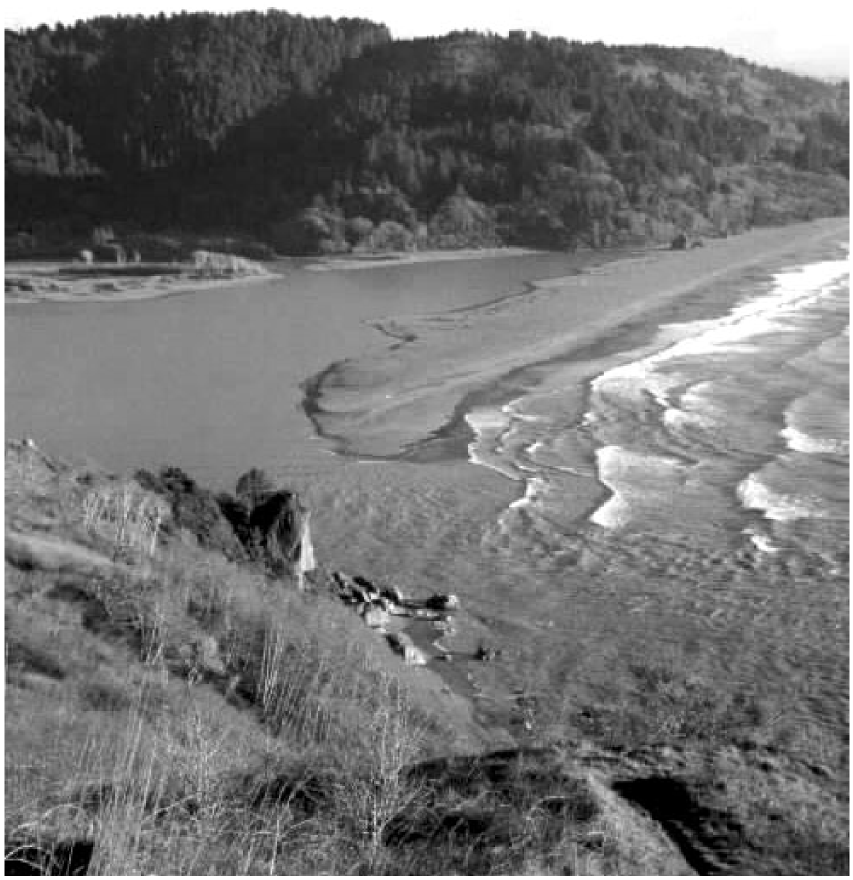
Agenda Item I.2.a
Attachment 3
September 2007

KLAMATH RIVER FALL CHINOOK OVERFISHING ASSESSMENT



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1.0 INTRODUCTION

Amendment 9 to the Council's FMP specified the conservation objective for Klamath River fall Chinook (KRFC) was to preserve 33%-34% of potential adult natural spawners, but no less than 35,000, in any one year. The preseason projected adult spawning escapement was 35,000 in both 2004 and 2005; however, the post season estimates were 24,100 and 26,800, respectively. In 2006 the preseason projection was 21,100, and the postseason estimate was 30,400.

Klamath River fall Chinook (KRFC) failed to meet the Pacific Fishery Management Council's (Council's) conservation objective of at least 35,000 adult natural spawners in 2004, 2005, and 2006. When a stock fails to meet its conservation objective for three consecutive years an Overfishing Concern is triggered under the terms of the Pacific Coast Salmon Plan (FMP) (PFMC 2003). An Overfishing Concern requires specific actions of the Council and its advisory bodies, and may result in a declaration by the National Marine Fisheries Service (NMFS) that the stock is overfished, and subsequent development of a rebuilding plan.

Specific actions required by the FMP when an Overfishing Concern is triggered include developing an assessment of the stock and the pertinent factors causing the stock depression and a review of Essential Fish Habitat (EFH) status affecting the stock. After review of the stock and EFH assessments, the Council will recommend actions to end any excessive fishing mortality, rebuild the stock, and achieve the conservation objective of the stock. If a rebuilding plan is required, it will include criteria for determining the end of the Overfishing Concern.

1.1 Purpose and Need

The purpose of this report is to review the current status of KRFC, determine the level and source of fishing mortality, identify pertinent factors leading to the Overfishing Concern, and assess the overall significance of the stock depression with regard to achieving maximum sustainable yield (MSY) on a continuing basis.

The Salmon Technical Team (STT) was directed by the Council to coordinate with relevant state, tribal, and federal agencies, and the Council's Habitat Committee (HC), to complete the stock assessment. The STT has primary responsibility for determining the status of KRFC and developing recommendations for any management changes that may be necessary to rebuild the stock for application beginning in 2008, and for determining the end of the overfishing concern.

During the 2006 preseason salmon management process, the Council was aware that KRFC had failed to meet the conservation objective for two consecutive years and was projected to not meet the conservation objective in 2006, even if all Council managed fishing that would impact KRFC were prohibited. These circumstances triggered a Conservation Alert according to the FMP and required the Council to request relevant state and tribal managers to complete an assessment of the primary factors leading to the shortfall. The Council assigned the HC to assess the EFH related factors associated with the Conservation Alert. The HC completed a draft report, which was the basis for part of this assessment.

This report is needed to fulfill the requirements of the FMP and the Magnuson-Stevens Reauthorization Act (MSRA) to prevent overfishing, and rebuild depressed stocks to sustainable levels. This report is the first step in a process designed to identify the cause of their depressed status and rebuild KRFC, which have triggered an Overfishing Concern, and therefore may be at risk of long term decline in MSY. KRFC are a primary constraint to ocean fisheries between Cape Falcon, Oregon and Point Sur, California, and an important contributor to catch in ocean fisheries between Humbug Mt., Oregon and Horse Mt., California, an area known as the Klamath Management Zone (KMZ). KRFC are the primary contributor to Klamath River recreational and tribal fisheries. When KRFC are depressed, fishing interests and communities in the entire area suffer hardship, as was the case in 2006 when a fishery failure was declared, and commercial ocean fisheries in southern Oregon and northern California, and the Klamath River recreational fishery were closed. Without a healthy, harvestable stock of KRFC, fisheries cannot proceed and tribal allocations cannot be met, which affect the cultural, economic, and religious fabric of Klamath River tribes. An abundant KRFC stock also contributes to the ecosystem function of the marine and freshwater environment by providing food for predators, scavengers, and decomposers and nutrient transport for forest ecosystems.

1.2 Assessment Objectives

The objectives for this Overfishing Assessment were to:

- Identify potential factors affecting adult KRFC natural spawning levels;
- Compare the status of factors during the overfishing assessment period (OAP) relative to appropriate benchmarks (e.g., long term average);
- Qualitatively rank the effects of factors that could be assessed, and ;
- Recommend actions to prevent future natural spawning shortfalls.

1.3 Background

A harvest rate plan for KRFC was developed by the Klamath River Technical Team (KRTT) and approved by the Klamath River Salmon Management Group (KRSMG) in 1986. The plan called for a 35% escapement rate (later changed to 33-34%) for each brood of naturally spawning fish except that 35,000 naturally spawning adults would be protected in all years (35,000 escapement floor, KRTT 1986). The KRTT report is the original source for the 35,000 fish escapement floor, which together with the escapement rate under full fishing, remains a key feature of the conservation objective for KRFC in the current salmon FMP. The KRTT concluded that the escapement floor of 35,000 was needed to protect the production potential of the resource in the event of several consecutive years of adverse environmental conditions. At that time, the KRTT concluded that the escapement floor represented approximately 50% of the adults required to achieve the best available estimate of maximum sustained yield (MSY).

The harvest rate plan recommended by the KRTT was subsequently adopted as part of Salmon Plan Amendment 9, which was first implemented in ocean fishing regulations beginning May 1, 1989. Amendment 9 incorporated the 35,000 fish escapement floor as part of the management objective for KRFC. The Council concluded that inclusion of the floor protected the stock by reducing the risk of prolonged depressed production, provided greater long term yield, and resulted in a high probability of attaining sufficient escapement for hatchery production.

Failure to meet the 35,000 natural adult escapement goal in 1990, 1991, and 1992 led to an Overfishing Review by the Council and the Klamath Fishery Management Council (KFMC) (PFMC 1994). One primary recommendation adopted from that Assessment was to reduce the bias in projecting ocean abundance of the stock by forcing the cohort regression relationships through the origin.

As part of its ongoing commitment to periodic review of management objectives, the Council asked the KFMC to conduct a modeling study of stock, recruitment, and yield of KRFC. The objective of the study was to evaluate the present management policy, and, particularly, the 35,000 fish escapement floor. The task was assigned to the Klamath River Technical Advisory Team (KRTAT). The KRTAT updated data and analysis done originally by the KRTT (1986), and explored new areas including the effects of environmental variability on recruitment. The KRTAT (1999) concluded that use of the 35,000 fish escapement floor remained a prudent choice and "near optimal" for the purpose of optimizing yield.

Ocean fishery management to protect Endangered Species Act (ESA) listed California Coastal Chinook (CCC) salmon began in 2000. The National Marine Fisheries Service (NMFS) ESA consultation standard resulted in a requirement that ocean fisheries be limited to a pre-season projected age-4 ocean harvest rate on KRFC of no more than 17.0% (lowered to no more than 16.0% in 2002 based on new estimation methodology). This rate was the maximum observed for the three-year period[1] prior to the CCC consultation and was used to curb further declines in abundance of CCC salmon stemming from ocean fishery impacts. The consultation standard takes precedence over the Council's 33%-34% spawner escapement rate policy as it applies to ocean fisheries, but does not affect Klamath Basin inriver fisheries.

In 2005, the Council asked for a review of the technical basis of the 35,000 escapement floor, (STT 2005a) and for a review of the relationship between spawning escapement and recruitment for KRFC (STT 2005b). The STT (2005b) updated information, explored several alternative spawner-recruit models, and also considered the effects of environmental factors on recruitment. The STT did not comment specifically on the 35,000 fish escapement floor, but did provide a range of MSY escapement values that depend on the assumptions and models used. The Model 2 stock/recruitment relationship from STT (2005b) included a juvenile survival index term and was considered to represent the best available science by the STT and the Scientific and Statistical Committee (SSC). The Model 2 estimate of MSY escapement was 40,700. Although the current estimate of MSY escapement is somewhat lower than the estimate provided by the KRTT (1986) twenty one years ago, the Council remained committed to reliance on the escapement floor as part of the conservation objective for KRFC. When the escapement floor was adopted into the Salmon FMP through Amendment 9, the Council required that modification of the floor could only occur by Plan amendment.

In 2006 the Council adopted Amendment 15 to the FMP, which allows *de minimis* impacts to KRFC in ocean salmon fisheries during years that might otherwise be closed because of a projected shortfall in the KRFC conservation objective of 35,000 naturally spawning adults. The intent of Amendment 15 was to provide some low level of economic relief for fisheries dependent communities without significantly impacting the long term productivity of KRFC.

[1] The three year period chosen to determine an appropriate harvest rate began in 1996, the year in which ESA requirements to protect Sacramento River winter Chinook were first implemented.

However, the Council specifically excluded modifying the floor itself, thus demonstrating a continued commitment to the 35,000 spawner floor as a conservation objective.

2.0 STOCK/ECOSYSTEM DESCRIPTION

2.1 Location and Geography

The Klamath Basin lies in Northern California and Southern Oregon and encompasses 40,632 km^2 (Figure 2-1). More than half of the watershed (20,875 km^2) lies in the Upper Klamath Basin. Anadromy in the upper basin was cut off by the construction of Copco Dam #1 in 1917, and was further limited by construction of Iron Gate Dam in 1962, built to reregulate the discharge of Copco Dam. Access to the upper Trinity Basin was cut off by the construction of Trinity Dam in 1962 and its re-regulation dam (Lewiston) in 1963, which together blocked access to the upper 459,264 acres (1,859 km^2) of the Trinity Basin, leaving an accessible watershed area of 17,898 km^2 remaining.

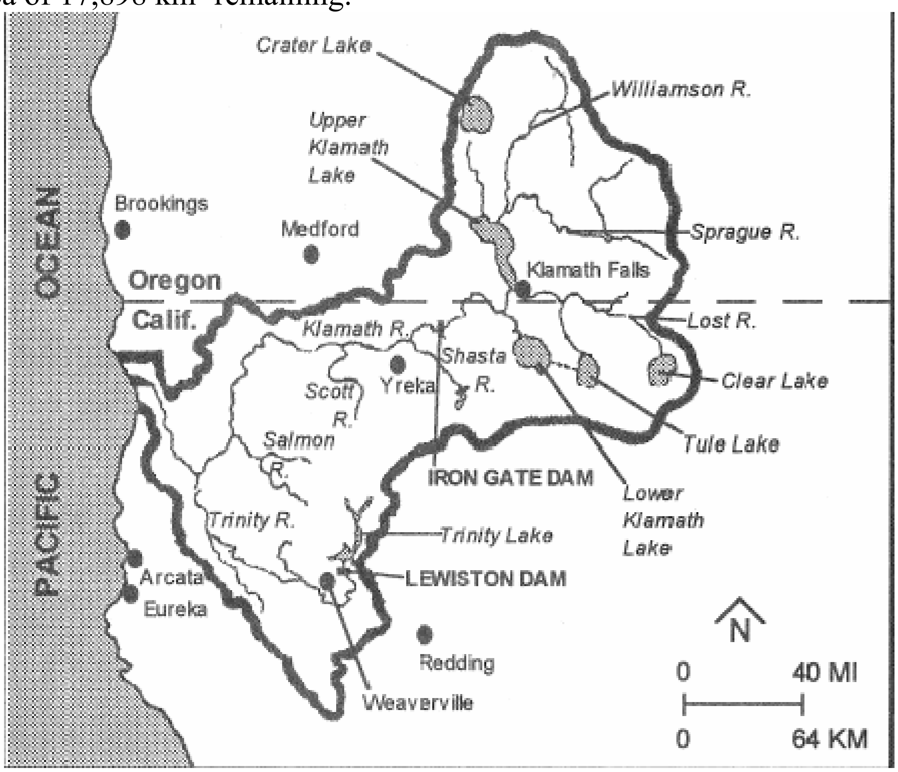

Figure 2-1. Map of the Klamath Basin.

All remaining habitat accessible to anadromous fish lies in California, though portions of the lower Klamath Basin Watershed extend into Oregon. Major tributaries to the Klamath River within the lower basin include the Trinity, Salmon, Scott, and Shasta Rivers, and Bogus Creek, which support spawning populations of KRFC. There is also a hatchery program for spring Chinook at Trinity River Hatchery (TRH), and some small populations of natural spring Chinook, the largest of which spawns in the Salmon River. In addition to Chinook salmon, other anadromous species supported by the basin include coho salmon (*O. kisutch*), steelhead (*O. mykiss*), coastal cutthroat (*O. clarkii*), Pacific lamprey (*Lampetra tridentata*), and green sturgeon (*Acipenser medirostris*). Coho salmon in the Klamath Basin are part of the ESA listed Southern Oregon-Northern California Coastal (SONCC) coho evolutionarily significant unit (ESU).

2.2 Production

Records of the estimated escapement of KRFC have been kept since 1978 and are available through 2006 (Figure 2-2). Production is heavily influenced by two hatcheries, constructed to mitigate habitat loss resulting from construction of the major dams in the basin. IGH (IGH) on the Klamath River has had a geometric mean return of 10,967 adult spawners annually in the period from 1978-2006. During the same period TRH has received a geometric mean of 5,849 adult spawners annually. Natural escapement of KRFC is dominated by the Trinity River, with 16,409 naturally spawning adult fall Chinook annually, and Bogus Creek with 5,254. Both of these sub-populations are adjacent to hatcheries. Other major spawning populations, and their 1978-2006 geometric mean adult fall Chinook spawning escapements include: the mainstem Klamath River, with 2,296, the Scott River with 3,377, the Shasta River with 2,722, and; the Salmon River with 1,756. Other miscellaneous tributaries of the Klamath and Trinity Rivers collectively account for another 1,996 adults. The grand total for the entire Klamath Basin is a geometric mean annual escapement of 38,721 natural spawning adult KRFC. The natural escapement into Bogus Creek includes substantial numbers of strays from IGHIGH, and the mainstem Trinity River receives substantial numbers of strays from TRH, but the remaining sub-populations are relatively free of hatchery influence.

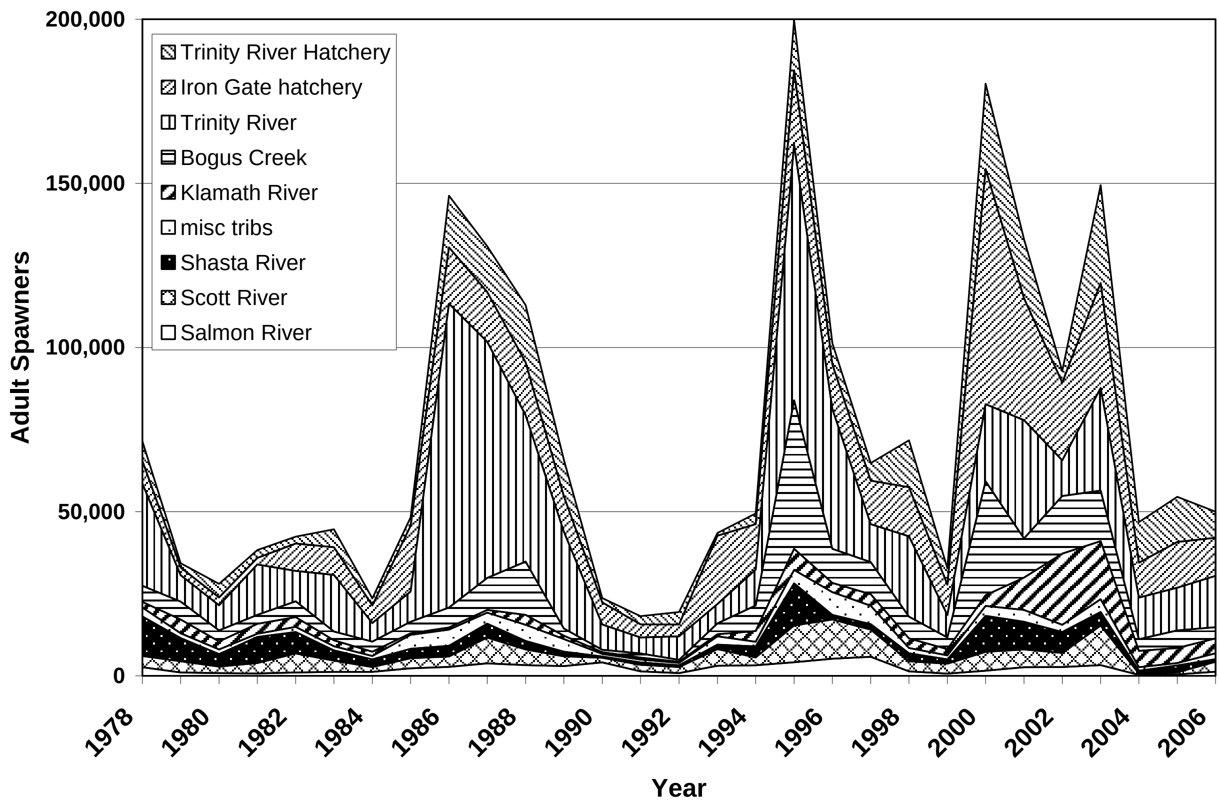

Figure 2-2. Annual spawning escapement in Klamath Basin tributaries and hatcheries, 1978-2006.

2.3 Stock Status

The preseason projections of naturally spawning adult KRFC in 2004 and 2005 were large enough to allow an ocean salmon fishery to proceed in accordance with the FMP, and the management target was set at the 35,000 escapement floor in both years. However, the postseason estimates of naturally spawning adults were 24,100 and 26,800 in 2004 and 2005, respectively, and failed to meet the KRFC conservation objective.

In 2006 a Conservation Alert was triggered during the preseason process when the number of naturally spawning adults was projected to fall short of the escapement floor even without any additional fishing that would impact KRFC. About 6,000 KRFC had already been harvested in marine fisheries during autumn 2005. The FMP requires all salmon fisheries within Council jurisdiction that impact the stock be closed when a Conservation Alert is triggered. As a result the projected shortfall in meeting the KRFC escapement floor in 2006 required an emergency rule be issued by the Secretary of Commerce (Secretary) to allow ocean salmon fishing to proceed with a projected natural escapement of 21,100 fish.

The postseason estimate of naturally spawning adult KRFC in 2006 was 30,400 fish. Although the postseason estimate was larger than the projected escapement of 21,100 fish, KRFC failed to meet the escapement floor for the third consecutive year triggering an Overfishing Concern in accordance with the FMP. The Overfishing Concern provisions in the FMP recognize that although failing to meet the conservation objective for three consecutive years could represent a normal variation in stock status, it could also indicate the beginning of a critical downward trend that could jeopardize the ability of the stock to produce MSY over the long term. Therefore, this report represents the initial phase in a plan designed to ensure the conservation objective is met or a rebuilding plan is implemented and any inadvertent excessive fishing is ended.

The projected spawning escapement of KRFC released during the 2007 preseason planning process was higher than it had been in recent years. This projection permitted ocean salmon fisheries to occur that were not limited by the KRFC conservation objective and without the need for an emergency rule. Due to an increased river allocation, management measures were crafted that will again target the 35,000 spawner escapement floor. Verification of whether or not the KRFC conservation objective is met in 2007 will not be possible until postseason estimates become available in February, 2008.

3.0 MANAGEMENT CONTEXT

The Salmon FMP establishes conservation and allocation guidelines for annual management of ocean salmon fisheries. This framework plan allows the Council to develop management measures responsive to annual circumstances such as relative stock abundance in the mixed stock ocean salmon fisheries.

The Council has authority to manage ocean fisheries but not inland fisheries or habitat issues; however those factors must be taken into account when setting management measures, establishing conservation and management objectives, and ensuring those objectives are met. For KRFC this means including annual forecasts of inriver fishery impacts when planning ocean fisheries to ensure the conservation objectives are met, and analyzing the effects of those fisheries if the conservation objectives are not met. It also means periodic review of conservation objectives to determine if they are appropriate for the current productive capacity of the Basin.

The FMP conservation objectives are based on achieving MSY, or an MSY proxy, for all Salmon Fishery Management Unit (FMU) stocks. The Council structures its salmon fisheries to achieve these objectives for each stock annually. If postseason estimates confirm that a stock conservation objective was not met, a rebuilding program for the following year is implicit in the conservation objective since it is based on annually meeting MSY. In addition, the Council reviews stock status annually and, where needed, identifies actions required to improve estimation procedures and correct biases. Such improvements provide greater assurance that objectives will be achieved in future seasons. Consequently, a remedial response is built into the preseason planning process to address excessive fishing mortality levels relative to the conservation objective of a stock. Because conservation objectives are generally based on MSY rather than a minimum stock size threshold, the Council's management approach is more conservative than recommended by the National Standard Guidelines.

The remedial response to stock depression acts as a default rebuilding plan, but only in terms of the biological needs of the stock, and not with regard to the socio-economic needs of fishing communities. The intent of Amendment 15 was to allow consideration of both of those needs within the short time frame necessary to complete the preseason planning process. Salmon abundance is highly variable from year to year because broods that contribute to fisheries only do so for one or two years. Therefore, developing a formal rebuilding plan to address both biological and socio-economic needs often takes longer than recovery to MSY levels. Amendment 15 provides the flexibility to provide some relief to fishing communities without significantly affecting the long-term productivity of KRFC, and without additional process delays.

3.1 Management Objectives

Section 5 of the FMP describes the overall objectives for the fisheries, including meeting biological objectives for the FMU stocks, meeting tribal trust responsibilities, maintaining continued participation of recreational and commercial fishing sectors, achieving optimal yield, minimizing bycatch, promoting safety at sea, etc. Section 3 of the Salmon FMP describes the conservation objectives for FMU stocks necessary to meet the dual MSA objectives of obtaining optimum yield from a fishery while preventing overfishing. Each stock within the Salmon FMU has a specific objective, generally designed to achieve MSY, or MSP, or in some cases, an exploitation rate to serve as an MSY proxy.

Amendment 9 to the FMP established the Council's conservation objective for KRFC as a minimum natural adult brood year spawner escapement rate of 33%-34%, but with no less than 35,000 natural adult spawners in any one year. Amendment 9 was approved in 1988 and implemented in ocean fishing regulations effective May 1, 1989.

The ESA consultation standard for CCC uses KRFC as an indicator stock and limits ocean fisheries to a pre-season projected age-4 ocean harvest rate of no more than 16.0%.

Amendment 15 to the FMP provided flexibility to allow limited harvest of KRFC in ocean salmon fisheries during years that might otherwise be closed because of a projected shortfall in the KRFC conservation objective of 35,000 naturally spawning adults. Amendment 15 allows an age-4 KRFC ocean impact rate of no more than 10%, although additional inriver tribal and recreational fisheries that occur must be accounted for. Because of these additional fisheries and associated impacts with age-3 and age-5 adults, an age-4 ocean impact rate of 10% is roughly equivalent to a spawner reduction rate (SRR) of about 25%, or a spawner escapement rate of 75%. Prior to Amendment 15, if the projected escapement of natural spawners was below 35,000, all ocean salmon fisheries affecting KRFC would be closed, unless authorized by emergency rule as was done in 2006. While Amendment 15 does allow fishing to occur when the 35,000 spawner conservation objective is not met, it does not change the FMP requirements relating to an Overfishing Concern. Therefore, if the 35,000 spawner escapement objective is not met for three consecutive years, an Overfishing Concern would still be triggered. These impact rates associated with Amendment 15 were determined to not likely to jeopardize the long term productive capacity of the stock.

Amendment 15 was not approved until 2007, after the Overfishing Concern was triggered, and therefore is relevant to this report primarily in the context of stock rebuilding and the implications for achieving MSY on a continuing basis.

3.2 Current Management Approach

The Secretary establishes annual commercial and sport ocean salmon fishing regulations for the federal Exclusive Economic Zone (EEZ, 3-200 nautical miles offshore) based on recommendations of the Council. The Oregon and Washington Fish and Wildlife Commissions adopt regulations annually for the Oregon and Washington ocean recreational and commercial salmon fisheries in their respective state waters. The California Fish and Game Commission sets recreational fishing regulations in state marine waters. The California Department of Fish and Game (CDFG) Director is authorized to conform commercial salmon fishing regulations in state waters to the management plans of the Council.

West Coast ocean salmon fisheries operate on mixed stocks of Chinook and coho from which the river of origin cannot be determined visually, although conservation objectives for the FMU stocks are based on river of origin or finer stratifications (PFMC 2003, Table 3-1). To manage ocean fisheries, impacts are projected using models based on historical timing and distribution estimated from coded wire tag (CWT) recoveries. Fisheries are managed on a weak stock basis, where harvest is allowed only to the point that the weakest stock is projected to meet its conservation and allocation objectives (PFMC 2007a); available harvest of other stocks is foregone or transferred to inland fisheries. To meet these conservation and allocation objectives, the fisheries impacting KRFC are managed through specification of time-area-specific fishing seasons (ocean commercial and recreational fisheries), or time-area-specific Chinook harvest quotas (ocean commercial fisheries), and anticipated Klamath River fall Chinook harvest levels in river tribal and recreational fisheries (PFMC 2007b).

KRFC are the limiting stock almost every year for ocean fisheries south of Cape Falcon, Oregon, either directly because of the KFRC spawning escapement objective of 35,000 natural adult spawners or indirectly because of the ESA consultation standard for CCC of no more than 16.0% age-4 ocean harvest rate on KRFC limits access to KRFC in the ocean.

In any particular year, the allowable harvest of KRFC is determined by the projected abundance of the adult stock (the ocean abundance of the age-3, age-4, and age-5 cohorts) in that year and the limits implied by the conservation objective, and is therefore conditionally independent of the abundance or survival of KRFC at earlier ages. The management approach is thus a conditional one: given the current year's KRFC forecast abundance, a set of fishery control measures are adopted that are expected to achieve the stock's annual conservation objective while meeting the desired harvest allocation objectives. For a given year, if the stock's abundance was sufficient to meet the conservation objective in the absence of fishing, but the objective was in fact not met in the presence of fishing, then the harvest management system is generally at fault. This statement applies equally for the case in which 2/3 brood reduction rate is exceeded in a 'full-fishing' year or the case in which the floor spawning level is violated. Alternatively, if the stock's abundance was insufficient to meet the conservation objective in the absence of fishing, the responsibility for failing to meet the conservation objective may not be the fault of the harvest management system, but might instead be due to especially poor KRFC production and/or survival at earlier life stages.

In years that the CCC consultation standard has not been the limiting factor, the Council has generally set the 35,000 KRFC natural adult spawning escapement floor as its management target. This was the case in 2004 and 2005. In 2006 the projected spawning escapement given Council adopted fisheries was only 21,100, which necessitated the Secretary promulgating an emergency rule for ocean fisheries.

Non-tribal river recreational salmon fishing takes place throughout the Klamath Basin and is regulated by the CFGC. A preseason quota is usually set by CFGC based on projected abundance, ocean harvest, and anticipated tribal harvest levels.

Tribal fisheries with recognized Federal fishing rights occur on the Yurok and Hoopa Valley Indian reservations located on the Lower Klamath and Trinity Rivers, respectively. The Yurok and Hoopa Valley tribal authorities adopt annual tribal fishing regulations for their respective reservations.

In 1993, the Interior Department Solicitor issued a legal opinion that concluded the Yurok and Hoopa Valley Tribes of the Klamath Basin had a Federally protected reserved right to 50% of the available harvest of Klamath Basin salmon. Under the Council annual salmon management process, half of the annual allowable catch of KRFC has been reserved for these tribal fisheries since 1994.

The tribal fisheries normally set aside a small (unquantified) number of fish for ceremonial purpose. Subsistence needs are the next highest priority use of KRFC by the Tribes. The subsistence catch has been as high as 32,000 fish since 1987 when separate tribal use accounting was implemented. Generally, commercial fishing has been allowed when the total allowable tribal catch was over 11,000 -16,000 adult KRFC.

Allocations among non-tribal fisheries are based on annual negotiations and preseason Council recommendations. Prior to 2006, the pre-season allocations of the non-tribal catch of KRFC were typically as follows: 15% (7.5% of total) to the Klamath River recreational fishery and 85% (42.5% of total) to the combined ocean troll and recreational fisheries. Within the ocean fishery allocation, the KMZ recreational fishery was typically allocated up to 17% of the ocean KRFC catch (7.23% of total). The Oregon and California troll fisheries generally shared the remaining KRFC catch as equally as practical, depending on annual circumstances.

In 2006, some of the preseason fishery allocations did not follow the typical pattern in response to the depressed condition of KRFC. Impacts to KRFC in areas of high concentration were constrained to allow limited access to more abundant stocks elsewhere; the KMZ sport fishery share was 8.8% and the Klamath River recreational allocation for directed harvest was 0%. In 2007, the Klamath River recreational share was 26% and the California/Oregon troll shares were 63%/37%. The increased river allocation was in response to a relatively high projection of KRFC abundance and constraints on other stocks such as ESA listed CCC and Lower Columbia River natural tule Chinook, which precluded taking a larger share of the allowable KRFC harvest in ocean fisheries. The troll shares resulted primarily from a modification of the Klamath Ocean Harvest Model (KOHM), which is used to estimate impacts of the fisheries on KRFC. The modification is covered in detail in Section 4.1.3 of this report, but generally was made in response to poor predictions of harvest rates in 2003-2005, and resulted in higher assumed contact per effort rates in California commercial fisheries.

The river sport fishery quota has typically been allocated based on sub-area quotas as follows: 1) the river mouth area closes when 15% of overall quota is taken below 101 Bridge; 2) Klamath River between the river mouth and Coon Creek Falls (river mile 35) closes when 50% of overall quota is reached; and 3) Klamath and Trinity rivers above Coon Creek Falls close when 100% of the quota is reached.

4. ASSESSMENT OF HARVEST FACTORS

4.1 Harvest Impacts

Harvest impacts occur in ocean commercial and recreational, river recreational, and tribal fisheries. Impacts result from retention of fish as well as incidental sources such as release of sublegal fish and drop-off/drop-out mortality. Harvest impacts are predicted prior to each fishing season using the KOHM (see section 4.1.3. Management authorities, including the Council, CDFG, and the tribes, determine levels of impacts to meet the conservation and allocation objectives for the stock. This combination of stock prediction and management responsibility is referred to as the management process, and includes both science and policy components. The management process is collectively responsible for ensuring harvest impacts are maintained at such a level that statutory requirements are met and that the long-term productivity of stocks is preserved.

4.1.1 Ocean Fishery Impacts

See Section 4.1.3 below

4.1.2 River Fishery Impacts

The preseason anticipated harvest impacts were exceeded in the river recreational fishery in 2005 and 2006 (Table 4-1) and slightly exceeded in tribal fisheries in 2006 (Table 4-2). When pre-season anticipated impacts are summed across both fisheries and compared to post-season impacts, estimated adult impacts exceeded expectations by 493 and 439 fish in 2005 and 2006 respectively.

Recreational

In-river recreational catch of KRFC is estimated in a variety of ways including creel census, angler tag returns, and historical ratio estimators (KRTAT 2007). There are several biological factors that complicate the estimation of angler harvest in the basin. Two of the primary factors are fall Chinook run-timing which overlaps with spring Chinook and the average size at which age-3 Chinook return annually. Additionally, there are regulatory factors that influence the quantity of harvest and area of harvest for fall Chinook. Regulatory factors include; 1) basin quotas, 2) sub-basin quotas, 3) sub-basin closures, 4) daily and weekly bag limits, 5) special fishery openings, 6) notification periods to close fisheries, 7) preseason size delineations that define jack and adult cutoff points, and 8) funding constraints that prohibit full real time harvest monitoring of the entire basin.

The consequence of these factors is that managing the fishery in real time to ensure that harvest allotments are not exceeded can be difficult. One of the major difficulties is trying to estimate in real time how many age-3 Chinook are harvested. This is due to the fact that a pre-season size limit of 22 inches is used to define the break off point between age-2 (jack) and age-3 (adult) Chinook. In some years, a significant number of fall Chinook in the 20 to 22 inch range are classified as jacks, however, post season age analysis often times leads to reclassifying some of these fish as adults. Additionally, in an effort to utilize excess hatchery produced fish, the upper Klamath and Trinity rivers are frequently reopened to take of adult Chinook once the two hatcheries have reached their mitigation egg take goals. These fish are included in the overall basin recreational harvest totals.

The mean annual harvest of adult KRFC in the Klamath Basin for the period between 1978 and 2006 was 6,556 fish, with a mean harvest rate (in-river harvest/in-river return) of 0.064 (Table 4-1). During the 2004-06 overfishing review period, harvest rates were below the long term average; however, the in-river recreational quota was exceeded in 2005 and 2006 by about 700 and 200 fish respectively.

Table 4-1. Summary of Klamath basin adult fall Chinook in-river recreational fishery impacts, 1978-2006.

Year	Total Adult Run-Size	Quota	Landed Catch	Incidental Harvest Impacts[a/]	Total Adult Chinook Harvest Impacts	Catch as Percent of Quota	Harvest Impact Rate (harvest/run)
1978	92,983		1,694	35	1,729	#DIV/0!	0.019
1979	51,295		2,141	44	2,185	#DIV/0!	0.043
1980	45,640		4,496	92	4,588	#DIV/0!	0.101
1981	80,292		5,983	122	6,105	#DIV/0!	0.076
1982	66,612		8,339	170	8,509	#DIV/0!	0.128
1983	57,546		4,235	86	4,321	#DIV/0!	0.075
1984	47,261		3,340	68	3,408	#DIV/0!	0.072
1985	64,438		3,582	73	3,655	#DIV/0!	0.057
1986	195,019	7,800	21,027	429	21,456	270%	0.110
1987	209,134	17,900	20,169	412	20,581	113%	0.098
1988	191,642	15,575	22,203	453	22,656	143%	0.118
1989	124,340	15,600	8,775	179	8,954	56%	0.072
1990	35,882	6,500	3,553	73	3,626	55%	0.101
1991	32,670	2,600	3,383	69	3,452	130%	0.106
1992	26,698	800	1,002	20	1,022	125%	0.038
1993	57,212		3,172	65	3,237	#DIV/0!	0.057
1994	63,983		1,832	37	1,869	#DIV/0!	0.029
1995	222,768		6,081	124	6,205	#DIV/0!	0.028
1996	175,773		12,766	261	13,027	#DIV/0!	0.074
1997	83,736		5,676	116	5,792	#DIV/0!	0.069
1998	90,647		7,710	157	7,867	#DIV/0!	0.087
1999	51,048		2,282	47	2,329	#DIV/0!	0.046
2000	218,077		5,650	115	5,765	#DIV/0!	0.026
2001	187,333		12,134	248	12,382	#DIV/0!	0.066
2002	160,788		10,495	214	10,709	#DIV/0!	0.067
2003	191,948		2,358	48	2,406	#DIV/0!	0.013
2004	78,943	4,796	4,003	82	4,085	83%	0.052
2005	65,125	1,244	1,985	41	2,026	160%	0.031
2006	61,629	300 [b/]	62	444	506	169%	0.008
Average	104,499	7,312	6,556	149	6,705	#DIV/0!	0.064

a/ Landed catch tmultiplied by 0.020408.

b/ In 2006 the adult KRFC quoat was zero, however 300 impacts were assumed for non retention mortality in the steelhead/jack Chinook recreational fishery.

Tribal

Table 4.1-2. Summary of Klamath basin adult fall Chinook in-river tribal fishery impacts, 1978-2006.

Year	Total Adult Run-Size	Preseason Expected Impacts	Landed Catch	Incidental Harvest Impacts[a/]	Total Adult Chinook Harvest Impacts	Catch as Percent of Quota	Harvest Impact Rate (harvest/run)
1978	92,983		18,200	1,583	19,783	#DIV/0!	0.213
1979	51,295		13,650	1,188	14,838	#DIV/0!	0.289
1980	45,640		12,013	1,045	13,058	#DIV/0!	0.286
1981	80,292		33,033	2,874	35,907	#DIV/0!	0.447
1982	66,612		14,482	1,260	15,742	#DIV/0!	0.236
1983	57,546		7,890	686	8,576	#DIV/0!	0.149
1984	47,261		18,670	1,624	20,294	#DIV/0!	0.429
1985	64,438		11,566	1,006	12,572	#DIV/0!	0.195
1986	195,019	28,250	25,127	2,186	27,313	89%	0.140
1987	209,134	59,000	53,096	4,619	57,715	90%	0.276
1988	191,642	51,725	51,651	4,494	56,145	100%	0.293
1989	124,340	52,000	45,565	3,964	49,529	88%	0.398
1990	35,882	24,500	7,906	688	8,594	32%	0.240
1991	32,670	10,300	10,198	887	11,085	99%	0.339
1992	26,698	4,920	5,785	503	6,288	118%	0.236
1993	57,212		9,636	838	10,474	#DIV/0!	0.183
1994	63,983		11,692	1,017	12,709	#DIV/0!	0.199
1995	222,768		15,557	1,353	16,910	#DIV/0!	0.076
1996	175,773		56,476	4,913	61,389	#DIV/0!	0.349
1997	83,736		12,087	1,052	13,139	#DIV/0!	0.157
1998	90,647		10,187	886	11,073	#DIV/0!	0.122
1999	51,048		14,660	1,275	15,935	#DIV/0!	0.312
2000	218,077		29,415	2,559	31,974	#DIV/0!	0.147
2001	187,333		38,645	3,362	42,007	#DIV/0!	0.224
2002	160,788		24,574	2,138	26,712	#DIV/0!	0.166
2003	191,948		30,034	2,613	32,647	#DIV/0!	0.170
2004	78,943	33,806	25,803	2,245	28,048	76%	0.355
2005	65,125	9,022	8,016	697	8,713	89%	0.134
2006[b/]	61,629	10,870	10,285	895	11,180	95%	0.181
Average	104,499		21,583	1,878	23,460	#DIV/0!	0.239

a/ Landed catch tmultiplied by 0.087.
b/ Preliminary.

4.1.3 Model Estimation Error/Uncertainty

Klamath Ocean Harvest Model

The Klamath Ocean Harvest Model (KOHM) is an age-specific cohort projection model for KRFC that the Council uses to forecast the number of natural spawning adults that are expected to result from a set of fishery control measures given the current year's forecast KRFC ocean abundance. The projection of the ocean abundance through to river spawning escapement covers a one-year time period from September 1, year *t-1* through August 31, year *t*, and is used to set the fishery control measures for the May 1, year *t* through April 30, year *t+1* period. The KOHM consists of several submodel components: 1) September 1 ocean abundance, 2) ocean fishery and natural mortality, 3) maturation, 4) out-of-basin straying, 5) river fishery mortality, and 6) proportion of spawners in natural areas versus hatcheries. For a detailed specification of the KOHM and its submodel components see Mohr (2006a).

The expected number of naturally spawning age-*a* adults, E_a, is modeled by the KOHM as

$$E_a = N_a o_a m_a (1 - w_a) r_a g_a, \qquad (1)$$

where all the quantities on the right-hand-side of the equation are age-*a* specific: N_a is the September 1, year *t-1* ocean abundance, o_a is the ocean survival rate from September 1, year *t-1* through August 31, year *t* (includes fishery-related and natural mortality), m_a is the maturation rate, w_a is the out-of-basin stray rate, r_a is the river survival rate (includes fishery-related mortality), and g_a is the proportion of spawners using natural areas. The sum, $E = E_3 + E_4 + E_5$, is the expected total number of naturally spawning adults, and may be expressed in the form above as

$$E = N \bar{o} \bar{m} (1 - \bar{w}) \bar{r} \bar{g}, \qquad (2)$$

where $N = N_3 + N_4 + N_5$, and the "bar" above each of the remaining quantities denotes the average of the respective age-specific rates weighted by the age-specific abundance immediately preceding that stage. The expected number of potential (absent fishing) adult natural spawners, E^0, may be determined from equations (1) and (2) above by assuming no fishery-related mortality. The conservation objective specifies 1) that $E / E^0 \geq 1/3$ or, equivalently, that the spawner reduction rate due to fishing, *SRR*, not exceed 2/3:

$$SRR = 1 - (E / E^0) \leq 2/3, \qquad (3)$$

and 2) that $E^o \geq 35{,}000$.

The KOHM is used annually by the Council to develop fishery control measures by substituting into equations (1), (2), and (3) that year's preseason forecast values of the right-hand-side components and determining whether the resulting *E* and *SRR* satisfy the conservation objectives. Mohr (2006a, 2006b) provides a description of the forecasting methods used for the KOHM submodel components.

KOHM Performance

The performance of the KOHM in 2004, 2005, and 2006, may be directly examined by comparing the preseason forecasts of the equation (1), (2), and (3) quantities with their postseason realized values (Table 4-3). Because of the multiplicative structure of equations (1) and (2), the postseason value of *E* is equal to the preseason value of *E* times the postseason/preseason ratios of the submodel components. Therefore, the degree to which a component postseason/preseason ratio is less than or greater than one has a comparable scaling effect on the postseason value of *E* relative to its preseason forecast value. This allows one to isolate which of these forecast components were primarily responsible for the observed difference between the postseason and preseason value of *E*.

Note first that the "absent fishing" postseason value of *E* in 2004 (71,949), 2005 (36,551), and 2006 (44,299), exceeded the FMP conservation objective of 35,000, while the realized (with fishing) postseason value of E in 2004 (24,079), 2005 (26,790), and 2006 (30,421) failed to meet this objective (Table 4-3). For the reason discussed previously, the harvest management system may thus be faulted for having not met the KRFC conservation objective in 2004, 2005, and 2006. However, the reasons why the harvest management system failed in each of these years differ as described below.

For 2004, the postseason value of E (24,079) was less than its preseason forecast (35,011) (Table 4-3). While the preseason age-specific ocean abundance forecasts all differed from their postseason values, the direction of these errors largely compensated each other, such that the preseason and postseason values of E^0 differed by only 388 fish (72,337 versus 71,949, respectively). Thus, in this case, the difference in the preseason and postseason value of E is entirely due to the under-forecast of the fishery spawner reduction rate (0.516 versus its postseason value of 0.665), which in turn is primarily attributable to the under-forecast of the ocean fishery mortality rate ($\bar{o}$ post/pre ratio of 0.73); more specifically, the ocean commercial fishery mortality rate (PFMC 2006 Appendix A; Mohr 2006c)."

For 2005, the postseason value of E (26,790) was less than its preseason forecast (35,023) (Table 4-3). Here, the age-3 and age-5 ocean abundance was well forecast, and the difference between the preseason value of E and its postseason value (8,233) is due entirely to forecast error associated with the age-4 cohort (the preseason and postseason value of E_4 differ by 8,194). In this case, the N_4 forecast error (post/pre ratio of 0.79) was compounded by optimistic forecasts of m_4 (post/pre ratio of 0.87) and g_4 (post/pre ratio of 0.75), and further compounded by the under-forecast of the age-4 ocean fishery mortality rate (o_4 post/pre ratio of 0.83). The age-4 forecast error was again due primarily to the ocean commercial fishery (PFMC 2006 Appendix A; Mohr 2006c).

For 2006, the postseason value of E (30,421) was greater than its preseason forecast of 21,089 (Table 4-3). In this year, N_4 was well forecast (63,710 preseason versus 68,913 postseason). The difference between the postseason and preseason value of E is accounted for by the N_3 post/pre ratio of 2, and the compounding of the slightly higher than forecast values of N_4, r_4, and g_4. The ocean fishery mortality rate was well forecast ($\bar{o}$ post/pre ratio of 0.99).

4.1.4 Conclusions

1. The harvest management system was responsible for not achieving the KRFC conservation objective in 2004, 2005, and 2006. The conservation objective would have been met in each of these three years absent fishing.

2. The KOHM biological components were for the most part adequately forecast in 2004, 2005, and 2006. For a particular year and age, forecast errors in several of these components, particularly when compounded, lead to a significant forecast error in age-specific escapement (e.g., age-4 in 2005 and 2006). This error tended to be compensated for, to some extent, by opposing errors for the other age classes.

3. The Klamath River tribal fishery, Klamath River recreational fishery, and ocean recreational fishery KRFC harvest impacts were adequately forecast in 2004, 2005, and 2006.
4. The principal reasons for the under-forecast of the ocean commercial fishery mortality rate in 2004 and 2005 was (a) unexpectedly high levels of fishing effort per day open in the sub-areas between Cape Falcon and Humbug Mountain, and (b) much higher than expected KRFC contact rates per unit of effort for the area south of Horse Mountain (PFMC 2006 Appendix A, Mohr 2006c). In response, the STT (a) modified the KOHM commercial fishery effort per day open submodel to account for effort transfer from closed to open sub-areas between Cape Falcon and Humbug Mountain, and (b) adjusted the KOHM commercial fishery contact rate per unit of effort submodel for the area south of Horse Mountain to reflect the higher rates observed in the 2003-2005 period (PFMC 2006 Appendix A, Mohr 2006c). Together, these adjustments resulted in an adequate KOHM forecast of the 2006 ocean fishery mortality rate.

5. Small errors in the KOHM component forecasts have the potential to determine whether the KRFC conservation objective is met in a given year, particularly if the adopted fishery control measures are expected to result in the minimum number of spawners that will satisfy this objective. It is conceivable, for example, that every component could be well forecast with the exception of one, and that error alone could result in the objective not being achieved.

6. If the harvest management system is unbiased with respect to forecasting KRFC natural spawning escapement, and harvest control measures are adopted annually which are expected to result in a KRFC spawning escapement of no more and no less than 35,000 adults, the chances of meeting the conservation objective in any one year are 50:50. This would result, on average, in the triggering of an overfishing concern (failing to meet the objective in three consecutive years) every eight years. If in addition Emergency Rules or FMP Amendment 15 are used in some years to target for spawning escapements lower than 35,000 adults, the average amount of time before an overfishing concern was triggered would be something less than eight years.

Table 4-3. Klamath Ocean Harvest Model (KOHM) submodel component forecasts compared with postseason estimates. N = preseason ocean abundance, o = ocean survival rate, (including fishery and natural mortality), m = maturation rate; w = out of basin stray rate; r = river survival rate (including tribal and recreational fisheries and prespawning mortality), g = proportion of naturally spawning fish, E = number of naturally spawning fish, and SRR = spawner reduction rate due to fishing mortality.

			With Fishing								Without Fishing					
Year	Age	Type	N	o	m	1-w	r	g	E	SRR	N	o	m	1-w	g	E
2004	3	Pre	72,100	0.54	0.38	0.99	0.76	0.55	6,132	0.302	72,100	0.58	0.38	0.99	0.55	8,780
		Post	160,628	0.45	0.46	1.00	0.78	0.44	11,469	0.401	160,628	0.58	0.46	1.00	0.44	19,162
		Post/Pre	2.23	0.83	1.22	1.00	1.03	0.80	1.87	1.33	2.23	1.00	1.22	1.00	0.80	2.18
	4	Pre	134,500	0.65	0.89	1.00	0.59	0.61	27,683	0.523	134,500	0.80	0.89	1.00	0.61	58,094
		Post	105,227	0.45	0.86	0.99	0.49	0.59	11,567	0.724	105,227	0.80	0.86	0.99	0.59	41,879
		Post/Pre	0.78	0.70	0.96	1.00	0.83	0.96	0.42	1.38	0.78	1.00	0.96	1.00	0.96	0.72
	5	Pre	9,700	0.49	1.00	0.99	0.36	0.71	1,197	0.781	9,700	0.80	1.00	0.99	0.71	5,463
		Post	17,247	0.31	1.00	1.00	0.25	0.79	1,043	0.904	17,247	0.80	1.00	1.00	0.79	10,908
		Post/Pre	1.78	0.63	1.00	1.00	0.69	1.12	0.87	1.16	1.78	1.00	1.00	1.00	1.12	2.00
	3+4+5	Pre	216,300	0.61	0.74	1.00	0.60	0.60	35,011	0.516	216,300	0.73	0.76	1.00	0.61	72,337
		Post	283,102	0.44	0.64	1.00	0.59	0.51	24,079	0.665	283,102	0.68	0.67	1.00	0.56	71,949
		Post/Pre	1.31	0.73	0.86	1.00	0.99	0.85	0.69	1.29	1.31	0.93	0.89	1.00	0.92	0.99
2005	3	Pre	185,653	0.57	0.38	0.99	0.90	0.54	19,278	0.123	185,653	0.58	0.38	0.99	0.54	21,983
		Post	201,518	0.56	0.39	1.00	0.85	0.50	18,778	0.183	201,518	0.58	0.39	1.00	0.50	22,991
		Post/Pre	1.09	0.99	1.03	1.00	0.94	0.93	0.97	1.49	1.09	1.00	1.03	1.00	0.93	1.05
	4	Pre	48,863	0.72	0.88	1.00	0.82	0.55	13,899	0.257	48,863	0.80	0.88	1.00	0.55	18,712
		Post	38,424	0.60	0.77	1.00	0.79	0.41	5,705	0.410	38,424	0.80	0.77	1.00	0.41	9,663
		Post/Pre	0.79	0.83	0.87	1.00	0.96	0.75	0.41	1.59	0.79	1.00	0.87	1.00	0.75	0.52
	5	Pre	5,171	0.69	1.00	0.99	0.72	0.72	1,846	0.372	5,171	0.80	1.00	0.99	0.72	2,942
		Post	6,915	0.57	0.99	1.00	0.83	0.71	2,307	0.408	6,915	0.80	0.99	1.00	0.71	3,896
		Post/Pre	1.34	0.82	0.99	1.01	1.15	0.99	1.25	1.10	1.34	1.00	0.99	1.01	0.99	1.32
	3+4+5	Pre	239,687	0.60	0.52	1.00	0.86	0.55	35,023	0.197	239,687	0.63	0.52	1.00	0.55	43,637
		Post	246,858	0.57	0.47	1.00	0.84	0.49	26,790	0.267	246,858	0.62	0.49	1.00	0.49	36,551
		Post/Pre	1.03	0.94	0.91	1.00	0.97	0.90	0.76	1.35	1.03	0.99	0.93	1.00	0.89	0.84
2006	3	Pre	44,105	0.56	0.38	0.99	0.87	0.67	5,479	0.166	44,105	0.58	0.38	0.99	0.67	6,571
		Post	87,677	0.58	0.37	1.00	0.85	0.57	9,025	0.157	87,677	0.58	0.37	1.00	0.57	10,711
		Post/Pre	1.99	1.03	0.96	1.00	0.98	0.85	1.65	0.95	1.99	1.00	0.96	1.00	0.85	1.63
	4	Pre	63,710	0.68	0.88	1.00	0.74	0.55	15,546	0.370	63,710	0.80	0.88	1.00	0.55	24,678
		Post	68,913	0.69	0.89	1.00	0.79	0.62	20,725	0.319	68,913	0.80	0.89	1.00	0.62	30,445
		Post/Pre	1.08	1.01	1.01	1.00	1.08	1.13	1.33	0.86	1.08	1.00	1.01	1.00	1.13	1.23
	5	Pre	2,228	0.07	1.00	0.99	0.59	0.72	63	0.950	2,228	0.80	1.00	0.99	0.72	1,277
		Post	5,321	0.24	1.00	1.00	0.71	0.74	671	0.787	5,321	0.80	1.00	1.00	0.74	3,143
		Post/Pre	2.39	3.60	1.00	1.01	1.19	1.02	10.57	0.83	2.39	1.00	1.00	1.01	1.02	2.46
	3+4+5	Pre	110,043	0.62	0.70	1.00	0.76	0.58	21,089	0.352	110,043	0.71	0.72	0.99	0.58	32,526
		Post	161,911	0.61	0.62	1.00	0.81	0.61	30,421	0.313	161,911	0.68	0.65	1.00	0.62	44,299
		Post/Pre	1.47	0.99	0.89	1.00	1.06	1.05	1.44	0.89	1.47	0.96	0.90	1.00	1.07	1.36

5. ASSESSMENT OF OTHER FACTORS

5.1 Spawning Escapements

5.1.1 Parent Stock Size and Distribution

Klamath basin fall Chinook spawning escapements are presented for 1978 through 2006, with a focus on the brood years 2000 through 2003 (PFMC 2007b). Returns from these three broods were the cohorts used to estimate ocean abundances, set preseason harvest levels, project in-river adult spawning escapement and estimate returns to the Klamath Basin for the 2004 through 2006 overfishing assessment period.

Mean escapement of naturally spawning fall Chinook for the 1994 to 2006 period was 66,549 fish; the average composition of the run was 59,794 adults and 6,755 jacks (Table 5-1). Since the establishment of the conservation objective of 35,000 naturally spawning adult KRFC in 1989, the objective has been achieved 9 times (50%) during the 18 year period from 1989 to 2006. Escapement to the two hatcheries between 1994 and 2006 averaged 36,876 KRFC, and was composed of an average of 2,333 jacks and 34,543 adults. Total combined hatchery escapement has ranged from 18% to 53% and averaged approximately 37% of the total escapement. The hatchery contribution to total run size was above average in 2004 and 2005 (47% and 50%, respectively) and on average in 2006). A portion of natural spawners each year are actually first generation hatchery fish that do not enter the hatchery facilities. This is especially true near the terminus of anadromy on the Klamath and Trinity Rivers, where large numbers of hatchery fish spawn in the river or tributaries near the hatchery facilities.

Table 5-1. Klamath basin fall Chinook escapement estimates, 1978-2006.

	Natural area escapement			Hatchery escapement			Hatchery
Year	Jacks	Adults	Total	Jacks	Adults	Total	percentage
1994	6,245	32,333	38,578	5,200	17,072	22,272	36.6%
1995	17,324	161,794	179,118	335	37,859	38,194	17.6%
1996	6,174	81,326	87,500	792	20,033	20,825	19.2%
1997	4,225	46,144	50,369	1,272	18,662	19,934	28.4%
1998	2,855	42,488	45,343	595	29,219	29,814	39.7%
1999	10,447	18,457	28,904	6,857	14,327	21,184	42.3%
2000	6,394	82,728	89,122	1,909	97,611	99,520	52.8%
2001	7,747	77,834	85,581	1,631	55,112	56,743	39.9%
2002	3,867	65,635	69,502	2,331	27,183	29,514	29.8%
2003	2,102	87,642	89,744	864	61,782	62,646	41.1%
2004	4,685	23,831	28,516	1,981	22,981	24,962	46.7%
2005	1,170	26,687	27,857	101	27,699	27,800	49.9%
2006	14,580	30,422	45,002	6,462	19,522	25,984	36.6%
Average	6,755	59,794	66,549	2,333	34,543	36,876	37.0%

Returns of age-2 Chinook are the least affected by ocean fishery harvest and generally are a good indicator of overall brood strength. Age-2 returns for the 2000 through 2003 brood years were all below the long term mean of 16,400 fish and contained two of the three lowest returns (3,800 in 2001 and 2,300 in 2003) since 1981 (Table 5-2). Age-3 and age-4 returns were also below the means for the period. The data indicate that KRFC survival, based on in-river age-2 returns, has fluctuated between below average and very poor for 2002 through 2005 return years (2000 to 2003 brood years). As noted previously, the increased hatchery component in 2004 and 2005, coupled with poor to very poor survival of broods contributing to the 2004 to 2006 overfishing assessment period, may have contributed to failing to meet the 35,000 adult natural escapement conservation objective for the Klamath Basin.

Table 5-2. Klamath basin fall Chinook in-river age composition, brood years 1979-2004.

Brood	Klamath Basin Return (thousands)				
year	Age-2	Age-3	Age-4	Age-5	Total
1979	28.2	30.1	20.7	1.1	80.1
1980	39.4	35.9	24.4	5.8	105.5
1981	3.8	21.7	25.7	2.3	53.5
1982	8.3	32.9	29.8	6.8	77.8
1983	69.4	162.9	112.6	3.9	348.8
1984	44.6	89.7	86.5	4.3	225.1
1985	19.1	101.2	69.6	1.3	191.2
1986	24.1	50.4	22.9	1.1	98.5
1987	9.1	11.6	21.6	1.0	43.3
1988	4.4	10.0	18.8	0.7	33.9
1989	1.8	6.9	8.2	1.0	17.9
1990	13.7	48.3	26.0	2.6	90.6
1991	7.6	37.0	18.3	0.3	63.2
1992	14.4	201.9	136.7	4.6	357.6
1993	22.8	38.8	44.2	1.7	107.5
1994	9.5	35.0	29.7	1.3	75.5
1995	8.0	59.2	20.5	0.5	88.2
1996	4.6	29.2	30.5	0.2	64.5
1997	19.2	187.1	88.2	3.7	298.2
1998	10.2	99.1	62.5	0.9	172.7
1999	11.3	94.6	96.8	5.3	208.0
2000	9.2	94.3	40.7	3.9	148.1
2001	3.8	33.2	17.5	1.3	55.8
2002[a/]	9.7	43.8	41.8		
2003[a/]	2.3	18.6			
2004[a/]	27.1				
Average	16.4	62.9	45.6	2.4	130.7

a/ These brood years are not yet complete.

5.1.2 Smolt Production/Recruitment - ST

Natural Production - ST

The Shasta River continues to be one of the most productive tributaries to the Klamath River in terms of fall Chinook salmon. Rotary trap data from 2001 to 2005 show an average of over 2.3 million juvenile Chinook emigrating from the Shasta River each year, with a strong correlation seen between spawning escapement and juvenile production (CDFG 2007).

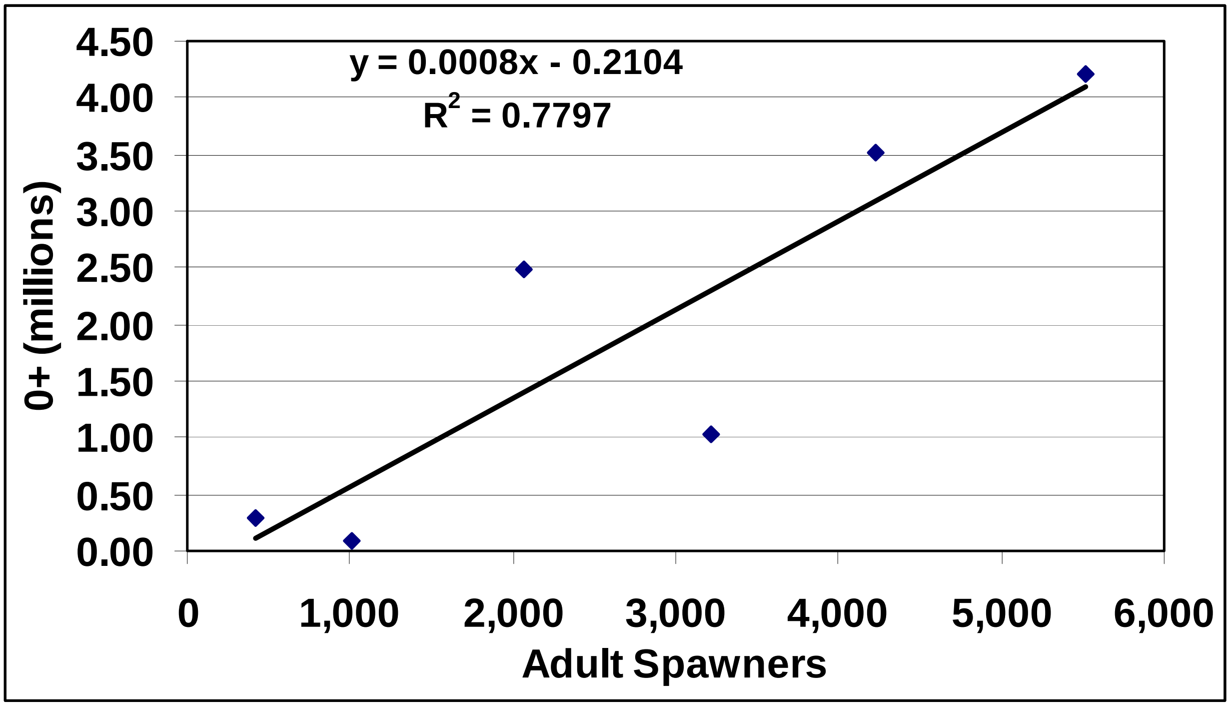

Figure 5-1. Shasta River fall Chinook spawner to age-0+ recruit relationship, brood years 2000-2005.

Table 5-3. Natural spawning area escapement within the Klamath Basin.

	Adult Natural Escapement			
Year	Shasta River	Scott River	Salmon River	Basin Total
1978	12,024	3,423	2,600	58,492
1979	7,111	3,396	1,000	30,637
1980	3,762	2,032	800	21,483
1981	7,890	3,147	750	33,857
1982	6,533	5,826	1,000	31,951
1983	3,119	3,398	1,200	30,784
1984	2,362	1,443	1,226	16,064
1985	2,897	3,051	2,259	25,677
1986	3,274	3,176	2,716	113,360
1987	4,299	7,769	3,832	101,717
1988	2,586	4,727	3,273	79,386
1989	1,440	3,000	2,915	43,868
1990	415	1,379	4,071	15,596
1991	716	2,019	1,337	11,649
1992	520	1,873	778	12,028
1993	1,341	5,035	3,077	21,858
1994	3,363	2,358	3,216	32,333
1995	12,816	11,198	4,140	161,794
1996	1,404	11,952	5,189	81,326
1997	1,667	8,284	5,783	46,144
1998	2,466	3,061	1,337	42,488
1999	1,296	3,021	670	18,457
2000	**11,025**	**5,729**	**1,544**	**82,728**
2001	**8,452**	**5,398**	**2,607**	**77,834**
2002	**6,432**	**4,261**	**2,669**	**65,635**
2003	**4,134**	**11,988**	**3,302**	**87,642**
2004	833	445	282	24,079
2005	2,018	698	401	26,789
2006	789			30,422
Average	4,034	4,396	2,285	49,175

Hatchery Production - ST

Two Klamath basin production hatcheries, IGH and TRH, currently produce fall Chinook. Both hatcheries were built to mitigate for lost habitat as a result of dams constructed on the Klamath and Trinity Rivers. Both hatcheries have been close to meeting or have slightly exceeded their mitigation production goals for broods associated with the overfishing assessment period, except for 2003 brood yearling production at IGH, which was 36% below the goal. The reduced 2003 brood yearling production would have affected adult returns in 2006 (Tables 5-4 and 5-5). Additionally, both hatcheries currently mark a portion of their KRFC production with an adipose fin-clip, accompanied by a CWT. At TRH, a constant proportion of 25% is marked. At IGHIGH, approximately 3- 5% of the smolt production (approximately 80% of fish released) and 10% of the sub-yearling production are marked annually.

Table 5-4. Fall Chinook production goals for Iron Gate and Trinity River hatcheries.

	Release Type[a/]		
Hatchery	Fingerling	Yearling	Total
Iorn Gate	4,920,000	1,080,000	6,000,000
Trinity River	2,000,000	900,000	2,900,000
Total	6,920,000	1,980,000	8,900,000

a/ Fingerlings are released May – June, yearlings October – November 15.

Table 5-5. Fall Chinook release totals from Iron Gate (IGH) and Trinity River (TRH) hatcheries, 2001-2004.

Brood	Release	Iron Gate Hatchery			Trinity River Hatchery			IGH+TRH
year	year	Smolts	Yearlings	Total	Smolts	Yearlings	Total	Total
2000	2001	4,938,000	1,092,636	6,030,636	2,113,804	872,666	2986470	9,017,106
2001	2002	4,966,640	1,087,081	6,053,721	2,084,069	940,049	3024118	9,077,839
2002	2003	5,116,165	1,083,900	6,200,065	2,078,192	954,286	3032478	9,232,543
2003	2004	5,182,092	685,819	5,867,911	2,105,708	908,913	3014621	8,882,532
Total		20,202,897	3,949,436	24,152,333	8,381,773	3,675,914	12,057,687	36,210,020

5.2 Freshwater Survival

5.2.1 Hatchery/Wild Interactions - GK, DH, ST

Juvenile – GK, DH

This section presents data on the coincidence of natural and hatchery produced Chinook juveniles within Klamath Basin. Whereas negative interactions, such as competition for food, may not be readily demonstrated, the coincidence and distributional overlap of these two groups is compelling, particularly in the Klamath estuary.

In 1993 CDFG concluded an inter-agency effort to review salmon and steelhead production in the Klamath River system. Among the findings and actions planned by CDFG pursuant this review was to release hatchery production under conditions that most closely approximate natural patterns while minimizing competition with naturally produced fish.

Coincidence of Hatchery and Naturally Produced Juvenile Chinook in the Klamath River

Upper River

The release of the nearly 5 million smolts (Table 5-4) from IGH coincides with the reduction in Klamath River flow and deterioration of water quality. Therefore, a large number of hatchery fish are forced to compete with natural fish for what is often marginal habitat conditions at best; sometimes resulting in extremely high densities of juveniles crowded into thermal refugia areas. A joint Hatchery Review Committee Report (CDFG and NMFS, 2001) noted this problem and recommended consideration for expanding the yearling program at IGH accompanied with a reduction in the smolt production.

The U.S. Fish and Wildlife Service (USFWS) and Karuk Tribe have conducted annual counts of outmigrant salmonids throughout Klamath River since 1987. Trapping at upper Klamath Basin traps typically begins in early spring and ends prior to arrival of IGH fingerling releases in late spring/early summer (Table 5-6). However traps at Kinsman Creek (RKm 237.1, 70.0 Km downstream of IGH) and Big Bar (RKm 81.9, 225.2 Km downstream of IGH typically have typically been in operation through June or later in some years. With the exception of 2002 wherein sampling at Kinsman Creek site was suspended prior to the arrival of IGH Chinook, contributions of IGH - Chinook smolts at these sites have ranged as high as 47% of total Chinook captured indicating an appreciable overlap in distributions of hatchery and naturally produced Chinook (Table 5-7). Co-mingling of hatchery and naturally produced Chinook in the mid-Klamath River appears contradictory to the management objectives at IGH to minimize these interactions. Review of release strategies with the objective of optimizing naturally production and hatchery contribution to fisheries may be indicated.

Estuary

Significant overlap of hatchery and naturally produced Chinook occurs in the Klamath River estuary (CDFG 2004). Of interest for this analysis were relative abundance for hatchery and natural KRFC in the summer period of 2001 through 2004 coincident with the presence of 2000-2003 brood years, which contributed as adults to fisheries and spawning escapement during the OAP. Unfortunately, data on the overlap of hatchery and naturally produced fish are limited to the 2000, 2001, and 2002 brood years. CDFG has utilized seines to trap juvenile fish in the estuary in the summer of 1998 through 2003. Captured Chinook were examined to determine the presence of adipose fin clips. Adipose-fin-clipped fish were sacrificed for coded-wire-tag extraction and determination of race and hatchery of origin. There were four unique categories of Chinook juveniles found in the estuary: IGH Fall Chinook (IGHFC); TRH Fall Chinook (TRHFC); TRH Spring Chinook (TRHSC); and Naturally Produced Chinook (NPC).

Generally, hatchery origin Chinook were most abundant in late June thorough early July of 1998 through 2003 and comprised 24-79% of total juvenile Chinook captured (Table 5-8). The arrival and co-occurrence of hatchery produced fish is consistent with their release timing and rapid migration to the estuary (Tables 5-6 and 5-9). As summer progressed, the presence of hatchery fish relative to naturally produced Chinook decreased. Meanwhile, naturally produced Chinook appeared to utilize the estuary over a much more protracted period and were detectable in seine samples as early as March and as late as September.

The duration of estuary residency by both hatchery and naturally produced juvenile Chinook reflects the significance of this habitat to pre-marine adaptation by smolts (March through September for natural fish, June through July for hatchery produced fish). Extensive distributional overlap of hatchery and naturally produced Chinook in the estuary suggests that in years of limited habitat and/or forage base, hatchery fish may represent a significant source of additional competition among naturally produced fish. The percent of hatchery produced Chinook for the 1999 and 2001 brood years (contributing to fisheries in 2004 and 2005) relative to hatchery and natural Chinook combined occupying the estuary in the June-July period, was within the observed range seen for the 1997 and 1998 broods (sampled broods that contributed to fisheries in years immediately prior to the OAP. However, the 2000 brood hatchery representation (24%) was well below that observed in adjacent years. Assuming habitat and forage were limiting in the estuary during the summer months of 2000 through 2004, the corresponding broods (1999 through 2003) may have experienced poor survival as a result of intra-specific competition. Future adjustments to release strategies for IGH and TRH may alleviate concerns in this regard.

Table 5-6. IGH fingerling Chinook releases for brood years 1999-2003.

			Release Dates	
Hatchery	Brood Year	Release Stage	Min	Max
Iron Gate	1999	Fingerling	9-Jun	10-Jun
Iron Gate	2000	Fingerling	21-May	26-May
Iron Gate	2001	Fingerling	5-May	28-May
Iron Gate	2002	Fingerling	13-May	4-Jun
Iron Gate	2003	Fingerling	13-May	3-Jun

Table 5-7. Proportion of Iron Gate Hatchery (IGH) Chinook contributing to rotary-screw-trap captures at Big Bar and Kinsman Creek sites, 2000-2004. Hatchery values represent expanded CWT recoveries from IGH.

Year	Trap Location	Start Date	End Date	Total Chinook	Percent IGH
2000	Big Bar	4/7/00	7/19/00	11,166	47%
	Kinsman Creek	No Sampling			
2001	Big Bar	4/9/01	7/25/01	10,923	14%
	Kinsman Creek	No Sampling			
2002	Big Bar	3/5/02	8/22/02	11,775	47%
	Kinsman Creek	3/14/02	5/29/02	21,106	0%
2003	Big Bar	4/24/03	12/3/03	9,269	35%
	Kinsman Creek	3/5/03	6/26/03	5,917	32%
2004	Big Bar	3/23/04	7/30/04	38,142	34%
	Kinsman Creek	3/10/04	7/3/04	2,311	33%

Table 5-8. Number of Chinook smolts recovered in the lower Klamath River estuary during June and July in 1998 through 2002. Hatchery values represent expanded CWT recoveries from Iron Gate Hatchery (IGH) and Trinity River Hatchery (TRH).

Year	Total Chinook	IGH	TRH Fall	TRH spring	Total Hatchery	Percent Hatchery
1998	942	608	22	117	747	79%
1999	223	79	22	26	127	57%
2000	1,835	880	54	45	979	53%
2001	1,407	185	144	4	333	24%
2002	719	125	248	41	414	58%

Table 5-9. Chinook salmon released from Trinity River Hatchery.

Brood Year	Date Released	Release Stage	Race	Fish Released	Totals
2000	June 6-13, 2001	Fingerling	Spring	1,093,525	
	June 6-13, 2001	Fingerling	Fall	2,113,804	3,207,329
	October 1-10, 2001	Yearling	Spring	401,743	
	October 1-10, 2001	Yearling	Fall	872,666	1,274,409
					4,481,738
2001	June 3-12, 2002	Fingerling	Spring	1,032,458	
	June 3-12, 2002	Fingerling	Fall	2,084,069	3,116,527
	October 10-15, 2002	Yearling	Spring	425,701	
	October 10-15, 2002	Yearling	Fall	940,049	1,365,750
					4,482,277
2002	June 3-9, 2003	Fingerling	Spring	1,005,179	
	June 3-9, 2003	Fingerling	Fall	2,078,192	3,083,371
	October 1-7, 2003	Yearling	Spring	429,979	
	October 1-7, 2003	Yearling	Fall	954,286	1,384,265
					4,467,636

Adult - ST

Interactions of hatchery and naturally produced Chinook salmon adults occur in both the Klamath and Trinity Basins, primarily as a result of straying by hatchery fish into natural spawning areas. This is especially true on the Trinity River where a large fraction of the natural spawners in the upper mainstem Trinity are composed of hatchery fish. In particular, the first several miles below TRH are heavily utilized by spawning Chinook salmon, both spring-run and fall-run. Up to 85% of the total natural spawning Chinook carcasses recovered in the Trinity Basin are found in the first several miles below Lewiston Dam, which leads to redd superimposition and racial mixing. In 2004 approximately 47% of KRFC carcasses recovered in the mainstem between Lewiston Dam and Cedar Flat (84 km) were of hatchery origin (Knechtle and Currier 2006).

On the Klamath River the incidence of straying appears to be greatest in Bogus Creek, a small tributary located adjacent to IGH, and in the Shasta River, located approximately 10 miles downstream of IGH. In Bogus Creek the estimated incidence (as a proportion of the total Bogus Creek return) of hatchery strays ranged from 7.5% to 61.6% and averaged 34.4% between 1999 and 2006 (Table 5-10) During those years between 1,019 and 13,025 hatchery KRFC spawned in Bogus Creek (Hampton 2007). The incidence of hatchery strays on the Shasta River ranged between 1.2% and 38.7% with an average of 15.4% between 2002 and 2006. (Table 5-10) In those years between 10 and 469 hatchery KRFC spawned in the Shasta River (Walsh and Hampton 2007). The incidence of IGH strays in other areas of the Klamath appears minimal. Very few CWTs were recovered elsewhere during annual carcass surveys performed on the upper mainstem Klamath River, Scott River, Salmon River, and various small tributaries in the Klamath Basin.

As noted above, a high incidence of redd superimposition occurs in the immediate vicinity of TRH in part due to a large number of hatchery strays, however it has not been determined if this is the case on the Klamath River. It is likely, however, that redd superimposition occurs in Bogus Creek. Other potential negative consequences of hatchery straying that may occur are the loss of genetic diversity, lowered productivity potential, lowered spawning success, and crowding in holding areas, which could lead to higher disease transmission. None of these issues have been thoroughly investigated to date.

Table 5-8a. Number of adipose-clipped fish observed through the counting flumes at Bogus Creek and the Shasta River with coded-wire-tag (CWT) expanded hatchery contributions.

Year	Total Escapement	Adipose Clips Observed	CWTs Recovered	Expanded Hatchery Contribution	Hatchery Chinook as Percent of Run
			Bogus Creek		
2002	6,820	3	1	79	1.2%
2003	4,195	25	0	436	10.4%
2004	962	23	0	372	38.7%
2005	2,129	32	11	469	22.0%
2006	2,163	6	1	10	4.9%
Average	3,254	17.8	2.6	273.2	15.4%
			Shasta River		
1999	6,165	93	83	2,915	47.3%
2000	35,051	212	186	13,025	37.2%
2001	12,575	66	40	7,747	61.6%
2002	17,835	40	40	1330	7.5%
2003	15,610	85	59	2,722	17.4%
2004	3,788	75	58	1,019	27.0%
2005	5,397	131	96	1,931	35.8%
2006	4,133	93	50	1,724	41.7%
Average	12,569	99.375	76.5	4,052	34.4%

5.2.2 Flows

Diversion

Both the Klamath and Trinity Rivers are impounded by major diversion structures. In addition, several of the major sub-basins such as the Scott and Shasta rivers are subject to water right appropriations, primarily for agricultural purposes.

Klamath River

The Federal Klamath Irrigation Project, (Project), operated by the U.S. Bureau of Reclamation (BOR), supplies irrigation water to over 240,000 acres of farm land in south-central Oregon and north-central California and regulates flows to the Klamath River downstream.

The Project is divided into two delivery areas: the Upper Klamath Lake (UKL) delivery area which provides water from Upper Klamath Lake and the Klamath River to both agriculture and two national wildlife refuges, and the East Side delivery area, which provides water from Clear Lake Reservoir, Gerber Reservoir and the Lost River to lands on the east side of the Project area.

In allocating water the BOR must maintain minimum elevation levels in Upper Klamath Lake in accordance with the USFWS Biological Opinion (May 2002) to manage for ESA listed Klamath Shortnose and Lost River suckers. The NMFS Biological Opinion (May 2002) provided minimum flows at Iron Gate Dam for maintenance of critical habitat for ESA listed SONCC coho salmon. These Biological Opinions were challenged in a 2003 lawsuit filed against the BOR and NMFS by the Pacific Coast Federation of Fishermen's Associations. In 2006 a 9th Circuit Court of Appeals judge remanded the NMFS Biological Opinion, ruling that it was in violation of the ESA, and requested a re-consultation, now in progress. In the interim, the judge ordered that minimum flows at Iron Gate Dam be maintained at a minimum of 1,000 cfs during the summer months to protect SONCC coho.

A protracted drought occurred in the Upper Klamath Basin, extending from 2001 through November 2005. 2005 was the fifth year Bureau of Reclamation operated the Project under a below average or dry water year type and the fourth year in a row that Chinook salmon were not provided suitable habitat by virtue of insufficient (less than 1,000 cfs) water releases to the Klamath River from the Project (Figure 5-2). At the same time, the Project provided full irrigation deliveries in 2002-2004.

Shasta River

The Shasta River provides irrigation water to approximately 46,400 acres of irrigated crop area (primarily pasture) in the Shasta River basin. Shasta River water rights have been adjudicated since 1932, with full appropriation from May 1 through October 31 (North Coast Regional Water Quality Control Board [NCRWQB] 2006).

The California Department of Water Resourced (DWR) data from 1945 to 1994 show a steady increase in consumptive impairment from the Shasta River ranging from 42,500 acre-feet in 1945 to 109,500 acre-feet in 1994 (DWR Bulletin no.87). During the irrigation season from March through September, flows decline markedly, averaging X cfs during the summer months (NRC 2004). Reduced flows, elevated temperatures, and low dissolved oxygen levels were identified as the water quality parameters having the most adverse impacts to cold water fish in the Shasta River (NCRWQCB 2006).

Scott River

Water from the Scott River is used to irrigate approximately 34,000 acres of pasture, alfalfa and grain in the Scott Valley, using about 98,100 acre-feet of applied water per year. Water rights were adjudicated in 1980, but do not include adjudication rights for fish upstream of the U.S. Geological Survey (USGS) gage at Fort Jones. Below the gage, the U.S. Forest Service (a junior appropriator) was allotted a minimum flow for fish of 30 cfs during August and September, 40 cfs during October and 200 cfs from November through March. However, there is no watermaster service on the mainstem, and the U.S. Forest Service adjudication is often not met (National Research Council [NRC] 2004). Irrigation withdrawals are supposed to cease on October 15, however, this is sometimes violated, minimizing migration flows for adult salmonids.

Historically, the Scott River has provided optimum coho salmon spawning and rearing habitat, with beaver dams throughout the valley. The hydrology of the Scott River watershed is not well documented, and a water budget is currently underway (CSWRCB 1995).

Trinity River

The Trinity River is impounded by Trinity and Lewiston Dams which were completed in 1963 as part of the 1955 Central Valley Project Act. An average of 1.1 million acre feet (af) flowed past Lewiston prior to the dam construction. In some years up to 90% of this inflow was diverted to the Sacramento River as part of the 1955 Act. Subsequent decline of the fisheries led to a series of administrative and congressional actions (1981 Interior Secretarial Decision for the Flow Evaluation Study; 1984 Trinity River Basin Fish and Wildlife Management Act; 1992 Central Valley Project Improvement Act), which culminated in the 2000 Record of Decision (ROD) co-signed by then Interior Secretary Bruce Babbitt and the Chairman of the Hoopa Valley Tribe. The ROD specified in-river flows based on five water year types that range from critically dry to extremely wet, with annual volumes of 369,000 af to 815,000 af. The goal of the Trinity River Restoration Program, which implements the ROD, is to restore populations of naturally produced anadromous fish to those levels observed prior to construction of the Trinity Division of the Central Valley Project.

Smaller diversions occur throughout the Trinity River Basin mostly for domestic water use; however, several small scale operations pump water for crop and pasture irrigation on the mainstem Trinity and in the South Fork Trinity Basins. Any potential direct fish losses as a result of pump/diversion entrainment are un-quantified at this time, but are believed to be minor.

Increased river flows, primarily in the spring to promote fluvial process and to provide more favorable thermal regimes for outmigrating juvenile salmonids, have been implemented since the signing of the ROD (Figure 5-3). Additional flows were released in the fall of 2003 and 2004 to assist in preventing unfavorable conditions that contributed to the adult fish die-off in the lower Klamath River in the fall of 2002 (Table 5-11). While no adult fish die-off occurred in either 2003 or 2004, the effectiveness of these flow releases from the Trinity in preventing this event is uncertain. Some of the possible negative reactions resulting from these atypical (primarily in duration) fall flows were fall Chinook salmon moving into the upper river up to two weeks early, increasing the probability of hybridizing with spring Chinook salmon.

The major change in fish habitat that has been implemented since the signing of the ROD was increased flows during the spring/summer outmigration period (USFWS and HVT 1999). Due to litigation over implementation of the ROD recommendations, full instream release volumes were not available until 2005; however, beginning in 2001, volumes were increased above that previously available (340,000 acre-feet), which allowed for meeting some of the flow based objectives recommended in the Trinity River Flow Evaluation (USFWS and HVT 1999) (Table 5-11).

Entrainments

The Yreka Screen Shop, which has been in operation since the 1940's, currently installs and maintains 70 screens during the diversion season. This includes 23 screens on diversions from the mainstem Klamath River and its tributaries from Seiad Creek to Bogus Creek, 32 screens on tributaries to the Scott River and 14 screens on the Shasta River and its tributaries. In 2007, the screen shop received a grant from the Wildlife Conservation Board to make repairs to 15 older screen sites, 13 of which are in the Scott River watershed. All repairs will be conducted after the irrigation season.

In addition to the screens, the screen shop maintains 11 fish ladders. Historically, the CDFG has, as a courtesy to landowners, provided assistance in trapping and relocating stranded fish. It is uncertain whether these activities will continue in the future. The Siskiyou and Shasta Resource Conservation Districts also identify unscreened diversions and install and maintain fish screens.

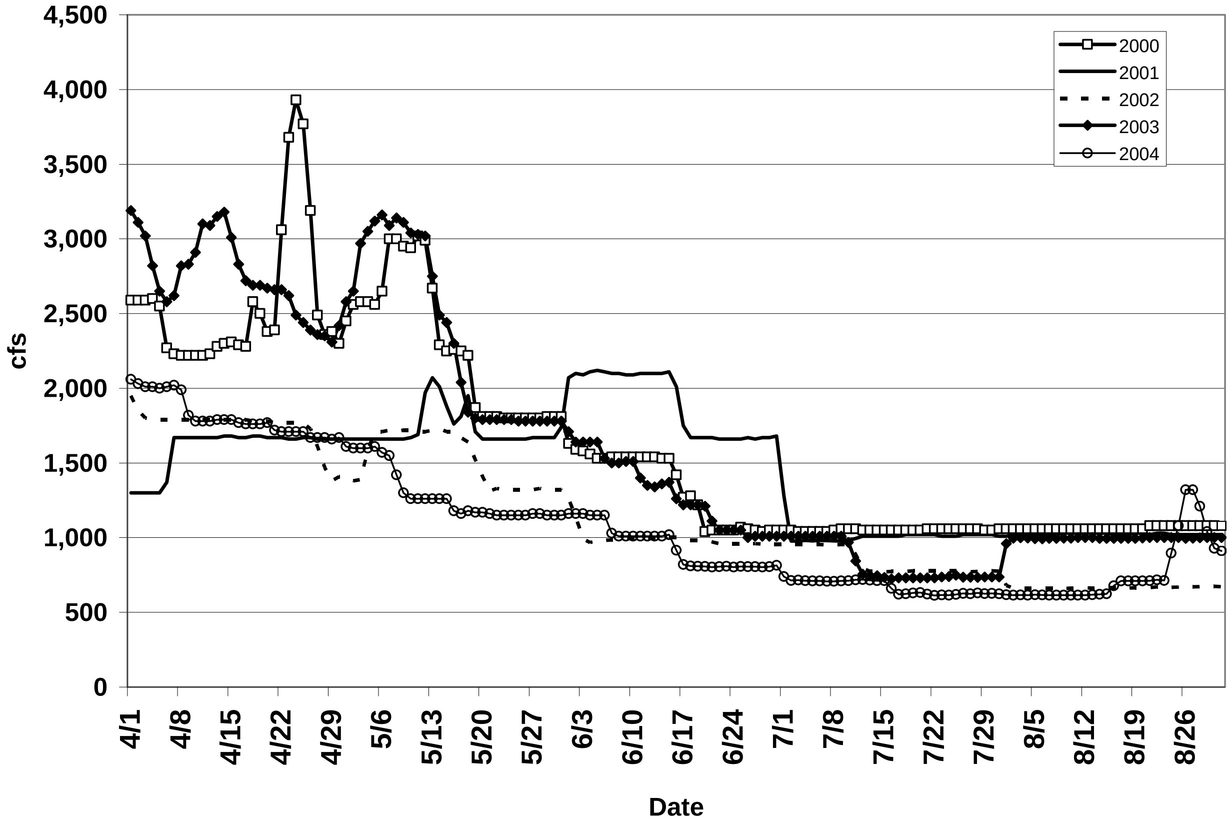

Figure 5-2. Mean daily flows at Iron Gate Dam during April through August, 2000 to 2004.

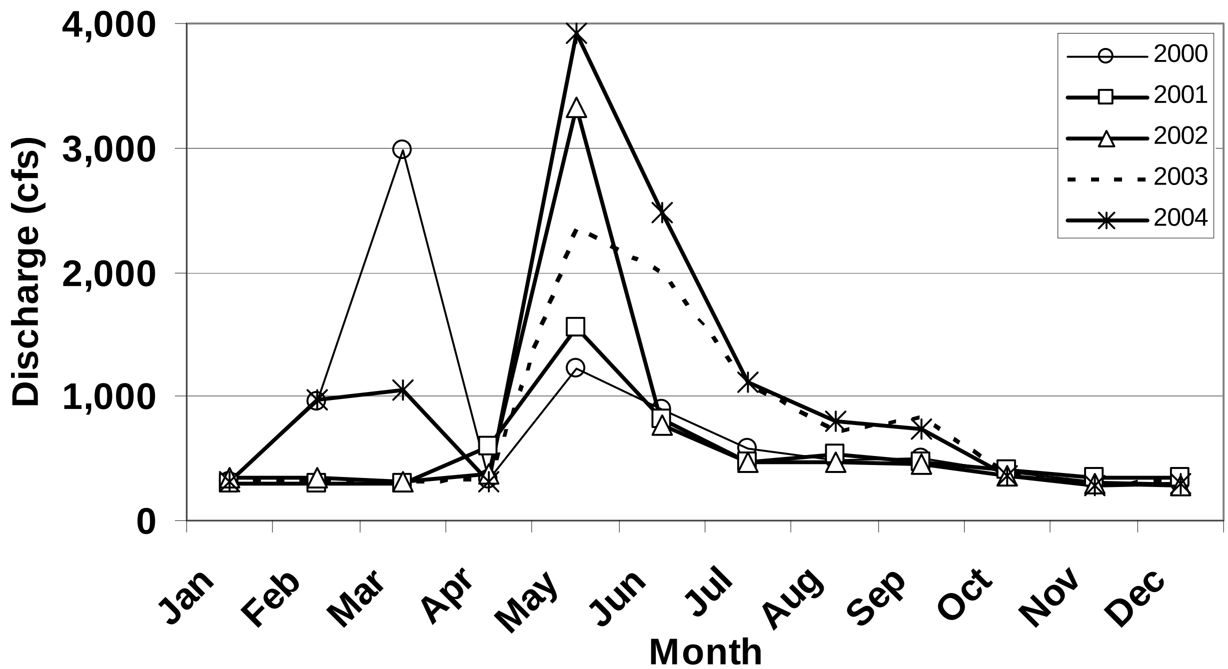

Figure 5-2. Mean monthly discharge in cubic feet per second (CFS) at Lewiston Dam, 2000-2004.

Figures 5-2 and 5-3 should be updated with 2005 and 2006 data if it is relevant to adult spawning escapement in those years.

During 2001-2004 (Brood years 2000 – 2003), releases from Lewiston Dam to provide spawning and rearing habitat (Figure 5-4) were the same as in previous years (Figure 5-5) with the exception of safety-of-dams (SOD) releases which are sometimes required to meet operational criteria. In 2004, a month long SOD release occurred but the potential impact of this on rearing Chinook salmon is unknown. The flow released was sufficient to overtop the riparian berms which currently constrain habitat availability at moderate flow levels (generally between 300 cfs to 2,000 cfs) but it is unknown if this increase in flow caused a premature emigration of fry and juvenile Chinook salmon. SOD releases of varying magnitude and duration have occurred in 8 of the 14 years form 19991 to 2004, including 1995 through 2000, which affected broods with relatively strong and weak returns. Therefore, it is unlikely the 2004 SOD had a substantial effect on 2003 brood survival.

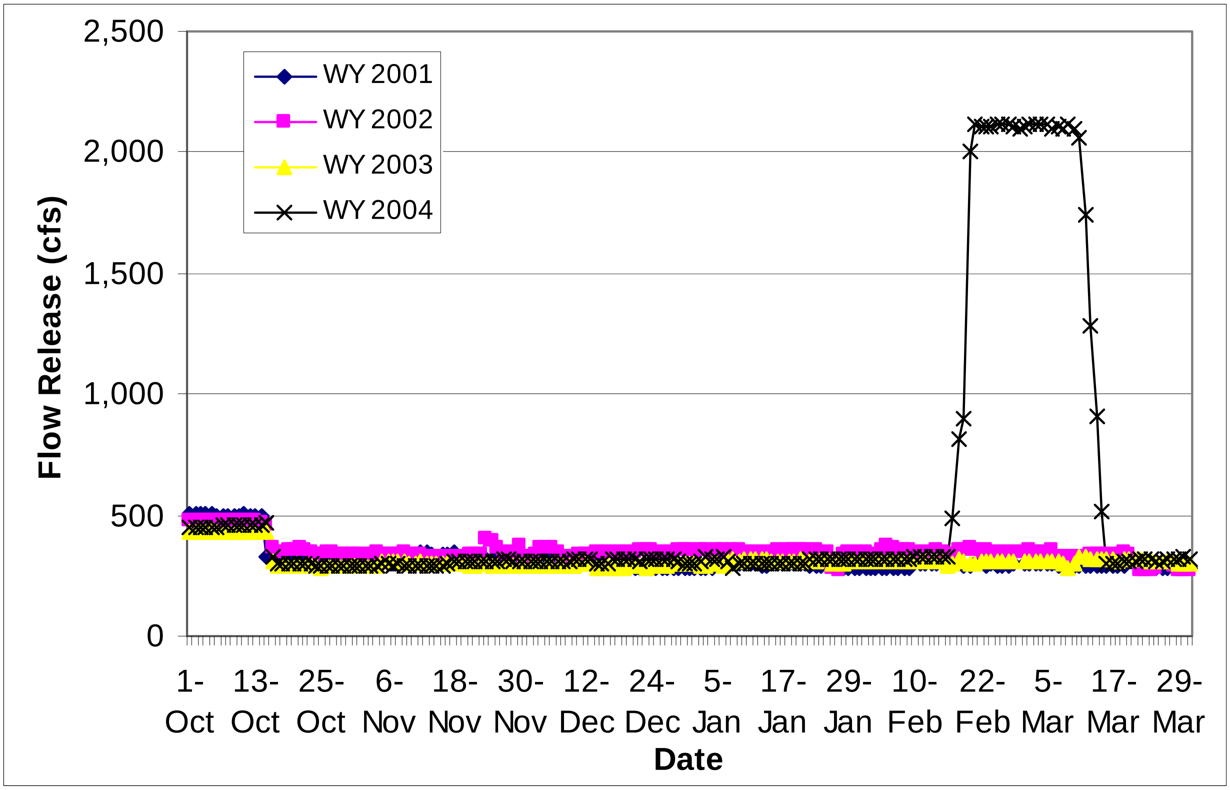

Figure 5-4. Releases into the Trinity River from Lewiston Dam during the spawning and rearing period, water years 2001-2004 (brood years 2000-2003).

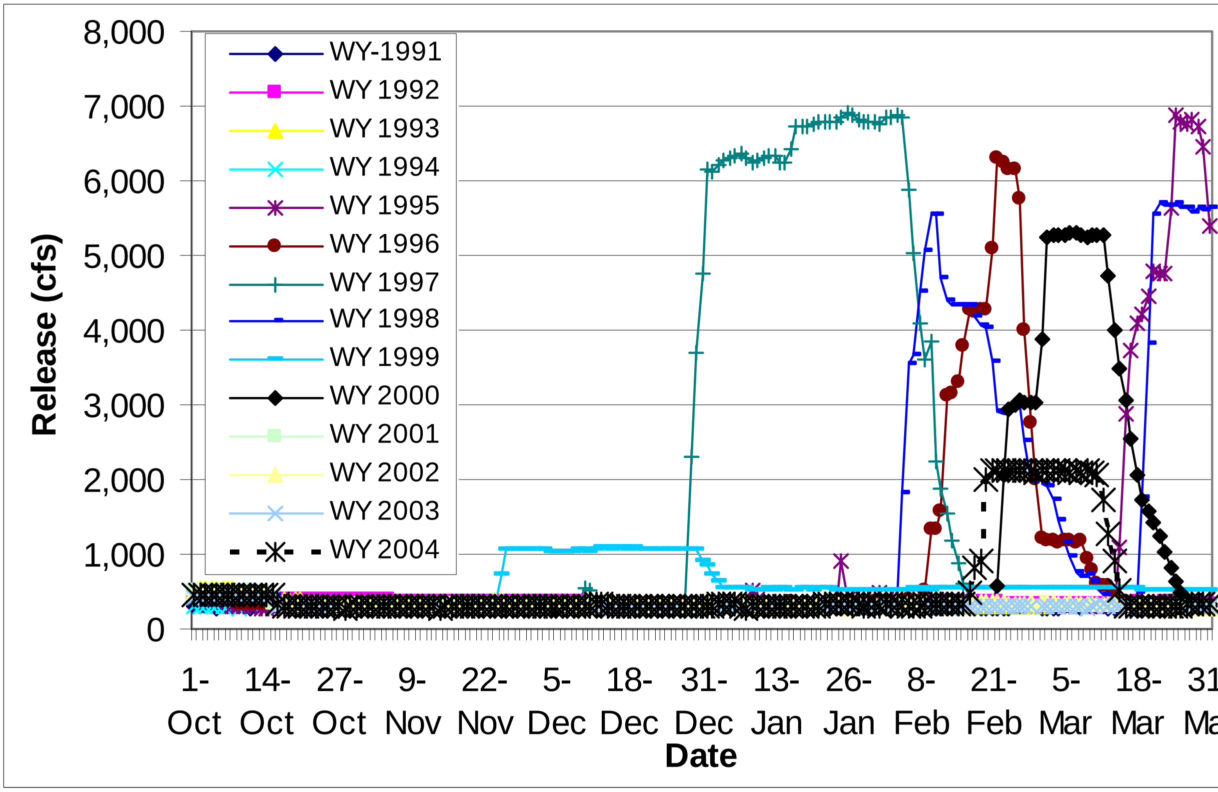

Figure 5-5. Releases into the Trinity River from Lewiston Dam during the spawning and rearing period, 1991-2004 (brood years 1990 – 2003).

Table 5-11 Trinity River Record of Decision (ROD) flow requirements and compliance.

Water Year[a/]	Annual Release Volumes (acre-feet): Actual Volume Released	Annual Release Volumes (acre-feet): Volume Necessary to meet ROD Objectives	Annual Release Volumes (acre-feet): Other Fishery Flows[c/]	Channel Rehabilitation Sites Constructed[d/]
2001[b/]	368,000	453,000		
2002[b/]	468,000	647,000		
2003[b/]	453,000	671,300	34,000	
2004[b/]	647,000	671,300	36,300	
2005	647,000	647,000		1
2006	815,000	815,000		4

a/ Water year begins in October of pervious year (i-1) and ends in September (year i).

b/ Flow volumes were limited due to court order and ongoing litigation over the implementation of the Record of Decision. During WY2005 full releases recommended in the ROD were able to be released.

c/ During the fall of 2003 and 2004 releases from the Lewiston Dam above ROD volumes to improve conditions in the lower Klamath River.

d/ Mechanical rehabilitation activities recommended in the ROD include 44 channel rehabilitation sites and 3 side channels.

5.2.3 Water Quality

Trinity River

Portions of the recommended hydrographs were developed to provide better thermal conditions during salmonid outmigration periods during the spring/early summer, based on water year type (USFWS and HVT 1999). During Normal and wetter water years, flows are scheduled to provide greater periods of optimum thermal regimes for outmigrating salmonids while during dry and critically dry water years flows were anticipated to provide marginal thermal regimes. Although temperature targets were established, flows are not managed on a real time basis to achieve the objectives. Part of the expectation of establishing a fixed schedule once the water year is established (early April) is to allow the downstream hydro-meteorological conditions influence dam releases to restore some semblance of natural and variable thermal regime.

Prior to May 20 temperatures at Weitchpec were in the optimum range during all years of interest (2001 to 2004) (Figure 5-6). The most favorable thermal regime through the lower Trinity River was observed for the period from May 20 through July 9, 2004 where optimal temperatures prevailed through mid-June and marginal temperatures through July 9. July 9 is the transition date when temperature targets shift from providing outmigration temperatures to those necessary to support upriver migrating adult salmonids in normal or wetter years.

Comparison of the percentage of days (from May 1 to July 9) that the marginal and optimal Chinook salmon outmigration temperature were achieved indicates that the 2001, 2002, and 2003 outmigrants (brood years 2000, 2001, and 2002, respectively) experienced the least favorable thermal conditions (Figure 5-7 and 5-8). During these years, optimal temperatures were achieved 31% to 51% of the time and marginal temperatures 66% to 79% of the time. During 2004, outmigrants (brood year2003) experienced marginal temperatures 100% of the time and optimal temperatures 64% of the time. Similar low percentages of attaining marginal temperatures (<80%) occurred in 1992 (59%) and 1994 (71%) and for optimal temperatures (<50%) occurred in 1991 (44%), 1992 (26%), 1994 (37%), and 1997 (50%).

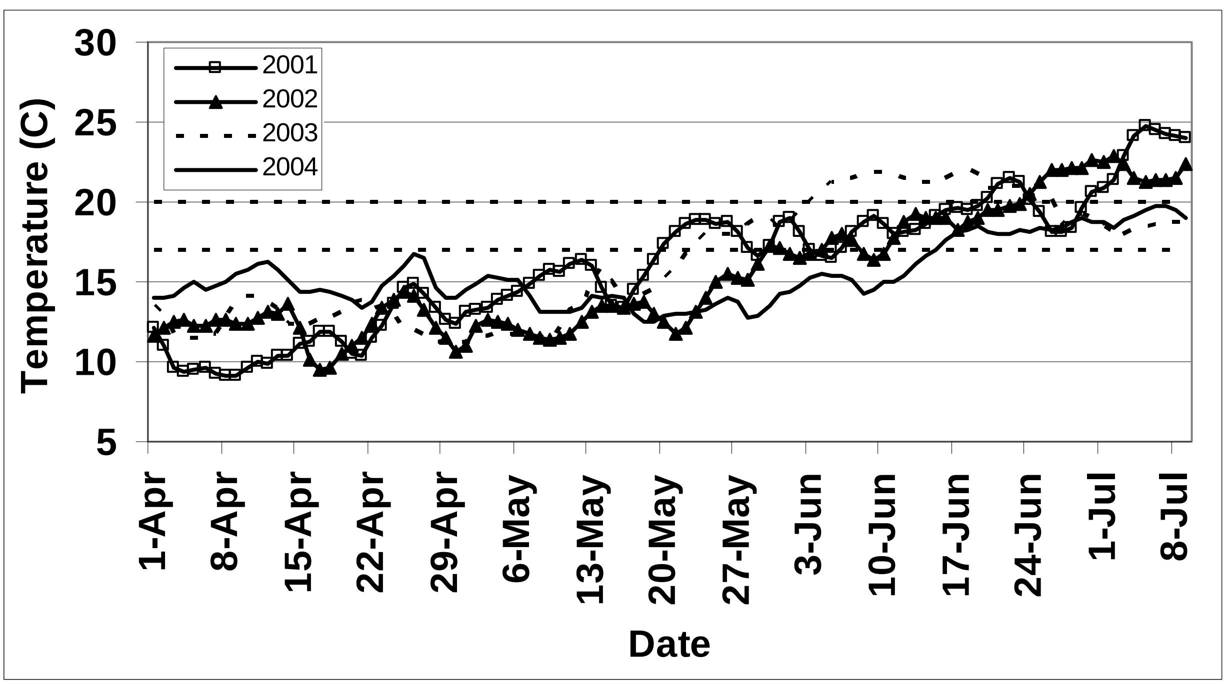

Figure 5-6. Mean daily water temperature on the Trinity River at Weitchpec, April 1 to July 9, 2001 – 2004. Dashed lines are upper level of optimal Chinook salmon smolt criteria and upper level of marginal Chinook salmon smolt criteria.

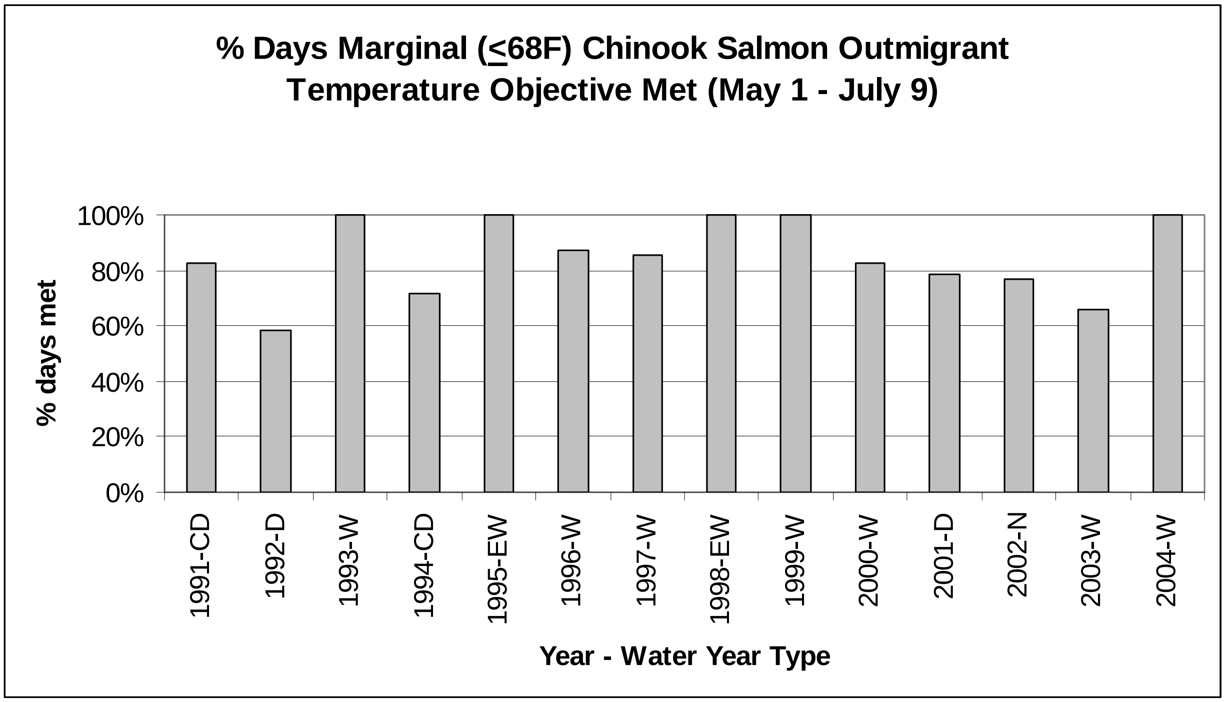

Figure 5-7. Percentage of days that Trinity River marginal Chinook salmon outmigrant water temperature objective was met for the period May 1 through July 9 at Weitchpec, 1991 – 2004.

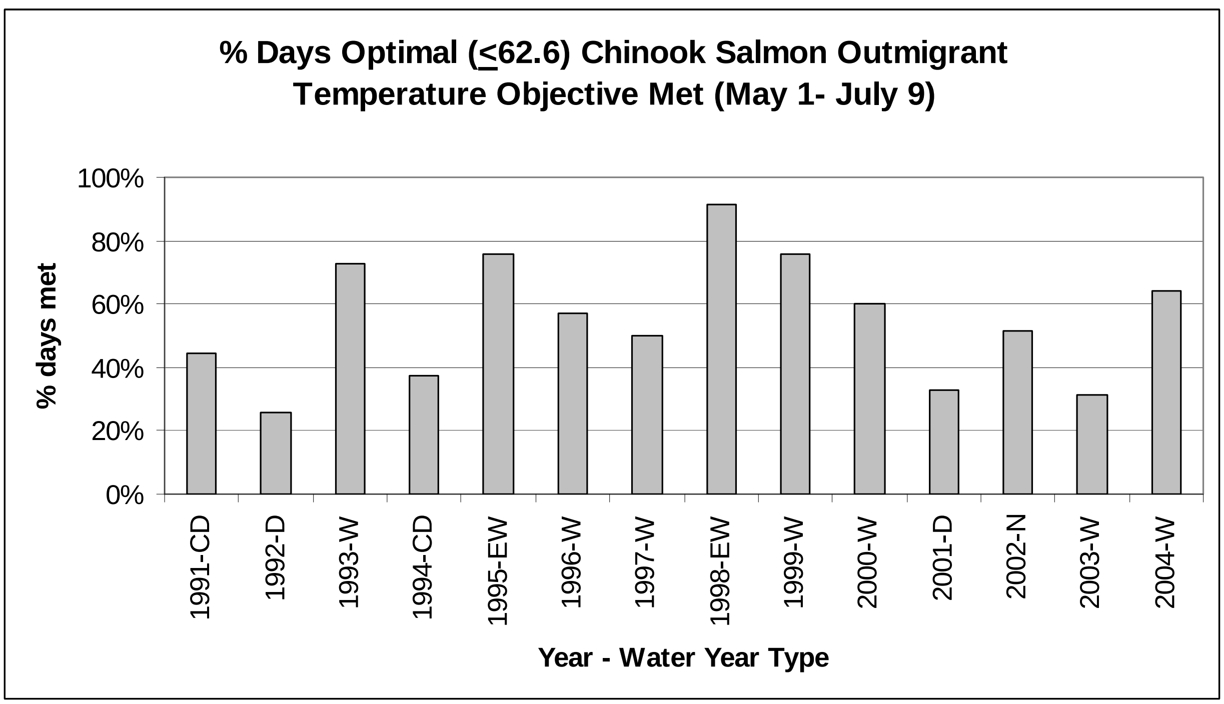

Figure 5-8. Percentage of days that Trinity River optimal Chinook salmon outmigrant water temperature objective was met for the period May 1 through July 9 at Weitchpec, 1991 – 2004.

Releases from Lewiston Dam are managed to meet adult holding and spawning temperature criteria (USFWS and HVT 1999). Generally releases ranging from 300 cfs (later in the year) to 450 cfs (during the summer) are necessary to meet the criteria, and during occasions when criteria are not met flows are increased (Figure 5-9). For 2000 to 2003 (Figure 5-10), water temperature objectives were generally met during fall Chinook salmon holding and spawning period (late September through November) except for minor exceedences (<1ºC) in early October during 2000, 2001, and 2003 (Figure 5-10). It does not appear that these relatively minor and short duration exceedences should have compromised the survival and spawning success of spawning fall Chinook during 2000-2004.

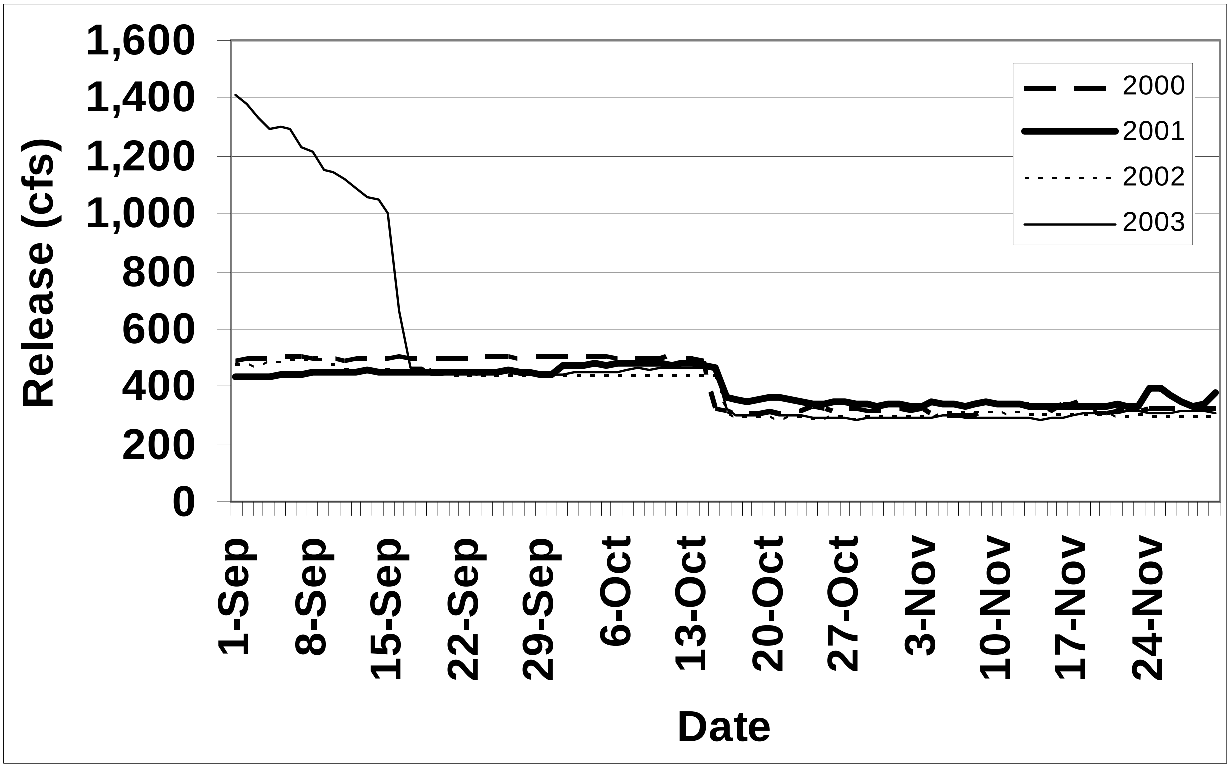

Figure 5-9. Mainstem Trinity River flow releases from Lewiston Dam from September through November, 2000-2003. Note: Large release in 2003 through mid-September was managed release to improved water conditions in the lower Klamath River and not made to meet the holding/spawning temperature criteria for the upper mainstem Trinity River.

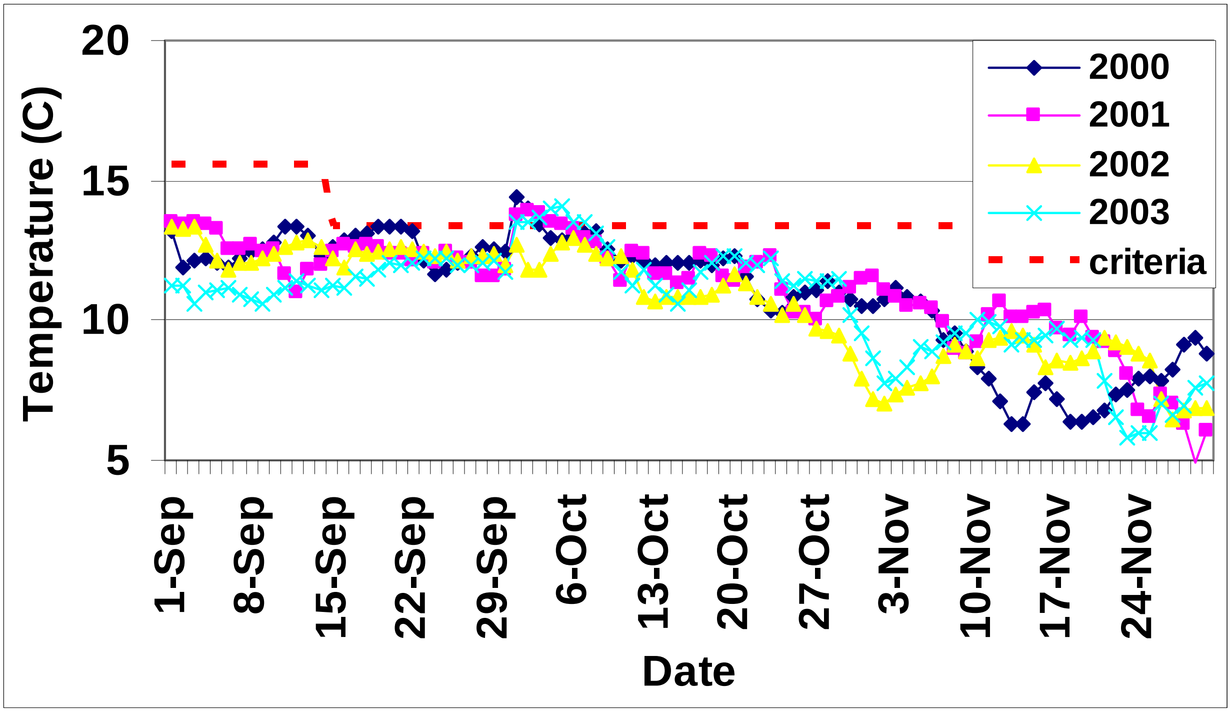

Figure 5-10.Mainstem Trinity River water temperature from September through November, 2000 – 2003.

5.2.4 Disease

Ceratomyxa shasta and Parvicapsula minibicornis

Increasing concerns over water quality, habitat conditions, and fish health have led to increasing efforts in assessing the incidence of pathogens in outmigrating juvenile Chinook salmon. Observations of large numbers of dead juvenile Chinook salmon along the Klamath River in 2002 and the adult fish-kill that occurred during the fall of 2002, led to heightened awareness of the salmonid fish health issues in the Klamath Basin. Following the 2002 adult fish-kill, the Klamath fish health assessment team (KFHAT) was formed to coordinate information and facilitate cooperative monitoring efforts in the event that fish health concerns were imminent due to water quality conditions or fish health observations from field studies. More information about KFHAT can be found at:
http://ncncr-isb.dfg.ca.gov/KFP/DesktopDefault.aspx?tabindex=0&tabid=1.

The primary pathogens implicated in the elevated disease-related mortality of juvenile Chinook salmon are the myxozoan parasites *Ceratomyxa shasta* and *Parvicapsula minibicornis* (Nichols and Foott 2005). Production from brood years 2000 through 2003 contributed to the 2004 to 2006 return years as age-3 and age-4 adults, which account for the majority of spawners. Juvenile KRFC from these brood years migrated from the Klamath Basin during the spring and summer of 2001 to 2004. Juvenile disease monitoring was conducted in the Klamath Basin in 2001, 2002, and 2004 (Foott et al. 2002; Nichols et al. 2003; Nichols and Foott 2006). No assessments were conducted in 2003. Monitoring has generally been divided into three areas: 1) the mainstem Klamath River above the confluence with the Trinity River, 2) the mainstem Trinity River above the confluence with the Klamath River, and 3) the Klamath River Estuary. Complete monitoring of the three areas was only conducted in 2001 and 2002.

Juvenile KRFC sampled in the Trinity River, 34 river kilometers above the confluence with the Klamath River, showed little incidence of infection with either pathogen (Table 5-9). In the 2002 samples from the estuary, TRH Chinook showed infection rates of 19% and 14% for *C. shasta* and *P. minibicornis*, respectively (Table 5-9), while the samples collected from the Trinity River indicated no infection, suggesting that the primary area for infection of these fish is the lower Klamath River.

Contrary to the Trinity River, disease incidence of juvenile KRFC sampled in the Klamath River was relatively high for *C. shasta* (34% to 50%) and *P. minibicornis* (77% to 95%) (Table 5-9). Samples collected in the estuary also indicated high incidences of infection by these pathogens, although the sample size of IGH Chinook was very small. Infection rates for juvenile Chinook sampled on the Klamath River in 1995 were somewhat similar for *C. shasta* (44% in 1995) but were much lower for *P. minibicornis* (47% in 1995).

While no definitive fish disease information exists to link the incidence of fish pathogens in juveniles to the poor adult returns in 2004 to 2006, the high incidence of disease, especially for *P. minibicornis*, concern managers. Almost every fish that was infected with *C. shasta* was also infected *P. minibicornis* which causes severe anemia and osmoregulatory problems (Foott, personal communication, 2007). This, along with the poor water quality conditions that might be encountered, compromises the ability of infected fish to fight the infection, resulting in mortality due to disease. While there are no data on the physiological effect of infections of juvenile KRFC it can be assumed that renal impairment reduces survival. For *C. shasta* and possibly *P. minibicornis*, a polychaete worm (*Manayunkia speciosa*) is the intermediate host (Bartholomew et al. 1997). Research is currently being conducted to assess the habitat conditions for the polychaete, especially the establishment of extensive algal beds, in the Klamath River below Iron Gate Dam. McKinney et al. (1999) suggested that reductions in the magnitude and duration of peak flows due to hydroelectric operations likely have increased the amount of polychaete habitat.

Table 5-12. Klamath Basin juvenile Chinook pathogen infection rates. (Sample size in parentheses)

Pathogen	Brood Year	Klamath	Trinity	Estuary		
				Iron Gate CWT	Trinity CWT	Unmarked
Ceratomyxa shasta	2000	50% (34)	0% (38)	NA	NA	29% (42)
Parvicapsula minibircornis	2000	88% (25)	6% (31)	NA	NA	84% (43)
Ceratomyxa shasta	2001	37% (38)	0% (14)	60% (5)	19% (68)	26% (47)
Parvicapsula minibircornis	2001	95% (39)	0% (19)	100% (5)	14% (64)	60% (47)
Ceratomyxa shasta	2003	34% (735)	Not Sampled	Not Sampled	Not Sampled	Not Sampled
Parvicapsula minibircornis	2003	77% (732)	Not Sampled	Not Sampled	Not Sampled	Not Sampled

5.2.5 Other Habitat Degradation

5.3 Marine Survival

The effects of marine survival on year-class strength are believed to be most variable in the early marine life history. The best measure of marine survival would be to calculate survival rates between smolts leaving the river and ocean abundance of the cohort at some later point in time. We can reconstruct the marine abundance of cohorts, using spawning runs and exploitation rates, back to September of the year they migrate to sea. Because very few age-2 fish are recovered in ocean fisheries, reconstructed ocean abundance is more indicative of the cohort abundance when age-2 jacks leave the ocean to spawn. However, there is no time series of emigration estimates for KRFC to compare this with; the nearest approximation is KRFC fingerling releases from the two hatcheries in the basin (STT 2005). Use of fingerling releases as a proxy for smolt emigration includes mortality in the period of riverine residence and migration in the estimate of early life-history survival. Therefore, the estimate of early life history survival reflects the period from the spring, when fingerlings are released, until September of the following year when age-2 jacks return to spawn.

The pattern of survival does not appear to have obvious trends and neither hatchery has consistently higher survival than the other (Figure 5-4). However, it appears that the survival of IGH fingerlings tends to be lower than that of TRH fingerlings in years with the lowest survival rates. This pattern suggests that years of very low survival may be driven by high mortality in freshwater, particularly in the mainstem Klamath River. This is consistent with *Ceratomyxa shasta* in the mainstem Klamath being a primary source of mortality in years of low survival, and having a lesser impact on fish from TRH by virtue of their shorter migration pathway in the mainstem Klamath River.

Spawning escapements in the three years that failed to meet the escapement floor were composed primarily of fish from the 2000 through 2003 brood years. Because the 2003 brood year was represented by age-3 spawners, the brood was too incomplete to calculate an early life-history survival rate. Of the 2000-2002 brood years, all exhibited the pattern of lower survival of Iron Gate fingerlings than that of Trinity River fingerlings, but only the 2001 brood year experienced abnormally low survival. The terminal run of age-3 fish in 2006 was 18,600 - the smallest run of age-3 Chinook since 1992 - and suggests that the survival rate of the 2003 brood year was even less than that of the 2001 brood year.

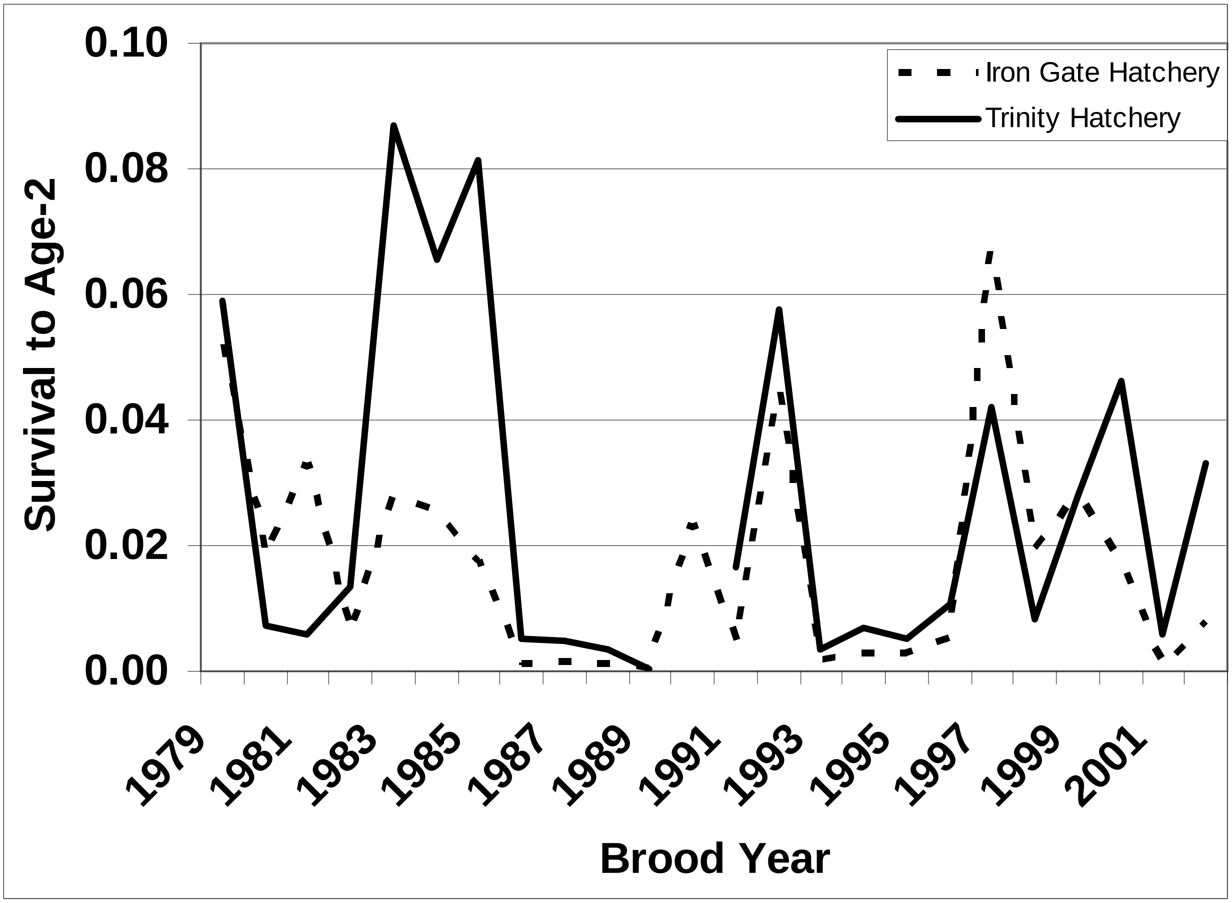

Figure 5-11.Survival of hatchery fingerling releases to age-2, September 1.

5.4 Predation

6. DISCUSSION

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