Status Determination Criteria for Willapa Bay Natural Coho

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Introduction

When the Council took final action on Amendment 16 to the Salmon FMP at the June, 2011 meeting in Spokane, among other things, Willapa Bay natural coho were added to the FMP. Because this stock is not currently included in the Pacific Salmon Treaty, they are subject to the annual catch limit (ACL) requirement. In addition, regardless of whether or not they are subject to the ACL requirement, they require specification of S_{MSY}, and status determination criteria (SDC). We currently report on the escapement of this stock in our annual review of Ocean Salmon Fisheries, and list a WDFW escapement goal of 13,090, but there is no FMP goal. The WDFW goal is based on watershed area, so it could be argued that it is an estimate of S_{MSY}, but that has not been done; the goal has not been reviewed or adopted by the Council, and there is no estimate of F_{MSY}. We also have no F_{MSY} proxy for tier 2 coho stocks (stocks with no direct estimate of F_{MSY}), so we have no basis for developing SDC or an ACL control rule. Consequently, the status quo is that S_{MSY}, SDC (MSST, OFL, FMFT), as well as ACL are all undefined.

The purpose of this report is to develop SDC for Willapa Bay natural coho from evaluation of spawner-recruit data.

Background

Willapa Bay coho were historically managed for hatchery production. Hatcheries are located on Forks Creek (Willapa River), Nemah River, and Naselle River. In the mid-1990s WDFW began monitoring natural spawning escapement and established natural escapement goals based on available habitat, assuming that habitat in the Willapa Bay drainage was half as productive as that in the lower Columbia River tributaries (Table 1).

In addition to ocean recreational and commercial fisheries, within Willapa Bay, there are commercial net fisheries, and recreational fisheries both in the bay itself, and freshwater fisheries in the tributaries.

Data and Methods

WDFW monitors spawning escapement and fisheries in Willapa Bay. The STT reports terminal catch data and spawning escapement in Appendix Table B-24 of our annual Review of Ocean Salmon Fisheries (STT 2013). Data in this table include natural spawners, hatchery spawners, terminal run, and terminal catches in gillnet and sport fisheries. However, WDFW maintains a more detailed dataset used for run reconstruction. The run reconstruction allocates catches to individual rivers and to hatchery and natural production on the basis of timing, location, and mark status. The run reconstruction backs natural and hatchery origin spawners out to terminal run size (Table 2). Spawner data used in this analysis were total natural area spawners regardless of origin, with no discounting for the effectiveness hatchery origin spawners in natural areas. Recruits were calculated by expanding the terminal run of natural origin adults by the pre-

terminal ocean exploitation rates for unmarked fish calculated using the fishery regulation assessment model (FRAM).

While CWT data are available for hatchery fish from Forks Creek, Naselle, and Nemah Hatcheries in Willapa Bay, natural production is unmarked. During the time period for which data are available, mark-selective ocean fisheries have been implemented. Because there have been mixtures of mark-selective and non-selective fisheries within fisheries in individual years, there is no easy way to infer exploitation rates on unmarked fish from CWT data. In order to infer incidental mortality on unmarked fish from CWT data, it would be necessary to examine the time and location of each tag recovery and determine whether or not the fishery in which it was recovered was mark-selective in that port on that date. Thus pre-terminal exploitation rates for unmarked fish from FRAM provide a more consistent and convenient framework for generating pre-harvest recruit estimates, and were used for this analysis (Table 3). This is consistent with the methods used for other Washington coast coho stocks.

A stochastic Ricker spawner-recruit relationship (SRR) was fitted to the data. The SRR was of the form:

(1) $$R_{t+3} = \alpha S_t e^{-\beta S_t + \varepsilon_t}$$

where R is natural origin pre-harvest recruits, S is natural area spawners, and ε assumed to be normally distributed independent errors with mean 0 and variance σ^2. The SRR was fitted by least squares regression after transforming it:

(2) $$\ln\left({R_{t+3}}/{S_t}\right) = \ln(\alpha) - \beta S_t + \varepsilon_t$$

Parameter estimates were corrected for process error, with estimation bias and measures of precision of parameter and reference point estimates derived by bootstrapping 100,000 samples using the methods described in STT (2005).

Results and Discussion

The bias corrected parameter estimates along with MSY reference points are presented in Table 4, along with bootstrapped estimates of bias and precision. The fit of the Ricker spawner-recruit relationship is shown in Figure 1. The estimated S_{MSY} of 17,200 natural area spawners is somewhat higher than the current WDFW escapement goal of 13,090 spawners for the aggregate of all subcomponents of the Willapa Bay coho stock based on habitat area (Table 1). However, the agency goal is for natural origin spawners, while the analysis presented here used all spawners in natural areas regardless of origin. Since 1996, natural origin spawners have accounted for approximately 79% of the total spawning escapement to natural areas. Applying this average percentage of natural origin spawners, the S_{MSY} value of 17,200 equates to 13,600 natural origin spawners. This is surprisingly similar to the current escapement goal.

The estimated F_{MSY} of 0.75 from this analysis is somewhat higher than values estimated for other Washington coastal coho stocks. Those ranged from 0.59 for the Quillayute River, to 0.69 for the Hoh River and Grays Harbor. However, despite Willapa Bay having a higher estimated maximum sustainable exploitation rate than other Washington coastal coho stocks, this rate was exceeded in 2005, 2006, and 2011.

Recommendations

The STT currently reports spawning escapement for Willapa Bay coho in terms of natural origin and hatchery origin fish. Current agency goals are also expressed in these terms. From a pragmatic standpoint, it makes more sense to have an escapement goal (and SDC) based on the total number of fish actually spawning naturally, rather than on a portion of the natural spawning escapement. This is consistent with escapement goals on for other Washington coho stocks, and with the SDC the Council has adopted for Klamath River fall Chinook. The analysis presented here supports reference points of $F_{MSY} = 0.75$, and $S_{MSY} = 17{,}200$.

Based on these reference points the recommended SDC are:

$MFMT = F_{MSY} = 0.75$,

and

$MSST = 0.5*S_{MSY} = 8{,}600$.

While other Washington coastal coho and Puget Sound coho stocks are exempt from the ACL requirement by virtue of being managed under an international agreement, Willapa Bay coho are not. Under the FMP, as a tier 1 stock, Willapa Bay coho would thus have an ACL set by the $F_{ABC} = 0.95*F_{MSY} = 0.71$.

References

STT. 2013. Review of 2012 Ocean Salmon Fisheries. Pacific Fishery Management Council. Portland, OR. February 2013. 364p.

STT 2005. Klamath River fall Chinook stock-recruitment analysis. Agenda Item G.1.b, Pacific Fishery Management Council. September, 2005. 31p.

Table 1. Current WDFW coho natural spawning escapement goals for Willapa Bay based on habitat area.

Watershed	Escapement Goal	Hatchery Program
North River/Smith Creek	5,286	No
Willapa River	4,030	Yes
Palix River	251	No
Nemah River	994	Yes
Naselle River	2,091	Yes
Bear River	438	No
Total	13,090	

Table 2. Summary of the terminal run reconstruction. Spawning escapement is separated into natural spawning and hatchery spawning, and fish are identified as either natural origin (NOR), or hatchery origin (HOR). Numbers that fed into the spawner-recruit analysis are indicated in bold.

	Spawners					Terminal Catch				Terminal Run Size	
	Natural			Hatchery		Recreational		Commercial			
Year	NOR	HOR	total	HOR	NOR	NOR	HOR	NOR	HOR	NOR	HOR
1996	15,711	25,824	**41,535**	23,071	-	796	3,256	7,953	30,369	24,460	82,520
1997	4,934	2,879	**7,813**	3,520	-	360	446	504	1,022	5,799	7,866
1998	13,804	1,971	**15,775**	4,814	-	297	555	5,687	7,453	19,788	14,793
1999	9,628	4,404	**14,032**	18,307	-	331	2,505	3,866	1,601	**13,825**	26,817
2000	23,031	3,648	**26,679**	25,500	3	177	1,603	3,702	6,624	**26,913**	37,375
2001	48,404	7,752	**56,156**	46,607	-	2,082	3,607	6,350	25,562	**56,836**	83,528
2002	52,722	13,702	**66,424**	41,136	-	1,500	4,185	15,395	44,037	**69,616**	103,061
2003	46,469	9,474	**55,943**	59,323	235	1,639	4,087	16,926	49,541	**65,269**	122,425
2004	36,437	7,996	**44,433**	13,224	202	968	1,393	9,190	7,336	**46,797**	29,949
2005	21,904	10,654	**32,558**	34,511	103	977	2,915	42,509	6,492	**65,493**	54,572
2006	12,009	2,292	**14,301**	5,796	297	342	464	9,934	10,014	**22,583**	18,565
2007	18,022	2,502	**20,524**	6,741	180	412	543	5,167	3,051	**23,781**	12,837
2008	14,778	3,784	**18,561**	8,704	120	540	687	11,067	5,632	**26,505**	18,806
2009	45,354	5,296	**50,650**	17,517	301	2,999	3,462	38,792	36,625	**87,447**	62,899
2010	76,434	16,594	93,028	23,581	139	1,311	3,618	16,698	21,414	**94,582**	65,207
2011	31,047	8,254	39,301	17,360	216	2,092	3,726	18,488	29,685	**51,843**	59,025
2012	20,024	4,323	24,347	12,846	232	2,735	2,317	13,913	11,978	**36,904**	31,464

Table 3. Spawning escapement and recruitment data used for Willapa Bay coho. Spawners include both natural origin fish and hatchery origin fish that spawned in natural areas. Recruits include only natural origin fish.

Return Year	Total ER	Ocean ER	Natural Esc (inc hatchery strays)	NOR Esc	NOR Terminal Run	NOR Adult Recruits (NOR TR/(1-OcnER))
1996	42%	14%	**41,535**	15,711	24,549	28,593
1997	22%	10%	**7,813**	4,934	5,823	6,459
1998	54%	5%	**15,775**	13,804	19,824	20,759
1999	24%	4%	**14,032**	9,628	14,061	**14,639**
2000	36%	6%	**26,679**	23,034	26,992	**28,768**
2001	46%	6%	**56,156**	48,404	56,959	**60,453**
2002	70%	5%	**66,424**	52,722	69,672	**73,546**
2003	69%	6%	**55,943**	46,704	65,408	**69,291**
2004	48%	9%	**44,433**	36,639	46,819	**51,350**
2005	76%	5%	**32,558**	22,007	65,594	**69,325**
2006	88%	7%	**14,301**	12,306	22,609	**24,383**
2007	43%	11%	**20,524**	18,202	23,805	**26,765**
2008	50%	4%	**18,561**	14,898	26,546	**27,645**
2009	61%	9%	**50,650**	45,655	87,732	**96,693**
2010	46%	4%	93,028	76,573	94,582	**98,294**
2011	92%	5%	39,301	31,263	51,843	**54,764**
2012	na	5% est.	24,347	20,256	36,904	**38,983**

Table 4. Parameter estimates and reference points for Willapa Bay coho from fitting a Ricker spawner-recruit relationship to Willapa Bay coho data with correction for process error. Estimates of bias and precision based on 100,000 bootstrap replicates.

	Point estimate	Bootstrap mean	Bootstrap cv	90% lower bound	90% upper bound
α	6.93	7.26	30.5%	4.18	10.32
β	0.0000433	0.0000433	18.5%	0.0000302	0.0000565
S_{MSY}	17,200	17,300	12.6%	14,300	21,300
F_{MSY}	0.75	.73	8.7%	0.62	0.83
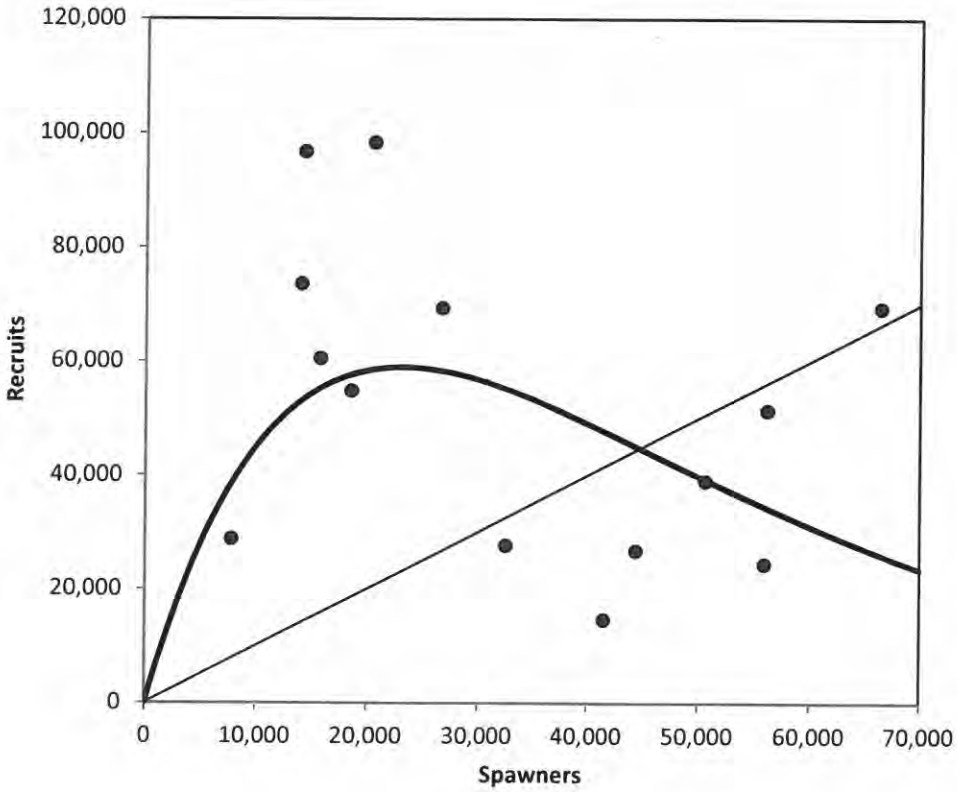
Figure 1. Fit of Ricker spawner-recruit relationship to Willapa Bay coho data including correction for process error. Spawners are in terms of total natural spawners, both hatchery and natural origin. Recruits are in terms of natural origin recruits.