Comments on the Science Underlying Oregon's Proposed Coho Restoration Plan

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Christopher A. Frissell
Senior Staff Scientist
The Pacific Rivers Council
PMB 219, 61529 Highway 93, SuiteA
Polson, MT 59860 USA
phone 406-883-1503
fax 406-883-1504
email: <hanfris@digisys.net>
wwww.pacrivers.org

Gary Carnefix
Research Associate
The Pacific Rivers Council
PMB 219, 61529 Highway 93, SuiteA
Polson, MT 59860 USA
phone 406-883-1503
fax 406-883-1504
email: gcarnefix@aol.com

Jack E. Williams
Senior Scientist
Trout Unlimited
329 Crater Lake Avenue
Medford, Oregon 97504

Peter B. Moyle
Department of Wildlife, Fish, and Conservation Biology
University of California
1 Shields Ave
Davis CA 95616

TO: cohoplan@state.or.us, Oregon Department of Fish and Wildlife, 3406 Cherry Avenue N.E., Salem, OR 97303 (Re: Coho Plan).

Introduction

Collectively, as the four coauthors of this letter we have invested a substantial amount of time over several years reviewing the state of Oregon's plans for restoration of Oregon coastal coho. The state has developed an impressive body of information relevant to the recovery of coastal coho populations. However, our review of the most recent draft document, the *State of Oregon Conservation Plan for the Oregon Coast Coho Evolutionarily Significant Unit*, reveals the repercussions of earlier weaknesses in the scientific assessment, known as the *Oregon Coastal Coho Assessment Part 2: Viability Criteria and Status Assessment of Oregon Coastal Coho*, dated May 5, 2005. In our view, certain key assumptions of the May 5, 2005 Assessment, which were raised in previous public comment but not adequately addressed in the final version, seriously jeopardize the likely success of the proposed Conservation Plan. Hence both documents rest on some puzzling and potentially crippling oversights that likely undermine and jeopardize the success of the restoration plan. We will describe these concerns in some detail below. We would be happy to engage in further dialogue on these matters if that would help clarify and settle these concerns.

To prepare these comments, we read the aforementioned documents, relevant portions of public comment on the draft Status Assessment, and consulted salient scientific literature. Our comments here do not pertain directly to the question of whether or not federal listing of Oregon coastal coho salmon is warranted, but concern only the scientific issues that underpin restoration or recovery planning.

Why Are the Science Issues Critical to the Conservation Plan?

A clear and substantiated assessment of biological status is critical to ensure that any conservation plan is likely to be successful. In the case of Oregon coastal coho, the Status Assessment sets the context of not just the level of threat, but the relative importance of various threats and the urgency of action to address them. The scientific context profoundly affects perceptions of level of acceptable risk associated with the status quo, the urgency of actions to alleviate specific threats, and the relative cost or risk of allowing additional incremental losses of habitat. *In particular, the Assessment profoundly shapes the Plan's assumptions about the adequacy of existing freshwater habitat conditions, of the success of existing regulatory mechanisms, and of urgency of restoration and improvement of freshwater habitat conditions.* Finally, the notion that uncertainty of success of incremental actions proposed in the recovery plan can await the outcome of monitoring and so-called "adaptive management" is also critical. This notion depends on problematic scientific assumptions about both the resilience and vagility of existing coho populations, the adequacy of existing and future freshwater and marine habitat, and also about the ability of managers to rapidly evaluate coho population status and trend.

Six Factors of Concern

Our review focuses on a small set of core scientific issues that will need to be fairly and fully addressed in order to ensure the likelihood of success of a coastal coho recovery or restoration plan. Each of these concerns was raised in public comment on the Oregon Coastal Coho Assessment, yet each was addressed only incompletely or not at all in the State of Oregon's response to comments and in the Final Status Assessment. We also referred to the original ESA petition filed with the National Marine Fisheries Service by The Pacific Rivers Council et al. (1993), and found that the basic outline of our concerns were identified and anticipated in that document, which perhaps should have played a more formal role in shaping the state's status assessment and conservation plan.

Our concerns fall into six categories briefly summarized here: 1) the modeling of coho population dynamics is strongly determined by questionable functions for survival at low density and for rapid dispersal and recolonization; 2) the model and the assessment overall ignore available empirical data directly pertinent to the extent and persistence of local extinctions, instead embracing model behavior that is inconsistent with the outcome of progressive local extinctions; 3) the assessment and conservation plan are based on highly questionable, mostly arbitrary assumptions about population structure that may bear little relation to real-world demographic and genetic pattern and process within the species; 4) a very key assumption that future environmental conditions never will get any worse than those seen in recent decades is never examined or justified, and appears to be highly questionable; 5) freshwater habitat is well-recognized to be the primary manageable element that is necessary for Oregon coho restoration, but the plan relies on tenuous, often unstated assumptions and passive, ill-defined and vaguely justified habitat conservation measures; 6) the conservation plan assumes that the results of incremental management will be quickly discernible in biological monitoring, but the basis for this assumption is unexplained, and the record reveals little or no critical examination of relevant literature that suggests highly precautionary conservation measures are warranted.

An important context for all of our points is established by an examination of the phenomenon of local extinction. This is a point of emphasis in the 1993 petition (Pacific Rivers Council et al. 1993, pp. 14-15) where local extinction was discussed in the context of maintaining the species across its range:

> **The coho salmon consists of a highly organized network of dynamically connected, locally adapted populations. Each population is locally adapted due to the effects of an environmental template and natural selection regime that is unique to each population. While each population has accumulated a unique combination of adaptive traits that cannot be duplicated or replaced in the span of a human lifetime, inbreeding depression and speciation were historically minimized or prevented by the infrequent but periodic exchange of individuals between neighboring populations. Since suitable habitats and thus coho populations are often small and relatively isolated, such occasional exchange of individuals (especially fish well-adapted to geographically nearby and similar habitats, and thus likely to reproduce successfully) between adjacent populations is beneficial.**

The maintenance of such a dynamic metapopulation structure, and the interpopulation diversity associated with it, is necessary to ensure the future of the species and its role in ecosystems. This means that each breeding population, is geographically, evolutionarily, and ecologically distinct, perhaps at as fine a scale as individual spawning tributary streams and major river reaches. Either the cumulative depletion or extinction of many populations, or the fragmentation and severing of natural linkages between populations, can precipitate rapid extinction of the species across large portions of the its range (Frissell 1993). Coho salmon are immediately threatened by both kinds of impacts.

Complex metapopulation structure is adaptive in a region subject to frequent catastrophic disturbance, such as volcanism, earthquakes, sea level change, large landslides, flooding, and wildfire (Frissell 1993). When such disturbances cause local extinctions, coho from adjacent populations colonize and eventually re-establish populations. Natural colonists of local origin, unlike hatchery fish or foreign stocks transferred from distant locations, are likely to be relatively well-adapted to the empty habitat by virtue of geographic proximity and environmental similarity. Thus given sufficient time they can successfully restore the former range of the species. Because the life span of a single population is likely to be less than a few thousand years or perhaps centuries, maintenance of a broad distributional range and an expansive network of such populations is critical for the long-term survival of the species as a whole. Large-scale fragmentation and collapses of range, such as coho have exhibited in California and the Columbia Basin this century, indicate that metapopulation structure and function is breaking down catastrophically, and that remaining populations face greatly increased risk of extinction.

Model Limitations and Uncertainties

1) Survival and Dispersal Assumptions

The Density-Dependent Population Growth Rate Recruitment Model used in the State of Oregon's Assessment – based on the Ricker population recruitment function with an added marine survival variable –models the average behavior of aggregates of populations. It does not directly emulate or otherwise account for the process of extinction of local breeding groups. Our contention is that a model that cannot simulate local extinctions under plausible range of conditions should not be taken as evidence that local extinction is not happening, or is not important. The fact is that progressive local extinction could be occurring in the wild, and this would be obscured by the way the state has modeled coho dynamics, rather than revealed by it. The fact that the model cannot simulate local extinctions, despite considerable evidence that these have in fact extensively occurred (see below), suggests it is not extinction in the real world that is unlikely, so much as that the accuracy of certain model assumptions is unlikely.

It appears that extinction resistance and robustness to fluctuating environmental conditions in the Oregon Assessment model are determined by three important factors: 1) virtually infinitely increasing density-dependent survival at small population sizes, 2) a high rate of spatial dispersal that is assumed to lead to effective reproduction in non-natal habitat; and 3) averaging or accumulation of occupancy data across multiple sites so that fine-scale patterns of extinction or extirpation would not be detected until they propagate into much broader-scale loss of habitat occupancy.

The sensitivity analysis conducted in the final version of the Assessment (as far as we can tell this is the principal or perhaps only substantive response to the many critical comments made by reviewers) only examines the first of these three issues. While this analysis shows that in terms of the present configuration of the model, outcomes are not strongly determined by the shape of the density-dependent survival function, we infer that this result was dictated by a large effect of the second issue, the dispersal function. The model runs under a default assumption of high dispersal rates from occupied to adjacent reaches (i.e., fish emigrate from natal stream segments to occupy and spawn in others in the system), with apparently an additional assumption that dispersed individuals exhibit no loss of reproductive success. These dispersal assumptions, based as far as we can discern on guesswork unverified by empirical data, result in so much dispersal that local population dynamics at low density are virtually always demographically swamped or overwhelmed by immigrants derived from other reaches of the basin. That is, until the last source population in a basin goes extinct.

Our view is that the sensitivity analysis included in the final Assessment only reveals the overriding importance of this dispersal function in the model's performance. Under different dispersal assumptions, the shape of a density-dependent survival function would quite likely have more substantial effects on modeled outcomes. The conservation biology and salmon population ecology literatures are replete with empirical examples and mechanistic explanations of depensatory survival functions – i.e., where per capita survival or reproductive success declines at low or very low population (e.g., Liermann and Hilborn 2001, Peterman and Gatto 1978, Peterman 1977). The assumption that Oregon coastal coho are immune from such small-population effects still seems highly incongruous with knowledge of salmonid ecosystems and population dynamics and is not clearly supported by empirical evidence, other than the observation – based on crudely averaged observations of population performance – that some degree of recovery has occurred after past stressful events.

Given the overriding importance of this dispersal function to model performance, there needs to be 1) empirical validation that it is modeled realistically, and/or 2) a sensitivity analysis to display its affect on population persistence and recovery under a plausible range of assumed dispersal functions. The behavior of the model strongly suggests that under plausibly low dispersal and disperser success rates, lower than those used as the default in the Assessment, the specific assumptions about the density-dependent survival function at small population size could be an important determinant of local persistence and potentially of basin-wide recovery and extinction risk. In other words, in its present form the dispersal model swamps all local behavior. Whether or not local extinctions happen and can influence basin-scale coho persistence and recovery is never addressed because the model's assumed dispersal functions seldom allow local extinction to happen. *It is a profound tautology, therefore, for Oregon to construe the performance of this model – structured by assumption to seldom allow extinctions – as evidence that costal coho in the real world are not at risk of extinction or decline.*

2) Problems of Scale of Demographic Units of the Model and the Species

Concerns about the model's possible obfuscation of local population dynamics via unrealistic dispersal and survival functions leads directly to uncertainties about the spatial scale of the aggregate population units considered in the model and whether they accurately match real demographic units of coho salmon. The model's principal spatial unit for determining restoration goals, the Evolutionarily Significant Unit (ESU), is ill-defined and is certainly much larger than any demographic functional unit within the species. From the 1993 petition, pp. 23-24:

> **While the legacy of local adaptation accumulated within local populations cannot be replaced by existing technology, neither has the genetic variation that underlies it been successfully measured and distinguished with existing technology. The failure to detect genetic or molecular differences between populations with current technology does not mean that such differences do not exist; it just as likely means the techniques, tests, and/or sampling designs applied were insufficient or inappropriate. Electrophoresis, for example, has often been unsuccessful in discriminating between coho salmon stocks, even where these populations have been demonstrated experimentally to be ecologically and evolutionarily noninterchangeable (e.g., Oregon coastal hatchery coho v. wild native coho from the same river systems, see Nickelson et al. [1986]).**

Little is known to date about at what scale coho extinction and survival is determined, i.e, what are the effective scales of genetic and demographic identity and coherence for the species. A pattern of patchy and isolated habitat, particularly for crucial winter survival, would suggest the likelihood of highly patchy population structure, with local populations differentiated by, for example, migration behavior that is necessarily fine-tuned to successfully locate winter habitat relative to the spawning and summer-fall rearing habitat location – see analogous examples for sockeye salmon (Brannon 1967, 1972; Brannon et al. 1981; Raleigh 1967) and rainbow trout (Lindsey et al. 1959; Northcote 1981). Similar localized behavioral adaptations are likely essential to contend successfully with summer thermal stresses that may require precisely timed movements or other fine-tuned behaviors.

While available genetic evidence on coho salmon is insufficient to either confirm or deny the presence of demes, or semi-independent demographic functional units at the scale of small tributaries and stream reaches, some recently-emerging data we have seen referenced may shed new light on this question for coho. Neighboring populations showing starkly different behaviors may show little biochemical evidence of genetic differentiation, using common and standard methods. Far more intensive sampling and genetic analysis for bull trout have revealed a preponderance of genetic and behavioral evidence of demographic structure at a very fine spatial scale – between reaches within river segments, and significant and stable genetic differences among neighboring populations (Kanda et al. 1997; Leary et al. 1993; Spruell et al. 1999; Taylor et al. 1999). Additional evidence, e.g., for bull trout (US Fish and Wildlife Service 2004) and chum salmon (e.g., Tallman & Healey 1994), suggests that while dispersal of adult spawners to non-natal populations occurs, it is most often not accompanied by evident gene flow. The most parsimonious explanation for this is that the fitness or reproductive success of dispersing individuals who emigrate to spawn outside of natal reaches is extremely low (see analogous evidence for kokanee and sockeye in Taylor et al. 1996).

The overriding importance of this question and its context for global survival of a species was highlighted in Frissell 1993 (p. 350), after explicitly mapping the then-known status of coho salmon across their range in the lower 48 US states:

> **Indigenous populations and subspecies can both be considered incipient and potential species (O'Brien & Mayr 1991). In the case of anadromous salmonids, and possibly other migratory genera such as the lampreys, it has long been recognized that homing to natal habitats facilitates the evolution of locally differentiated populations, each subtly but uniquely adapted to its home stream (Rich 1939; Ricker 1972; MacLean & Evans 1981). Around the North Pacific Rim, anthropogenic transfers of anadromous salmonid stocks between river basins have been only rarely successful in establishing new runs, and there are virtually no published cases of such an intervention reinvigorating a depressed or relict population (Ricker 1972; Altukhov & Salmenkova 1990; Steward & Bjornn 1990)… Given that locally adapted stocks cannot be replaced, anthropogenically accelerated rates of population extinction, especially coupled with depleted sources of suitable, locally adapted colonists, could therefore seriously fragment and precipitously jeopardize the viability of an anadromous species across major portions of its range. The risk of collapse or even extinction of such a species may increase nonlinearly as populations are lost and its range fragmented. This would be exacerbated in case of rapid change in global climate, or intensified land use that disturbs habitat widely and frequently.**

The 1993 petition, therefore, explicitly argued that ignorance of local population diversity and its demographic and evolutionary significance in existing regulatory mechanisms and policies was itself a threat to the survival of the species, and that in this view no genetic or demographic evidence supported the imposition of an ESU-level classification for the species within its range in the Lower 48 states. Despite some steps forward that attempt to adopt higher-resolution indicators of local persistence, the current Assessment still suffers from a high potential for obscuring the importance of local processes and population performance, and in our view, the model's predicted basin- and regional-scale outcomes could be grossly wrong as a result. Other than the isolated sensitivity analysis of density-dependent survival function, little attention is given in the Assessment to the importance of these assumptions and the possibility that they obscure, rather than reveal, biological reality.

Careful theoretical examination relative to available literature, empirical validation against known data from real populations, and additional sensitivity analysis of the model are all feasible and necessary, but the record does not show these have been done. Instead the State has chosen to sweep scientific criteria under the rug, rest on preliminary conclusions that seem presently convenient to managers, and beg the rest of us to rely on future monitoring to determine the consequences of such uncertainties, only after they are manifest on the species at risk.

3) Failure to Empirically Validate Key Extinction and Recolonization Assumptions

Empirical data are available to shed light on local extinction and its reversibility, but the Assessment is silent about the use of such information to validate or calibrate the model performance. Historical ODFW coastal spawner suveys, going back to the mid-1950s, can be used in tandem with more recent surveys to assess persistence, recolonization, and patterns of contraction and expansion of occupied habitat within the range of the species. In fact, the 1993 petition presented a very preliminary look at such information, which appears to go unanswered in Oregon's assessment. The 1993 petition (pp. 9-10; Frissell, unpublished analysis of ODFW spawner count data) offered a preliminary examination that revealed evidence of progressive loss of spatial distribution, or occupancy of putatively suitable habitat, over time:

> **"Stratified random" surveys of coho spawner abundance were begun by ODFW in 1990 to determine whether the standard and supplemental survey sites used by harvest managers to assess overall coho abundance in coastal Oregon were truly representative of coastal Oregon coho populations (Jacobs and Cooney 1991; Pearcy et al. 1992)."[sic] The new ODFW surveys are largely consistent with the analysis in Brown, et al., (in press [published 1994]), as are the results: the new data are consistent with a pattern of widespread local extinction. Whereas just 4 of 48 standard and supplemental survey streams (8.3%) showed zero counts in 1991-92,**

zero coho were observed in 52 of 187 random survey streams (27.8%) (ODFW, unpublished data). In the 1990-91 season (Jacobs and Cooney 1991), 81 (50.6%) of 160 random survey streams had zero counts. Since the random surveys were conducted in habitat thought to support coho salmon historically, the data indicate that the standard surveys and models used in coho management (Pearcy et al. 1992) greatly underestimate the extent of vacant habitat. This quite likely reflects a cumulative trend of local population extinctions. More careful analysis of historical surveys should be undertaken to compare current and historic distribution of coho populations in coastal Oregon.

Walters and Cahoon (1985) offered similar evidence of attrition of productive or detectable populations over time from coastal BC, and provided a defensible and uncomplicated protocol for analysis of survey data. The paper provided a lucid discussion of why such a trend of loss of what they aptly referred to as "spatial diversity" indicated erosion of the productive capacity and resilience of salmon species. The authors further point out that even if the pattern is in part attributable to loss of resolution or systematic biases in survey programs, they still should be considered threatening to the health of the species at stake – a lesson which, despite some significant reforms in recent years, still bears repeating judging by assumptions made unchecked in Oregon's Coho Assessment.

Brown et al. (1994) performed a similar investigation using salmon survey data in California, and their analysis, like Walters and Cahoon's (1985) look at BC salmon and Frissell's preliminary look at Oregon coastal coho data, showed a clear pattern of local extinction within the range of coho in California. There is no evident biological or environmental reason why such a pattern manifest among salmon both north and south of Oregon would not also occur in Oregon. Hence, we are puzzled that the Assessment does not even hint that such an analysis has been made for Oregon (the spatial coverage and dispersion of the field data for Oregon, both in the historical and the recent data sets, are probably far better than the data available for the BC or California studies). Direct empirical examination of these data – for specific spawning segments of rivers and streams, NOT aggregated – would refute the core assumption of the Assessment model that local extinction is either a rare event or is so rapidly reversed through recolonization that it functionally does not occur at all under prevailing conditions. The field survey data offer a large data set to directly test two hypotheses: 1) that local populations do not go extinct (reaches with coho present do not decline to 0 counts); and 2) that locally vacant habitat patches are rapidly recolonized via dispersal (reaches that start a period of years with 0 counts end it with >0 counts). Presumably there has been some recovery seen since the run of severe ocean survival years in the 1990s, but was such recovery manifest in a reappearance of populations that were entirely lost during the poor years, or was it based on rebound of that set of populations that did not quite diminish to the vanishing point? Where is the evidence that rules out the possibility that each such episode of poor survival years leads to spatial attrition of the species, such that in aggregate, rebound may occur, but it occurs based on fewer and fewer populations? This is exactly the scenario Walters and

Cahoon (1985) cite as indicating profound erosion of resilience and, ultimately, of productive capacity and persistence of a salmon species.

4) Unexamined Assumptions about Future Environments

We are seriously concerned that the Assessment is underpinned by an unexamined assumption that conditions will never get any worst than those that prevailed during the most recent "poor ocean years." It is an absolutely crucial premise of the Assessment's conclusions that the recent past serves as an adequate model for all future environmental variation that will tax coho survival and recovery. Where is the evidence that the adverse ocean conditions experienced by coho in the 1990s are worse than those that prevailed during previous periods of climate and marine stress? Where is the careful description of exactly what conjunction of events occurred in the 1990s to cause severe declines?

Moreover, the Assessment gives no consideration to the likely influence of climate warming on both marine and freshwater conditions. Recent scientific reports and reviews (e.g., Harley et al. 2006) point to strong linkage between ocean conditions and global temperature, and among the predicted relationships is increasing intensity, duration, and possibly frequency of El Nino events with increasing global temperature. Large and rapid biological and physical changes in oceans can be expected (Harley et al. 2006), and many of these changes are highly likely to be hostile to Pacific coast salmon. Freshwater conditions may also be increasingly taxing, with increased climate variability signaling increased duration of high temperatures and drought and increased frequency and magnitude of fall, winter, and spring storms (e.g., Rapp 2004, many others).

Oceanic 'dead zones' pose a relatively recent and unprecedented concern for coastal fisheries off central Oregon, including coho salmon. A hypoxic zone of water first appeared off central Oregon in 2002. This was the first 'dead zone' to be recorded off the Oregon coast and it has reappeared as a larger zone of hypoxic waters in each successive year. According to researchers at Oregon State University, the 2006 'dead zone' was the largest and longest lasting event recorded off the central Oregon coast (Oregon State University 2006). The 2006 event started in mid-June in the Heceta Bank near Florence and lasted until late October and impacted an area "the size of Rhode Island." Scientists at OSU report that changes in oceanic and atmospheric conditions leading to stronger and more persistent northerly winds, which contribute to the hypoxic conditions, are consistent with global warming and may signal a break down in the more typical upwelling events that bring cold, nutrient rich waters to Oregon coastal areas. If this phenomenon continues to expand and affects larger areas for longer time periods, it is likely to detrimentally impact coho salmon through changes in food availability and abundance, available migratory pathways, and nearshore habitat suitability. Such changes are novel for Oregon coastal coho and are not adequately addressed in the State of Oregon Conservation Plan for the Oregon Coast Coho ESU.

It remains largely a matter of speculation how climate change might interact with now-extensive land use alterations of ecosystems (by grazing, agriculture, logging, roads, and local urbanization), but there are a myriad of reasons to accept that these alterations affect the natural resilience of watersheds, rivers, and estuaries in ways that will likely increase their vulnerability to adverse climate change. Moreover, if Oregon coho have grown increasing fragmented in distribution as has been established for California coho (Brown et al. 1994), then increasingly isolated populations are at ever-greater risk of going extinct in the face of growing environmental stress.

By overlooking all of these concerns, the Assessment fails to identify and account for the key mechanisms of biological and physical resilience that will determine whether the coho salmon effectively adapts to and survives in the face of inevitable environmental stresses. If such an accounting were accurately made, it might indicate that Oregon coastal coho will need more high-quality habitat than is available to them in order to get through future bad episodes. Under even moderately stressful circumstances, robust populations in high-quality habitat are sometimes extinguished by natural or human-exacerbated catastrophe (e.g., a landslide dam creating a large and persistent barrier to spawning migration). The present model does not apparently account for such catastrophes, and in fact assumes they are not important enough to be modeled (although including catastrophe is a routine element of conservation assessment, and it has been shown in many cases that the failure to account for its affect on population ecology can seriously bias such assessments (Mace & Lande 1991; Propst et al. 1992)).

5) Freshwater Habitat Assessment is Critical, but Neglected

Oregon's Assessment appears to bypass the principal lesson that application of the Nickelson-Lawson model repeatedly teaches: *freshwater habitat is critical*. Since the lucid warning of Lawson (1993), it has been well–recognized by scientists working with adaptations of the Nickelson-Lawson life cycle model for Oregon coastal coho that despite the masking effect of marine variations in survival over time, the quality, spatial extent, and distribution of freshwater habitat place ultimate limits on productivity and recovery. Oosterhout et al. (2005) investigated the potential role of supplementation of wild populations with hatchery fish with an adaptation of the Nickelson-Lawson model, and concluded that hatchery actions were largely fruitless because compensatory survival mechanisms appear to afford wild coho the capacity to expand quickly to exploit the limits of available freshwater habitat. While it is important to note that Oosterhout et al.'s (2005) conclusion was based on the same uncertainties about dispersal and survival at very small population size as noted above for the Oregon Assessment, the paper's ultimate conclusion about freshwater habitat limitation appears to be justified under all reasonable model conditions. Instead of taking this lesson and using it to carefully evaluate the current condition of coho habitat and prescribe appropriate habitat management actions, the Assessment and Oregon Plan simply make assumptions that 1) practices have changed, therefore 2) freshwater habitat is not being harmed as severely as it once was, therefore 3) habitat must be getting better all the time.

The latter two assumptions in particular remain unexamined and largely undocumented in the Assessment and Oregon Plan.

A simple change in practices does not ensure that freshwater habitat is improving. There are several basic and well-recognized biophysical reasons for this, all as far as we can tell, completely unexamined in the Assessment. First, past practices have created impacts that lag in their full expression in streams. Roads, for example, constructed 50 years ago remain vulnerable to erosion and landslides half a century later, and some may increase in their impact, e.g., because of decaying organic material embedded in road fills (Swanson and Dyrness 1975. Sidle and Ochiai 2006). The loss of large trees by logging in riparian zones affects the recruitment and retention of large wood in streams over many decades to a century. Hence many coastal streams are just now entering the period when the impacts of distant past riparian logging are being maximally expressed, as residual pre-logging debris is naturally decaying and disappearing. Coarse woody debris conditions today are worse than they were 20-70 years ago, when harmful riparian logging was originally conducted. A second category of explanation is that the persistent effects of past habitat disturbance often reduce resilience to future disturbance. Hence even very small impacts today may have disproportionately large biological effects. One simple but pervasive example: that depletion of coarse wood in streams and loss of large trees from stream banks and floodplains reduces the resilience of streams to sediment inputs. The capacity for physical storage and sorting of fine sediment is greatly reduced, and even rather small injections of fine sediment may now elevate suspended sediment levels and harm the quality of spawning gravels for very long distances from the source. Hence, habitat quality may remain impaired or even worsen even under a reduced incidence of human disturbance. There are also biological aspects of reduced resilience and increased vulnerability. Coho salmon, for example, inhabit less freshwater habitat area than they formerly did, and populations are more fragmented than they were early in the previous century when they experienced the first round of large effects from human development. Today, even locally restricted damage to habitat can impact the last remaining productive population in a basin.

It is also unclear whether harm is on balance reduced when the cumulative spatial extent and timing of habitat-disturbing management practices are not accounted for. While the per-acre impact of forestry operations may be reduced, for example, an increase in the number of acres disturbed may cumulatively offset or negate any benefit from improved practices. For some land uses, it remains poorly documented what if any freshwater habitat improvement has resulted from changes in practice. Has the general decline of grazing in the Oregon Coast Range actually led to improvement in freshwater habitat, for example? Or is remaining grazing concentrated in locations and with methods that still remain just as harmful to coho salmon? Beyond that, land use transitions have not been considered. Much valley bottom and floodplain land formerly used for grazing is being converted to residential and commercial uses. Does that transition improve or further harm coho habitat? These examples point to why the kind of information developed by the CLAMS project and similar efforts can be very important. Recent literature provides the necessary information on historical landscape patter (e.g., Ripple 1994), changes in land use and landscape pattern under recent and future scenarios of human activity (e.g., Thompson et al. 2006), the spatial distribution of potential historical and future coho habitat associated with these landscape patterns (e g., Burnett et al. PNW "High Intrinsic Potential" habitat modeling), and a spatially explicit analytic framework to examine linkages between landscape management and fish habitat (Spies et al., in press). Decades of research has shown that the fate of coastal salmon habitat, and hence the salmon themselves, is vitally affected by the pattern of human and natural disturbance and recovery of habitat (e.g., Reeves et al. 1995), yet these questions remain strangely unasked and unanswered in the Assessment and Oregon Plan. Addressing them is a fundamental step necessary to ensuring the success of any conservation plan for coho salmon. It is entirely insufficient, and in our view, indicative of seriously misplaced priorities, to defer such analysis to some future planning process, because the answers and uncertainties that only this analysis can illuminate are vital to the persistence and recovery of coastal coho salmon.

To augment this concern about the failure to account for landscape management and its effects on present and future coho habitat, Oregon's complacency about the adequacy of existing land management practices is not scientifically justified. For example, the Assessment and Oregon plan ignore recently-published papers that provide detail and increased certainty about long-debated downstream impacts of logging riparian zones in headwater stream channels (above the fish-zone). Allen & Dietrich (2005), for example, found that present forest practice rules for low-order channels in California are clearly insufficient to protect downstream fish-bearing waters from harmful summer temperature increases, and there is every reason to believe the same physics apply to Oregon streams and forest practices. Rashin et al. (2006) document extensive and biologically harmful sediment delivery to stream networks during and after clear-cut or partial-cut logging of headwater streams under Washington Forest Practice rules (comparable to or more conservative than Oregon's current practices). Sharma and Hilborn (2001) showed that variation in coho salmon density in Washington streams was negatively correlated with road density, among other habitat-related covariates. Why has a similar analysis not been conducted in Oregon? While there may be scattered site-specific activity occurring that is locally beneficial, Oregon has only a very limited regulatory program in place to reduce the impacts of roads on private forest land where road densities are very high, with no regulatory handle on abandoned or "legacy" (pre-Forest Practices Act) roads, and no coherent strategic framework to reduce the impact on water quality of roads on agricultural or residential lands within the range of the Oregon coho. Finally, recent research by Wigington et al. (2006) demonstrates the use of many small streams with ephemeral or intermittent flow by coho salmon during portions of their life history. The application of stream protection rules continues to neglect the importance of these stream types.

The factors identified above offer just a few examples of consequences of land use activity influences on headwater streams and watershed conditions. They are examples that scientists have long brought to the attention of managers, but managers have remained unwilling to respond to with appropriate and well-recognized protective practices. Oregon does have access to the knowledge necessary to craft policies to avoid such harms – Oregon (like many other jurisdictions) simply has been politically unwilling to do so.

Meanwhile. The current Administration in Washington DC appears intent on rolling back protections for Oregon coho habitat on federal lands under the Northwest Forest Plan. Reeves et al. (2006) showed that watershed conditions improved in a majority (64%) of watersheds within the Northwest Forest Plan in just 10 years of the plan implementation. Protection of smaller stream systems was a critical component of the ACS. However, the US Forest Service revised the language of the Northwest Forest Plan Aquatic Conservation Strategy in a way that substantially weakens the protection it affords from harm to locally important habitat and from the cumulative impact of multiple such harms. Now the BLM is in the process of revising their land use plans for all of the public lands in western Oregon, and the current draft EIS analyzes 4 alternatives, 2 of which would "apply new criteria for designating the width of riparian management areas" and would likely result in much less riparian zone protection than in current BLM plans pursuant to the Northwest Forest Plan (BLM publishes the "Western Oregon Plan Revision News, October 2006 edition, Newsletter No. 6). Protection for the kind of streams that Wigington et al. (2006) flag as important for coho survival and production would appear to be greatly diminished under 3 of the 4 alternatives being considered by the BLM (save for the No Action Alternative that would retain existing management direction). Given these federal policy directions, it is increasingly clear that federal lands cannot be counted on to provide the kind of restoration of coho salmon habitat they have been providing in the recent past.

6) Monitoring and Adaptive Management: Can it Pick Up the Pieces?

We do not take comfort in the Assessment and Oregon Plan's deferral of key ecological uncertainties to future monitoring and anticipated "adaptive management." While it is foolish to oppose "adaptive management" in a general sense, it is wise to question it in specific applications. The first question to be asked is whether available scientific knowledge has been adequately evaluated and carefully and cogently summarized, in order that uncertainties and the adaptive management protocols necessary to address them will be as specifically defined as possible. In this Plan, it seems to us that future monitoring and anticipated adaptive management are not serving their proper role of a focused means of reducing key uncertainties so that serious mistakes and harm might be avoided. In fact, it is rather apparent here that monitoring and adaptive management are serving the opposite function: they are intended as a general tonic to absolve today's Oregon Plan managers of the need to do their homework and take a hard look at available science and its implications, disclose to the public what the risks might be, and develop pro-active conservation initiatives that stand a better chance of reducing harm and hastening recovery. "Adaptive management" in the context of this plan boils down to: "We know we haven't explained a lot of important things, but look at this complicated model we developed. Just believe the model and trust us….we'll let you know if the fish eventually tell us we've messed up."

There are many reasons why this paradigm is ineffective for biological conservation. It is in fact identical with the age-old Oregon coho management paradigm that got us to where we are today. There is some basic science that bears on the core biological monitoring assumption here: as published power analyses of salmonid spawner or redd count data show (Dunham et al. 2001; Maxell 1999; Rieman & Mcintyre 1996; Rieman & Myers 1997), the capacity of even the best field surveys to detect population trends is very limited. Under the best of circumstances, it might take 15 years before an underlying, real biological trend can be substantiated – simply because the interannual variance of spawner count data is moderately high. The problematic variance is probably higher for coho salmon because of their less-diverse age at maturity and sensitivity to fluctuating ocean conditions. This means Oregon coast coho might experience at least 15 years of irreversible harm and progressive erosion of habitat, population diversity and productive capacity before Oregon managers would be able to substantiate that a problem existed. It remains a mystery to us why the appropriate power analyses were apparently not done, or are not offered to evaluate the utility and limits for decisionmaking of coho return data.

What would be needed to render adaptive management effective for coho recovery? First, a critical assessment of status that accounts for uncertainties and spatial distribution and diversity concerns using available information. Second, a "default" management and conservation plan that makes conservative assumptions and avoids placing the species, its key populations, and its habitat at risk of irreversible harm or progressive loss. Third, a monitoring, research, and adaptive management protocol that identifies those specific scientific unknowns for which the answers matter most to coho status and recovery, identifies which of those can be answered through empirical means, and puts in place the studies and reporting systems necessary to answer them. Examples might include surveys to establish that recolonization of (not just first-generation dispersal into) depopulated habitat does in fact occur. Fourth and last, a "safety net" monitoring protocol that keeps tabs on coho survival, spatial distribution, key elements of habitat condition, and "leading indicators" of patterns in land use, climate, natural disturbance such as wildfire, and other factors deemed to be important in dictating the future of Oregon coastal coho salmon. One other element of the Plan that Oregon might point to as a "safety net" for the concerns we have stated is the stated numerical goal in the Plan, Appendix 2:

> **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.**

Much more could be said about the quantitative goals explained in Appendix 2 than we have time or space for here, but it appears to us they have received little in the way of external review or critical scrutiny. The derivation, justification, and definition of these goals remain in many respects very unclear. However, for the moment we would offer that a simple doubling of the abundance of a presently-severely-diminished population does relatively little to improve its prospects for long-term survival. Long-term survival, or viability, is determined in part by population size and distribution relative to temporal variability. Relative to prevailing variability imposed by fluctuating climate, ocean conditions, and density-independent freshwater survival, a simple doubling of average returns would likely have only a fractionally tiny, incremental effect on viability. Only by 1) reducing variability in survival or 2) greatly increasing abundance and distribution – e.g., by manifold – can the viability of Oregon coho significantly be increased. Unfortunately, the present goal seems almost calculated to avoid either of these effective outcomes.

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