Oregon Coast Coho Conservation Plan for the State of Oregon
Appendix 2

Desired Status: Measurable Criteria for the Oregon Coast Coho Conservation Plan for the State of Oregon

Prepared by
Oregon Department of Fish and Wildlife
In Partnership with State and Federal Natural Resource Agencies

March 16, 2007

Desired Status: Measurable Criteria for the Oregon Coast coho ESU

Introduction

Setting clear goals and measuring progress towards the desired status goal using objective criteria is mandated by the Native Fish Conservation Policy. Four critical considerations were applied during the development of the benchmarks (i.e. measurable criteria) to evaluate the success of this Conservation Plan:

1. The criteria must be scientifically defensible and tied to the most recent science regarding on salmonid viability.
2. The criteria must be stated in quantifiable units and utilize data that are readily available.
3. The criteria must be relatively easy to understand.
4. The application of the criteria to the status of coastal coho must yield consistent results that can be independently confirmed by others.

For this Conservation Plan, six measurable criteria have been established for independent populations and two for dependent populations. The goal of this Conservation Plan will be met when: 1) all independent populations pass the six measurable criteria for independent populations and 2) the aggregate of dependent populations within a biogeographic stratum pass the two measurable criteria for dependent populations. It should, however, be possible to observe positive improvements long before the overall goal is achieved,. As a measure of a *minimum level of desired status*, the following condition must be met:

- All 21 independent populations pass all the *sustainability* criteria (as defined by the Oregon/Northern California Coast TRT). A pass is defined as any positive truth value for the individual criteria, a fail is a truth value ≤ 0.0. Populations that currently pass (as defined in previous sentence) must maintain or improve upon their current scores.

Measurable Criteria for Independent Populations

For independent populations, measurable criteria were developed for the following attributes of species performance:

1. Abundance – the number of naturally-produced spawners.
2. Persistence – the forecast likelihood that the population will persist in the future.
3. Productivity – the number of recruits (progeny) produced per spawner (parent).
4. Distribution – the distribution of spawners among habitats within a population's home range.
5. Diversity – indices of genetic variability related to a population's ability to adequately respond to unpredictable natural variations in the environment and retain those adaptive genetic characteristics that promote optimum survival in basin specific habitats.

6. Habitat – The amount of available high quality habitat across all freshwater life stages.

Criterion 1 – Adult Abundance

Metric
The annual estimates of abundance of naturally-produced spawners in each independent population and the ESU as a whole.

Evaluation Thresholds
Pass – The observed spawner abundance is ≥ the *marine survival*-specific escapement target (Tables 1 and 2) at least six times in any 12-year period.
Fail – The observed spawner abundance is > the *marine survival*-specific escapement target (Tables 1 and 2) 5 times or less in any 12-year period.

Discussion and Rationale: **Criterion 1 – Adult Abundance**
This criterion is intended to ensure that adequate numbers of adult spawners return to ensure the health of the population and provide, in the majority of years, economic, societal and ecological benefits. Adult abundance is described in terms of naturally-produced spawners.

Marine survival rates for coho are known to fluctuate widely with annual variations in ocean temperature and upwelling (Nickelson 1986; Logerwell et al. 2003) as well as decadal scale cycles associated with broader climatic conditions (Beamish and Bouillon 1993; Beamish et al. 2000). Observed smolt to adult survival rates between high and low years have typically been in the range of ten-fold. Therefore a desired status abundance goal must be scaled to variable ocean survival rates. Annual estimates of marine survival will be based on smolt-to-adult survival averaged across the six life cycle monitoring sites in the Oregon Coast coho ESU.

The working hypothesis for this adult abundance criterion is based on observations of naturally produced spawners in independent populations during 1993-1999 return years. The 1993-1999 return years were characterized by: 1) an average estimated smolt to adult survival of naturally produced coho of 1.1 %; and 2) an average escapement of 50,500 naturally produced adults (calculated by summing individual independent population estimates).

This conservation plan calls for a doubling of the average abundance observed during 1993-1999 scaled to future ocean survival rates. In other words, achieving desired status would require an average escapement of 101,000 spawners during years with marine survival similar to the 1993-99 return years. To achieve this abundance would require production of approximately 9.9 million wild smolts (109,000 needed for preharvest divided by 1.1% smolt to adult survival). Goals for total adult recruits and spawners are calculated for any given marine survival rate by (1) multiplying 9.9 million smolts by specific ocean condition categories defined in Amendment 13, and (2) applying *marine* *survival*-specific allowable harvest rates. The results of these calculations and the resulting *marine survival*-specific adult abundance goals are shown in table 1. These goals represent the *minimum* expected spawner abundance and the *maximum* harvest rates as allowed under the Amendment 13 harvest matrix.

Abundance targets were developed for all independent populations to ensure that naturally produced spawners are broadly distributed throughout the ESU (Table 2). For the lake populations (Siltcoos, Tahkenitch, and Tenmile) the targets at extremely low marine survival are equal to the average number of spawners observed during periods of similar marine survival in the 1990's. For the non-lake populations, these targets were based on the assumption that the proportion of the total amount of Coho High Winter Intrinsic Potential habitat in all non-lake populations that is in each population represents the inherent relative capacity of that population to support coho.

It should be noted that because these abundance criteria are based on production from high quality habitat, it is possible that a climate regime that is characterized by

Table 1. Desired status goals for adult coho abundance under different marine survival conditions.

Smolt to Adult Survival[1]			**Maximum Allowable Harvest[2]**		
Category	**Average Survival**	**Recruits**	**Harvest Rate**	**Number**	**Spawners**
Extremely Low	1.1%	109,000	7%	8,000	101,000
Low	4.4%	436,000	15%	65,000	371,000
Medium	10.3%	1,021,000	30%	306,000	715,000
High	15.0%	1,486,000	45%	669,000	817,000

[1]For wild fish as indexed at Life Cycle Monitoring Sites
[2]Based on Amendment 13

Table 2. Escapement goals under different marine survival conditions (average survival rate in parentheses) for independent populations comprising the Oregon Coast coho ESU.

Strata	Population	Marine Survival Category			
		Extremely Low (1.1%)	Low (4.4%)	Medium (10.3%)	High (15%)
North Coast	Necanicum	1,300	4,800	9,200	10,500
	Nehalem	10,300	37,800	72,900	83,300
	Tillamook	4,000	14,700	28,300	32,400
	Nestucca	2,000	7,300	14,200	16,200
Mid-Coast	Salmon	500	1,800	3,500	4,000
	Siletz	2,900	10,700	20,500	23,500
	Yaquina	5,000	18,400	35,400	40,400
	Beaver	800	2,900	5,700	6,500
	Alsea	4,500	16,500	31,900	36,400
	Siuslaw	13,300	48,900	94,200	107,600
Umpqua	Lower Umpqua	8,000	29,400	56,600	64,700
	Middle Umpqua	9,400	34,500	66,500	76,000
	North Umpqua	1,900	7,000	13,500	15,400
	South Umpqua	10,900	40,000	77,200	88,200
Lakes	Siltcoos	3,200	11,800	22,700	25,900
	Tahkenitch	1,900	7,000	13,500	15,400
	Tenmile	4,500	16,500	31,900	36,400
Mid-South Coast	Coos	6,100	22,400	43,200	49,300
	Coquille	8,400	30,900	59,500	67,900
	Floras	1,600	5,900	11,300	12,900
	Sixes	500	1,800	3,500	4,000
	Total	101,000	371,000	715,000	817,000

consecutive years of relatively good marine survival as was experienced in the 1960s and early 1970s may result in a "false positive" result of assessment of this metric. This is because under these conditions significant smolt production emanates from marginal freshwater habitats that would be unoccupied during an unfavorable climate regime. Thus one could conclude that the conservation goals had been achieved when in reality when the regime shifts back to an unfavorable marine survival conditions, the populations would fail the criteria. By conducting the analysis over a twelve year time period should minimize the potential for false positives. In addition, adding a habitat criterion provides a metric to evaluate whether the increased production during an extended period of good marine survival is due to improved marine survival and/or improved habitat capacity, further reducing the risks of a "false positive".

Analysis: **<u>Criterion 1 – Adult Abundance</u>**

As demonstrated by Table 3, not surprisingly, all populations fail this criterion. The closest populations to achieving the desired status were the Siltcoos population, which met the abundance target four times in the last 12 years, followed by the Tenmile, Tahkenitch, and Beaver populations , which each met the target three times. On average, the Siltcoos population achieved 81% of the target levels followed by the Tenmile at 80%, Beaver at 78%, and Tahkenitch at 70% of the target levels. The performance of these populations is consistent with our assessment that they are the most productive populations on the coast, three being lake populations and Beaver having some of the best habitat in the form of intact wetlands.

Overall the ESU averaged 40% of the target levels. This is not surprising because the desired status was established as a doubling of abundance during the base period of 1993-99.

Table 3. Abundance of wild coho salmon spawners by population compared to desired status. Percent observed is highlighted in bold for those instances where observed spawners exceeded population goals.

	Retun year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Population	Marine surv.	EL	EL	EL	EL	EL	L	L	M	L	M	L	L
Necanicum	Goal	1,300	1,300	1,300	1,300	1,300	4,700	4,700	9,100	4,700	9,100	4,700	4,700
	Observed	269	181	416	97	575	351	359	4,832	2,047	2,377	2,198	896
	% of Goal	21%	14%	32%	7%	44%	7%	8%	53%	44%	26%	47%	19%
Nehalem	Goal	10,300	10,300	10,300	10,300	10,300	37,700	37,700	72,700	37,700	72,700	37,700	37,700
	Observed	2,844	1,700	527	1,187	1,206	3,555	14,462	21,928	17,164	32,517	18,736	9,156
	% of Goal	28%	17%	5%	12%	12%	9%	38%	30%	46%	45%	50%	24%
Tilllamook	Goal	4,000	4,000	4,000	4,000	4,000	14,400	14,400	28,100	14,400	28,100	14,400	14,400
	Observed	1,105	341	733	437	358	1,831	2,178	1,944	13,334	13,008	2,532	974
	% of Goal	28%	9%	18%	11%	9%	13%	15%	7%	93%	46%	18%	7%
Nestucca	Goal	2,000	2,000	2,000	2,000	2,000	7,400	7,400	14,200	7,400	14,200	7,400	7,400
	Observed	266	1,537	440	230	202	2,357	1,219	4,164	16,698	10,194	4,695	663
	% of Goal	13%	77%	22%	12%	10%	32%	16%	29%	**226%**	72%	63%	9%
Salmon	Goal	500	500	500	500	500	1,900	1,900	3,600	1,900	3,600	1,900	1,900
	Observed	91	105	82	16	86	14	179	225	543	42	1,642	160
	% of Goal	18%	21%	16%	3%	17%	1%	9%	6%	29%	1%	86%	8%
Siletz	Goal	2,900	2,900	2,900	2,900	2,900	10,800	10,800	20,900	10,800	20,900	10,800	10,800
	Observed	621	314	395	298	316	1,209	3,387	1,595	2,129	8,038	8,179	11,637
	% of Goal	21%	11%	14%	10%	11%	11%	31%	8%	20%	38%	76%	**108%**
Yaquina	Goal	5,000	5,000	5,000	5,000	5,000	18,500	18,500	35,600	18,500	35,600	18,500	18,500
	Observed	2,040	4,723	4,578	419	510	2,563	637	3,589	23,800	16,484	5,539	6,464
	% of Goal	41%	94%	92%	8%	10%	14%	3%	10%	129%	46%	30%	35%
Beaver	Goal	800	800	800	800	800	2,800	2,800	5,400	2,800	5,400	2,800	2,800
	Observed	675	308	1,296	497	401	1,511	1,464	1,832	3,217	5,552	4,569	985
	% of Goal	84%	39%	**162%**	62%	50%	54%	52%	34%	**115%**	**103%**	**163%**	35%
Alsea	Goal	4,500	4,500	4,500	4,500	4,500	16,600	16,600	32,100	16,600	32,100	16,600	16,600
	Observed	828	441	1,060	601	108	1,341	3,363	3,228	9,073	10,281	5,233	10,191
	% of Goal	18%	10%	24%	13%	2%	8%	20%	10%	55%	32%	32%	61%
Siuslaw	Goal	13,300	13,300	13,300	13,300	13,300	49,000	49,000	94,400	49,000	94,400	49,000	49,000
	Observed	3,159	6,161	7,234	501	1,020	2,980	6,532	10,606	55,445	29,003	8,729	15,716
	% of Goal	24%	46%	54%	4%	8%	6%	13%	11%	**113%**	31%	18%	32%
Lower Umpqua	Goal	8,000	8,000	8,000	8,000	8,000	29,500	29,500	56,900	29,500	56,900	29,500	29,500
	Observed	2,762	10,854	7,985	1,257	4,552	2,623	5,781	11,639	18,881	16,494	8,989	26,512
	% of Goal	35%	**136%**	99.8%	16%	57%	9%	20%	20%	64%	29%	30%	90%
Middle Umpqua	Goal	9,400	9,400	9,400	9,400	9,400	34,600	34,600	66,700	34,600	66,700	34,600	34,600
	Observed	2,162	3,250	5,086	563	1,257	1,748	4,555	8,940	10,738	11,090	6,375	9,150
	% of Goal	23%	35%	54%	6%	13%	5%	13%	13%	31%	17%	18%	26%

Table 3. (continued)

Population	Retun year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Marine surv.	EL	EL	EL	EL	EL	L	L	M	L	M	L	L
North Umpqua	Goal	1,900	1,900	1,900	1,900	1,900	6,800	6,800	13,100	6,800	13,100	6,800	6,800
	Observed	899	1,293	1,069	577	765	1,194	1,677	2,634	3,368	2,862	4,025	2,113
	% of Goal	47%	68%	56%	30%	40%	18%	25%	20%	50%	22%	59%	31%
South Umpuqa	Goal	10,900	10,900	10,900	10,900	10,900	40,100	40,100	77,400	40,100	77,400	40,100	40,100
	Observed	1,081	4,715	7,040	937	3,177	3,011	2,581	11,871	10,517	4,337	10,997	10,576
	% of Goal	10%	43%	65%	9%	29%	8%	6%	15%	26%	6%	27%	26%
Siltcoos	Goal	3,200	3,200	3,200	3,200	3,200	11,800	11,800	22,700	11,800	22,700	11,800	11,800
	Observed	1,302	4,415	4,707	2,653	3,122	2,756	3,835	5,104	4,636	6,628	7,969	4,364
	% of Goal	41%	**138%**	**147%**	83%	98%	23%	33%	22%	39%	29%	68%	37%
Tahkenitch	Goal	1,900	1,900	1,900	1,900	1,900	7,000	7,000	13,500	7,000	13,500	7,000	7,000
	Observed	1,056	1,577	1,627	1,842	2,817	3,664	634	3,510	3,480	3,188	3,496	1,897
	% of Goal	56%	83%	86%	97%	**148%**	52%	9%	26%	50%	24%	50%	27%
Tenmile	Goal	4,500	4,500	4,500	4,500	4,500	16,500	16,500	31,900	16,500	31,900	16,500	16,500
	Observed	3,354	5,092	7,092	4,092	5,169	6,123	8,278	10,990	13,861	6,260	7,148	8,464
	% of Goal	75%	**113%**	**158%**	91%	**115%**	37%	50%	34%	84%	20%	43%	51%
Coos	Goal	6,100	6,100	6,100	6,100	6,100	22,300	22,300	42,900	22,300	42,900	22,300	22,300
	Observed	14,500	10,302	12,128	1,112	2,985	4,818	4,704	33,595	33,120	25,761	23,337	23,222
	% of Goal	**238%**	**169%**	**199%**	18%	49%	22%	21%	78%	**149%**	60%	**105%**	**104%**
Coquille	Goal	8,400	8,400	8,400	8,400	8,400	30,900	30,900	59,600	30,900	59,600	30,900	30,900
	Observed	5,119	2,034	15,814	5,720	2,412	2,667	6,253	13,833	7,676	22,403	22,138	18,152
	% of Goal	61%	24%	**188%**	68%	29%	9%	20%	23%	25%	38%	72%	59%
Floras	Goal	1,600	1,600	1,600	1,600	1,600	5,800	5,800	11,200	5,800	11,200	5,800	5,800
	Observed	2,653	1,351	1,519	482	879	670	1,477	5,664	3,272	952	7,446	385
	% of Goal	**166%**	84%	95%	30%	55%	12%	25%	51%	56%	9%	**128%**	7%
Sixes	Goal	500	500	500	500	500	1,700	1,700	3,300	1,700	3,300	1,700	1,700
	Observed	238	77	194	143	558	56	136	95	95	86	491	62
	% of Goal	48%	15%	39%	29%	**112%**	3%	8%	3%	6%	3%	29%	4%
Total	Goal	101,000	101,000	101,000	101,000	101,000	371,000	371,000	714,000	371,000	714,000	371,000	371,000
	Observed	47,024	60,771	81,022	23,661	32,475	47,042	73,691	161,818	253,094	227,557	164,463	161,739
	% of Goal	47%	60%	80%	23%	32%	13%	20%	23%	68%	32%	44%	44%

Criterion 2 - Persistence.

Metric
The forecast probability of persistence for each independent population based on results from population viability simulation models.

Evaluation Thresholds
Pass – If the average probability of persistence from the models is greater than or equal to 0.99.
Fail – If the average probability of persistence from the models is less than 0.99.

Discussion and Rationale: **Criterion 2 - Persistence.**
A persistence criterion of a 99% or greater probability of persistence significantly increases the likelihood that the ESU is will remain viable under extreme marine survival conditions while providing substantial environmental, cultural, and economic benefits. Future analyses will be based on an average persistence value from the four population viability models developed by the TRT in their viability report.

Analysis: **Criterion 2 - Persistence.**
For a population to pass this criterion it must have an average probability of persistence of 0.99 or greater as estimated by the four PVA models used by the TRT (Wainwright et al. 2006). Because of the uncertainty of demographic effects at low population size, the TRT used two levels of "quasi-extinction" (1 and 50) to model persistence of the populations. The results of the model simulations are presented in Table 4. Eleven of the 21 populations currently pass this criterion. Only three populations, the Necanicum, Salmon, and Sixes fall below 95% persistence.

Table 4. Average probability of persistence for coho salmon population based on the results of four simulation models used by the Oregon Coast coho TRT (Wainwright et al. 2006). Values in bold pass the criterion.

Model	**Ricker**		**Hockey-Stick**		**Beverton-Holt**		**Nickelson-Lawson**		
Population	**QET=1**	**QET=50**	**QET=1**	**QET=50**	**QET=1**	**QET=50**	**QET=1**	**QET=50**	**Average**
Necanicum	1.000	0.998	0.999	0.986	0.995	0.986	0.923	0.183	0.884
Nehalem	0.995	0.994	1.000	1.000	0.991	0.991	1.000	0.995	**0.996**
Tillamook	0.948	0.943	1.000	1.000	0.995	0.992	0.991	0.929	0.975
Nestucca	1.000	1.000	1.000	1.000	0.969	0.957	0.999	0.967	0.987
Salmon	0.000	0.000			0.990	0.857	0.999	0.907	0.626
Siletz	0.962	0.935	1.000	1.000	0.991	0.982	0.999	0.991	0.983
Yaquina	1.000	0.999	1.000	0.998	0.959	0.948	1.000	0.999	0.988
Beaver	1.000	1.000	1.000	1.000	0.968	0.926	1.000	0.954	0.981
Alsea	0.997	0.997	1.000	1.000	0.998	0.996	1.000	0.998	**0.998**
Siuslaw	1.000	1.000	1.000	1.000	0.996	0.996	1.000	0.998	**0.999**
Siltcoos	1.000	1.000	1.000	1.000	1.000	1.000			**1.000**
Tahkenitch	1.000	1.000			0.971	0.970			0.985
Tenmile	1.000	1.000	1.000	1.000	0.997	0.997			**0.999**
Lower Umpqua	1.000	1.000	1.000	1.000	0.973	0.973	1.000	0.998	**0.993**
Middle Umpqua	1.000	1.000	1.000	1.000	0.975	0.966	1.000	0.998	**0.992**
North Umpqua	0.958	0.885	1.000	1.000	0.993	0.981	1.000	0.990	0.976
South Umpqua	1.000	1.000	1.000	1.000	0.990	0.987	1.000	0.999	**0.997**
Coos	1.000	1.000			0.978	0.977	1.000	1.000	**0.993**
Coquille	1.000	1.000	1.000	1.000	0.994	0.994	1.000	0.999	**0.998**
Floras	1.000	1.000					1.000	0.982	**0.996**
Sixes	0.077	0.002			0.994	0.965	1.000	0.973	0.669

Criterion 3 – Productivity

Metric

The annual estimates of number of naturally-produced recruits per spawner (R/S) in each independent population and the ESU as a whole.

Evaluation Thresholds

Pass – Over a 12-year period, R/S values, standardized to a spawner density equal to the spawner abundance goal for each marine survival category, are statistically greater than or equal to 1.0.

Fail – Over a 12-year period R/S values, standardized to a spawner density equal to the spawner abundance goal for each marine survival category, are statistically less than 1.0.

Discussion and Rationale: **Criterion 3 – Productivity**

Productivity, as used here, is defined as the number of adult recruits produced per parent spawner. This ratio is calculated by dividing recruits (counted as those fish that survive to spawn) by the number of fish in the same basin three years previously (i.e. the parents). Only naturally produced fish are counted as recruits. However, both natural fish and hatchery fish (if present) are counted as parents.

For coho to recover and be sustainable into the future, they must be able to persist through natural periods of low marine survival and have the capacity to rebound quickly when these natural conditions improve. The ability of a population to achieve such performance is largely dependent on its productivity. The higher the productivity, expressed in terms of recruits per spawner (R/S), the greater the population's resiliency and likelihood of persistence. In contrast, populations with low productivity lack resilience and are less likely to rebound from low abundance and are more vulnerable to extinction.

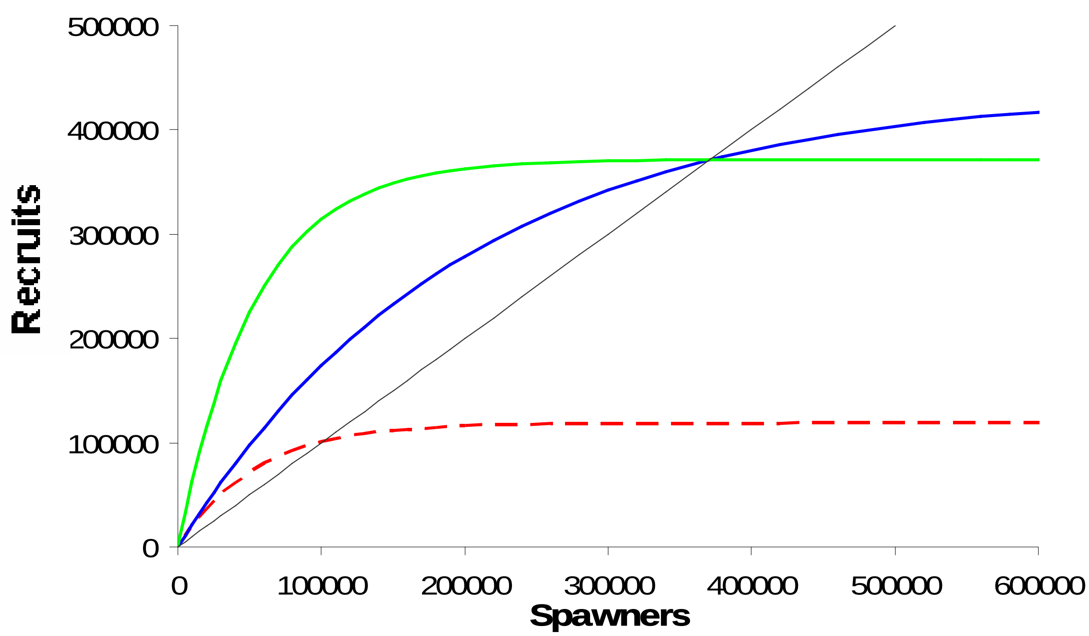
The problem is that while productivity is recognized as a critical population characteristic, it is not easy to estimate. First, R/S values calculated from observed spawner and recruit data sets are strongly influenced by natural fluctuations in marine survival. Observations during periods of high marine survival will yield high R/S values. In contrast, low R/S values are typically observed during periods of low marine survival. Without the context of the underlying marine survival conditions, R/S estimates are very difficult to interpret and compare among years.

A second concern is that even if marine survival is constant, R/S values are also correlated with spawner density. When spawner density is low, competition among juvenile offspring is minimal and the individual probability of survival is high, even though the total number of surviving juveniles may be low. This ultimately results in high R/S values. When the reverse is true and spawner density is high, then juvenile competition is high and their relative survival is low, resulting in low R/S values. Therefore, if measures of productivity are to be used to assess progress toward recovery goals it is biologically mandatory that R/S values be standardized for both marine survival and spawner density.

Development of standardized R/S measurements is a technical problem that requires a case by case understanding of the relationship between spawners, recruits, and marine survival conditions for each population. Although ODFW has made several attempts have been made to do this, additional development is necessary, especially with respect to obtaining a better index for variations in marine survival conditions. As noted in earlier assessments, the Oregon Production Index (OPI) for hatchery coho works well for northerly populations in the ESU, but does not appear to be a good marine survival index for the more southerly populations. ODFW is currently examining several alternative marine indices for these southerly populations. Included are smolt to adult survival rates estimated from recently implemented life cycle monitoring sites, survival estimates from other hatchery coho programs (e.g., Umpqua and Rogue basins), and other environmental variables such as mountain snow accumulation.

However, while these efforts are underway an interim approach for the productivity criterion to be used to track progress towards recovery is needed. The interim approach developed is anchored on concept is that for any marine survival category, if spawner densities are equal to the spawner abundance goal (abundance criterion), then the observed R/S should be 1.0 or greater. The idea is that the change from pre-recovery to post-recovery status can be described as a spawner-recruit curve that passes through the abundance recovery goal at replacement (R/S = 1.0) instead of the pre-recovery observed abundance. This concept is illustrated in Figure 1 for the entire Oregon coast coho ESU, under marine survival conditions corresponding to the low category.

Figure 1. Hypothetical relationship between spawner and recruits for entire Oregon coast coho ESU under the low marine survival category for pre- and post-recovery conditions, dotted line represents pre-recovery condition, solid lines represent two strategy scenarios that both will achieve recovery goals (desired post-recovery condition).



The curved solid lines in Figure 1 pass through the ESU abundance goal (371K for the low marine survival category) at the replacement line (straight black line). This point is equal to an R/S of 1.0. Standardizing to this reference points requires the knowledge of the shape of the recruitment curve at different spawner densities. The shape of this curve depends on which recovery strategies are implemented and how the population responds to them. For example, the top green curved line represents one hypothetical class of strategies that functionally cause an improvement in life cycle survival independent of spawner density. The lower blue line represents another class of recovery strategies that will mostly act to increase the capacity of the habitat to produce juvenile coho. In reality, the package of recovery strategies implemented will vary among populations and will be a mix of those that target survival and those that target capacity. Therefore, in this example, the area between the two solid curve lines represents the most likely zone for a recruitment curve of a recovered ESU to fall.

As noted, developing these relationships for individual populations and devising means to standardize R/S measures when spawner densities equal the abundance recovery goal is a work in progress. For the interim, the best available information will be used to make inferences as to whether the R/S values being recorded are consistent with recruitment performance needed to achieve recovery goals.

Criterion 4 – Within Population Distribution.

Metrics

1. The percentage of random, spatially balanced surveys that have $\geq$ 4 wild adult spawners/mile for each independent population (percent occupancy).
2. Comparison of the spatial pattern of potential spawning distribution to that observed using SVB or other spatial statistics for each independent population.

Metric 1 Evaluation Thresholds

Pass – The observed percent occupancy is $\geq$ the *marine survival*-specific occupancy target (Table 5) at least six times in any 12-year period.

Fail – The observed percent occupancy is > the *marine survival*-specific occupancy target (Table 5) 5 times or less in any 12-year period.

Metric 2 Evaluation Thresholds

Pass – The observed regularity ratio is not significantly different from a random distribution at least six times in any 12-year period.

Fail – The observed regularity ratio is significantly different from a random distribution at least six times in any 12-year period.

Discussion and Rationale: **Criterion 4 – Within Population Distribution**.

The manner in which juveniles and adults (spawners) are distributed within the freshwater portion of a population's home range is an important consideration in assessing the conservation status of a population (McElhany et al. 2000, Bisson et al. 1997). Healthy populations will experience periods when the distribution of spawners becomes spatially compressed (e.g., during poor marine survival periods) and periods when the spatial distribution of spawners expands (e.g., during good marine survival). It is important to keep in mind that distribution is also governed by some factors that are unrelated to coho population size, like weather patterns. During years with little rain and low stream flows, fish may not be able to access much of the habitat and distribution may be constricted even if the population size is large. The challenge is to select a criterion that will identify when a restriction in spawner distribution is greater than expected for a healthy population under given marine survival conditions. For coastal coho populations, distribution data obtained during the recent period of poor marine survival provides the opportunity to develop a metric that helps quantify the patterns of distribution during periods of poor marine survival.

These metrics are based on monitoring statistically sampled, spatially balanced, survey reaches throughout the compete range of coho spawning habitat. These data represent approximately 250 survey reaches/ESU from 1989 to 1996 and approximately 475 survey reaches/ESU from 1997 to 2003. In recent years, about ten percent of the total spawning miles were sampled annually with multiple observations of coho spawners made for each surveyed sample reach each year. This design assures comprehensive representation of spawning habitats within the range of available spawning habitat.

A minimum density of 4 fish/ mile was selected on the basis of the spawner frequency distributions developed by Talabere and Jones (2001), and by work conducted by Sharr et al. (2000) that suggested that at densities less than this level, the probability of each spawner finding a mate within a section of stream may decline.

Four fish per mile is a threshold for defining occupancy and is unrelated to population specific abundance criterion thresholds described earlier which essentially assumes that a low spawner density is spread out evenly across the entire likely habitat. The distribution criterion was designed under the opposite assumption that spawners are not distributed evenly and that spatial heterogeneity of spawning coho is informative with respect to the status of the population.

The occupancy threshold of four fish/mile has several nuances. First, only adult coho are counted towards the density threshold, jacks are excluded. Also excluded are naturally spawning hatchery fish. Excluding hatchery fish keeps the interpretation of fish distribution data consistent with the intent of the distribution criterion and the diversity criteria. Specifically, to ensure that distribution measurements are not confounded by breaking the closed loop between the natural habitat and the fish that interact exclusively interacted with this natural habitat.

Although four adults/mile is not a high density, we believe that this number represents a threshold were spawning is likely to occur. The probability of “finding” a mate is reasonably high because of the behavior of the fish as they move through the reaches and a key into rare patches of holding and spawning habitat. The typical spawning stream reach is 1.6 km long, 6m wide with about 150m^2 of spawning gravel and has about 8 deep pools with cover for holding habitat (ODFW Aquatic Inventory and Spawner Survey Project unpublished data). Within this small fraction of total stream area, there is a good probability of a male-female paring (87.5%) although this may be reduced in populations with unequal sex ratios.

To develop the benchmarks for the percentage occupancy metric (#1), a curve was fitted to the occupancy rates observed for each population from 1990-2005, assuming an exponential rise to a maximum occupancy ≤ 100%; $y=a(1-e^{-bx})$. The percent occupancy goal for each specific marine survival spawner goal was then determined by the where the spawner goal intersects the occupancy curve. An example of the application of this approach as applied to data for the Yaquina and Alsea populations is shown in figure 2. The coefficients, adjusted R^2 and p values for the regression, and occupancy goals for each population are presented in Table 5. Because abundances are consistently very high in the lakes populations (Siltcoos, Tahkenitch and Tenmile), it was not possible to construct of curve relating population size to occupancy for these populations. In order to pass, these populations would need to have 100% occupancy at least 6 out of 12 years.

The second metric uses a statistic that describes the regularity of a spatial point pattern and compares the regularity of the pattern of occupied sites with the regularity of the pattern of the original group of sample sites. The statistic that will be used to describe the regularity of the point pattern is the SVB statistic(Stevens, 2006). To calculate the SVB statistic, a polygon will be drawn around each point that encompasses the area closer to that point than to any other. If the polygons are similar in size and shape, then the distribution is more regular. If the polygons differ in size and shape then the distribution is more clustered. One criterion that is sensitive to both variation in area and shape is the variation of the distance from a point to the boundary of its polygon. If we define a Side as a division between two polygons, a Boundary as a segment of the domain boundary, and a Vertex as the intersection between two Sides or a Side and a Boundary, then the SVB can be approximated by the mean square deviation (MSD) of the distance from a sample point to Sides, Vertices, and Boundaries, relative to a nominal value (such as the MSD for a hexagon with area = [domain area / number of samples]).

To test that occupancy occurs at random over the domain, a pattern of random presence/absence can by simulated a by assigning each of the survey points either 0 (indicating absence) or 1 (indicating presence). By repeating the process multiple times, each time calculating the regularity ratio, a distribution of the SVB statistic can be constructed. The distribution will be specific to that particular population, because it will depend on the geometry of the stream network occupied by a population. The distribution will also depend on the occupancy rate.

Various hypotheses can be tested by choosing an occupancy rate, and then assigning absence following some hypothesized relationship. For example, to test the hypothesis of a shrinking domain, higher probability of absence could be assigned to stream sites near the domain boundary, or to stream segments deemed to have less suitable habitat. Standard randomization test procedures can then be used to establish significance level of the test. It is then possible to test various hypotheses about the actual distribution by comparing the observed value to the random distribution. A population would pass this criterion as long as the regularity ratio did not significantly differ from the random distribution.

Analysis: **Criterion 4 – Within Population Distribution**

Because prior data were used to construct the curves that provide occupancy goals at different spawner densities, all populations would pass a retrospective analysis by definition. Because of this and the fact that we do not have 12 years of spatially-balanced occupancy data, a retrospective analysis of the occupancy criteria will not be provided here. A retrospective analysis of the spatial distribution metric (#2) is under development.

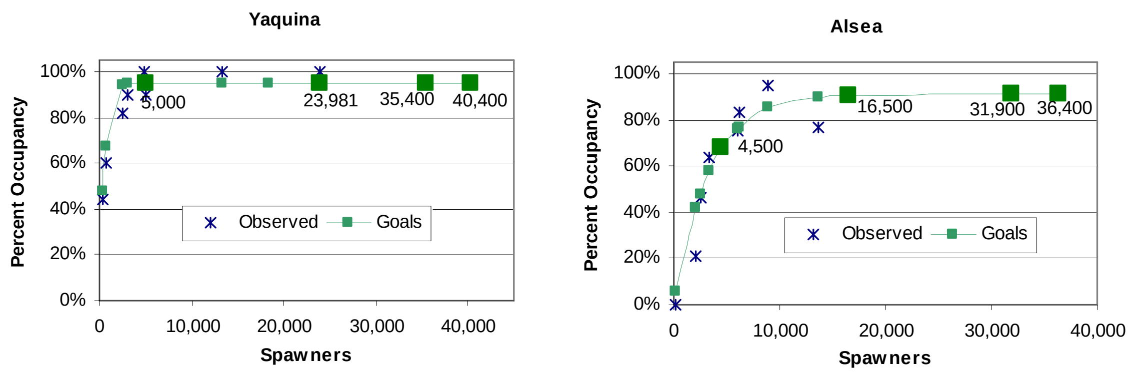


Figure 2. Occupancy goals and observed occupancy for two populations: Yaquina and Alsea.

Table 5. Occupancy Goals and results of Nonlinear Regressions between numbers of adult coho spawners and percent occupancy.

	Results of Nonlinear Regression				Occupancy Goals			
Population	a	b	Adj R^2	P	Extremely low (1.1%)	Low (4.4%)	Medium (10.3%)	High (15%)
Necanicum	1.0282	0.0008	0.907223	0.0006	66%	100%	100%	100%
Nehalem	0.7713	0.0002	0.871944	0.0004	67%	77%	77%	77%
Tillamook	0.8129	0.0005	0.820211	0.0012	70%	81%	81%	81%
Nestucca	0.8104	0.0004	0.510684	0.028	45%	77%	81%	81%
Salmon	0.9129	0.0026	0.456152	0.0395	66%	90%	91%	91%
Siletz	0.9269	0.0009	0.820486	0.0031	86%	93%	93%	93%
Yaquina	0.9506	0.0019	0.883093	0.0003	95%	95%	95%	95%
Alsea	0.9142	0.0003	0.876016	0.0004	68%	91%	91%	91%
Siuslaw	0.869	0.0002	0.916503	0.0001	81%	87%	87%	87%
Siltcoos	518.6703	0	0	1	100%	100%	100%	100%
Tahkenich	6842.513	0	0	1	100%	100%	100%	100%
L. Umpqua	0.8963	0.0003	0.793311	0.0019	81%	90%	90%	90%
U. Umpqua	0.7748	0.0001	0.847565	0.002	69%	77%	77%	77%
Tenmile	1504.702	0	0	1	100%	100%	100%	100%
Coos	0.9193	0.0002	0.902336	0.0002	65%	91%	92%	92%
Coquille	0.85	0.0003	0.774483	0.0024	78%	85%	85%	85%

Criterion 5 - Diversity.

Metric
The average of the 100-year harmonic mean of spawner abundance for each independent population, as forecast from a population viability model.

Evaluation Thresholds
Pass – If 100-year harmonic mean is greater than 1,200.
Fail – If 100-year harmonic mean is less or equal to than 1,200.

Discussion and Rationale: **Criterion 5 - Diversity.**
Within-population diversity is the result of phenotypic differences among individuals. These differences provide the flexibility of the population as a whole to respond successfully to short-term environmental variations. They also are the basis by which populations are able to adapt and evolve as conditions within their home range go through changes that are more permanent. Therefore, maintaining sufficient within-population diversity is an issue of both short-term and long-term survival. This criterion is based upon the importance of diversity as a factor in evaluating the conservation status of a population and is modeled after the viability criteria in the Oregon Coastal Coho Assessment.

Within-population diversity is affected by a variety of forces including: evolutionary legacy, immigration from other populations, mutation, selection, and random loss of genetic variation due to small population size. However, population size (abundance) is most commonly recognized as a concern for species that are vulnerable to extinction. The genetic consequences of small population size and numerous approaches to defining minimum population abundance thresholds have been investigated widely (Soulé 1980; Lande 1995; Franklin and Frankham 1998; Rieman and Allendorf 2001). In nearly all cases, this becomes an exercise of identifying a rate at which genetic variation can be lost without causing a risk to a population's short or long-term persistence. The diversity criterion incorporates this concept.

This desired status criterion requires predicted maintenance of at least 97.5% (*conversely*, losing no more than 2.5%) of a population's heterozygosity over a 100-year period. This criterion is significantly more conservative that the viability threshold applied in the Oregon Coastal Coho Assessment – predicted maintenance of at least 95% (*conversely*, losing no more than 5%) of a population's heterozygosity over a 100-year period.

We recognize that within-population diversity is just one measure of the diversity of a species, but there is no consensus within the Oregon/Northern California Coast TRT or the Region on what and how to adequately measure other indicators of diversity, such as life-history diversity. Oregon will continue to work on this important issue, but until a viable approach is determined, life history diversity will not be evaluated.

Analysis: **Criterion 5 - Diversity.**

The results of this analysis rely on projected abundances for a period of 100 years by a simulation model. As such, the results rely upon the assumptions and parameters of the model (see Chilcote et al. 2005). The Ricker PVA model used in the ODFW coho assessment and the TRT persistence assessment was used to assess this criterion. Fourteen of the 21 independent populations currently pass this criterion and a fifteenth population is close to passing (Table 6).

Table 6. Harmonic mean population abundance as predicted by a Ricker simulation model (Chilcote et al. 2005). Values in bold pass the criterion of 1,200.

Population	Harmonic mean	Population	Harmonic mean
Necanicum	777	Siltcoos	**5,118**
Nehalem	**2,926**	Tahkenitch	**2,786**
Tillamook	721	Tenmile	**14,891**
Nestucca	**2,850**		
Salmon	1	Coos	**15,241**
Siletz	401	Coquille	**12,439**
Yaquina	**2,591**	Floras	1,110
Beaver	**1,389**	Sixes	2
Alsea	**1,505**		
Siuslaw	**10,320**		
Lower Umpqua	**10,219**		
Middle Umpqua	**4,477**		
North Umpqua	252		
South Umpqua	**3,319**		

Criterion 6 – Habitat Conditions

Metric
The amount of available high quality habitat across all freshwater life stages in each independent, non-lake population.

Evaluation Thresholds
Pass – The miles of high quality habitat (i.e. capable of producing ≥ 2,800 smolts/mile) for independent, non-lake populations measured at five year increments equals or exceeds the goals established in table 7 .
Fail - The miles of high quality habitat (i.e. capable of producing ≥ 2,800 smolts/mile) for independent, non-lake populations measured at five year increments are less than the goals established in Table 7.

Discussion and Rationale: **Criterion 6 – Habitat Conditions**
With the exception of the three lake populations, achieving the desired status goals of this Conservation Plan will require significant improvement to the quality of freshwater habitat. Because individual populations differ in inherent capacity for high quality habitat and in current amount of high quality habitat, goals for the amount of high quality habitat needed to achieve desired status goals need to be tailored to each population. For this Conservation Plan, high quality habitat is defined as that habitat that can produce 2,800 smolts/mile. This value is based on the methods described by Nickelson (1998) and essentially represents the number of smolts/mile needed so that adult spawners will replace themselves during extended periods of 3% marine survival. Based on this definition of high quality habitat, the goals for high quality habitat for each non-lake independent population are shown in Table 7.

It is important to emphasize that the calculations used to estimate the goals for high quality habitat miles are based on two major assumptions: 1) smolts during poor ocean conditions are only produced from high quality habitat; and 2) high quality habitat is strictly defined as habitat that can produce 2,800 smolts/mile. As RM&E provides refinement to our quantitative understanding of the productivity the spectrum of coho habitat, these habitat goals will undoubtedly need to be revised and thus should be viewed as interim habitat goals.

Analysis: **Criterion 6 – Habitat Conditions**
Table 7 shows the percentage of high quality habitat needed to achieve desired status that is estimated to currently be available in the non-lake independent populations. Based on this analysis, on a percentage basis freshwater habitat supporting the Coos population is closest to the desired status goals (75%) and the farthest from the goals in the Sixes (14%), with an ESU average of 28% of the miles of high quality habitat needed currently available.

Table 7. Goals for the amount of high quality habitat in each non-lake independent coho population in the Oregon Coast Coho ESU.

	3% Marine Survival				High Quality Habitat Miles			
Population	Spawner Goal[1]	Adult Recruit Goal[2]	Observed Spawners[3]	Estimated Observed Recruits[4]	Total Needed[5]	Current[6]	Additional[7]	Current % of Total Needed
Necanicum	3,545	4,171	628	739	50	9	41	18%
Nehalem	28,091	33,048	5,857	6,891	393	82	311	21%
Tillamook	10,909	12,834	1,896	2,231	153	27	126	17%
Nestucca	5,455	6,417	2,262	2,661	76	32	45	41%
Salmon	1,364	1,604	227	267	19	3	16	17%
Siletz	7,909	9,305	2,284	2,687	111	32	79	29%
Yaquina	13,636	16,043	3,923	4,615	191	55	136	29%
Beaver	2,182	2,567	1,365	1,606	31	19	11	63%
Alsea	12,273	14,439	3,075	3,618	172	43	129	25%
Siuslaw	36,273	42,674	9,069	10,669	508	127	381	25%
Lower Umpqua	21,818	25,668	7,872	9,261	306	110	195	36%
Middle Umpqua	25,636	30,160	4,125	4,853	359	58	301	16%
North Umpqua	5,182	6,096	1,525	1,794	73	21	51	29%
South Umpqua	29,727	34,973	4,831	5,684	416	68	349	16%
Coos	16,636	19,572	12,526	14,736	233	175	58	75%
Coquille	22,909	26,952	7,705	9,065	321	108	213	34%
Floras	4,364	5,134	1,366	1,607	61	19	42	31%
Sixes	1,364	1,604	189	222	19	3	16	14%
Total	249,273	293,262	70,725	83,206	3,491	991	2,501	28%

[1]Spawner goal @ 1.1% marine survival (Table 2) divided by 0.03/0.011.

[2]Spawner goal @ 3% marine survival/(1-0.15). 15% is maximum allowable harvest rate under Amendment 13 during periods of 3% marine survival.

[3]The average number of spawner observed during years with a 3% marine survival rate from 1990-2003.

[4]Observed spawners @3% marine survival /(1-0.15).

[5]The adult recruit goal divided by 0.03 (marine survival) to obtain an estimate of the number of smolts needed. The number of smolts needed was then divided by 2,800 (smolts/mile produced by HQ habitat -based on Nickelson 1998).

[6]The observed recruits divided by 0.03 (marine survival) to obtain an estimate of the number of smolts needed. The number of smolts needed was then divided by 2,800 (smolts/mile produced by HQ habitat -based on Nickelson 1998).

[7]Total miles high quality habitat needed - current miles high quality habitat

Desired Status: Measurable Criteria for Dependent Populations

As defined by the TRT, dependent populations are historically dependent on nearby independent populations for long-term persistence. These smaller populations may experience periodic local extinctions, especially during extended periods of poor marine survival and be repopulated by immigration of spawners from other nearby populations.

Oregon is establishing criteria for these dependent populations for two reasons: 1) relationships among independent and dependent populations that contribute to diversity and sustainability of the ESU may not be fully described; and 2) to establish maintenance of these populations as an element of Oregon's desired status goal. Therefore, Oregon will monitor some aspects of the performance of dependent populations.

Criterion 1 – Spawner trend for Dependent Populations

Metric
Comparison of trend lines for the three-year running average of total adult escapement for independent populations within a population stratum, and adult escapement for dependent populations within the same population stratum.

Evaluation Thresholds
Pass – No significant difference in trend lines, except where dependent populations exhibit steeper trends.
Fail – Significant difference in trend lines

Discussion and Rationale: **Criterion 1 – Spawner trend for Dependent Populations**

A similarity in the trends of dependent and independent populations within a stratum is expected and is consistent with the presently defined population structure of the ESU. Any future observation that the abundance-trend lines of independent and dependent populations differ would be unexpected and stimulate further monitoring and evaluation.

Analysis: **Criterion 1 – Spawner trend for Dependent Populations**

Available data are currently inadequate to assess this criterion. Beginning in the Fall 2006 sampling season, spawning surveys will be conducted in each of the 3 strata in the ESU that contain dependent populations. These randomly selected, spatially balanced surveys will sample 30 sites or 30% (whichever comes first) of the habitat available to spawning coho in the dependent populations. This survey design will result in data for the strata grouped dependent populations that should have similar precision (±30- 40%) to that obtained for the independent populations. An example of how the analysis would be applied is shown in figure 3.

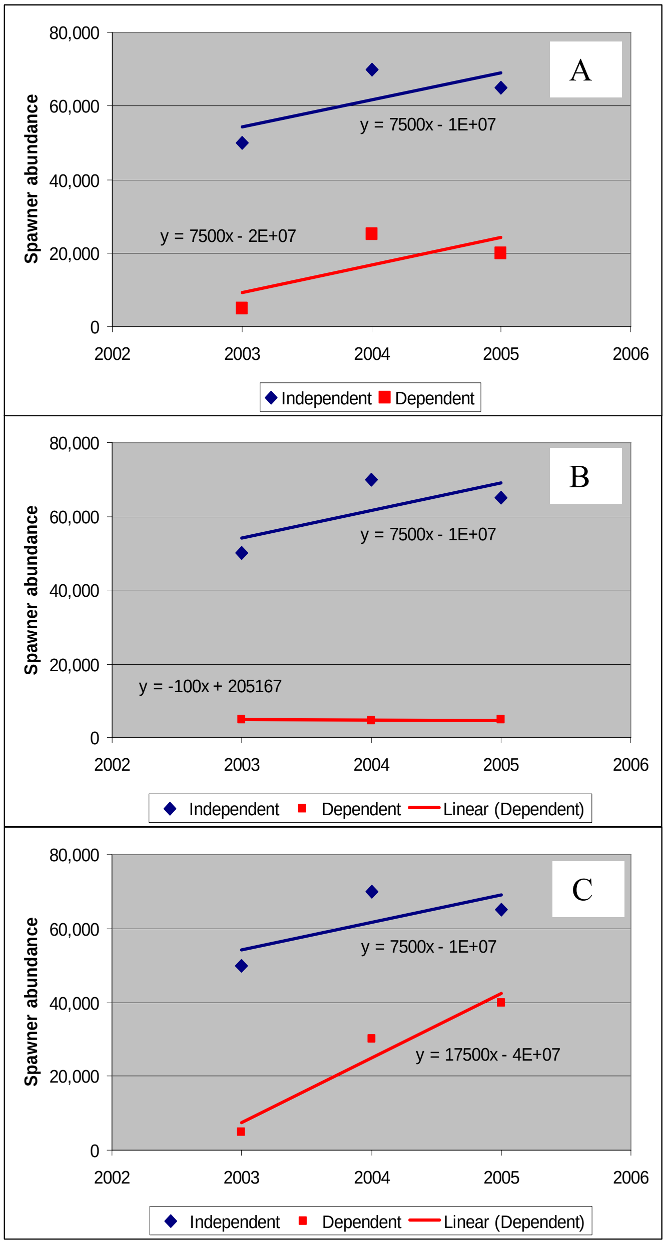


Figure 3. A) Example of a pass for criterion 1, with similar trends in abundance for independent and dependent populations; B) example of a failure for criterion 1, with the abundance of independent populations increasing and dependent populations remaining relative constant; and C) example of a pass for criterion 1, with dependent populations increasing faster than independent populations.

Criterion 2 – Habitat Conditions for Dependent Populations

Metric
The amount of available high quality habitat across all freshwater life stages.
Evaluation Thresholds
Pass – The amount of high quality habitat for dependent populations aggregated by strata remains stable or increases as measured at five year increments.
Fail - The amount of high quality habitat for dependent populations aggregated by strata declines.

Discussion and Rationale: **Criterion 2 – Habitat Conditions for Dependent Populations**

As described for Criterion 6 for independent populations, the condition of freshwater habitat has a significant impact on the status of coho populations. Because this Conservation Plan does not have specific goals for coho abundance for dependent populations, no goals have been established for the miles of high quality habitat needed in each dependent population. Instead, as with the criteria for coho abundance in dependent populations, the criterion for habitat in dependent populations is based on evaluating the trend in habitat conditions.

Analysis
Available data are currently inadequate to assess this criterion. Beginning in the winter of 2006, habitat surveys will be conducted in each of the 3 strata in the ESU that contain dependent populations. The goal of these randomly selected, spatially balanced surveys is to detect a minimum change of 30% in habitat conditions in the dependent populations grouped by strata. An example of how the analysis would be applied is shown in figure 4.

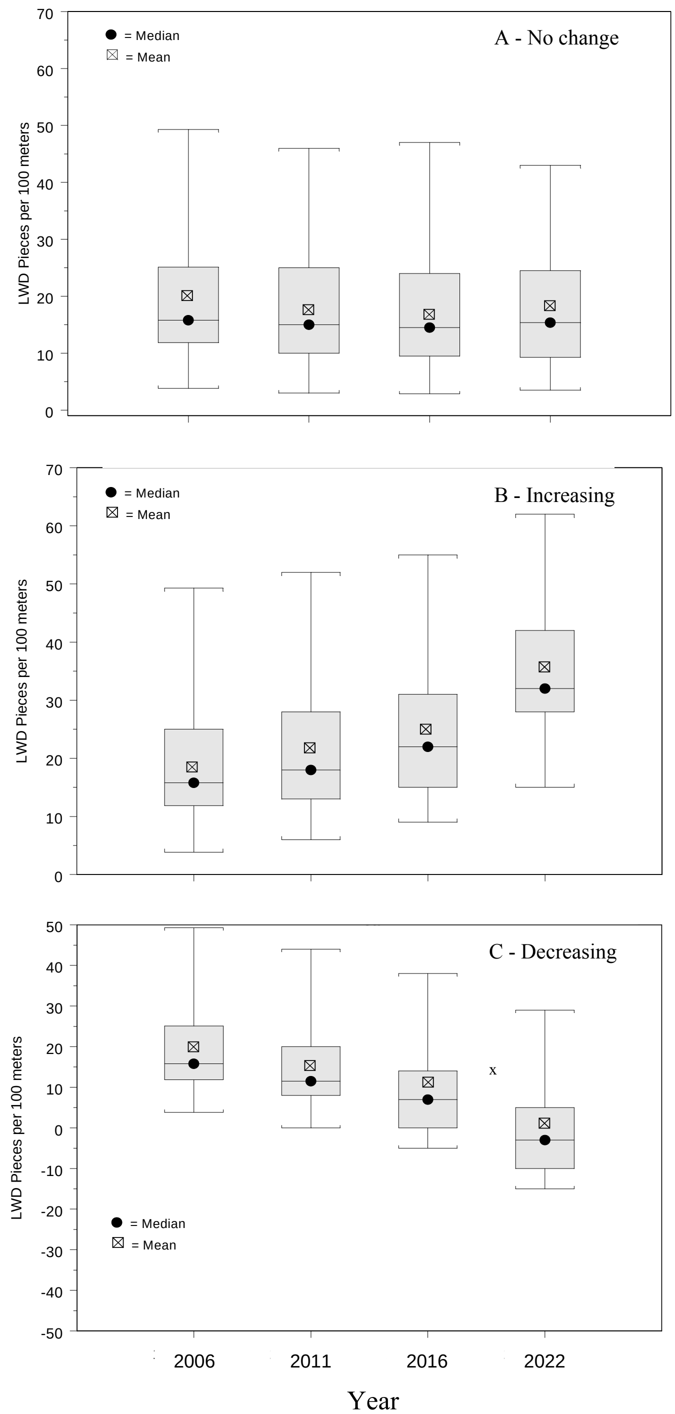


Figure 4. Examples of no change (a), increasing (b), and decreasing (c) trends in one component of high quality habitat (large wood pieces). Black circles are mean values, small x-boxes are median values, grey box enclose 25th and 75th percentiles, and t-bars are ranges.

References

Beamish, R., and D. Bouillon. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50:1002-1016.Beamish et al. 2000

Bisson. P. A., G. H. Reeves, R. E. Bilby, and R. J. Naiman. 1977. Watershed management and Pacific salmon: Desired future conditions. *In:* D. J. Stouder, P. A. Bisson, and R. J. Naiman (eds.), Pacific salmon and their ecosystems, p. 447-474. Chapman and Hall, New York.Chilcote et al. 2005

Franklin, I.R. and R. Frankham. 1998. How large must populations be to retain evolutionary potential? Animal Conservation. 1:69-34.

Lande, R. 1995. Mutation and conservation. Conservation Biology 9:782-791.

Logerwell, E.A., N. Mantua, P.W. Lawson, R.C. Fransis, V.N. Agostini. 2003. Tracking environmental processes in the coastal zone for understanding and predicting Oregon coho (Oncorhynchus kisutch) marine survival. Fish. Oceanogr. 12:6, 554-568

McElhany, P., M.H.Ruckelshaus, M.J.Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Technical Memorandum NMFSNWFSC-42. 156p.

Nickelson, T.E. 1986. Influences of upwelling, ocean temperature, and smolts abundance on marine survival of coho salmon (Oncorhynchus kisutch) in the Oregon production area. Can. J. Fish. Aquat. Sci. 43:527-535.

Rieman, B.E. and F.W. Allendorf. 2001. Effective population size and genetic conservation for bull trout. North American Journal of Fisheries Management 21:756-764.

Sharr, S., C. Melcher, T. Nickelson, P. Lawson, R. Kope, and J. Coon. 2000. 2000 review of Amendment 13 to the Pacific Coast Salmon Plan. Pacific Fisheries Management Council. Portland, Oregon.

Soulé, M.E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential, in Conservation Biology: An evolutionary-ecological perspective. M.E. Soulé and B.A. Wilcox (eds). Sinauer, Massachusetts.

Stevens, Jr., D.L. 2006. Spatial properties of design-based versus model-based approaches to environmental sampling, pp. 119-125 in *Proceedings of Accuracy 2006*: *The 7th international symposium on spatial accuracy assessment in natural resources and environmental sciences*. Instituto Geographica Portugales, Lisboa, Portugal. 908 pp.

Talabere, A. and K. K. Jones. 2001. Pacific Salmon Conservation: Designating Salmon Anchor Habitat Areas, A Process to Set Priorities for Watershed Protection and Restoration. Oregon Department of Fish and Wildlife. Conservation Biology Program. Corvallis, Oregon.

Wainwright, T. C., M. W. Chilcote, P. W. Lawson, T. Nickelson, C. W. Huntington, J. S. Mills, K. M. S. Moore, G. H. Reeves, H. A. Stout, and L. A. Weitkamp. 2006. Biological Recovery Criteria for the Oregon Coast Coho Salmon Evolutionarily Significant Unit. Draft Report, July 2006.