In-River Sport Fishing Economics Technical Report

For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon

Prepared by

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Acronyms and Abbreviations

AAA	American Automobile Association
CDFG	California Department of Fish and Game
DPV	Discounted Present Value
DRA	Dam Removal Alternative
EDRRA	Evaluation of Dam Removal and Restoration of Anadromy
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FMP	Fishery Management Plan
IGD	Iron Gate Dam
IMPLAN	Impact Analysis for Planning
KBRA	Klamath Basin Restoration Agreement
KRFC	Klamath River Fall Chinook
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
LRS	Lost River Sucker
NAA	No Action Alternative
NED	National Economic Development
NEV	Net Economic Value
NMFS	National Marine Fisheries Service
ODFW	Oregon Department of Fish and Wildlife
PFMC	Pacific Fishery Management Council
RED	Regional Economic Development
SCF	Sectional Center Facility
SNS	Shortnose Sucker
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USWRC	U.S. Water Resources Council

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I. Introduction

In March 2012, the Secretary of the Interior – in consultation with the Secretary of Commerce – will make a determination regarding whether removal of four Klamath River dams (Iron Gate, Copco 1, Copco 2 and J.C. Boyle) owned by the utility company PacifiCorp advances restoration of salmonid fisheries and is in the public interest. Among the fisheries potentially affected by the Secretarial Determination are the existing inriver recreational fisheries for salmon, steelhead and redband trout, and the currently inactive recreational sucker fishery (which has been closed since 1987). This report analyzes the economic effects on these four inriver fisheries of three alternatives being considered by the Secretary:

- <u>Alternative 1 – No Action:</u> This alternative involves continued operation of the four dams under current conditions, which includes no fish passage and compliance with Biological Opinions by the U.S. Fish and Wildlife Service (USFWS) and NOAA National Marine Fisheries Service (NMFS) regarding the Bureau of Reclamation's Klamath Project Operation Plan.
- <u>Alternative 2 – Full Facilities Removal of Four Dams:</u> This alternative involves complete removal of all features of the four dams, implementation of the Klamath Basin Restoration Agreement (KBRA 2010), and transfer of Keno Dam from PacifiCorp to the U.S. Department of the Interior (USDOI).
- <u>Alternative 3 – Partial Facilities Removal of Four Dams:</u> This alternative involves removal of selected features of each dam to allow a free flowing river and volitional fish passage for all anadromous species. Features that remain in place (e.g., powerhouses, foundations, tunnels, pipes) would be secured and maintained in perpetuity. KBRA and transfer of Keno Dam are also part of this alternative.

Throughout this report, Alternative 1 is referred to as the no-action alternative and Alternatives 2 and 3 as the action alternatives.

Section II describes existing conditions in the inriver recreational fisheries and Section III describes the biological sources of information underlying the economic analysis of fishery effects. Sections IV and V respectively analyze the alternatives in terms of two 'accounts' specified in guidelines provided by the U.S. Water Resources Council (USWRC 1983): Net Economic Development (NED) and Regional Economic Development (RED). NED pertains to analysis of economic benefits and costs from a national perspective and RED pertains to analysis of regional economic impacts in terms of jobs, income and output. Sections VI summarizes results and conclusions of the previous sections, and Section VII provides a list of references cited in the report. Appendices A-D supplement the report with additional technical information.

II. Existing Fishery Conditions
II.A. Salmon

The particular salmon stocks influenced by the no-action and action alternatives are the two component populations of the Upper Klamath-Trinity Evolutionarily Significant Unit (ESU)[1] (Klamath River fall and spring Chinook) and the Southern Oregon Northern California Coast (SONCC) coho ESU. In order to analyze the effects of these stocks on the inriver recreational salmon fishery, it is important to understand how that fishery is managed.

The Pacific Fishery Management Council (PFMC) is responsible for determining the total allowable harvest of adult Klamath River fall Chinook (KRFC) and the distribution of this harvest among fisheries.[2] The State of California splits the inriver recreational portion of the allowable harvest 50-50 between two subareas: (i) the lower river – extending from the river mouth to the confluence with the Trinity River at Weitchpec, and (ii) the upper river – extending from Weitchpec to Iron Gate Dam (IGD), plus the lower Trinity River. Once a subarea quota is met, anglers are still allowed to fish for grilse[3] in that subarea but must release any adult Chinook caught. The fall Chinook season extends August 15-December 31; Chinook caught before August 15 are generally considered to be spring Chinook. Total length of 22 inches is used to distinguish adults from grilse. SONCC coho was listed as ‘threatened’ under the Endangered Species Act (ESA) in 1997, and coho retention is prohibited in the inriver fishery. Table II-1 provides further details of California Chinook regulations for the 2010-11 season.

Table II-1. California Chinook sport fishing regulations for the Klamath River, 2010-11 season.

Area	*Season*	*Daily Bag/Size Limits*
Klamath River from Iron Gate Dam to Weitchpec	Jan 1-Aug 14	0 Chinook
	Aug 15-Dec 31	3 Chinook – only 2 Chinook >22” total length until subquota met 0 Chinook>22” total length after subquota met
	Fall Run Quota Exception: Chinook salmon over 22 inches total length may be retained from 3,500 feet downstream of Iron Gate Dam to the Interstate 5 bridge when the Department determines that the adult fall-run Chinook salmon spawning escapement at Iron Gate Hatchery exceeds 8,000 fish. Daily bag and possession limits specified for fall-run Chinook salmon apply during this exception.	
Klamath River downstream of Weitchpec	Jan 1-Aug 14	2 Chinook
	Aug 15-Dec 31	3 Chinook – only 2 Chinook >22” total length until subquota met 0 Chinook>22” total length after subquota met
	Fall Run Quota Exception. Spit Area (within 100 yards of the channel through the sand spit formed at the Klamath River mouth) closed to all fishing after 15% of the Lower Klamath River sub quota has been met.	

Source: CDFG 2010

[1] An Evolutionarily Significant Unit is a population or group of populations that is reproductively isolated and of substantial ecological/genetic importance to the species (Waples 1991).
[2] See Appendix A for a description of PFMC salmon management.
[3] A grilse is a young salmon that returns to the river to spawn after one year in the ocean.

Since 1978 the California Department of Fish and Game (CDFG) has conducted an annual creel survey on the Klamath River to help address PFMC and State management needs. The survey covers the mainstem Klamath from the river mouth to IGD (excluding the Trinity River). A separate creel survey on the lower Trinity River is conducted by the Hoopa Valley Tribe. However, creel estimates for the Trinity River (the major tributary of the Klamath River) are not included in this analysis, as the productivity of Trinity River stocks is not expected to differ between the no action and action alternatives. Unless otherwise noted, all references to the Klamath River salmon fishery in the remainder of this report exclude the Trinity River.

CDFG's creel survey extends from August to November – timed with the return of fall Chinook to the river. Data collected by samplers include: (i) numbers and species of fish caught and released (distinguishing among juveniles, grilse and adults), (ii) biological data (e.g., species, fork length, fin clips, coded wire tags, scale samples, (iii) hours fished, and (iv) first three digits of the angler's zipcode of residence. Sampling is geographically stratified as follows: area 1 – river mouth (river mile 0) to the Highway 101 bridge at Klamath (rm 3), area 2 – Highway 101 bridge (rm 3) to Highway 96 bridge at Weitchpec (rm 24), and area 3 – Highway 96 bridge (rm 24) to IGD (rm 191). The subarea quota for the lower river applies to areas 1 and 2; the subarea quota for the upper river pertains to area 3 plus the lower Trinity River (Borok 2009). Areas 1 and 2 are sampled annually. Sampling in area 3 occurred during 1999-2002 but ceased in 2003 due to budget constraints; post-2002 harvests in that area are inferred via a regression projection method devised by CDFG.

Figure II-1 depicts 1999-2010 Chinook harvest (adults and grilse) in areas 1-3. Annual harvest in the three areas averaged 4,236 adults and 1,763 grilse during 1999-2010. In 2006, record low returns of Klamath River Chinook lead to unprecedented restrictions on inriver and ocean fisheries. The prohibition on adult Chinook retention on the Klamath River in 2006 is the reason why 99 percent of the inriver harvest in that year consisted of grilse.

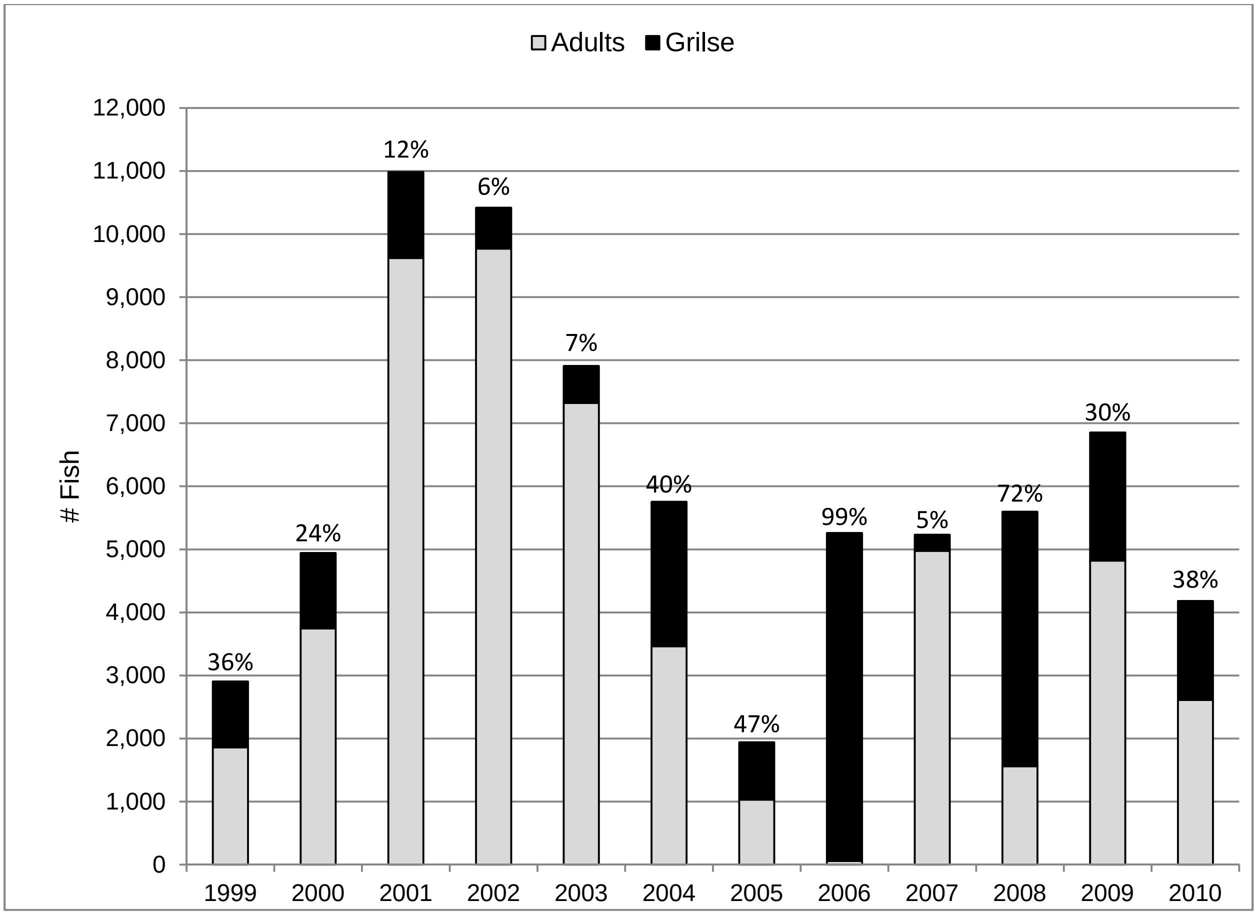

Figure II-1. Recreational harvest of Chinook adults and grilse (# fish), and grilse as percent of total harvest on the Klamath River (areas 1-3), 1999-2010 (data source: CDFG 2011).

Figure II-2 depicts 1999-2010 fishing effort (angler days) in areas 1-3. During the years when area 3 was sampled (1999-2002), the proportion of total Klamath River effort attributable to area 3 averaged 29 percent (range: 27-34 percent). For purposes of this analysis, annual effort in area 3 during 2003-10 was estimated by similarly assuming that area 3 effort comprised 29 percent of total effort in each year.

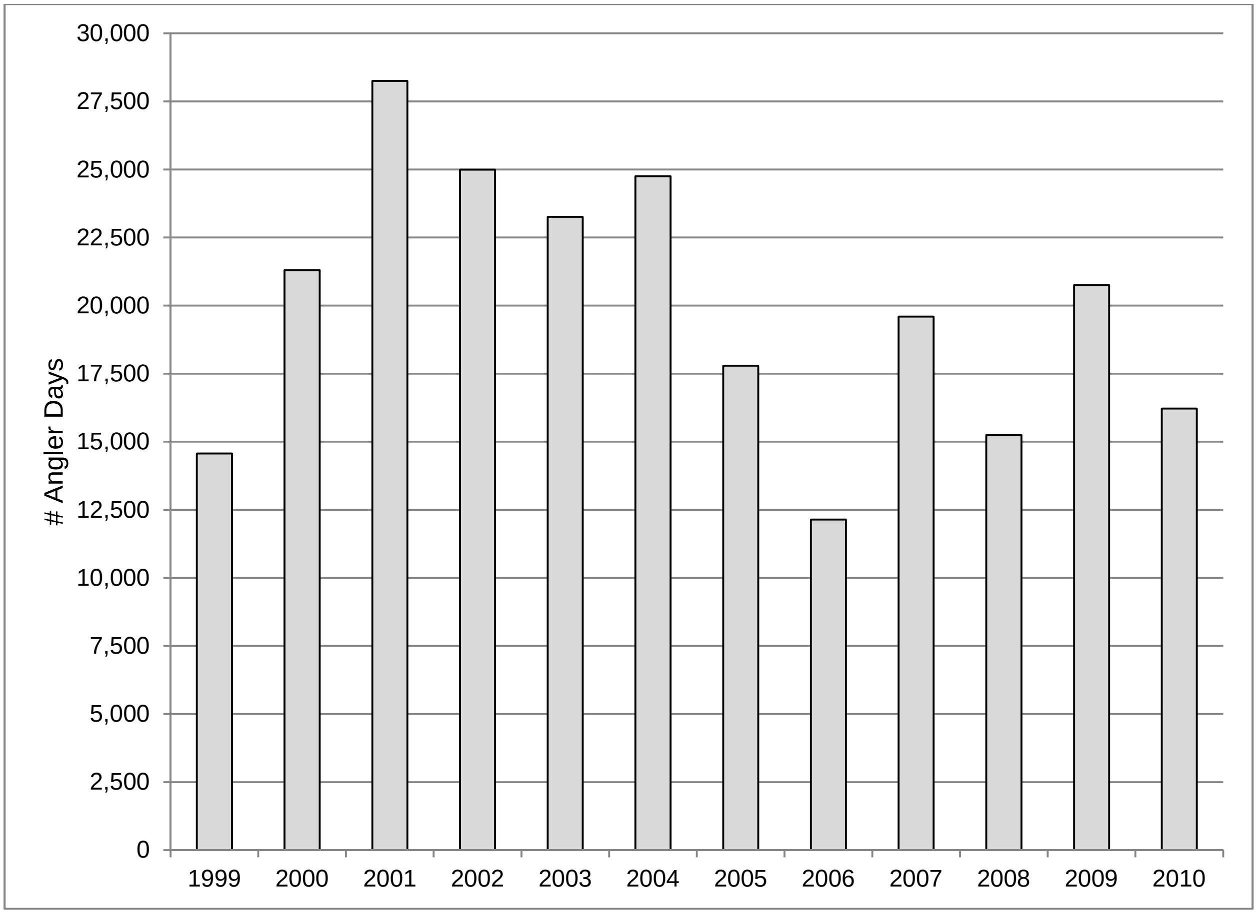

Figure II-2. Number of salmon angler days on the Klamath River (areas 1-3), 1999-2010 (data source: Sara Borok, CDFG).

II.B. Steelhead

The California steelhead fishery is characterized here in terms of steelhead fishing effort (angler days) on the Klamath River during 2003-08. Effort was estimated on the basis of steelhead report card data collected by CDFG. The Trinity River (the major tributary of the Klamath River) is excluded from this analysis, as the productivity of Trinity River steelhead is not expected to differ between the no action and action alternatives. Unless otherwise noted, all references to the Klamath River steelhead fishery in the remainder of this report exclude the Trinity River.

The Steelhead Trout Catch Report-Restoration Card (later renamed the Steelhead Fishing Report-Restoration Card) was implemented by CDFG in 1993. The program requires all steelhead anglers 16 years of age and older to possess a report card when fishing for steelhead in anadromous waters and to report their catch of all steelhead greater than 16 inches (both kept and released). In 1997 CDFG implemented a 100 percent marking program for all hatchery steelhead, and in 1998 began requiring anglers to release non-adipose fin clipped steelhead (i.e., wild steelhead) on all rivers (except the Smith River and portions of the Sacramento River). Following establishment of the mark selective fishery, the report card was modified in 1999 to include information on the origin (wild or hatchery) of steelhead catch. Klamath River regulations include a daily possession limit of one hatchery trout or hatchery steelhead; all wild fish must be released (CDFG 2010).

Table II-2 describes annual steelhead fishing effort during 2003-08 – 2003 being the year when compliance with the report card program became mandatory and report card returns began to increase (Jackson 2007). The methodology used to derive these estimates is described in Appendix B.

Table II-2. Estimated number of steelhead angler days on the Klamath River (excluding the Trinity River), 2003-08.[1]

2003	2004	2005	2006	2007	2008	Average
19,183	14,345	13,216	19,371	15,622	21,192	17,155

[1] Methodology used to derive angler day estimates is described in Appendix B.

An important component of the Klamath River steelhead fishery is the half-pounder fishery.

> "The 'half pounder' life history is unique to north coast and southern Oregon steelhead populations. 'Half pounders' are small (250-344 mm), sexually immature steelhead that return to fresh water after spending less than a year in the ocean (Kesner and Barnhart 1972; Everest 1973). Their distribution is limited principally to the Klamath, Mad, and Eel Rivers and the Rogue River in Oregon. These fish do not spawn (except a small percentage of precocious males), eventually return to the ocean, and in subsequent years return to fresh water as larger, mature steelhead (Kesner and Barnhart 1972). 'Half pounders' support a viable and important sport fishery in the Klamath River" (McEwan and Jackson 1996, p 41).

Data on the half-pounder fishery are not available from steelhead report cards, as report card holders are required to report only kept and released steelhead larger than 16 inches. Due to lack of data, effects of the no action and action alternatives on the half-pounder fishery are not considered in this analysis.

II.C. Redband Trout

Oregon Department of Fish and Wildlife (ODFW) documents the existence of a recreational redband trout fishery on the upper Klamath River in the early 1900s: "From 1913 to 1955, a fish trap and egg taking station was maintained near the mouth of Spencer Creek where, annually, hundreds of trout, averaging 16 inches in length, were spawned for culture and distributed to Spencer Creek and other waters" (ODFW 1997, p 71). Titles of newspaper articles maintained by the Klamath County Museum (http://www.co.klamath.or.us/museum/news1899-1909.htm) indicate that the reputation of redband trout as a trophy fishery was well established by the 1920s:

- "Fine fishing at Rocky Point, says C.E. Riley; more than a ton of fish Harvested" (*Evening Herald*, July 24, 1919, p1).
- "Trout caught near Rocky Point by Dr. A.E. Sykes largest trout west of Rocky Mountains" (*Evening Herald*, July 28, 1922, p 1).

- "Silver Cup for Landing biggest Trout Won by San Fransisco [sic] man 18lb 14oz" (*Evening Herald*, January 8, 1925, p 1).
- "Biggest rainbow trout in 1927 in U.S. (20 1/2 pounds) taken from Upper Klamath Lake" (*Evening Herald*, Jan. 25, 1928, p1).

Stocking was implemented in the 1920s as a management strategy (Mesmer and Smith 2007), then superseded in the late 1970s by wild trout management policies:

> "Stocking was discontinued after 1978 when Klamath River was classified for wild trout management. Also, *Ceratomyxa Shasta* has been identified in the Klamath River below Iron Gate Dam and in Klamath Lake. Most hatchery stocks of rainbow trout are susceptible to this parasite" (Toman 1983, p 10).

Results of a statistical creel conducted on Upper Klamath Lake and Agency Lake during May 18 – September 30, 2009 indicate that 15,191 angler days occurred during the survey period (Table II-3).

Table II-3. Estimated redband trout angler trips during March 18–September 30, 2009, by location and fishing mode.

	Fishing Mode		
Location	*Bank*	*Boat*	*Total*
Upper Klamath Lake	5,218	7,278	12,496
Agency Lake	891	1,804	2,695
Total	6,109	9,082	15,191

Source. William Tinniswood, ODFW

Redband trout fishing also occurs in the tributary streams above Upper Klamath Lake. Messmer and Smith (2007, p 92) note that "These streams offer some of the best fly fishing in the United States". However, quantitative estimates of effort and harvest are not available for the tributary fishery. A redbound trout fishery also exists in the Keno Reach (Keno Dam to J.C. Boyle Dam), where redband also reach trophy size. Fishing effort below J.C. Boyle is likely modest, as hydropower operations make fishing conditions (fishable flows) during daylight hours unpredictable (pers. comm. William Tinniswood, ODFW). Estimates of harvest and effort for the area below Keno Dam are not available.

Current regulations reflect the status of redband trout as a trophy fishery:

> "ODFW fishing regulations protect the large trophy redband/rainbow trout of the Upper Klamath Basin by permitting only one trout per day per angler in Upper Klamath Lake, the Williamson River, and the Keno reach. The Wood River recreational fishery is only open from April 24 to October 31 and is catch and release only. The Keno reach fishery is further restricted as it is open January 1 to June 15, then closes during high temperature stress conditions from June 16 to September 30 (3.5 months). The Keno Reach fishery then re-opens again from October 1 to December 31 (Oregon Sport Fishing Regulations 2010)" (Buchanan *et al*. 2011, p 72).

II.D. Suckers

A recreational snag fishery for Lost River and shortnose suckers (also known as mullet) existed in the early 1900s: According to Markle and Cooperman (2001, p 98): "The first reference to sport fishing of 'mullet' seems to be a 1909 reference to sportsmen snagging 'mullet' in the Link River at Klamath Falls (*Klamath Republican*, October 14, 1909)." ODFW began regulating this fishery in 1959 and instituted a ten-fish bag limit in 1969. Recreational harvest declined from about 12,500 fish in 1966 to 687 in 1985; ODFW closed the fishery in 1987 (Markle and Cooperman 2001). Both Lost River and shortnose suckers were listed as 'endangered' under the ESA in 1988. Recreational harvest opportunities for these suckers have been nonexistent for over two decades.

III. Biological Assumptions

The economic effects of the no-action and action alternatives on the inriver recreational fishery are largely driven by the effects on fish populations. This section discusses the biological effects of the alternatives on salmon, steelhead, redband trout and suckers.

III.A. Salmon

III.A.1. SONCC Coho

The status of SONCC coho is discussed here in the context of NMFS' viability criteria and conclusions of the Biological Subgroup for the Secretarial Determination and an Expert Panel convened in December 2010 to evaluate the effects of the alternatives on steelhead and SONCC coho.

The SONCC coho ESU consists of 28 coho population units that range from the Elk and Rogue Rivers in southern Oregon to the Eel River in Northern California, including the coho populations in the Klamath Basin. NMFS' framework for assessing the biological viability of the SONCC coho ESU involves categorization of these component populations into seven diversity strata that reflect the environmental and genetic diversity across the ESU. Risk of extinction is evaluated on the basis of measurable criteria that reflect the biological viability of individual populations, the extent of hatchery influence, and the diversity and spatial structure of population units both within and across diversity strata (Williams *et al*. 2008).

The Klamath diversity stratum includes five population units, three of which (Upper Klamath, Shasta, Scott) are potentially affected by the action alternatives. According to the Biological Subgroup, "None of the population units of Klamath River coho salmon is considered viable at this point in time" (Biological Subgroup 2011, p 89) and "…all five of these Population Units have a high risk of extinction under current conditions" (Biological Subgroup 2011, p 90).

According to the Coho/Steelhead Expert Panel, adverse effects of dam removal on coho would likely be short-lived:

> "The short-term effects of the sediment release … will be injurious to upstream migrants of both species [coho and steelhead]…. However, these high sediment concentrations are

> expected to occur for periods of a few months in the first two years after the beginning of reservoir lowering and sediment flushing. For a few years after that period, suspended sediment concentrations are expected to be higher than normal, especially in high flow conditions, but not injurious to fish (Dunne *et al*. 2011, pp 18-19).

The Expert Panel noted the likely continuation of poor coho conditions under the no action alternative and a modest to moderate response of coho under the action alternatives (the moderate response being contingent on successful KBRA implementation):

> "Although Current Conditions will likely continue to be detrimental to coho, the difference between the Proposed Action and Current Conditions is expected to be small, especially in the short term (0-10 years after dam removal). Larger (moderate) responses are possible under the Proposed Action if the KBRA is fully and effectively implemented and mortality caused by the pathogen *C. shasta* is reduced. The more likely small response will result from modest increases in habitat area usable by coho with dam removal, small changes in conditions in the mainstem, positive but unquantified changes in tributary habitats where most coho spawn and rear, and the potential risk for disease and low ocean survival to offset gains in production in the new habitat. Very low present population levels and low demographic rates indicate that large improvements are needed to result in moderate responses. The high uncertainty in each of the many individual steps involved for improved survival of coho over their life cycle under the Proposed Action results in a low likelihood of moderate or larger responses….Nevertheless, colonization of the Project Reach between Keno and Iron Gate Dams by coho would likely lead to a small increase in abundance and spatial distribution of the ESU, which are key factors used by NMFS to assess viability of the ESU" (Dunne *et al*. 2011, p ii).

The Biological Subgroup also notes the benefits of the action alternatives on coho viability:

> "Reestablishing access to historically available habitat above IGD will benefit recovery of coho salmon by providing opportunities for the local population and the ESU to meet the various measures used to assess viability (e.g., abundance, productivity, diversity, and spatial structure (Williams et al., 2006). Thus there would be less risk of extinction when more habitat is available across the ESU" (Biological Subgroup 2011, p 92).

The action alternatives are expected to improve the viability of coho populations in the Klamath Basin and advance the recovery of the SONCC coho ESU. However, since the action alternatives do not include coho restoration actions outside the Klamath Basin, they alone will not bring about the conditions that would warrant de-listing of the SONCC coho ESU throughout the species range. The potential for coho harvest under the no action and action alternatives is evaluated in the context of this conclusion.

III.A.2. Klamath River Spring and Fall Chinook

Biological effects of the no action and action alternatives on Klamath River Chinook are evaluated on the basis of two models – the Evaluation of Dam Removal and Restoration of Anadromy Model (Hendrix 2011) and a habitat-based model (Lindley and Davis 2011) – and conclusions of the Biological Subgroup (Hamilton *et al*. 2011) and an Expert Panel convened in

January 2011 to evaluate the effects of the alternatives on Klamath River Chinook (Goodman *et al*. 2011).

III.A.2.a. Evaluation of Dam Removal and Restoration of Anadromy (EDRRA) Model

The Evaluation of Dam Removal and Restoration of Anadromy (EDRRA) model (Hendrix 2011) is a simulation model that provides 50-year projections of Klamath Chinook escapement, as well as separate harvest projections for the inriver recreational, ocean recreational, ocean troll and tribal fisheries under the no action alternative and dam removal alternatives (denoted as NAA and DRA respectively by Hendrix). Projections from the EDRRA model begin in 2012 (the year of the Secretarial Determination) and span the period 2012-61. The harvest projections for the DRA reflect the following assumptions: (i) active introduction of Chinook fry to the Upper Basin beginning in 2011, (ii) short-term effects on Chinook of sedimentation associated with dam removal, (iii) gains in the quantity and quality of salmonid habitat associated with dam removal and KBRA, and (iv) loss of Iron Gate as a production hatchery in 2028.
The 50-year escapement and harvest projections provided by the model were each iterated 1000 times to capture the influence of uncertainties in model inputs on model outputs. The harvest projections pertain to Klamath/Trinity River Chinook and do not distinguish between spring and fall runs. Klamath/Trinity Chinook harvest (all fisheries combined) is estimated for each simulated year on the basis of the KRFC harvest control rule recommended by the PFMC to NMFS in June 2011 as part of a pending amendment to the Pacific Salmon FMP (Figure III-1). As an added constraint, the model also caps the forecast harvest rate for age-4 KRFC in the ocean fishery at 16 percent to address the consultation standard for California Coastal Chinook (listed as ‘threatened’ in 1999 – see Appendix A).

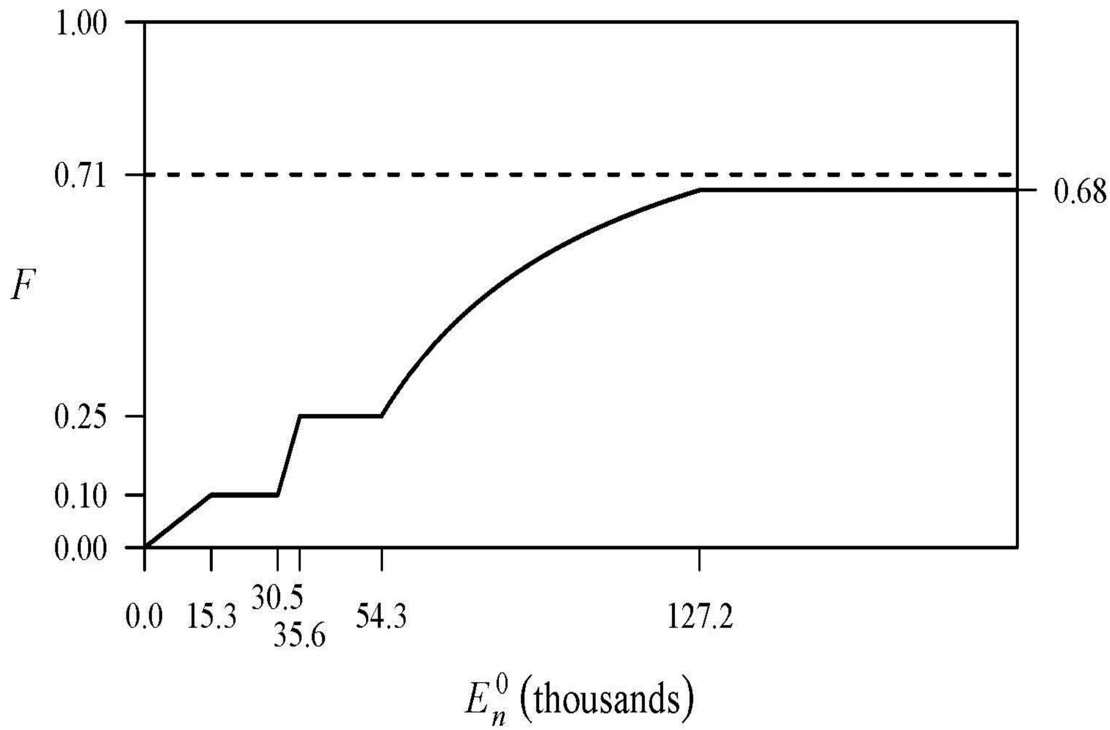

Figure III-1. Harvest control rule used in the EDRRA model (E_n^0 = annual escapement prior to ocean and inriver harvest, F = harvest rate) (graphic by Michael Mohr, NMFS).

As reflected in Mohr (in prep) and consistent with PFMC practice, the model distributes the allowable harvest among fisheries as follows: 7.5 percent to the inriver recreational fishery (up to a maximum of 25,000 fish – with any surplus above 25,000 allocated to escapement), 8.5 percent to the ocean recreational fishery, 34.0 percent to the ocean commercial fishery, and 50.0 percent to tribal fisheries. The 50 percent tribal share is a 'hard' allocation specified by the Department of the Interior (USDOI 1993) on behalf of the Yurok and Hoopa Valley Tribes. The distribution of the remaining 50.0 percent among the three non-tribal fisheries represents customary practice rather than mandatory conditions (Appendix A).

Table III-1 summarizes model results for the entire 50-year projection period (2012-61) and for the following subperiods: (i) 2012-20 (pre-dam removal, hatchery influence); (ii) 2021-32 (post-dam removal, continued hatchery influence), and (iii) 2033-61 (post-dam removal, no hatchery influence).[4]

[4] The model assumes that Iron Gate would cease to operate as a production hatchery in 2028. Hatchery influence on the fishery would continue for another 3-4 years (the length of the life cycle of the last year class released from the hatchery).

Table III-1. EDRRA model results for the inriver recreational fishery under the no action alternative (NAA) and dam removal alternative (DRA)

Model Results	*Time Period*			
	2012-61	*2012-20*	*2021-32*	*2033-61*
50th percentile harvest: % diff between NAA and DRA[1]	+8%	+0%	+8%	+11%
5th percentile harvest: % diff between NAA and DRA[1]	-56%	-88%	-47%	-50%
95th percentile harvest: % diff between NAA and DRA[1]	+1393%	+847%	+1513%	+1513%
Average # years when DRA harvest > NAA harvest: % diff between NAA and DRA[2]	60%	48%	62%	62%
Average # years when pre-harvest adult natural spawning escapement ≤ 30,500: % diff between NAA and DRA[3]	-66%	-4%	-79%	-80%

[1] Source: EDRRA model outputs provided by Hendrix (2011). Derivation provided in Appendix C.1.b.
[2] Derivation provided in Appendix C.3.
[3] Derivation provided in Appendix C.4.
2012-61: 50-year projection period
2012-20: pre-dam removal
2021-32: post-dam removal, hatchery influence
2033-61: post-dam removal, no hatchery influence

The EDRRA model assumes that ocean abundance is known without error and that the harvest control rule exactly achieves the escapement objective (Hendrix 2011). Given that the absolute harvest projections provided by the model are an idealized version of real world conditions, model results are best considered in terms of relative rather than absolute differences between alternatives. The average percent difference between EDRRA's 50th percentile harvest projections for the NAA and DRA is +8 percent for the inriver recreational fishery. The annual increase varies by subperiod, with harvest remaining unchanged prior to dam removal (2012-2020), then increasing to +8 percent during 2021-32 and +11 percent during 2033-61 (Table III-1). The relatively modest increase in harvest is largely due to the fact that the EDRRA model caps the inriver recreational harvest at 25,000 fish – with any surplus above 25,000 allocated to escapement.

EDRRA model results indicate that the 5th percentile harvest value for the DRA is 56 percent lower than the 5th percentile value for the NAA and that the 95th percentile harvest value is 1393 percent higher; that is, the DRA harvest distribution is positively skewed and exhibits a high degree of overlap with the NAA harvest distribution. The EDRRA model also provides information regarding the percent of simulated years in which DRA harvest exceeds NAA harvest (50 percent indicating no difference between the two alternatives). These paired comparisons were made possible by applying the parameter draws associated with each iteration of the simulation to both the NAA and DRA. The results in Table III-1 indicate virtually no difference between the alternatives during 2012-20 (48 percent) but higher harvests under DRA in 62 percent of years in each of the two subsequent subperiods (2021-32 and 2033-61).

The harvest control rule incorporated into the EDRRA model (Figure III-1) limits the harvest rate to 10 percent or less when pre-harvest escapements fall below 30,500 adult natural spawners. Escapements this low would likely be accompanied by major regulatory restrictions and adverse economic conditions for the fishery. Such conditions occur in 66 percent fewer years under the DRA than the NAA – with the greatest declines (-79 percent during 2021-32, -80 percent during 2033-61) occurring in the post-dam removal years (Table III-1).

III.A.2.b. Biological Subgroup

According to the Biological Subgroup, the action alternatives are expected to provide habitat favorable to spring Chinook:

> "If dams were removed it is reasonable to expect reestablished spring-run Chinook salmon to synchronize their upstream migration with more natural flows and temperatures. The removal of Project reservoirs would also contribute important coldwater tributaries (e.g., Fall Creek, Shovel Creek) and springs, such as the coldwater inflow to the J.C. Boyle Bypassed Reach, to directly enter and flow unobstructed down the mainstem Klamath River, thereby providing thermal diversity in the river in the form of intermittently spaced patches of thermal refugia. These refugia would be useful to migrating adult spring-run Chinook salmon by extending opportunities to migrate later in the season. The thermal diversity would also benefit juvenile salmon" (Hamilton *et al*. 2011, p 87).

III.A.2.c. Lindley/Davis Habitat Model

The Lindley/Davis habitat model focuses on potential Chinook escapement to the Upper Basin above Iron Gate Dam (IGD). The analytical approach involved compilation of escapement and watershed attribute data for 77 fall and spring Chinook populations in various watersheds in Washington, Oregon, Idaho and Northern California, and comparison of those attribute sets with the attributes of Upper Basin watersheds. Based on their analysis, the authors concluded that Upper Basin attributes fall well within the range of spring bearing watersheds.
According to Lindley and Davis:

> "Our model predicts a fairly modest increase in escapement of Chinook salmon to the Klamath basin if the dams are removed. The addition of several populations of spring-run Chinook salmon with greater than 800 spawners per year to the upper Klamath would significantly benefit Klamath Chinook salmon from a conservation perspective, in addition to the fishery benefits….The last status review of the UKTR [Upper Klamath and Trinity Rivers] ESU expressed significant concern about the very poor status of the spring-run component of the ESU (Myers *et al*. 1998). Viable populations of spring-run Chinook salmon in the upper Klamath would increase the diversity and improve the spatial structure of the ESU, enhancing its viability (McElhaney *et al*., 2000) and improving the sustainability of the ESU into the uncertain future" (Lindley and Davis 2011, p 13).

III.A.2.d. Chinook Expert Panel

The Chinook Expert Panel concluded that "The Proposed Action offers greater potential for increased harvest and escapement of Klamath Chinook salmon than the Current Conditions" (Goodman *et al*. 2011, p 16). More specifically, the Panel noted that

"…a substantial increase[5] in Chinook salmon is possible in the reach between Iron Gate Dam and Keno Dam. A modest or substantial increase in Chinook upstream of Keno Dam is less certain. Within the range of pertinent uncertainties, it is possible that the increase in Chinook salmon upstream of Keno Dam could be large, but the nature of the uncertainties precludes attaching a probability to the prediction by the methods and information available to the Panel. The principal uncertainties fall into four classes: the wide range of variability in salmon runs in near-pristine systems, lack of detail and specificity about KBRA, uncertainty about an institutional framework for implementing KBRA in an adaptive fashion, and outstanding ecological uncertainties in the Klamath system that appear not to have been resolved by the available studies to date" (Goodman *et al*. 2011, p 7).

With regard to spring Chinook, the Panel noted:

"The prospects for the Proposed Action to provide a substantial positive effect for spring Chinook salmon is much more remote than for fall Chinook. The present abundance of spring Chinook salmon is exceptionally low and spawning occurs in only a few tributaries in the basin. Under the Proposed Action, the low abundance and productivity (return per spawner) of spring Chinook salmon will still limit recolonization of habitats upstream of IGD. Intervention would be needed to establish populations in the new habitats, at least initially. Harvests of spring Chinook salmon could occur only if spring Chinook salmon in new and old habitats survive at higher rates than at present. Therefore, habitat quality would need to be higher than at present, and KBRA actions would need to greatly improve survival of existing populations of spring Chinook salmon. Factors specifically affecting the survival of spring Chinook salmon have not been quantified" (Goodman *et al*. 2011, p 25).

III.B. Steelhead

Biological effects of the alternatives on Klamath River steelhead are evaluated on the basis of results of an Expert Panel convened in December 2010 to evaluate the effects of the alternatives on steelhead and coho (Dunne *et al*. 2011) and conclusions of the Biological Subgroup (Hamilton *et al*. 2011) regarding steelhead.

III.B.1. Coho/Steelhead Expert Panel

The Coho/Steelhead Expert Panel did not expect current conditions to be conducive to expansion of the steelhead fishery:

"Current Conditions will not, in the short to medium term, result in an expansion of the fishery. Projecting harvest under the Current Conditions depends on the fate of the

[5] The Panel defined the term 'substantial increase' to mean 'a number of fish that contributes more than a trivial amount to the population' and cited 10 percent of the average number of natural spawners or 10,000 fish as a rough approximation to what they mean by 'substantial'. As indicated in their report, "The Panel does not suggest that this figure is a likely increase or a minimum increase that is expected. It is only used as a benchmark for our discussions and to provide a basis for interpreting our response to the question" (Goodman *et al*. 2011, p 7, footnote 3).

hatcheries and specifics of harvest policies into the future, which are insufficiently defined at this time" (Dunne *et al*. 2011, p 58).

Dam removal activities are expected to be injurious to steelhead but these effects are expected to be short-term.

> "The short-term effects of the sediment release will be sediment concentrations in the range of 1,000 to more than 10,000 milligrams per liter (mg/L), which will be injurious to upstream migrants of both species, and especially to any adult steelhead or 'half pounders' that hold or spawn in the mainstem. However, these high sediment concentrations are expected to occur for periods of a few months in the first two years after the beginning of reservoir lowering and sediment flushing. For a few years after that period, suspended sediment concentrations are expected to be higher than normal, especially in high flow conditions, but not injurious to fish" (Dunne *et al*. 2011, pp 18-19).

The Panel anticipates a long-term increase in abundance and distribution of steelhead under the action alternatives, provided certain conditions are met.

> "If the Proposed Action is implemented effectively, and the other related actions occur [e.g., Total Maximum Daily Load (TMDL)], then the response of steelhead may be broader spatial distribution and increased numbers of individuals within the Klamath system. This assessment is based on the likelihood of steelhead being given access to substantial new habitat, steelhead being more tolerant than coho to warmer water, the fact that other similar species (resident redband/rainbow trout) are doing well in the upstream habitat, and that steelhead are currently at lower abundances than historical values but not yet rare" (Dunne *et al*. 2011, p ii-iii).

The Panel notes, however, that long-term positive effects are subject to a number of uncertainties:

> "The Panel identified six principal obstacles to drawing convincing conclusions between the two alternatives: (1) insufficient specificity of the KBRA; uncertainties about (2) fish passage through Keno Reservoir and Upper Klamath Lake, (3) hatchery effects, (4) disease, and (5) water demand responses to KBRA; and (6) limited understanding about coho and steelhead abundances, migration patterns, and factors affecting survival at each life stage" (Dunne *et al.* 2011, p iii).

III.B.2. Biological Subgroup

The Biological Subgroup concluded that the action alternatives would lead to expansion of the steelhead fishery above the current dam sites.

> "…it is likely that access under the without dams and with the KBRA management scenario would create a sport fishery for anadromous species, in particular steelhead, above IGD [Iron Gate Dam]" (Hamilton *et al*. 2011, p 68).

The Subgroup expects the action alternatives to be more beneficial to steelhead than to other anadromous species due to steelhead's habitat adaptability and disease resistance.

"Because of their ability to navigate steeper gradient channels and spawn in smaller and intermittent streams (Platts and Partridge 1978), steelhead would realize the extent of anadromous habitat gain to a greater degree than other species" (Hamilton *et al*. 2011, p 51).

"For steelhead, habitat above IGD [Iron Gate Dam] has the potential to increase returns by 6,800 to 20,000 spawners (Table 1). Disease problems in the Klamath River are far less likely to interfere with steelhead returns than with salmon returns, as Klamath steelhead trout are resistant to *C. Shasta* (Administrative Law Judge 2006)" (Hamilton *et al*. 2011, p 112).

III.C. Redband Trout

The recreational fishery for redband trout currently occurs in two locations: (i) above Keno Dam in Upper Klamath Lake and the lower Williamson and Wood Rivers, and (ii) below Keno Dam in the Keno Reach of the Klamath River.
The Resident Fish Expert Panel was convened in August 2010 to evaluate the effects of the no-action and action alternatives on resident fish, including redband/rainbow trout and sucker species. The Panel expected redband trout populations to be stable under the no action alternative:

Above Keno Dam: "Under the Current Conditions with Dams, distribution and abundance of Lake/River redband/rainbow trout is expected to remain stable…." (Buchanan *et al*. 2011, p 72).

Below Keno Dam: "Under current conditions the population of redband/rainbow trout, and therefore the harvest level, in the area immediately downstream of Keno Dam (in the free-flowing 5.9 mi or 9.5 km) is influenced by adverse water quality but the population appears to be stable…." (Buchanan *et al*. 2011, p 73).

The Resident Fish Expert Panel predicted marked improvement in the redband trout fishery under the action alternative both above and below Keno Dam:

Above Keno Dam: "The distribution and abundance of resident adfluvial trout in Upper Klamath Lake, and the lower Williamson and Wood rivers, three very important areas for harvest, are also expected to expand….Under successful implementation of KBRA measures, the large size of resident trout within these areas is expected to remain stable" (Buchanan *et al*. 2011, p 73).

Below Keno Dam: "While there would be short-term adverse impacts from dam removal …, the Proposed Action would likely create significant increases in the size, abundance, and distribution of resident trout in the 43 mi (69.2 km) of the Klamath River between J.C. Boyle Reservoir and Iron Gate Dam" (ibid, p 73). The Panel further noted that, "It is expected that eventually the entire reach downstream of Keno Dam would be capable of supporting a resident redband/rainbow trout fishery after the removal of the four dams. It is possible that the trophy fishery will expand seven times from below Keno Dam to the Iron Gate reach" (Buchanan *et al*. 2011, p 74).

III.D. Suckers

The Resident Fish Expert Panel expressed serious concerns about the status of Lost River suckers (LRS) and shortnose suckers (SNS) – both listed as 'endangered' in 1988: "Available data show that both LRS and SNS are declining under current conditions and that they could become extinct in the near future unless a major recruitment event occurs soon" (Buchanan *et al*. 2011, p 76). Given these circumstances, harvest opportunities are precluded: "With declining populations under the current conditions, there are no opportunities for tribal or recreational harvest" (Buchanan et *al*. 2011, p 71).

The Panel notes that dam removal may negatively impact resident species below Iron Gate Dam but that this effect will likely be short-lived:

> "Immediately after dam removal, high suspended sediments may adversely affect resident species located below and near Iron Gate Dam, but the resident fish abundances are likely to quickly recover and increase as the resident fish population moves into the dam removal reach" (Buchanan *et al*. 2011, p 70).

The Panel anticipates the possibility of future harvest under the action alternatives, but cautions that such harvest should not occur until a long-term positive trajectory has been established for the sucker populations.

> "Under KBRA, populations are likely to increase beginning about 2022 based on increased survival of larval and juvenile suckers and recruitment of new adult year classes….However, until population monitoring indicates an upward trend in the population over at least a decade with major recruitment events and multiple age classes, harvest would reduce or negate population growth. Since suckers have high reproductive potential, population numbers can increase rapidly if favorable conditions are reestablished. For instance, from the late 1980s until the mid 1990s LRS and SNS populations increased from a few thousand to upwards of 100,000. However, if unfavorable conditions return, then numbers can crash to unsustainable levels as demonstrated in the 2002-2007 period. Therefore, these short-term rapid increases should not be used as a basis for establishing harvest of these species. Harvest other than ceremonial tribal harvest should only occur after a sustained population growth can be shown over a period of decades" (Buchanan *et al*. 2011, pp 71-72).

IV. Inriver Recreational Fishing Economic Value for Benefit-Cost Analysis (NED Account)

This section describes the economic effects of the no action and action alternatives on the inriver recreational fisheries for salmon, steelhead, redband trout and suckers.

IV.A. Methodology and Assumptions
IV.A.1. Salmon
IV.A.1.a. SONCC Coho

As indicated in Section III.A.1, the SONCC coho ESU is listed as 'threatened' under the ESA. This ESU includes coho populations both inside and outside the Klamath Basin. The action alternatives are expected to increase the viability of Klamath River coho populations and advance recovery of the ESU (Hamilton *et al.* 2011, Dunne *et al*. 2011). However, since the action alternatives do not include coho restoration outside the Klamath Basin, they alone will not create conditions that would warrant de-listing of the SONCC coho ESU throughout its range. Thus, while they are expected to provide long term, positive biological effects, the action alternatives are not likely to affect the availability of coho to the inriver recreational fishery.

IV.A.1.b. Klamath River Spring and Fall Chinook

The EDRRA model (Hendrix 2011) is the basis for the quantitative projections of harvest, effort and economic value used to compare the no action and action alternatives. These variables were estimated as follows:[6]

(i) As indicated in Section III.A.2.a, the absolute harvest projections provided by the EDRRA model reflect idealized rather than real world conditions. Thus model results are best considered in terms of relative rather than absolute differences between alternatives. To anchor EDRRA projections to the real world, average annual inriver recreational harvest of adult Klamath Chinook during 2001-05 (6,241 fish; data source: CDFG 2011) was used to characterize the no action alternative. Annual harvest under the DRA (6,720 fish) was estimated by scaling average 2001-05 harvest upward, based on the difference between EDRRA's 50th percentile harvest projections for the NAA and DRA (+8 percent, according toTable III-1). The years 2001-05 were selected as the base period for the following reasons: KRFC fell within a moderate range of abundance during those years (Figure A-3) and fishery regulations that reflect the influence of the 50-50 tribal/non-tribal harvest allocation and the listing of SONCC coho were well established by that time. Record low fishery conditions experienced after 2005 made those years unsuited for base period characterization.

(ii) Inriver recreational harvest was converted to angler days by multiplying the harvest projected for each alternative by a conversion factor (3.955) – calculated as the ratio of angler days to adult Chinook harvest on the basis of 2001-04 data.

(iii) Total NEV was estimated by multiplying the number of angler days associated with each alternative by an estimate of NEV per angler day ($66.74) – which was derived from salmon valuation estimates from the economics literature, converted to angler day equivalents (as needed), adjusted for inflation to 2012 dollars, and averaged across studies.[7]

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[6] See Appendix C for more details regarding the methods and assumptions underlying the harvest, effort and net economic value projections for each alternative.

[7] See Table D-1.

Harvest projections provided by the EDRRA model do not differentiate between spring and fall Chinook. However, actual harvest opportunities may differ somewhat by fishery – depending on the extent to which the harvestable surplus includes spring Chinook. The Biological Subgroup indicates that the action alternatives will result in expansion and restoration of habitat beneficial to spring Chinook. The Lindley/Davis model anticipates positive conservation benefits in terms of returning spring Chinook to Upper Basin watersheds and enhancing the viability of the Klamath/Trinity Chinook ESU, as well as modest fishery benefits. The Chinook Expert Panel indicates that a 'substantial increase' in Chinook between IGD and Keno Dam is possible but is more cautious regarding the possibility of successful Chinook introduction above Keno Dam and benefits to spring Chinook. The Biological Subgroup, Lindley/Davis and Expert Panel results (Section III.a.2.b-d) are used here to qualify and expand on the EDRRA results by considering what the availability of modest amounts of spring Chinook in the harvestable surplus might mean for the inriver recreational fishery.

IV.A.2. Steelhead

For the recreational steelhead fishery, analysis of the no action alternative is based on current fishery conditions, as little change in the status of steelhead is anticipated under that alternative. The economic value of the steelhead fishery under the no action alternative was estimated by applying an estimate of NEV per angler day to the average annual number of angler days during 2003-08 on the mainstem Klamath River and its tributaries (except the Trinity). The Trinity River was excluded from this analysis, as steelhead fishing on the Trinity is not expected to differ between the no action and action alternatives. The estimate of NEV per angler day used for this analysis is $83.15, based on steelhead valuation estimates from the economics literature – converted to angler day equivalents (as needed), adjusted for inflation to 2012 dollars, and averaged across studies. [8]

Evaluation of the action alternative is largely qualitative, with conclusions largely based on information provided by the Biological Subgroup and the Coho/Steelhead Expert Panel (Section III.B).

IV.A.3. Redband Trout

The recreational fishery for redband trout is concentrated in two locations: (i) above Keno Dam in Upper Klamath Lake and the lower Williamson and Wood Rivers, and (ii) below Keno Dam in the Keno Reach of the Klamath River. Effects of the no action and action alternatives are considered separately for these two areas, based on conclusions of the Resident Fish Expert Panel.

Analysis of the no action alternative is based on current fishery conditions, as the Resident Fish Expert Panel expected little change in the status of redband trout under that alternative. Information on current fishery conditions includes creel survey results for the Upper Klamath Lake fishery and qualitative information regarding the fishery elsewhere. Effects of the action alternatives are described in qualitative terms (Section III.C).

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[8] See Table D-2.

IV.A.4. Suckers

A recreational snag fishery for Lost River and shortnose suckers existed in the early 1900s. The fishery peaked in the 1960s, but had declined precipitously by the 1980s. Oregon Department of Fish and Wildlife (ODFW) closed the fishery in 1987 (Markle and Cooperman 2001). Both Lost River and shortnose suckers were listed as 'endangered' under the ESA in 1988, and recreational harvest opportunities have been nonexistent for over two decades. The Resident Fish Expert Panel included suckers in their evaluation. The qualitative analysis provided here reflects the Panel's views on the prospects of recreational sucker harvest under the no action and action alternatives (Section III.D).

IV.B. Alternative 1 – No Action Alternative

IV.B.1. Salmon

IV.B.1.a. Coho Fishery

Coho retention is prohibited in the Klamath River recreational fishery to address the consultation standard for SONCC coho. This prohibition is expected to continue into the future under Alternative 1.

IV.B.1.b. Chinook Fishery

Under Alternative 1, annual Klamath Chinook harvest is 6,241 fish and annual fishing effort is 24,683 angler days, with an associated NEV of $1.647 million (based on the methodology described in Section IV.A.1.b). Inriver recreational harvest of Klamath Chinook consists almost exclusively of fall run fish. This stock composition is likely to persist into the future under Alternative 1.

IV.B.2. Steelhead

The Coho/Steelhead Expert Panel did not consider a change in the status of steelhead to be likely under the no action alternative (Dunne *et al*. 2011). Thus, Alternative 1 is characterized here in terms of existing conditions. Annual fishing activity under existing conditions is approximately 17,155 angler days with an estimated net economic value of $1.426 million (based on the methodology described in Section IV.A.2).

An important component of the Klamath River steelhead fishery is the half-pounder fishery. The estimates of angler days and net economic value provided here do not include the half-pounder fishery and thus underestimate steelhead fishing activity and value under Alternative 1.

IV.B.3. Redband Trout

The Resident Fish Expert Panel expected the distribution and abundance of redband/rainbow trout to remain stable under the no action alternative (Buchanan *et al*. 2011). Thus current fishery conditions provide a reasonable representation of fishing activity under the no action alternative.

The redband trout fishery is a renowned trophy fishery. Results of a statistical creel conducted by ODFW indicate that 15,191 angler days occurred on Upper Klamath Lake and Agency Lake in 2009. This is a conservative estimate of redband effort, as the extent of redband fishing on the tributaries (lower Williamson and Wood Rivers) and below Keno Dam is unknown. Little change in the status of redband trout is expected under Alternative 1.

IV.B.4. Suckers

The recreational sucker fishery has been closed since 1987 and the prospects of a future fishery are unlikely under the no action alternative. As noted by the Resident Fish Expert Panel, "With declining populations under the current conditions, there are no opportunities for tribal or recreational harvest" (Buchanan *et al*. 2011, p 71).

IV.C. Alternative 2 – Full Facilities Removal of Four Dams
IV.C.1. Salmon
IV.C.1.a. Coho Fishery

Alternative 2 is expected to improve the viability of coho populations in the Klamath stratum of the SONCC coho ESU, but is unlikely to lead to de-listing, since the ESU also includes stocks outside the Klamath Basin whose viability is not affected by this action (Section III.A.1). Thus the prohibition on coho retention in California's inriver recreational fishery will likely continue under this alternative.

IV.C.1.b. Chinook Fishery
IV.C.1.b.i. Effects on Average Annual Harvest, Effort and Net Economic Value

Under Alternative 2, annual adult Klamath Chinook harvest is 6,720 fish and annual fishing effort is 26,578 angler days, with an associated NEV of $1.774 million (based on the methodology described in Section IV.A.1.b). Annual NEV is $126.4 thousand higher under Alternative 2 than Alternative 1.

To the extent that spring Chinook production become sufficient to support some modest level of harvest, much of that harvest will accrue to inriver fisheries (recreational and tribal), as spring Chinook will have largely returned to the river by the season opening of the ocean troll and recreational fisheries. Spring Chinook are expected to yield economic benefits to the inriver recreational fishery, as spring Chinook are highly desirable for their fat content and have the potential to temporally expand recreational harvest opportunities beyond the current fall Chinook season.

IV.C.1.b.ii. Discounted Present Value of Change in Net Economic Value

Figure IV-1 depicts the annual trajectory of NEV for Alternatives 1 and 2 during 2012-61. These annual values were derived by multiplying average annual NEV associated with each alternative ($1.647 million and $1.774 million respectively) by an annual adjustment factor that reflects the variation in annual adult Klamath Chinook harvest relative to mean 2012-61 harvest – as projected by the EDRRA model (Appendix B.2).

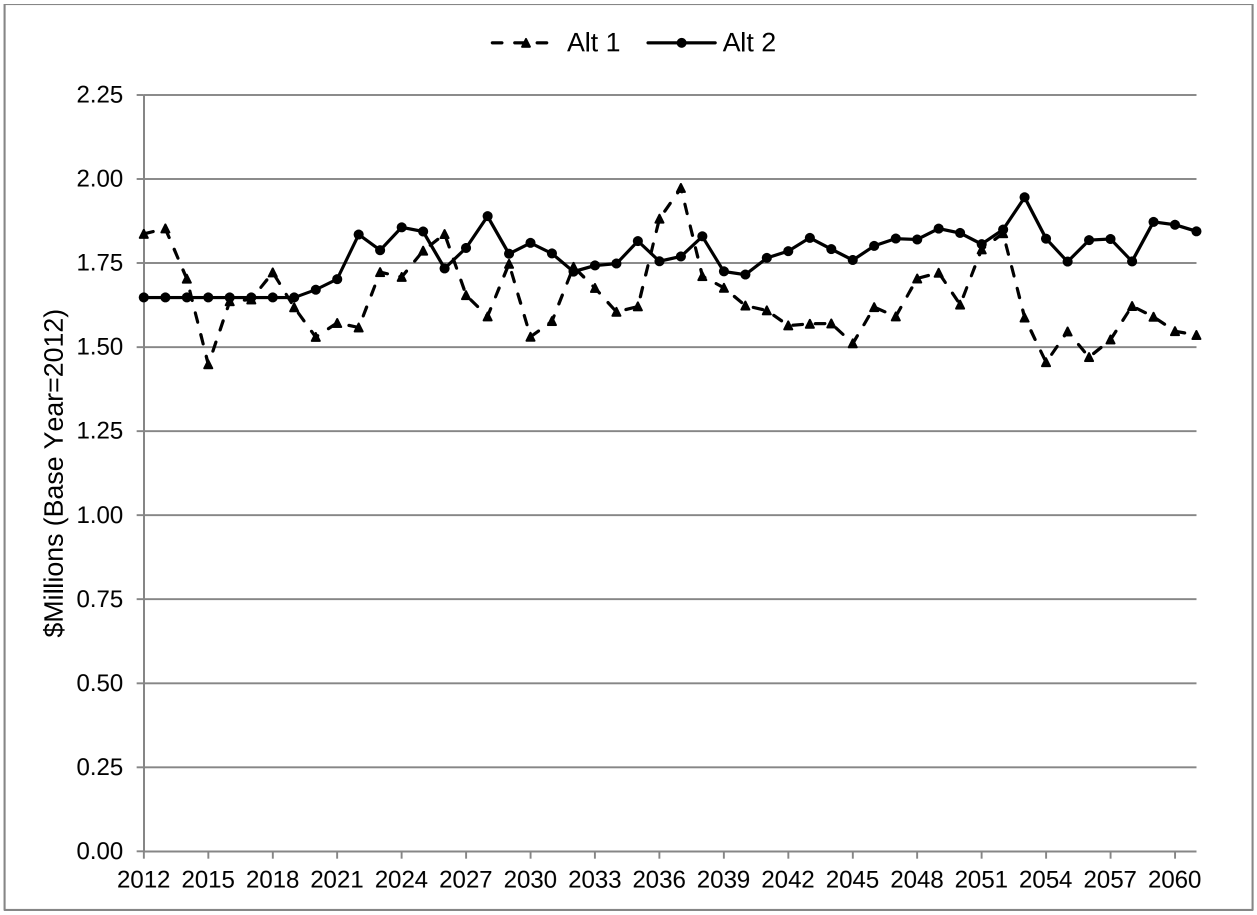

Figure IV-1. Projected annual net economic value under Alternatives 1 and 2, 2012-61 (calculated according to the methodology described in Appendix B-2).

Results of the NED analysis provided here are also included in two summary reports (Reclamation 2011a, 2011b) that describe all quantifiable economic benefits and costs in terms of discounted present value (DPV). Discounting is based on the premise that benefits that occur more immediately are preferred to benefits that occur farther into the future. Discounting has the effect of attaching progressively smaller weights to changes in NEV that occur later in the time series, with diminution of these weights becoming more rapid at higher discount rates. The discount rate used in the NED analysis is 4.125 percent, the rate currently prescribed for Federal water resources planning (Reclamation 2010).

DPV for the inriver recreational fishery was calculated by applying a discount factor to each of the annual NEV estimates provided in Figure IV-1, then summing the results (Appendix C-2). Table IV-1 provides estimates of DPV associated with the prescribed 4.125 percent rate and several rates lower and higher than 4.125 percent (including 0.000 percent – no discounting). DPV associated with the 4.125 percent discount rate is $1.755 million, which is 28 percent of the undiscounted present value (discount rate of 0.000 percent) and almost three times the value of DPV associated with the 8.000 percent discount rate.

Table IV-1. Discounted present value of the increase in net economic value under Alternative 2 relative to Alternative 1 (2012$), calculated on the basis of alternative discount rates.

Discount Rate	*Discounted Present Value (2012$)*
0.000%	6.328 million
2.000%	3.303 million
4.125%	1.755 million
6.000%	1.041 million
8.000%	0.606 million

Calculations based on methodology described in Appendix B.2.

Figure IV-2 depicts the stream of the annual discounted increases in NEV that were summed to derive the DPV estimate associated with each of the discount rates in Table IV-1. As indicated in the figure, changes in NEV are relatively insensitive to the choice of discount rate in the first decade of the time series but can diverge rather widely in subsequent decades. The differences in the DPV estimates shown in Table IV-1 are influenced by the fact that changes in NEV under Alternative 2 do not increase appreciably until after dam removal, which does not occur until close to the end of the first decade of the projection period 2012-61.

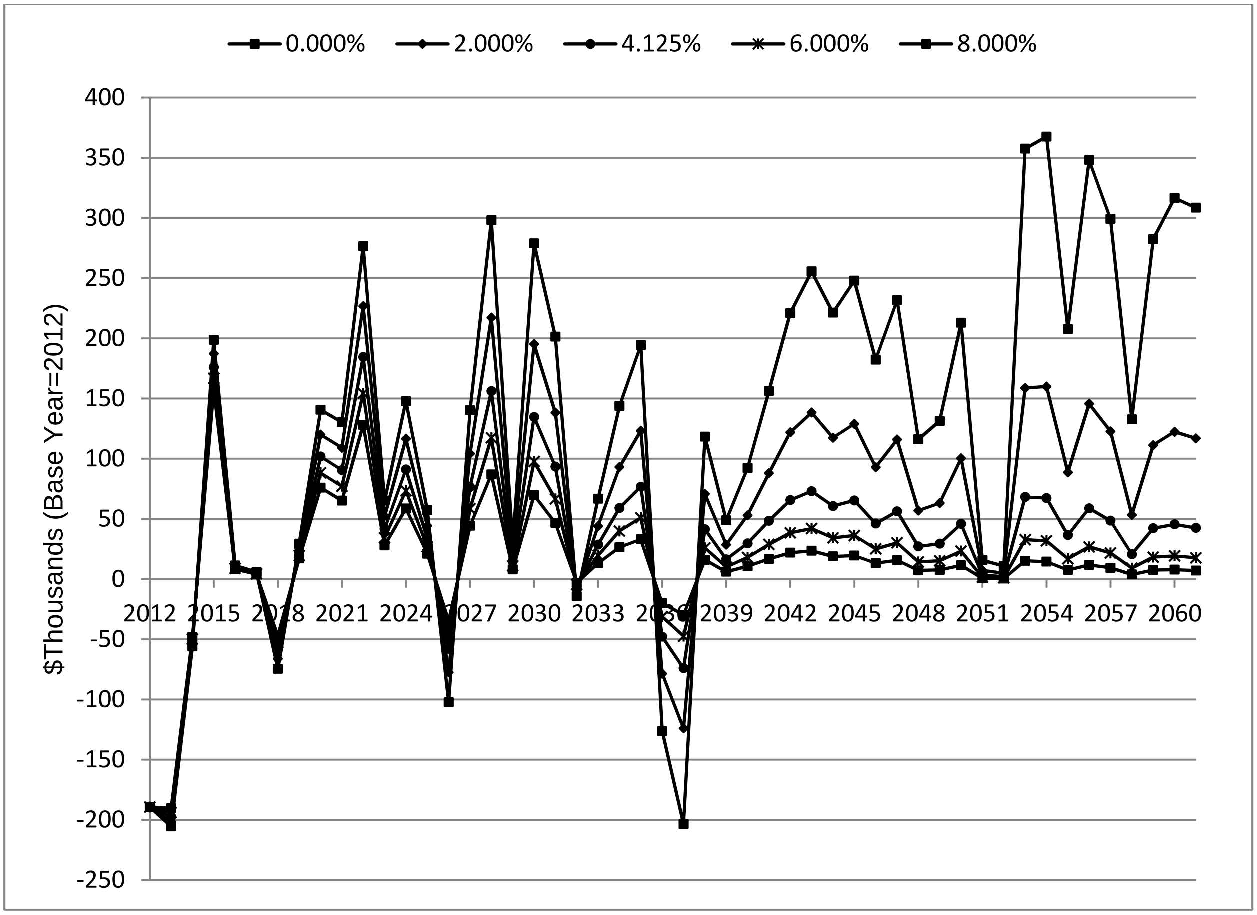

Figure IV-2. Annual discounted value of the increase in net economic value under Alternative 2 relative to Alternative 1 (2012 dollars) during 2012-61, calculated using alternative discount rates of0.000% (no discounting), 2.000%, 4.125%, 6.000%, and 8.000%.

IV.C.1.b.iii. Effects at Low Levels of Abundance

Economic effects pertain not only to how harvest opportunity is affected on an average basis but also under more unusual conditions. As indicated in Figure III-1, the KRFC harvest control rule adopted by the PFMC in June 2011 limits the harvest rate to 10 percent or less when pre-harvest escapements fall below 30,500 adult natural spawners. Escapements this low would be accompanied by adverse economic conditions that are reminiscent of the situation in 2006, when inriver recreational fishing effort fell to 51 percent of average effort during 2001-05. Results of the EDRRA model indicate that pre-harvest escapements below 30,500 would occur in 66 percent fewer years under Alternative 2 than Alternative 1, with the greatest decline (-79 percent) occurring in the post-dam removal years (Table III-1). While the quantitative economic results provided in Sections IV.C.1.b.i. and IV.C.1.b.ii pertain to how the action alternatives would affect fishery conditions under moderate levels of abundance, it is important to note that Alternative 2 will also reduce the incidence of low abundances and associated adverse effects on the inriver recreational fishery.

IV.C.2. Steelhead

According to the Coho/Steelhead Expert Panel, the adverse effects of dam removal activities on steelhead would likely be short term. Over the longer term, the Panel concludes that Alternative 2 is expected to lead to increases in the abundance and spatial distribution of steelhead, including successful colonization of the Upper Basin (Dunne *et al*. 2011) – assuming effective implementation of the KBRA and successful fish passage through Keno Reservoir and Upper Klamath Lake. The Biological Subgroup (Hamilton *et al*. 2011) notes the the opportunity for Upper Basin colonization under Alternative 2 would be more beneficial to steelhead than to other anadromous species, due to steelhead's habitat adaptability and disease resistance (Section III.B.2). The expansion of the steelhead fishery under Alternative 2 would be accompanied by an increase in the economic value of the fishery; however, due to data limitations, the extent of this increase cannot be quantified.

IV.C.3. Redband Trout

The Resident Fish Expert Panel predicts marked improvement in the redband trout fishery under Alternative 2 (Section III.C). With regard to the fishery above Keno Dam, the Panel predicts an expansion in the distribution and abundance of large-sized trout in Upper Klamath River and the lower Williamson and Wood Rivers. With regard to the fishery below Keno, the Panel concludes that short-term adverse impacts from dam removal would be outweighed by increases in the size and abundance of resident trout in the 43 miles between J.C. Boyle Reservoir and Iron Gate Dam and a potential seven-fold increase in the fishery (Buchanan *et al*. 2011).

The seven-fold expansion cited by the Panel is relative to current conditions, which is difficult to quantify due to lack of data on fishing effort below Keno. Nevertheless, even without quantitative estimates, such an increase would likely represent a major change from current conditions and a considerable increase in the value of the fishery.

IV.C.4. Suckers

The prospects for restoration of the recreational sucker fishery appear quite limited under Alternative 2 (Section III.D). As noted by the Resident Fish Expert Panel, "Under KBRA, populations are likely to increase beginning about 2022 based on increasing survival of larval and juvenile suckers and recruitment of new adult year classes. However, until population monitoring indicates an upward trend in the population over at least a decade with major recruitment events and multiple age classes, harvest would reduce or negate population growth. … Harvest other than ceremonial tribal harvest should only occur after a sustained population growth can be shown over a period of decades" (Buchanan *et al*. 2011, pp 71-72).

IV.D. Alternative 3 – Partial Facilities Removal of Four Dams

IV.D.1. Salmon

Alternative 3 provides the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. The effects of this alternative on salmon populations and salmon fisheries – including the in-river recreational fishery – are expected to be the same as Alternative 2.

IV.D.2. Steelhead

Alternative 3 provides the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. The effects of this alternative on steelhead populations and the recreational steelhead fishery are expected to be the same as Alternative

IV.D.3. Redband Trout

Alternative 3 provides the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. The effects of this alternative on redband trout and the recreational redband fishery are expected to be the same as Alternative 2.

IV.D.4. Suckers

Alternative 3 provides the same KBRA benefits as Alternative 2 and thus expected to provide the same benefits to sucker populations. The recreational sucker fishery is unlikely to reopen under all alternatives.

V. Inriver Recreational Fishing Expenditures for Regional Economic Impact Analysis (RED Account)

V.A. Methodology and Assumptions

Regional economic impacts pertain to effects of the no action and action alternatives on employment, labor income and output in the regional economy. These impacts include: direct effects on the economy as recreational anglers make expenditures on guide fees, boat fuel (for private boats), gasoline, bait and tackle, food, lodging, and the like; indirect effects as payments by fishery support businesses to their vendors generate additional economic activity; and induced effects associated with changes in household spending by workers in all affected businesses. Estimation of this so-called multiplier effect is based on assumptions such as constant returns to scale, no input substitution, no supply constraints, and no price or wage adjustments. Thus regional impacts as estimated here are more suggestive of the economy's short-term response rather than long-term adjustment to infusions of money into the economy.

Regional impacts were estimated using Impact Analysis for Planning (IMPLAN) software and data and are based on the makeup of the economy at the time of the underlying IMPLAN data (2009). The applicability of the impacts thus estimated to any particular year of the 50 year study period is affected by the extent to which the underlying economy in that year deviates from the economy in 2009. The employment impacts include full time, part time, and temporary positions. These impacts may not be fully realized to the extent that businesses deal with changes in demand by adjusting the workload of existing employees or increasing their use of capital relative to labor rather than hiring new employees.

The regional economic analysis provided here is based on average annual angler expenditures projected for the no action and action alternatives. A basic assumption underlying this regional impact analysis is that increases in expenditures by resident anglers associated with expanded fishing opportunities would be accommodated by reducing expenditures on other locally purchased goods and services – with no net change in local economic activity. For non-resident anglers, however, increases in local expenditures associated with increases in local fishing opportunities would be accomplished by diverting money that they would otherwise spend outside the local area. Thus the economic impact analysis focuses on non-resident angler expenditures, which represent 'new money' whose injection serves to stimulate the local economy. More detailed documentation of the methods used to estimate regional impacts is provided in Reclamation (2011a).

The area of analysis used in the regional economic impact analysis for inriver recreational fisheries includes Del Norte, Humboldt and Siskiyou counties in California and Klamath County in Oregon. The three California counties cover the current location of the inriver salmon and steelhead fisheries; the Oregon county (Klamath) covers the area above the dams where salmon and steelhead could potentially recolonize under the action alternatives. The redband trout fishery occurs in two of these counties – Siskiyou and Klamath. However, lack of redband effort estimates for the tributaries above Upper Klamath Lake and for the fishery below Keno Dam preclude quantitative consideration of the regional economic impacts of this fishery. Those impacts are instead discussed qualitatively. The recreational sucker fishery is not considered in the regional analysis, as that fishery closed in 1987 and is unlikely to re-open under the no action and action alternatives.

IV.A.1. Salmon

Expenditures in Del Norte, Humboldt and Siskiyou counties by anglers residing outside those counties provide the basis for the multiplier effects. Non-resident expenditures were estimated by multiplying the annual number of angler days attributable to non-residents by average non-resident expenditures per angler day. These variables were derived as follows for the no action and action alternatives:

- Annual number of salmon angler days by nonresident anglers: The estimates of annual angler days used here for the no action and action alternatives are identical to and were derived in the same manner as the estimates used in the NED analysis (24,683 and 26,578 angler days respectively – Section V.A.1). The proportion of angler days attributable to nonresident anglers (which was not relevant to the NED analysis) was calculated on the basis of location-of-residence data collected in the CDFG creel survey. Location of residence is reported in the creel survey as the first three digits of the angler's zip code of residence. Each three-digit location corresponds to a Sectional Center Facility (SCF) of the U.S. Postal Service – a processing and distribution center that serves zip code destinations beginning with those three digits. For purposes of this analysis, anglers residing in SCF 955 and 960 are defined as resident anglers. Because these two areas (Figure V-1) extend beyond the four-county regional economic impact area (Del Norte, Humboldt, Siskiyou and Klamath counties), the analysis provided here likely understates expenditures by nonresident anglers and their contribution to the regional economy.

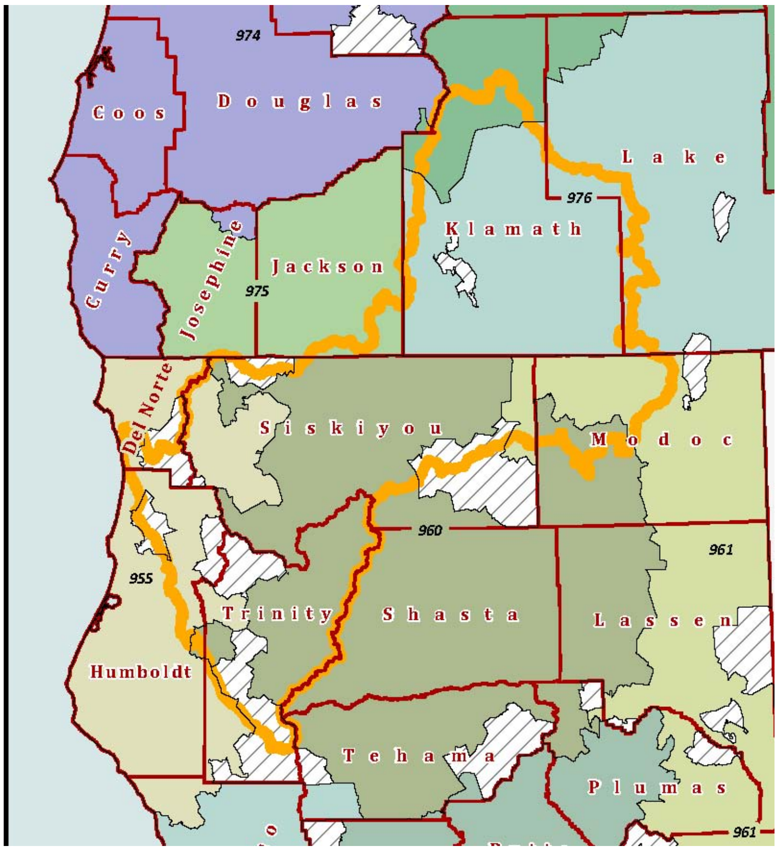

Figure V-1. Sectional Center Facilities (color coded) and counties (outlined in red) in the vicinity of the Klamath Basin (outlined in yellow) – illustrating counties included in SCF 955 and SCF 960. Crosshatched areas are areas for which there is no zipcode coverage (graphic by Aaron Cole).

Table V-1 describes the proportion of angler days attributable to non-resident anglers (i.e., anglers living outside SCF 955 and 960) during 2001-05. This proportion tends to be quite stable within a given area over time and also to decline the further upriver the activity occurs. The number of angler days made by non-resident anglers under the no action and action alternatives was estimated by multiplying total effort projected for each alternative (24,683 and 26,578 angler days respectively) by 0.641 (the 2001-05 average non-resident proportion for all areas provided in Table V-1).

Table V-1. Estimated proportion of Klamath River salmon angler days accounted for by non-resident anglers, 2001-05.

Year	*Area 1*	*Area 2*	*Area 3*[1]	*Weighted Average All Areas*[2]
2001	0.745	0.649	0.482	0.641
2002	0.724	0.659	0.471	0.634
2003	0.751	0.638	0.483	0.632
2004	0.823	0.672	0.483	0.673
2005	0.763	0.620	0.483	0.625
2001-05Avg	0.761	0.648	0.480	**0.641**

Area 1= river mouth to Highway 101 bridge at Klamath
Area 2 = Highway 101 bridge to Highway 96 bridge at Weitchpec
Area 3 = Highway 96 bridge to Iron Gate Dam
[1] Sampling ceased in Area 3 after 2002; 2003-05 estimates represented by 1999-02 average.
[2] Estimated by weighting the Area 1-3 proportions by the number of angler days estimated to occur in each area.
Data source: Sara Borok (CDFG).

- Nonresident expenditures per angler day: Average expenditures per angler day (for lodging, food, gasoline for transportation to/from the fishing site, fishing gear, boat fuel, guide fees) by nonresident salmon anglers were estimated at $105.02 (2012 dollars). This estimate is based on data from a 2004 economic survey of in-river salmon and steelhead anglers sponsored by NMFS. In cases where a fishing trip involved multiple days and/or multiple anglers, expenditures per angler day were estimated by dividing total trip expenditures by the number of angler day equivalents associated with that trip. Costs in all expenditure categories were adjusted for inflation to 2012 dollars.

  To estimate the gasoline component of expenditures, the round-trip travel distance between each respondent's zipcode of residence and fishing site was estimated using PC Miler (specialized transportation software), then converted to distance per angler day by dividing by the number of angler days associated with the trip. Gasoline cost per angler day was estimated by multiplying miles traveled per angler day by fuel cost per mile, which was derived as follows: Estimates of fuel cost per mile during 2006-10 were obtained from the American Automobile Association (AAA 2006, 2007, 2008, 2009, 2010). To reflect the differential between gasoline prices in the proximity of the Klamath Basin and prices assumed by the AAA in its estimates, the per-gallon price of fuel in Humboldt county during 2006-10 (pers. comm. Erick Eschker, Humboldt Economic Index) was divided by AAA's assumed price for the same year, and the resulting ratio was multiplied by AAA's fuel cost per mile. These adjusted estimates of fuel cost per mile (reflecting the regional differential in fuel prices) were then corrected for inflation and averaged over the years 2006-10 – yielding a mean value of $0.147 per mile (2012 dollars).[9]

[9] Gasoline prices are subject to considerable uncertainty over the 50-projection period. Changes in gasoline prices can have a notable influence on angler expenditures associated with travel to the

V.A.2. Steelhead

Economic impacts of the no action alternative on the inriver steelhead fishery were analyzed on the basis of current fishery conditions, as little change in the status of steelhead is anticipated under that alternative. Estimation of regional impacts for the action alternatives was not possible; instead those effects are expressed in qualitative terms.

For the no action alternative, angler expenditures needed for the IMPLAN model were estimated by multiplying the average annual number of angler days attributable to non-resident anglers during 2003-08 by average non-resident expenditures per angler day. These two variables were derived as follows:

- Aggregate annual number of steelhead angler days by non-resident anglers: Annual steelhead fishing effort under the no action alternative was estimated from CDFG steelhead report card data, and is identical to and derived in the same manner as the effort estimate used in the NED analysis (17,155 angler days – Section IV.B.2). The proportion of annual effort attributable to non-resident anglers (which was not relevant to the NED analysis) was estimated on the basis of county-of-residence data obtained from 2003-08 steelhead report cards. About 65 percent of total effort or 11,103 angler days is attributable to non-resident anglers.

- Non-resident expenditures per angler day: Average expenditures per angler day (for lodging, food, gasoline for transportation to/from the fishing site, fishing gear, boat fuel, guide fees) by non-resident steelhead anglers were estimated at $105.98 (2012 dollars). This estimate is based on data from a 2004 economic survey of inriver salmon and steelhead anglers sponsored by NMFS. In cases where a fishing trip involved multiple days and/or multiple anglers, expenditures per angler day were estimated by dividing total trip expenditures by the number of angler day equivalents associated with that trip; costs in all expenditure categories were adjusted for inflation to 2012 dollars. Gasoline cost per mile used in this analysis ($0.147 per mile, 2012 dollars) is identical to and derived in the same manner as the estimate used for the regional analysis of the inriver recreational salmon fishery (Section V.A.1).

Half-pounders are an important component of the steelhead fishery. However, half-pounder catch and effort are not included on steelhead report cards and data for this fishery from other sources is sparse (Section II.B). Thus the regional impacts estimated for the no action alternative should be viewed as conservative.

V.A.3. Redband Trout

The recreational redband trout fishery is a well-known trophy fishery. Major fishing sites include Upper Klamath Lake, the lower Williamson and Wood Rivers, and the Keno Reach of the Klamath River. Effort estimates for Upper Klamath Lake and Agency Lake are available from a statistical creel conducted by ODFW in 2009. However similar estimates are not

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recreational site, as well as the cost of other recreational goods and services whose prices are sensitive to changes in energy costs.

available for the lower Williamson and Wood Rivers or for the Keno Reach – making it difficult to infer how much is spent on this fishery. Regional economic impacts of this fishery are qualitatively assessed, based on the growth and enhancement of this fishery anticipated by the Resident Fish Expert Panel under the action alternative.

The redband trout fishery is a renowned trophy fishery. According to results of a statistical creel conducted during May-September 2009, fishing effort on Upper Klamath Lake totaled 15,191 angler days during that period (pers. comm. William Tinniswood, ODFW). County-of-residence data collected as part of the creel indicate that 24 percent of this effort was by nonresident anglers. Effort estimates for other major fishing sites (lower Williamson and Wood Rivers, Keno Reach of the Klamath River) are not available. A popular guide fishery occurs on the lower Williamson. Given that demand for guide trips is generally higher among nonresident than resident anglers, the proportion of trips by nonresident anglers is likely higher on the Williamson than in Upper Klamath Lake; however, data are lacking to verify this.

V.B. Alternative 1 – No Action Alternative

V.B.1. Salmon

Annual salmon fishing effort on the Klamath River is estimated at 24,683 angler days under the no action alternative (based on 2001-05 average annual harvest of adult Chinook and the harvest-to-angler-day conversion factor discussed in Section IV.A.1.b). The portion of this effort attributable to non-resident anglers is 15,822 angler days (Section V.A.1). Expenditures in the regional impact area by non-resident anglers is estimated at $1.662 million (2012 dollars). These non-resident expenditures generate 34 jobs, $0.93 million in income and $2.01 million in output on an annual basis (Table V-2).

Table V-2. Annual regional economic impacts of inriver recreational salmon expenditures by non-resident anglers under Alternative 1.

Impact Type	*Employment (Jobs)*	*Labor Income ($Millions)*	*Output ($Millions)*
Direct	27.7	0.69	1.28
Indirect	2.3	0.09	0.28
Induced	4.2	0.15	0.45
Total	**34.2**	**0.93**	**2.01**

Source: Reclamation 2011b, presented in 2012 dollars.
Employment measured in number of jobs. Labor income is dollar value of total payroll (including benefits) for each industry in the analysis area plus income received by self-employed individuals in the analysis area. Output represents dollar value of industry production.

V.B.2. Steelhead

The no action alternative is characterized in terms of recent steelhead fishing activity. Based on steelhead report card data, steelhead effort on the Klamath River during 2003-08 averaged 17,155 angler days during 2003-08, of which 11,103 were attributable to non-resident anglers

(Section V.A.2). Annual expenditures by non-residents in the regional impact area is estimated at $1.126 million. These non-resident expenditures generate 20 jobs, $0.62 million in income and $1.31 million in output on an annual basis (Table V-3).

Table V-3. Annual regional economic impacts of inriver recreational steelhead expenditures by non-resident anglers under Alternative 1.

Impact Type	*Employment (Jobs)*	*Labor Income ($Millions)*	*Output ($Millions)*
Direct	15.6	0.46	0.83
Indirect	1.5	0.06	0.18
Induced	2.8	0.10	0.30
Total	**19.9**	**0.62**	**1.31**

Source: Reclamation 2011b, presented in 2012 dollars.
Employment measured in number of jobs. Labor income is dollar value of total payroll (including benefits) for each industry in the analysis area plus income received by self-employed individuals in the analysis area. Output represents dollar value of industry production.

As indicated in Section II.B, steelhead report cards do not cover the half-pounder fishery. Thus the regional impacts of the steelhead fishery under the no action alternative are understated.

V.B.3. Redband Trout

According to results of a statistical creel conducted during May-September 2009, fishing effort on Upper Klamath Lake totaled 15,191 angler days during that period (Table II-3). County-of-residence data collected as part of the creel survey indicate that 24 percent of this effort was by non-resident anglers (data source: William Tinniswood, ODFW). Effort estimates for other major fishing sites (lower Williamson and Wood Rivers, Keno Reach of the Klamath River) are not available. A popular guide fishery occurs on the lower Williamson. Given that demand for guide trips is generally higher among non-resident than resident anglers, the proportion of trips by non-resident anglers is likely higher on the Williamson than in Upper Klamath Lake; however, data are lacking to verify this.

V.C. Alternative 2 – Full Facilities Removal of Four Dams

V.C.1. Salmon

Of the 26,578 angler days estimated to occur annually under Alternative 2 (Section IV.C.1.b.i), 17,036 are attributed to nonresident anglers. Nonresident expenditures in the impact region total $1.789 million – an annual increase of $128 thousand in direct expenditures over Alternative 1. As indicated in Section V.A.1, due to the use of three-digit zip codes to distinguish resident and nonresident anglers, these estimates should be viewed as conservative.

Table V-4. Estimated total annual inriver salmon angler days, non-resident angler days, and non-resident angler expenditures under Alternative 2, and change from Alternative 1.

	Alternative 2	*Change from Alternative 1*
Total angler days	26.578	1,895
Non-resident angler days	17,036	1,214
Non-resident angler expenditures (2012$):	$1.789M	$127.5K

Total angler days obtained from Table IV-2. Number of angler days attributable to non-resident anglers estimated from non-resident proportions provided in Table V-1. Non-resident angler expenditures based on estimate of non-resident expenditure per angler day of $102.87 (2012$).

Alternative 2 was estimated to create approximately three more jobs, $0.19 million in labor income and $0.54 million in output compared to Alternative 1 (Table V-5).

Table V-5. Annual regional economic impacts associated with increase in inriver recreational salmon expenditures by non-resident anglers under Alternative 2 relative to Alternative 1.

	Employment		*Labor Income*		*Output*	
Impact Type	*Jobs*	*Percent change from Alternative 1*	*$Millions*	*Percent change from Alternative 1*	*$Millions*	*Percent change from Alternative 1*
Direct	2.2		0.05		0.10	
Indirect	0.2		0.01		0.02	
Induced	0.3		0.01		0.03	
Total	**2.6**	**7.6**	**0.07**	**7.7**	**0.15**	**7.7**

Source: Reclamation 2011b, presented in 2012 dollars.
Employment measured in number of jobs. Labor income is dollar value of total payroll (including benefits) for each industry in the analysis area plus income received by self-employed individuals in the analysis area. Output represents dollar value of industry production.

V.C.2. Steelhead

The Coho/Steelhead Expert Panel was generally positive regarding the potential for increased distribution and abundance of steelhead under Alternative 2 – assuming that KBRA and other actions (e.g., TMDL) were effectively implemented (Dunne *et al*. 2011). The Biological Subgroup for the Secretarial Determination concludes that Alternative 2 would provide conditions conducive to establishment of a steelhead fishery above Iron Gate Dam and be more beneficial to steelhead than other anadromous species (Hamilton *et al*. 2010, pp 51, 68, 112). While it was not possible to quantify the effects of Alternative 2 on the steelhead fishery, expansion of that fishery is expected to generate additional expenditures and additional jobs and income in the regional economy.

V.C.3. Redband Trout

The Resident Fish Expert Panel concluded that the action alternative would result in increased abundance and distribution of redband trout in Upper Klamath Lake and its tributaries and a potential seven-fold increase in the fishery below Keno Dam (Buchanan *et al*. 2011). The effects of this increase could not be quantified with available data but may yield notable economic impacts, given the size of the potential increase in the fishery noted by the Expert Panel.

V.D. Alternative 3 – Partial Facilities Removal of Four Dams

V.D.1. Salmon

Alternative 3 provides the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. The effects of this alternative on salmon populations and salmon fisheries – including the inriver recreational fishery – are expected to be the same as Alternative 2.

V.D.2. Steelhead

Alternative 3 provides the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. The effects of this alternative on steelhead and the recreational steelhead fishery are expected to be the same as Alternative 2.

V.D.3. Redband Trout

Alternative 3 provides the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. The effects of this alternative on redband trout and the recreational redband fishery are expected to be the same as Alternative 2.

VI. Summary and Conclusions

Stocks historically and/or currently harvested in the inriver recreational fishery that are influenced by the no action and action alternatives include Klamath River fall and spring Chinook, steelhead, redband trout, the SONCC coho ESU, and Lost River and shortnose suckers. SONCC coho is listed as 'threatened' and the two sucker species are listed as 'endangered' under the ESA. Adverse fishery impacts associated with dam removal activities are expected to be short term in nature. Long-term economic benefits and economic impacts of the no action and action alternatives on inriver recreational fisheries are as follows:

<u>Klamath River Chinook</u>

- *Economic benefits:* Under the no action alternative, average annual recreational harvest of Klamath River Chinook is estimated to be similar to what occurred during 2001-05 (6,241 fish). Average annual fishing effort associated with such harvest is 24,683 angler days with a net economic value of $1.647 million. Under the action alternatives, harvest is estimated to increase by an annual average of 8 percent over the 2012-61 projection period. The modest size of this increase (relative to the increases expected for the tribal and ocean commercial and recreational fisheries) is largely due to the fact that the EDRRA model caps the annual inriver recreational harvest at 25,000 fish. The action alternatives are expected to result in an annual average harvest of 6,720 fish and annual effort of 26,578 angler days with a net economic value of $1.774 million. The increase in annual net economic value under the action alternatives relative to no action is $126.4 thousand. The discounted present value of this increase over the 2012-61 period is $1.755 million (based on a discount rate of 4.125 percent).

Other relevant characteristics of the action alternatives: (i) The harvest control rule underlying the Klamath Chinook harvest projections limits the harvest rate to 10 percent or less in years when pre-harvest escapements fall below 30,500 adult natural spawners. Escapements this low would likely be accompanied by major regulatory restrictions and adverse economic conditions similar to what was experienced in 2006. Such low escapements would occur in 66 percent fewer years under the action alternatives, with the greatest decline (-79 percent) occurring in the post-dam removal years. (ii) A modest increase in spring Chinook harvest opportunity is anticipated under the action alternatives. To the extent that this opportunity is realized, it will likely yield economic benefits to the inriver recreational fishery, as spring Chinook are highly desirable for their fat content and have the potential to temporally expand recreational harvest opportunities beyond the current fall Chinook season.

- *Economic impacts:* Of the 24,683 angler days anticipated under the no action alternate on an annual average basis, 15,822 are attributable to non-resident anglers with associated non-resident expenditures of $1.662 million. Of the 26,578 angler days projected for the action alternatives, 17,036 are attributable to non-resident anglers who are expected to spend $1.789 million in the regional impact area. The additional $127.5 thousand in non-resident expenditures projected under the action alternatives is estimated to provide an additional three jobs, $0.07 million in labor income, and $0.15 million in output relative to the no action alternative.

<u>Steelhead</u>

Economic benefits: Effects of the no action alternative on the steelhead fishery were analyzed on the basis of current fishery conditions, as little change in the status of steelhead is anticipated under that alternative. Average annual steelhead effort under no action is estimated to be similar to average 2001-05 effort on the Klamath River (17,155 angler days), with an associated net economic value of $1.647 million. Under the action alternatives, steelhead are expected to increase in abundance and spatial distribution and to colonize the Upper Basin. These changes would be accompanied by an increase in fishing effort and the net economic value of the fishery; however, due to data limitations, the extent of this increase cannot be quantified. (Note: An important component of the steelhead fishery is the half-pounder fishery. Due to data limitations, the estimates of angler days and net economic value provided here for the no action alternative do not include the half-pounder fishery and thus underestimate steelhead effort and value under that alternative.)

- *Economic impacts:* Of the 17,155 angler days associated with under the no action alternative, 11,103 are attributable to non-resident anglers who are expected to spend $1.126 million annually in the regional impact area. Annual economic impacts associated with these expenditures include 20 jobs, $0.62 million in income, and $1.31 million in output. The economic impacts of the action alternatives could not be quantified; however, expansion of the steelhead fishery is expected to generate additional expenditures and additional jobs and income in the regional economy.

<u>Redband trout</u>

- *Economic benefits:* Redband trout supports a trophy fishery in Upper Klamath Lake and its tributaries and the Keno Reach of the Klamath River. Little change in the status of redband trout is anticipated under the no action alternative. The action alternatives are expected to result in increased abundance and distribution of redband trout in Upper Klamath Lake and its tributaries and a potential seven-fold expansion of the inriver fishery below the Keno Reach. The effects of these changes could not be quantified with available data but are likely to yield a notable increase in economic value, given the size of the potential increase in the fishery.

- *Economic impacts:* Enhancement and expansion of the redband trout fishery under the action alternatives is expected to yield a notable increase in angler expenditures and generate additional economic activity in terms of jobs, income and output. As with economic benefits, these economic impacts cannot be quantified with available data.

<u>SONCC coho ESU:</u> Coho retention is prohibited in the Klamath River recreational fishery to meet consultation standards for the SONCC coho ESU. Little improvement in the status of the ESU is expected under the no action alternative. Thus the current fishery prohibition on coho retention is likely to continue into the future under this alternative. The two action alternatives are expected to improve the viability of Klamath coho populations and advance the recovery of the SONCC coho ESU, but are unlikely to lead to de-listing since the ESU also includes stocks outside the Klamath Basin whose viability is not affected by this action. Thus coho retention will likely continue to be prohibited in the Klamath River recreational fishery under these alternatives.

<u>Suckers:</u> The recreational sucker fishery has been closed since 1987 and the prospects of a future fishery are unlikely under the no action alternative. The prospects for restoration of the fishery are also quite limited under the action alternatives. Tribal harvests are an important priority and harvests other than for tribal ceremonial use are unlikely to occur until sucker populations exhibit a pattern of sustained growth.

Main areas of uncertainty in the analysis of inriver recreational fisheries include natural variability in biological and environmental parameters, uncertainty regarding future harvest management policies, and uncertain gasoline prices, which can have a notable influence on angler expenditures – not just in terms of travel costs but also in terms of expenditures on other recreational goods and services whose prices are sensitive to changes in energy prices.

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Appendix A. Salmon Fishery Management

In 1976 the U.S. Congress implemented the Magnuson Fishery Conservation and Management Act (now the Magnuson-Stevens Fishery Conservation and Management Act), which established eight regional fishery management councils whose mandate was to phase out foreign fishing and manage domestic fisheries in the U.S. Exclusive Economic Zone (EEZ).[10] The Pacific Fishery Management Council (PFMC) – whose members include representatives of California, Oregon, Washington and Idaho – is the entity responsible for management of EEZ fisheries off the coasts of Washington, Oregon and California. The PFMC implemented the Pacific Coast Salmon Fishery Management Plan (FMP) in 1978. The FMP addresses management needs of multiple salmon stocks that originate in rivers along the Pacific coast. California, Oregon and Washington are members of the PFMC and coordinate with the PFMC in setting regulations for their inriver recreational salmon fishery.

PFMC management reflects conservation objectives for targeted stocks, consultation standards for weak stocks, and harvest allocation requirements (PFMC 2011):

- *Targeted stocks:* For ocean fisheries south of Cape Falcon, the major targeted stocks are Sacramento River fall Chinook (SRFC) and Klamath River fall Chinook (KRFC). Conservation objectives for these stocks[11] are as follows:

  - In 1989, following a period of sizeable KRFC harvests, low KRFC escapements and a major El Niño in 1982-83, the PFMC adopted more conservative harvest policies for KRFC, including a return of 34-35 percent of adult natural spawners and an escapement floor of 35,000 adult natural spawners (KRTT 1986, PFMC 1988). Figure A-1 depicts KRFC escapements during 1978-2010 relative to the escapement floor that was in effect during 1989-2006. In 2007 the floor was increased to 40,700 to help rebuild KRFC after the stock collapsed in 2006.

[10] The EEZ includes waters that extend 3-200 miles from the U.S. coast.

[11] The conservation objectives for KRFC and SRFC discussed here are intended to facilitate interpretation of historical fishery trends. In June 2011 the PFMC recommended modifications to these objectives to address new requirements of the MSFCMA; these changes will likely become effective in 2012.

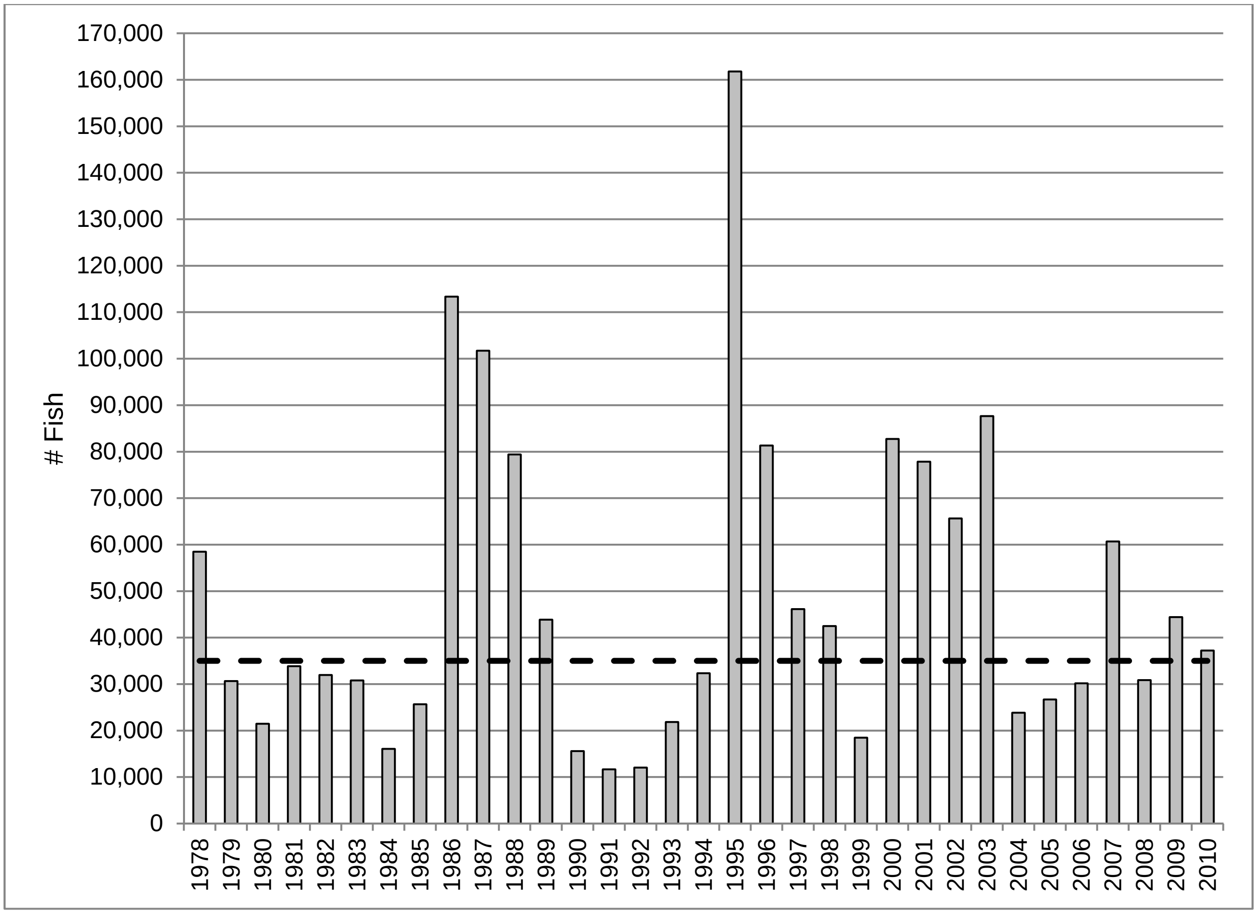

Figure A-1. Klamath River adult natural spawner escapement, 1978-2010. Dotted line represents 35,000 escapement floor in effect during 1989-2006 (source: PFMC 2011a)

- The conservation objective for SRFC is a spawner escapement goal of 122,000-180,000 hatchery and natural area adults. Figure A-2 depicts SRFC escapements during 1978-2010 relative to the escapement goal, which has been in effect since 1978.

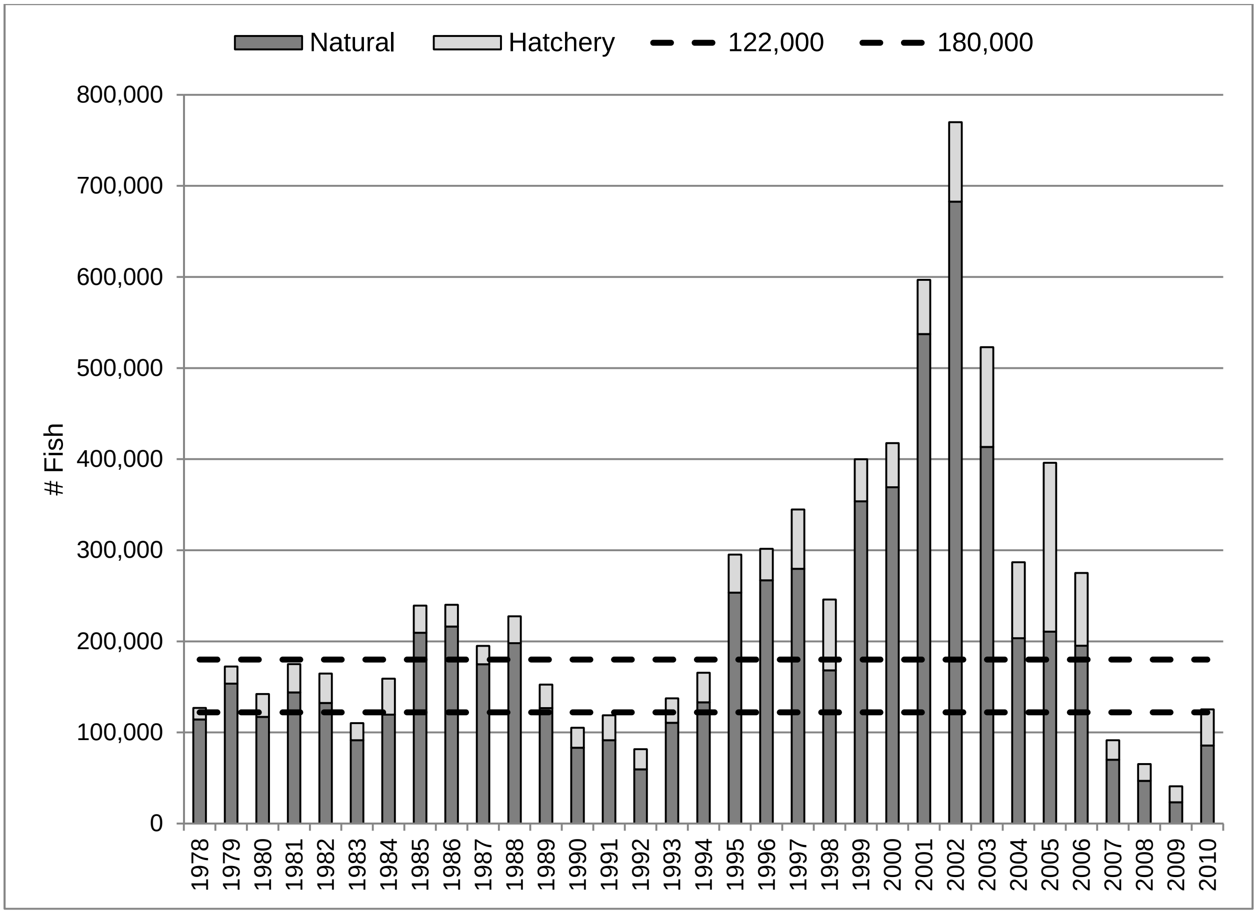

Figure A-2. Sacramento River adult spawner escapement (natural + hatchery), 1978-2010. Dotted lines represent PFMC escapement goal of 122,000-180,000 (source: PFMC 2011a).

- *Stocks listed under the Endangered Species Act (ESA):* The PFMC is bound by consultation standards for six ESA-listed Chinook and coho stocks that occur in the ocean fishery south of Cape Falcon.[12]

    - Sacramento River winter Chinook was listed as 'threatened' in 1989 and reclassified as 'endangered' in 1994. The current consultation standard includes area, season and size limit restrictions for ocean commercial and recreational fisheries from Point Arena, California to the U.S./Mexico border.
    - Central California Coast coho was listed as 'threatened' in 1996 and reclassified as 'endangered' in 2005. The consultation standard is a ban on coho retention in all commercial and recreational fisheries in California.
    - SONCC coho was listed as 'threatened' in 1997. The consultation standard caps the marine exploitation rate on Rogue/Klamath River hatchery coho at 13 percent.
    - Oregon Coastal Natural (OCN) coho was listed as 'threatened' in 1998, de-listed in 2006 following a NMFS update of all its listing determinations, and re-listed in 2008 after the

[12] A seventh stock – Central Valley spring Chinook – was listed as 'threatened' in 1999. NMFS determined that PFMC-managed fisheries presented 'no jeopardy' to this stock.

de-listing was successfully challenged in Court. OCN coho is managed on the basis of exploitation rates that vary with habitat production potential (freshwater and marine) – measured by parent spawner status and smolt-to-adult marine survival (PFMC 1999, OCN Work Group 2000).

  - California Coastal Chinook (CCC) was listed as 'threatened' in 1999. Using KRFC as an indicator stock, the consultation standard for CCC caps the forecast harvest rate for age-4 KRFC in the ocean fishery at 16 percent.
  - Lower Columbia Natural coho was listed as 'threatened' in 2005. The consultation standard is a maximum exploitation rate of 15 percent (marine and Columbia River combined).

- *Stock rebuilding:* The PFMC designates a 'conservation alert' when a stock fails to meet its conservation objective in a single year and a 'conservation concern' when this happens in three consecutive years. A conservation alert may warrant precautionary management in the year of the alert, while a conservation concern (which is more indicative of a downward trend) may require a longer-term management strategy – including a stock rebuilding plan (PFMC 2003).

- *Allocation:* In 1993, the Department of Interior's Office of the Solicitor issued an opinion requiring that 50 percent of Klamath-Trinity River salmon be reserved for the Yurok and Hoopa Valley Tribes (USDOI 1993). This was considerably higher than the 30 percent tribal reserve that was in effect during 1987-91 (Pierce 1998) and required reduced allocations to non-tribal fisheries. The 50-50 tribal/non-tribal allocation remains in effect today.

In most years, the distribution of KRFC harvest is fairly stable as follows: 50.0 percent to tribal fisheries, 7.5 percent to the inriver recreational fishery (up to a maximum of 25,000 fish – with any surplus above 25,000 contributing to escapement), 34.0 percent to the ocean commercial fishery, and 8.5 percent to the ocean recreational fishery. As indicated above, the 50 percent tribal share is a 'hard' allocation specified by the Department of the Interior (USDOI 1993). The distribution of the remaining 50 percent among non-tribal fisheries represents customary practice rather than mandatory conditions. Deviations from this typical non-tribal distribution tend to occur in years where the ocean fisheries (recreational and troll) are unusually constrained by factors other than KRFC abundance. In such years, ocean harvests of KRFC are lower than what they would have been in the absence of such constraints; these foregone harvests instead contribute to escapement and to the inriver recreational fishery. An example of this occurred in 2008-09, when anomalously low SRFC abundance resulted in severe restrictions on the ocean fisheries.

It is important to note that KRFC natural spawner escapement – as depicted in Figure A-1 – is not necessarily indicative of stock abundance. Ocean abundance pertains to the number of fish that migrate to the ocean and (i) are harvested in ocean or inriver fisheries, (ii) contribute to natural or hatchery escapement, (iii) remain unharvested in the ocean, or (iv) are subject to natural mortality or non-retention (hooking or dropoff) mortality.[13] Figure A-3 provides an

[13] Natural mortality is the mortality associated with factors such as disease and non-human predation. Hooking mortality pertains to fish that die after being hooked and released. Dropoff mortality pertains to fish that die after being dropped from the fishing gear as a result of such encounters with the gear.

index of KRFC abundance that includes the escapement and harvest components of abundance (unharvested migrants and natural and non-retention mortality being more difficult to estimate).[14] The size of the escapement and harvest components of Figure A-3 depends on factors such as the extent of hatchery production, how much of the ocean abundance is made available for harvest, and how the available harvest is distributed among fishery sectors (ocean and inriver).

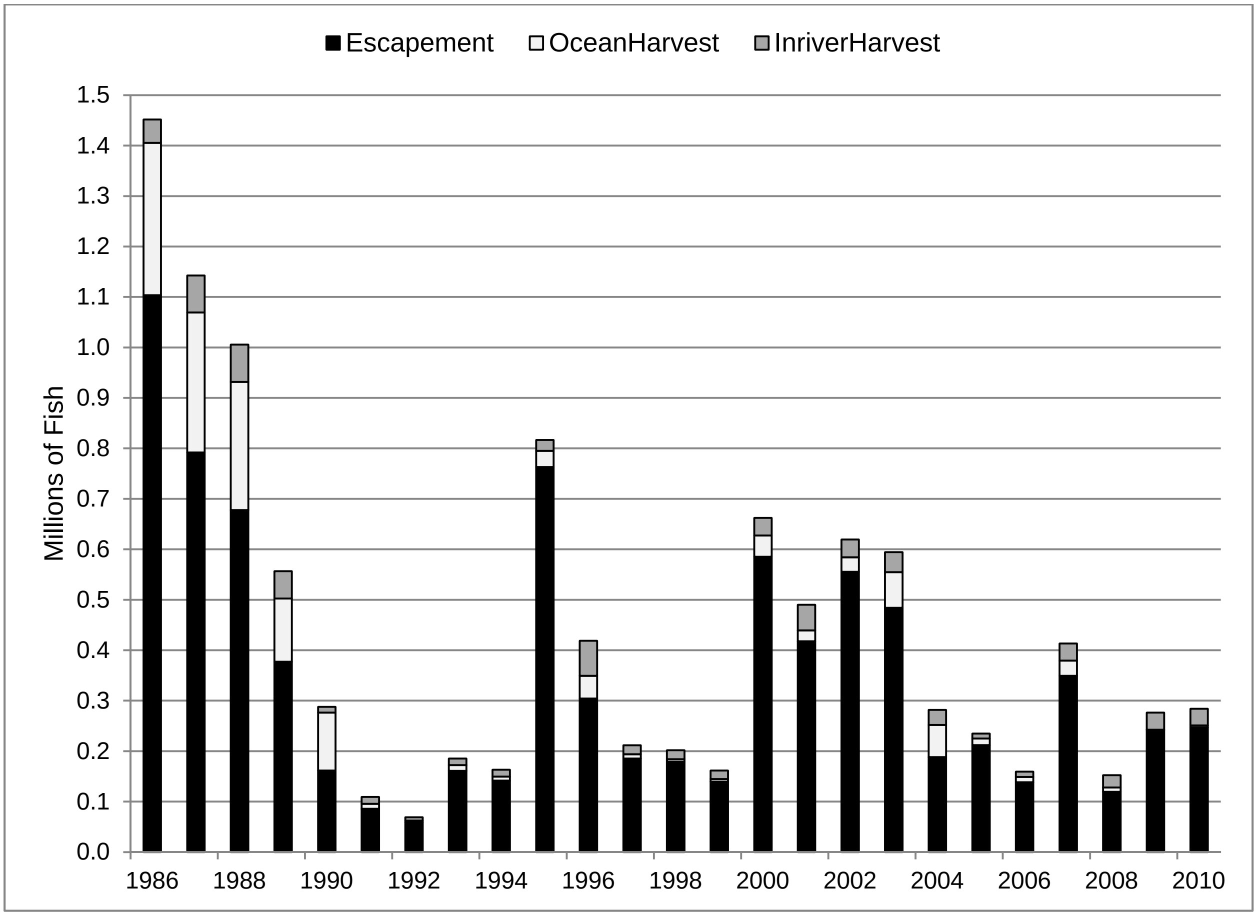

Figure A-3. Klamath River fall Chinook ocean abundance index (millions of fish), including contribution of escapement (natural and hatchery) and ocean and inriver harvest, 1986-2010 (source: PFMC 2011a).

As with KRFC, SRFC adult spawner escapement – as depicted in Figure A-2 – is not indicative of stock abundance. Figure A-4 provides an index of ocean abundance for SRFC that includes escapement and harvest components.[15] The pattern of abundance differs considerably from the escapement pattern.

[14] The escapements depicted in Figures A-1 and A-3 are not comparable. Figure A-1 includes natural escapement only, while Figure A-3 includes both natural and hatchery escapement.

[15] The escapement portion of Figure A-4 is identical to escapement as depicted in Figure A-2, as both figures include both natural and hatchery escapement.

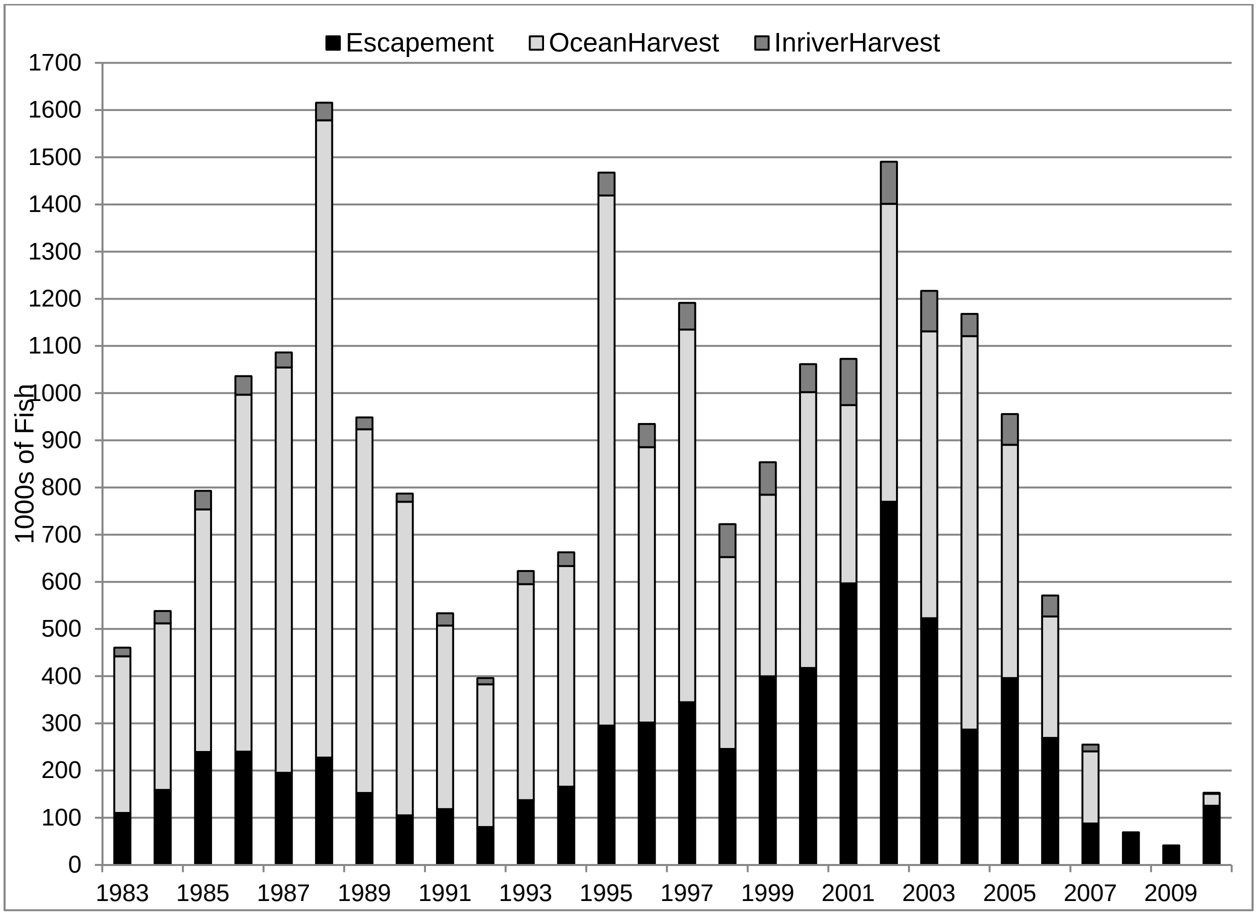

Figure A-4. Sacramento River fall Chinook ocean abundance index (1000s of fish), 1983-2010 (source: PFMC 2011a).

Escapement as a share of total SRFC abundance increased from an annual average of 21 percent during 1981-95 to 40 percent during 1996-2007 to 91 percent during 2008-10 – reflecting the effect of more conservative harvest policies over time (Figure A-4). The 91 percent reflects the effects of stringent fishery regulations associated with record low stock conditions during 2008-10. It is not clear whether the record low SRFC abundances experienced in recent years signal a future pattern of persistently low abundances, are part of a cyclical pattern, or are events that may recur on a rare or occasional basis.

Appendix B. Methodology for Estimating Klamath River Steelhead Fishing Effort

Table B-1 describes the methods used to estimate annual steelhead fishing effort during 2003-08.

Table B-1. Estimated number of steelhead angler days on the Klamath River (excluding the Trinity River), 2003-08.

Row #	Variable Estimated	2003	2004	2005	2006	2007	2008	03-08 Average
1	# Steelhead Report Card Holders: Annual Lifetime Total	 55,757 NA 55,757	 51,827 3,430 55,257	 47,091 3,639 50,730	 40,558 4,006 44,564	 50,162 4,360 54,522	 44,994 4,640 49,643	 48,398 3,347 51,746
2	# active steelhead anglers - CA	37,357	37,022	33,989	29,858	36,530	33,261	34,669
3	% active CA anglers who fished on Klamath River	0.184	0.171	0.154	0.246	0.156	0.188	
4	# active steelhead anglers – Klamath River	6,868	6,315	5,241	7,351	5,698	6,247	6,287
5	# active steelhead anglers (Klamath R) who returned RC	1,120	1,336	809	761	1,419	1,101	1,091
6	# active steelhead anglers (Klamath R) who did not return RC	5,748	4,979	4,432	6,590	4,279	5,146	5,196
7	Average # Klamath trips/year by Klamath anglers who returned RC and did not catch or release any steelhead on any of their Klamath trips during the year	2.68	2.04	2.37	2.53	2.51	3.21	
8	Average # Klamath trips/year by all Klamath anglers who returned RC	3.40	3.14	3.34	3.59	3.45	4.25	
Method (i): Estimated # steelhead angler days on Klamath River (assuming that anglers who do not return RC fish as frequently as anglers who return RC but do not catch or release any fish on the Klamath River):								
9a	By anglers who returned RC	3,806	4,197	2,705	2,729	4,897	4,678	3,835
9b	By anglers who did not return RC	15,377	10,148	10,511	16,642	10,725	16,514	13,319
9c	Sum – all anglers	19,183	14,345	13,216	19,371	15,622	21,192	**17,155**
Method (ii): Estimated # steelhead angler days on Klamath R (assuming that anglers who do not return RC fish as frequently as anglers who do return RC)								
10	Sum - all anglers	23,339	19,839	17,522	26,361	19,664	26,543	**22,212**
Data sources: CDFG 2003-08 steelhead report cards, NMFS 2004 steelhead angler survey.								

<u>Row 1:</u> Number of annual and lifetime steelhead report cards issued by CDFG in each year (source: http://www.dfg.ca.gov/licensing/pdffiles/sf_items_10yr.pdf).

<u>Row 2:</u> Annual number of active steelhead anglers in California, estimated by multiplying the numbers in Row 1 by 67%, based on results of a 2004 survey sponsored by NMFS in which 67%

of steelhead report card holders randomly contacted via telephone indicated that they had actually gone steelhead fishing during the year.[16]

Row 3: Percent of active steelhead anglers who fished on the Klamath River, estimated from steelhead report card data (data source: Terry Jackson, CDFG).

Row 4: Annual number of active steelhead anglers who fished on the Klamath River, estimated by multiplying Row 2 by Row 3.

Row 5: Annual number of active steelhead anglers (Klamath R) who returned their report card, determined from report card data (data source: Terry Jackson, CDFG).

Row 6: Annual number of active steelhead anglers (Klamath R) who did not return their report card, estimated by subtracting Row 5 from Row 4.

Row 7: Average # Klamath trips/year by Klamath River anglers who returned their report card and did not catch or release any steelhead on any of their Klamath trips during the year, estimated from report card data (data source: Terry Jackson, CDFG).

Row 8: Average # Klamath trips/year by all Klamath River anglers who returned their report card, estimated from report card data (data source: Terry Jackson, CDFG).

Row 9a: Number of steelhead angler days on the Klamath River by anglers who returned their report card, estimated by multiplying Row 5 by Row 8.

Row 9b: Number of steelhead angler days on the Klamath River by anglers who did not return their report card, estimated by multiplying Row 6 by Row 7. These estimates assume that anglers who do not return their report card have similar avidity to anglers who return their report card but did not catch or release any steelhead on any of their Klamath trips during the year.

Row 9c: Total number of steelhead angler days on the Klamath River, estimated by summing Rows 9a and 9b.

Row 10: Total number of steelhead angler days on the Klamath River (based on assumption that anglers who do not return their report card have same avidity as anglers who do return), estimated by multiplying Row 4 by Row 8.

[16] There are several reasons why anglers may purchase a steelhead report card but not go steelhead fishing: (i) Anglers often purchase a steelhead report card at the same time that they purchase their annual license. Given the modest cost of a report card (currently $6.48) and the fact that proceeds from report card sales go to a 'good cause' (steelhead habitat restoration), some anglers may purchase a card even if they are uncertain about their steelhead fishing plans during the year. (ii) Anglers who purchase a Life Time Sportfishing License have the option of purchasing an 'Additional Fishing Privileges' package that includes a second-rod validation, a north coast salmon report card and an ocean enhancement validation in addition to a steelhead report card. Anglers who purchase this package are identified in CDFG's database as lifetime steelhead report card holders, even if they purchased the package for privileges other than steelhead fishing.

Results of Table B-1 indicate that average annual steelhead effort on the Klamath River (excluding the Trinity) ranged from 17,155 to 22,212 angler days during 2003-08. The former estimate is based on the assumption that anglers who do not return their report card have similar avidity (on average) to anglers who return their card but did not catch or release any steelhead on any of their Klamath trips during the year; the latter estimate is based on the assumption that all anglers (even those who do not return their report card) have similar avidity (on average) to anglers who return their card. For purposes of evaluating the effects of the no action and action alternatives, the 17,155 estimate was deemed to be more reasonable, based on CDFG experience (pers. comm. Terry Jackson, CDFG) indicating that active steelhead anglers who do not catch any fish are also less likely to return their report card.

Appendix C. Some Methodologies Used to Quantify Economic Effects of No Action and Action Alternatives

This appendix provides documentation regarding how EDRRA model projections were used in combination with fishery data to quantify the economic effects of the no action and action alternatives on the inriver recreational fishery.

C.1. Estimation of Harvest, Effort and Net Economic Value

Table C-1 describes the equations used to estimate Klamath Chinook harvest, fishing effort (angler days) and net economic value under the no action and action alternatives. Derivation of the variable PCTHARV (row #1 of Table C-1) is discussed in Appendix C.1.b.

C.1.a. Equations and Parameter Values

Table C-1. Equations used to project average inriver recreational harvest of Klamath Chinook and associated fishing effort and net economic value, by management area i and year t (2012-61), under the no action alternative (NAA) and dam removal alternative (DRA).

#	*No-action alternative (NAA/Alternative 1)*	*Dam removal alternative (DRA/Alts 2 and 3)*
1	$KLAMCHNK^{NAA} = KLAMCHNK_{mean(01\text{-}05)}$	$KLAMCHNK^{DRA} = KLAMCHNK^{NAA} \times PCTHARV$
2	$ANGLERDAYS^{NAA} = TOTCHNK^{NAA} \times CONVERT$	$ANGLERDAYS_i^{DRA} = TOTCHNK^{DRA} \times CONVERT$
3	$NEV^{NAA} = ANGLERDAYS_i^{NAA} \times NEVDAY$	$NEV^{DRA} = ANGLERDAYS^{DRA} \times NEVDAY$

Note: Variables with NAA and DRA superscripts pertain to outputs of the economic analysis. Variables with asterisked versions of these superscripts (NAA* and DRA*) pertain to outputs of the EDRRA model.

$KLAMCHNK^{NAA}$ = average annual inriver recreational harvest of Klamath River Chinook under NAA (# fish, all areas).
$KLAMCHNK_{mean(01\text{-}05)}$ = average annual inriver recreational harvest of Klamath River Chinook during 2001-05 (# fish).
$KLAMCHNK^{DRA}$ = average annual inriver recreational harvest of Klamath River Chinook under DRA (# fish).
PCTHARV = percent increase in Klamath Chinook harvest under DRA, as projected by EDRRA model (+8 percent).

$ANGLERDAYS^{NAA}$ = average annual number of angler days under the NAA
$ANGLERDAYS^{DRA}$ = average annual number of angler days under the DRA
CONVERT = conversion factor used to convert harvest to angler days (3.955 angler days per adult Chinook harvested)

NEV^{NAA} = annual net economic value (2012$) under NAA
NEV^{DRA} = annual net economic value (2012$) under DRA
NEVDAY = net economic value per angler day ($66.74)

C.1.b. Derivation of PCTHARV

The percent increase in Klamath Chinook harvest under the DRA relative to the NAA projected by the EDRRA model (PCTHARV) was estimated by Hendrix (2011) as follows:

$$PCTHARV=1/T \sum_{t=1,\ldots,T} \{Median_{t,j=1,\ldots,1000} [(KLAMCHNK_{t,j}^{DRA*} - KLAMCHNK_{t,j}^{NAA*})/ KLAMCHNK_{t,j}^{NAA*}]\} \qquad [C1]$$

where

$KLAMCHNK_{t,j}^{NAA*}$ = inrier recreational harvest of Klamath Chinook projected for year t and iteration j under the NAA by the EDRRA model;

$KLAMCHNK_{t,j}^{DRA*}$ = inriver recreational harvest of Klamath Chinook projected for year t and iteration j under the DRA by the EDRRA model;

the term in [ ] is the percent difference between DRA harvest and NAA harvest projected by the EDRRA model for each iteration j=1,…,1000 and year t=1,..,T;

$Median_{t,j=1,\ldots,1000}$ [ ] is the median of the 1000 values of [ ] generated for year t;

$1/T \sum_{t=1,\ldots,T} \{Median_{t,j=1,\ldots,1000} [\ ]\}$ is the mean of the median values of [ ], calculated over the years t=1.,…,T.

C.2. Estimation of Discounted Present Value of Net Economic Value

The NED analysis (Section IV) involved estimation of the discounted present value of the annual net economic value (NEV) of the inriver recreational fishery; this requires that a discount factor be applied to NEV in each year of the 50-year projection period. In order to estimate NEV for each year t, average annual NEV projected for Alternative 1 (Table IV-1) was multiplied by a factor that reflects the interannual variation in Klamath Chinook harvest relative to mean harvest – as projected by the EDRRA model under the NAA. This factor is applicable to NEV as well as harvest, due to the proportional relationship between harvest and NEV. Specifically:

$$NEV_t^{Alt1} = NEV^{Alt1} \times KLAMCHNK_t^{NAA*} / KLAMCHNK_{mean(12-61)}^{NAA*} \qquad [C2]$$

where

NEV^{Alt1} = average annual net economic value (all areas) under Alternative 1 ($1.647 million, according to Table IV-2), and

$KLAMCHNK_t^{NAA*}$ / $KLAMCHNK_{mean(12\text{-}61)}^{NAA*}$ = the ratio of Klamath Chinook harvest in each year t to annual Klamath Chinook harvest averaged over the projection period t=2012,…,2061, as projected by the EDRRA model for the NAA.

Annual NEV for each year t under Alternative 2 ($NETREV_t^{Alt2}$) was similarly calculated, as follows:

$$NETREV_t^{Alt2} = NETREV^{Alt2} \times KLAMCHNK_t^{DRA*} / KLAMCHNK_{mean(12\text{-}61)}^{DRA*} \qquad [C3]$$

where

$NETREV^{Alt2}$ = average annual NEV under Alternative 2 ($1.774 million, according to Table IV-3), and

$KLAMCHNK_t^{DRA*}$ / $KLAMCHNK_{mean(12\text{-}61)}^{DRA*}$ = the ratio of Klamath Chinook harvest in each year t to annual Klamath Chinook harvest averaged over the projection period t=2012,…,2061, as projected by the EDRRA model for the DRA.

The discounted present value (DPV) of future increases in net economic value under Alternative 2 relative to Alternative 1 was estimated as follows:

$$DPV = \sum_{t=2012,\ldots,2061} [(NEV_t^{Alt2} - NEV_t^{Alt1})] (1+r)^{-t} \qquad [C4]$$

where

NEV_t^{Alt1} and NEV_t^{Alt2} = NEV projection in year t for Alternatives 1 and 2 respectively, calculated on the basis of equations [C2] and [C3] above; and

r = discount rate.

C.3. Estimation of Percent of Years when DRA Harvest > NAA Harvest

The percent of years in which DRA harvest exceeds NAA harvest (PCTYRS) was estimated from EDRRA model outputs as follows:

$$PCTYRS=1/T \sum_{t=1,\ldots,T} \{(1/1000)\ COUNT_{t,j=1,\ldots,1000} [KLAMCHNK_{t\,j}^{DRA*} > KLAMCHNK_{t,j}^{NAA*}]\} \qquad [C5]$$

where

$KLAMCHNK_{t,j}^{NAA*}$ = inriver recreational harvest of Klamath Chinook projected by EDRRA model for year t and iteration j under the NAA;

$KLAMCHNK_{t,j}^{DRA*}$ = inriver recreational harvest of Klamath Chinook projected by EDRRA model for year t and iteration j under the DRA;

$\{(1/1000)\ COUNT_{t,,j=1,\ldots,1000}\ [\ ]\}$ = percent of iterations j=1,…,1000 when DRA harvest > NAA harvest, estimated separately for each year t. [ ] is shorthand for what appears in brackets in equation [B5]);

$1/T \sum_{t=1,\ldots,T} \{(1/1000)\ COUNT_{t,,j=1,\ldots,1000}\ [\ ]\}$ = mean of $\{(1/1000)\ COUNT_{t,,j=1,\ldots,1000}\ [\ ]\}$ over years t=1,…,T.

C.4. Estimation of Percent Difference in Frequency of Pre-Harvest Escapement ≤ 30,500

The percent difference between the NAA and DRA in the frequency of pre-harvest adult natural spawner escapements ≤ 30,500 (PCTDIFF) was estimated from EDRRA model outputs as follows:

$$PCTDIFF = 1/T \sum_{t=1,\ldots,T} \{[COUNT_{t,j=1,\ldots,1000}^{DRA*}\ (ESCAPE_{t\,j}^{DRA*} \leq 30{,}500) - COUNT_{t,j=1,\ldots,1000}^{NAA*}\ (ESCAPE_{t\,j}^{NAA*} \leq 30{,}500)] / COUNT_{t,j=1,\ldots,1000}^{NAA*}\ (ESCAPE_{t\,j}^{NAA*} < 30{,}500)\} \qquad [C6]$$

where

$ESCAPE_{t\,j}^{NAA*}$ = pre-harvest escapement of Klamath Chinook projected by the EDRRA model for year t=1,…,T and iteration j=1,…,1000 under the NAA;

$ESCAPE_{t\,j}^{DRA*}$ = pre-harvest escapement of Klamath Chinook projected by the EDRRA model for year t=1,…,T and iteration j=1,…,1000 under the DRA;

$COUNT_{t,j=1,\ldots,1000}^{NAA*}\ (ESCAPE_{t,j}^{NAA*} \leq 30{,}500)$ = number of iterations j in year t when $ESCAPE_{t\,j}^{NAA*} \leq 30{,}500$ under the NAA;

$COUNT_{t,j=1,\ldots,1000}^{DRA*}\ (ESCAPE_{t,j}^{DRA*} \leq 30{,}500)$ = number of iterations j in year t when $ESCAPE_{t\,j}^{DRA*} \leq 30{,}500$ under the DRA;

$[COUNT_{t,j=1,\ldots,1000}^{DRA*}\ (\ ) - COUNT_{t,j=1,\ldots,1000}^{NAA*}\ (\ )] / COUNT_{t,j=1,\ldots,1000}^{NAA*}\ (\ )$ = percent difference between DRA and NAA in number of iterations when pre-harvest adult natural spawner escapement ≤ 30,500, estimated separately for each year t. ( ) is shorthand for what appears in parentheses in equation [B6];

$1/T \sum_{t=1,\ldots,T} \{[COUNT_{t,j=1,\ldots,1000}^{DRA*}\ (\ ) - COUNT_{t,j=1,\ldots,1000}^{NAA*}\ (\ )] / COUNT_{t,j=1,\ldots,1000}^{NAA*}\ (\ )\}$ = mean of percent differences over years t=1.,…,T.

D. Benefit Transfer

D.1. Benefit Transfer Methods and Results

Estimating the net economic value (NEV) of nonmarket goods, such as recreational fishing, requires primary data collection. When these data are lacking or prohibitively expensive to obtain or when there is insufficient time to collect and analyze the data, benefit transfer may be used to obtain a reasonable estimate of NEV. Rosenberger and Loomis (2003) define benefits transfer as the "adaptation of information derived from original research in a different context." Specifically, benefit transfer applies nonmarket values previously estimated at one site (a study site) to another site (a policy site) for use in policy evaluation. Several studies provide an overview of methods and issues associated with benefits transfer, including Dumas et al (2005), Rosenberger and Loomis (2003), Rosenberger and Loomis (2000), Brouwer (2000), and Bergstrom and De Civita (1999).

The validity of any benefit transfer exercise depends on several factors (Brouwer 2000). First, the primary studies that estimate NEV must be based on sound economic and empirical techniques and adequate data. Second, the study sites and policy site must have similar populations of anglers. Third, the fishery conditions should be similar between study sites and the policy site. We address these criteria in selecting the study sites to draw our estimate from.

We apply benefit transfer to estimate the NEV of a fishing day for inriver salmon and steelhead fishing on the Klamath River. We follow steps below, which are based on the criteria for valid benefit transfer listed above and on Rosenberger and Loomis (2003).

- Define the policy context. This includes defining the fisheries to be valued and the units needed.
- Identify relevant original research. This includes conducting a thorough literature review and obtaining any available relevant studies.
- Screen the original research studies. This includes evaluating the studies for quality (consistent with the first criterion above) and relevance (consistent with the second and third criteria above). This also includes evaluating whether the study estimates are in the right units or can be converted to the right units.
- When NEV estimates are not provided, use estimated coefficients to calculate this measure.
- If multiple NEVs are reported in a study, calculate the average of these values.
- Calculate the average NEV of all selected studies for use at the policy site.

The objective is to obtain a proximate value for NEV per day of fishing for salmon and steelhead (separately) on the Klamath River. Candidate studies should estimate the NEV for Pacific salmon or steelhead in the western United States or Canada.

To identify relevant original research, we conducted a thorough literature review using Google Scholar, and forward and backward citation analysis of known relevant valuation studies.

In several cases, the original studies do not estimate NEV for a fishing day, but rather estimate NEV per fish caught or the change in NEV due to some change in site quality. In these cases, we estimate the NEV of a fishing day if the original study provides sufficient information about the estimated demand equations and the data. In the case of travel cost method studies that estimated the total number of trips as a function of travel cost, the formula for calculating the consumer surplus per fishing day differs slightly, depending on the functional form and statistical specification of the estimated demand equation.

Demand equations are often estimated in semi-log form, as in equation D1,

$$ln(Trips) = \beta_0 + \beta_1 TC + \beta_2 Z + \varepsilon \qquad [D1]$$

where TC is travel cost to the site, Z is a vector of other explanatory variables, β's are estimated coefficients, and ε is an error term. Demand equations may also be estimated via maximum likelihood methods using a count data distribution, usually the Poisson or negative binomial. For semi-log functional forms (equation D1) or count data models, NEV per fishing day is calculated as in equation D2.

$$CS_{per\ day} = -1/\beta_1 \qquad [D2]$$

Demand equations are sometimes estimated as a simple linear function of travel cost, as in equation D3,

$$Trips = \beta_0 + \beta_1 TC + \beta_2 Z + \varepsilon \qquad [D3]$$

where TC is travel cost to the site, Z is a vector of other explanatory variables, β's are estimated coefficients, and ε is an error term. In this case, NEV per fishing day is calculated as in equation D4,

$$CS_{per\ day} = -1/2\beta_1 \qquad [D4]$$

The formulas in equations D2 and D4 are standard results and can be found, for example, in Creel and Loomis (1990), Smith and Desvousges (1985), and Adamowicz *et al*. (1989).

We report a value for one RUM. In this case, we divide the total reported NEV by the number of observed angler days.

Individual studies often report more than one value for NEV. This is because they often evaluate several different sites or present results from several different model specifications. In these cases we take the average NEV over all reported values to get a single estimate for each study. This is to avoid over-weighting results from studies that present multiple estimates.

Finally, we were unable to locate five studies that were cited in a literature review performed by the Foster Wheeler Environmental Corporation for the U.S. Army Corps of Engineers (Radtke *et al* 1999). For these five studies, we take the NEV per trip values reported in the literature review.

The results of the benefit transfer are presented in Table D-1 for inriver salmon fishing and in Table D-2 for inriver steelhead fishing. In both tables, the study's primary author, the year the study was published, and the area from which the data was derived are presented in the first three columns. The fourth column, labeled “Estimation Method”, indicates the method used to estimate the values in the primary study. These methods include the travel cost model (TCM), random utility model (RUM), and contingent valuation model (CVM). One study is itself a benefit transfer and is marked “Lit Review.” The fifth column, labeled “Calculation Method,” indicates how NEVs were transferred from the primary study to this study. In some cases, NEV per angler day was reported in the primary study. When this is the case, the location of these estimates in the primary study is reported in the “Calculation Method” column. In other cases, an aggregate NEV for the entire fishery is reported in the primary study. When this is the case, aggregate NEV was divided by the number of angler days. In other cases NEV per angler day was calculated using the formulas presented in equations [D2] and [D4]. We also transferred five values from an analysis performed by the Foster Wheeler Environmental Corporation for the U.S. Army Corps of Engineers (Radtke *et al.* 1999).

The number of distinct estimates reported in each primary study is reported in the fifth column. Studies may report multiple estimates if they use different methods or if they estimated values for multiples sites. In cases where more than one estimate is generated, we used the average in order to use only one value from each study. The sixth column presents the year for which dollar values are reported in the primary study. This year is used to adjust reported values for inflation to 2012 dollars.

The seventh column is the inflation-adjusted value for each study. Table D-1 shows that salmon values range from $38.37 to $104.84 per angler day. The average value of a day of recreational salmon fishing is $66.74. Table D-2 shows that steelhead values range from $40.00 to $206.61 per angler day. The average value of a day of recreational steelhead fishing is $83.15.

Table D-1. Net economic value estimates for a day of inriver salmon fishing (2012 dollars)

(1) Author	*(2)* Study Year	*(3)* Area	*(4)* Estimation Method	*(5)* Calculation Method	*(6)* Number of Reported Estimates	*(7)* Average Reported Value $/day	*(8)* Year$	*(9)* Value $/day 2012$
Anderson	1993	Washington (Columbia R.)	Lit Review	From text	1	$ 59.82	1992	$ 96.19
Jones & Stokes	1987	Alaska (Multiple sites)	RUM	Divide reported CS by reported angler-days (freshwater, resident only)	7	50.93	1986	104.84
Layman, Boyce & Criddle	1996	Alaska (Gulkana R.)	TCM	Tables 6, 7	3	23.86	1992	38.37
Meyer et al	1983	Oregon (statewide)	TCM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	70.13	1998	97.07
Olsen et al.	1990	Oregon, Washington (statewide)	CVM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	41.16	1998	56.96
Olsen et al.	1990	Oregon, Washington (Columbia R.)	CVM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	61.99	1998	85.80
Olsen & Richards	1992	Oregon (Rogue R.)	CVM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	29.97	1998	41.48
Riely	1984	Oregon, Washington (statewide)	TCM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	32.44	1998	44.89
Average								$ 66.74

Table D-2. Net economic value estimates for a day of steelhead fishing (2012 dollars)

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Author	*Study Year*	*Area*	*Estimation Method*	*Calculation Method*	*Number of Reported Estimates*	*Average Reported Value $/day*	*Year$*	*Value $/day 2012*
Brown	1983	Oregon (Rogue R.)	TCM	p. 155, second column	2	$ 55.50	1977	$ 206.61
Demirelli	1988	Washington (statewide)	TCM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	2	78.54	1998	108.70
Donnelly et al	1985	Idaho (multiple sites)	TCM, CVM	Table 4, page 11, CS divided by number of days	33	17.11	1982	40.00
McKean	2000	Idaho (statewide)	TCM	p.18, first paragraph	1	35.71	1998	49.42
Meyer et al.	1983	Oregon (statewide)	TCM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	69.34	1998	95.97
Olsen et al.	1990	Oregon, Washington (statewide)	CVM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	43.72	1998	60.51
Olsen et al.	1990	Oregon, Washington (Columbia R.)	CVM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	58.30	1998	80.70
Olsen, and Richards	1992	Oregon (Rogue R.)	CVM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	38.69	1998	53.55
Riely	1984	Oregon, Washington (statewide)	TCM	Foster Wheeler, Table 2.II.1, Part 2, Chapter II, Page 21	1	32.44	1998	44.89
Strong	1983	Oregon (statewide)	TCM	Divide reported CS by reported angler days	4	24.49	1977	91.16
Average								$ 83.15

D.2. References

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