EXECUTIVE SUMMARY OF PRELIMINARY DRAFT PACIFIC COAST SALMON PLAN AMENDMENT 15: AN INITIATIVE TO PROVIDE FOR DE MINIMIS FISHING OPPORTUNITY FOR KLAMATH RIVER FALL-RUN CHINOOK SALMON

This Salmon Fishery Management Plan (FMP) amendment process began in November 2005, for the purpose of initiating an FMP amendment to consider *de minimis* fisheries associated with impacts on Klamath River fall run Chinook salmon (KRFC). The initial interest in the amendment was the result of constraints on the 2005 fishery due to depressed status of KRFC, which precluded access to a record forecast abundance of California Central Valley fall run Chinook salmon. The purpose of this action is to provide for minimal or *de minimis* salmon fishery impacts to KRFC during times when the conservation objective for the stock precludes fishery access to co-mingled Chinook salmon stocks. This action is needed to prevent a level of fishery restrictions that can lead to severe economic consequences to local communities that target more robust salmon stocks, which are typically available for harvest in the Council area, while ensuring the long-term productive capacity of KRFC is not jeopardized. Currently, this can be addressed only through the emergency regulation process as provided in the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and implemented by the National Marine Fisheries Service (NMFS).

The alternatives considered for this amendment address only KRFC, and include:

1. Status quo (no fishing);
2. A sliding scale allowing increasingly lower total ocean and river fishery impacts (catch + incidental mortality) as stock abundance decreases;
3. A 5% age-4 ocean impact rate cap;
4. A 16% age-4 ocean impact rate cap;
5. A rebuilding feature that would limit *de minimis* fisheries to no more than three consecutive years, with a minimum of three consecutive years with escapement above the 35,000 natural spawner floor before additional *de minimis* fisheries could occur; and
6. The prohibition of any fall/winter fisheries (September 1 through March 14) following spring/summer (March 15 to August 31) *de minimis* fisheries.

Alternatives 5 and/or 6 would be in concert with one of the *de minimis* fishery Alternatives (2, 3, or 4) above.

The criteria used to evaluate the Alternatives include:

1. The probability of a natural spawning escapement lower than any historically observed (12,000).
2. The probability of any of the major mid-Klamath Basin substock (Shasta, Scott, or Salmon rivers) having a natural spawning escapement of less than 500 adults in any year.
3. The probability of a spawning escapement below the 35,000 natural spawner floor in any year.
4. The probability of three consecutive years of spawning escapement less than the 35,000 floor within a 40-year time period.
5. The probability that hatchery egg collection goals will be met every year.
6. The probability of meeting the terms of the NMFS consultation standard for the California Coastal Chinook evolutionary significant unit, which is an Ocean harvest rate of no more than 16.0% on age-4 KRFC.
7. Annual community and state level personal income impacts generated from Council-area commercial and recreational salmon fisheries, and river tribal and recreational salmon fisheries.

The criteria were evaluated relative to the Status Quo Alternative, which assumed no fisheries that impact KRFC would be allowed if the projected natural spawning escapement was less than the 35,000 floor.

The primary analyses used to evaluate the alternatives included:

1. A hindcast model that applied the alternatives to past season's population structure to estimate compliance with the stock's conservation objectives. This provided an historical perspective of implementation frequency and fishery effect of the *de minimis* fishery alternatives (Appendices D and E).
2. An age structured stochastic stock recruitment model (SSRM) that generates probabilities of population events such as spawning escapement below certain thresholds, which are used to estimate the effects of the alternatives on the KRFC population and to compare results among alternatives (Appendix F).
3. An economic assessment of ocean fisheries using generic season expectations based on the 2006 Klamath Ocean Harvest Model (KOHM) and historical total catch levels (Appendix H).

The methods used in the analyses are included in appendices D, E, F, and H. Appendix F also includes a more detailed examination of the results of the SSRM analysis.

The very brief summary of preliminary results presented in the following tables include an analysis of a 10% ocean impact rate cap to provide additional resolution between the 5% and 16% Cap Alternatives.

The Status Quo Alternative has no fishing in any area except some winter/spring recreational fisheries in Fort Bragg, and Central and Northern Oregon. (Table ES-1) The allowable fishing time provided by the four *de minimis* fishing scenarios appears to decline in a linear manner from several months of troll fishing under the 16% Cap Alternative to less than three weeks of troll fishing under the Sliding Scale Alternative.

The SSRM analysis predicts a higher probability than the hindcast analysis that escapement would be below the 35,000 floor in any one year, or for three consecutive years (Table ES-2). The SSRM uses 40 years*200 iterations (800 possibilities) as opposed to the hindcast method, which has only 16 years to evaluate, so the difference in outcome is not unexpected.

The differences in economic impacts among alternatives are small for the short-term analysis of recreational fisheries, except for Status Quo, because full fishing is allowed under all Alternatives except Status Quo. The difference between Status Quo and the other alternatives would be smaller if revenue from the Fort Bragg and Oregon winter/spring fisheries had been included. The long-term analysis of the troll fishery also indicates little difference among the alternatives, primarily because there is little influence of the few years with *de minimis* fisheries on long-term average revenues. There is, however substantial differences among the alternatives for the short-term troll economic impacts, which appear to decline linearly from the 16% Cap Alternative to the Status Quo Alternative. There has been no analysis of the level at which participants in the troll fishery would begin to drop out, or when infrastructure losses would occur, although this could be potentially important information.

The analyses were not sufficiently complete to estimate values for some of the criteria in time for the September briefing book, including:

1. The probability of Klamath Basin substocks having a natural spawning escapement of less than 500 adults in any year; and
2. Economic analyses of the Klamath River tribal and recreational fisheries.

Table ES-1. Season structure scenarios (January-August only) for individual de minimis fishing alternatives and California Coastal Chinook salmon consultation standard. The Status Quo Alternative is for a Conservation Alert Year. Alternatives are expressed as ocean impact rates.[1/]

	Alternative					CCC standard
Season	Status Quo	2.5%[2/]	5%[3/]	10%	16%	(16% OHR)
Sport Season Outside KMZ	43 days, FB, Feb-March; 47 days, NO/CO, March-April	full	full	full	full	full
KMZ Sport:	closed	45 days, May-June[4/] else closed	22 days, May-June	82 days, May-July	Full season (123 days): May-August plus previous fall fishery	Full season (123 days): May-August plus previous fall fishery
OR Troll	closed	10 days, NO, March	45 days, NO, March-April	98 days, NO, March-June; 30 days, CO, April	61 days, NO and CO, March-April; 92 days NO, May-July	92 days, NO and CO, March-May; 63 days, NO, June-August
CA Troll	closed	17 days, SF & MO, August	7 days, MO, May: 31 days, SF & MO, August	38 days, MO, May-June; 31 days, SF & MO, August	53 days, MO, May-June; 31 days, SF & MO, August	58 days, MO, May-June; 31 days, SF & MO, August

1/ KMZ = Horse Mt., California to Humbug Mt., Oregon
OR = Oregon; CA = California
NO (Northern Oregon) = Florence south jetty to Cape Falcon, Oregon
CO (Coos Bay) = Florence south jetty to Humbug Mt., Oregon
SF (San Francisco) = Point Arena

2/ The 2.5% ocean impact rate is a mid-range point for the Sliding Scale Alternative.

3/ This scenario is somewhat less restrictive than the maximum age-4 impact on the Sliding Scale Alternative.

4/ The extra days, compared to the 5% Cap Alternative, are due to elimination of previous fall KMZ sport catches.

Table ES-2. Comparison of alternatives relative to evaluation criteria, including a 10% cap analysis.

Impact Criterion	Method	Status quo	Sliding Scale	≤5% Cap	≤10% Cap	≤16% Cap	Rebuilding	Precautionary
KRFC Criteria								
Probability of a natural spawning escapement lower than any historically observed (12,000) in any one year.	Hindcast	Low[1]	Low	Low	Low	Low	NA	NA
	SSRM	1.2%	1.2%	1.9%	5.1%	17.7%	NA	
Probability of any of the major mid-Klamath Basin substocks having a natural spawning escapement of less than 500 adults in any year.	SSRM	NA	NA	NA	NA	NA	NA	NA
Probability of a spawning escapement below the 35,000 natural spawner floor in any year.	Hindcast	9.1%	13.6%	13.6%	31.8%	50.0%	NA	Same as Other Alternatives
	SSRM	39.2%	37.7%	40.2%	42.7%	48.8%	NA	
Probability of three consecutive years of spawning escapement less than the 35,000 floor within a 40-year time period.	Hindcast	Low	Low	Low	Low	100%[2]	Yes for 16%	NA
	SSRM	90.5%	88.5%	91.5%	91.0%	93.0%	Same as Other Alternatives	
Probability that hatchery egg collection goals will be me every year.	SSRM	75.7%	75.8%	75.5%	74.3%	71.4%	NA	NA
ESA Consultation Standards								
Probability of exceeding Klamath fall Chinook Age-4 ocean harvest rate CCC ESA standard) of ≤16.0%within a 40 year period.	SSRM	70.8%	70.2%	70.1%	73.7%	81.9%	NA	NA
Socio-Economic Criteria								
Recrational fishery local and state impacts	I/O Model/ Conservation Alert	$0[3]	$22.5M	$21.8M	$23.9M	$26.3M	NA	NA
Troll fishery local and state impacts	I/O Model/ Conservation Alert[3]	$0[3]	$2.2M	$5.9M	$13.9M	$19.7M	NA	NA
	I/O Model/ Long-term Analysis[4]	$17.1M	$17.0M	$17.7M	$18.8M	$19.4M	NA	NA
Tribal fishery impacts	NA	NA	NA	NA	NA	NA	NA	NA
River recreational fishery impacts	NA	NA	NA	NA	NA	NA	NA	NA

1/ Low probibility, but no precise estimate.

2/ Based on 2 events in 16 yrs, which exludes 1985-1988 and 2004-2006.

3/ Some revenue would generated from fisheries with no observed KRFC impacts (e.g.,March-April Oregon Recreational), but was not estimated.

4/ Medium success rate scenario used.

APPENDIX D. Carry-over effect of 16% Cap Alternative.

The hindcast analysis was static in part because the effect of reduced stock size due to *de minimis* fishing was not evaluated relative to impacts on future recruitment. *De minimis* fishing also affects age-3 and age-4 fish that would carry-over in the ocean for one or two more summers. The effect of the 16% Cap Alternative on carry-over of age-3 and age-4 KRFC was analyzed based on the ocean survival probability of the 16% Cap Alternative compared to the Status Quo Alternative.

The 16% Cap Alternative is the most liberal of the Council's *de minimis* fishery alternatives, and the relative impact of the other *de minimis* fishing alternatives on ocean carry-over of age-3 and age-4 KRFC can be inferred from the following results.

Methods

The approach used was to estimate (adjust) ocean abundance levels in years following the implementation of the 16% Cap Alternative, which were analyzed in the text in Section 4.1.2. The formulas were:

N(t).4.adj = N(t).4.pre * [1-i(A,t-1*.20)] / [1-i(SQ,t-1*.20)].

N(t).5.adj = N(t).5.pre. * { [1-i(A,t-2*.20)] / [1-i(SQ,t-2*.20)] } * { [1-i(A,t-1)] / 1-i(SQ,t-1)] }

where,

N(t).4.pre and N(t).5.pre are the year t preseason forecasts of record,
i(A,t) is the age-4 ocean impact rate in year t under alternative A (16% Cap in this case), and
i(SQ,t) is the age 4 ocean impact rate in year t under status quo management, which was assumed to be 0.4 x the status quo spawner reduction rate. Both of these harvest rates were reduced by 80% to account for the lower vulnerability and smaller size of age-3 fish compared to age-4 fish. No adjustment was applied for fish carrying over from age-4 to age-5

The above ratios approximate the reduction in ocean survival with the 16% Cap Alternative compared to Status Quo. The Rebuilding Alternative which precludes further *de minimis* fishing after three successive years of failure to meet the natural adult spawner floor was not applied to this analysis.

Results

Implementation of the 16% Cap had a slight ripple effect in the ocean population sizes of age-4 and age-5 fish, which affected 13 (59%) of the 22 years in the series. The differences between unadjusted (static) and adjusted ocean population sizes over the entire series were small: 0.4% reduction in ocean population size of age-4 fish and 1.2% of age-5 fish. Abundance of natural spawners in the absence of fishing for the entire series declined by an average of 200 fish per year (0.2%). Considering only the years affected by *de minimis* fishery carry-over effect, the population size reductions were higher at 1.1% for age-4 fish and 3.9% for age-5 fish. The reduction in natural run size in the absence of fishing in carry-over years was 0.4% (Table D-1).

Table D-1. Ocean abundance and natural spawner projections for hindcast analysis, 1985-2006 (thousands) showing unadjusted (static) and adjusted population levels under the status quo and 16% Cap alternatives.

	Ocean Abundance							No fishing natural spawners (static)	No fishing natural spawners (adjusted)
Season	Age 3	Age 4 (static)	Age 4 (adjusted)	Age 5 (static)	Age 5 (adjusted)	Total (static)	Total (adjusted)		
1985	113.0	56.9	56.9	0.0	0.0	169.9	169.9	38.4	38.4
1986	426.0	66.3	64.6	0.0	0.0	492.3	490.6	81.5	80.8
1987	511.8	206.1	206.1	5.3	5.2	723.2	723.1	154.8	154.7
1988	370.8	186.4	186.4	13.3	13.3	570.4	570.5	133.1	133.2
1989	450.6	215.5	215.5	10.1	10.1	676.2	676.2	153.8	153.8
1990	479.0	50.1	50.1	7.6	7.6	536.8	536.7	85.5	85.5
1991	176.2	44.6	44.6	1.5	1.5	222.3	222.3	41.9	41.9
1992	50.0	44.8	43.9	1.3	1.2	96.0	95.1	26.0	25.6
1993	294.4	39.1	37.8	1.1	0.9	334.6	333.2	54.1	53.5
1994	138.0	86.1	85.8	0.5	0.5	224.6	224.2	54.2	54.1
1995	269.0	47.0	46.8	2.0	2.0	318.0	317.8	54.8	54.7
1996	479.8	268.5	267.6	1.1	1.1	749.4	748.5	175.0	174.6
1997	224.6	53.9	53.9	7.9	7.9	286.4	286.4	55.4	55.4
1998	176.0	46.0	45.9	3.3	3.3	225.3	225.2	43.4	43.4
1999	84.8	78.8	77.5	2.0	1.8	165.6	164.1	45.3	44.6
2000	349.6	38.9	38.4	1.4	1.3	389.9	389.2	61.1	60.8
2001	187.2	247.0	247.0	1.3	1.2	435.5	435.4	129.3	129.3
2002	209.0	143.8	143.8	9.7	9.7	362.5	362.5	94.8	94.8
2003	171.3	132.4	132.4	6.5	6.5	310.2	310.2	87.1	87.1
2004	72.1	134.5	134.5	9.7	9.7	216.3	216.3	72.3	72.3
2005	185.7	48.9	48.9	5.2	5.2	239.8	239.8	43.7	43.7
2006	44.1	63.7	62.7	2.2	2.0	110.0	108.8	32.5	32.0
All yrs (avg):		104.5	104.1	4.2	4.2	357.1	356.6	78.1	77.9
Static/adjusted:			1.004		1.012		1.001		1.002
Carry-over yrs (avg)		77.9	77.1	2.3	2.2			74.4	74.1
Static/adjusted:			1.011		1.039				1.004

The adjusted ocean population sizes did not change the years or frequency of implementation of the 16% Cap Alternative based on the hindcast analysis years of 1985-2006. The average natural escapement projection declined by about 100 fish (0.4%) compared to the unadjusted population projections. The natural escapement declined 200-300 fish (1%) in the very low abundance years of 1992 and 1999 (Table D-2) The spawner reduction rates for the adjusted population projections are shown in Table D-3.

Table D-2. Escapement projections to natural areas under unadjusted and adjusted status quo and 16% Cap alternatives, 1985-2006 (thousands). Seasons with no change in projections are omitted from the table for clarification. The actual SRRs are shown in Table D-3.

	Status quo		16% Cap		
Season	Unadjusted	Adjusted	Unadjusted	Adjusted	Diff
1985	35.0	35.0	22.3	22.3	0.00
1986	35.0	35.0	51.1	50.8	
1987	51.6	51.6	89.4	89.3	
1988	44.4	44.4	72.5	72.6	
1989	51.3	51.3	86.0	86.0	
1990	35.0	35.0	51.7	51.7	
1991	35.0	35.0	24.9	24.9	0.00
1992	26.0	25.6	14.2	14.0	0.01
1993	35.0	35.0	33.8	33.5	0.01
1994	35.0	35.0	30.9	30.9	0.00
1995	35.0	35.0	33.4	33.3	0.00
1996	58.3	58.2	100.7	100.5	
1997	35.0	35.0	30.8	30.8	0.00
1998	35.0	35.0	25.1	25.1	0.00
1999	35.0	35.0	24.7	24.4	0.01
2000	35.0	35.0	38.5	38.3	
2001	43.1	43.1	70.9	71.0	
2002	35.0	35.0	47.9	47.9	
2003	35.0	35.0	45.7	45.6	
2004	35.0	35.0	36.0	36.0	
2005	35.0	35.0	28.3	28.3	0.00
2006	32.5	32.0	17.0	17.0	0.00
avg=	31.1	31.1	23.8	23.7	0.00

Table D-3. Spawner reduction rates for unadjusted and adjusted status quo and 16% Cap alternatives, 1985-2006 seasons.

	Status quo		16% Cap	
Season	Unadjusted	Adjusted	Unadjusted	Adjusted
1985	8.8%	8.8%	41.8%	41.9%
1986	57.1%	56.7%	57.1%	56.7%
1987	66.7%	66.7%	66.7%	66.7%
1988	66.7%	66.7%	66.7%	66.7%
1989	66.7%	66.7%	66.7%	66.7%
1990	59.1%	59.1%	59.1%	59.1%
1991	16.4%	16.4%	40.5%	40.6%
1992	0.0%	0.0%	45.5%	46.1%
1993	35.3%	31.8%	37.5%	38.0%
1994	35.5%	34.4%	43.0%	43.1%
1995	36.1%	35.6%	39.1%	39.2%
1996	66.7%	66.7%	66.7%	66.7%
1997	36.8%	36.8%	44.4%	44.4%
1998	19.4%	18.8%	42.1%	42.2%
1999	22.7%	17.0%	45.4%	46.1%
2000	42.7%	41.4%	42.7%	41.4%
2001	66.7%	66.7%	66.7%	66.7%
2002	63.1%	63.1%	63.1%	63.1%
2003	59.8%	59.8%	59.8%	59.8%
2004	51.6%	51.6%	51.6%	51.6%
2005	19.9%	19.9%	35.3%	35.3%
2006	0.0%	0.0%	47.5%	47.7%

APPENDIX E. Formulas and data used in the hindcast analysis.

Section 1. Escapement goals under the de minimis fishery alternatives

The adult natural (*n*) area spawning escapement (E_n) goal under the status quo (E_n^{Q}), sliding scale (E_n^{S}), and fixed-cap (E_n^{F}) *de minimis* fishery alternatives are, respectively:

$$E_n^{\mathrm{Q}} = \begin{cases} E_n^0 & \text{, when } E_n^0 \le 35{,}000 \\ 35{,}000 & \text{, when } 35{,}000 < E_n^0 \le 105{,}000 \\ E_n^0 / 3 & \text{, when } E_n^0 > 105{,}000 \end{cases} \tag{0.1}$$

$$E_n^{\mathrm{S}} = \begin{cases} E_n^0(1 - 0.09(E_n^0 / 35{,}000)) & \text{, when } E_n^0 \le 38{,}889 \\ E_n^{\mathrm{Q}} & \text{, when } E_n^0 > 38{,}889 \end{cases} \tag{0.2}$$

$$E_n^{\mathrm{F}} = \min(E_n^0 - I_{n\text{-SE}}^{\mathrm{F}}\ , E_n^{\mathrm{Q}}), \tag{0.3}$$

where E_n^0 is the natural area escapement absent fisheries, and $I_{n\text{-SE}}^{\mathrm{F}}$ is the total number of impacts (all fisheries) under the fixed-cap alternative of natural area destined fish in spawner equivalent (SE) units[1] (Table 1 provides a list of notation). The quantity $I_{n\text{-SE}}^{\mathrm{F}} / E_n^0$ is not a fixed fraction under the fixed-cap alternative—not even in a particular year—as it depends on season-structure, age-structure, user-group harvest allocation, etc.

The natural area escapement absent fisheries is

$$E_n^0 = \sum_{a=3}^{5} R_a^0 \times g_a, \tag{0.4}$$

with

$$R_a^0 = N_a \times S_a \times m_a \times (1 - w_a), \tag{0.5}$$

where the subscript *a* denotes age {3,4,5}, R_a^0 is the river run abundance absent fisheries, g_a is the proportion of spawners that are destined for natural areas, N_a is the starting (Sept 1) ocean abundance, S_a is the annual survival rate absent fisheries, m_a is the maturation rate, and w_a is the out-of-basin stray rate.

For the fixed-cap alternatives, the total number of impacts (all fisheries) of natural area destined fish in spawner equivalent units is

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[1] SE units are the number of the referred to quantity that would have spawned in the *current year* absent fisheries, as distinguished from adult equivalent (AEQ) units which are the number that would have spawned in the *current or future years* absent fisheries.

$$I_{n\text{-SE}}^{\mathrm{F}} = \sum_{a=3}^{5} ((I_{o,a} \times p_{o,a}) + I_{r,a} + I_{t,a}) \times g_a, \tag{0.6}$$

where $I_{o,a}, I_{r,a}$, and $I_{t,a}$ are the impacts of the ocean (*o*), river recreational (*r*), and river tribal (*t*) fishery, respectively, and $p_{o,a}$ is the proportion of the $I_{o,a}$ that would have spawned at age *a* absent fisheries:

$$p_{o,a} = \sum_{\tau=\mathrm{Sept}}^{\mathrm{Aug}} I_{o,a,\tau} \times S_{a,\tau} \times m_a \times (1 - w_a) / I_{o,a}; \tag{0.7}$$

$I_{o,a,\tau}$ is the ocean age *a* impacts in month $\tau = \{\text{Sept, Oct, ..., Aug}\}$, and $S_{a,\tau}$ is the age *a* survival rate absent fisheries from month τ through the end of August (just prior to maturation). Under the fixed-cap alternatives, $I_{o,4}$ is constrained such that $I_{o,4} / N_4 \le i_{o,4}^{\mathrm{F}}$; the ocean age-4 impact rate cap, and the $\{I_{o,a,\tau}\}, \{I_{r,a}\}$, and $\{I_{t,a}\}$ are forecast by the KOHM subject to the $i_{o,4}^{\mathrm{F}}$ constraint and the user group harvest allocations. Note that while the tribal harvest allocation is annually fixed at 50% of the total allowable harvest, the river sport allocation is not determined by the PFMC—it is annually specified by the California Fish and Game Commission.

For each alternative A ={Q,S,F}, the spawner reduction rate (SRR) due to fishing is

$$SRR = 1 - E_n^{\mathrm{A}} / E_n^0. \tag{0.8}$$

Section 2. Hindcast analysis of escapement goals and spawner reduction rates under the de minimis fishery alternatives over the 1985-2006 period.

For the purpose of hindcasting, additional formulas consistent with the KOHM are presented below that allow one to approximate the annual escapement goal and spawner reduction rate under each of the *de minimis* fishery alternatives were they in effect during the 1985–2006 period.

For the ocean fishery:

$$I_{o,a} = N_a \times i_{o,4} \times v_{o,a} \quad \text{, where } v_{o,a} = i_{o,a} / i_{o,4}, \tag{0.9}$$

with $v_{o,a}$ denoting the ocean impact rate at age *a* relative to the age-4 rate. The ocean harvest total (H_o) may be expressed in terms of the $\{I_{o,a}\}$ and the age-specific harvest rate / impact rate ratios ($q_{o,a}$) as

$$H_o = \sum_{a=3}^{5} I_{o,a} \times q_{o,a} \quad \text{, where } q_{o,a} = h_{o,a} / i_{o,a}, \tag{0.10}$$

and $h_{o,a} = H_{o,a} / N_a$ is the ocean age *a* harvest rate.

For the river fisheries:

$$H_r = H_o \times \pi_r / (1-\pi_r) \quad , \quad H_t = H_o \times \pi_t / [(1-\pi_t)(1-\pi_r)], \tag{0.11}$$

where π_r is the proportion of the nontribal harvest allocated to the recreational fishery (H_r), and π_t is the proportion of the total harvest allocated to the tribal fishery (H_t). The age-specific river harvests are

$$H_{r,a} = H_r \times u_{r,a} \quad , \quad H_{t,a} = H_t \times u_{t,a}, \tag{0.12}$$

where $\{u_{r,a}\}$ and $\{u_{t,a}\}$ is the age-composition of the respective harvests, which depends on the age-specific abundances of the river run $\{R_a\}$ and on the gear selectivity of the respective fisheries:

$$u_{r,a} = \frac{R_a \times v_{r,a}}{\sum_{a=3}^{5} R_a \times v_{r,a}} \quad , \quad u_{t,a} = \frac{R_a \times v_{t,a}}{\sum_{a=3}^{5} R_a \times v_{t,a}}, \tag{0.13}$$

where the selectivity coefficients $\{v_{r,a}\}$ and $\{v_{t,a}\}$ are relative to the selectivity at age-4, and

$$R_a = R_a^0 - (I_{o,a} \times p_{o,a}). \tag{0.14}$$

Finally, the respective age-specific impacts are

$$I_{r,a} = H_{r,a} / (1-d_r) \quad , \quad I_{t,a} = H_{t,a} / (1-d_t), \tag{0.15}$$

with dropoff mortality rate values of $d_r = 0.02$ and $d_t = 0.08$.

Hindcast Methods:

For each year in the 1985–2006 period, the above formulas were applied to the yearly age-specific pre-season ocean abundance forecasts $\{\hat{N}_a\}$ to determine the yearly escapement goal and spawner reduction rate under each of the de minimis fishery alternatives were they in effect during this period. Values for several of the parameters in these formulas were not readily available for the 1985–2001 period, and for these years the average value of the parameters over the 2002–2006 period (Table 2) was used for the analysis. Harvest allocations of $\pi_r = 0.15$ and $\pi_t = 0.50$ (the norm values) were assumed for all years in the analysis. These simplifications should provide reasonably good approximations for the present purpose. Below, we superscript the formula-derived quantities by a “*”.

For the status quo and sliding scale alternatives:

1. E_n^{0*} was calculated according to equations (1.4) and (1.5) using $\{\hat{N}_a\}$ and the Table 2 quantities.
2. $E_n^{\mathrm{Q}*}$ and $E_n^{\mathrm{S}*}$ were determined by equations (1.1) and (1.2).
3. $SRR_n^{\mathrm{Q}*}$ and $SRR_n^{\mathrm{S}*}$ were calculated by equation (1.8).

For the fixed-cap alternatives:

1. E_n^{0*} and $\{R_a^{0*}\}$ were calculated according to equations (1.4) and (1.5) using $\{\hat{N}_a\}$ and the Table 2 quantities.
2. $\{I_{o,a}^*\}$ and H_o^* were calculated according to equations (1.9) and (1.10) using $\{\hat{N}_a\}$, the alternative's $i_{o,4}^{\mathrm{F}}$ cap, and the Table 2 quantities.
3. $\{I_{r,a}^*\}$ and $\{I_{t,a}^*\}$ were calculated according to equations (1.11–1.15) and using $\{\hat{N}_a\}$, $\{R_a^{0*}\}$, $\{I_{o,a}^*\}$, H_o^*, and the Table 2 quantities.
4. $I_{n\text{-SE}}^{\mathrm{F}*}$ was calculated by equation (1.6).
5. $E_n^{\mathrm{F}*}$ was determined by equations (1.3) and (1.1).
6. $SRR_n^{\mathrm{F}*}$ was calculated by equation (1.8).

For a particular year, $I_{n\text{-SE}}^{\mathrm{F}*}$ will be nearly proportional to $i_{o,4}^{\mathrm{F}}$ in this analysis owing to the linear nature of equations (1.4-1.15). (The $\{I_{o,a}\}$, I_r, and I_t are proportional to $i_{o,4}^{\mathrm{F}}$, but $\{I_{r,a}\}$ and $\{I_{t,a}\}$ are not because of the dependence of $\{u_{r,a}\}$ and $\{u_{t,a}\}$ on $\{R_a\}$ which is not proportional to $i_{o,4}^{\mathrm{F}}$.)

It is important to note that this analysis is *static*. It does not account for the reduction in the following year's preseason ocean abundance from the (hypothetical) implementation of de minimis fisheries (i.e. doesn't account for cohort carryover effects). Similarly, it does not account for changes to preseason ocean abundance in future years due to any changes in recruitment associated with the reduced number of spawners under *de minimis* fisheries.

Table 1. Notation used in the hindcast analysis.

Symbol	*Description*
0	Superscript denoting “absent fisheries”
a	Subscript denoting age, $a \in \{3,4,5\}$
A	Superscript denoting de minimis alternative, $\mathrm{A} \in \{\mathrm{F},\mathrm{Q},\mathrm{S}\}$
F	Fixed cap
Q	Status quo
S	Sliding scale
d	Dropoff mortality rate (dropoff mortality / impacts)
E_n	Escapement in natural areas
g	Proportion of spawners destined for natural areas
h	Harvest rate
H	Harvest
i	Impact rate
I	Impacts (harvest, hook-and-release, dropoff)
$I_{n\text{-SE}}$	Impacts of natural area destined fish in spawner equivalent units
k	Subscript denoting fishery sector, $k \in \{o,r,t\}$
o	Ocean
r	River recreational
t	River tribal
m	Maturation rate
N	Preseason ocean abundance
p	Proportion of impacts that would have spawned in current year absent fisheries
π_r	Proportion of nontribal harvest taken by river recreational fishery
π_t	Proportion of total harvest taken by river tribal fishery
q	Ratio: harvest rate / impact rate
R	River run abundance
S_a	Survival rate absent fisheries, age a
$S_{a,t}$	Survival rate absent fisheries, age a, month τ through Aug
SRR	Spawner reduction rate due to fisheries
τ	Subscript denoting month, $\tau \in$ {Sept, Oct, …, Aug}
u	Harvest age composition (proportion at age)
v	Vulnerability relative to age-4
w	Out-of-basin stray rate

Table 2. Parameters values used in hindcast analysis. The 2002–2006 values were taken from the KOHM adopted by the PFMC in those years, respectively.

Quantity	*2002*	*2003*	*2004*	*2005*	*2006*	**Average**
S_3	0.5848	0.5848	0.5848	0.5848	0.5848	0.5848
S_4	0.8	0.8	0.8	0.8	0.8	0.8
S_5	0.8	0.8	0.8	0.8	0.8	0.8
m_3	0.3747	0.3790	0.3806	0.3784	0.3815	0.3788
m_4	0.8809	0.8828	0.8882	0.8814	0.8812	0.8829
m_5	1.0	1.0	1.0	1.0	1.0	1.0
w_3	0.0057	0.0055	0.0052	0.0054	0.0063	0.0056
w_4	0.0038	0.0037	0.0035	0.0035	0.0046	0.0038
w_5	0.0029	0.0090	0.0085	0.0082	0.0090	0.0075
$p_{o,3}$	0.3586	0.3614	0.3637	0.3564	0.3650	0.3610
$p_{o,4}$	0.8249	0.8055	0.8075	0.7715	0.7518	0.7922
$p_{o,5}$	0.9151	0.8932	0.8316	0.8520	0.7951	0.8574
g_3	0.62	0.46	0.55	0.538	0.672	0.568
g_4	0.61	0.71	0.61	0.545	0.552	0.605
g_5	0.65	0.69	0.71	0.717	0.723	0.698
$v_{o,3}$	0. 3796	0.3071	0.2870	0.1957	0.1664	0.2672
$v_{o,4}$	1.0	1.0	1.0	1.0	1.0	1.0
$v_{o,5}$	1.1641	1.1562	2.2598	1.3770	6.6171	1.3770[*]
$q_{o,3}$	0.9110	0.8883	0.8637	0.8411	0.8442	0.8697
$q_{o,4}$	0.9437	0.9270	0.9099	0.8582	0.8305	0.8939
$q_{o,5}$	0.9511	0.9509	0.9432	0.9356	0.9225	0.9407
$v_{r,3}$	1.4	1.4	1.35	1.359	1.406	1.383
$v_{r,4}$	1.0	1.0	1.0	1.0	1.0	1.0
$v_{r,5}$	1.0	1.0	0.93	0.929	0.914	0.955
$v_{t,3}$	0.5	0.5	0.49	0.481	0.489	0.492
$v_{t,4}$	1.0	1.0	1.0	1.0	1.0	1.0
$v_{t,5}$	1.7	1.7	1.63	1.626	1.570	1.645

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[*] Median.

4.1.4 POPULATION VIABILITY ANALYSIS (PVA)

Summary

The biological analysis projected the effects of *de minimis* fishery implementation at various levels on future population size and fishery harvest. The key question is whether the effects low fishing rates in low run years on spawning escapement significantly affects future numbers. Projections were based on a Population Viability Analysis (PVA) using a stochastic, age-structured, stock-recruitment population model (SSRM). A population viability analysis is conceptually the same approach that has been applied to the identification of take limitations based on impact levels deemed to pose no jeopardy to future viability for listed salmon stocks under the ESA. The model is an adaption of the model previously used by Prager and Mohr (2001) to evaluate the effects of fishery alternatives.

The model estimates annual fish numbers, harvest, and fishery impacts based on fishery strategies including the historic management plan, the status quo, and alternative *de minimis* fishing rates. The fish population portion of the model estimates age-specific numbers of natural and hatchery-produced fish in the ocean, returning to the river, and escaping fisheries to return to natural spawning areas or hatcheries. The fishery portion of the model estimates encounter, harvest, and impact numbers and rates for ocean troll, ocean recreational, river net, and river recreational fisheries. The model is configured using historical Klamath Fall Chinook data on natural and hatchery production, survival, and maturation rates. Variability in fish population and fishery dynamics is incorporated into stochastic simulations with multiple iterations (e.g. 200) of a 40 year period beginning with current conditions. The model is built in Excel using Visual Basic. The current calibration of the model produces outputs that closely match historical averages and ranges of fish numbers and harvest in the ocean and the river.

The modeling confirms future effects of low fishing rates on escapement and harvest are lost in the normal real world variability in the system. Conclusions are the same as those previously reported by Prager and Mohr (2001) using a similar modeling approach. The model estimates a 39% frequency of escapements of less than 35,000 under current management (35,000 spawner floor and a 16% ESA limit on ocean fishery harvest rates of age 4 fish). Escapements regularly fall under the floor due to uncertain fishery forecasts and catchability. *De minimis* fishing rates of 2.5%, 5%, 10%, and 16% increase the absolute value of low run size risks by 0.4%, 1%, 3%, and 10% respectively. Frequencies of 2 or 3 consecutive years of escapements less than 35,000 are little affected by *de minimis* fisheries of 10% or less. *De minimis* fisheries would occur in 10-12% of years at rates of 5% or less and up to 17% of years at an impact rate of 16%. Average harvest and escapement of Klamath fall Chinook are little affected by the implementation of *de minimis* fisheries of 16% or less.

Concerns for effects of substock structure within the aggregate Klamath fall Chinook return were addressed with simulations examining the sensitivity of results to pessimistic assumptions of stock productivity, a negative trend in production, highly autocorrelated ocean survival patterns, and a depensatory stock-recruitment relationship at low spawner numbers. Sensitivity analyses to different combinations of input parameters confirm that the relative effects of *de minimis* fishing rates are consistent among different parameterizations of the model. This biological analysis evaluates the effects of fishing on the KRFC population and fishery, but does not directly consider the effects of the effects of KRFC harvest constraints on the much larger catches of other California and Oregon chinook stocks in ocean fisheries. These results will inform policy decisions on appropriate fishing strategies. Acceptable levels of effect and risk will remain a policy decision.

Methods

Model Description

The model estimates annual fish numbers, harvest, and fishery impacts based on various fishery strategies including the historic management plan, the status quo, and alternative *de minimis* fishing rates. The fish population portion of the model estimates age-specific numbers of natural and hatchery-produced fish in the ocean, returning to the river, and escaping fisheries to return to natural spawning areas or hatcheries. The fishery portion of the model represents represents fisheries in the Klamath Management Zone of the ocean and in the Klamath River system (ocean troll, ocean recreational, river tribal, and river recreational). Fishery variables include encounter, harvest, and impact numbers and rates. The model is configured using historical Klamath Fall Chinook data on natural and hatchery production, survival, and maturation rates. Fishery parameters include age and fishery-specific vulnerabilities, legal fractions, catch-release mortality rate, and drop-off mortality rate as well as the prescribed allocation of harvest among fisheries.

The model couples fishery dynamics with a Ricker stock-recruitment function in a stochastic framework. A stochastic approach allows explicit analysis of conservation and future fishery risks associated with fishing at low population levels. The model includes uncertainty and variability in both fish population and fishery dynamics. Stochastic simulations involve multiple iterations (e.g. 500) of a 40 year time interval beginning with current conditions. The 40 year period was based on the spawning escapement policy for Klamath River Fall Chinook (KRTT 1986). Results are expressed in terms of averages, variances, ranges, and frequeny distributions. Risks were expressed based on probabilities of various outcomes (e.g. probability of future spawning escapement of less than 35,000 fish).

The essential formulation of the model is depicted in Figure 1. The model is built in Excel using Visual Basic. A simple interface page facilitates model use and review. Fishery alternatives and inputs are configured to allow for simulation of different combinations and easy examination of results in statistical and graphical format. A more detailed description and discussion of the model formulation and results may be found in the appendix.

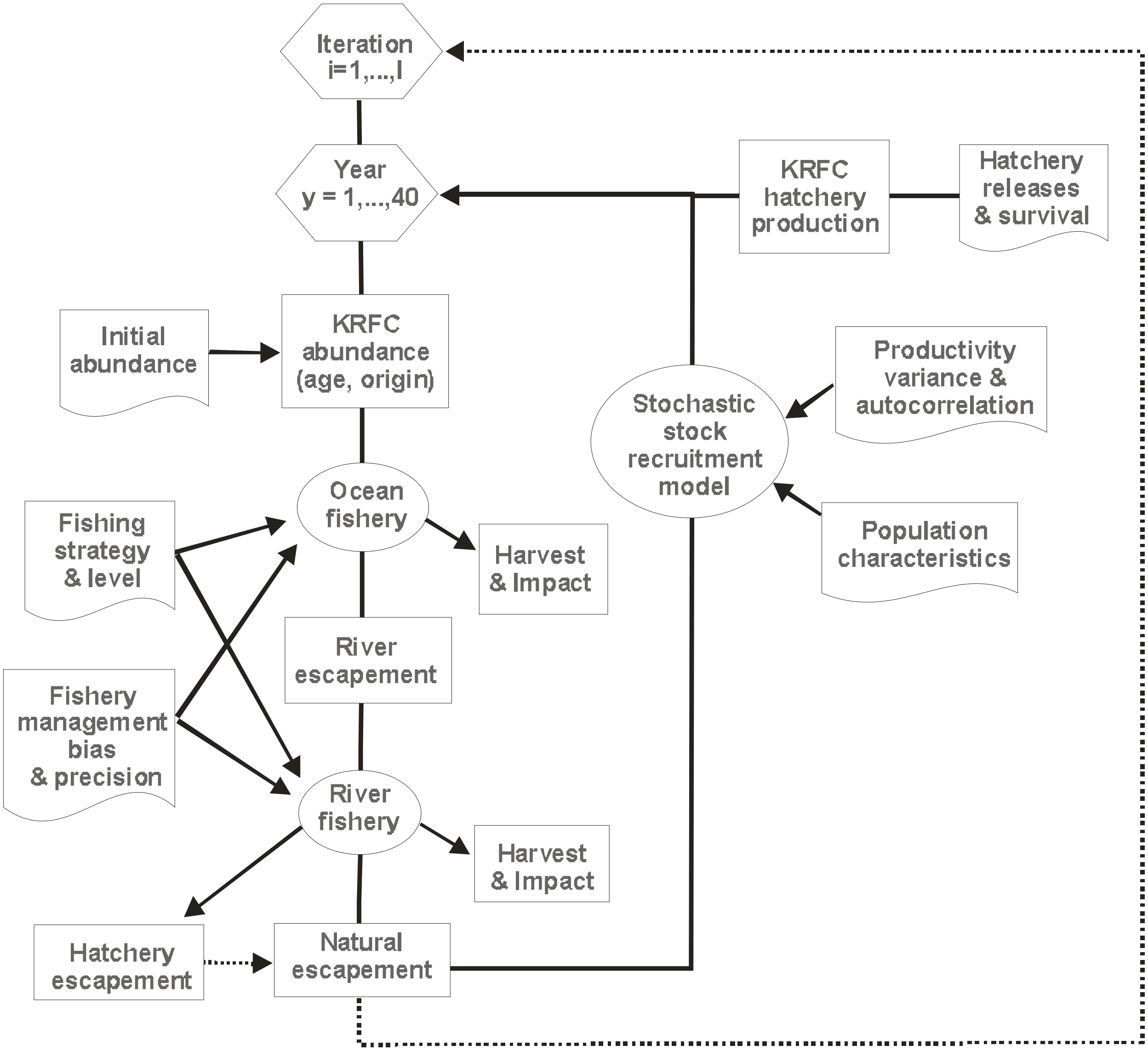


Figure 1. Model algorthim.

Fishery Alternatives

The model simulates the effects of fishery strategies identified as inputs by the user. Strategies are defined primarily based on the ocean fishery. Fishing rates consistent with each strategy are input as an ocean age 4 fishery impact rate unless otherwise identified. Fishery impacts include direct and indirect fishery mortalities from harvest, catch and release, and dropoff. Inriver fisheries are scaled to match ocean fisheries according to current legal requirements for tribal:non-tribal shares and Council policies or actions relative to non-tribal shares. Alternatives include:

Fixed rate.– A simple fixed fishing rate is included as a model option. This rate applies in all years regardless of fish abundance. This strategy was primarily used for model development and calibration purposes and does not represent a fihery alternative under consideration in the plan amendment.

Fishery Management Plan.– The historical fisheries management plan provides a baseline point of comparison representative of historical fishing patterns. For this option, the model calculates a fishing rate that takes all fish in excess of a prescribed natural spawning escapement floor (35,000) unless the spawner reduction rate is projected to exceed 67%, whereupon a fishing rate is selected to produce a 67% spawner reduction rate. Spawner reduction rate is defined as the proportional reduction in escapement relative to that projected in the absence of fishing. Under the fishery management plan alternative, no fisheries would occur in years of projected spawner escapements less than the spawner floor.

De minimis fishing rate.– A *de minimis* fishing rate strategy operates the same as the fishery management plan except that no fisheries occur in years of projected spawner escapements less than the spawner floor at a prescribed fishing rate (e.g. 5%, 10%, 16%). Fishing rate inputs for this option are defined as an ocean age 4 fishery impact rate.

Sliding scale.– The sliding scale is an alternative to a fixed *de minimis* ocean age-4 impact rate where the rate is reduced linearly from 4% to 0% at spawner projections between 39,000 and 0.

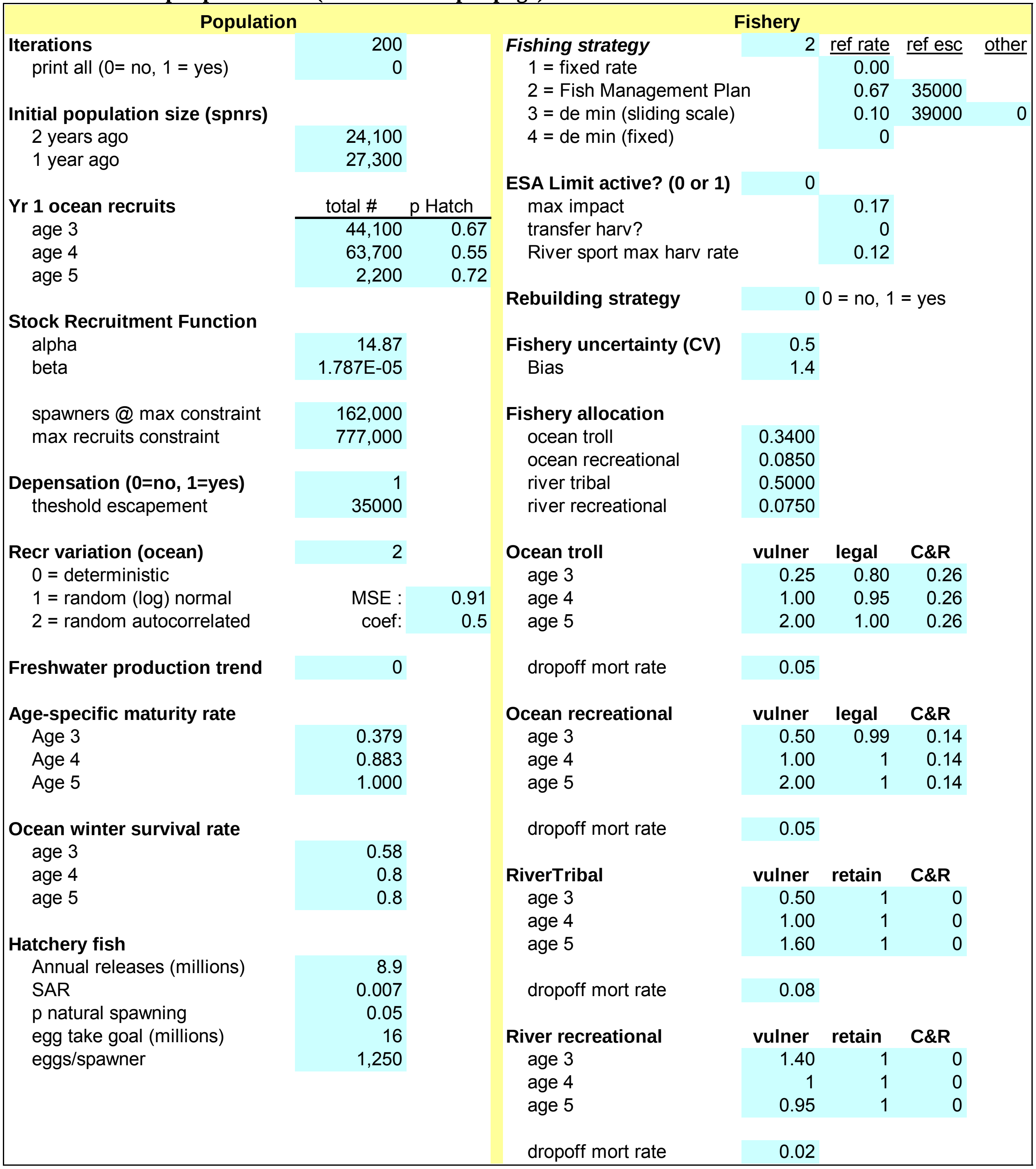
ESA constraint.– The ESA constraint may be used to cap the ocean fishery impact at a prescribed rate (e.g. 16% ocean age-4 harvest rate). This input works independent of other model fishery alternatives so that it can be used in combination with other alternatives. As per management practice, KRFC inputs foregone by ocean fisheries are transferred to the river sport fishery up to a harvest level limit based on the maximum observed in the historical dataset.

Recovery strategy.– The recovery strategy is another optional input that may be used in concert with *de minimis* fishery alternatives to limit implementation of *de minimis* fisheries following successive years of poor escapements. Like the ESA constraint, this option works independent of other fishery options so that it can be used in combination with other alternatives. Under this constraint, no *de minimis* fishery for KRFC may be prosecuted for more than three consecutive seasons, and if during all three of those years the spawner floor was not met, *de minimis* fishing could not occur until the stock met the floor for at least three consecutive seasons.

Model Variables and Parameters

A full list of model inputs may be found in Table 1. Descriptions of derivation and application of model variables and inputs are as follows:

Table 1. Model input parameters (from model input page).



Population		
Iterations	200	
print all (0= no, 1 = yes)	0	
Initial population size (spnrs)		
2 years ago	24,100	
1 year ago	27,300	
Yr 1 ocean recruits	total #	p Hatch
age 3	44,100	0.67
age 4	63,700	0.55
age 5	2,200	0.72
Stock Recruitment Function		
alpha	14.87	
beta	1.787E-05	
spawners @ max constraint	162,000	
max recruits constraint	777,000	
Depensation (0=no, 1=yes)	1	
theshold escapement	35000	
Recr variation (ocean)	2	
0 = deterministic		
1 = random (log) normal	MSE :	0.91
2 = random autocorrelated	coef:	0.5
Freshwater production trend	0	
Age-specific maturity rate		
Age 3	0.379	
Age 4	0.883	
Age 5	1.000	
Ocean winter survival rate		
age 3	0.58	
age 4	0.8	
age 5	0.8	
Hatchery fish		
Annual releases (millions)	8.9	
SAR	0.007	
p natural spawning	0.05	
egg take goal (millions)	16	
eggs/spawner	1,250	

Fishery				
Fishing strategy	2	ref rate	ref esc	other
1 = fixed rate		0.00		
2 = Fish Management Plan		0.67	35000	
3 = de min (sliding scale)		0.10	39000	0
4 = de min (fixed)		0		
ESA Limit active? (0 or 1)	0			
max impact		0.17		
transfer harv?		0		
River sport max harv rate		0.12		
Rebuilding strategy	0	0 = no, 1 = yes		
Fishery uncertainty (CV)	0.5			
Bias	1.4			
Fishery allocation				
ocean troll	0.3400			
ocean recreational	0.0850			
river tribal	0.5000			
river recreational	0.0750			
Ocean troll	**vulner**	**legal**	**C&R**	
age 3	0.25	0.80	0.26	
age 4	1.00	0.95	0.26	
age 5	2.00	1.00	0.26	
dropoff mort rate	0.05			
Ocean recreational	**vulner**	**legal**	**C&R**	
age 3	0.50	0.99	0.14	
age 4	1.00	1	0.14	
age 5	2.00	1	0.14	
dropoff mort rate	0.05			
RiverTribal	**vulner**	**retain**	**C&R**	
age 3	0.50	1	0	
age 4	1.00	1	0	
age 5	1.60	1	0	
dropoff mort rate	0.08			
River recreational	**vulner**	**retain**	**C&R**	
age 3	1.40	1	0	
age 4	1	1	0	
age 5	0.95	1	0	
dropoff mort rate	0.02			

Fishing rates.– Annual fishing rates were estimated in the model based on the designated fishing strategy and annual numbers of fish available as described above. The model uses different routines to identify a target fishing rate in each year for each fishery depending on the fishing strategy. The model uses ocean age 4 impact rates as a key metric for describing and scaling fisheries consistent with current management practice. Input fishing rates are typically entered as the ocean age 4 impact rate. Impacts include harvest, catch-release, and drop-off mortalities. The model scales fishery contact rates, harvest rates, and impact rates for each fishery to produce the desired impact or spawner reduction rate based on fishery allocation goals, age-specific fishery parameters, and age-specific fish numbers. Fishery allocations among ocean troll, ocean recreational, river tribal, and river recreational fisheries are a user input. Fishery parameters include vulnerability, proportion of catch that is retained, catch-and-release mortality rate, and drop-off mortality rate. The fishery formulations are similar to those in the KOHM annual fishery management model although parameters in the SSRM are annual rather than by month or area numbers. Fishery parameters are described in greater detail in Mohr et al. (2001) and Prager and Mohr (1999, 2001).

Fishery Variance.– The model included a fishery variance term to capture the effects of forecast error and variable fishing success on fishing rates. Fishery management variance results from the effects of uncertain forecasts, effort, and catch rates which are reflected in differences between in-season target and post season actual fishing rates (Figure 2). Thus, target fishing rates were randomly varied to produce a pattern equivalent to that observed in comparisons of target and actual fishing rates in post season analyses. The fishery variance input was expressed as a coefficient of variation consistent with observed heteroscedasticity of the error variance. Error variance in fishery impact rate is not constant over the range of rates but rather increases with increasing rate. Fishery variance was estimated from relative values of postseason versus preseason estimates of age 4 ocean harvest rate. This variance was propagated through all fisheries as a result of contact, harvest, and impact rates being scaled according to the fishery allocation formula. All fisheries are constrained not to exceed an 80% contact rate of the available fish to avoid unrealistic extremes generated from a random distribution.

Historical comparisons of postseason harvest rate estimates and preseason harvest rate forecasts also revealed a significant negative bias in forecast harvest rates by ocean fisheries. Actual rates averaged 40% greater than forecast rates for 1986-2006 (Figure 3). The model included a bias parameter in ocean harvest rates to reflect this historical pattern. In actual practice, this consistent underestimation of ocean harvest rates has not been matched by the in-river tribal fishery due to the effort versus quota based management structure of the fisheries. As a result, tribal harvest shares have regularly fallen below the 50% target. However, for future modeling purposes we elected to maintain the tribal harvest allocation at 50% to reflect the management intent. In the model, the only times when the tribal harvest share falls below 50% occur when very high ocean harvest rates result in too few fish in the river to meet the tribal allocation goal consistent with the escapement rules identified in the modeled fishing strategy.

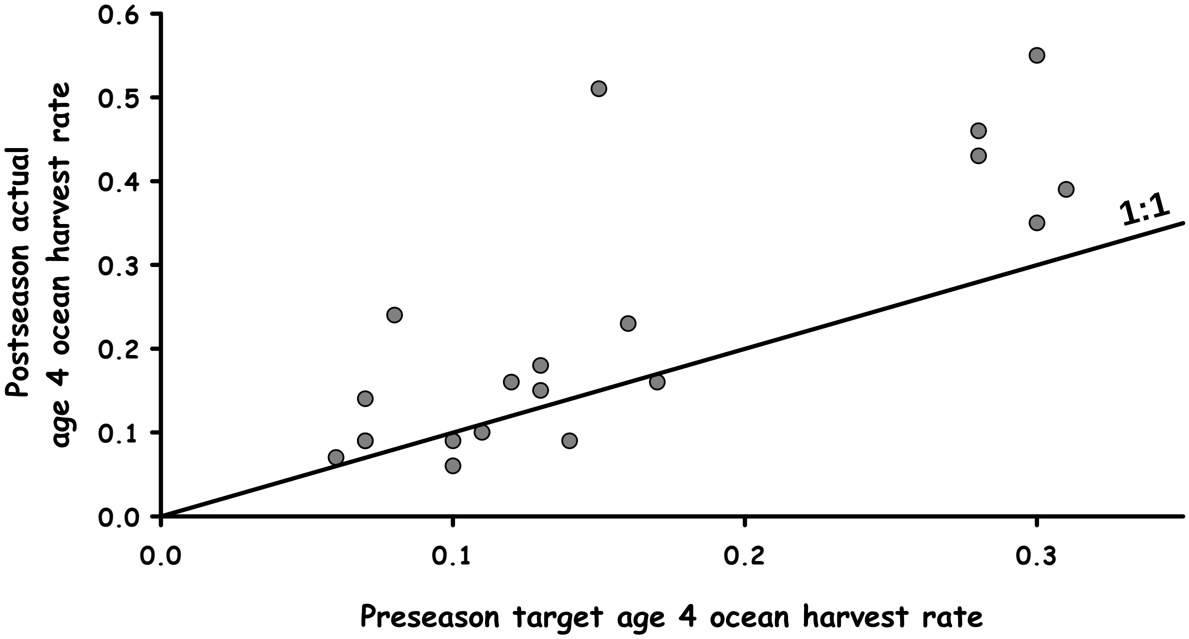


Figure 2. Examples of fishery implementation error based on preseason target and post-season actual estimates of age 4 ocean fishery harvest rates of Klamath fall Chinook for 1986-2006 (data from PFMC 2006).

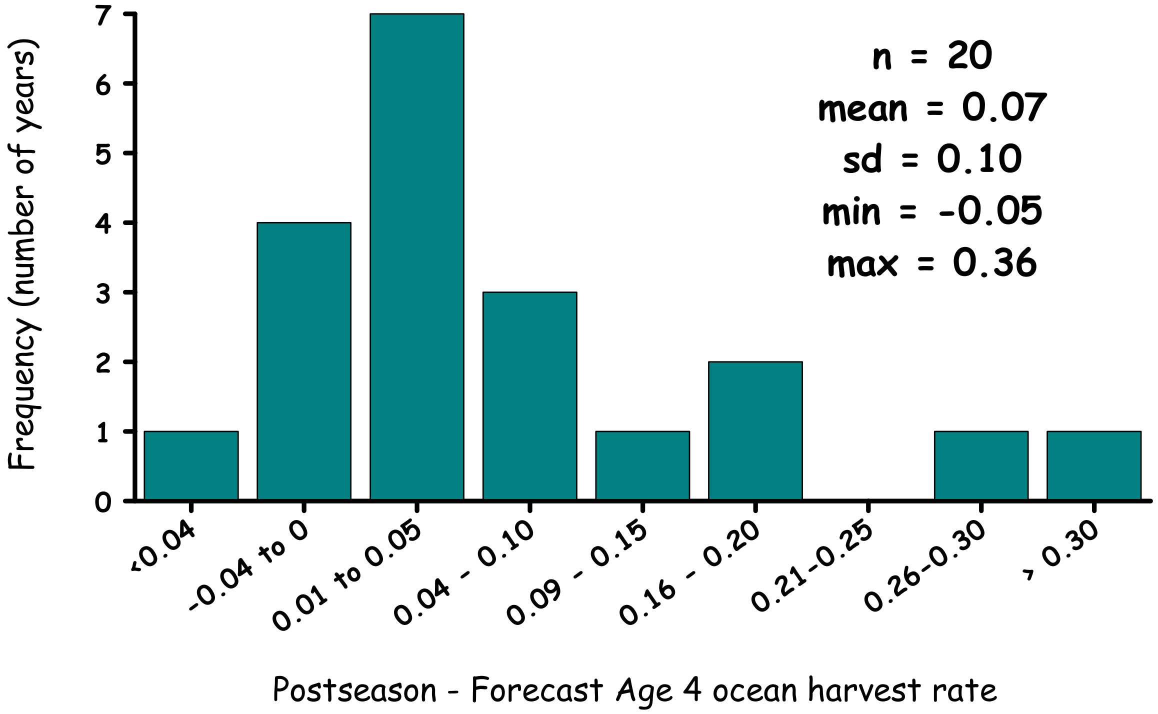


Figure 3. Error distribution of postseason estimates versus preseason forecasts of ocean age 4 harvest rates of Klamath fall Chinook for 1986-2006.

Initial Population Size.– Model runs are initiated with a starting population size (recent age-specific returns for partial cohorts rather than spawners). Near term numbers and risks are typically quite sensitive to this number while long term numbers and risks are not. The starting population size was based on forecast ocean numbers by age for 2006 and spawning recruits during the two previous years.

Stock-Recruitment Function.– Annual ocean recruitment of age-3 fish (Sept. 1) is estimated in the model from spawner numbers using a Ricker stock-recruitment function. Natural spawners include both naturally-produced fish and hatchery-origin fish that do not return to the hatchery. Stock-recruitment function productivity and capacity parameters were derived from 1979-2000 brood year data based on a 2-stage survival formulation (model 2) as developed by the STT (2005). For modeling purposes, the function was refit to ocean age 4 recruits rather than spawner equivalent recruits as reported by the STT. Corresponding reference points were a stock size at sustainable equilibrium production (SEQ) of 112,300, a maximum sustainable production (SMSP) of 56,900, and maximum sustainable yield (SMSY) of 40,700. For Klamath fall Chinook, the Ricker stock-recruitment function accounts for about half of the density-independent model residual variation (STT 2005). The stochastic simulation model incorporated variability about the stock-recruitment function to describe annual variation in fish numbers and productivity due to the effects of variable freshwater and marine survival patterns. The model assumed this variance to be lognormally distributed and highly autocorrelated. While stock-recruitment function parameters were derived using the 2-stage formulation, prospective simulations were based on the equivalent one-stage function, variance, and autocorrelation coefficients to avoid potential problems of covariance in error terms of the 2-stage model. Predicted future recruitment patterns were equivalent. The model also included limits on recruitment to prevent unrealistically large or small random numbers. Recruitment was limited to a maximum of 777,000 age 3 fish in the ocean corresponding to the maximum observed. Model escapements exceeding the maximum observed value of 162,000 were constrained to produce recruits equal to the model predicted-value for 162,000 spawners.

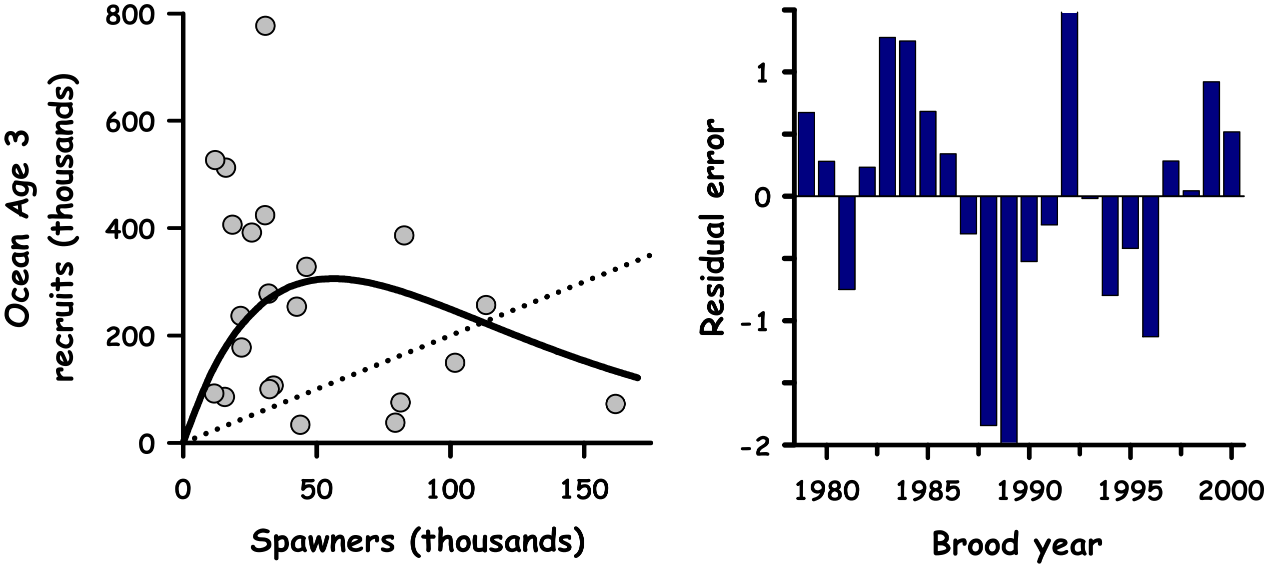


Figure 4. Stock-recruitment relationship and annual pattern of residual error for 1979-2000 brood year data for Klamath fall chinook.

Depensation.– The model provided an option to limit recruitment at low spawner numbers consistent with depensatory effects of stock substructure and small population processes. Depensation was used to simulate population level effects of underseeding of all spawning areas if significant substock structure exists for Klamath Fall Chinook. Because we lack data on substock structure and population dynamics at low escapements, model simulations assumed a depensatory response at escapements below 35,000 (corresponding to the management floor).

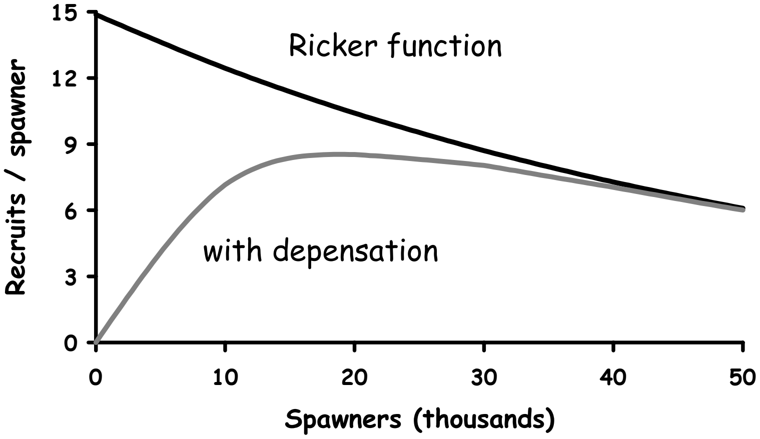


Figure 5. Effect of depensation function on recruits per spawner at low spawner numbers.

Freshwater Production Trend.– An input parameter was included to allow the stock-recruitment productivity pattern to be annually incremented upward or downward so that effects of trends in habitat conditions might be considered. An annual decrement of 1% was used in sensitivity analysis of the effects of *de minimis* fishery alternatives under pessimistic conditions.

Maturation and Survival Rates.– Numbers of fish were returning to the river or remaining in the ocean and surviving natural mortality were calculated by the model from ocean numbers using average annual natural mortality and maturation rates input as constant model parameters. Values were equivalent to those used in the Klamath Ocean Harvest Model (KOHM). The KOHM is a fishery management model that provides detailed estimates of catch by ocean fishery and month, fishery impact levels, and escapement for a given run size and fishing configuration in one year. Monthly natural survival rates used by KOHM were translated into an annual equivalent for use in the SSRM.

Hatchery production.– Hatchery and natural populations are modeled separately. Hatchery numbers recruiting to the age 3 population in the ocean are estimated from the current production goal for Klamath Fall Chinook and a juvenile to adult survival rate calibrated with the model to produce average hatchery escapements and hatchery:natural fractions comparable to those observed in the historical dataset. Release numbers and survival rates represent combined subyearling and yearling release numbers. Hatchery stray rates are an explicit model input and were a personal communication from LB Boydstun based on a review of the limited available data. Normal variation in hatchery survival rates among release cohorts was captured in the model using a scalar based on natural productivity derived from stock-recruitment function residual error. Thus, hatchery and natural numbers varied in strict tandem. The driving assumption was that variation in hatchery and wild production was highly correlated due to common effects of freshwater and marine factors. This is obviously an oversimplification of hatchery stock dynamics but appears to represent numbers and variation on a scale consistent with the historical data. Future modifications of this analysis might consider a more explicit representation of natural and hatchery covariation patterns.

Model Calibration

A series of model calibration runs were made to test the model function and determine whether model inputs consistent with fishery patterns (see Table 12) produced fishery and population dynamics like those observed in the historical dataset. Figure 6 illustrates example model results for one iteration of a 40 year simulation of the calibration conditions. This example illustrates the normal variation in ocean population size, harvest in combined ocean and inriver fisheries, and natural spawning escapement. Of course, annual patterns vary from iteration to iteration in a random fashion consistent with population and fishery variance inputs into the model.

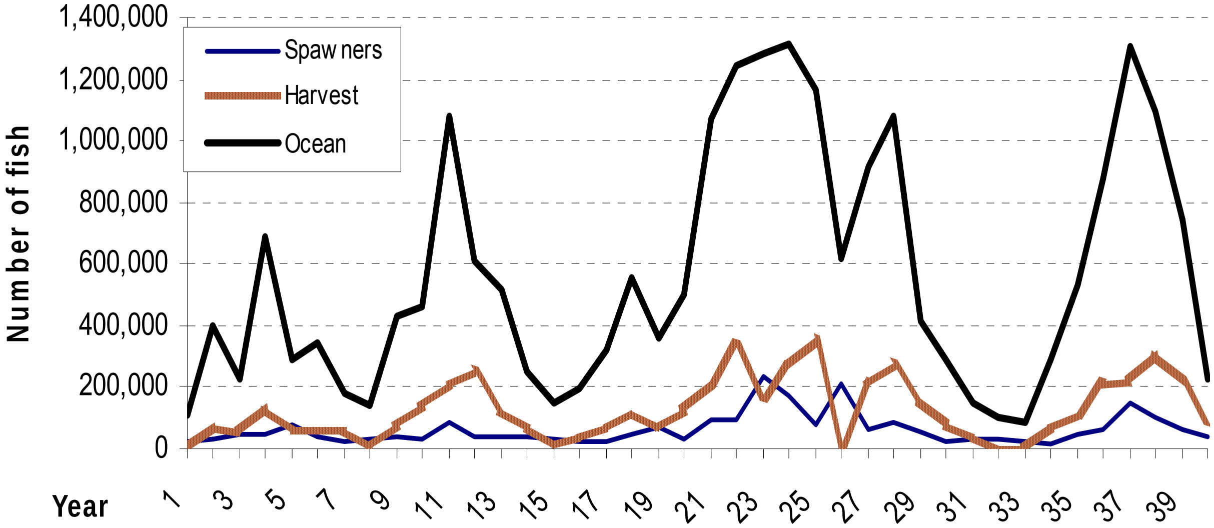


Figure 6. Example results of a stochastic 40-year simulation under the historical fisheries management plan with fisheries operating with a 35,000 escapement floor with a maximum 67% spawner reduction rate and random normal variation in recruits per spawner and fishing rates relative to annual targets.

The current calibration of the model produces outputs that closely match historical averages and ranges of fish numbers and harvest in the ocean and the river (Table 2). Frequency distributions of ocean and spawning escapement numbers are closely comparable (Figure 7). The model generally harvests fewer fish in the ocean than the historical average (63,000 vs 80,000) and substantially more fish in the river than the historical average (60,000 vs. 30,000). In part this reflects the harvest rate calculations built into the model that allocate 50% of the annual harvest to the river net fishery although the tribal harvest share has often fallen short of 50% as previously discussed. Lower estimates of average ocean harvest by the model might partly reflect the model parameterization that closes fisheries in years of low escapement. In contrast, at least some ocean harvest of Klamath fall Chinook occurred in all years from 1981-2005. Optimistic estimates by the model of the Klamath river runs relative to the 1981-2005 averages and maximums might also reflect poorer than average production conditions represented in the recent historical record as well as changes in hatchery contributions over the last two decades. Despite modest departures from the historical patterns in some model calibration results, the model produce very similar results for key variables of interest in evaluations of de minimis fishery alternatives including ocean harvest rates and spawning escapement. For instance, the model-predicted frequency of spawning escapements less than 35,000 (0.48) was very close to the estimated frequency from 1981-2005.

Table 2. Model results relative to actual historic numbers (based on fishery management according to the Fish Management Plan, 35,000 escapement floor with a maximum 67% spawner reduction rate). Results are based on long term average results (model years 6-40) in 500 iterations of the model.

		Mean	CV	Minimum	Max
Ocean abundance [a]	1981-2005	490,000	70%	70,000	1,450,000
	Model	520,000	67%	11,000	1,700,000
Ocean harvest	1981-2005	80,000	130%	3,000	300,000
	Model	63,000	83%	0	370,000
Ocean harvest rate	1981-2005	27%	66%	6%	60%
(age 4)	Model	27%		0%	78%
River run	1981-2005	110,000	61%	27,000	223,000
	Model	130,000	63%	6,000	480,000
River harvest	1981-2005	30,000	70%	7,000	74,000
	Model	60,000	75%	0	230,000
Spawners (natural)	1981-2005	50,000	74%	12,000	160,000
	Model	50,000	77%	5,000	360,000
Spawners < 35,000	1981-2005	0.56	--	--	--
(frequency)	Model	0.48	--	--	--
Hatchery return	1981-2005	26,000	80%	4,400	98,000
	Model	27,000		1,000	330,000
Hatchery fraction	1981-2005	35%	32%	12%	54%
(in escapement	Model	37%			

[a] *combined hatchery and wild fish, age 3 and 4 only.*

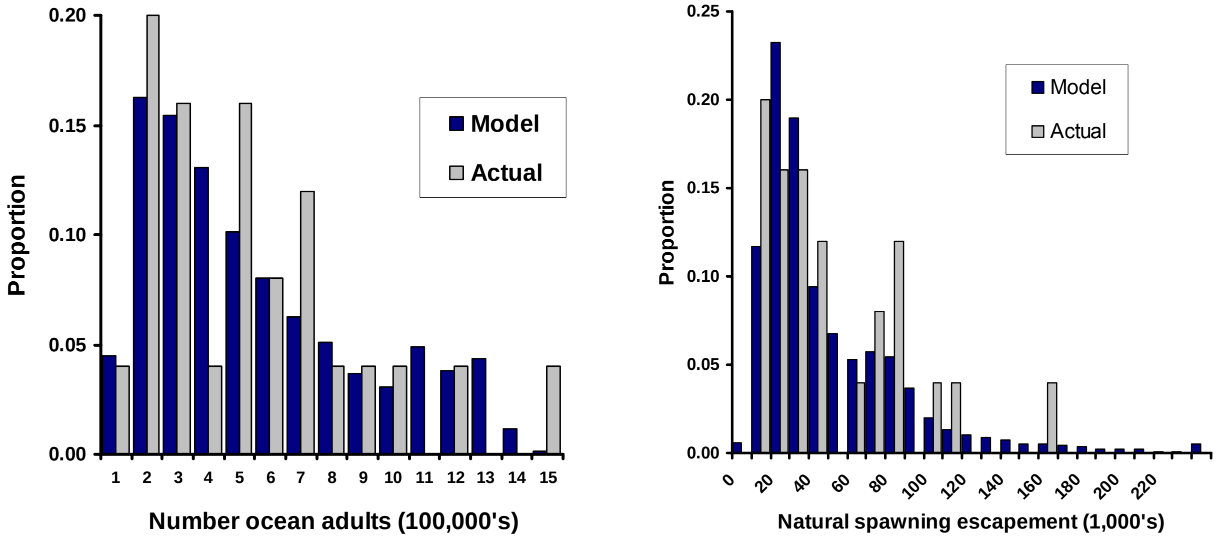


Figure 7. Frequency distribution of ocean hatchery and natural adult abundance (left) and natural spawning escapement (right) of Klamath fall Chinook in 500 iterations of a 40 year simulation with the stochastic stock recruitment model relative to observed distribution estimated for 1981-2005.

Results

Fishery Alternatives.– Status quo management is best represented by simulations of the fishery management plan with a 16% ESA limit on ocean fishery harvest rates of age 4 fish (Figure 8, Table 3). The model estimates a 39% frequency of escapements of less than 35,000 under this management strategy. The 16% limit on ocean harvest rates has reduced the model frequency of low escapements by an absolute value of 10% relative to the fisheries management plan with only a 67% SRR cap.

Analyses of fishery alternatives confirm that *de minimis* fishing rates of 10% or less have a very small effect on the incidence of spawning escapements of less than 35,000 (Figure 8, Table 3). *De minimis* rates of 2.5%, 5%, 10%, and 16% increase the absolute value of low run size risks by 0.4%, 1%, 3%, and 10% respectively. The sliding scale alternative actually reduces low run size risks by a very small amount relative to the current fishery strategy because it begins to limit fishery impacts at projected spawner escapments greater than 35,000.

Frequencies of 2 or 3 consecutive years of escapements less than 35,000 are likewise little affected by *de minimis* fisheries of 10% or less.

De minimis fisheries would occur in 10-12% of years at rates of 5% or less and up to 17% of years at an impact rate of 16% (Table 3). The increased frequency is due to a greater number of years where the rate is applicable rather than a long term effect of fishing on fish numbers.

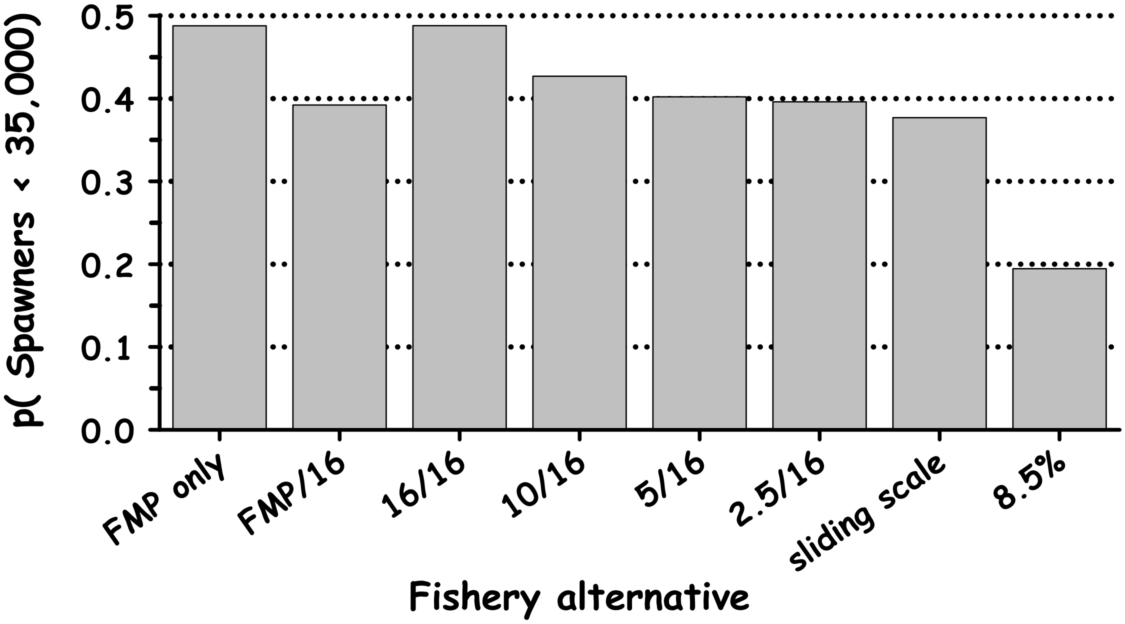


Figure 8. Effects of fishing levels on the incidence of natural spawning escapements of less than 35,000. Format of labels is *de minimis* ocean fishery impact rate / maximum ocean fishery harvest rate (age 4 fish). FMP refers to KRFC conservation objective in the Salmon fishery management plan.

Table 3. Key results from Klamath stochastic stock recruitment model for *de minimis* fishing and other alternatives (using 200 iterations of 40 year time series.

Key Factors:	FMP only[2]	All with 16% ocean harvest rate limitation[1]						8.5% OIR for 80%p>35K[9]
		FMP[3]	16%[4]	10%[5]	5%[6]	2.5%[7]	Sliding Scale[8]	
yrs(E < 35,000)[10]	0.488	0.392	0.488	0.427	0.402	0.396	0.377	0.1945
yrs(E < 21.000) [11]	0.148	0.108	0.315	0.201	0.141	0.114	0.108	0.0839
yrs(E < 12,000) [12]	0.014	0.012	0.177	0.051	0.019	0.015	0.012	0.0196
yrs(egg take goal) [13]	0.732	0.757	0.714	0.743	0.755	0.756	0.758	0.8306
yrs(de min fishery) [14]	0.000	0.000	0.300	0.173	0.116	0.101	0.108	0.0000
yrs(ocn 4 IR <= 0.05) [15]	0.128	0.126	0.020	0.026	0.059	0.128	0.136	0.0839
Iter (3yrs<35,000 in 40) [16]	0.980	0.905	0.930	0.910	0.915	0.905	0.885	0.5900
freq (2yrs<35000 in 40) [17]	13	10	14	11	10	10	9	5
freq (3yrs<35000 in 40) [18]	9	5	10	7	6	6	5	2
Ocean Harvest [19]	60,574	47,611	44,143	46,565	47,338	47,518	47,230	24,926
River Harvest [20]	59,975	57,252	52,817	56,033	56,953	57,155	56,776	32,652
Natural Escapement[21]	50,725	62,621	51,929	58,754	61,290	62,042	63,045	94,786

[1] *Ocean harvest rate (landed catch only) limitation based on California coastal chinook ESA standard (~17% ocean fishery impact rate).*

[2] *Fishery management plan with no fishing below 35,000 floor and the spawner reduction rate not to exceed 67%.*

[3] *Fishery management plan with 16% (~17% ocean fishery impact rate including nonlanded mortality). Status quo management*

[4] *16% de minimis ocean fishery impact rate on age 4 fish and a maximum harvest rate of 16% (~17% ocean fishery impact rate).*

[5] *10% de minimis ocean fishery impact rate on age 4 fish and a maximum harvest rate of 16% (~17% ocean fishery impact rate).*

[6] *5% de minimis ocean fishery impact rate on age 4 fish and a maximum harvest rate of 16% (~17% ocean fishery impact rate).*

[7] *5% de minimis ocean fishery impact rate on age 4 fish and a maximum harvest rate of 16% (~17% ocean fishery impact rate).*

[8] *Sliding scale de minimis ocean fishery strategy based on a linear reduction in ocean fishery impact rate from 4% to 0 at projected escapements from 39,000 to zero (approximately equivalent to a spawner reduction rate range of 10% to 0%.*

[9] *Ocean fishery impact rate (8.5%) that produces an 80% probability of spawning excapements greater than 35,000.*

[10] *Annual frequency of escapements of less than 35,000 natural spawners (n= 200 iterations x 40 years).*

[11] *Annual frequency of escapements of less than 21,000 natural spawners (n= 200 iterations x 40 years). 21,000 is an arbitrary reference point representing a more conservatrive risk level than the spawner floor.*

[12] *Annual frequency of escapements of less than 12,000 natural spawners (n= 200 iterations x 40 years). 12,000 is an reference point representing the lowest number of spawners historically observed.*

[13] *Annual frequency of hatchery escapements that provide the egg take needed to meet hatchery production goals (n= 200 iterations x 40 years).*

[14] *Annual frequency of de minimis fishery implementation (n= 200 iterations x 40 years).*

[15] *Annual frequency of years in which ocean fishery impact rates on age 4 fish are 5% or less (n= 200 iterations x 40 years).*

[16] *Proportion of 40-year iterations in which spawning escapement falls below 35,000 in three consecutive years (n= 200 iterations).*

[17] *Average number of years in 200 iterations where spawning escapement falls below 35,000 in 2 consecutive years.*

[18] *Average number of years in 200 iterations where spawning escapement falls below 35,000 in 3 consecutive years.*

[19] *Average annual ocean harvest in combined troll and recreational fisheries (n= 200 iterations x 40 years).*

[20] *Average annual river harvest in combined net and recreational fisheries (n= 200 iterations x 40 years).*

[21] *Average annual spawning natural escapement of natural and hatchery produced fish (n= 200 iterations x 40 years).*

Average harvest and escapement of Klamath fall Chinook are little affected by the implementation of *de minimis* fisheries of 16% less (Table 3). The small numbers of fish affected during fishery implementation in low run years do not contribute significantly to total averages. Harvest benefits of small fisheries in years are also partically offset by tradeoffs in future production due to escapement effects. However, tradeoffs between current and future harvests are practically a wash at *de minimis* fishery rates of 10% or less when considered solely based on KRFC.

In contrast, the institution of a 16% fishery cap has reduced the average ocean harvest of Klamath fall Chinook by about 20% from the fishery management plan alternative. For a relatively productive stock like Klamath fall chinook, any production benefits of increased escapements at low run sizes are more than offset by foregone harvest in large run years. The 16% cap produces long term average escapements of approximately 60,000 that are substantially greater than the 40,700 spawners estimate by the STT to produce maximum sustained yield.

Near-term vs. long term risks.– The model tracks results separate in years 1 to 5 and years 6-40 in order to assess near term and long term risks. Because of recent low numbers of spawners, near term risks of low escapements are greater than long term risks and near term harvest levels are less than long term expectations.

Table 4. Near-term (1-5 year) and long-term (6-40 year) risks of natural spawning escapements of less than 35,000 Klamath fall Chinook and average ocean harvests under selected fishery strategies (labels as per Table 3). Rates are of *de minimis* fisheries. All alternatives except for FMP-only include a 16% maximum ocean harvest rate target limitation.

	FMP only	FMP	5%	10%	16%
P (E < 35,000)					
Years 1-5	0.617	0.539	0.553	0.588	0.644
Years 6-40	0.469	0.371	0.381	0.404	0.465
Ocean harvest					
Years 1-5	43,225	32,611	32,689	32,456	32,774
Years 6-40	63,053	49,754	49,431	48,580	45,767

Recovery strategy.– The recovery strategy allows no *de minimis* fishery for Klamath River fall Chinook to be prosecuted for more than three consecutive seasons, and if during all three of those years the spawner floor was not met, *de minimis* fishing could not occur until the stock met the floor for at least three consecutive seasons. The recovery strategy reduced low escapement risks by absolute values of 0.3% to 7.3% for de minimis fishery rates from 5% to 16%.

Table 5. Effect of recovery strategy implementation on risks of natural spawning escapements of less than 35,000 Klamath fall Chinook and average ocean harvests under selected fishery strategies (labels as per Table 3). Rates are of *deminimis* fisheries. All alternatives except for FMP-only include a 16% maximum ocean harvest rate target limitation.

	FMP only	FMP	5%	10%	16%
No recovery strategy	0.488	0.392	0.402	0.427	0.488
With recovery strategy	--	--	0.399	0.405	0.415

Pessimistic Analysis.– To test sensitivity of conclusions regarding the risks associated with use of de minimis fishing rates, we conduced analyses of implementation under a pessimistic suite of modeling assumptions. Pessimistic assumptions included a stock-recruitment productivity of only half the empirical value, a negative trend in stock productivity of 1% per year, an increase in autocorrelation of recruitment variation from 0.5 to 0.99 and an increase in the fishery uncertainty CV from 0.5 to 0.7. These arbitrarily-selected values are not related to any expectation of future conditions and were selected merely to explore model behavior. While pessimistic assumptions substantially increased the incidence of low run sizes and decreased average numbers of fish harvested, the pattern of de minimis fishery effect was similar to that observed under likely future based on empirical data. In both cases, the absolute value of changes in low run size risk varied approximately 10-12% across the range of alternatives considered (Table 6).

Table 6. Effects or pessimistic assumptions of future conditions on long term (year 6-40) risks of natural spawning escapements of less than 35,000 Klamath fall Chinook and average ocean harvests under selected fishery strategies (labels as per Table 3). Rates are of *de minimis* fisheries. All alternatives except for FMP-only include a 16% maximum ocean harvest rate target limitation.

	FMP only	FMP	5%	10%	16%
P (E < 35,000)					
Likely	0.469	0.371	0.381	0.404	0.465
Pessimistic	0.893	0.855	0.879	0.929	0.973
Ocean harvest					
Likely	63,053	49,754	49,431	48,580	45,767
Pessimistic	13,623	12,575	13,041	12,085	12,144

Discussion

The modeling confirms that at low fishing rates, future effects on escapement and harvest are lost in the normal real world variability in the system. Conclusions are the same as those previously reported by Prager and Mohr (2001) using a similar modeling approach.

Comparisons of the relative effects of alternative fishing strategies on population and fishery performance are a relatively robust application of the modeling tool. Sensitivity analyses to different combinations of input parameters confirm that the relative effects of de minimis fishing rates are consistent among different parameterizations of the model. (Relative changes in escapement and harvest due to changes in de minimis fishing rates are similar for different combinations of population and fishery parameters.)

The modeling necessarily relies on some simplifying assumptions that warrant additional evaluation in order to qualify results. One assumption of particular concern concerns the effects of substock structure within the aggregate Klamath fall Chinook return. An aggregate stock-recruitment relationship may not adequately reflect the conservation risks associated low spawning escapements where substock structure exists (due to potential underseeding of some areas and possible low population genetic or demographic risks). Corresponding risks were examined in this analysis with population simulations examining the sensitivity of results to alternative assumptions using the least productive substock, a depensatory stock-recruitment relationship at low spawner numbers.

Model analyses were focused on Klamath fall Chinook. Fishery effects will be highly dependent on the productivity of the subject stock –highly productive stocks tend to be much less sensitive to fishing at low escapements than less productive stocks that are less likely to bounce back quickly and seem to be more prone to large swings in survival. Thus, fishing strategies appropriate for Klamath fall Chinook may not be specifically transferable to other stocks of interest. Sensitivity analyses of the effects of fishing strategies and rates at a range of inherent stock productivities to would provide a basis for consideration of other applications as appropriate.

These results will inform policy decisions on appropriate fishing strategies. Acceptable levels of effect and risk will remain a policy decision. Thus, the modeling answers the effect questions (what are the effects of the fishery alternatives?) but still requires policy answers to the corresponding goal question (what effects are acceptable?). e.g. Is a 1% increase in the frequency of escapements of less than 35,000 an acceptable risk in exchange for increased management flexibility in low run years? One approach to considering how much risk is too much would be to ask how many years of data would be required to detect a difference caused by implementation of an alternative fishery strategy. Future analyses will include this evaluation.

This biological analysis evaluates the effects of fishing on the Klamath Fall chinook population and fishery but does not directly consider the effects of the effects of Klamath fall Chinook harvest constraints on the much larger catches of other California and Oregon chinook stocks in ocean fisheries. Companion economic analyses will paint a much more complete picture of the broader effects of Klamath fishing levels.

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APPENDIX H. Formula Used to Estimate Long-Term Landed Catch and Data on Effect of Ex-Vessel Price on Troll Fishery Revenues for Each *De Minimis* Fishing Alternative.

Long-term catch formula

The SRSM model was used to estimate long-term (40-yr time frame) average annual landed catch for each *de minimis* fishing alternative, as follows:

$$LC_{i,\ s} = \sum (P_{r,\ i,\ s} * C_{r,\ i.\ s})$$

and

$$C_{r,\ i,\ s} + V_{i,\ a} * CE_{a,\ s}$$

where:

$LC_{i,s}$=average annual landed catch for a de minimis alternative over a 40 year time frame
$P_{r,i,s}$=proportion of the 40 year time period in six ocean impact rate categories
$C_{r,i,s}$=landed catch at ocean impact rate category (0.0%, 2.5%, 5%, 10%, 16%, 16% OHR)
$V_{i,a}$=vessel-days by area from KOHM at ocean impact rate category
$CE_{a,s}$=average catch per vessel-day by ocean troll area

r=ocean impact rate category
    1=0-2%
    2=3-4%
    3=5-8%
    4=9-12%
    5=13-16%
    6=>16%
i=de minimis alternatives
s=low, medium, high fishing success

Data on ex-vessel price effects on Troll Fishery Revenues

Since price along with landings determines revenue and price is hard to predict because many factors determine price, such as local supply and demand, import supply and demand, and input prices to name a few, four different price constraints were used to show possible ex-vessel revenues.

Year 2005 average prices by State is the first price constraint used. Oregon tracks historical prices by salmon size. Oregon's average price per pound for salmon greater than 11 pounds was used, because the average size of salmon caught in the past five years is about 12 pounds. There are also revenue projections based on $6.00 per pound because this is about the average price fishermen obtained in the first half of 2006's season (calculated from preliminary data). Since year 2006 had extremely restricted management measures for commercial fishermen and therefore salmon supply is very low from OR (South of Cape Falcon) and CA fishermen, $6.00 per pound may represent a de minimis year's price.
Table 4-11-2 shows revenue estimates based on historical (1991-2005) prices for the low and high years by State. Oregon's lowest price per pound was in 2002 at $1.66 and the high was in 2004 at $3.54. California's lowest price per pound was in 1997 at $1.62 and the high was in 1992 at $3.55.

Table H-1: Estimated Oregon and California troll fishery revenues ($ 000s) under the Council's *de minimis* fishery alternatives in a hypothetical Conservation Alert year for KRFC based on three levels of troll fishery success rate and using 2005 and 2006 ex-vessel prices.

	Revenue based on 2005 per pound price ($3.10 for OR & $2.97 for CA)					Revenue Based on 2006 per pound price ($6.00)				
AREA and Relative Success Rate[1/]	Status Quo[2/]	2.50%	5%	10%	16%	Status Quo[2/]	2.50%	5%	10%	16%
OREGON:										
Tillamook-Newport										
low	$0	$116	$421	$1,049	$1,877	$0	$224	$816	$2,030	$3,634
medium	$0	$241	$877	$2,183	$3,907	$0	$466	$1,698	$4,225	$7,561
high	$0	$391	$1,425	$3,547	$6,349	$0	$756	$2,759	$6,866	$12,287
Coos Bay										
low	$0	$0	$0	$93	$240	$0	$0	$0	$181	$464
medium	$0	$0	$0	$255	$654	$0	$0	$0	$494	$1,267
high	$0	$0	$0	$370	$949	$0	$0	$0	$716	$1,838
TOTAL										
low	$0	$116	$421	$1,142	$2,117	$0	$224	$816	$2,211	$4,097
medium	$0	$241	$877	$2,438	$4,561	$0	$466	$1,698	$4,719	$8,828
high	$0	$391	$1,425	$3,917	$7,298	$0	$756	$2,759	$7,582	$14,125
CALIFORNIA:										
San Francisco										
low	$0	$524	$956	$956	$956	$0	$1,059	$1,931	$1,931	$1,931
medium	$0	$820	$1,496	$1,496	$1,496	$0	$1,657	$3,021	$3,021	$3,021
high	$0	$1,310	$2,389	$2,389	$2,389	$0	$2,647	$4,825	$4,825	$4,825
Monterey										
low	$0	$95	$557	$2,232	$3,008	$0	$192	$1,125	$4,510	$6,077
medium	$0	$174	$1,016	$4,074	$5,489	$0	$351	$2,052	$8,229	$11,089
high	$0	$298	$1,745	$6,998	$9,430	$0	$603	$3,525	$14,137	$19,050
TOTAL										
low	$0	$620	$1,513	$3,188	$3,964	$0	$1,252	$3,056	$6,441	$8,009
medium	$0	$994	$2,511	$5,569	$6,985	$0	$2,008	$5,074	$11,251	$14,111
high	$0	$1,608	$4,134	$9,387	$11,818	$0	$3,249	$8,351	$18,963	$23,875

1/ Low, medium and high refer to years of low, medium and high troll fishery success rate during 1991-2004 measured as Chinook salmon catch per troll fishing day.

2/ Assumed to be a year when the projected natural escapement of KRFC is < 35,000 adult fish in the absence of fishing. The *de minimis* fishery thresholds vary between the alternatives, thus some level of fishing would be allowed when stock sizes were in the range of 35,000 to about 54,000 natural spawners in the absence of fishing depending on the alternative.

Comparing options and being conservative, let's assume, for example that there will be a low catch level. If so, and the west coast fishermen were obtaining year 2005 prices, the West Coast would earn approximately $735,000 at the 2.5% option, $1,935,000 at the 5% option, $4,330,000 at the 10% option and $6,080,000 at the 16% level.

Looking at how catch levels affect revenue, on average, the West Coast high catch level is about twice as large in revenue as the medium catch level and the medium catch level is about 1.5 times greater than the low catch level.

Comparing across options, in the Tillamook/Newport area, the 16% option produces about twice the revenue of the 10% option. The 10% option is about 2.5 times the revenue of the 5% option and the 5% option is about 3.5 times the revenue of the 2.5% option. In the Coos Bay area, the 16% option is about 2.5 times the revenue of the 10% option and there is no 5% or 2.5% option. In San Francisco, options 16%, 10% and 5% produce identical revenues and are all about double that of the 2.5% option. In Monterey, the 16% option is about 1.5 times that of the 10% option. The 10% option is about four times that of the 5% option and the 5% option is about 6 times that of the 2.5% option. This data shows that as the option levels increase, the revenues increases at a decreasing rate.

The following table shows the same affect as described above and is shown here to provide a range of total revenues that may be achieved from a de minimis fishing season. Note that due to a small catch in a de minimis year, it is more likely that prices would be closer to the historical high prices than low prices.

Table H-2: Estimated Oregon and California troll fishery revenues ($ 000s) under the Council's *de minimis* fishery alternatives in a hypothetical Conservation Alert year for KRFC based on three levels of troll fishery success rate and using low and high ex-vessel prices.

	Revenue based on low year price per pound ($1.66 for OR & $1.62 for CA)					Revenue Based on high year price per pound ($3.28 for OR and $3.55 for CA)				
AREA and Relative Success Rate[1/]	Status Quo[2/]	2.50%	5%	10%	16%	Status Quo[2/]	2.50%	5%	10%	16%
OREGON:										
Tillamook-Newport										
low	$0	$62	$226	$562	$1,005	$0	$122	$446	$1,110	$1,986
medium	$0	$129	$470	$1,169	$2,092	$0	$254	$928	$2,310	$4,133
high	$0	$209	$763	$1,900	$3,400	$0	$414	$1,508	$3,753	$6,717
Coos Bay										
low	$0	$0	$0	$50	$128	$0	$0	$0	$99	$254
medium	$0	$0	$0	$137	$350	$0	$0	$0	$270	$692
high	$0	$0	$0	$198	$508	$0	$0	$0	$392	$1,005
TOTAL										
low	$0	$62	$226	$612	$1,134	$0	$122	$446	$1,209	$2,240
medium	$0	$129	$470	$1,306	$2,442	$0	$254	$928	$2,580	$4,826
high	$0	$209	$763	$2,098	$3,908	$0	$414	$1,508	$4,145	$7,722
CALIFORNIA:										
San Francisco										
low	$0	$286	$521	$521	$521	$0	$627	$1,143	$1,143	$1,143
medium	$0	$447	$816	$816	$816	$0	$981	$1,788	$1,788	$1,788
high	$0	$715	$1,303	$1,303	$1,303	$0	$1,566	$2,855	$2,855	$2,855
Monterey										
low	$0	$52	$304	$1,218	$1,641	$0	$114	$665	$2,668	$3,596
medium	$0	$95	$554	$2,222	$2,994	$0	$208	$1,214	$4,869	$6,561
high	$0	$163	$952	$3,817	$5,144	$0	$357	$2,086	$8,365	$11,271
TOTAL										
low	$0	$338	$825	$1,739	$2,162	$0	$741	$1,808	$3,811	$4,738
medium	$0	$542	$1,370	$3,038	$3,810	$0	$1,188	$3,002	$6,657	$8,349
high	$0	$877	$2,255	$5,120	$6,446	$0	$1,923	$4,941	$11,220	$14,126

1/ Low, medium and high refer to years of low, medium and high troll fishery success rate during 1991-2004 measured as Chinook salmon catch per troll fishing day.

2/ Assumed to be a year when the projected natural escapement of KRFC is < 35,000 adult fish in the absence of fishing. The *de minimis* fishery thresholds vary between the alternatives, thus some level of fishing would be allowed when stock sizes were in the range of 35,000 to about 54,000 natural spawners in the absence of fishing depending on the alternative.

The following two tables show average revenue over a 40 year time period. There is an FMP option shown here, because over a 40 year time period, there would be de minimis and non-de minimis fishing seasons.

Table H-3: Projected long-term 3/ average annual Oregon and California troll fishery revenues ($ 000s) under the Council's *de minimis* fishery alternatives for KRFC based on three levels of troll fishery success rate and using 2005 and 2006 ex-vessel prices.

	Revenue based on 2005 per pound price ($3.10 for OR & $2.97 for CA)					Revenue Based on 2006 per pound price ($6.00)				
AREA and Relative Success Rate[1/]	Status Quo[2/]	4% Sliding Scale	5%	10%	16%	Status Quo[2/]	4% Sliding Scale	5%	10%	16%
OREGON:										
Tillamook-Newport										
low	$1,457	$1,444	$1,498	$1,609	$1,655	$2,821	$2,794	$2,898	$3,114	$3,203
medium	$3,033	$3,004	$3,116	$3,348	$3,444	$5,870	$5,814	$6,031	$6,480	$6,665
high	$4,929	$4,882	$5,064	$5,441	$5,596	$9,539	$9,449	$9,801	$10,530	$10,831
Coos Bay										
low	$269	$267	$268	$289	$309	$520	$516	$519	$559	$598
medium	$734	$728	$733	$789	$843	$1,420	$1,409	$1,418	$1,528	$1,632
high	$1,064	$1,056	$1,063	$1,145	$1,223	$2,060	$2,044	$2,057	$2,216	$2,368
TOTAL										
low	$1,726	$1,710	$1,766	$1,898	$1,964	$3,341	$3,310	$3,418	$3,673	$3,800
medium	$3,767	$3,732	$3,849	$4,137	$4,287	$7,290	$7,223	$7,449	$8,008	$8,297
high	$5,993	$5,938	$6,127	$6,586	$6,819	$11,599	$11,493	$11,859	$12,746	$13,198
CALIFORNIA:										
San Francisco										
low	$851	$836	$933	$943	$945	$1,720	$1,689	$1,885	$1,905	$1,910
medium	$1,332	$1,308	$1,460	$1,476	$1,479	$2,690	$2,643	$2,949	$2,981	$2,988
high	$2,127	$2,089	$2,331	$2,357	$2,362	$4,297	$4,221	$4,709	$4,761	$4,772
Monterey										
low	$2,679	$2,655	$2,743	$2,946	$3,045	$5,413	$5,364	$5,542	$5,952	$6,152
medium	$4,889	$4,845	$5,006	$5,376	$5,557	$9,877	$9,788	$10,112	$10,861	$11,226
high	$8,399	$8,323	$8,599	$9,235	$9,546	$16,967	$16,815	$17,372	$18,657	$19,285
TOTAL										
low	$3,531	$3,492	$3,676	$3,889	$3,991	$7,132	$7,054	$7,427	$7,858	$8,062
medium	$6,221	$6,153	$6,465	$6,852	$7,036	$12,567	$12,431	$13,061	$13,842	$14,214
high	$10,525	$10,413	$10,930	$11,592	$11,908	$21,263	$21,036	$22,081	$23,418	$24,057

1/ Low, medium and high refer to years of low, medium and high troll fishery success rate during 1991-2004 measured as Chinook salmon catch per troll fishing day.

2/ Assumed to be a year when the projected natural escapement of KRFC is < 35,000 adult fish in the absence of fishing.

3/ Based on the stochastic stock recruitment model (SSRM).

Table H-4: Projected long-term[3/] average annual Oregon and California troll fishery revenues ($ 000s) under the Council's *de minimis* fishery alternatives for KRFC based on three levels of troll fishery success rate and using low and high ex-vessel prices.

	Revenue based on low year price per pound ($1.66 for OR & $1.62 for CA)					Revenue Based on high year price per pound ($3.28 for OR and $3.55 for CA)				
AREA and Relative Success Rate[1/]	Status Quo[2/]	4% Sliding Scale	5%	10%	16%	Status Quo[2/]	4% Sliding Scale	5%	10%	16%
OREGON:										
Tillamook-Newport										
low	$780	$773	$802	$862	$886	$1,553	$1,555	$1,572	$1,624	$1,685
medium	$1,624	$1,609	$1,669	$1,793	$1,844	$3,232	$3,235	$3,272	$3,379	$3,506
high	$2,639	$2,614	$2,712	$2,913	$2,997	$5,253	$5,257	$5,317	$5,490	$5,697
Coos Bay										
low	$144	$143	$144	$155	$165	$251	$251	$251	$257	$273
medium	$393	$390	$392	$423	$452	$685	$685	$685	$702	$745
high	$570	$565	$569	$613	$655	$994	$994	$993	$1,019	$1,081
TOTAL										
low	$924	$916	$946	$1,016	$1,051	$1,804	$1,805	$1,823	$1,881	$1,958
medium	$2,017	$1,998	$2,061	$2,215	$2,295	$3,918	$3,920	$3,957	$4,081	$4,251
high	$3,209	$3,180	$3,281	$3,526	$3,652	$6,247	$6,251	$6,310	$6,509	$6,778
CALIFORNIA:										
San Francisco										
low	$464	$456	$509	$514	$516	$1,018	$1,000	$1,115	$1,127	$1,130
medium	$726	$714	$796	$805	$807	$1,592	$1,564	$1,745	$1,764	$1,768
high	$1,160	$1,140	$1,272	$1,285	$1,288	$2,542	$2,497	$2,786	$2,817	$2,823
Monterey										
low	$1,461	$1,448	$1,496	$1,607	$1,661	$3,203	$3,174	$3,279	$3,522	$3,640
medium	$2,667	$2,643	$2,730	$2,932	$3,031	$5,844	$5,791	$5,983	$6,426	$6,642
high	$4,581	$4,540	$4,690	$5,038	$5,207	$10,039	$9,949	$10,279	$11,039	$11,410
TOTAL										
low	$1,926	$1,904	$2,005	$2,122	$2,177	$4,220	$4,173	$4,394	$4,649	$4,770
medium	$3,393	$3,356	$3,527	$3,737	$3,838	$7,435	$7,355	$7,728	$8,190	$8,410
high	$5,741	$5,680	$5,962	$6,323	$6,495	$12,581	$12,446	$13,065	$13,856	$14,234

1/ Low, medium and high refer to years of low, medium and high troll fishery success rate during 1991-2004 measured as Chinook salmon catch per troll fishing day.

2/ This is a year when the projected natural escapement of KRFC is < 35,000 adult fish in the absence of fishing.

3/ based on the stock recruitment simulation model

Comparing options and being conservative again, let's assume, for example that there will be a low catch level. If so, and the west coast fishermen were obtaining year 2005 prices, the West Coast would earn approximately $5,257,000 under the FMP Option, $5,202,000 for the sliding scale option, $5,442,000 at the 5% option, $5,442,000 at the 10% option and $5,954,000 at the 16% option.

Looking at catch levels, on average, the West Coast high catch level is about twice as large in revenue as the medium catch level and the medium catch level is about 1.5 times greater than the low catch level.

Comparing across options and looking at the differences between the FMP Option compared to the 16% Option, which would be the maximum difference in revenue across all options, in the Tillamook/Newport area, $124,141 is the difference between revenue at the low catch level, $258,332 at the medium catch level and $419,802 at the high catch level. In the Coos Bay area, $20,757 is the difference at the low catch level, $56,692 at the medium catch level and $82,244 at the high catch level.

In San Francisco, $63,933 is the difference at the low catch level, $100,019 at the medium level, $159,730 at the high level. In Monterey, $223,137 is the difference at the low catch level, $407,157 at the medium level and $699,451 at the high level.

Therefore the difference of revenue between options increases at the catch level increases. Monterey produces the largest revenue difference of $699,451 assuming a high catch level.