Agenda Item C.3.a
Attachment 3
November 2012

2012 Technical Revision to the OCN Coho Work Group Harvest Matrix

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September 2012

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Abstract

Amendment 13 (A13) to the Pacific Fishery Management Council Pacific Coast Salmon Fishery Management Plan sets Oregon Coastal Natural (OCN) coho salmon harvest impact rates through a two dimensional matrix with parental status and a marine survival index as the axes. When A13 was developed available data on wild coho salmon marine survival was limited and Oregon Production Index Hatchery (OPIH) jack/smolt ratios, as a predictor of OPIH adult marine survival, was used as a proxy. Recognizing these limits the authors stipulated that the "methods of estimating the technical parameters" could be changed as a technical revision without plan amendment. We propose using the wild coho salmon jack/smolt ratios from the Mill Creek (Yaquina) Life Cycle Monitoring site as a more direct predictor of wild adult marine survival. The Oregon Department of Fish and Wildlife as part of the Oregon Plan for Salmon and Watersheds has conducted monitoring on OCN abundance, survival, and habitat since 1998. These data show that OPIH abundance and survival are not correlated with OCN abundance and survival. They also show that the forecast skill of the marine survival prediction could be increased from $r = 0.30$ to $r = 0.86$ by utilizing the proposed predictor. In a retrospective analysis from 1999 to 2011 the proposed predictor would have provided greater differentiation in impact rates between the top three recruitment years, middle seven recruitment years, and bottom three recruitment years. Allowable impact rates would have been 28%, 18%, and 10% for the high, middle, and low abundance years under the current proposal versus 15%, 13%, and 12% for the 2000 OCN Work Group matrix. The increase in forecast skill would improve the performance of the A13 matrix, appropriately limiting impact rates when survival is expected to be low but allowing harvest opportunity when it is expected to be high.

Introduction

Oregon's coastal coho salmon (*Oncorhynchus kisutch*) populations are an important ecological and cultural component of the coastal landscape and have historically contributed to significant recreational and commercial fisheries. The abundance of Oregon coastal coho salmon in the late 1800's to early 1900's was likely in the range of one to two million fish (ODFW 2007). By the 1990's the runs had declined to less than 100,000 fish a year (PFMC 2012). Oregon Coastal Natural (OCN) coho salmon have been managed as an aggregate of stocks from the Necanicum River in the north to the Winchuck River in the south. These stocks compose all of the Oregon Coast Coho Evolutionarily Significant Unit (ESU) and part of the Southern Oregon/Northern California Coasts Coho ESU. Both of these ESUs are listed as "threatened" under the Federal Endangered Species Act (National Marine Fisheries Service 2005, National Marine Fisheries Service 2011).

The majority of coho salmon in Oregon return to spawn at three years old, with a variable proportion of precocious males returning at two years old after only four to six months in the ocean (Sandercock 1991). The early marine life-stage may be a marine survival bottleneck for coho salmon (Logerwell et al. 2003; Beamish et al. 2004). Jack coho salmon also experience these early ocean conditions, so that high jack return rates indicate favorable early ocean conditions for adults of that brood cycle, and thus jack returns can be a predictor of adult marine survival (Briscoe et al. 2005). Amendment 13 (A13) currently relies on this relationship, using the Oregon Production Index Hatchery (OPIH) jack/smolt ratio to predict OCN marine survival. At the time of A13 development, data on wild adult coho salmon marine survival were unavailable and OPIH data were used as a proxy. The relationship between OPIH jack/smolt ratios and OPIH adult returns was strong (PFMC 1999), but subsequent data from multiple monitoring projects focused on wild coho salmon show that OPIH abundance and survival are not correlated to OCN abundance and survival. However, with these additional data we no longer need OPIH as a proxy and can use OCN data directly for OCN harvest management.

Harvest impacts to OCN coho salmon are managed by the Pacific Fishery Management Council (PFMC) in ocean areas beyond three miles from the coast. In the ocean within three miles of the coast, and within estuary and freshwater areas harvest management is the responsibility of the State of Oregon. Oregon has committed to manage OCN coho salmon harvest based on A13 in the 2007 Coho Conservation Plan (ODFW 2007) and in terminal areas in the Fisheries Management and Evaluation Plan (ODFW 2009). In 1997 the council adopted A13 (PFMC 1999) to the Pacific Coast Salmon Plan. A13 utilizes a matrix of OCN parental spawner status and a marine survival index to establish allowable fishery impact rates. In 2000 the OCN Work Group (Sharr et al. 2000) reviewed A13 and expanded the matrix from a 3 x 3 to a 4 x 5 matrix to address management at very low marine survival and parental abundance. The OCN Work Group matrix was adopted by PFMC and has been used as technical guidance on implementation of A13 since 2001. A13 stated a goal for harvest management of OCN coho salmon:

> *"Thus, the primary goal of the amendment is to assure that fishery related impacts will not act as a significant impediment to the recovery of depressed OCN coho and to more uniformly rebuild each component population subgroup to a higher level."*

In developing A13 the authors acknowledged the limits of the available data on OCN coho salmon and the uncertainties in the proposed management regime, and in response to these concerns A13 included a Monitoring and Evaluation section (2.2.3). This included *"…a comprehensive evaluation mechanism on a pre-determined schedule."* with the first review to occur in 2000. The 2000 OCN Work Group report is the result of that review. Section 2.2.3 of A13 also calls for a comprehensive monitoring program including: juvenile surveys, spawner surveys, habitat surveys, comprehensive monitoring sites, and fishery impact monitoring. The authors anticipated that the results of improved monitoring and periodic reviews might result in changes to the matrix. Specifically, on page 7 of A13 they state:

> *"To incorporate the best science, the methods of estimating the technical parameters used in this proposal may change without plan amendment, if approved by the Council following a technical review and recommendation for change by the Scientific and Statistical Committee."*

From 1998 to present the Oregon Department of Fish and Wildlife (ODFW) has conducted an integrated monitoring program (Firman and Jacobs 2001) as part of the implementation of the Oregon Plan for Salmon and Watersheds (OPSW). The OPSW monitoring program addresses the first four monitoring components called for by A13. The program consists of three geographically extensive monitoring projects based on a spatially balanced random site selection, and one project that intensively monitors specific sub-basins. The three geographically extensive projects are based on the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program sample design. These projects incorporate a Generalized Random Tessellation Stratified sampling design to establish a shared set of random, spatially balanced sample points (Firman and Jacobs 2001; Stevens 2002). These projects provide the juvenile surveys, adult spawner surveys, and habitat surveys called for in A13. The fourth project is the Life Cycle Monitoring (LCM) project, which determines adult and juvenile coho salmon abundance and survival at specific sub-basins, providing the comprehensive monitoring sites called for in A13.

During 2010-11 ODFW staff conducted a review of A13 and the thirteen years of OPSW monitoring data on OCN coho salmon. The results of that review showed the LCM data could provide an improvement to the method of estimating the marine survival index parameter. The analysis suggested that this change could substantially improve the performance of the A13 matrix in both restricting harvest impacts during years of low OCN abundance and allowing for greater harvest opportunities in years of higher OCN abundance.

Methods

OPSW Monitoring Data

A LCM site consists of a paired adult trap and out-migrant trap. Data presented here were collected from 1998-2012 from six sites in the Oregon Coast Coho ESU (Figure 1). Data from the East Fork Trask LCM site were not used in this analysis because it has not been operational for the entire study period. Spawner abundance at LCM sites was either a direct count from traps at complete barriers or estimated by mark-recapture methodology (Ricker 1975). Fish that entered traps were identified to species and sex and distinguished as wild or hatchery-produced based on presence or absence of an adipose fin clip. Jack coho salmon (≤ 50 cm fork length) were distinguished from adults. Downstream juvenile salmonid out-migrants were captured with rotary screw traps or motorized incline plane traps. Fish were enumerated by species and age or size class, with coho salmon identified as fry (age 0) or smolts (age 1+). Trap capture efficiency was evaluated daily and weekly out-migrant estimates were summed for season totals. Additional details on adult and juvenile estimation methods and site specific details are found in Suring et al. (2012).

The LCM smolt to adult marine survival rate was derived by dividing the female spawner abundance in year *t* by half of the smolt production, assuming a 1:1 smolt sex ratio, in year *t-1*. The OCN marine survival index was calculated by averaging the marine survival rate from all sites.

Trap design at most LCM sites does not capture jack coho salmon, but the LCM adult trap on Mill Creek (Yaquina) captures all upstream migrating fish, including jack coho salmon, as the head gate controlling flow into the trap below the Mill Creek reservoir dam creates a velocity barrier. Live fish placed above the trap represent the entire spawning population. A motorized inclined plane trap was used immediately below the fish ladder and spillway of the dam to estimate juvenile out-migrant populations each spring (Suring et al. 2012). The jack/smolt ratio was calculated by dividing the jack spawner abundance in the fall of year *t-1* by the half the smolt production, assuming a 1:1 smolt sex ratio, out-migrating in the spring of year *t-1*.

OPIH Data

Oregon production index hatchery coho salmon abundance data used in this revision are from the 2012 PFMC Preseason Report I (PFMC 2012, Table C-2). Adult marine survival was the total adult pre-harvest abundance divided by the total number of smolts released by brood year. The jack/smolt ratio was the total number of jacks divided by the total number of smolts released.

Marine Survival Categories

Matrix marine survival categories for the current proposal are unchanged from the 2000 A13 review (Sharr et al. 2000) definition of marine survival categories. The current proposal would change the metric for determining marine survival categories from the OPIH jack/smolt ratio to a forecast of wild coho salmon smolt to adult survival. The OCN Work Group described the expected wild adult coho salmon marine survival rates and an assumed ratio of wild to hatchery adult marine survival associated with each category (Sharr et al. 2000). These definitions and relationships were used to develop the proposed metric values for the marine survival axis. The OCN Work Group determined the appropriate exploitation rates for the marine survival categories using a habitat based production model (Nickelson and Lawson 1998). The current proposal does not change any of the OCN Work Group exploitation rates.

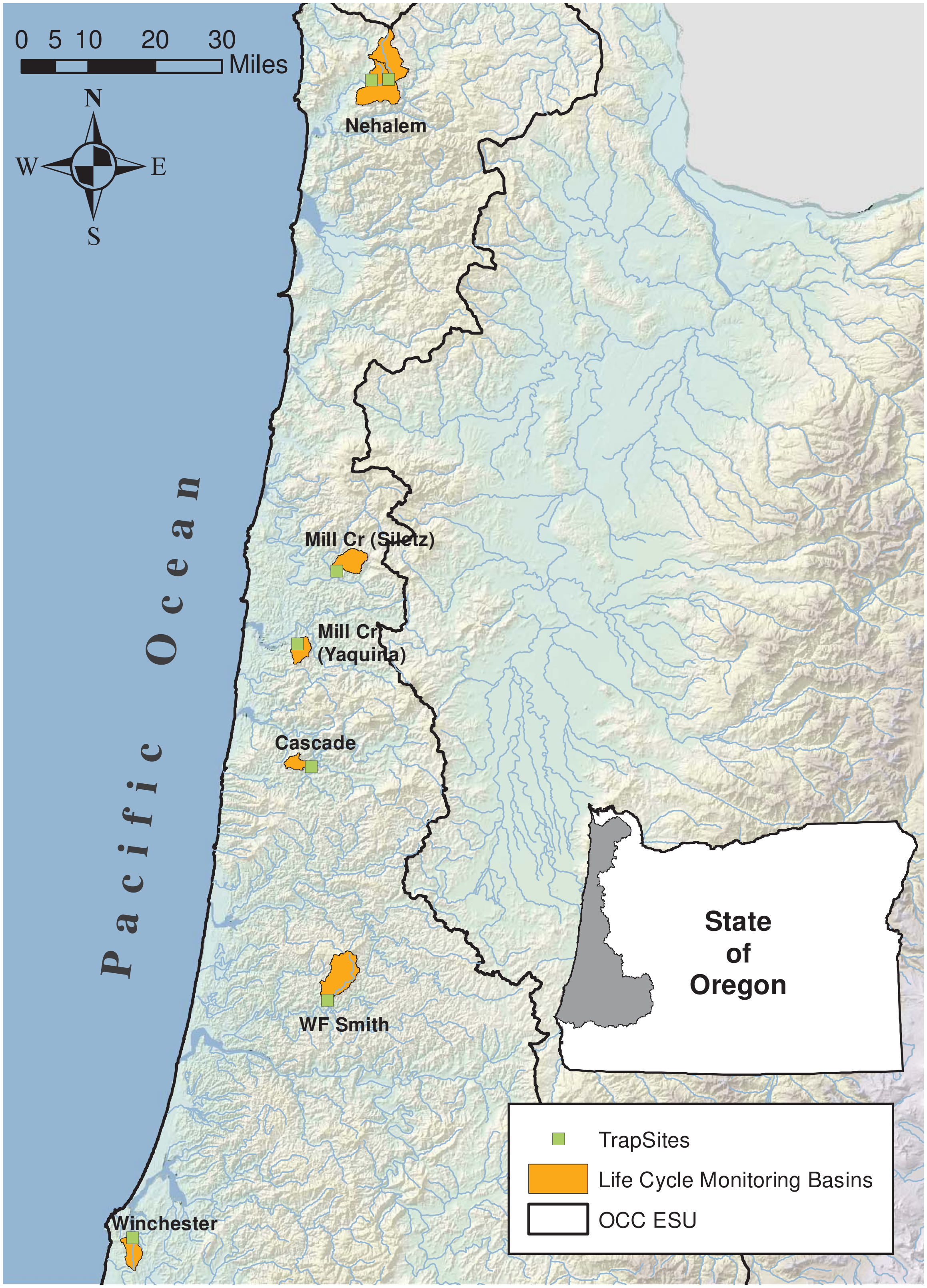

Figure 1. Oregon Department of Fish and Wildlife Life Cycle Monitoring Basins where both coho salmon adult returns and juvenile out-migrants are estimated.

Retrospective Analysis

Harvest management performance of A13 (PFMC 1999), the OCN Work Group guidance on implementation of A13 (Sharr et al. 2000), and the current proposal were compared through a retrospective analysis. The analysis used actual recent pre-season metrics for the parental spawner status and marine survival index and actual pre-harvest ocean abundance of wild adult coho salmon for the Oregon Coast Coho ESU. The allowable total fishery impact rate was determined for each management strategy (A13, OCN Work Group, current proposal) for each year in the data set, 1999 through 2011. Maximum allowable harvest impact and minimum spawning escapement were calculated for each year based on the actual pre-harvest ocean abundance of wild adult coho salmon for the Oregon Coast Coho (OCC) ESU and assumed harvest impacts at the maximum allowable rate for each management strategy. Because the goal of the analysis was to compare the three management strategies performance across a consistent set of pre-season metrics, the 2002 through 2011 parental spawner status was not adjusted for the different allowable harvest impact rates that could have been implemented under each management strategy.

Post season estimates of wild adult coho salmon spawner abundance in the OCC ESU were obtained from ODFW, and are the same numbers submitted to the Oregon Production Index Technical Team meeting each February, for inclusion in the PFMC Preseason Report I. The estimated exploitation rate on OCN coho salmon was based on the post-season MSM-FRAM coho salmon run reconstruction (PFMC 2012). The spawner abundance (spawners) and OCN exploitation rate (ER) were used to generate the actual pre-harvest ocean abundance (recruits) of wild adult coho salmon for the OCC ESU; recruits = spawners / (1 – ER). Allowable fishery impact rates under A13 and the OCN Work Group were obtained from Table V-7 in the 2012 Preseason Report I (PFMC 2012). Pre-season predictions of marine survival from the Mill Creek LCM site are available from the 1999 adult return year to present (Table 2). The allowable total fishery impact rate for the current proposal was based on these marine survival predictions and the OCN Work Group parental spawner status.

Results

OPSW Monitoring Data

An index of OCN coho salmon smolt to adult marine survival can be calculated from 14 years of complementary adult return and smolt production data at six LCM sites and jack/smolt ratios at one site (Table 1), providing information on wild coho salmon survival that was not available during the initial development of A13. The LCM sites are distributed latitudinaly but were not selected by a statistical design. The LCM sites in aggregate, however, are representative of ESU conditions based on spawner abundance and freshwater productivity as modeled by habitat surveys. Average spawner abundance at LCM sites, normalized to spawners/mile, correlates well with ESU wide escapement estimates (R^2=0.89, p<0.001, Figure 2). The relationship is linear over a wide range of abundance. The distribution of habitat quality as measured by the integrative metric of modeled winter parr/km productivity (Anlauf et al. 2009) is similar between LCM sites and the ESU as a whole (Figure 3).

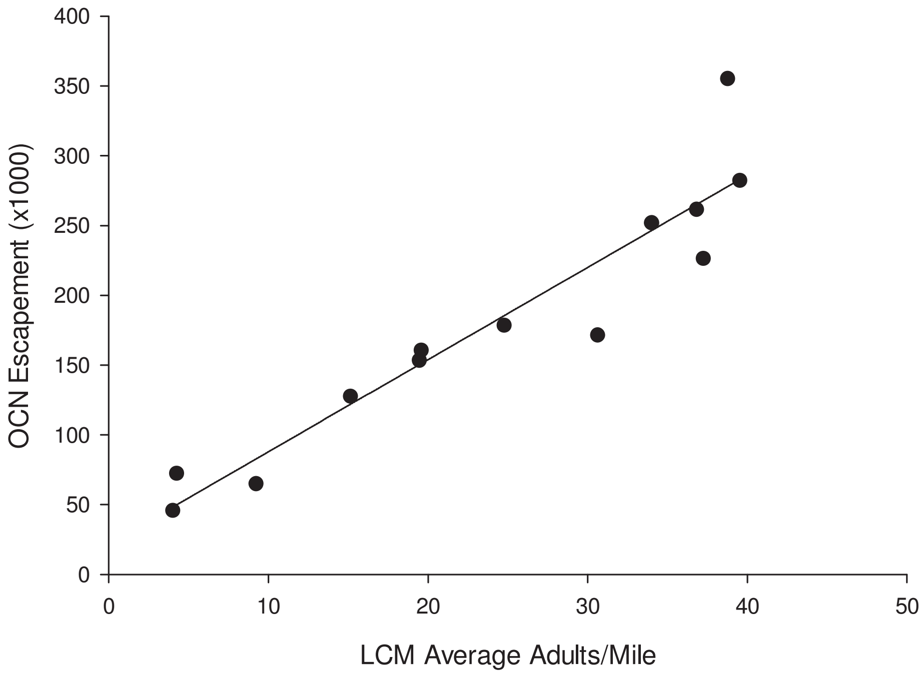

Figure 2. The relationship between adult coho salmon returns to Life Cycle Monitoring sites (n=6) and Oregon Coastal Natural escapement (R^2=0.89, p<0.001).

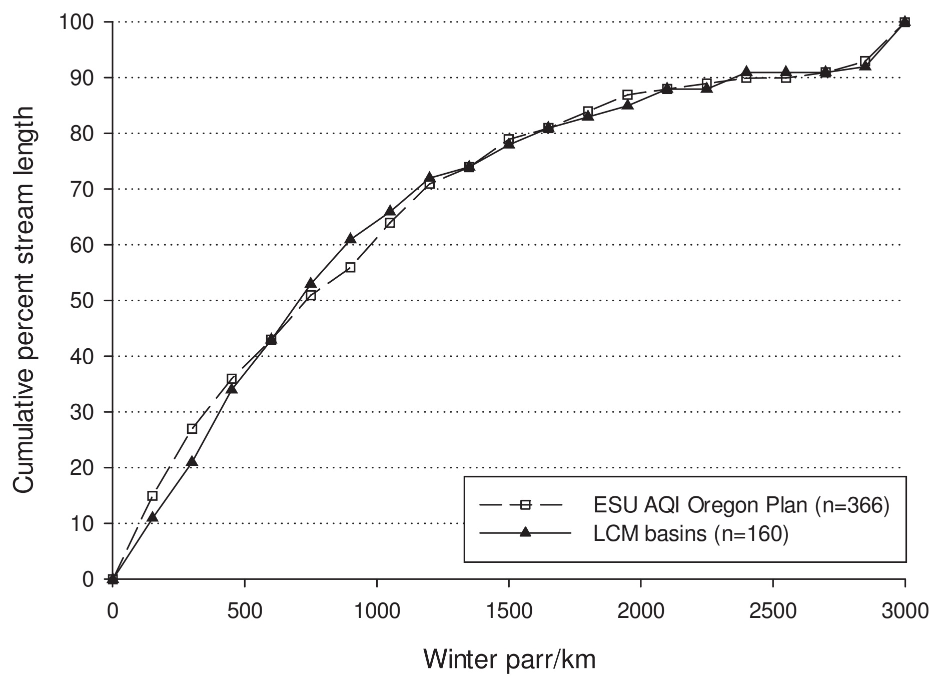

Figure 3. The cumulative distribution of modeled winter parr/km above LCM trap sites and ODFW Aquatic Inventories ESU wide probability surveys.

Table 1. Coho salmon adult marine survival and jack/smolt ratios from Life Cycle Monitoring sites and OPI hatchery returns.

Return Year	LCM adult survival	LCM Mill Cr Jacks/Smolt	OPIH adult survival	OPIH Jacks/Smolt
1998	6.0%	0.0186	1.0%	0.0004
1999	1.5%	0.0057	1.3%	0.0010
2000	3.8%	0.0459	2.1%	0.0012
2001	9.3%	0.0922	4.5%	0.0027
2002	8.7%	0.0581	2.8%	0.0009
2003	10.1%	0.0717	4.2%	0.0020
2004	5.5%	0.0415	2.8%	0.0014
2005	5.0%	0.0136	2.0%	0.0011
2006	2.8%	0.0068	2.5%	0.0012
2007	2.3%	0.0049	2.7%	0.0017
2008	6.5%	0.0385	2.6%	0.0007
2009	9.6%	0.0649	4.6%	0.0027
2010	8.3%	0.0165	2.5%	0.0012
2011	10.7%	0.1015	2.4%	0.0012
2012		0.0384		0.0009

The OPIH jack/smolt ratio remains a strong predictor of OPIH adult marine survival (R^2=0.82) as data collected since the original A13 analysis are added (1970-2011, PMFC 2012). However, there is no relationship between OPIH jack/smolt ratio and the OCN adult marine survival index measured at the LCM sites (Figure 4). Similarly, there is no relationship between OPIH and OCN adult abundance (R^2=0.02, p=0.65). The OPIH jack/smolt ratio predicted the wrong marine survival category in ten of the last thirteen years (Table 2). The jack/smolt ratio from the Mill Cr (Yaquina) LCM site has a strong relationship with wild adult coho salmon marine survival (Figure 5). The relationship with logit transformed variables is shown in Equation 1. This relationship can be used to predict adult marine survival by Equation 2.

Equation 1. $logit(\text{adult marine survival}) = -1.011 + 0.516 * logit(\text{jack/smolt})$

Equation 2. $\text{Predicted marine survival} = \frac{1}{1+e^{\left(-\left(-1.011+0.516*\left(ln\left(\frac{\text{jack/smolt}}{\text{1-jack/smolt}}\right)\right)\right)\right)}}$

This relationship would have predicted the correct adult OCN survival rate category in eight of the last thirteen years (Table 2). The proposed method over predicted the survival category twice and under predicted three times, one time by two categories. The OPIH method over predicted twice and under predicted eight times, four times by two categories.

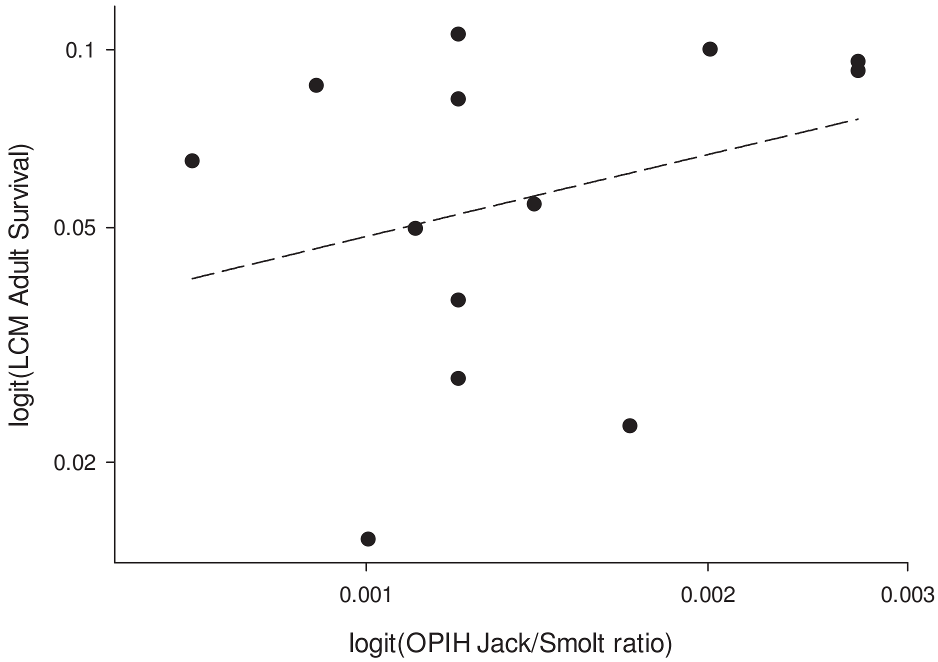

Figure 4. The relationship between the OPIH jack/smolt ratio and LCM adult marine survival (R^2=0.087, p=0.33)

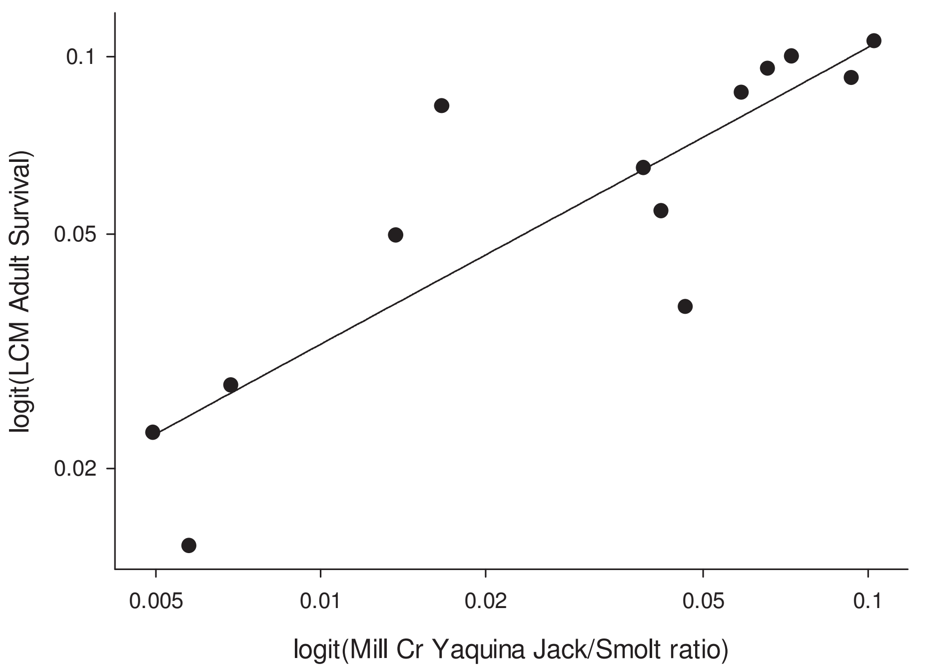

Figure 5. The relationship between the Mill Cr (Yaquina) jack/smolt ratio and LCM adult marine survival (R^2=0.74, p=0.0002)

Marine Survival Categories

This revision retains the four marine survival categories established in the 2000 review of A13 (Sharr et al. 2000) but alters the category values to be expressed as wild adult marine survival rather than OPIH jack/smolt ratios (Table 3). The proposed A13 matrix is shown in Table 4.

Table 2. Observed and predicted marine survival and marine survival categories. Incorrect predictions using OPIH and LCM jack/smolt ratios are highlighted.

Return Year	LCM observed adult survival	LCM predicted adult survival	OPIH Jacks/Smolt	LCM observed adult category	OPIH predicted category	LCM predicted category
1999	1.5%	2.5%	0.0010	Ex. Low	Low	Low
2000	3.8%	7.1%	0.0012	Low	Low	Medium
2001	9.3%	10.0%	0.0027	High	Medium	High
2002	8.7%	8.0%	0.0009	High	Low	Medium
2003	10.1%	8.9%	0.0020	High	Medium	High
2004	5.5%	6.7%	0.0014	Medium	Medium	Medium
2005	5.0%	3.8%	0.0011	Medium	Low	Low
2006	2.8%	2.7%	0.0012	Low	Low	Low
2007	2.3%	2.3%	0.0017	Low	Medium	Low
2008	6.5%	6.5%	0.0007	Medium	Ex. Low	Medium
2009	9.6%	8.4%	0.0027	High	Medium	High
2010	8.3%	4.2%	0.0012	High	Low	Low
2011	10.7%	10.6%	0.0012	High	Low	High

Table 3. Marine survival categories delineated in the OCN Work Group 2000 review of Amendment 13 harvest management matrix (Sharr et al. 2000, pg 16 & 21).

	Extremely Low	Low	Medium	High
Wild Adult Marine Survival	< 2%	2% to 4.5%	>4.5% to 8%	> 8%
OPIH Adult Marine Survival	< 1%	1% to 3%	>3% to 8%	> 8%
OPIH Jack/Smolt Ratio	<0.0008	0.0008 to 0.0014	>0.0014 to 0.0040	>0.0040

Table 4. Proposed revisions to the OCN Work Group 2000 review of Amendment 13 harvest management matrix. *Changes are highlighted and italicized*.

Parent Spawner Status[1]	**Marine Survival Index** *(Wild adult coho survival as predicted by Mill Cr (Yaquina) jack/smolt ratios)*			
	Extremely Low *<2%*	**Low** *2%-4.5%*	**Medium** *>4.5%-8%*	**High** *>8%*
High Parent Spawners > 75% of full seeding	**E** ≤ 8%	**J** ≤ 15%	**O** ≤ 30%	**T** ≤ 45%
Medium Parent Spawners > 50% & ≤ 75% of full seeding	**D** ≤ 8%	**I** ≤ 15%	**N** ≤ 20%	**S** ≤ 38%
Low Parent Spawners > 19% & ≤ 50% of full seeding	**C** ≤ 8%	**H** ≤ 15%	**M** ≤ 15%	**R** ≤ 25%
Very Low Parent Spawners > 4 fish per mile & ≤ 19% of full seeding	**B** ≤ 8%	**G** ≤ 11%	**L** ≤ 11%	**Q** ≤ 11%
Critical Parent Spawners ≤ 4 fish per mile	**A** 0 – 8%	**F** 0 – 8%	**K** 0 – 8%	**P** 0 – 8%

Sub-aggregate and Basin Specific Spawner Criteria Data

Sub-aggregate	Miles of Available Spawning Habitat	100% of Full Seeding	"Critical"		Very Low, Low, Medium & High		
			4 Fish per Mile	12% of Full Seeding	19% of Full Seeding	50% of Full Seeding	75% of Full Seeding
Northern	899	21,700	3,596	NA	4,123	10,850	16,275
North-Central	1,163	55,000	4,652	NA	10,450	27,500	41,250
South-Central	1,685	50,000	6,740	NA	9,500	25,000	37,500
Southern (*Removed per adoption of Amendment 16*)							
Coastwide Total	*3,747*	*126,700*	*14,988*		*24,073*	*63,350*	*95,025*

1 Parental spawner abundance status for the OCN aggregate assumes the status of the weakest sub-aggregate.

Retrospective Analysis

The last 13 years provides a wide range of pre-harvest OCN coho salmon ocean recruitment levels for a comparison of harvest management performance, from 51,000 in 1999 to 385,000 in 2011 (Table 5). The allowable fishery impact rates for the period 1999 through 2011 averaged 17% under A13, 13% under the OCN Work Group guidance, and would have been 18% under the current proposal (Table 5). All of these rates are well below the levels seen prior to implementation of A13 in 1998 (Table III-2 in PFMC 2012). In addition, actual fishery impact rates for the period 1999 through 2011 were consistently below the allowable rate, averaging 42% and ranging from 24% to 59% of the allowable rate. In this

Table 5. Retrospective analysis of allowable Fishery Impact Rate (FIR) under three management regimes for Oregon Coastal wild coho salmon.

	Actual Spawners, and FIR based on MSM/FRAM			Amendment 13 (Implemented 1998)			OCN Work Group (Implemented 2001)			Current Proposal		
Fishery Year	Pre-Harvest Recruits	Spawners	FIR	Harvest	Spawners	FIR	Harvest	Spawners	FIR	Harvest	Spawners	FIR
1999	50,959	47,239	0.07	7,644	43,315	0.15	4,077	46,882	0.08	4,077	46,882	0.08
2000	77,017	73,782	0.04	11,553	65,464	0.15	6,161	70,856	0.08	6,161	70,856	0.08
2001	168,606	162,705	0.04	25,291	143,315	0.15	13,488	155,118	0.08	13,488	155,118	0.08
2002	271,733	258,418	0.05	40,760	230,973	0.15	40,760	230,973	0.15	40,760	230,973	0.15
2003	249,358	229,409	0.08	37,404	211,954	0.15	37,404	211,954	0.15	62,340	187,018	0.25
2004	187,192	172,778	0.08	28,079	159,113	0.15	28,079	159,113	0.15	28,079	159,113	0.15
2005	161,170	154,595	0.04	32,342	129,368	0.20	24,257	137,453	0.15	24,257	137,453	0.15
2006	139,415	128,819	0.08	27,883	111,532	0.20	20,912	118,503	0.15	20,912	118,503	0.15
2007	75,137	66,271	0.12	15,027	60,110	0.20	15,027	60,110	0.20	11,271	63,866	0.15
2008	183,166	179,686	0.02	27,475	155,691	0.15	14,653	168,513	0.08	54,950	128,216	0.30
2009	281,602	262,735	0.07	42,240	239,362	0.15	42,240	239,362	0.15	70,401	211,201	0.25
2010	296,768	283,413	0.05	44,515	252,253	0.15	44,515	252,253	0.15	44,515	252,253	0.15
2011	385,146	356,260	0.08	77,029	308,117	0.20	57,772	327,374	0.15	173,316	211,830	0.45
2012						*0.20*			*0.15*			*0.30*
Avg.	**194,447**	**182,778**	**0.06**	**32,096**	**162,351**	**0.17**	**26,873**	**167,574**	**0.13**	**42,656**	**151,791**	**0.18**
Highest Three Recruitment Years (2009, 2010, 2011)												
Avg.	**321,172**	**300,803**	**0.06**	**54,595**	**266,577**	**0.17**	**48,176**	**272,996**	**0.15**	**96,077**	**225,095**	**0.28**
Min.		262,735			239,362			239,362			211,201	
Middle Seven Recruitment Years (2001 through 2006, 2008)												
Avg.	**194,454**	**183,773**	**0.05**	**31,319**	**163,135**	**0.16**	**25,650**	**168,804**	**0.13**	**34,969**	**159,485**	**0.18**
Min.		128,819			111,532			118,503			118,503	
Lowest Three Recruitment Years (1999, 2000, 2007)												
Avg.	**67,704**	**62,431**	**0.08**	**11,408**	**56,296**	**0.17**	**8,422**	**59,283**	**0.12**	**7,170**	**60,535**	**0.10**
Min.		47,239			43,315			46,882			46,882	

sense, all three management scenarios were successful in achieving the goal of ensuring that harvest impacts are consistent with OCN recovery needs.

The assumption inherent in the OCN harvest matrix concept is that the metrics for parental status and marine survival have a relationship with actual pre-harvest ocean recruitment levels. To evaluate this assumption, average results from the retrospective analysis were calculated for three categories: top three recruitment years, bottom three recruitment years, and middle seven recruitment years (Table 5). The A13 matrix did not provide any differentiation of high, middle, and low recruitment years with average allowable fishery impact rates of 17%, 16% and 17% respectively (Table 5). The OCN Work Group matrix had some differentiation, but the differences between high, middle, and low recruitment years were small, with average allowable fishery impact rates of 15%, 13% and 12% respectively (Table 5). The current proposal using wild jack/smolt ratios provides much more differentiation of recruitment levels than those using OPIH jack/smolt ratios, averaging 28%, 18% and 10% fishery impact rates for the high, middle and low recruitment years (Table 5).

Discussion

The goal for harvest management of OCN coho salmon is to control harvest impacts such that they do not impede recovery of OCN coho salmon while also allowing for incidental harvest of OCN coho salmon during harvest of other salmon species or stocks and the directed harvest of OCN coho salmon when appropriate. Achieving this goal is dependent on forecasts that accurately represent OCN coho salmon. ODFW, as part of the OPSW, has monitored OCN coho salmon spawner abundance (Lewis et al. 2011), freshwater habitat (Anlauf et al. 2009), and an index of marine survival and jack/smolt ratios (Suring et al. 2012) from 1998 to present, providing data directly related to OCN coho salmon that were unavailable when A13 was developed. These data show that LCM sites in aggregate are representative of OCN coho salmon in regards to both adult returns and habitat quality and that the LCM marine survival index is a reasonable index of OCN adult marine survival. The LCM jack/smolt ratio explains much more of the variation in OCN adult marine survival than the OPIH jack/smolt ratio and provides a higher forecast skill. There is no indication that the relationship between OPIH jack/smolt ratios and OPIH adult marine survival has changed since the development of A13, however, OPIH data, either abundance or survival, are not correlated with OCN data.

Revising the source of the A13 marine survival axis from OPIH jacks/smolt to LCM jacks/smolt would increase the forecast skill, as measured by Pearson’s correlation coefficient r, from 0.30 to 0.86. Rupp et al. (2012) conducted a management strategy evaluation (MSE) examining the effect of forecast skill on A13 performance. While Rupp et al. (2012) did not consider a forecast skill improvement of this magnitude, their “poor” forecast skill had an r = 0.50 and their “good” had an r = 0.90, the increase in skill from 0.50 to 0.90 resulted in a 5% increase in long-term harvest and a reduction in the frequency of falling below the critical spawner density of 1%. These performance improvements would be expected to be higher given the greater increase in forecast skill in this proposal.

The potential for management improvement under this proposal has also been evaluated by comparing outcomes under the observed conditions of the last 13 years. The current proposal would have done a better job of meeting the management objectives of reducing impact rates in low recruitment years and allowing greater harvest opportunities in high recruitment years. In the lowest recruitment years the current proposal would have capped impact rates at an average of 10% versus 12% under the OCN Work Group and 17% under the original A13 (Table 5). In high recruitment years the current proposal allows harvest of 28% versus 15% and 17%. Overall the OCN Work Group and original A13 results have little or no differentiation in impact rates at different abundance levels compared to the results for the current proposal. Return year 2007 had the lowest pre-harvest coho salmon abundance of the last 12 years. However, the original A13 and OCN Work Group matrix mistakenly categorized the marine survival index as medium and allowed a 20% impact rate, the highest either method has allowed during the last 12 years. The resulting actual impact rate for OCN coho salmon in 2007 was 12%, which was the highest since A13 was adopted. The proposed predictor correctly identified 2007 as a return year with low marine survival, although an allowable harvest rate of 15% would have still been set based on parental spawner abundance.

One concern with using the Mill Creek (Yaquina) jack/smolt ratio as the basis for the marine survival axis is that it is based on a single site. If an unexpected event changes the out-migrating smolt condition such that it impacts the jack rate or early marine survival of these fish, it could disrupt the relationship between the jack/smolt ratio and the OCN marine survival index. In the springs of 2011 and 2012 smolt production has been less than expected given the number of adult spawners (Suring et al. 2012). While the level of absolute smolt production does not necessarily have an impact on the predictor, as it is normalized to the number of smolts, lower smolt production may cause higher uncertainty due to low sample sizes and may be a sign that conditions have changed at the Mill Creek site. The reliance on a single site could be ameliorated by modifying or creating new LCM sites so that jacks can be enumerated. Candidates include the North Fork Nehalem, the East Fork Trask River, and Cascade Creek. Future work will also include incorporating additional sources of information, such as ocean environmental indictors. The Mill Creek jack/smolt ratio and the OCN marine survival index relationship will be monitored annually and, if its performance deteriorates beyond that of the current predictor, the status quo of OPIH jack/smolt ratios will continue to be available as an alternative.

This proposed change to the implementation of A13 does not alter the current parental spawner axis, allowable fishery impact rates, or the categories of the marine survival axis. It changes the method of determining the OCN marine survival axis category from one based on Columbia River hatchery coho salmon to one based on wild coho salmon within the OCN area. We expect the adoption of this technical revision will result in improved management of OCN coho salmon harvest impacts. By increasing the forecast skill of the marine survival prediction fishery impact rates will better match true pre-harvest abundance levels. While the MSE conducted by Rupp et al. (2012) suggested that improvements will be moderate it also demonstrated that the risk of this proposal is relatively low.

Recommendations

Based on the results of this analysis we recommend the following technical updates to the OCN Work Group guidance on implementation of Amendment 13:

- Remove the Southern sub-aggregate from the Parental Spawner Axis criteria of the matrix as a housekeeping measure per adoption of Amendment 16.
- Change the metric for the Marine Survival Index Axis from the OPIH jack/smolt ratio to predicted wild coho salmon adult survival based on the Mill Creek (Yaquina) wild jack/smolt ratio.

Additionally ODFW and partners will continue to investigate improvements to the OCN adult marine survival predictor:

- Pursue developing jack collections at other LCM sites as additions to the Mill Creek LCM data.
- Pursue analysis of the OCN abundance predictor (ocean conditions) and other data sets as additions or alternatives to the Mill Creek LCM data as an OCN adult marine survival predictor.

Acknowledgments

The authors would like to acknowledge the contributions of Bob Buckman, ODFW District Biologist, Kevin Goodson, ODFW Conservation and Recovery Program, and Chris Kern, ODFW Fisheries Management in providing motivation and feedback on this proposal.

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