APPENDIX MS7. COMMERCIAL FISHING ECONOMICS TECHNICAL REPORT FOR THE SECRETARIAL DETERMINATION ON WHETHER TO REMOVE FOUR DAMS ON THE KLAMATH RIVER IN CALIFORNIA AND OREGON

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ABBREVIATIONS AND ACRONYMS

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
KMZ	Klamath Management Zone
KMZ-CA	Klamath Management Zone – California
KMZ-OR	Klamath Management Zone – Oregon
KRFC	Klamath River Fall Chinook
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAA	No Action Alternative
NED	National Economic Development
NMFS	National Marine Fisheries Service
PFMC	Pacific Fishery Management Council
RED	Regional Economic Development
SONCC	Southern Oregon Northern California Coast
SRFC	Sacramento River Fall Chinook
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USWRC	U.S. Water Resources Council

TABLE OF CONTENTS (MS7)

I. Introduction 907

II. Existing Fishery Conditions 908

III. Biological Assumptions 915

SONCC Coho 915

Klamath River Spring and Fall Chinook 916

IV. Commercial Fishing Economic Value for Benefit-Cost Analysis (NED Account) 921

Methodology and Assumptions 921

Alternative 1 – No Action 923

Alternative 2 – Full Facilities Removal of Four Dams 925

Alternative 3 – Partial Facilities Removal of Four Dams 930

V. Commercial Fishing Expenditures for Regional Economic Impact Analysis (RED Account) 930

Methodology and Assumptions 930

Alternative 1 – No Action 931

Alternative 2 – Full Facilities Removal of Four Dams 933

Alternative 3 – Partial Facilities Removal of Four Dams 937

VI. Summary and Conclusions 937

VII. References 939

Appendix A. Salmon Fishery Management 942

Appendix B. Methodologies Used to Quantify Economic Effects of No Action and Action Alternatives 950

LIST OF TABLES AND FIGURES (MS7)

Figure II-1. Ocean salmon management areas south of Cape Falcon, Oregon (graphic by Holly Davis). 908

Figure II-2. Landings of troll-caught Chinook and coho south of Cape Falcon, Oregon (millions of fish), 1981-2010 (sources: PFMC 1990, 1991, 1998, 2009, 2010, 2011b). 910

Table II-1. Landings of troll-caught Chinook and coho (# fish), 1981-2010, by management area 911

Table II-2. Landings of troll-caught Chinook and coho (1000s of pounds dressed weight), 1981-2010, by management area 912

Table II-3. Ex-vessel value of troll-caught Chinook and coho ($1000s, base year=2012), 1981-2010, by management area 913

Table II-4. Average annual harvest of troll-caught Chinook and coho during 1985-1989 – pounds, numbers of fish, and percent of total pounds and fish consisting of coho, by management area. 914

Figure III-1. Harvest control rule used in the EDRRA model (En0 = annual escapement to natural areas prior to ocean or inriver harvest, F = harvest rate) (graphic by Michael Mohr, NMFS). 917

Table III-1. EDRRA model results for the troll fishery under the no action alternative (NAA) and dam removal alternative (DRA)[1] 918

Table IV-1. Projected average annual ocean troll harvest of Klamath Chinook and total Chinook (all stocks) attributable to Klamath Chinook abundance, and associated gross and net revenues under Alternative 1 – by management area.[1] 923

Table IV-2. Projected average annual ocean troll harvest of Klamath Chinook, total Chinook (all stocks) attributable to Klamath Chinook abundance, and gross and net revenues under Alternative 2, and change in net revenue from Alternative 1 – by management area. 925

Figure IV-1. Projected annual net revenue under Alternatives 1 and 2 during 2012-61 (calculated according to the methodology described in Appendix B-2). 927

Table IV-3. Discounted present value of the increase in net revenue under Alternative 2 relative to Alternative 1 (2012$), calculated to illustrate the sensitivity of the estimates to alternative discount rates. 928

Figure IV-2. Annual discounted values of the increase in net revenue under Alternative 2 relative to Alternative 1 (2012$) during the projection period 2012-61, calculated on the basis of alternative discount rates of 0% (no discounting), 2%, 4.125%, 6%, and 8%. 929

Table V-1. Average annual gross revenue under Alternative 1, by management area[1] 931

Table V-2. Annual regional economic impacts associated with average annual gross revenue projected for Alternative 1, by management area 931

Table V-3. Average annual gross revenue under Alternative 2 and change from Alternative 1 – by management area. 933

Table V-4. Annual regional economic impacts associated with projected average annual increase in ex-vessel revenue under Alternative 2 relative to Alternative 1, by management area. 934

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) 943

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). 944

Table A-1. Years of no coho retention (NoCoho), closure of both Chinook and coho fisheries (Closure), and closure of Crescent City portion of KMZ-CA (ClosureCC)[1] in the troll fishery south of Cape Falcon, 1990-2010, by management area. 946

Figure A-3. Klamath River fall Chinook ocean abundance index (millions of fish), 1986-2010 (source: PFMC 2011a) 948

Figure A-4. Sacramento River fall Chinook ocean abundance index (1000s of fish), 1983-2010 (source: PFMC 2011a) 949

Table B-1. Equations used to project average annual troll harvest of Klamath Chinook and total Chinook and associated gross and net revenues, by management area i and year t (2012-61), under no action alternative (NAA) and dam removal alternative (DRA). 950

Table B-2. Parameter values used to estimate Klamath Chinook and total Chinook harvest (all stocks), and gross and net revenue by management area under the no-action and action alternatives. 952

Figure B-1. Imports of edible salmon products into the U.S., 1975-2010 (source: NOAA National Marine Fisheries Service, Office of Science and Technology, Silver Spring, MD). 954

Figure B-2. Ex-vessel prices of troll-caught Chinook in California and Oregon south of Cape Falcon during 1981-2010 and in Southeast Alaska during1984-2009 (2012$) (sources: PFMC 1998, 2011b; ADFG 2009). 955

Figure B-3. Annual landings (pounds dressed weight) and ex-vessel price (2012$) of troll-caught Chinook south of Cape Falcon, Oregon, 1981-2010 (sources: PFMC 1990, 1991, 1998, 2001, 2011b). 956

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. One of the fisheries potentially affected by the Secretarial Determination is the ocean commercial salmon fishery. This report analyzes the economic effects on that fishery of three alternatives that will be considered by the Secretary:

Alternative 1 – No Action: This alternative involves continued operation of the four dams under current conditions, which include 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.

Alternative 2 – Full Facilities Removal of Four Dams: 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).

Alternative 3 – Partial Facilities Removal of Four Dams: 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. The 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 ocean commercial (troll) fishery 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.

II. EXISTING FISHERY CONDITIONS

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)[2] (Klamath River fall and spring Chinook) and the Southern Oregon Northern California Coast (SONCC) coho ESU. These stocks (like other salmon stocks that originate in rivers south of Cape Falcon, Oregon) generally limit their ocean migration to the area south of Cape Falcon. The area south of Falcon is divided into six fishery management areas: Monterey, San Francisco, Fort Bragg, Klamath Management Zone (KMZ), Central Oregon, and Northern Oregon. For purposes of this analysis, the KMZ (which straddles the Oregon-California border) is divided at the border into two areas: KMZ-OR and KMZ-CA (Figure II-1). To the extent possible, the effects of the alternatives are analyzed separately for each area (including KMZ-OR and KMZ-CA).

Figure II-1. Ocean salmon management areas south of Cape Falcon, Oregon (graphic by Holly Davis).

SONCC coho and Klamath Chinook co-mingle with other salmon stocks in the ocean commercial fishery. The Pacific Fishery Management Council (PFMC) manages such 'mixed stock' fisheries on the principle of 'weak stock management' whereby harvests of healthier stocks are constrained more by the need to protect weaker stocks than by their own abundance (see Appendix A for

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[2] 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).

detailed description of PFMC management).[3] The implications of weak stock management as it relates to SONCC coho and Klamath Chinook are as follows.

PFMC-managed ocean fisheries south of Cape Falcon are subject to consultation standards for two Chinook and four coho ESUs listed under the Endangered Species Act (ESA) – including the SONCC coho ESU (listed in 1997). To meet consultation standards for the coho ESUs, the PFMC has banned coho retention in the troll fishery in KMZ-CA and KMZ-OR since 1990 and in all other management areas south of Cape Falcon since 1993 (with the exception of limited fisheries in 2007 and 2009 in Central and Northern Oregon).

The major salmon stocks targeted by ocean fisheries south of Cape Falcon are Sacramento River fall Chinook (SRFC) and Klamath River fall Chinook (KRFC). For most of the past three decades, KRFC has been more constraining on the troll fishery than SRFC. Because SRFC and KRFC intermix in the troll harvest, regulations devised to limit harvest of KRFC necessarily constrain SRFC harvest as well to levels below what would have been allowed in the absence of the KRFC constraint.

Figure II-2 describes harvest trends over the past 30 years. Troll harvests south of Cape Falcon declined markedly from the 1980s to the 1990s. A number of factors contributed to that decline – e.g., the more conservative harvest control rule for KRFC adopted in 1989, implementation of weak stock management policies in the 1990s, the spate of ESA listings that occurred during the 1990s, and the 50-50 tribal/non-tribal allocation of Klamath-Trinity River salmon implemented in 1993. These regulatory changes were compounded by drought and El Niño conditions during 1991-92 and 1997-98 that contributed to low Chinook and coho returns and prompted major fishery restrictions during the 1990s. The 1990s were followed by a period of more stable, moderate harvests during 2001-05. During 2006-10 landings fell to record low levels due to low KRFC abundance in the mid-2000s and record low SRFC abundance in the late 2000s. The lack of coho landings since 1993 is due to the non-coho retention policy adopted in that year (Appendix A).

[3] See Appendix A for a description of PFMC salmon management.

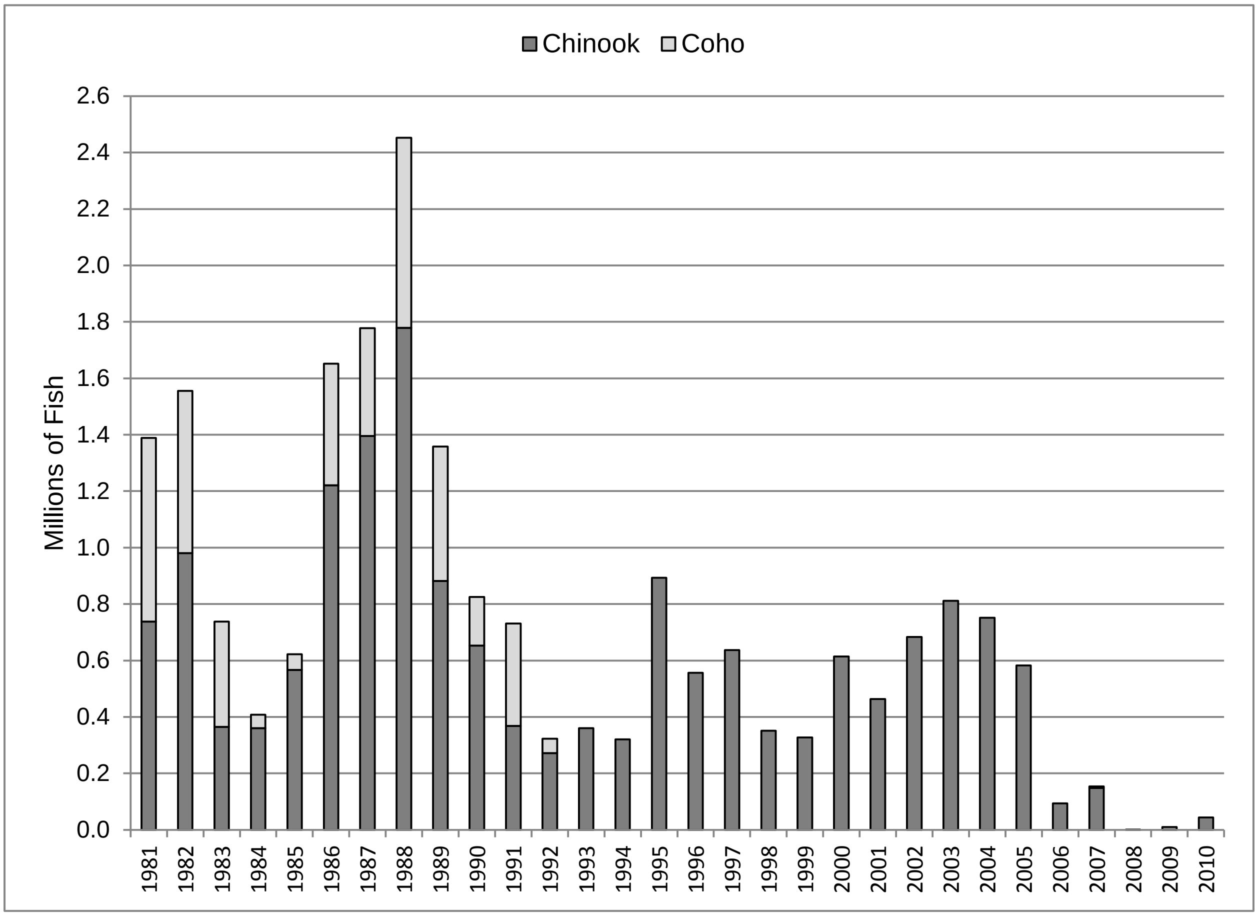

Figure II-2. Landings of troll-caught Chinook and coho south of Cape Falcon, Oregon (millions of fish), 1981-2010 (sources: PFMC 1990, 1991, 1998, 2009, 2010, 2011b).

Tables II-1 and II-2 summarize trends in troll landings (numbers and pounds of fish) by management area. Landings are generally highest in San Francisco and lowest in KMZ-CA and KMZ-OR. Landings reductions began occurring in KMZ-CA and KMZ-OR in the mid-1980s to address conservation concerns for KRFC; low landings remain a persistent features in those areas. The precipitous decline in landings after 2005 was felt in all areas.

Table II-1. Landings of troll-caught Chinook and coho (# fish), 1981-2010, by management area

Year(s)	Management Area							
	Monterey	San Fran	Ft Bragg	KMZ-CA	KMZ-OR	CentralOR	NorthOR	Total
81-85Avg	85,260	186,680	124,320	124,020	61,320	170,560	190,200	942,360
86-90Avg	146,460	360,480	278,380	56,120	33,920	385,940	351,700	1,613,000
91-95Avg	137,720	205,480	14,760	1,540	1,000	36,820	128,240	525,560
96-00Avg	156,305	195,662	12,529	3,505	3,542	36,042	89,479	497,065
01-05Avg	64,827	210,228	96,466	12,401	5,245	117,529	151,698	658,393
06-10Avg	5,330	24,806	7,906	1,752	1,188	7,736	11,598	60,315
2001	35,940	136,630	14,993	5,523	3,599	72,272	195,001	463,958
2002	69,980	242,872	65,336	13,467	6,803	122,174	162,415	683,047
2003	36,099	202,876	248,875	4,044	5,072	132,156	182,066	811,188
2004	64,707	298,229	107,259	31,915	8,484	140,142	100,965	751,701
2005	117,408	170,531	45,869	7,054	2,266	120,900	118,044	582,072
2006	11,204	47,689	10,835	0	738	1,979	21,759	94,204
2007	14,009	75,254	16,116	8,762	4,097	24,096	11,393	153,727
2008	0	0	0	0	236	208	76	520
2009	0	0	0	0	0	979	8,738	9,717
2010	1,435	1,086	12,577	0	869	11,418	16,022	43,407

Sources: PFMC 1990, 1991, 1998, 2009, 2010, 2011b.

Table II-2. Landings of troll-caught Chinook and coho (1000s of pounds dressed weight), 1981-2010, by management area

Year(s)	Management Area							
	Monterey	San Fran	Ft Bragg	KMZ-CA	KMZ-OR	CentralOR	NorthOR	Total
81-85Avg	748	1,849	1,218	967	495	1,140	1,080	7,497
86-90Avg	1,601	3,700	2,434	624	537	2,765	2,259	13,921
91-95Avg	1,350	1,949	194	31	32	339	869	4,764
96-00Avg	1,699	2,155	146	37	92	435	861	5,425
01-05Avg	756	2,704	1,268	149	204	1,124	1,605	7,809
06-10Avg	54	318	163	24	40	86	156	841
2001	418	1,735	192	64	152	776	1,898	5,235
2002	912	3,060	872	162	218	1,223	1,722	8,169
2003	498	2,753	3,096	45	142	1,353	1,890	9,777
2004	853	3,712	1,292	373	267	1,214	1,256	8,967
2005	1,098	2,258	889	102	239	1,054	1,259	6,899
2006	87	684	273	0	45	56	290	1,435
2007	165	888	357	115	101	246	160	2,032

2008	0	0	0	0	8	0	20	28
2009	0	0	0	0	5	5	82	92
2010	20	16	187	4	43	122	226	618

Sources: PFMC 1990, 1991, 1998, 2001, 2011b.

Table II-3 summarizes trends in salmon ex-vessel revenue[4] by management area. Revenues (like landings) are generally highest in San Francisco and lowest in KMZ-CA and KMZ-OR. Revenues are influenced by ex-vessel prices[2] as well as landings. Price declines during 1981-2002 accentuated the landings declines that occurred during the 1980s and 1990s; price increases since 2003 have tended to offset (albeit modestly) the landings declines that occurred after 2005.

Table II-3. Ex-vessel value of troll-caught Chinook and coho ($1000s, base year=2012), 1981-2010, by management area

Year(s)	Management Area							
	Monterey	San Fran	Ft Bragg	KMZ-CA	KMZ-OR	CentralOR	NorthOR	Total
81-85Avg	3,671	9,170	5,881	4,536	2,426	4,637	3,965	34,286
86-90Avg	7,003	16,751	10,884	2,736	2,219	10,983	8,128	58,703
91-95Avg	4,095	6,097	670	104	98	899	2,349	14,312
96-00Avg	3,755	4,912	340	81	217	1,038	1,950	12,292
01-05Avg	2,129	7,422	3,371	440	608	3,206	4,280	21,456
06-10Avg	307	1,797	925	134	243	500	834	4,740
2001	1,051	4,362	483	161	311	1,586	3,878	11,831

[4] Ex-vessel revenue pertains to the value of fish landed dockside and ex-vessel price to the price received by fishermen for those landings.

2002	1,766	5,927	1,689	314	420	2,354	3,309	15,778
2003	1,164	6,432	7,233	105	342	3,260	4,539	23,076
2004	2,912	12,672	4,411	1,273	1,096	4,982	5,096	32,442
2005	3,754	7,719	3,039	349	872	3,846	4,577	24,156
2006	497	3,911	1,561	0	275	342	1,757	8,344
2007	925	4,981	2,002	645	607	1,451	789	11,400
2008	0	0	0	0	62	0	150	212
2009	0	0	0	0	27	11	188	226
2010	114	91	1,063	23	245	696	1,286	3,517

Sources: PFMC 1990, 1991, 1998, 2001, 2011b.

The effects of the coho non-retention policy implemented in the KMZ in 1990 and in all other areas south of Cape Falcon in 1993 have been disproportionately felt in Oregon. In the five years prior to implementation of this policy (1985-89), coho dependence was most pronounced (both absolutely and as a proportion of total salmon landings) in Central and Northern Oregon. This dependence is somewhat higher when considered in terms of numbers of fish rather than pounds, as weight per fish is lower for coho than Chinook (Table II-4).

Table II-4. Average annual harvest of troll-caught Chinook and coho during 1985-1989 – pounds, numbers of fish, and percent of total pounds and fish consisting of coho, by management area.

Management Area	1000s of Pounds Dressed Weight			Number of Fish		
	Chinook	Coho	Coho as % of Total Lbs	Chinook	Coho	Coho as % of Total Fish
Monterey	1,403	3	0.002	124,560	500	0.004

San Francisco	3,685	26	0.007	345,360	4,120	0.012
Fort Bragg	2,532	124	0.051	266,420	22,440	0.083
KMZ-CA	537	63	0.106	45,740	9,700	0.179
KMZ-OR	444	65	0.110	29,580	5,140	0.097
Central OR	2,119	643	0.217	249,400	129,700	0.318
Northern OR	1,072	1,114	0.448	107,800	231,960	0.597

Sources: PFMC 1990, 1991, 1998, 2001, 2011b.

III. BIOLOGICAL ASSUMPTIONS

The economic effects of the no action and action alternatives on the troll fishery are largely driven by the effects on fish populations. This section discusses the biological effects of the alternatives on the SONCC coho ESU and Klamath River fall and spring Chinook.

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, and includes 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.

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).

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 ocean troll, ocean recreational, inriver recreational 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).

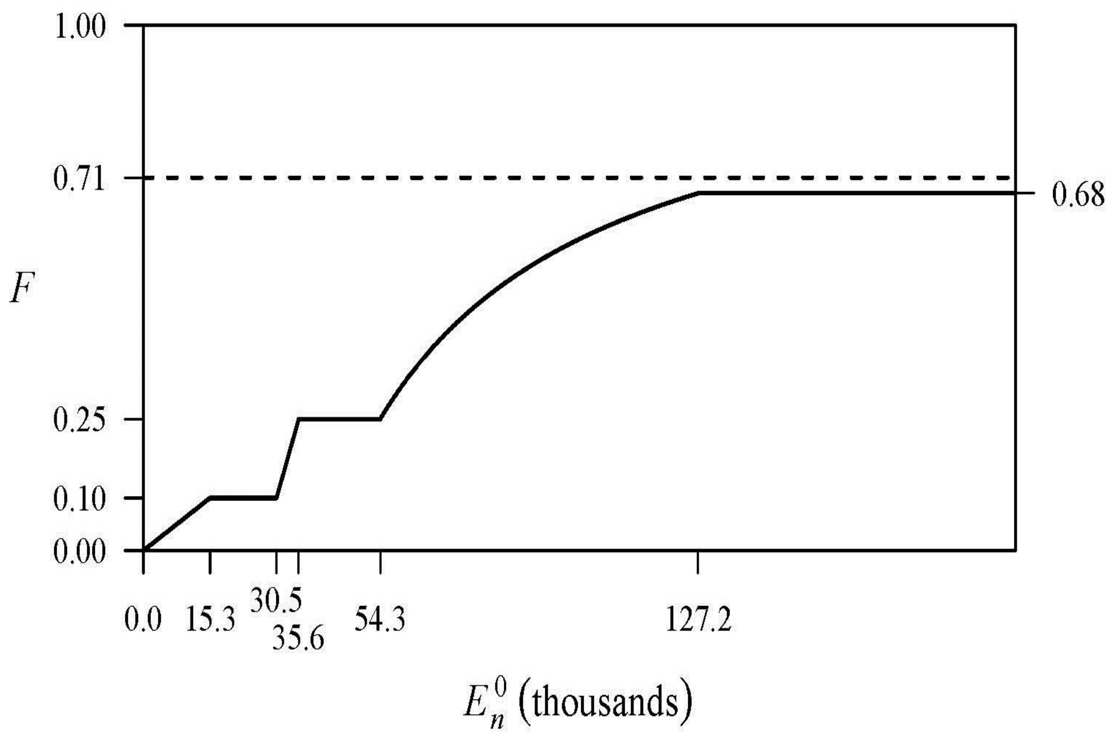

Figure III-1. Harvest control rule used in the EDRRA model (En0 = annual escapement to natural areas prior to ocean or inriver harvest, F = harvest rate) (graphic by Michael Mohr, NMFS).

As reflected in Mohr (in prep) and consistent with PFMC practice, the model distributes the allowable harvest among fisheries as follows: 34.0 percent to the ocean commercial fishery, 8.5 percent to the ocean recreational fishery, 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), 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).[5]

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

Model Results	Time Period			
	2012-61	2012-20	2021-32	2033-61
50th percentile harvest: % diff between NAA and DRA[1]	+43%	+7%	+60%	+47%
5th percentile harvest: % diff between NAA and DRA[1]	-57%	-77%	-46%	-55%
95th percentile harvest: % diff between NAA and DRA[1]	+725%	+421%	+821%	+780%
Average # years when DRA harvest > NAA harvest: % diff between NAA and DRA[2]	70%	54%	78%	71%
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 B.1.b.
[2] Derivation provided in Appendix B.3.
[3] Derivation provided in Appendix B.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

[5] 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).

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 +43 percent for the troll fishery. The annual increase varies by subperiod, with harvest increasing by +7 percent prior to dam removal (2012-2020), peaking at +60 percent during the 12 years after dam removal when the fishery is still influenced by hatchery production (2021-32), then diminishing somewhat to +47 percent during 2033-61 after hatchery influence dissipates in 2032 (Table III-1).

EDRRA model results indicate that the 5th percentile harvest value for the DRA is 57 percent lower than the 5th percentile value for the NAA and that the 95th percentile harvest value is 725 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 (54 percent) but higher harvests under DRA in the two subsequent subperiods (2021-32 and 2033-61) in a notable majority of years (78 percent and 71 percent respectively).

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).

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).

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).

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[6] 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).

[6] 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).

IV. COMMERCIAL FISHING ECONOMIC VALUE FOR BENEFIT-COST ANALYSIS (NED ACCOUNT)

METHODOLOGY AND ASSUMPTIONS

The economic analysis provided here assumes that the troll fishery will continue to be constrained by consultation standards associated with ESA listings and that KRFC will continue to be a binding constraint in most areas south of Cape Falcon. This has been the case in most years since the PFMC initiated its weak stock management policy in the early 1990s. Notable exceptions occurred in the late 2000s, when abundance of SRFC fell to record low levels and SRFC became the binding constraint on the troll fishery in all areas south of Cape Falcon. However, as indicated in Appendix A, it is not clear whether such low SRFC abundances signal a future pattern of persistent low abundances, are part of a cyclical pattern, or are events that may recur on a rare or occasional basis.

SONCC COHO

As indicated in Section II.A, 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 troll fishery.

KLAMATH RIVER SPRING AND FALL CHINOOK

The EDRRA model (Hendrix 2011) is the basis for the quantitative projections of harvest, gross revenue and net revenue used to compare the no action and action alternatives. These variables were estimated as follows:[7]

As indicated in Section III.B.1, 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 troll harvest of Klamath Chinook during 2001-05 (35,778 fish, according to PFMC 2011) was used to characterize the no action alternative. Annual harvest under the DRA (51,082 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 (+43 percent, according to Table 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); abundance of SRFC (which is targeted along with KRFC in the troll fishery south of Cape Falcon) also fell within a moderate range (Figure A-4); and management constraints and policies that are likely to continue into the future – e.g., policies established in the 1990s to protect weaker stocks (including

[7] See Appendix B for more details regarding the methods and assumptions underlying the harvest and revenue projections for each alternative.

ESA-listed stocks), the 50-50 tribal/non-tribal harvest allocation – were well established by that time. Record low fishery conditions experienced after 2005 made those years unsuited for base period characterization.[8]

(ii) Harvest of Klamath River Chinook varies by management area due to factors such as the biological distribution of the stock and fishery regulations. To reflect the influence of these factors, annual average Klamath Chinook harvest projected under the no action and action alternatives was distributed among management areas, based on the relative geographic distribution of KRFC harvests experienced in the troll fishery during the 2001-05 base period (data source: Michael O'Farrell, NMFS).[9]

In San Francisco, Fort Bragg, KMZ-CA, KMZ-OR and Central Oregon, KRFC is managed as a 'constraining stock'; that is, the amount of Chinook harvest (all stocks) made available to the troll fishery is contingent on the allowable harvest of KRFC. To estimate average annual Chinook harvest (all stocks) attributable to the availability of Klamath Chinook in each of these areas, average annual Klamath Chinook harvest projected for each area under the no action and action alternatives was divided by an area-specific expansion factor – calculated as the average ratio of annual Chinook harvest (all stocks) to annual Klamath Chinook harvest during 2001-05 (data source: Michael O'Farrell, NMFS). For Monterey and Northern Oregon, Klamath Chinook is not a constraining stock except in years of very low Klamath Chinook abundance. For these latter two areas, the expansion factor was set equal to 1.000 to reflect the fact that Klamath Chinook availability in these areas does not affect the troll fishery's access to other stocks; thus Klamath Chinook harvest is treated as a simple addition to total harvest under the no action and action alternatives.[10]

Total Chinook harvest (all stocks) in each area attributable to the availability of Klamath Chinook was converted from numbers of fish to pounds dressed weight, based on the 2001-05 mean weight of troll-caught Chinook south of Cape Falcon (11.9 pounds according to PFMC 2011b).

Total Chinook harvest (all stocks) was converted from pounds to gross revenue, based on the 2004-05 average ex-vessel price of troll Chinook landings south of Cape Falcon ($3.59 per pound dressed weight according to PFMC 2011b, calculated in 2012 dollars). This average price was calculated based on fishery data for 2004-05 – a period when prices reflect recent consumer preferences and more normal fishery conditions than 2006-10 (Appendix B.1.c).

(vi) The economic value of the fishery was measured in terms of net revenue (gross revenue minus trip expenses). Net revenue was estimated as 81.3 percent of gross ex-vessel revenue – based on survey data indicating that salmon troll trip costs (fuel, food/crew provisions, ice, bait) comprise 18.7 percent of gross revenue (source: Jerry Leonard, NMFS).

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[8] The decades prior to the 2000s were also deemed unsuitable for characterizing the no action alternative. The 1980s pre-date current weak stock management policies. The 1990s was a period of adjustment to constraints that are expected to continue into the future (e.g., consultation standards for ESA-listed stocks, 50-50 tribal/non-tribal allocation) and also includes years of unusually low landings.

[9] Distribution of troll harvests of KRFC during 2001-05 was as follows: Monterey 4.7 percent, San Francisco 34.4 percent, Fort Bragg 17.9 percent, KMZ-CA 4.3 percent, KMZ-OR 1.9 percent, Central Oregon 27.8 percent, Northern Oregon 9.0 percent.

[10] The expansion factors used in the analysis are as follows: Monterey 1.000, San Francisco 0.058, Fort Bragg 0.065, KMZ-CA 0.199, KMZ-OR 0.107, Central Oregon 0.062, Northern Oregon 1.000.

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 (Section III.B). The Biological Subgroup, Lindley/Davis and Expert Panel results 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 troll fishery.

ALTERNATIVE 1 – NO ACTION

SONCC COHO

As indicated in Section II, coho retention has been prohibited in the troll fishery south of Cape Falcon since 1993 to meet consultation standards for SONCC coho and three other coho ESUs listed under the ESA. Little improvement in the status of the SONCC coho ESU is expected under Alternative 1. Thus current fishery prohibitions on coho retention are likely to continue into the future under this alternative.

KLAMATH RIVER SPRING AND FALL CHINOOK

Under Alternative 1, annual Klamath Chinook harvest is 35,778 fish and annual Chinook harvest (all stocks) attributable to the availability of Klamath Chinook is 491,100 fish. In all areas except Monterey and Northern Oregon, total Chinook harvest (all stocks) is higher than Klamath Chinook harvest, due to the use of expansion factors to account for total harvest of all stocks associated with the availability of Klamath Chinook. In Monterey and Northern Oregon, Klamath Chinook is not a constraining stock; that is, increases in Klamath Chinook harvest represent a simple addition to total harvest and do not yield benefits in terms of increased access to other stocks.[11] Average annual gross and net revenue under Alternative 1(all areas) are $21.0 million and $17.1 million respectively (Table IV-1).

Table IV-1. Projected average annual ocean troll harvest of Klamath Chinook and total Chinook (all stocks) attributable to Klamath Chinook abundance, and associated gross and net revenues under Alternative 1 – by management area.[1]

	# Klamath	# Chinook	Gross Revenue	Net Revenue

[11] It is important to note that total Chinook harvest (all stocks) and gross revenues reported in Table IV-1 pertain only to harvest and revenues that are attributable to the availability of Klamath Chinook. Because Klamath Chinook is not normally a constraining stock (i.e., does not affect access to other stocks) in Monterey and Northern Oregon, harvest and revenues in those areas attributable to Klamath Chinook (Table IV-1) are much less than actual harvest and revenues during the 2001-05 base period (Tables II-1 and II-3).

Management Area	Chinook	(All Stocks)	(2012$)	(2012$)
Monterey	1,671	1,671	71,367	58,021
San Fran	12,312	213,608	9,125,553	7,419,075
Fort Bragg	6,413	98,382	4,202,992	3,417,033
KMZ-CA	1,530	7,691	328,574	267,131
KMZ-OR	667	6,247	266,894	216,985
Central OR	9,963	160,274	6,847,058	5,566,658
Northern OR	3,223	3,223	137,696	111,946
Total	35,778	491,097	20,980,134	17,056,849

[1] Calculations based on methodology discussed in Section IV.A.2.

It is also important to note that troll harvest of Klamath Chinook consists almost exclusively of fall run fish. This stock composition is expected to persist into the future under Alternative 1.

ALTERNATIVE 2 – FULL FACILITIES REMOVAL OF FOUR DAMS

SONCC COHO

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). Thus Alternative 2 will yield little change in coho harvest opportunities. Coho retention will likely continue to be prohibited in the California and Oregon troll fisheries south of Cape Falcon.

KLAMATH RIVER SPRING AND FALL CHINOOK

EFFECTS ON ANNUAL HARVEST AND GROSS AND NET REVENUE

Under Alternative 2, annual average salmon harvest is projected to include 51,082 Klamath Chinook and 701,162 total Chinook (all stocks). In all areas except Monterey and Northern Oregon, total Chinook harvest (all stocks) is higher than Klamath Chinook harvest, due to the use of expansion factors to estimate total harvest of all stocks attributable to the availability of Klamath Chinook in those areas. In Monterey and Northern Oregon, increases in Klamath Chinook harvest represent a simple addition to total harvest and do not yield benefits in terms of increased access to other stocks.[12] Associated gross and net revenues (all areas) are $30.0 million and $24.4 million respectively. Average annual net revenue is higher under Alternative 2 (relative to Alternative 1) by $7.3 million (Table IV-2).

Table IV-2. Projected average annual ocean troll harvest of Klamath Chinook, total Chinook (all stocks) attributable to Klamath Chinook abundance, and gross and net revenues under Alternative 2, and change in net revenue from Alternative 1 – by management area.

Management Area	# Klamath Chinook[1]	# Chinook (All Stocks)[1]	Gross Revenue (2012$)[1]	Net Revenue (2012$)[1]	Change in Net Revenue[2]
Monterey	2,385	2,385	101,894	82,840	24,819
San Fran	17,578	304,979	13,028,998	10,592,576	3,173,501

[12] It is important to note that total Chinook harvest (all stocks) and gross and net revenues reported in Table IV-2 pertain only to harvest and revenues that are attributable to the availability of Klamath Chinook. Because Klamath Chinook is not normally a constraining stock (i.e., does not affect access to other stocks) in Monterey and Northern Oregon, harvest and revenues attributable to Klamath Chinook in those areas are likely much less than actual total harvest and revenues (all stocks) that would occur under the Klamath Chinook conditions projected for Alternative 2.

Fort Bragg	9,156	140,465	6,000,817	4,878,665	1,461,632
KMZ-CA	2,184	10,981	469,121	381,396	114,265
KMZ-OR	952	8,920	381,058	309,800	92,815
Central OR	14,225	228,831	9,775,879	7,947,790	2,381,132
Northern OR	4,602	4,602	196,595	159,831	47,885
Total	51,082	701,162	29,954,363	24,352,897	7,296,049

[1] Calculations based on methodology described in Section IV.A.2.
[2] Difference in net revenue between Alternative 2 (column 5 of this table) and Alternative 1 (column 5 of Table IV-1).

To the extent that spring Chinook production increases sufficiently to provide a harvestable surplus, the EDRRA projections (which include but do not distinguish between spring and fall Chinook) may over-estimate troll harvest. The reason for this has to do with the timing of the run relative to the timing of the fishery. Specifically, the troll fishery north of Point Arena, California does not open until April 1; the troll fishery south of Point Arena (which includes the San Francisco and Monterey management areas) does not open until May 1 to meet the consultation standard for ESA-listed Sacramento River winter Chinook (PFMC 2011). Given this season structure, the harvest potential of spring Chinook may be limited for the troll fishery, as a large portion of the spring run will have returned to the river by the time the season opens.

DISCOUNTED PRESENT VALUE OF CHANGE IN NET REVENUE

Figure IV-1 depicts the annual trajectory of net revenues for Alternatives 1 and 2 during 2012-61. These annual values were derived by multiplying average annual net revenue (all areas) associated with each alternative (Tables IV-1 and IV-2 respectively) by an annual adjustment factor that reflects the variation in annual Klamath Chinook harvest relative to mean 2012-61 harvest – as projected by the EDRRA model (Appendix B.2). As indicated in Figure IV-1, the difference between the two alternatives diverges considerably after dam removal.

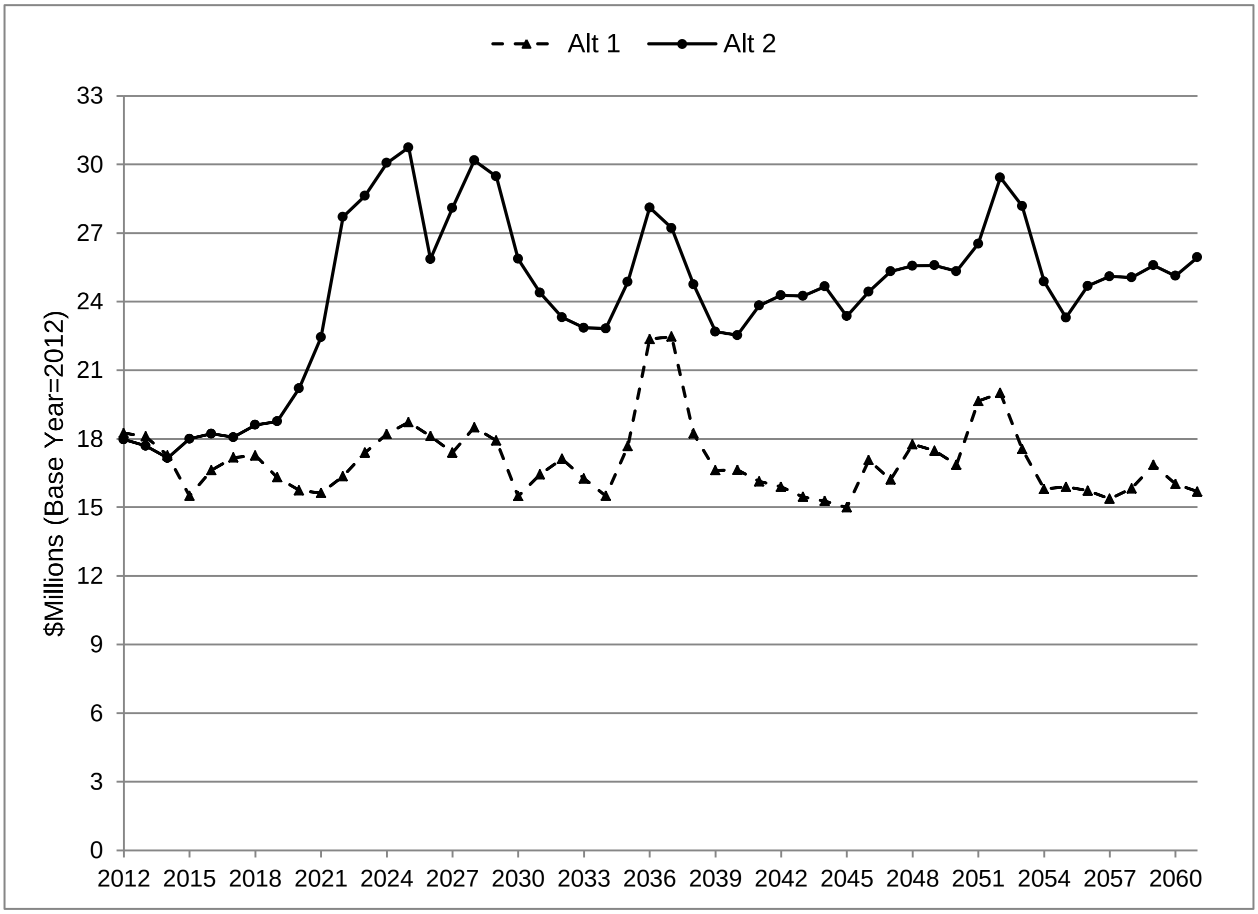

Figure IV-1. Projected annual net revenue under Alternatives 1 and 2 during 2012-61 (calculated according to the methodology described in Appendix B-2).

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 net economic value 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 troll fishery was calculated by applying a discount factor to each of the annual net revenue estimates provided in Figure IV-1, then summing the results (Appendix B-2). Table IV-3 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 $134.5 million, which is 37 percent of the undiscounted present value (discount rate of 0.000 percent) and twice the value of DPV associated with the 8.000 percent discount rate.

Table IV-3. Discounted present value of the increase in net revenue under Alternative 2 relative to Alternative 1 (2012$), calculated to illustrate the sensitivity of the estimates to alternative discount rates.

Discount Rate	Discounted Present Value (2012$)
0.000%	364,801,854
2.000%	216,684,556
4.125%	134,494,901
6.000%	93,378,408
8.000%	66,327,564

Calculations based on methodology described in Appendix B.2.

Figure IV-2 depicts the stream of the annual discounted increases in net revenue that were summed to derive the DPV estimate associated with each of the discount rates in Table IV-3. As indicated in the figure, changes in net revenue 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-3 are influenced by the fact that changes in net revenue 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.

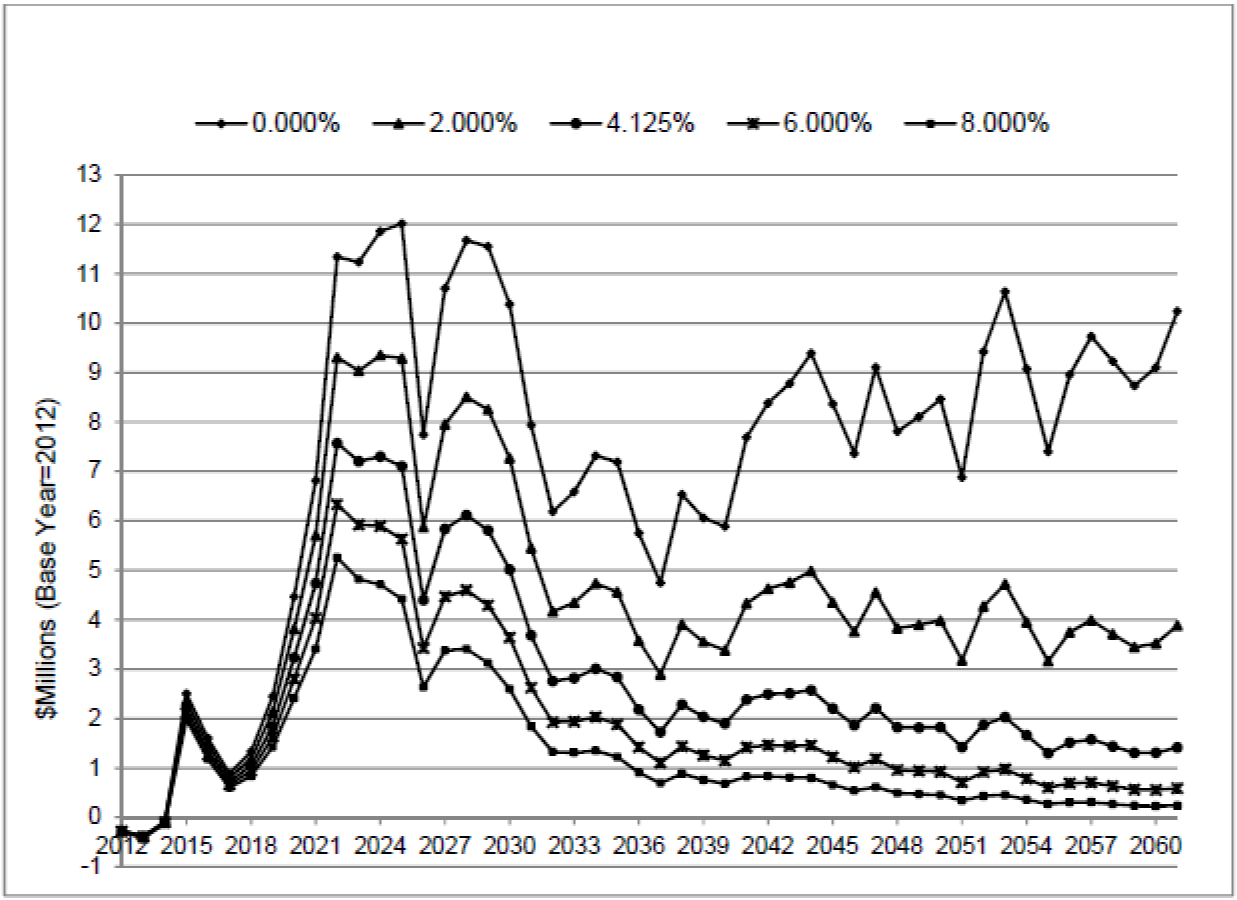

Figure IV-2. Annual discounted values of the increase in net revenue under Alternative 2 relative to Alternative 1 (2012$) during the projection period 2012-61, calculated on the basis of alternative discount rates of 0% (no discounting), 2%, 4.125%, 6%, and 8%.

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 actions to protect KRFC required major reductions in harvest of all salmon stocks in all areas south of Cape Falcon (including Monterey and Northern Oregon, where KRFC does not normally constrain harvest of other stocks). Salmon troll landings and revenues were 18 percent and 39 percent respectively of their 2001-05 average values (Tables II-2 and II-3), and $60.4 million in Commercial Fishery Disaster Assistance was provided to affected businesses and communities. 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.2.a and IV.C.2.b pertain to how the action alternatives would affect fishery conditions at 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 troll fishery.

ALTERNATIVE 3 – PARTIAL FACILITIES REMOVAL OF FOUR DAMS

Alternative 3 is intended to provide 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. Therefore the effects of this alternative on salmon populations and the salmon troll fishery are expected to be the same as Alternative 2.

V. COMMERCIAL FISHING EXPENDITURES FOR REGIONAL ECONOMIC IMPACT ANALYSIS (RED ACCOUNT)

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 trollers spend their revenues on labor shares and payments to support businesses that provide food/crew provisions, fuel, ice, boat maintenance/repair, moorage, 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 gross revenues projected for the no action and action alternatives. About 99 percent of revenues from Chinook harvest (all stocks) that are attributable to the availability of Klamath Chinook is concentrated in five of the seven management areas under the no action and action alternatives (Tables IV-1 and IV-2). Thus the regional economic analysis focuses on those five areas: San Francisco (San Mateo, San Francisco, Marin and Sonoma Counties), Fort Bragg (Mendocino County), KMZ-CA (Humboldt and Del Norte Counties), KMZ-OR (Curry County), and Central Oregon (Coos, Douglas and Lane Counties). Revenues spent in the region and the multipliers used to estimate the impacts of these expenditures will vary, depending on how the affected region is defined. Thus regional impacts will differ, depending on whether impacts are (i) estimated separately for each of the five areas or (ii) estimated for a single study area defined as the aggregation of all five areas. Because the impacts provided here were estimated in the manner of (i), summing those impacts across areas will not provide an accurate estimate of the impacts in all areas combined. More detailed documentation of the methods used to estimate regional impacts is provided in Reclamation (2011a).

ALTERNATIVE 1 – NO ACTION

Table V-1 describes average annual gross revenue in each of the five management areas covered by the regional economic analysis. These revenue estimates were used in conjunction with IMPLAN software and data to analyze the regional impacts of Alternative 1 in each area.

Table V-1. Average annual gross revenue under Alternative 1, by management area[1]

Management Area	Gross Revenue (2012$)
San Francisco	9,125,553
Fort Bragg	4,202,992
KMZ-CA	328,574
KMZ-OR	266,894
Central Oregon	6,847,058

[1] Extracted from Table IV-1.

The associated impacts of Alternative 1 on employment, labor income and output are shown in Table V-2 by management area. Consistent with the revenue pattern (Table V-1), impacts are highest in San Francisco and lowest in KMZ-CA and KMZ-OR.

Table V-2. Annual regional economic impacts associated with average annual gross revenue projected for Alternative 1, by management area

San Francisco			
Impact Type	Employment (Jobs)	Labor Income ($Millions)	Output ($Millions)
Direct	480.0	4.27	9.13

Indirect	8.0	0.56	2.70
Induced	22.0	1.27	3.69
Total	510.0	6.10	15.52
Fort Bragg			
Impact Type	Employment (Jobs)	Labor Income ($Millions)	Output ($Millions)
Direct	150.0	1.98	4.20
Indirect	1.4	0.07	0.18
Induced	10.6	0.40	1.24
Total	162.0	2.45	5.62
KMZ-CA			
Impact Type	Employment (Jobs)	Labor Income ($Millions)	Output ($Millions)
Direct	43.0	0.15	0.33
Indirect	0.1	0.01	0.02
Induced	0.9	0.03	0.10
Total	44.0	0.19	0.45
KMZ-OR			
	Employment	Labor Income	Output

Impact Type	(Jobs)	($Millions)	($Millions)
Direct	25.0	0.13	0.27
Indirect	0.1	0.00	0.01
Induced	0.5	0.02	0.05
Total	25.6	0.15	0.33
Central Oregon			
Impact Type	Employment (Jobs)	Labor Income ($Millions)	Output ($Millions)
Direct	293.0	3.21	6.85
Indirect	4.1	0.17	0.46
Induced	21.8	0.77	2.24
Total	318.9	4.15	9.55

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.

ALTERNATIVE 2 – FULL FACILITIES REMOVAL OF FOUR DAMS

Table V-3 describes average annual gross revenue in each of the five management areas covered by the regional economic analysis. The changes in gross revenue from Alternative 1 to Alternative 2 was used in conjunction with IMPLAN software and data to estimate the regional impacts associated with Alternative 2.

Table V-3. Average annual gross revenue under Alternative 2 and change from Alternative 1 – by management area.

Management		

Area	Gross Revenue (2012$)[1]	Change from Alternative 1[2]
San Francisco	13,028,998	3,903,445
Fort Bragg	6,000,817	1,797,825
KMZ-CA	469,121	140,547
KMZ-OR	381,058	114,164
Central Oregon	9,775,879	2,928,821

[1] Extracted from Table IV-3.
[2] Difference in gross revenue between Alternative 2 (column 2 of this table) and Alternative 1 (Table V-1).

The impacts of the increase in troller revenues under Alternative 2 on employment, labor income and output are shown in Table V-4 for each management area. The increases in employment, labor income and output relative to Alternative 1 are 42 to 43 percent in each area.

Table V-4. Annual regional economic impacts associated with projected average annual increase in ex-vessel revenue under Alternative 2 relative to Alternative 1, by management area.

San Francisco						
Impact Type	Employment		Labor Income		Output	
	Jobs	% change from Alt 1	$Millions	% change from Alt 1	$Millions	% change from Alt 1
Direct	205.0		1.79		3.90	
Indirect	3.5		0.24		1.15	
Induced	9.3		0.53		1.55	
Total	217.8	42.7	2.56	42.0	6.6	42.6

Fort Bragg						
Impact Type	Employment		Labor Income		Output	
	Jobs	% change from Alt 1	$Millions	% change from Alt 1	$Millions	% change from Alt 1
Direct	64.0		0.85		1.80	
Indirect	0.5		0.03		0.08	
Induced	4.5		0.17		0.53	
Total	69.0	42.7	1.05	42.8	2.41	42.8
KMZ-CA						
Impact Type	Employment		Labor Income		Output	
	Jobs	% change from Alt 1	$Millions	% change from Alt 1	$Millions	% change from Alt 1
Direct	18.0		0.06		0.14	
Indirect	0.1		0.00		0.01	
Induced	0.4		0.01		0.04	
Total	18.5	41.7	0.07	42.0	0.19	42.6
KMZ-OR						
Impact Type	Employment		Labor Income		Output	
		% change from Alt 1		% change from Alt 1		% change from Alt 1

	Jobs		$Millions		$Millions	
Direct	11.0		0.05		0.11	
Indirect	0.0		0.00		0.00	
Induced	0.2		0.01		0.02	
Total	11.2	43.8	0.06	42.8	0.13	42.8
Central Oregon						
Impact Type	Employment		Labor Income		Output	
	Jobs	% change from Alt 1	$Millions	% change from Alt 1	$Millions	% change from Alt 1
Direct	125.0		1.35		2.93	
Indirect	1.8		0.07		0.20	
Induced	9.1		0.32		0.94	
Total	135.9	42.6	1.74	42.0	4.07	42.6

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.

ALTERNATIVE 3 – PARTIAL FACILITIES REMOVAL OF FOUR DAMS

Alternative 3 is intended to provide 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. Therefore the effects of this alternative on salmon populations and the salmon troll fishery are expected to be the same as Alternative 2.

VI. SUMMARY AND CONCLUSIONS

The particular salmon stocks influenced by the no action and action alternatives are the SONCC coho ESU (which is listed under the ESA) and Klamath River fall and spring Chinook. Economic effects of the no action and action alternatives on the troll fishery as they relate to these stocks are as follows:

SONCC COHO ESU

Coho retention has been prohibited in the troll fishery south of Cape Falcon since 1993 to meet consultation standards for SONCC coho and three other coho ESUs listed under the ESA. Little improvement in the status of the SONCC coho ESU is expected under the no action alternative. Thus current fishery prohibitions on coho retention are likely to continue into the future under this alternative. The action alternatives are expected to yield similar improvements in 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 California and Oregon troll fisheries south of Cape Falcon under these alternatives.

KLAMATH RIVER CHINOOK

Economic benefits: Under the no action alternative, average annual troll harvest of Klamath Chinook is estimated to be similar to what it was during 2001-05 (35,778 fish). Reflecting the constraining influence of Klamath Chinook on the availability of Chinook (all stocks) in the San Francisco, Fort Bragg, KMZ-CA, KMZ-OR and Central Oregon management areas, Klamath Chinook harvest of 35,778 provides the opportunity for the troll fishery to harvest 491,100 Chinook (all stocks) south of Cape Falcon, Oregon. Average annual net revenue associated with such harvest is $17.1 million.

Under the action alternatives, annual salmon troll harvest is estimated to increase by an average of 43 percent over the 2012-61 projection period. Average annual harvest under these alternatives is projected to include 51,082 Klamath Chinook and 701,162 total Chinook (all stocks), with associated net revenue of $24.4 million. The increase in annual net revenue under the action alternatives relative to no action is $7.3 million. The discounted present value of this increase over the 2012-61 period is $134.5 million (based on a discount rate of 4.125 percent).

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.

Economic impacts: Regional economic impacts associated with the no action and action alternatives are largely concentrated in the five management areas where Klamath Chinook is the constraining stock. Regional impacts associated with the $20.8 million in gross revenue generated in those five areas under the no action alternative vary widely by area. For San Francisco, Fort Bragg and Central Oregon, annual impacts (depending on the area) include 162 to 510 jobs, $2.45 million to $6.10 million in labor income, and $5.62 million to $15.52 million in output. For KMZ-CA and KMZ-OR, annual impacts include 26 to 44 jobs, $0.15 million to $0.19 million in labor income, and $0.33 million to $0.45 million in output.

The additional $8.9 million in gross revenue in the same five areas under the action alternatives generates regional impacts that vary widely by area. For San Francisco, Fort Bragg and Central Oregon, annual impacts (depending on the area) include an additional 69 to 218 jobs, an additional $1.05 million to $2.56 million in labor income, and an additional $2.41 million to $6.6 million in output. For KMZ-CA and KMZ-OR, the annual impacts include an additional 11 to 19 jobs, an additional $0.06 million to $0.07 million in labor income, and an additional $0.13 million to $0.19 million in output.

Main areas of uncertainty in this analysis include natural variability in biological and environmental parameters, uncertainty regarding future harvest management policies, and uncertain ex-vessel prices (which are affected by global supply and demand for farmed as well as wild salmon).

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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 or MSFCMA), 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).[13] The Pacific Fishery Management Council (PFMC) 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. The PFMC and its member states manage the troll fishery south of Cape Falcon with regulations such as area closures, season closures, gear restrictions, minimum size limits, vessel landing limits, stock retention prohibitions, and mark-selective fishing.[14]

Salmon stocks that originate in rivers south of Cape Falcon, Oregon generally limit their ocean migration to the area south of Falcon. The major salmon species harvested in the south-of-Falcon fishery are Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*). The area south of Falcon is divided into six management areas: Monterey, San Francisco, Fort Bragg, Klamath Management Zone (KMZ), Central Oregon, and Northern Oregon. For purposes of this analysis, the KMZ (which straddles the Oregon-California border) is divided at the border into two areas: KMZ-OR and KMZ-CA.

Management of the troll fishery is complicated by the fact that multiple salmon stocks with different conservation objectives mix in the ocean harvest. These ‘mixed stock’ fisheries are managed on the general principle of ‘weak stock’ management, whereby harvest opportunity for more abundant stocks is constrained by the need to meet conservation objectives for weaker stocks.

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[15] are as follows:

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

[14] A mark selective fishery is a fishery in which hatchery fish are marked in a visually identifiable manner (e.g., by clipping the adipose fin), thereby allowing fishermen to selectively retain marked fish and release unmarked (wild) fish.

[15] 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.

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 (Klamath River Technical Team 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.

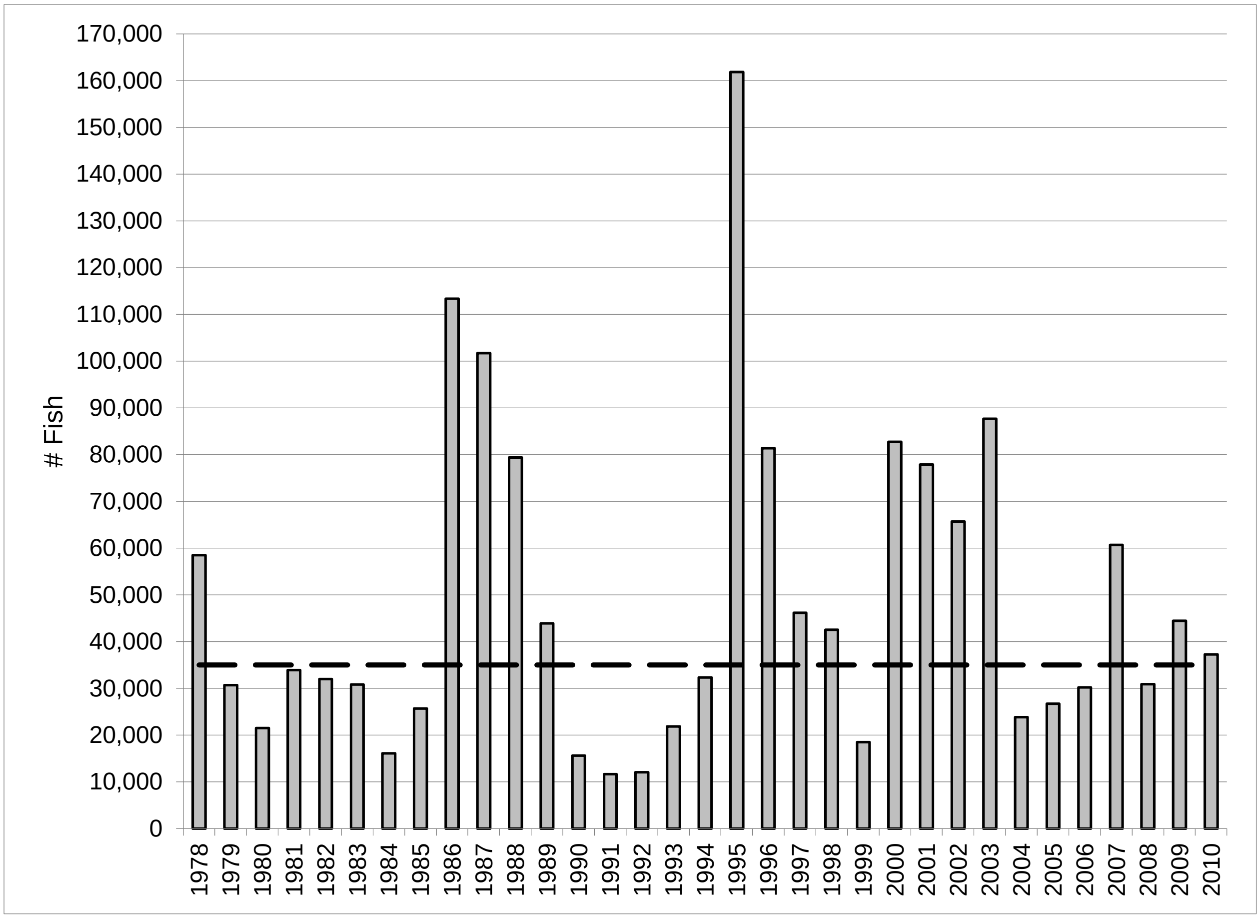

Figure A-1. Klamath River adult natural spawner escapement, 1978-2010. Dotted line represents 35,000 escapement floor in effect during 1989-2006 (source: PFMC 2011a)

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

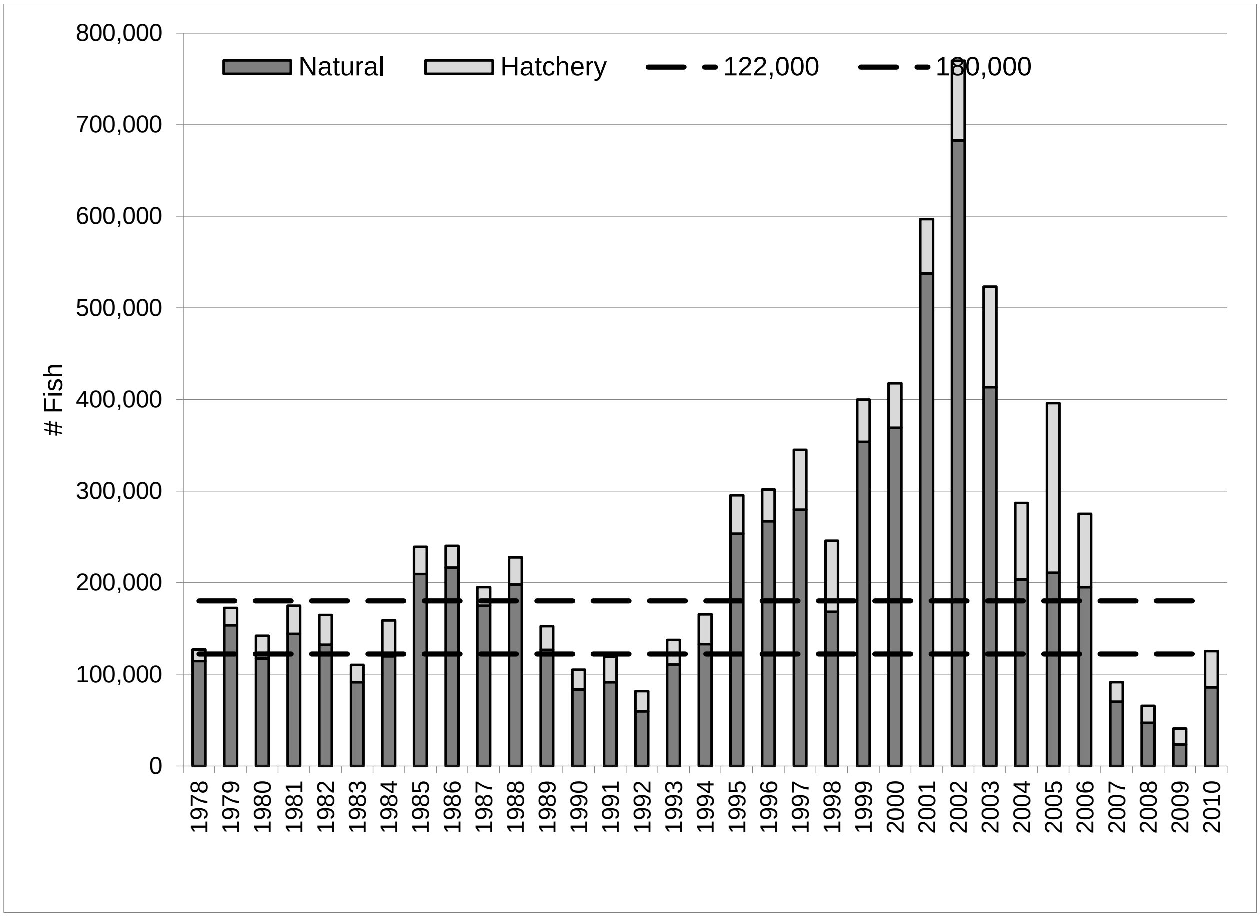

Figure A-2. Sacramento River adult spawner escapement (natural + hatchery), 1978-2010. Dotted lines represent PFMC escapement goal of 122,000-180,000 (source: PFMC 2011a).

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.[16]

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.

[16] 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.

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 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 was listed as 'threatened' in 1999. Using KRFC as an indicator stock, the consultation standard for California Coastal Chinook 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 the Interior, 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.

Table A-1 identifies periods of particularly stringent troll regulations associated with low coho and/or Chinook abundances. The table illustrates the long-term nature of non-retention policies to protect coho and the frequency of fishery closures, which tend to occur when Chinook abundance is also low.

Table A-1. Years of no coho retention (NoCoho), closure of both Chinook and coho fisheries (Closure), and closure of Crescent City portion of KMZ-CA (ClosureCC)[1] in the troll fishery south of Cape Falcon, 1990-2010, by management area.

Year	Management Area				
	SanFran & Monterey	Ft Bragg	KMZ-CA	KMZ-OR	CentralOR & North OR
1990			NoCoho	NoCoho	
1991			NoCoho, ClosureCC	NoCoho	
1992		Closure	Closure	Closure	
1993	NoCoho	NoCoho	Closure	Closure	NoCoho
1994	NoCoho	NoCoho	Closure	NoCoho	NoCoho
1995	NoCoho	NoCoho	Closure	NoCoho	NoCoho
1996	NoCoho	NoCoho	NoCoho	NoCoho	NoCoho
1997-98	NoCoho	NoCoho	NoCoho, ClosureCC	NoCoho	NoCoho
1999-05	NoCoho	NoCoho	NoCoho	NoCoho	NoCoho
2006	NoCoho	NoCoho	Closure	NoCoho	NoCoho,
2007	NoCoho	NoCoho	NoCoho	NoCoho	
2008	Closure	Closure	Closure	NoCoho	NoCoho
2009	Closure	Closure	Closure	Closure	
2010	NoCoho	NoCoho	Closure	NoCoho	NoCoho

Sources: PFMC 1998, 2009. 2010, 2011b.

[1] KMZ-CA includes Crescent City and Eureka-area ports.

Circumstances underlying the regulatory restrictions identified in Table A-1 are as follows:

Periods of drought and El Niño conditions during 1991-92 and 1997-98 contributed to low Chinook and coho returns and prompted major fishery restrictions during the 1990s – including Commercial Fishery Disaster Assistance in 1994 ($15.7 million), 1995 ($13.0 million) and 1998 ($3.5 million) (pers. comm. Stephen Freese, NMFS). Actions taken by the PFMC to deal with the persistent decline in coho stocks included a ban on coho retention in KMZ-CA and KMZ-OR since 1990 and in all other management areas south of Cape Falcon since 1993, with the exception of limited fisheries in 2007 and 2009 in Central and Northern Oregon.

Fishery closure (all stocks) generally occurs when conservation concerns for SRFC and/or KRFC occur in conjunction with the prohibition on coho retention. During 1990-92, KRFC and SRFC failed to reach their respective conservation objectives – triggering a conservation concern for both stocks (Klamath River Fall Chinook Review Team 1994, Sacramento River Fall Chinook Review Team 1994). Major fishery restrictions including closures in Fort Bragg in 1992, KMZ-CA during 1992-95, and KMZ-OR during 1992-93.

During the prolonged drought in the 2000s, KRFC failed to achieve its conservation objective for three consecutive years (2004-06). Subsequent fishery restrictions – including closure of KMZ-CA in 2006 – prompted $60.4 million in Commercial Fishery Disaster Assistance in 2007 (Upton 2010). The PFMC also increased the adult natural spawner escapement floor from 35,000 to 40,700 as a rebuilding strategy.

Failure of SRFC to achieve its conservation objective during 2007-09 triggered a conservation concern (Lindley *et al.* 2009). Historically unprecedented restrictions were imposed on the troll fishery (including complete closure of the California fishery in 2008-09. Congress appropriated $170 million in Commercial Fishery Disaster Assistance, of which $117 million was disbursed in 2008 and $53 million in 2009 (Upton 2010; pers. comm. Stephen Freese, NMFS).

It is important to note that KRFC natural spawner escapement – as depicted in Figure A-1 – does not necessarily reflect 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 and dropoff) mortality.[17] Figure A-3 provides an 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).[18] The size of the escapement and harvest components of Figure A-3 depends on

[17] 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.

[18] 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.

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).

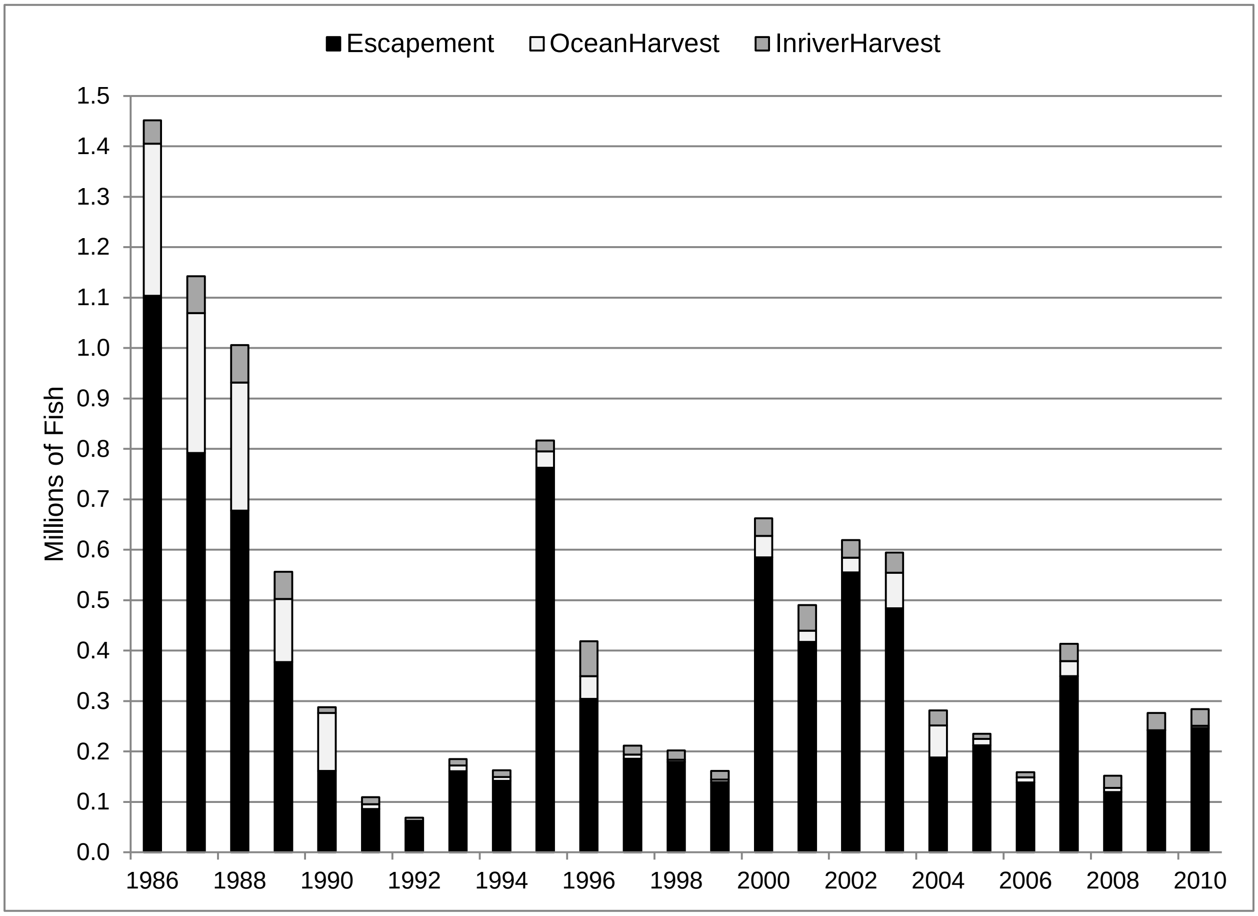

Figure A-3. Klamath River fall Chinook ocean abundance index (millions of fish), 1986-2010 (source: PFMC 2011a).

As with KRFC, SRFC adult spawner escapement – as depicted in Figure A-2 – is not necessarily indicative of stock abundance. Figure A-4 provides an index of ocean abundance for SRFC that includes the two major components of abundance (escapement and harvest).[19] The pattern of abundance differs considerably from the escapement pattern.

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

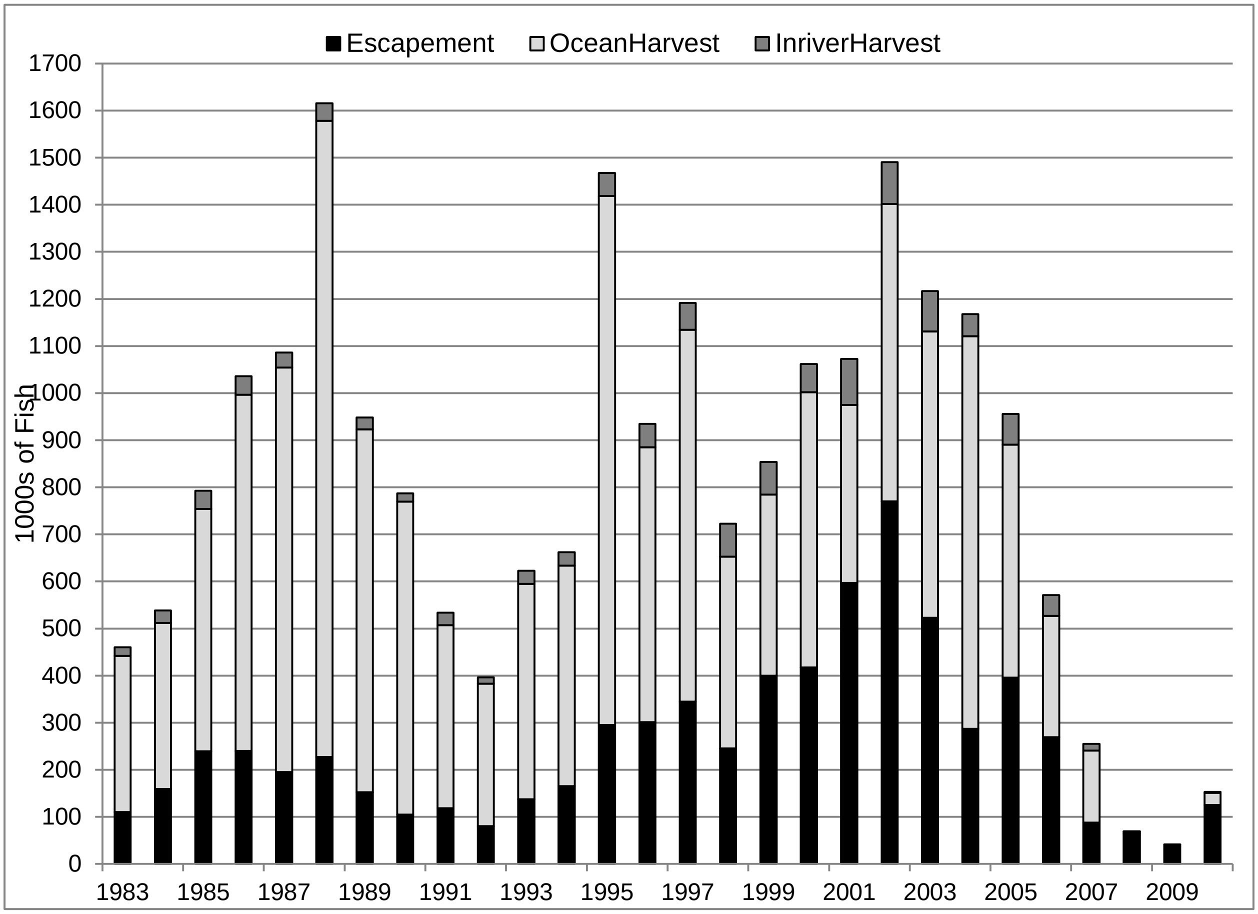

Figure A-4. Sacramento River fall Chinook ocean abundance index (1000s of fish), 1983-2010 (source: PFMC 2011a).

Escapement as a proportion of the SRFC abundance index 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 estimate 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. METHODOLOGIES USED TO QUANTIFY ECONOMIC EFFECTS OF NO ACTION AND ACTION ALTERNATIVES

This appendix provides documentation of 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 troll fishery.

ESTIMATION OF ANNUAL HARVEST AND GROSS AND NET REVENUE

Table B-1 describes the equations used to estimate Klamath Chinook harvest, total Chinook harvest (all stocks), and gross and net revenues under the no action and action alternatives. The net revenue estimates are inputs in the Net Economic Development (NED) analysis (Section IV); the gross revenues are inputs in the Regional Economic Development (RED) analysis (Section V). Numeric values of the parameters that appear in Table B-1 (α_i, $EXPAND_i$, LBFISH, PRICE, PCTREV) are provided in Table B-2. Derivation of the variable PCTHARV (row #1 of Table B-1) is discussed in Appendix B.1.b. Derivation of the variable PRICE (row #5 of Table B-1) is discussed in Appendix B.1.c.

EQUATIONS AND PARAMETER VALUES

Table B-1. Equations used to project average annual troll harvest of Klamath Chinook and total Chinook and associated gross and net revenues, by management area i and year t (2012-61), under no action alternative (NAA) and dam removal alternative (DRA).

#	No-action alternative (NAA/Alternative 1)	Dam removal alternative (DRA/Alts 2 and 3)
1	$KLAMCHNK^{NAA} = KLAMCHNK_{mean(01-05)}$	$KLAMCHNK^{DRA} = KLAMCHNK^{NAA} \times PCTHARV$
2	$KLAMCHNK_i^{NAA} = \alpha_i \times KLAMCHNK^{NAA}$	$KLAMCHNK_i^{DRA} = \alpha_i \times KLAMCHNK^{DRA}$
3	$TOTCHNK_i^{NAA} = KLAMCHNK_i^{NAA} / EXPAND_i$	$TOTCHNK_{i,}^{DRA} = KLAMCHNK_{i,}^{DRA} / EXPAND_i$
4	$TOTCHNKLB_i^{NAA} = TOTCHNK_i^{NAA} \times LBFISH$	$TOTCHNKLB_i^{DRA} = TOTCHNK_i^{DRA} \times LBFISH$
5	$GROSSREV_i^{NAA} = TOTCHNKLB_i^{NAA} \times PRICE$	$GROSSREV_i^{DRA} = TOTCHNKLB_i^{DRA} \times PRICE$
6	$NETREV_i^{NAA} = GROSSREV_i^{NAA} \times PCTREV$	$NETREV_i^{DRA} = GROSSREV_i^{DRA} \times PCTREV$
Note: Variables with subscripts NAA and DRA 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 troll harvest of Klamath River Chinook under NAA (# fish, all areas).

$KLAMCHNK_{mean(01-05)}$ = average troll harvest of Klamath River Chinook during 2001-05 (# fish, all areas).

$KLAMCHNK^{DRA}$ = average annual troll harvest of Klamath River Chinook under DRA (# fish, all areas).

PCTHARV = percent increase in Klamath Chinook harvest under DRA, as projected by EDRRA model (see Appendix B.1.b).

$KLAMCHNK_i^{NAA}$ = annual harvest of Klamath River Chinook (# fish) in area i under NAA.

$KLAMCHNK_i^{DRA}$ = annual harvest of Klamath River Chinook (# fish) in area i under DRA.

α_i = proportion of troll-caught Klamath River Chinook harvest occurring in area i under NAA and DRA (see Table B-2)

$TOTCHNK_i^{NAA}$ = annual Chinook harvest (# fish, all stocks) in area i under NAA

$TOTCHNK_i^{DRA}$ = annual Chinook harvest (# fish, all stocks) in area i under DRA

$EXPAND_i$ = expansion factor used to project Chinook harvest (all stocks) associated with access to Klamath Chinook in each area i under NAA AND DRA (see Table B-2)

$TOTCHNKLB_i^{NAA}$ = annual Chinook harvest (# pounds dressed weight, all stocks) in area i under NAA

$TOTCHNKLB_i^{DRA}$ = annual Chinook harvest (# pounds dressed weight, all stocks) in area i under DRA

LBFISH = average pounds dressed weight per Chinook (see Table B-2)

$GROSSREV_i^{NAA}$ = annual gross ex-vessel revenue (all stocks, 2012$) in area i under NAA

$GROSSREV_i^{DRA}$ = annual gross ex-vessel revenue (all stocks, 2012$) in area i under DRA

PRICE = ex-vessel price per pound dressed weight (2012$) (see Table B-2)

$NETREV_i^{NAA}$ = annual net revenue (all stocks, 2012$) in area i under NAA

$NETREV_i^{DRA}$ = annual net revenue (all stocks, 2012$) in area i under DRA

PCTREV = net revenue as percent of gross revenue (see Table B-2)

Table B-2. Parameter values used to estimate Klamath Chinook and total Chinook harvest (all stocks), and gross and net revenue by management area under the no-action and action alternatives.

Parameter	Management Area						
	Monterey	SanFran	FtBragg	KMZ-CA	KMZ-OR	CentralOR	NorthernOR
α_i	0.047	0.344	0.179	0.043	0.019	0.278	0.090
$EXPAND_i$	1.000	0.058	0.065	0.199	0.107	0.062	1.000
LBFISH	11.9	11.9	11.9	11.9	11.9	11.9	11.9
PRICE	3.59	3.59	3.59	3.59	3.59	3.59	3.59
PCTREV	0.813	0.813	0.813	0.813	0.813	0.813	0.813

α_i = proportion of Klamath River Chinook harvested by troll fishery in management area I, estimated using 2001-05 fishery data (data source: Michael O'Farrell, NMFS).

$EXPAND_i$ = ratio of total Chinook harvest (all stocks) to Klamath Chinook harvest in management area i, estimated using 2001-05 fishery data (data source: Michael O'Farrell, NMFS).

LBFISH = mean weight (pounds dressed weight) per troll-caught Chinook south of Cape Falcon during 2001-05 (data source: PFMC 2011b).

PRICE = mean ex-vessel price per pound dressed weight of troll-caught Chinook south of Cape Falcon, estimated using 2004-05 fishery data (data source: PFMC 2011b).

PCTREV = estimated percent of gross salmon troll revenue remaining after payment of trip expenses (source: Jerry Leonard, NMFS)

DERIVATION OF PCTHARV

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

$$PCTHARV=1/T \sum_{t=1,\ldots,T} \{Median_{t,j=1,\ldots,1000} [(KLAMCHNK_{t,j}^{DRA*} - KLAMCHNK_{t,j}^{NAA*})/ KLAMCHNK_{t,j}^{NAA*}]\} \quad [B1]$$

where

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

$KLAMCHNK_{t,j}^{DRA*}$ = troll 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.

DERIVATION OF PRICE

Over the past three decades, ex-vessel salmon prices have been heavily influenced by national and international market conditions. The relatively low prices of farmed salmon and the rapid increase in farmed salmon imports since the 1980s (Figure B-1) resulted in declining prices for both west coast and Alaska salmon (Figure B-2). The reversal of this trend, which began in 2002, is attributed to a number of factors, including increasing prices of farmed salmon compounded by growing consumer differentiation between wild and farmed salmon.

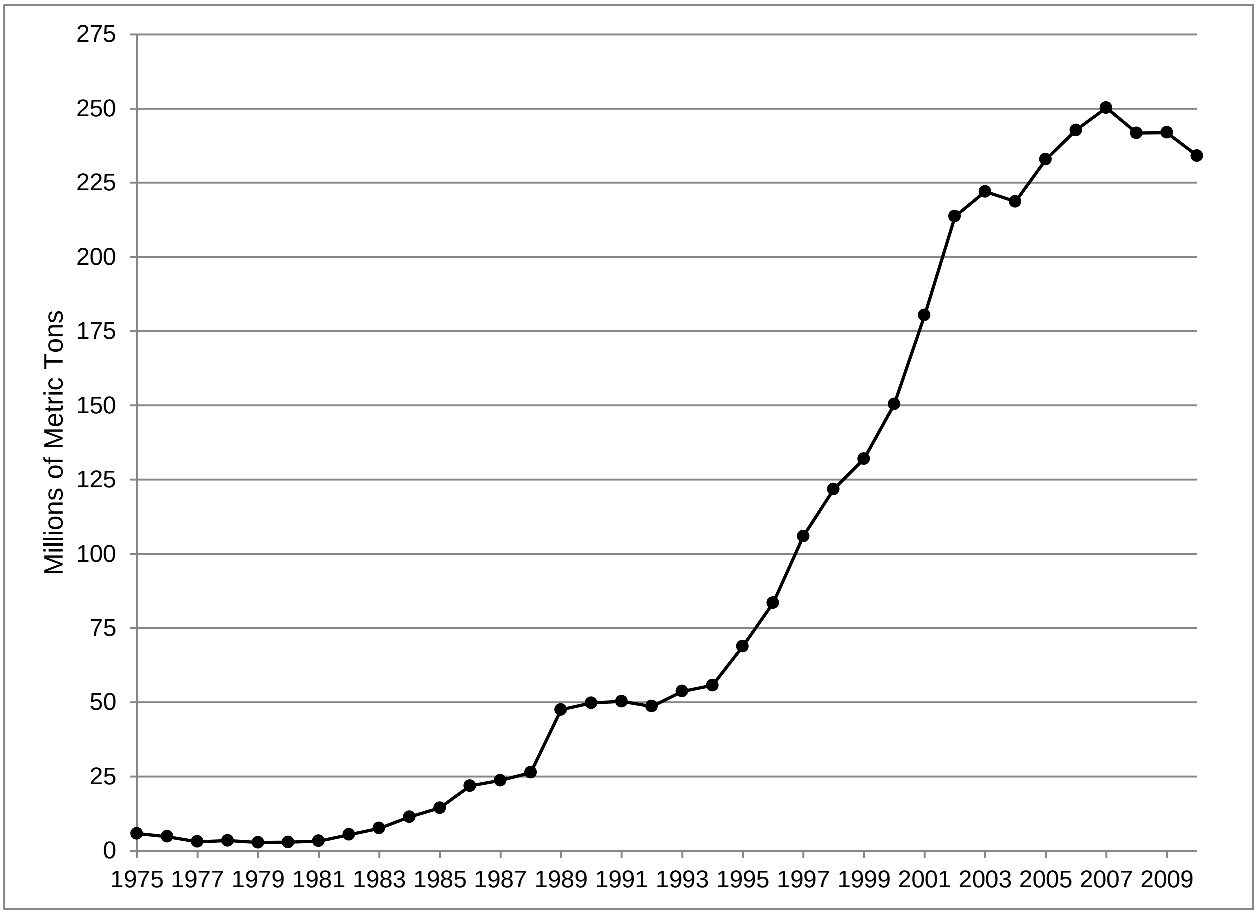

Figure B-1. Imports of edible salmon products into the U.S., 1975-2010 (source: NOAA National Marine Fisheries Service, Office of Science and Technology, Silver Spring, MD).

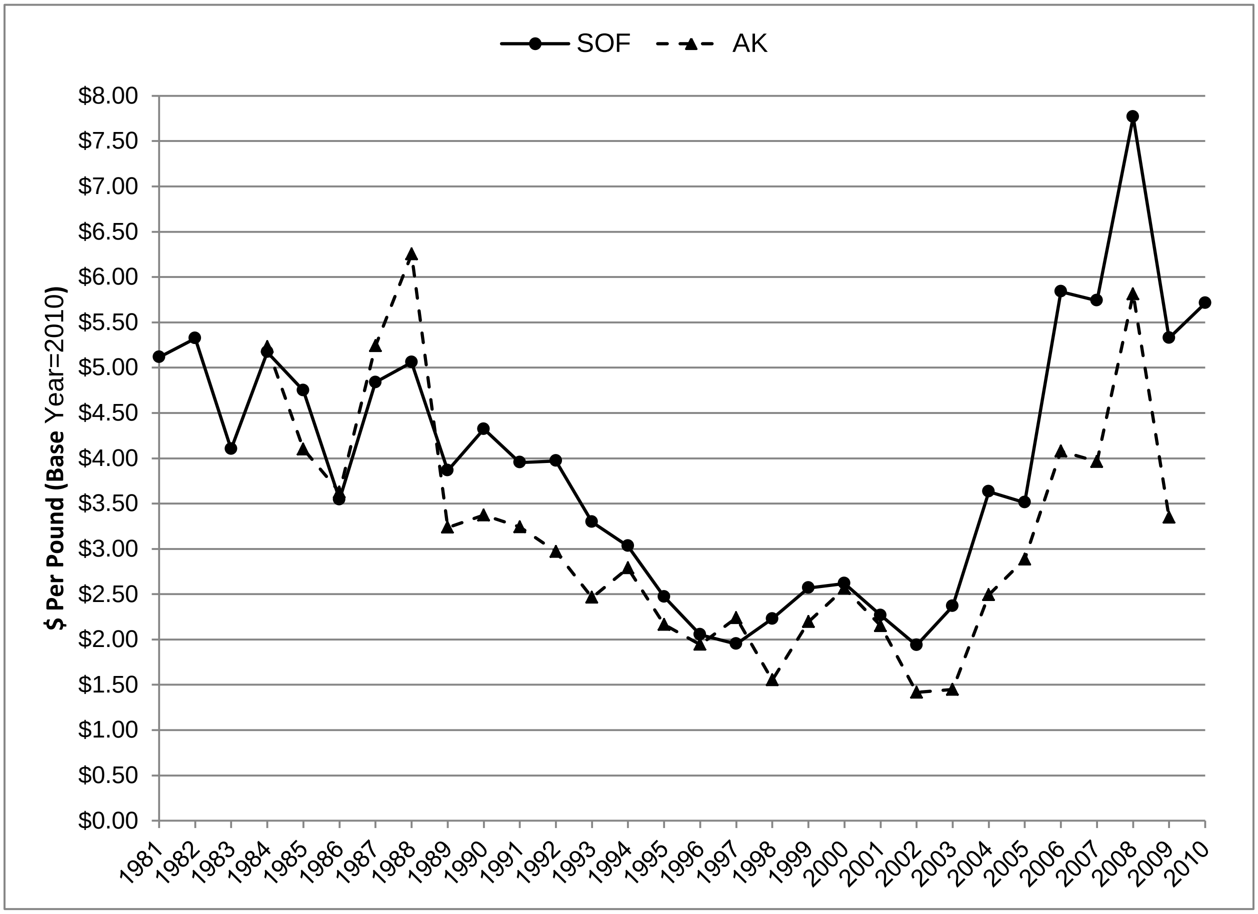

Figure B-2. Ex-vessel prices of troll-caught Chinook in California and Oregon south of Cape Falcon during 1981-2010 and in Southeast Alaska during1984-2009 (2012$) (sources: PFMC 1998, 2011b; ADFG 2009).[20]

The record high prices during 2006-10 coincided with years of record low landings on the west coast (Figure B-3), suggesting that the precipitous landings decline in those years was sufficiently large to have its own influence on prices. PRICE (the ex-vessel price of troll-caught Chinook south of Cape Falcon, Oregon) was calculated based on fishery data for 2004-05 – a period where prices reflect recent consumer preferences and more moderate fishery conditions than 2006-10.

[20] To help ensure comparability with prices of troll-caught Chinook south of Cape Falcon, Oregon, Alaska prices pertain to Chinook harvested in Southeast Alaska, where a large majority of the commercial Chinook harvest is caught with troll gear (85 percent in 2010, according to Skannes *et al.* 2011).

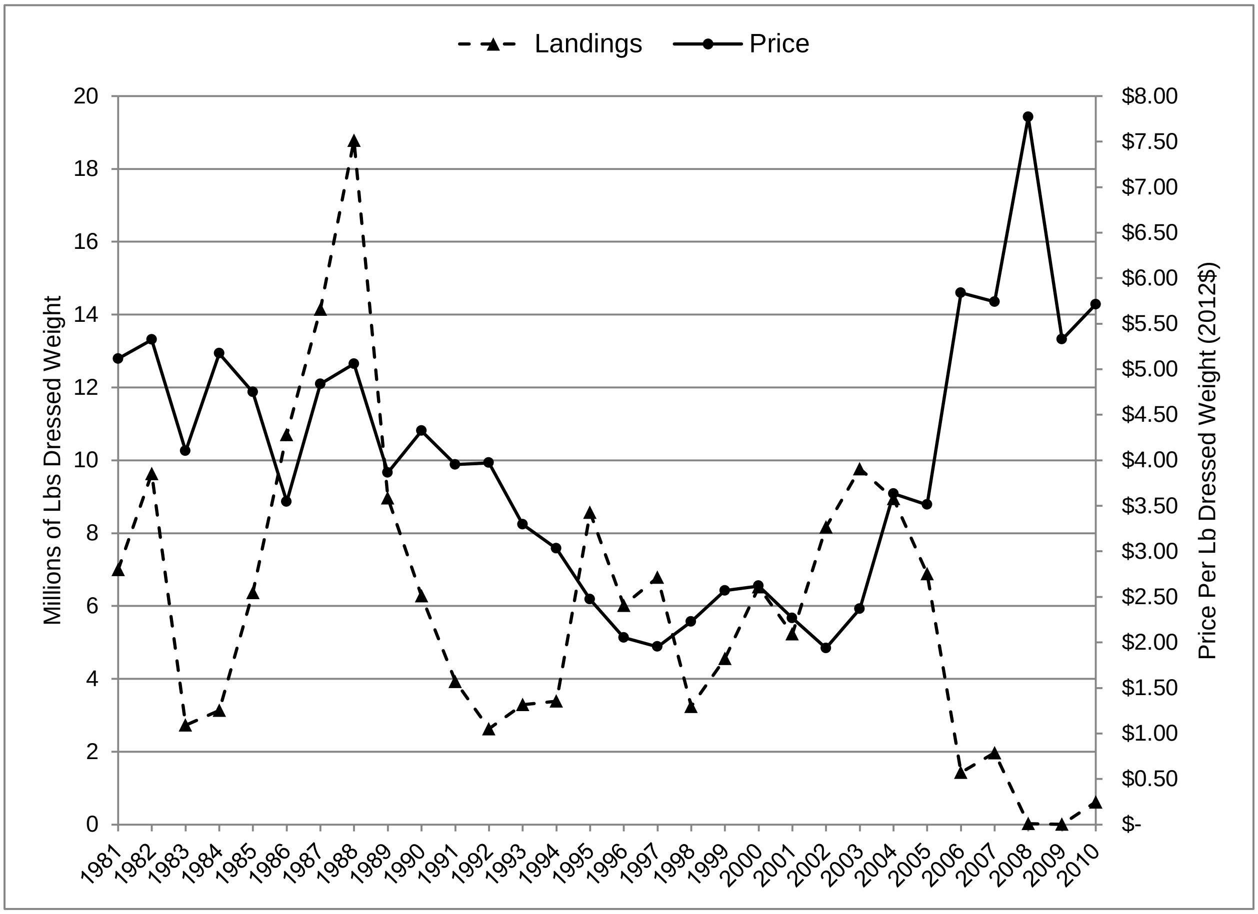

Figure B-3. Annual landings (pounds dressed weight) and ex-vessel price (2012$) of troll-caught Chinook south of Cape Falcon, Oregon, 1981-2010 (sources: PFMC 1990, 1991, 1998, 2001, 2011b).

ESTIMATION OF DISCOUNTED PRESENT VALUE OF NET REVENUE

The NED analysis (Section IV) involved estimation of the discounted present value of net revenues; this requires that a discount factor be applied to net revenue in each year of the 50-year projection period. In order to estimate net revenue for each year t, average annual net revenue (all areas) 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 net revenues as well as harvest, due to the proportional relationship between harvest and net revenues. Specifically:

NETREVtAlt1 = NETREVAlt1 x KLAMCHNKtNAA* / KLAMCHNKmean(12-61)NAA* [B2]

where

NETREVAlt1 = average annual net revenue (all areas) under Alternative 1 ($17.1 million, according to Table IV-1), and

KLAMCHNKtNAA* / KLAMCHNKmean(12-61)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 net revenue for each year t under Alternative 2 (NETREVtAlt2) was similarly calculated, as follows:

NETREVtAlt2 = NETREVAlt2 x KLAMCHNKtDRA* / KLAMCHNKmean(12-61)DRA* [B3]

where

NETREVAlt2 = average annual net revenue (all areas) under Alternative 2 ($24.4 million, according to Table IV-2), and

KLAMCHNKtDRA* / KLAMCHNKmean(12-61)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 revenue under Alternative 2 relative to Alternative 1 was estimated as follows:

DPV= ∑t=2012,…,2061 [(NETREVt Alt2 - NETREVt Alt1)] (1+r)-t [B4]

where

NETREVt Alt1 and NETREVt Alt2 = net revenue projection in year t for Alternatives 1 and 2 respectively, calculated on the basis of equations [B2] and [B3] above; and

r = discount rate.

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:

$PCTYRS=1/T \sum_{t=1,\ldots,T} \{(1/1000)\ COUNT_{t,j=1,\ldots,1000}\ [KLAMCHNK_{tj}^{DRA*}>KLAMCHNK_{t,j}^{NAA*}]\}$ [B5]

where

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

$KLAMCHNK_{t,j}^{DRA*}$ = troll 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.

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:

$PCTDIFF = 1/T \sum_{t=1,\ldots,T} \{[COUNT_{t,j=1,\ldots,1000}^{DRA*} (ESCAPE_{tj}^{DRA*} \leq 30{,}500)$

$- COUNT_{t,j=1,\ldots,1000}^{NAA*} (ESCAPE_{tj}^{NAA*} \leq 30{,}500)]/$

$COUNT_{t,j=1,\ldots,1000}^{NAA*} (ESCAPE_{tj}^{NAA*} < 30{,}500)\}$ [B6]

where

$ESCAPE_{t\,j}^{NAA*}$ = pre-h arvest 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.

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This is a web-based report and meant to be accessed online. Please note that this PDF version does not include some transitional material included on the website. Please reference as follows:

Full report :

Levin, P.S., B.K. Wells, M.B. Sheer (Eds). 2013. California Current Integrated Ecosystem Assessment: Phase II Report. Available from ***http://www.noaa.gov/iea/CCIEA-Report/index***.

Chapter (example):

K.S. Andrews, G.D. Williams, and V.V. Gertseva. 2013. Anthropogenic drivers and pressures, In: Levin, P.S., Wells, B.K., and M.B. Sheer, (Eds.), California Current Integrated Ecosystem Assessment: Phase II Report. Available from ***http://www.noaa.gov/iea/CCIEA-Report/index***.

Appendix, example for MS5:

Gray, I.A., I.C. Kaplan, I.G. Taylor, D.S. Holland, and J. Leonard. 2013. Biological and economic effects of catch changes due to the Pacific Coast Groundfish individual quota system, Appendix MS5, Appendix to: Management testing and scenarios in the California Current, In: Levin, P.S., Wells, B.K., and M.B. Sheer (Eds.). California Current Integrated Ecosystem Assessment: Phase II Report. Available from ***http://www.noaa.gov/iea/CCIEA-Report/index***.