An Approach To Limiting Factors Analysis and Restoration Planning In Sixth Field Sub-Watersheds

December 3, 2003

Prepared by
Bio-Surveys, LLC
P.O. Box 65
Alsea, OR 97324
541-487-4338
Contact: Steve Trask

Sialis Company
154 SE Rivergreen Ave.
Corvallis, OR 97333
541-753-7348
Contact: Duane Higley

Funded by
Technical Assistance Grant 203-231
Oregon Watershed Enhancement Board
775 Summer Street NE, Suite 360
Salem, OR 97301-1290

Submitted to
MidCoast Watersheds Council
157 NW 15th St
Newport, OR 97324

Executive Summary

A limiting factor analysis approach to the restoration of Coho salmon habitats in 6^{th} field watersheds of coastal Oregon is presented. The scale of effort was reduced to a single "target" species (Coho) and a 6^{th} field watershed geographic scale due to budget limitations, the social/economic value of Coho, the manageable size of a 6^{th} field for the development of a restoration plan, and the preceding effort of the Midcoast Assessment that analyzed and ranked restoration priorities by 6^{th} field.

Specific use is made of the terms Core Area and Anchor Site to advance the methodologies of finding and improving 6^{th} field habitats currently supporting remnant Coho populations. By "Core Area" we mean a contiguous section of stream channel or channel system where juveniles rear on a consistent (year to year) basis. The term Anchor Site is used to specify the portion of the Core Area which provides all essential habitat features necessary to support the complete Coho freshwater life history. In making these definitions, we identify the specific sites and conditions of the aquatic system that support the remnant population and explain how these sites function together to allow completion of the Coho freshwater life history. This leads to the identification of restoration actions aimed at the conservation and expansion of the deme through the protection and enhancement of the Core Area(s).

The plan concept is a limiting factor analysis that identifies habitat conditions restricting the success of one or more Coho life history stages. The assessment process uses a questionnaire approach, as opposed to tabulating existing data to be compared with fixed standards. The questionnaire includes structured sets of questions designed to reveal the status and needs of stream channels in relation to Coho habitat use. The end product is lists of specific needs and actions (prescriptions) prioritized according to effectiveness, urgency, cost, and practicality.

In accordance with commonly stated guidelines, the plan emphasizes restoration actions that both improve aquatic habitat conditions and normalize watershed events and processes. This is accomplished with a mix of strategies involving the recovery of riparian canopies, culvert removal or improvement, securing headwater wood and substrate recruitment corridors, instream wood placement, road assessment/removal, easement acquisition and cooperative planning strategies.

Introduction

This document describes the approach used in conducting limiting factor analyses of Coho salmon habitats in five small mid-coastal Oregon 6th field watersheds[1]. The project was funded by the Oregon Watershed Enhancement Board (OWEB), and was administered by the MidCoast Watershed Council (MCWC).

The sub-watersheds selected for restoration by MCWC were Steere Creek (Siltez River Basin), Rock Creek (Devils Lake drainage), North Fork Yachats (Yachats River Basin), Olalla Creek (Yaquina River Basin), and North Fork Beaver Creek (Beaver Creek Basin at Ona Beach). These sub-watersheds were judged to have high potential for ecosystem restoration and Coho habitat enhancement based on a MCWC assessment process that ranked all Midcoast 6^{th} fields for their current abundance of Coho and Steelhead as well as the presence of functional winter and summer habitat. The underlying objective was to expend restoration efforts in locations with the highest immediate potential for expanding the range of current distributions, provide connectivity among freshwater habitats, improve the quality of known refugia, and restore long term natural processes that have been degraded.

Coho salmon were selected as the "target species" of the restoration efforts because of budget limitations, limits on scope of work, availability of assessment data and the current status of the population in the ESU (listed). The primary goal is to identify how the system currently provides for each life history phase and

[1]For purposes of resource management, the land surface of the United States has been divided into successively smaller water drainage systems referred to as "hydrologic units". The highest order unit ("1st field") comprises a large region of the country, such as the Pacific Northwest. At the lower end of the scale, an 8th field unit would be a small stream valley. Intermediate in this hierarchy are 6th field hydrologic units, also called sub-watersheds. For ease of use, this paper refers to these sub-watersheds as simply "6^{th} fields".

then define restoration goals consistent with and supporting natural processes that support and extend these mechanisms. There are pros and cons of focusing on a target species. We are resting on the assumption that restoration efforts designed to benefit Coho will have negligible negative impacts on other aquatic species and in most cases benefit a diverse array of aquatic organisms and salmonid species.

There is a dichotomy of views in the restoration literature with regard to where restoration effort should be expended. One contemporary scientific perspective is that there will be much greater recovery of suppressed Coho populations achieved with the restoration of lowland rearing habitats than achieved by improving conditions in the upper reaches of coastal basins. The alternate view emphasizes the essential needs of conserving remnant populations by improving conditions in the upper basin habitats currently supporting the population. The decision by the MCWC to assess and rank sub-watersheds on the 6^{th} field scale establishes a hierarchical approach to this dichotomy. In essence, it is the approach that most closely resembles the Bradbury method (Bradbury et al. 1995) that promotes the recovery of ecosystem function (a top down strategy) as the highest priority.

The specific nature of the 6^{th} field strategy above allows us to set specific, achievable goals within a restricted budget and allows us to focus efforts immediately on current strongholds. It also provides a real potential for addressing the cumulative effects issues of degraded headwater ecosystems that affect the functionality of lowland habitats.

The broad project goal was to identify factors limiting the survival of Coho salmon in these sub-watersheds and to develop restoration plans that removed the immediate limitations to the freshwater survival of Coho. Although the project focused on the needs of a single species, we recognized the importance of implementing changes that simultaneously met the needs of all salmonid species while improving ecosystem function. That is, an essential criterion posed for each habitat enhancement was that it benefit and not interfere with the normalization of watershed events and processes.

The tools utilized to accomplish the tasks of restoration are broadly accepted and involve the recovery of riparian canopies, culvert removal or improvement, securing headwater wood and substrate recruitment corridors, instream wood placement, road assessment/removal, easement acquisition and cooperative planning strategies. A mix of these strategies can be utilized to accomplish both the short and long term objectives of restoring ecosystem function. While not comprehensive in terms of the whole basin, the 6^{th} field approach accumulates benefits to the system below. In addition, each prescription initiates, stimulates, or removes obstacles to natural processes on hill slopes, in the riparian zone, and in the aquatic corridor.

The terms Anchor Habitat and Core Area are often used in contemporary literature to describe watersheds or habitats that provide critical spawning and rearing functions. We have adopted these terms and redefined them to represent specific sections of 6th field stream channels which provide all habitat characteristics required for Coho salmon to complete the freshwater portion of their life history. The specificity of these definitions provided a clear basis for establishing restoration goals and prescriptions.

Guidelines followed

In defining the restoration approach, we were guided by literature sources that describe the freshwater habitat requirements of Coho salmon, successful approaches to watershed restoration, and methods for identifying critical areas for restoration. Among these, the most important were several papers that review the extensive literature on the restoration of salmonid populations and watershed functionality (Bilby et al., 2003; Bradbury et al., 1995; Frissell, 1998; Roni et al, 2002; and Talabere and Jones, MS.). These sources provide conceptual frameworks, implementation methods, and pitfalls of salmonid restoration biology. Dominant themes are apparent that provided guidelines for the current work.

Goals

- Protect remnant (core) populations against extinction.
- Protect the refuge areas which support core populations.
- Protect life history and genetic diversity.

- Emphasize protection of intact habitats over restoration of degraded habitats.
- Emphasize restoration of ecosystem functionality over site-specific habitat enhancement.
- Emphasize restoration of low-elevation floodplains and wetlands where resources and land ownership allow.
- Ensure that the habitat needs of all life history phases are supported.
- Ensure connectivity (accessibility) among the habitats needed by all life history stages.
- Ensure that habitat enhancement actions support the natural recovery of the system.

Strategies

- Select restoration sites that will ultimately contribute overflow stocks to surrounding areas.
- Establish ways to measure the status of aquatic habitats and target species populations in relation to ecosystem health.
- Select an effective scale of assessment and restoration effort
- Develop an explicit strategy for restoration.
- Develop an explicit model of species-habitat interaction.
- Use coordinated mapping to relate species and habitat distributions.
- Ask what is keeping the population from achieving its potential.
- Maximize potential effects of site-specific restoration actions.
- Mimic natural processes when implementing habitat enhancements.
- Avoid attempts to optimize all sites for a single species.
- Avoid the “collect/summarize all data” syndrome.
- Avoid rigid use of fixed habitat standards.
- Compose an end product of specific needs and actions (prescriptions) prioritized according to effectiveness, urgency, cost, and practicality.

Plan concept

The plan concept is a limiting factor analysis focused on the habitat requirements of all life history stages of Coho salmon.

The Independent Scientific Advisory Board (Bilby, et al 2003) argues that limiting factor tables are misguided if they attempt only to find divergences from fixed habitat standards, such as pool/riffle ratios and extreme thermal tolerances. This is because habitat conditions naturally fluctuate widely, and Coho salmon have adaptive behaviors to exploit these changing conditions.

We agree that limiting factor analyses aimed at consolidating and analyzing “all available data” often lack a directing point of view, and thus may lead to prolific and confusing data summaries that only illustrate the obvious, or worse provide no definitive road maps for establishing goals or decision making. Of these, the Habitat Matrix, with its Standards vs. Current Conditions provides a typical unwieldy example. Tables of existing data are not necessarily an effective basis for a limiting factor analysis.

An effective project design requires a point of view that reduces the enormous complexity of species survival mechanisms and ecosystem functionality to an addressable set of problems and actions. It is, of course, not possible to address all species and system problems, especially in a modestly funded program. Thus the practicality of focusing on a target species. However, the short-term needs of the target species must be balanced with the long-term needs of the ecosystem.

The point of view taken in the current project was to assess the habitat limitations of a single, economically and socially important species, and to address these needs with a critical concern for the effects of restoration actions on ecosystem health. This is accomplished using site level evaluations with the following point of view: *How can we stimulate normal channel function and improve habitat conditions at* *sites identified as Coho refugia, and do this in conjunction with riparian and upslope protection or enhancement activities that augment ecosystem function over the long term.*

Thus, an important guideline followed in plan development was that efforts to improve critical Coho habitat should stimulate normal floodplain events and should therefore neither interfere with natural landscape processes nor create an unnatural distribution of habitats. Although the restoration work is aimed at the needs of a single species, the intent must be to implement changes in ways that benefit general system functionality on both the landscape and aquatic system scales.

In this context, productive questions like the following may be asked.

- What geologic and channel habitat features constitute a Coho refugium?
- How can refugia be identified in different systems?
- How well is the refugium in question functioning for each Coho freshwater life stage and what factors most limit this functionality?
- What actions can be taken to improve this functionality that also benefits system processes?

These types of questions lead us away from data tabulation toward a questionnaire approach as the basis of a limiting factor analysis. The assessment process used relies heavily on structured sets of questions designed to reveal the status and needs of stream channels in relation to Coho habitat use. This questionnaire is presented in the section "Restoration Approach".

Selecting the restoration area

Advantages of working at the 6^th field level

The current direction of scientists involved in the definition and classification of Coho populations suggests that a population exhibiting distinct genetic characteristics exists within each of the major 4th field coastal basins (although some smaller coastal basins may not exhibit genetic distinction). However, if we were to focus our restoration efforts at this level, watershed size and the complexity of the ecosystem would overwhelm budget capabilities for assessment and restoration and limit success.

Fourth ^and fifth field watersheds generally have gradients too low to sort spawning gravels for Coho, while 6^th field watersheds have sections that support this process. Because of this, 6^th field watersheds are the historic spawning centers that have generated a flow of fry and parr to the potentially extensive lowland winter rearing areas of 4^th and 5^th field mainstems, wetlands, and intertidal zones. These lowland zones have been greatly reduced and / or degraded, forcing successful remnant populations to complete their freshwater life cycle in sections of the stream which have historically functioned primarily for spawning, and only to a minor degree as rearing habitat.

In some systems, the losses of lower rearing areas combined with the degradation of habitat in the spawning reaches have reduced the production potential of the 6^th field subpopulation (deme) below the threshold of population continuity: Some demes have been lost. These 6^th fields may occasionally be seeded by strays from adjacent "source" 6^th field watersheds, creating a boom and bust scenario.

According to Talabere and Jones (Oregon Department of Fish and Wildlife, MS), the 6^th field watershed was selected for their analyses because it, "...had a standardized and available map base for the coastal basins of Oregon, was biologically meaningful for salmonid populations, had sufficient data available to allow for summarization of biological parameters and physical features, and is of a size that can be effectively managed for landscape processes." They also state, " This size of watershed was considered the minimum necessary to support a self-sustaining (viable) population of Coho salmon given moderate to high quality aquatic habitat…".

The importance of these 6^th fields is extremely high for maintaining diverse life histories in the population and for providing the continuity of adjacent high quality spawning and rearing habitat. Various terminologies have been used to refer to these remnant habitats. Terms such as Core, Anchor, Critical, and Source emphasize their perceived importance both to the continuity of the basin population and to the potential for population recovery.

Lowlands vs. upper 6th field

One of the contemporary scientific perspectives is that there will be much greater recovery of suppressed Coho populations achieved by restoring lowland rearing habitats than by improving conditions in the upper reaches of coastal basins. The alternate view emphasizes the essential needs of conserving remnant populations by improving conditions in the upper basin habitats currently supporting the population.

Reasons for focusing on lower mainstem and lowland habitats include: 1) A few adults using a small amount of spawning gravel can produce very large numbers of fry to seed downstream habitats; 2) The upstream areas, even if restored to optimal conditions, cannot provide high production capacity due to the limitations of valley and channel geomorphology (limited valley width for the development of low velocity winter habitat and relatively high gradients); 3) The lower parts of the 6th field mainstem with its wider valley floor and very low gradients, and the lowlands outside the 6th field offer much greater potential for the development of low velocity winter rearing habitats.

Reasons for focusing on upper basin habitats include: 1) Land use and land values, present great obstacles to restoration in the lower mainstems and lowlands; 2) Population survival, genetic flow and conservation of diverse genotypes may be sacrificed or compromised while encouraging a single life history strategy; 3) Large investments in the development of cooperative relationships exist between public, small private and industrial land managers in the upper segments of coastal watersheds that form the functional foundation of the Oregon Plan; 4) The restoration of long term ecosystem function will not be successful with a bottom up approach that does not address the importance of temperature maintenance, sediment contribution, water quality, nutrient and raw resource delivery from the headwaters; 5) Adoption of the Bradbury method demands that we focus our attention on the recovery of function first; 6) There is much more at stake in a top down restoration strategy than Coho production because multiple species receive benefit from upper basin recovery strategies that would receive limited benefit from a lowland focus (e.g., Steelhead).

Ideally, work would proceed comprehensively at both levels. Budget limitations, practicality, and the focus on salvaging remnant Coho salmon populations direct our attention primarily to the upper 6th field habitats.

Approaching the upper 6th field work sites

Decisions on what types of restoration work to perform and where to perform it in the upper 6th field habitats must be guided by a sound understanding of Coho habitat needs, current conditions in the upper 6th field relative to these needs, and development of a structured approach to solving habitat problems. In the following sections, we describe how these elements were formulated into a restoration plan that specifies how to select restoration sites and actions.

Coho habitat requirements and problems

Ecological setting

Coho salmon are highly mobile, exhibit great variation in population size over time and space, and require multiple types of habitat to complete the freshwater part of their life history. The requirements for successful completion of spawning, incubation, fry, parr, and smolt stages vary, and these requirements are typically met in a complex of habitats distributed throughout a stream system. Year to year changes in habitat structure and population levels alter how important a specific habitat type or life history stage is to smolt production.

Habitat-fish productivity studies elucidate mechanisms of how factors affect populations on fine scales, but do not address the "broader biological consequences of a restoration action unless they are part of large scale, integrated evaluation effort" (Bilby, et al. 2003, p 23). We therefore cannot assess or manage anadromous salmonid populations at solely a local level. Protection or restoration of whole 6th fields is an appropriate approach. This work must exist within a broader perspective of the status of landscape processes and the distribution and viability of related populations distributed throughout the basin.

However, there are local circumstances that demand immediate solution, and weighing the benefits of local crisis management against a broader scale landscape recovery process becomes a challenging analysis.

Historically, Coho used stream habitats distributed from lowlands and marshes in the basin mainstem up into narrowing valleys with moderate gradients (e.g., 6th fields). Spawning was concentrated where moderate gradients (1-3%) combined with locally widened floodplains to collect abundant, clean gravel. These sites produced great numbers of fry, some of which reared onsite, but most of which reared downstream in the complex habitats of lower 6th field reaches and below in the basin's lowland marshes and estuaries.

In many basins, human use of the landscape has altered much of this lowland habitat, and compromised the rearing potential of the lower 6th field mainstem habitats. These alterations have resulted in elevated summer temperatures and a loss of interactive floodplain habitats. The reduced capacity of these lowland reaches to function for multiple life stages shifts the burden of production higher in the system to a reach that functioned primarily for spawning and incubation. The ability of these spawning sites to support rearing to the smolt stage was never large. In addition, these spawning and incubation reaches have also been compromised by timber extraction, road construction, and agriculture that have resulted in reduced wood volumes and channel simplification.

If we view these habitats from the perspective of historic abundance, the current status of Coho and the distribution of complex habitats they once used could reasonably be called "remnant". Remnant populations are using remnant spawning and rearing habitats.

Obviously, not all basins and 6th field watersheds conform to this description. Some 6th field watersheds open directly into the ocean, or flow into a lake, or are part of a basin that retains significant lowland rearing habitat. In the end, each restoration project is distinct and different. Still, the description is commonly applicable, and helps us define restoration goals.

Effects of habitat simplification

Complex vs. simplified habitats

The term "complex habitat" is commonly used to describe meandering or braided stream channels that possess a variety of wood and rock structures, overhanging banks, and deep pools. Basically, anything that deviates from straight and smooth is an aspect of habitat complexity. Diverse channel characteristics are initiated by large wood and substrate that create deflection and erosion. The more diverse the channel form, the more opportunity there is for the development of habitat complexity.

Habitat simplification is the result of one or more unnatural events superimposed on the natural processes that generate complexity. The fundamental cause of channel simplification in Coho streams has been the removal of riparian and upslope wood resources, which erosion, wind throw, and landslide would normally deliver to the channel. Historically, these wood resources were instrumental in maintaining complex channels that exhibited floodplain interaction, channel meander, and both substrate and nutrient retention.

Simplified aquatic habitats have low wood densities, low sinuosity, channel entrenchment, low abundances of interactive off-channel habitats, limited recruitment potential in the riparian of coniferous species, and low substrate diversity. In the Oregon Coast Range, most aquatic habitats currently exhibit the attributes of habitat simplification

Problems that simplified habitats create

A richly complex stream channel creates and maintains a diversity of low velocity habitats required by different aquatic organisms, from simple algae to juvenile salmonids. Abundant opportunities exist in complex channels for fish to seek shelter from current and predators, as well as for the growth of food organisms. Thus, in an undisturbed system, the regular input of timber, canopy litter, cobble, and boulders enriches the channel, maintaining the habitat complexity suited to the proliferation of juvenile Coho salmon.

Channel simplification, on the other hand, progressively leads to trough-like channels that provide less and less opportunity for aquatic organisms to take refuge from predators and increases in water flow. Without aquatic complexity, juvenile Coho are forced to expend valuable energy during winter flow regimes to maintain position in habitats lacking low velocity refuge. They also suffer indirectly from the lack of nutrient retention that occurs when canopy litter and sediments are no longer stored, but are flushed downstream.

Habitat requirements of each life history stage

The fundamentals of Coho-centric watershed restoration revolve around the specific habitat conditions required by each life history stage, and how these are met or not met in streams exhibiting varying degrees of channel simplification. Specifying needs by life stage is necessary when making a limiting factor analysis of the way the population currently uses its habitat resources. The following description of habitat needs is fundamental for assessing the life stage requirements of Coho.

Spawning and egg incubation

Gravel bedded riffles and pool tail-outs in proximity of cover suitable for adult spawners (e.g., deep pools, undercut banks, debris jams). Gravels need to be well sorted and exhibit limited embeddedness to function properly as an incubation site that is capable of delivering oxygen to the egg and pre-emergent fry. The location and hydraulic nature of these gravels is very significant because of the need for oxygen delivery.

Early fry rearing

Low velocity with cover in close proximity to a food source that is typically associated with shallow, channel margin habitat, with cover from wood and overhanging vegetation. These productive margin habitats are most prolific in complex channels that exhibit an interactive floodplain, high wood densities and a lack of entrenchment. Entrenchment without roughness will rapidly result in the loss of emergent fry from the habitats of concern.

Summer rearing

Pool habitat with cover in close proximity to a food source that is typically associated with low gradient channels, pool/riffle morphology, streams in flood plain valley type. Juveniles are extremely focused during summer flow regimes on the detection and consumption of food items. If optimum stream temperatures are exceeded during this portion of their life history there are survival consequences that are related to their condition factor. The range of juvenile Coho distribution during the summer in the Coast Range is partially a result of the thermal barriers caused by habitat degradation.

Winter rearing

Low velocity refuge with cover typically associated with off-channel habitat on floodplains including low gradient tributaries, secondary channels and ponds. Maintenance of the body condition attained during the summer is critical during winter flow regimes. Locations that provide interaction with the floodplain guarantee that as flows fluctuate, a shift to adjacent low velocity habitats will require limited use of their caloric resource. Preferred habitats are a combination of complex cover and no velocity.

Application of Core and Anchor concepts

The concept of critical Core and Anchor areas

Various terminologies and rationales have been used to identify and rank watersheds or stream sections as to their condition and importance for restoring populations of salmon and other key species. The terms Key Watershed, Core Habitat, Source Area, and Anchor Habitat have been used in this respect. Prioritization method has included water quality, habitat condition, potential for population extinction, spawner or juvenile fish densities, ability to supply adjacent watersheds with spawner overflows, and professional judgment.

In implementing the Oregon Plan, the Oregon Department of Fish and Wildlife focuses attention on identifying 6th field watersheds that are judged important for saving local (6th field) populations in the short-term, and for the persistence of basin populations on the long-term. Generally, this view identifies which 6th field watersheds to protect or restore, but does not identify the specific channel forms and locations within the 6th field watershed that support the remnant population.

In the restoration concept presented here, we use the term Core Area to refer to a section of a 6th field stream channel that supports a remnant 6th field population. It refers to a contiguous section of stream channel or to a channel system where juveniles rear on a consistent (year to year) basis, as opposed to a whole 6th field watershed. The term Anchor Site is then used to specify the portion of the Core Area which provides all essential habitat features necessary to support the complete Coho freshwater life history.

In making these definitions, we identify the specific sites and conditions of the aquatic system that support the remnant population and explain how these sites function together to allow completion of the Coho freshwater life history. This leads to specifications of restoration actions aimed at the conservation and expansion of the population through protection and enhancement of the Core Area(s).

Primary 6th field subdivisions

While restoration actions are focused on the upper mainstem and its Core Area and Anchor Sites, other downstream rearing areas must be considered in assessing the condition and needs of the population. The plan addresses this need by breaking the 6th field into two segments, Lower and Upper.

Lower 6th Field

The Lower 6th Field extends from the stream mouth up to where channel gradients consistently rise above 1%. It is characterized by limited gravel deposition and substrates dominated by sand, silt, fines and organics.

In degraded systems, this section of the stream commonly exhibits poor water quality, entrenchment, low gravel resources, and low pool complexity. The transition from the Lower 6th field to the upper is a qualitative judgment that depends on the state of degradation.

In systems with limited historical degradation (good habitat suitability and function have been retained), the Core Area (see below) may extend into or encompass the entire lower 6th field.

This section does not provide significant amounts of spawning and incubation habitat. However, it may provide spring, summer and winter rearing habitat for Coho fry, parr and presmolts depending on the level of riparian degradation and on the cumulative impacts of loss of aquatic and upslope function higher in the watershed.

Upper 6th Field

The Upper 6th Field channel is characterized by gradients greater than 1%, providing for significant gravel deposition and potential for sorting that creates Coho spawning sites. There are of course lower densities of sand, silt, fines and organics.

Functional areas within or below the 6th field

Specific terms are used to describe areas or sites that support a 6th field Coho population by providing spawning and rearing habitats. These are “Core Area”, “Anchor Sites”, “Secondary Branch Sites” and “Lowland Rearing Areas”. These spawning and rearing sites are complemented by “Critical Contributing Areas”, which are potential sources of wood and sediments to the stream channel.

Other habitat types may exist within the 6th field that are not currently defined in this concept.

Core Area

The Core Area is the zone that encompasses the majority of the productive habitat for juvenile Coho within a degraded 6^{th} field. This zone is characterized by gradients that range from 1- 6 % and is defined by the observed range of summer parr distribution.

The Core Area may include different stream orders, channel forms, and aquatic habitats in different watersheds. The common factor is that within any specific 6^{th} field, habitat conditions in the Core Area function corporately for the provision of habitat for all life history stages.

The Core is a zone that is capable of floating up and downstream within a 6^{th} field, across the boundaries of the primary subdivisions (upper / lower) as a response to changes in habitat function.

The Core contains Anchor sites and Secondary Branch habitats, and may contain portions or all of the Lower 6^{th} field (depending on the state of degradation).

Anchor Sites

The highest production spawning and rearing habitat typically is located in 6th fields immediately below main branch confluences and in deposition plains (plateaus). The primary driver in the location of these sites is gradient and valley form. These sites have gentle gradients (1-2.5%) and are formed by a combination of variables, including morphological pinch points, torrent depositions, beaver colonization, increased flood prone widths, increased valley width index and increases in stream order.

Anchor habitats represent a complete habitat system for Coho because the juxtaposition of gradients and changes in channel form provide for the deposition of gravels, the accumulation and retention of course woody material, the deposition of macro and micro nutrients, and the development of floodplain interaction independent of the presence of wood in the system. They provide some of every type of habitat required to complete the Coho life history to the smolt stage.

Anchor habitats are extremely significant in highly degraded systems because they provide refugia as a function of geomorphology. These habitats are critical for the persistence of the Core population, and in years of low abundance provide a foundation for higher than average fresh water survival rates.

Secondary Branch Sites

Secondary Branch Sites occur in low stream order branches and tributaries. Compared to Anchor Sites, this habitat is typified by steeper gradients, reduced habitat surface area, and reduced flow volume. These habitats continue to sort gravels and may create additional spawning sites. However, their rearing potential is very low compared to the mainstem.

Floodplain interaction is typically less, and favorable habitat typically extends only a short distance up each branch. High riffle frequency can contribute significant food resources to mainstem inhabitants below. The habitats in these zones provide very limited potential for winter refuge.

These habitats support genetic diversity within the 6^{th} field, but are less critical than Anchor habitats for the persistence of the deme.

Lowlands

The term Lowlands refers to wetlands, marshes, lakes, sloughs, estuaries, sinuous pasture trench habitat, and similar habitats usually found downstream and outside the boundaries of the 6th field that function primarily as over-wintering habitat. These locations typically provide no spawning or incubation habitat. They also typically do not provide significant spring and summer rearing habitat for fry or parr because of the potential for elevated summer temperatures in degraded systems and the physical distance from the point of fry emergence. There are exceptions based on the level of degradation to aquatic and upslope function higher in the watershed (systems with limited upslope degradation maintain higher water quality in the lowland habitats) and proximity to spawning and incubation areas.

Although this type of habitat is usually not contained within the 6th field, the importance of its provision of critical winter habitat can not be overstated because lack of the over-wintering habitat most frequently limits the production potential of 6th field watersheds for juvenile Coho.

Critical Contributing Areas

Critical Contributing Areas are sites with the 6th field that contain wood and/or sediments which erosion or slope failures are likely to deliver to the stream channel. These portions of the 6th field are therefore very important in maintaining functionality within the fish bearing segments of the channel. They are indirectly responsible for thermal control, as well as sediment, substrate, nutrient and wood delivery.

Because they enter the Core in different locations (above, below, within) and their potential for initiation and delivery to the Core vary, we suggest that they exhibit variable levels of significance to a prioritized restoration strategy.

Restoration approach

The approach to restoration planning is goal oriented. The following goals and associated questions guide the Assessment of existing data resources as well as the collection of supplemental inventory data in the Field Questionnaire.

Goals

- Define current Coho habitat structure and usage by 6th field
  - How and why is it working now?
  - What part does each habitat subdivision play?
  - How are the fish currently using the system?
- Protect the remnant population
- Create a system of habitats that optimizes success of all life phases
  - What needs to be done to make the Core habitat function for all life phases and to function at a higher level?
- Augment ability of system to support Coho through all life stages by enhancing and extending high priority habitat areas
- ID factors and/or life history stages that limit survival and production.
  - How and when are the greatest looses generated to the population?
- Address limiting factors in an orderly way
  - Within the Core habitat, what are the dominant limiting factors?
  - Within the 6th field, what are the dominant limiting factors?
  - Within the 4th field, what are the dominant limiting factors?
- Reduce the need for fry and parr (pre-smolt) migrations that are density independent.
  - Are there temperature dependant movements that may expose juveniles to predation?
  - We assume that if there are life history strategies present in the remnant population that dictate density independent migrations, that improvements in site specific complexity and function will not negatively effect the genetic diversity of the population within the 6th field.
- Open corridors, remove passage barriers
  - Where are the barriers?
- ID and address thermal problems.
  - What temperature problems are apparent?
  - Where are the temperature refugia located?

- Recognize that the habitat required to complete a freshwater life history can be met in many ways: Suggests flexibility in goals, encourage diversity and intend to optimize production.
- Ensure flow of habitat-creating resources into channel
  Always address upslope issues and their relationship to Critical contributing tributaries.
  What is the best upslope work that supports the instream work?
- Identify instream segments for restoration that will address the factors that limit Coho salmon production.
- Identify upslope and riparian segments for restoration that will address the factors limiting the recovery of the long term function of ecosystem process.
- Develop a two tiered approach to prioritizing restoration that ensures the consideration of both long and short term strategies.
- Link functional anchor habitat segments within the Core area.
- Link functional Core 6th fields (restored / enhanced / protected) with adjacent degraded 6th fields by expanding restoration efforts into these adjacent 6th fields.
- Restore natural process to the system as a long term vision.
- Insure the perpetuation of remnant populations with short term restoration assistance.
- Expand on the distribution of functional habitat or improve the functionality of an already functioning component.
- Accept the assumption that Coho demes exhibit unique adaptive characteristics that are expressed genetically and consider diversification in all restoration planning.

Prioritization

The Bradbury Method

The Bradbury Method (Bradbury et al. 1995) has been adopted as the general approach to restoration Prioritization.

- First remove or stop the human caused perturbations that are degrading aquatic habitats and biological conditions.
- Allow the watershed time to recover naturally.
- If the watershed cannot recover naturally or cannot recover quickly enough to prevent serious depletion of native fish populations, identify restoration activities that will help return ecosystem processes to conditions that will sustain native fishes.
- Once a restoration strategy is determined to be the tactic of choice, a prioritization protocol guides us in determining what the appropriate locations, techniques and order of importance are for restoration.

Prioritization Protocol

The current paradigm adopted by scientists in the contemporary literature is that the preservation, protection and enhancement of functional ecological refugia on the 6th field scale (key watersheds, Frissell,1998) should be the highest restoration priority. The rationale suggests that these habitats are currently providing a disproportionately large segment of salmonid production on the watershed scale. These 6th fields are also significant immediately for maintaining at risk populations or demes.

Within these key 6th fields we have previously described four potential habitat subdivisions that function uniquely for different species and life history stages.

Two prioritization protocols have been developed that address short term and long term recovery. The short term process is designed to provide immediate increases in freshwater survival to address the critical condition in some watersheds of listed salmonid species.

The long term process is designed to provide a logical step wise approach to restoring ecosystem function that will provide the foundation for restoring self sustaining natural function. These are not mutually exclusive processes.

Where it has been determined that populations or population diversity is threatened, both protocols should be implemented as parallel processes. One should not be implemented without the other. Where it has been determined that populations and diversity are stable and exhibiting recovery (increases in abundance), then priority should be shifted to the implementation of the long term prioritization protocol that is designed to restore self sustaining ecosystem function (The Bradbury method).

Short Term

Protect, expand and enhance the Coho Anchor sites because they provide some of each of the habitats required to complete all of the Coho life history stages. Improvements in habitat complexity, floodplain interaction and riparian health at these sites can immediately improve survival rates to smoltification.

- Target identified Coho Anchor sites within higher stream orders first because they exhibit the greatest production potential and thus the greatest cost / benefit ratio.
- Link Coho Anchor sites within the Core with aquatic and riparian recovery strategies that provide short term cover and complexity as well as future recruitment potential for the provision of cover and complexity.
- Expand the Core into the lower mainstem with restoration strategies designed to improve long term function. These areas may eventually provide the greatest recovery potential because they are low gradient and frequently act as a sink for over-wintering juveniles.

Long Term

- Protect, acquire and enhance Critical contributing areas that exhibit the potential for a disproportionately high rate of slope failure and resource delivery to the Core (40-60 % of all aquatic wood resources originate from these sources).
- Protect, enhance and restore riparian conditions within the Core to provide the long term source of nutrients, wood, shade and complexity. Encourage later seral stages in lower reaches (temperature maintenance and potential recruitment) and mixed seral stages in upper reaches (increase primary productivity at the site of pool/riffle complexes).
- Remove, redesign and restore roads and crossings that retard or terminate the delivery of resources to the Core.
- Protect, enhance and restore Secondary branch riparian corridors because they provide potential life history diversity to the Core. These sites offer spawning and incubation habitat and do not function at a high level for the provision of summer or winter habitat. These sites are not high priority for instream restoration activities. These riparian corridors provide the bulk of the future wood and nutrient recruitment from canopy litter and torrent activity.
- Encourage riparian diversity in species and seral stage to promote a foundation for emulating the dynamic nature of historical conditions.
- Incorporate the riparian diversity required to sustain and promote the colonization and expansion of Beaver populations.
- Expand protection of water quality to upslope management regimes.

Expected results

With the introduction of wood into the channel and recovery of system function, we expect the following improvements:

- Increases in channel sinuosity and floodplain interaction.

- A conversion to higher densities of coniferous species in the riparian corridor to address the long term need for an LWD source.
- An expansion of the rearing population lower in the 6th field mainstem.
- Higher base adult population sizes.
- Expanded interest in the protection and acquisition of upslope resource areas that are critical for natural recruitment to the aquatic corridor.

Methods

Data resources and models

AQHI

Primarily only summer habitat inventories available. With the abundance of low velocity, edge oriented or backwater winter habitat the most common limiting factor for salmonids it is difficult to utilize this tool for the assessment of these critical habitats.
Best uses include reach definition and characteristics, channel types, side channel frequency, Valley form / VWI, gradient profiles. The inventories are less suited for quantifying spawning gravels, identifying specific habitat features needed by Coho and providing qualitative assessments of complexity and function.

Juvenile snorkel surveys

RBA inventory data for multiple years to quantify and map summer juvenile distribution. These surveys provide site specific abundance data that assist in the identification of spawning and rearing hotspots.

GIS spatial mapping

- Maps that exhibit gradient profiles, VWI shifts, and canopy condition.
- ODF mapping that assesses slope failure and delivery potential.
- PNW Probability of Debris Flow Model
- RBA overlays to correlate with morphological attributes

Models

We used the Nickelson Coho Production Model (Tom Nickelson, Oregon Department of Fish and Wildlife, Corvallis Or, personal communication, 2003) to estimate smolt production of each specific life history stage. The model relies on spawning, summer, and winter habitat abundances. ODFW AQHI data and spawning gravel data collected as a by product of this analysis were utilized for each 6^{th} field. In addition, a supplemental model is utilized from the Alsea Watershed Study (James Hall, personal communication) to compare variable life stage survival rates.

Field Assessment

Field inventories will be utilized to ground truth the conclusions developed by the pre survey review of historical data resources. Each 6^{th} field will be re-surveyed to collect additional attributes for the Field questionnaire below. The following attributes will be evaluated in the course of this supplemental field inventory.

Evaluate habitat quality and Coho production

- Riparian vegetation
- Lineal distance / location of deciduous

- Lineal distance / location of coniferous
- Lineal distance / location of open canopy
- Recruitment potential and time frame
- Potential for thermal problems
- Channel form and floodplain interaction
- Lineal distance / location of functional anchor habitat
- Lineal distance / location of potential anchor habitat
- Quality, quantity and location of spawning gravel
- Character and distribution of Summer Cover (lacks quantitative evaluation and relies on professional judgment)
- Character and distribution of Winter Cover (lacks quantitative evaluation and relies on professional judgment)

Locate migration barriers

- Season of effect
- Species and age class affected

Identify potential sites for restoration work

- Location
- Problem
- Goal
- Method
- Expected problems
- Expected results

Document potential restoration sites with photos

List and rank the factors currently limiting Coho production

Include professional judgment of potential lowland habitats existing outside the boundaries of the 6th field analysis for the provision of winter habitat

Make overall assessment of current roles of each Area in Coho production

Utilize pool abundance data and spawning gravel counts in conjunction with the Nickelson / Lawson model to develop current production potential and the Lobster Cr. long term monitoring data to describe future production potential.

Utilize these modeling criteria to affirm assessments of limiting factors

Recommend a plan of action that includes a ranked list of restoration efforts

The plan will be two tiered (short and long term issues addressed)

The plans prioritization will undergo revision upon delivery to the landowners where we assume that not all owners will be willing cooperators

Explain how the modifications will interact and increase production

Primarily relevant to modifications that effect passage. An estimate of increased production should be developed for all habitats where access to salmonids has been denied or compromised. This will facilitate an evaluation of cost /benefit and assist in the development of prioritized culvert replacement program

Modifications to Critical contributing habitats, riparian corridors and instream reaches will be difficult to quantify and will rely on existing evaluations of restoration activities

Assessment questionnaire

Morphology

- Describe the valley form, constraint, and floodplain.
- Assess the potential for the development of meander, braiding, side channel, alcove, backwater channel forms.
- What is the current status of development of these channel forms? Include a description of entrenchment as the alternate state.
- What proportion of the system's Coho production appears to be provided by this zone? Describe in terms of spawning, incubation, summer rearing, and winter rearing ability.
- List and rank the factors currently limiting the development of channel complexity.
- Are these factors addressable through restoration work?
- Provide ranked recommendations for both instream and long term work.

Riparian corridor

- Describe the riparian corridor and its potential to provide wood. How long before recruitment?
- To what degree would land use and ownership allow restoration work?
- What other factors limit the current and long term ability of the corridor to deliver large coniferous woody debris to the channel?
- What is the potential to increase channel complexity in the long term through natural recruitment processes, with and without restoration?
- Describe ranked restorations procedures, their expected impact, and time scale.

Overall assessment of zone

- How does this zone contribute to Coho production by the whole?
- In what ways does it work with the primary upstream summer rearing and incubation sites to support the core population?

Core Area

Anchor sites

- Do anchor site(s) exist?
- If so, describe the location, dimensions, gradients, and salient habitat features.
- Describe how the site contributes to spawning, incubation, summer rearing and winter rearing.
- What proportion of the system's summer Coho production appears to be provided by this site?
- Rank the site in terms of each of these functions (abundance of pool surface area, spawning gravel, % of summer production).

- Which function(s) limits the site's production potential, and what causes this limitation?
- List and rank the restoration work at this site that would most effectively increase survival within the Anchor site and stabilize the core population at a higher base level.

Secondary Branch sites

- Do secondary branch site(s) exist?
- If so, describe the location, dimensions, gradients, and salient habitat features.
- Describe how the site contributes to spawning, incubation, summer and winter rearing
- What proportion of the system's summer Coho production appears to be provided by this site(s)?
- Rank the site in terms of each of these functions (abundance of pool surface area, spawning gravel, % of summer production).
- Which function(s) limits the site's production potential, and what causes this limitation?
- List and rank the restoration work at this site that would most effectively increase survival and stabilize the Core population.

Critical contributing areas

- Do Critical contributing areas exist?
- If so, describe the location, dimensions, gradients, and salient habitat features.
- How is each CCA related spatially to the Core and it's Anchor sites?
- What are the specific potentials of each CCA to deliver resources to the fish bearing Core area?
- Rank the CCA's in order of their importance for protection, restoration or acquisition.

Lowlands outside the 6th field

- Do lowland habitats exist that could function as potential winter habitat for Coho?
- If so, describe the location, dimensions, gradients, and salient habitat features.
- What is the spatial relationship of the lowland habitat to spawning and incubation sites in the watershed?
- What are the problems associated with the abundance, location or condition of these lowlands?
- What are the obvious lowland issues to consider for future planning activities within the watershed.

How does the current Coho production system work?

- Describe how and where the principle spawning, incubation, summer rearing, and winter rearing is shared among the sites described.
- What types and seasons of movement would be required to utilize these functional sites?
- How long are the migration routes among the sites?
- How safe are the routes?
- What factors limit the production potential of the system as currently composed?
- From the recommendations listed above, list and rank the restoration work that most effectively stabilizes the population at a higher base level.

What are the probable effects on other species?

- At the prescription level, address how the work to aid Coho production impacts other species. Don't assume positive. E.g. Migratory gravel trapped robs lower mainstem.

Products

6th field Plan

- Description of habitat conditions and the location of key habitats within the 6th field
- Assessment of factors limiting Coho production within the 6th field
- Prioritized dual pronged (short and long term) restoration strategy for the 6th field

A working concept of project flow

- Gather existing data
- Map and compare attributes for relationships that may help locate Core and anchor habitat locations
- Conduct field inventories to address questionnaire and ground truth attribute mapping
- Prepare 6th field plan and prioritized restoration strategy
- Meet with 6th field landowners to deliver assessment data and propose restoration strategy
- Develop restoration proposals to accomplish goals of 6th field plan

References

Bilby, R.E., et al. 2003. A Review of Strategies for Recovering Tributary Habitat. ISAB Report 2003-2 prepared by the Independent Scientific Advisory Board for the Northwest Power Council, Portland, OR.

Bradbury, W., W. Nehlsen, T. Nickleson, K. Moore, R. Hughes, D. Heller, J. Nicholas, D. Bottom, W. Weaver, R. Beschta. 1995 . Handbook for Prioritizing Watershed Protection and Restoration to Aid Recovery of Native Salmon. Published by Pacific Rivers Council, Eugene, OR. 47 p.

Frissell, C.A. 1998. Landscape Refugia for Conservation of Pacific Salmon in Selected River Basins of the Olympic Peninsula and Hood Canal, Washington. Biological Station Open File Report Number 147-98. Flathead Lake Biological Station, University of Montana, Polson, MT.

Roni, Philip, Timothy J. Beechie, Robert E. Bilby, Frank E. Leonetti, Michael M. Pollock, and George R. Pess, 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Stream. North American Journal of Fisheries Management 22:1-20, 2002.

Talabere, Andrew G. and Kim K. Jones, MS. Pacific Salmon Conservation: Designating Salmon Habitat Diversity Watersheds, A Process to Set Priorities for Watershed Protection and Restoration. Draft 2.0 released December 30, 2002 by the Oregon Department of Fish and Wildlife, Corvallis OR.