,725	5,520	39	7,284	92%	1,758
1998	1,375	3,493	2,340	4,868	6,480	0	11,348	90%	5,091
1999	1,124	2,272	592	3,396	1,477	86	4,959	89%	3,507
2000	926	3,397	5,289	4,323	10,670	0	14,993	97%	4,387
2001	1,036	9,613	3,373	10,649	18,119	0	28,768	90%	10,781
2002	2,084	5,013	1,571	7,097	8,323	0	15,420	96%	7,198
2003	2,184	8,995	3,338	11,179	12,880	0	24,059	85%	11,859
2004	1,167	8,736	5,665	9,903	19,884	40	29,827	77%	10,983
2005	1,640	15,785	3,012	17,425	11,233	21	28,679	91%	18,355
2006	1,991	8,335	1,331	10,326	8,128	0	18,454	92%	10,500
2007	1,276	1,430	503	2,706	1,845	0	4,551	79%	2,928
2008	1,119	3,701	2,290	4,820	3,851	0	8,671	87%	5,188

Table 5. Spawner-recruit ratios for the Trinity River from 1997 to 2008.

Run Year	Marked and Unmarked natural adult female spawners (S)	Unmarked adult estimated run size at WC weir	Ocean incidental mortality	Estimated Yurok unmarked Trinity harvest	Estimated Hoopa unmarked harvest	Estimated total adult unmarked recruits	Estimated adult unmarked recruits (year+3) (R)	R/S	LN (R/S)
1997	531	252	0.050	2	3	271	386	0.727	-0.318
1998	2,945	1,101	0.117	6	54	1,297	3,386	1.150	0.140
1999	843	555	0.049	9	36	629	519	0.616	-0.485
2000	3,158	342	0.060	1	22	386	4,352	1.378	0.321
2001	8,666	3,075	0.030	111	100	3,386	10,081	1.163	0.151
2002	3,356	458	0.077	4	20	519	2,853	0.850	-0.162
2003	7,235	3,930	0.096	23	17	4,352	1,734	0.240	-1.429
2004	11,356	8,901	0.086	302	80	10,081	1,257	0.111	-2.201
2005	5,630	2,659	0.055	24	21	2,853	1,302	0.231	-1.464
2006	4,964	1,586	0.052	24	38	1,734	NA	NA	NA
2007	1,222	1,157	0.058	17	14	1,257	NA	NA	NA
2008	1,709	1,223	0.010	13	53	1,302	NA	NA	NA

Table 6. Parameter estimates for the Beverton-Holt S-R curve. The Beverton Holt curve was calculated by least squares regression of 1/R on 1/S. Spawners defined as female coho salmon with a replacement value of 2. Maximum recruitment (alpha/beta) is 6,326.

Parameter	Est value	St dev	t student	Prob(>|t|)
b0	0.000202	0.00015	1.35100	0.21873
b1	1.27890	0.19450	6.57518	0.00031
				y = b0 +
Residual St dev	0.00034			b1.x1
R2	0.86065			
R2(adj)	0.84074			
F	43.23300			
Prob(>F)	0.00031			
Density dependence	**Beta**	**0.00020**		
productivity	**Alpha**	**1.27890**		