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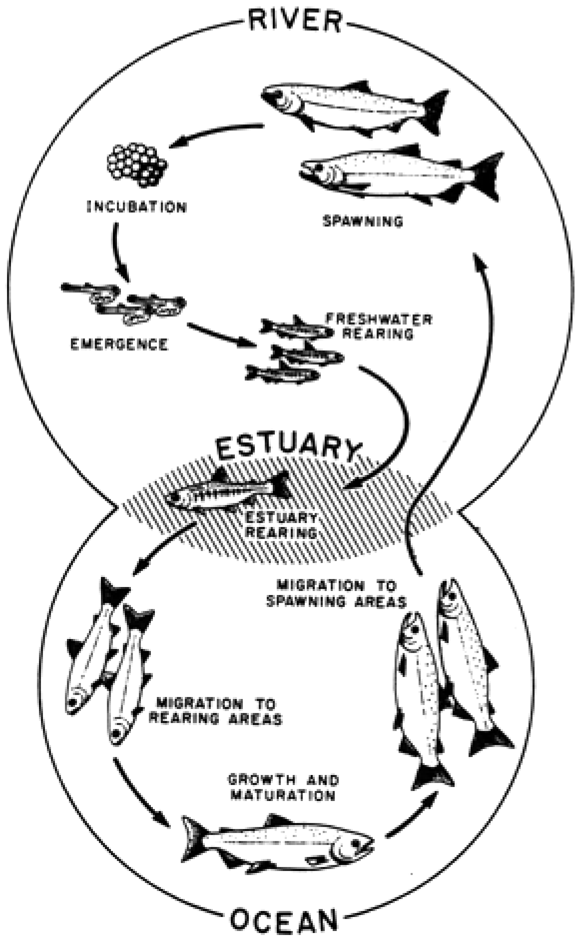

Limiting Factors Analysis

For Coho Salmon and Other Anadromous Fish

Scott River Sub-Basin

A Product of the
Scott River Watershed Council Fish Committee
April 2006

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All other participation was provided through local agency representation and volunteer efforts.

1. INTRODUCTION:

1.1 Objectives

One of the objectives of the Scott River Watershed Council (SRWC) is to conserve and enhance the resources of the Scott River watershed. Anadromous fish are one of those resources. The SRWC wished to better direct its conservation efforts by identifying which activities and conditions in the Scott River watershed caused the greatest harm to anadromous fish. The Fish Committee of SRWC set out to accomplish this by assigning a sub-committee that would use a science-based process known as a limiting factors analysis (LFA). An LFA seeks to identify the most important environmental factors that are causing a population to decline and preventing its recovery. The information can then be used to direct efficient, effective restoration of habitat and improvement of management practices to restore anadromous species.

Although the Fish Committee is concerned with steelhead, coho and Chinook salmon, the committee chose coho salmon as the focus of this LFA, because it is the most threatened. Many of the factors that limit coho salmon also limit the other anadromous species, so implementation of restoration actions for coho may help those species as well. The SRWC intends to use this LFA as a template for steelhead and Chinook LFA's to be completed in the future.

The sub-committee compiled of local citizens, landowners and agency representatives began by searching for and reviewing existing LFA's to find an accepted protocol. It found a variety of approaches, rather than one standard protocol. However, there was a general common framework shared by all the LFA's that contained these subject areas:

- The objectives of the LFA and the history of the problem
- The compilation and review of existing data and local knowledge
- An analysis of each life stage of the species to identify limiting factors
- The identification of important unanswered questions, the development of hypotheses, and the design of studies to address the questions
- The refinement of the LFA by incorporating new data and study results
- The identification of focused restoration tasks to remedy the limiting factors
- Continued monitoring and validation

1.2 Methods

The sub-committee agreed upon the following methods to complete an LFA for the coho salmon population of the Scott River watershed.

Assemble and Review Available Information

The sub-committee used their professional knowledge, literature, and data on hand to define the life stages and timing of the coho in the Scott River watershed. Included were the life stages spent in the Klamath River and Pacific Ocean. The life stages were:

I. Adult Migration
   a. Klamath River (September –October)
   b. Scott River (October – November)
II. Spawning (November – January)
III. Egg Incubation and Alevins in Gravel (December – May)
IV. Juvenile Rearing
   a. Spring (March 22 – June 21)
   b. Summer (June 22- September 21)
   c. Fall (September 22 – December 21)
   d. Winter (December 22 – March 21)
V. Juvenile Outmigration
   a. Scott River (March – May)
   b. Klamath River (March – June)
   c. Estuary (April – July)
VI. Ocean Rearing (approximately 14-18 months)

A library specialist, Adrienne Harling, was hired to research and compile existing studies on the needs of coho salmon by life stage. She summarized the results of these studies in a convenient format (see Appendix A). The sub-committee identified unpublished datasets on the coho population and habitat conditions, collected locally and in other relevant watersheds. This information was described and recorded in the limiting factor tables for each life stage (described below).

Identify Limiting Factors by Life Stage

One life stage at a time, the sub-committee reviewed the assembled information on a particular life stage, and then identified the factors that potentially cause stress and mortality for fish in that stage. Erich Yokel, a fisheries technician with several years of field experience in the Scott River watershed, was hired to assist with this process. The committee worked as a group to enter the information in spreadsheets that were displayed with a projector for the entire group to see (Appendix C). There were some potential limiting factors (such as "water temperature out of preferred range") that were broken down into sub-categories according to their cause ("insufficient shading", "tail water", "low surface flow", etc.) For each of these factors and sub-categories, the committee came to a consensus on the likelihood that the factor was limiting. It assigned each factor one of the following values: 1-definitely, 2-likely, 3-unlikely, 4-definitely not, 5-not enough information to decide. The committee also identified research needs for each factor, the causes/sources of the problem, and any general location information on its occurrence. Because the committee had less professional experience outside the Scott River watershed, it had to rely more on the literature to assess the life stages in the Klamath River and Pacific Ocean.

Identify Questions, Develop Hypotheses and Studies

Once the potential limited factors tables for each life stage were complete, the sub-committee revisited the tables to piece together a picture of the factors that are most limiting in the Scott River watershed, to identify the gaps in that picture, and to set a course to fill in those gaps. The committee assembled all the factors it had identified as "definitely" or "likely", and grouped the factors according to priority. A factor had the highest priority if it had a strong effect and harmed coho during more than one life stage. The committee also assembled all the factors with "not enough information to decide", and discussed which of these were the most likely and therefore had the highest priority for study.

For the high priority factors for study, the committee identified unanswered questions about the factor and developed hypotheses about how the factor may be operating. The committee gathered information and ideas for the types of studies needed to collect field data and test hypotheses. It is in the process of building this information into a Plan of Action for studies.

Design and Conduct Studies

Once the Plan of Action for studies is complete, the sub-committee will follow the plan, and design studies using as much academic advice as possible. The studies will test hypotheses about the behavior of Scott River coho and their relationships to habitats. The committee will then write proposals for funding, with the studies to be carried out by the Siskiyou RCD or some other entity.

In late 2003, the Sub-committee found that even though the Plan of Action was not yet complete, there was an opportunity to apply for funding to study the one strong segment of the Scott River coho population (fish that were spawned in 2001-2002 and would spawn in 2004-2005). Since that opportunity would not arise for another three years, the committee wrote and submitted three proposals to study questions it had identified. The proposals (approved by the SRWC) were to study spawning, the use of summer rearing habitat by juveniles, and the movement of juveniles in winter.

Integrate LFA with Strategic Action Plan

To make sure that the priority limiting factors and studies are reflected in the Scott River Strategic Action Plan (SAP), the Sub-committee identified which SAP actions correspond to each of its limiting factors and studies in the Plan of Action. It also did the same for the tasks in the State of California's Shasta Scott Coho Recovery Plan. As studies are designed and implemented, the information will be incorporated into the SAP through annual updates. These updates will be in the form of addendums related to the appropriate section..

2. RESULTS

Summarized below are the major factors the Sub-committee identified as limiting coho survival. The highest priority factors that affect many life stages are listed first, followed by the factors for each life stage. The committee was satisfied that some limiting factors had been scientifically documented in the Scott River. These limiting factors are listed first. Some other factors the committee identified using "professional judgment", but there have not been formal studies to verify their existence. These suspected limiting factors are listed in two categories of importance, and will be the foundation for future studies. Within the categories, the factors are not ranked by priority (ie. "a." is not more important than "b.").

2.1 Limiting Factors affecting all life stages:

A. **Altered channel structure.** The loss of flood plain and side-channels reduces the amount of available habitat (especially in winter). The loss of riparian corridor and increased width-to-depth ratio decreases habitat complexity and pool occurrence and affects the thermal regime of the stream. Large channel alterations (e.g. tailing piles, downcutting) have a hydrologic effect on large reaches of the river, affecting stream, riparian and groundwater function.

B. **Altered flow regime.** Decreased summer/fall flows reduce the volume of available habitat, increase the temperature regime of the stream, and prematurely disconnect stream reaches, leading to stranding of juveniles and delayed access to spawning grounds. Increased peak winter flows can decrease embryo survival (emergence rate) and displace rearing juveniles.

C. **Increased sediment load.** Increased sediment reduces habitat complexity through the filling of pools. High levels of sediment can accumulate in alluvial reaches (aggradation), creating areas were the stream goes subsurface, cutting connectivity and decreasing inter-gravel flows. Alteration of the natural mix of cobbles, gravel, and sand in the streambed (size distribution of substrate) can reduce spawning habitat, suffocate embryos, destroy redds through scouring and impede channel stability.

D. **Current population status of coho salmon in the Scott River.** Monitoring has shown that two of the three brood years for coho salmon in the Scott River are severely depressed. This increases the challenge of restoring the population. The small population also increases the possibility of loss of genetic diversity through in-breeding and/or hatchery influence.

2.2 Spawning and Incubation

A. Limiting Factors affecting spawning and incubation:
   a. Low flow barriers, fish passage barriers, and loss of connectivity can impede access to suitable spawning grounds.
   b. The current population structure (two of three brood years currently have a severely depressed population in the Scott River) impedes adult pairing and could generate loss of genetic diversity.
   c. High percentages of fine sediment and embedded substrate degrade and limit available spawning gravel.

B. Suspected limiting factors – high priority needs:
   a. The current depressed population of wild coho salmon in the Scott River could be easily influenced by straying hatchery fish
   b. Increased fine sediment may impede proper embryonic development and fry emergence.
   c. Changes in upslope hydrology and channel structure probably have altered the occurrence and intensity of high winter flows (freshets), increasing the occurrence of channel scour and redd destruction.
   d. Physical disturbance of redds could cause direct mortality.
   e. Diversion ditches could play a positive or negative role as potential spawning grounds.

C. Suspected limiting factors – low priority needs:
   a. Very low temperatures can impede embryo/alevin development.

2.3 Summer/Fall Rearing

A. Limiting Factors affecting summer/fall rearing:
   a. Low summer/fall flows reduce the amount of habitat.
   b. Disconnected streams lead to stranding and mortality of fish in areas of isolated habitat.
   c. Water temperature exceeds the coho's preferred range due to low flows, altered channel structure, and degraded riparian condition.
   d. Increased sediment reduces the volume and quality of habitat – e.g. filling of pools. Increased sediment aggrades alluvial reaches creating loss of connectivity and habitat. Increased fine sediment can impede inter-gravel flow.
   e. Historic channel alterations removed habitat and channel complexity.
   f. The volume and quality of cold-water refugia have been reduced.
   g. The alteration of stream channels, removal of riparian vegetation, and reduced large woody debris recruitment has impeded the formation of suitable rearing habitat.

B. Suspected limiting factors – high priority needs:

a. The current amount and condition of available habitat could increase the likelihood of predation, fish stress, and inter-specific and intra-specific competition. These factors control the condition and survival of the population.
b. Groundwater use may affect surface flow and temperature.
c. Areas of lost connectivity could impede movement to access existing suitable habitat.

2.4 Winter/Spring Rearing

A. Limiting Factors affecting winter/spring rearing:
   a. A lack of preferred in-stream and off-channel habitats deprives juveniles of refuge from periodic high winter flows.
   b. Water temperatures below the coho's preferred range (due to altered channel structure and degraded riparian vegetation) decrease their condition and ability to function.

B. Suspected limiting factors – high priority needs:
   a. Altered winter/spring flow regime may increase likelihood of displacement and mortality.
   b. Streams may lack areas of winter temperature refuge.
   c. Diversion ditches could play positive or negative role for winter rearing. Fish screens could be breached and strand fish.

C. Suspected limiting factors – low priority needs:
   a. Increased turbidity could cause direct mortality and decrease feeding opportunity.
   b. Decreased feeding opportunity because of lack of access to food and possible lack of food source.

2.5 Smolt Out-Migration in Scott River

A. Limiting Factors affecting smolt out-migration in Scott River:
   a. Juvenile coho prematurely out-migrate due to suspected limitations in rearing habitat.

B. Suspected limiting factors – high priority needs:
   a. There may be inadequate habitat to "hold" the out-migrating smolts in their journey down the Scott River.

C. Suspected limiting factors – low priority needs:
   a. The river condition may increase stress and vulnerability to disease in out-migrating smolts.
   b. Predation may be increased due to reduced refugia and cover in the Scott River.

3. BACKGROUND AND RESTORATION INFORMATION

This section describes in greater detail the issues of concern regarding habitat problems in each life stage. As we develop an *action plan* for addressing the issues we will work to verify whether or not the habitat problems exist in areas within the Scott River watershed using the information below as a guideline. Reference to the factors identified in Section 2 are made on the left border. Only the life stages where we have the ability to make improvements within the Scott River watershed are addressed. Studies to address the issue and examples of projects to reduce or remove the limiting factor are included. Each study and project example identified also indicates a reference to the *Shasta/Scott Recovery Team* recommendations (SSRT) and *Scott River Watershed Council Strategic Action Plan's* action number (SAP) using a table format.

3.1 Spawning and Incubation

(**2.1 c**) A. **Increased sediment degrades quantity and quality of spawning gravels**:

(**2.2 Ac**) a. Area of suitable spawning habitat is limited by fine sediment:

Adult coho choose areas of appropriately sized gravel, suitable water velocity and inter-gravel flow for spawning. Large amounts of fine sediment can fill the spaces around (embed) coarser gravels, reducing inter-gravel flow and a fish's ability to produce a desirable redd. Highly embedded bedloads could decrease the amount of available spawning habitat and indicate areas with lower fry emergence (see below).

Factors affecting issue:

- The composition of a stream channel's bedload is the result of stream processes (influenced by flow, gradient, sediment delivery, sediment load, and geomorphology).
- Low gradient alluvial streams are often "depositional" areas that collect sediment delivered from higher energy channels. Increased sediment delivery will generally increase the volume of bedload in alluvial streams.
- An increase in the source and delivery of fine sediments can increase the percentage of fines in the bedload.

Studies to address issue:	***SSRT***	***SAP***
A sediment budget would show areas that are likely to accumulate large percentages of fine sediment. The sediment budget would also demonstrate the "sources" of this accumulation.	SSRT Scott HM-4b, Scott HM-4c, MA-1a	F-2-A.a
A geomorphology survey, sediment survey, and upslope sediment source survey would survey individual components controlling stream function. These would all	SSRT Scott HM-2a	F-2-F.a

be components of the sediment budget.		
A survey for suitable spawning habitat would determine locations and areas of usable spawning habitat.	SSRT Scott HM-4a, MA-1c, MA-2b	Monitoring Plan - Fish Habitat, F-1-A.a, W-2-B.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Identification and reduction of sediment sources (e.g. road upgrading and decommissioning) will reduce the volume of sediment delivered to the stream system. Restoration of hydrologic processes to return alluvial streams to dynamic equilibrium will create a natural distribution of sediment.	SSRT Scott HM-4b, Scott HM-4c	F-2-F.c, F-2-F.b, L-2-A.a, W-2-B.b, W-2-B.c, W-2-B.d

(**2.2 B.b., 2.2 B.c.**)

b. Incubation habitat is potentially degraded during periods of high winter flow:

Adult coho choose areas of appropriately sized gravel, suitable water velocity and inter-gravel flow for spawning. Redd formation aids in the removal of fine sediments, further increasing the inter-gravel flow and the essential delivery of dissolved oxygen to the developing embryos and alevin. The alluvial stream channels that are characteristically used for spawning are areas of sediment transport and deposition. The period of coho incubation (January – March/April) coincides with some of the seasonal high flows for the Scott River. Winter freshets can degrade established redds by delivering sediment that infiltrates the redd's interstitial space. This increased sedimentation would impede inter-gravel flow and could physically block fry emergence. Additionally, high water velocities can scour the substrate of the redd destroying the incubation habitat.

Factors affecting issue:

- An increase in fine bed load sediment, stream bank erosion, and upslope sediment delivery would increase the amount of sediment that could be deposited on the redd.
- Altered fluvial processes and hydrologic regime (increased winter peak flows) could increase the deposition of sediment and/or increase the scouring of sediment.
- Areas of stream channel alteration (e.g. tailing piles, artificially sorted gravels) could have increased rates of bed load movement and redd scour.

Studies to address issue:	***SSRT***	***SAP***
A biological study to determine fry emergence (redd cap) would show emergence success at different locations.	MA-2a	F-1-A.a
Studies to assess the current bed load composition would	Scott HM-4b	F-2-A.a

indicate areas that have desirable and undesirable amounts of fine sediment.		
A geomorphology survey would indicate the processes that are shaping the bed load and hydraulic regime, potentially indicating areas that restoration would return to dynamic equilibrium.	Scott HM-2a	F-2-F.a
A study of the rate of scour in areas perceived to be susceptible to scour (tailing piles, etc.) would show where this is a problem.	Scott HM-4b	F-2-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Restore stream channels, including floodplain connectivity and stream sinuousity, to slow winter stream flows, settle out fine sediment, and reduce scour.	WM-10b, WM-11b, HM-2a, HM-4c, MA-1d	F-2-F.a, W-1-A.d, W-2-A.a, F-1-B.a, F-2-A.a, W-2-B.c, W-1-B.d, W-2-B.d

(**2.1 B**) B. **Impaired water quality and quantity adversely affects access to spawning grounds and the development and survival of embryos and alevins**:

(**2.2 A.a.**) a. Low flow barriers can impede the migration of adult fish to the desired spawning grounds:

During periods of drought and in years of late fall precipitation, barriers to adult coho migration in the main stem Scott River and tributaries can persist past the time that adults enter the river. These migration barriers cause fish to be held longer in warm water, increasing the possibility of a disease outbreak and decreasing the viability of the eggs. Additionally, man made barriers can potentially impede adult migration at all flow levels.

Factors affecting issue:

- In periods of drought and/or late fall precipitation the low flow regime can persist into late November/ early December – potentially generating low flow barriers to migrating adult coho that have already entered the Scott River. This flow/passage problem is exacerbated by: alteration of hydrologic regime, aggradation of tributaries, and reduced groundwater storage.
- Road crossings (culverts) also can prevent fish passage.

Studies to address issue:	***SSRT***	***SAP***
Identify man made barriers to fish passage and prioritize for replacement.	HM-3b	F-2-B.a
Determine timing of adult coho movement throughout the system. Document areas that present passage problems.	HM-3a	F-1-A.a, F-1-A.b, F-2-B.a,

Determine barriers that have been formed by impaired hydrologic processes.		F-2-B.c, W-2-A.b
Perform stream cross-section measurements at locations believed to impede adult migration – use measurements to determine minimum flow to allow passage.	WM-9	F-2-B.c
Develop water balance – determine affects of water use on flow regime during period of adult migration. Determine affect of added water on instream flows.	WM-11a	Monitoring Plan – Flow, W-1-A.d, W-1-B.f

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Determine and implement practices to increase instream flows during period of adult migration.	WM-11a	W-1-B.a, W-1-B.b
Utilize Scott River Water Trust to add water to instream flows at critical periods to allow adult migration.	WA-1a, WA-1d, WA-7a	W-1-B.f
A long-term restoration of watershed processes and stream geomorphology could remove barriers formed by altered hydrology.	Scott HM-2a	F-2-F.a

(**2.2 C.a**) b. Abnormally low winter temperatures can slow embryo and alevin development and facilitate formation of anchor ice:

Colder water temperatures slow the development of the embryo and alevin, thus altering the timing of fry emergence. Embryos and alevin are capable of surviving temperatures approaching freezing, but anchor ice can prove lethal due to its ability to block inter-gravel flow and dissolved oxygen delivery to the redd.

Factors affecting issue:

- Lack of thermal cover (riparian vegetation), alteration of hydrologic regime (reduced local flows), impaired inter-gravel flow, and reduced groundwater inflow can alter the stream's mechanism of thermal buffering.

Studies to address issue:	***SSRT***	***SAP***
Determine winter water temperature regime in known areas of adult spawning and correlate with factors affecting thermal buffering.	MA-1d	Monitoring Plan – Temperature, F-2-A.a
Continue to monitor presence of anchor ice throughout Scott watershed (landowners and survey crews).	MA-1c	F-2-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Restore riparian corridors in identified essential reaches	HM-1-1c, HM-	F-2-D.a, F-2-

with impaired cover.	1-1d	E.a, F-2-D.b

(**2.1 D**, **2.2 A.b,** **2.2 B.a**)

C. **Current population structure impedes adult pairing and could generate loss of genetic diversity**:

Historical events in the Scott River Watershed have led to extremely depressed adult coho populations in 2 out of the 3 coho brood years. In these years with low adult runs (escapement), adult spawners spaced widely across the watershed could fail to find a mate. A breeding population that is depressed below a certain level will exhibit genetic problems.

Factors affecting issue:

- The depressed population could lose genetic diversity and specific environmental adaptations via inbreeding.
- Straying hatchery fish (mainly from Iron Gate Hatchery and Trinity River Hatchery) could have a genetic effect on these depressed populations.
- The coho's relatively strict compliance with a three-year life cycle impedes its ability to repopulate the depressed brood years.

Studies to address issue:	***SSRT***	***SAP***
Assess the spatial distribution of adult spawners through the continuation of adult spawning surveys and compilation of distribution data.	HM-4a, MA-2b	Monitoring Plan – Fish Population, F.1.A.a
Determine the proportion of wild and hatchery-origin adults in the Scott spawning run.	MA-2c	Monitoring Plan – Fish Population, F.1.A.a
Determine the genetic structure of the Scott coho population – e.g. analyze already-collected genetic samples.	MA-2f	F.1.C.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Protect existing population.	P-1,P-2, P-3, P-4, P-5, P-6, P-7	F-1-E.a, F-1-E.b, F-1-E.c, F-1-E.d, F-1-F.a, W-1-B.f, W-2-A.a, F-1-B.b, F-1-F.c, F-1-F.d

(**2.2 b.d.**)

D. **Physical disturbance of redds and the surrounding channel causes direct mortality**:

Coho embryos and alevins are susceptible to vibrations and compression. Physical disturbance of stream channels used for spawning could directly cause mortality during incubation.

Factors affecting issue:

- Any activity within the stream channel creating compression of the substrate and vibrations could adversely affect survival of incubating coho.
- Some alevins in colder tributaries persist in redds later than is widely perceived, (probably until as late as May), increasing the period that stream channel disturbance could affect alevins.

Studies to address issue:	***SSRT***	***SAP***
Determine the timing of fry emergence using two methods: 1) calculation of emergence timing using spawning and water temperature data and 2) direct observation of emerged fry.	MA-2b, P-5	Monitoring Plan – Fish Population, F.1.A.a
Inventory areas with in-channel activity during the time of coho incubation and develop alternatives that would reduce physical disturbance.	P-5	

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Educate the public on the effects of disturbance on incubating coho and timing of incubation.	EO2	O-1-A.b
Reduce all in channel activity during coho incubation (e.g. exclusion fencing).	P-5	

3.2 Summer/Fall Rearing of Coho Salmon

(**2.1 A**, **2.1 B**, **2.1 C**)

A. **Poor water quantity and quality reduces available habitat, degrading the physical condition of rearing coho and causing mortality**:

(**2.3 A.a, 2.3 A.b, 2.3 A.f, 2.3 B.b, 2.3 B.c**)

a. Reduced summer low flows degrade and decrease habitat:

Lowered stream flows reduce the volume and quality of available habitat, cause loss of connectivity between potential habitats, create mortality from stranding, and exacerbate water quality issues.

Factors affecting issue:

- Diversions
- Ground water pumping

- Channel alteration and aggradation
- Loss of pool volume by sedimentation.

Studies to address issue:	***SSRT***	***SAP***
Develop a water balance that includes a valid understanding of ground water connectivity to the Scott River.	WM-11a	Monitoring Plan – Flow, W-1-A.d, W-1-B.f
Perform a flow/habitat model (e.g. Instream Flow Incremental Methodology – IFIM) to identify critical flow levels to maintain Coho habitat.	WM-9	Monitoring Plan – Fish Habitat, F-2-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Study feasibility of utilizing small impoundments for groundwater recharge and storage.	WA-2b, WA-3a, WA-3b, WA-4c, WA-5	W-1-B.a, W-1-A.c
Pursue willing participants for conservation easement of diversion water.	WA-1a, WA-7a	W-1-B.f

(**2.3 A.c, 2.3 A.f, 2.3 B.a, 2.3 B.b**)

b. Water temperature outside the coho's preferred range limits their ability to utilize habitat and decreases their physical condition:

Coho salmon prefer a cold water temperature regime for rearing. Higher water temperature speeds up the fish's metabolism, increasing stress and susceptibility to disease and decreasing growth. Extremely warm water temperatures are lethal to coho.

Factors affecting issue:

- A series of factors can operate together to increase stream temperatures in streams and/or stream reaches, including: an in increased width/depth ratio of channels, loss of channel complexity (occurrence of pools), loss of riparian shading, decreased flow volume and velocity, loss of ground water connectivity, and decreased inter-gravel flow

Studies to address issue:	***SSRT***	***SAP***
Perform aerial photo analysis, combined with ground-truthing, to identify locations of channel degradation and poor riparian shading.	P-2, MA-1b	F-2-D.a, F-2-D.b, W-2-A.a
Perform geomorphology study to identify areas of channel degradation.	Scott HM-2a	F-2-F.a, W-2-A.a
Identify areas of thermal refuge via a basin-wide temperature monitoring protocol (e.g. Forward Looking Infra-Red – FLIR).	Scott HM-1-1a, Scott HM-1-2b	F-2-G.a, W-2-A.a, W-2-A.c
Develop a model that correlates temperature regimes with	HM-1-2d	Monitoring –

flow throughout basin.		Temperature, W-2-A.a, W-2-A.b

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Implement riparian planting and fencing to increase stream shade.	P2, Scott – HM-1-1c, Scott – HM-1-1d	F-1-B.b, F-2-E.a, W-2-A.a, L-3-B.b
Pursue feasibility of stream alteration to restore historic character to channel.	Scott HM-2a	F-2-F.b, W-2-A.a
Perform enhancements to increase volume and carrying capacity of thermal refugia.	HM-1-1b	F-2-G.b

(**2.1 C**, **2.3 A.d, 2.3 A.f, 2.3 B.c**)

B. **Increased sediment load reduces volume and quality of available habitat**:

Increased loads of sediment directly reduce the volume and number of pools (rearing habitat). Increased sediment can inhibit benthic production and exacerbate water quality and quantity issues by increasing sub-surface flow and/or decreasing inter-gravel flow.

Factors affecting issue:

- Increased sediment delivery can come from anthropogenic sources and/or alteration of sediment transport and storage in the river channel

Studies to address issue:	***SSRT***	***SAP***
Compile existing information on sediment sources (e.g. road inventories).	MA-1a, Scott HM-4c	F-1-B.a, L-2-A.a
Develop a sediment budget for the anadromous watersheds of the Scott River.	Scott HM-4b, Scott HM-4c, MA-1a	Monitoring – Sediment, F-2-A.a
Coordinate with USFS to develop Cumulative Watershed Effects (CWE) for anadromous watersheds of the Scott River.	MA-1c	F-1-B.a, F-2-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Pursue feasibility of coordinated effort to reduce sediment sources in a key watershed (e.g. French Creek Watershed Assessment Group).		L-2-A.a, W-2-B.c
Pursue habitat restoration techniques that can aid in “sorting’ the bed load in essential reaches.	Scott HM-1-1b	F-2-F.b

(**2.1 A, 2.3 A.e, 2.3 A.g**)

C. **Historic channel alterations have reduced rearing habitat**:

Management activities in the Scott River watershed (e.g. beaver removal, mining, loss of floodplain, and bank armoring) have removed many of the natural features of an alluvial river system that create coho habitat. These features include river meanders, side channels, and beaver ponds. Areas of complex historic rearing habitat have been degraded or extirpated through a series of channel alterations. The present form of many valley streams is an armored single channel.

Factors affecting issue:

- Flood control
- Erosion control
- Beaver removal
- Mining

Studies to address issue:	***SSRT***	***SAP***
Identify areas where historic habitat complexity exists and where complexity can be restored without serious loss of economic benefit.	Scott HM-1-1b, Scott HM-2b, Scott HM-2c	F-2-F.c, F-2-C.a, F-2-C.b, F-2-F.b
Perform a geomorphology study to the determine current "state" of the Scott River and the processes that control stream morphology.	Scott HM-2a	F-2-F.a, W-2-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Pursue a plan to integrate upslope and in-channel restoration, in order to restore the functions of a healthy watershed and a more natural geomorphology.	HM-2a	F-2-F.a, F-2-F.c, F-2-C.a, F-2-F.b, L-2-A.a, W-2-B.c

(**2.3 B.a**) D. **Lack of suitable habitat for summer/fall rearing inhibits growth and survival**:

The volume of suitable summer habitat is a potential bottleneck for Scott River coho production. Coho demonstrate a high preference for pools with large amounts of cover for summer rearing. Water quality and food availability controls the growth rate of coho. This preferred habitat has been greatly reduced through the cumulative effect of the above-mentioned factors.

Factors affecting issue:

- Alteration of channel and riparian corridor
- Lack of large woody debris
- Poor water quality and quantity
- Aggradation and pool filling by excessive bed load

Studies to address issue:	***SSRT***	***SAP***
Continue the existing habitat typing program to assess essential watersheds that have not been characterized – tributaries of the East Fork Scott, South Fork Scott, Johnson Cr., Crystal Cr., Big Slough, Kidder Cr., Kidder Slough, Tompkins Cr., and Moffett Cr.	MA-1c	Monitoring - Fish Habitat, F-1-A.a, F-1-B.a
Determine current summer rearing carrying capacity for coho salmon in the Scott River.	MA-2a, MA-1j	Monitoring – Fish Population, F.1.A.b
Study summer/fall habitat utilization by coho. Determine fully occupied and under-utilized areas.	Ma-2c, MA-1j	Monitoring – Fish Population, F-1-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Increase water quantity and quality in areas that contain good physical habitat.	WA-1a, WA-1d, WA-7a	W-1-B.f
Remove barriers and increase flow to improve access to suitable habitat.	Scott HM-1-2a,WA-1a, WA-1d, WA-7a	W-1-B.f, W2-A.b, F-2-B.c, F-2-F.a
Perform instream and riparian restoration to increase the frequency and quality of ideal habitat.	Scott HM-1-1a, b, c, d, &e	F-2-E.a, F-2-F.a, F-2-F.c, F-2-C.b, F-2-D.b, F-2-F.b, F-2-G.b, F-1-B.b

(2.3 A.e) E. **Alteration of the stream channel, riparian corridor, and coarse wood recruitment impedes the formation of suitable habitat**:

The hydrologic processes that control the formation of suitable salmon rearing habitat are driven by the overall state of the watershed. Alterations in the landscape of the watershed can greatly alter these processes, leading to a lack of habitat formation.

Factors affecting issue:

- Upslope impacts such as road-building and vegetation change have altered the delivery of sediment and large wood to streams, and the flow regime of the watershed.
- Channel alteration and riparian clearing have altered the channel profile in the low gradient portions of the watershed.

- Lack of wood recruitment, increased sediment delivery, and channel degradation decrease the potential for future pool formation.

Studies to address issue:	***SSRT***	***SAP***
A sediment budget, geomorphology survey, determination of cumulative watershed effects, determination of large woody debris recruitment, and riparian surveys would all be applicable.	MA-1c	F-1-B.a, F-2-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Any restoration program that would restore the processes of the watershed (e.g. reduction of sediment delivery through upslope road restoration).	Scott HM-1-1a, b, c, d, &e	F-2-E.a, F-2-F.a, F-2-F.c, F-2-C.b, F-2-D.b, F-2-F.b, F-2-G.b, F-1-B.b

3.3 Winter/Spring Rearing of Coho Salmon

(**2.1 A, 2.4 A.a, 2.4 B.b**)

A. **The loss of in-stream and off-channel habitats deprive coho juveniles of refuge from periodic high winter flows that can displace, injure or destroy them**:

Coho require particular types of winter habitat (backwaters, dammed pools, alcoves, floodplains and other low velocity off habitats) that offer cover and refuge from high velocity stream flows. These types of habitat are believed to be in short supply because of a legacy of stream alteration, loss of flood plain connectivity, and decrease of instream cover. Lack of sufficient winter habitat can cause density dependent mortality (e.g. due to insufficient food and cover for the number of juveniles present) as well as density independent mortality (e.g. from increased winter peak flows and decreased water temperatures).

Factors affecting issue:

- Channel alteration prevents streams from overflowing onto the flood plain (loss of floodplain connectivity) in many of the alluvial reaches of the Scott watershed.
- A decrease in the frequency and quality of in-stream cover reduces the volume of low velocity refuges.
- Simplified stream channels (e.g. straightened, armored streams without side channels or woody debris) provide little winter rearing habitat.

Studies to address issue:	*SSRT*	*SAP*
An initial study to assess the locations and amounts of available winter habitat is necessary. An integrated approach of aerial photo analysis (to identify areas offering potential winter habitat, e.g. side channels) combined with ground verification could locate reaches within the watershed offering potential winter habitat.	HM-1-1a, MA-1c	F-1-A.a, F-1-B.a, F-2-D.a
Qualitative habitat typing during winter could be used to estimate carrying capacity for winter rearing in a system – a protocol that would identify winter habitat at different flow levels would need to be developed.	HM-1-1a, MA-1c, WM-9	Monitoring Plan - Fish Habitat, F-1-A.a, F-1-B.a, F-2-A.a
An assessment of the coho population before and after winter could be used to estimate survival through this life stage.	MA-2a, MA-2c	F-1-A.a, F-1-A.b
Study the utilization of individual habitat types by coho over winter. Identify habitats with the greatest carrying capacity. Study the utilization of main channels and tributaries.	MA-2a, MA-2c, MA-1j	Monitoring Plan – Fish Population, F-1-A.a, F-1-A.b
Investigate areas that offer refuge (cover and low velocities) during extreme high flows.	MA-1c, MA-1d, MA-1f	F-2-A.a
Develop methods to protect and enhance identified winter rearing habitats. Investigate the possibility of using conservation easements to protect critical areas of winter rearing habitat.	Scott HM–1-1b, Scott HM-1-1d, HM-2b, P-2	F-2-C.a

Examples of projects to reduce or remove limiting factor:	*SSRT*	*SAP*
Introduce coarse woody debris to the system to increase cover and velocity refuge.	Scott HM-1-1b	F-1-B.b
Perform stream restoration that would increase the volume of suitable winter rearing habitat – e.g. dammed pools and artificial off channel habitats.	Scott HM-1-1e, Scott HM-2b, Scott HM-2c, P-2	F-2-C.a, F-2-C.b, F-1-B.b
Pursue projects to enhance and protect existing off-channel habitats and introduce man-made off-channel habitats.	Scott HM-1-1e, Scott HM-2b, Scott HM-2c, P-2	F-2-C.a, F-2-C.b, F-1-B.b

(**2.1 B, 2.4 B.a., 2.4 C.a**)

B. **Increased peak winter flows**:

Increased upslope hydrologic connectivity and lack of flood plain connectivity can alter the timing and magnitude of peak winter flows. These increased peak flows can overwhelm the velocity refuges used for winter rearing, leading to displacement and density independent mortality. Increased peak flows could also lead to abnormally high levels of turbidity, potentially affecting fish behavior and growth.

Factors affecting issue:

- Altered upslope processes (e.g. decrease in infiltration rate and increase in hydrological connectivity) can alter the timing and magnitude of flow delivery to the stream channel.
- Stream simplification (loss of meander, loss of natural impoundments, and stream bank armoring) and loss of flood plain connectivity confine flows into one channel, increasing water velocities and decreasing surface water's infiltration into ground water.

Studies to address issue:	***SSRT***	***SAP***
Cumulative watershed effects (CWE) can be used to identify watersheds with a high and low possibility of altered peak flows.	MA-1c, MA-1d	F-1-B.a, F-2-A.a
A continuation of tributary flow monitoring into the winter would identify magnitude and duration of peak flows.	MA-1d	Monitoring Plan – Stream Flow, F-1-B.a, F-2-A.a
Measurement of velocities in utilized winter habitats during peak flows would determine habitat features that help maintain velocity refuge during peak flows.	MA-1c	F-2-A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Restore upland processes to decrease occurrence and magnitude of peak winter flows.		L-2-A.a, W-2-B.c
Restore flood plain connectivity and channel geomorphology to dissipate peak flows.	Scott HM-2a, Scott HM-2b, Scott HM-2c	F-2-C.a, F-2-C.b, F-2-F.b, F-1-B.b
Implement habitat restoration that would produce suitable refuge from peak flows.	Scott HM-1-1e, Scott HM-2b, Scott HM-2c, P-2	F-2-C.a, F-2-C.b, F-1-B.b

(**2.4 A.b, 2.4 B.b, 2.4 C.b**)

C. **Low water temperatures increase mortality, and streams lack winter habitats offering temperature refuge**:

Very low water temperatures decrease a fish's swimming ability, feeding opportunity and ability to maintain position in preferred habitat. Low winter temperatures could reduce the condition of fish and increase mortality. Off channel habitats with groundwater influx can maintain water temperatures higher than adjacent in channel habitats – offering fish an opportunity for feeding and growth.

Factors affecting issue:

- Winter temperature regime is altered by the loss of riparian vegetation and increased stream surface area (increased width-to-depth ratio). These alterations increase the exposure of the stream to cold ambient temperatures.
- The loss of off channel habitats due to stream modification precludes the availability of this potential winter thermal refuge.
- Groundwater depletion could reduce winter groundwater inflows to springs and streams.

Studies to address issue:	***SSRT***	***SAP***
Continue and broaden temperature monitoring over winter months in tributaries believed to be essential for winter rearing.	MA-1d	Monitoring – Temperature, F.2.A.a
Utilize groundwater study to predict areas of warmer stream temperature due to groundwater influence.	WM-10b	W-1-A.d
Determine actual over winter temperatures within known winter rearing habitats. Determine if off-channel habitats offer a milder temperature regime than in-channel habitat.	MA-1d	Monitoring – Temperature, F.2.A.a & F-2-G.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Restore, enhance, and protect the riparian corridor and channel structure in order to restore the process of energy exchange between the stream and air.	Scott HM-1-1c, Scott HM-2a, Scott HM-2b, Scott HM-2c	F-2-F.a, F-2-F.b, F-2-G.b, F-2-D.b, F-1-B.b
Restore, enhance, and protect winter habitats offering warmer winter temperature regimes, particularly off-channel habitats that would provide thermal refuge.	Scott HM-1-1b, Scott HM-1-1e	F-2-C.a, F-2-C.b

3.4 Out-Migration in Scott River

(2.5.A.a) A. **Coho salmon prematurely out-migrate during their first spring, rather than as yearlings the following spring**.

It has been observed that in the years of large adult escapements and a large brood of juvenile coho, some juvenile coho out-migrate before the desired year of freshwater rearing in the Scott River. The fate of these displaced juvenile coho in the main-stem Scott River and Klamath River is largely unknown.

Factors affecting issue:

- Inadequate rearing habitat in the Scott River may force premature emigration due to lack of sufficient carrying capacity.
- Main-stem habitats become limited during periods of poor water quantity and quality.

Studies to address issue:	***SSRT***	***SAP***
Identify the location, condition, and volume of suitable rearing habitats in main-stem Scott River.	MA-1c	Monitoring – Fish Habitat, F-1-A.a, F-1-B.a
Identify the habitats utilized and determine the carrying capacity of habitats in the main-stem Scott River for juvenile coho salmon.	MA-2a, MA-1j	Monitoring Plan – Fish Population, F.1.A.b
Document the causes of premature out-migration.		

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Protect, enhance, and restore available habitats in the main-stem Scott River.	Scott HM-1-1a, b, c, d, &e	F-2-E.a, F-2-F.a, F-2-F.c, F-2-C.b, F-2-D.b, F-2-F.b, F-2-G.b, F-1-B.b

(2.5.B.a) B. **Inadequate habitat to hold out-migrating smolts in the mainstem Scott River increases mortality**.

Coho salmon undergo smoltification after a year of rearing in freshwater habitats. Yearling coho smolts out-migrate in spring and early summer, heading to the estuary and ocean to enter their salt-water life phase. These migrating smolts require suitable habitat conditions to survive their passage through the main-stem Scott River. Late migrating smolts could encounter water quality and quantity conditions that limit available habitat in the main-stem Scott River.

Factors affecting issue:

- Reduction in the occurrence of woody cover, pools, and cold water refuges in the mainstem Scott River

- Poor water quality and quantity reduces the volume of available habitats

Studies to address issue:	***SSRT***	***SAP***
Determine timing and habitat needs of out-migrating coho smolts in the Scott River.	MA-2a, MA-1j	Monitoring – Fish Population, F.1.A.b
Determine the location, condition, and volume of habitats required by out-migrating smolts.	MA-1c	Monitoring – Fish Habitat, F-1-A.a, F-1-B.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Protect, enhance, and restore available habitats in main-stem Scott River.	Scott HM-1-1a, b, c, d, &e	F-2-E.a, F-2-F.a, F-2-F.c, F-2-C.b, F-2-D.b, F-2-F.b, F-2-G.b, F-1-B.b

(2.5.C.a & 2.5.C.b)

C. **Reduced habitat quantity and quality in the main-stem Scott River could increase stress, disease, and predation of out-migrating smolts**:

Inadequate volumes of suitable habitat can directly increase the probability of predation and the occurrence of stress and disease. Smolts leaving the Scott River in a weakened condition would be more susceptible to mortality in the Klamath River.

Factors affecting issue:

- Inadequate habitat and water quality increases the crowding of fish leading to stress and disease.
- Lack of cover and increased fish density increases predation.
- Increased occurrence of predators.

Studies to address issue:	***SSRT***	***SAP***
Monitor fish pathology throughout the summer to determine if disease occurs in Scott River salmon.	MA-2a	F-1-A.a, F-1.A.b
Determine the condition of coho salmon before and after migration through the main-stem Scott River.	MA-2d	F-1-A.a ,F-1.A.b

Determine the rate of predation and predator populations in the mainstem Scott River.	MA-2a	F-1.A.a

Examples of projects to reduce or remove limiting factor:	***SSRT***	***SAP***
Protect, enhance, and restore available habitats in the main-stem Scott River – especially elements used for cover and habitat partitioning.	Scott HM-1-1a, b, c, d, &e	F-2-E.a, F-2-F.a, F-2-F.c, F-2-C.b, F-2-D.b, F-2-F.b, F-2-G.b, F-1-B.b

4. CONCLUSION

The goals of the first iteration of the Limiting Factors Analysis (LFA) process were to identify limiting factors that are known through various literature and local knowledge of the Scott River Watershed. Because we are uncertain about the relationship and relevance of external watersheds (as depicted in various literature) to the Scott River we are pursuing investigative assessments that should result in a thorough comparison of their existence in the watershed. This process will help to identify essential data gaps in our knowledge of factors that could limit coho production. The development of the LFA Tables by Life Stage (Appendix C) through a committee process brought all available information together in an organized format. The process of completing the tables and analysis of the results allowed us to identify many data gaps and suspected limiting factors. The prioritization of limiting factors largely determined the development and importance of studies and restoration efforts to be performed. The implementation of these studies is essential to gather missing information to better define the limiting factors that control aquatic production. The restoration approach would be based on the knowledge of watershed processes and use of resources in order to maintain a sustainable community. The SRWC will direct the restoration approach through input and participation by various stakeholders and representatives from numerous watershed interests.

Through the process of analyzing all potential limiting factors to the production of coho salmon in the Scott River Watershed, the committee identified four limiting factors that affect all life stages of coho salmon and several limiting factors that affect individual life stages (Chapter 2). Efforts toward habitat improvement and fish protection should be designed to remove or ameliorate limiting factors that control fish production. Many of the major limiting factors identified are already a high priority in the Scott River Watershed with extensive efforts in progress to further understand and remove the conditions creating the limiting factor. A concerted effort to remove these limiting factors is the committee's desire. To this end, the Scott River Watershed Council (SRWC) intents to develop a Plan of Action to outline a time-line for essential studies and actions to address the four major limiting factors. An organized community-based approach to the removal of the actual limiting factors controlling aquatic production is the only way to generate an increase in population.

Several gaps in our knowledge of habitat requirements, fish distribution, carrying capacity, and the current population of several life stages were identified. A quantitative assessment of the available carrying capacity in the Scott River Watershed through all life stages improves the power of this LFA to narrow down the factors we have identified to a single most important limiting factor. A continuation of habitat utilization studies in all life stages would further identify seasonal habitat needs in the Scott River Watershed. The LFA outlines numerous studies that have been developed to address these essential data gaps. These proposed studies are referenced to tasks of the SRWC Strategic Action Plan and Shasta-Scott Recovery Team, demonstrating their importance in the concerted recovery of Scott River coho. The execution of these studies is the next step to refine the information used for the next iteration of the LFA.

In addition to fisheries studies, many studies have been proposed that analyze the factors and conditions that control in-stream habitat quality and quantity. An understanding of the watershed processes that control the condition and formation of suitable aquatic habitat in the Scott River Watershed will identify the sources of many limiting factors. A holistic community approach to watershed management pursues restoration and protection throughout the watershed (from confluence to ridge) in order to restore a stream to its properly functioning state. Process restoration allows for the removal of limiting factors at their source and should lead to long term habitat production and maintenance of a healthy watershed.

The pursuit of ideal long-term solutions must be accompanied by immediate actions to protect the existing depressed population of coho salmon in the Scott River Watershed. Immediate restorations, enhancements, and protections are essential to maintain the existing population while long-term restoration efforts are underway. The Plan of Action will emphasize this simultaneous execution of short term and long-term goals.

On March 10, 2005 the SRWC attended a presentation of the information compiled by the sub-committee and most received a copy of the draft LFA prior to this presentation. Private landowners, agency representatives, environmental interests and representatives from the Farm Bureau were in attendance for the presentation and discussion. The SRWC agreed to accept this draft version for a broader review by peers. Two separate attempts were made to distribute the document for review with no response. Therefore, in April 2006, the SRWC adopted the initial phase of the LFA so further work can be developed. The sub-committee will begin work on a Plan of Action for describing the next steps for necessary assessments and studies. Each study will be presented to the SRWC prior to implementation.

APPENDICES:

A. Literature Reviews

Adult Migration Life Stage

Migration Timing and Conditions

- Arrive at rivers of origin in November/December for spawning migration (Sandercock 1991)
- Duration of spawning migration is three months or more (Sandercock 1991)
- Migrate during daylight hours (Sandercock 1991)
- In the Klamath River, coho run between September and late December, peaking in October – November (Moyle 2002)

Flow

- Coho begin upstream migration when there is a large increase in flow (Sandercock 1991, Moyle 2002)
- Migration does not occur during peak floods (Sandercock 1991, Moyle 2002)
- If temperature or flow conditions in the stream are unsuitable, fish will often mill about in the vicinity of the stream mouth and wait weeks or months for conditions to change (Sandercock 1991)

Temperature

- Coho normally migrate when water temperature is in the range of 7.2-15.6C, the minimum depth is 18 cm, and the water velocity does not exceed 2.44 m/s (Sandercock 1991)
- Coho rarely migrate more than 240 km up large rivers to spawn (but there are exceptions) (Sandercock 1991)
- Thermally stratified cold pools provide refugia holding habitat for salmon (Nielsen 1991)

Turbidity / Dissolved O2

- Maximum sustained swimming speeds of juvenile and adult coho salmon at temperatures of 10-20C were reduced when DO dropped below air saturation levels, and performance declined sharply when DO fell to 6.5-7 mg/L at all temperatures tested (Bjornn and Reiser 1991)
- Migrating salmonids avoid waters with high silt loads, or cease migration when such loads are unavoidable (Bjornn and Reiser 1991)

Age at Maturity

- Most coho mature at three years old (age 1.1), but there are exceptions (ages 1.0 and 2.1 are the most common exceptions) (Sandercock 1991)

- Due to fairly strict 3 year life cycle, runs are generally isolated both temporally and spatially (Moyle 2002)

Adult Use of Klamath River Mainstem

- Adults typically start to enter the river for spawning in late September. They reach peak migration strength between late October and the middle of November. A few fish enter the river through the middle of December. (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003, Shaw, Jackson, Nehler and Marshall 1997)

  The presence of small numbers of adult coho in the fish kill of September 2002, indicates that some coho begin migration without the usual stimuli of water temperatures under 16°C and increased flows due to rainfall. (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003)

September 2002 Fish Kill

- An estimated of 0.5% to 1% of the fish carcasses from the 2002 fish kill were identified as coho salmon (Department of Fish and Game – Northern California – North Coast Region 2003)
- The fish die-off in the lower Klamath River in 2002 was a result of a combination of factors that began with an early peak in the return of a large run of fall Chinook salmon. Low river discharges apparently did not provide suitable attraction flows for migrating adult salmon, resulting in large numbers of fish congregating in the warm waters of the lower River. The high density of fish, low discharges, warm water temperatures, and possible extended residence time of salmon created optimal conditions for parasite proliferation and precipitated an epizootic of Ich and columnaris, which resulted in the death of an estimated 34,056 fish (primarily chinook). (Department of Fish and Game – Northern California – North Coast Region 2003, Guillen 2003)

Fishing Regulations

- The Yurok and Karuk Tribes do not have a commercial fishery for coho, but have an open subsistence coho fishery. A voluntary no take policy is often implemented. (Toz Soto, Karuk Tribal Fisheries Biologist, personal communication)
- Sport fishing for coho is completely closed. (Alex Corum, Karuk Tribe, Personal Communication)

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Spawning and Incubation Life Stages

Spawning timing

- Spawning season: generally between November and January, but in N. America, coho spawn over an extended period from October to March (Sandercock 1991)
- Early run fish may spawn early, but also may hold for weeks/months before spawning (Sandercock 1991)
- Late-run fish tend to spawn soon after arrival on the grounds or following a short holding period (Sandercock 1991)
- Spawning takes about a week to complete, during which time each female lays 1400 to 3000 eggs (Moyle 2002)

General spawning habitat characteristics

- Coho select small streams where the flow is 5.0-6.8 cubic meters per minute and the stream width does not exceed 1 m (Sandercock 1991)
- on the spawning grounds, coho tend to seek out sites of groundwater seepage and favor areas where the stream flow is .30-.55 m/s (Sandercock 1991)

- Females generally select a redd site at the head of a riffle area where there is good circulation of oxygenated water through the gravel (Sandercock 1991, Moyle 2002)
- The size of the redd is directly proportional to the size of the female, and is inversely related to the size of the gravel and the degree to which it is compacted (Sandercock 1991)
- Preferred substrate is gravel 15 cm diameter or smaller (Sandercock 1991)
- 5% of redds are located in areas having a high proportion of mud, sand or silt (Sandercock 1991)
- California coho bury their eggs to a depth of 25 cm (average) in gravel that averages 9.4 cm in diameter, with water velocity averaging .58m/s and depth of water over the redd at 15.7 cm. (Sandercock 1991)

Competition

- Females tolerate other females upstream or downstream of her redd, but not adjacent to it (Sandercock 1991)
- A pair of spawning coho requires about 11.7 sqare meters for redd and inter-redd space (Sandercock 1991)

Restoration of spawning habitat

- Installation of 15 gabion structures that fully spanned the band-full channel width was followed by over 50% of the coho and steelhead spawning on gravels associated with these structures on East Fork Lobster Creek, an Oregon coastal tributary of the Alsea River (House 1996)

References:

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Incubation

Incubation time

- The length of time required for eggs to incubate in the gravel is largely dependent on temperature dissolved oxygen concentration (Sandercock 1991, Moyle 2002)
- Embryos hatch after 8-12 weeks of incubation (Moyle 2002)
- Early emergence is more likely when eggs are buried in clean, loose gravel, and water temperatures are relatively warm (Sandercock 1991)

Survival of eggs and fry

- Causes of mortality to eggs and alevins include: low flows, winter flooding, freezing of gravel, heavy silt loads, bird and insect predators, and infections. (Sandercock 1991)
- Under average conditions, 15%-27% survive to emergence; under favorable conditions, 65%-85% survive (Sandercock 1991, Moyle 2002)
- Under adverse conditions of high scouring or heavy siltation, mortality can get close to 100% (Moyle 2002)

Flow

- Low winter flows can result in drying of the redds or exposure to freezing temperatures (Sandercock 1991)
- Flooding may cause gravel movement and result in eggs being dislodged and swept downstream (Sandercock 1991)
- Winter flooding accounts for a high proportion of mortality of eggs and alevins (Sandercock 1991)
- Peak flow can influence survival of incubating eggs and alevins through changes in the stability of spawning gravels, or when they are linked with changes in composition of the streambed. (Scrivener and Brownlee 1989)
- Winter flooding and the associated silt load may reduce water circulation in the gravel to the point where oxygen levels become critical or lethal (Sandercock 1991)

Sedimentation and substrate

- Sediment composition affects the permeability and porosity of spawning gravel. Permeability affects delivery and removal rates of oxygen, carbon-dioxide, and other metabolites, which influence survival. (Scrivener and Brownlee 1989)
- Salmonid eggs have incubated successfully in redds that contained mostly sand, but usually the fry could not escape from the substrate. (Scrivener and Brownlee 1989, Sandercock 1991, Scrivener and Brownlee 1989)
- Increasing fines have been correlated with declining sizes within the total population of emerging coho fry, which can reduce survival among returning adults (Scrivener and Brownlee 1989)
- When gravel beds have high concentration of fine sediment and sand (up to 50%), survival to emergence is lower (Sandercock 1991)

Nutrients

- Incubating salmonid eggs require the greatest oxygen concentrations just before hatching, but alevins survive at a lower DO because their gill membranes obtain oxygen more efficiently (Scrivener and Brownlee 1989)
- Following spawning and the associated carcass decomposition, age-0 coho salmon exhibit a doubling in rate of growth (Bilby, Fransen and Bisson 1995)
- The proportion of nitrogen contributed by spawning salmon was more than 30% for juvenile coho salmon. (Bilby, Fransen and Bisson 1995)
- The proportion of carbon contributed by spawning salmon was up to 34% in juvenile coho salmon. (Bilby, Fransen and Bisson 1995)

- Coho tend to survive better when leaf litter is present during their transition from yolk-sac to actively feeding fry, by providing a baseline source of food or to reduce stress and thereby affect survival. (Parker, Durbin and Specker 1990)

Temperature

- Optimum temperatures for embryonic development of coho are 2-8C (Tang, Bryant and Brannon 1987)
- Optimum temperature for coho egg incubation is 4C to 11C (Sandercock 1991)
- Nearly 100% mortality occurs at 14C and below 1.3C (Tang, Bryant and Brannon 1987, Murray and McPhail 1988)
- Abrupt temporary changes in incubation temperature lasting 8 hours and ranging from +8.4C to -6.2C results in little or no increase in embryo mortality except at the highest incubation temperature (Tang, Bryant and Brannon 1987)

Hatchery influence

- Newly-emerged fry from captive reared females display competitive domination over fry from wild females (Berejikan, Tezak, Schroder, Flagg and Knudson 1999)
- Captive-bred eggs and fry are paler in color than wild eggs and fry; pale color is associated with competitive advantage. (Berejikan, Tezak, Schroder, Flagg and Knudson 1999)

Effects of logging

- Increase in fines after logging originates more from erosion of streambanks or from upstream storage areas than from transport as bedload. (Scrivener and Brownlee 1989)
- Following logging, survival to emergence declined from 29.1% to 16.4% for coho salmon in the Carnation Creek watershed, British Columbia. (Scrivener and Brownlee 1989)
- Higher winter water temperatures and more frequent freshets that result from streamside logging can lead to fry emergence up to six weeks earlier than during years before logging. (Scrivener and Anderson 1984)
- Deposition of fine logging debris can increase summer coho fry densities, but if such debris is removed by freshets, fry densities can decline to levels lower than pre-logging. (Scrivener and Anderson 1984)
- Early emergence after logging can lead to a longer growing season, resulting in larger fry (Scrivener and Anderson 1984)

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Coho Summer Rearing Life Stage

Temperature

- Preferred temps: 12-14C (Sandercock 1991, Moyle 2002)
- Upper lethal temp: 25C (Sandercock 1991, Moyle 2002)
- Do not persist in streams with temps 22-25C for extended periods of time or where there are high fluctuations in temperature in the upper end of their range of tolerance (Moyle 2002)
- In the Mattole watershed, CA, coho were absent from streams with MWMT above 18C for more than a week (Welsh, Hodgson and Harvey 2001)
- In the Mattole watershed, CA, coho were present in all streams with MWMT less than 16.3C or MWAT less than 14.5 (Welsh, Hodgson and Harvey 2001)
- Water temps should not exceed 20C for more than 2 weeks (Reeves et al. 1989)

Cover and Instream Structures

- Prefer shady areas with overhanging branches (Sandercock 1991)
- Associated with instream cover (instream structures such as rocks and logs, and undercut banks) (Sandercock 1991, Moyle 2002)
- More structurally complex streams support larger numbers of fry (Sandercock 1991)
- Cover helps protect from competition (Sandercock 1991)
- Instream structures serve as water current shelters that help minimize the energy costs associated with maintaining position on the stream while feeding on drifting food (Giannico 2000)
- Logs increase pool frequency, augment retention of sediments, and slow down the downstream migration rate of gravel (Giannico 2000)

Other Habitat Elements

- Inhabit backwaters, side channels and small creeks (Sandercock 1991)
- Often move from natal habitat (Sandercock 1991)
- Inhabit pools and riffles, but prefer pools (Sandercock 1991, Reeves et al. 1989, Nickelson et al. 1991, Leidholt-Bruner, Hibbs and McComb 1992)
- Pools of 10-8 cubic meters are optimum (Sandercock 1991)
- Deep, cold pools >1m with overhead cover are ideal (Moyle 2002)
- As stream flows diminish in summer, they increase concentration in pools or deeper runs (Moyle 2002)
- Even moderate silt loads can damage gills and growth rates (Moyle 2002)
- Preferred summer habitat is pools of all types and beaver ponds (Reeves et al. 1989)
- Stream gradient <3% (Reeves et al. 1989)
- In Oregon coastal streams, beaver dams increased summer pool habitat 7-14% (Leidholt-Bruner, Hibbs and McComb 1992)
- Beaver dams can improve the quality of summer habitat by increasing the amount of slow water in pools (Leidholt-Bruner, Hibbs and McComb 1992)
- Beaver dams can prevent stranding by raising water levels in streams (Leidholt-Bruner, Hibbs and McComb 1992)
- Open foraging areas interspersed with woody debris is preferred coho summer habitat (Giannico 2000)

Feeding and growth

- Growth rates vary directly with temperature (Sandercock 1991, Irvine and Johnston 1992)
- Put on most of growth during summer; the more they grow, the better their chances for winter survival (Sandercock 1991, Irvine and Johnston 1992)
- When steelhead density is higher than coho density, growth of coho may be suppressed through competition (Moyle 2002)
- Distribution of juveniles in the summer is primarily due to availability and distribution of food and by the presence of woody debris, with food availability playing a dominant role (Giannico 2000)

- When food is abundant, coho select pools with less woody debris; when food is low in availability, coho select pools with greater amounts of woody debris (Giannico 2000)

Water Discharge

- Correlation between summer flows and adult catch 2 years later (Sandercock 1991)
- Low summer flows reduce potential rearing areas, cause stranding in isolated pools, and increases vulnerability to predators (Sandercock 1991)
- Water velocity is ideal when between 0.09-0.46 meters per second (Moyle 2002)
- Coho actively seek refuge from high water velocities (Moyle 2002)

Predation

- Especially vulnerable when aggregated in pools or side channels, or periods of high density (Sandercock 1991)
- *Oncorhynchus mykiss* is a prominent predator (Sandercock 1991)
- In California, predators are primarily fish, garter snakes, and birds (dippers, robins, crows, herons, ducks (e.g. mergansers)) (Sandercock 1991)
- Birds are predators primarily during the summer (Sandercock 1991)
- Predation increases when density of fish increases and cover decreases (Sandercock 1991)

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Coho Winter Rearing Life Stage

Seasonal movement of juveniles

- Coho immigrate to runoff tributaries, or off-channel and floodplain habitats in the fall-winter period, conincIding with the onset of fresheting and associated high water velocities, turbidity and gravel movement (Sandercock 1991, Cederholm and Scarlett 1981, Quinn and Peterson 1996, Swales, Lauzier and Levings 1986, Tschaplinski and Hartman 1983, Moyle 2002, Bramblett et al. 2002)
- Coho can move a considerable distance downstream before entering tributaries for winter rearing. (Sandercock 1991)
- Emigration occurs primarily during the rapid decline in light levels at twilight. (McMahon and Hartman 1989)
- Stream sections with adequate winter habitat (deep pools, log jams, and undercut banks with tree roots and debris) lose fewer fish during freshets and have higher numbers of coho in the winter than in reaches without these elements (Tschaplinski and Hartman 1983, McMahon and Hartman 1989)

General Habitat Descriptions

- Preferred overwintering habitat for coho includes the following features: low water velocity, abundant cover, high water temp compared to main channel, relative lack of predators and an abundant food supply (Swales, Lauzier and Levings 1986)

- Some of the best overwintering habitat includes streams with spring-fed ponds adjacent to the mainstem or protected, slow flowing side channels that may only be wetted in winter (Sandercock 1991, Moyle 2002, Swales, Lauzier and Levings 1986, Cederholm and Scarlett 1981)
- During winter, juvenile coho are most abundant in alcoves and beaver ponds (with beaver ponds supporting fish at a higher density) (Nickelson, Rodgers, Johnson and Solazzi 1992)
- Maximum pool depth during winter is significantly correlated with density of juvenile coho (Nickelson, Rodgers, Johnson and Solazzi 1992, Quinn and Peterson 1996)
- The most suitable winter cover for coho combines all three environmental features of low velocity, shade, and three-dimensional complexity (McMahon and Hartman 1989)

Substrate

- Coho prefer clean rubble to silted rubble (Sandercock 1991)
- Salmonids hide in interstitial spaces in stream substrates, particularly in winter, when the voids are accessible (Bjornn and Reiser 1991)
- The summer or winter carrying capacity of the stream for fish declines when fine sediments fill the interstitial spaces of the substrate (Bjornn and Reiser 1991)
- In winter, substrate is a more important source of cover than it is for food (Bjornn and Reiser 1991)

Cover (instream and riparian)

- Overwinter survival of juvenile coho is correlated with the availability of woody debris (upturned tree roots, accumulations of logs, and cobble substrate) (Heifetz, Murphy and Koski 1986, McMahon and Hartman 1989, Quinn and Peterson 1996, Swales, Lauzier and Levings 1986, Tschaplinski and Hartman 1983)
- Riffles, glides and pools without cover are not used (Heifetz, Murphy and Koski 1986)
- Juvenile coho only inhabit undercut banks when there are logs and /or root masses (Heifetz, Murphy and Koski 1986, McMahon and Hartman 1989, Tschaplinski and Hartman 1983)
- Wood debris provides protection from predators during low water temperatures, and from downstream displacement form high velocities by frequent and at times severe winter freshets (McMahon and Hartman 1989)
- Complex cover may help reduce the frequency of aggressive interactions in winter by increasing visual isolation of individual fish (McMahon and Hartman 1989)
- Non-organic cover such as overhanging banks and ice and snow shelves are also important habitat (Swales, Lauzier and Levings 1986)

Velocity

- Slow current velocities (< or = 30cm/s) are important to coho in winter habitat selection, but only when in conjunction with cover that provides shade and three-dimensional complexity (McMahon and Hartman 1989, Quinn and Peterson 1996, Swales, Lauzier and Levings 1986, Bjornn and Reiser 1991, Tschaplinski and Hartman 1983)
- Velocity refuges are the most important feature selected by age-0 coho in the early summer (Fauch 1993)

Turbidity

- Juvenile coho avoid water with turbidities exceeding 70 NTU (Bjornn and Reiser 1991)
- Turbidities in the 25-50 NTU range reduced growth and caused more young coho to emigrate from lab streams than did clear water (Bjornn and Reiser 1991)

Temperature

- When water temperatures go below 7C, coho have been observed to move into areas with water depths over 45 cm and lower velocities (15cm/s) (Sandercock 1991)
- When temperatures in the stream approached 2C, coho moved closer to cover provided by logs, tree roots, undercut banks, etc. (Sandercock 1991)
- Prolonged exposure to water temps close to 0C is tolerated by coho, but a sharp drop in temp from 5C to almost 0C results in mortality (Sandercock 1991)
- During periods of low temperature, salmonids have lower metabolism, reduced food requirements, and less swimming ability; thus, their survival depends more on areas of shelter and rest than of food (Heifetz, Murphy and Koski 1986)
- At 3C, the critical swimming speed of coho 60 mm long is 50% less than that at summer temperatures (McMahon and Hartman 1989)
- Lower lethal temperatures are near 0C (Bjornn and Reiser 1991)
- As temperatures decline in fall, salmonids change behavior from mostly feeding and defending territory to hiding and schooling (coho make this shift when water temperatures get to about 7C (Bjornn and Reiser 1991)

Feeding and growth

- During winter months, feeding virtually ceases and growth stops. (Sandercock 1991, Moyle 2002)
- Larger coho survive better over the winter than smaller coho (Quinn and Peterson 1996)
- It has been observed that coho stop feeding when sediment concentrations exceed 300 mg/L but they do not abandon their territories even when sediment loads approach 4000 mg/L (Sandercock 1991)
- Where side channels are fed by groundwater, temperatures may be such that coho continue to feed and grow during the winter (Sandercock 1991)
- In Pudding Creek, winter coho fed on flying insects and mayfly larvae when flows were low but on earthworms when flows were high (Moyle 2002)

- Observed juvenile coho eating large numbers of earthworms and arachnids during high flows, indicating that high flows may be an important feeding opportunity for fish in off-channel habitats (Bell, Duffy and Roelofs 2001)
- When adults are spawning, decaying carcasses and loose eggs can be major foods for juvenile coho (Moyle 2002)

Predation

- Avian predation rate is much lower in winter than in summer (Sandercock 1991)
- Mink and otter prey heavily on overwintering juveniles (Sandercock 1991)

Floods

- Coho fry production has been shown to be a function of the stability of winter flows (Sandercock 1991)
- Flooding can have significant impact if over 50% greater than average flood (Sandercock 1991)
- After a 5-year flood event, fidelity and out-migrant trap capture were greater for juvenile coho occupying alcoves than for those occupying backwaters or main-channel pools. (Bell, Duffy and Roelofs 2001)
- Juvenile coho tend to migrate to other types of habitat in response to high discharge, which may increase chances of survival (Bell, Duffy and Roelofs 2001)
- The measured densities of juvenile coho salmon in off-channel habitat may not indicate the number of fish that utilize that habitat solely during peak discharge. (Bell, Duffy and Roelofs 2001)
- Immigration rates were over 100% in alcove and backwater habitats; thus, it is likely that these habitats were accessible during the flood and probably not at carrying capacity before the event (Bell, Duffy and Roelofs 2001)

Impacts from logging

- Reaches in clear-cut areas without buffer strips had significantly less area of pool habitat than old-growth reaches (Heifetz, Murphy and Koski 1986)
- In some cases, blowdown from buffer strips added large organic debris to the stream and increased the cover within pools (Heifetz, Murphy and Koski 1986)
- Clear-cut reaches have less large organic debris and less pool area, but cover within pools was not reduced (Heifetz, Murphy and Koski 1986)
- Winter habitat can be maintained during and after logging by leaving wood debris in the stream and ensuring its continued recruitment by leaving buffer strips of trees along streambanks (McMahon and Hartman 1989, Heifetz, Murphy and Koski 1986)
- The number of overwintering coho is low in stream reaches where debris abundance has been reduced by debris removal associated with streamside logging or other disturbance (McMahon and Hartman 1989)

Restoration

- Found that low-cost restoration (involving creating six 7m long x 4m wide x 1-2.5m deep ponds in one tributary of the Clearwater River, creating a "beaded channel") was effective in increasing overwintering survival of coho juveniles. (Cederholm and Scarlett 1991)
- Full-width structures that improve summer habitat for coho (by making plunge pools) do not improve winter habitat for them. (Nickelson, Solazzi, Johnson and Rodgers 1992)
- Constructed dammed pools support a lower density of coho than natural dammed pools (Nickelson, Solazzi, Johnson and Rodgers 1992)
- Constructed dammed pools support more fish when deeper (Nickelson, Solazzi, Johnson and Rodgers 1992)
- Addition of bundles of small trees to constructed dammed pools can increase coho inhabitation of those pools (Nickelson, Solazzi, Johnson and Rodgers 1992)
- Constructed alcoves provide winter habitat for coho, provided that the access to the alcove has adequate depth and flow (Nickelson, Solazzi, Johnson and Rodgers 1992)
- Streams treated with addition of large woody debris had increased summer populations and overwinter survival of juvenile coho (Solazzi, Nickelson, Johnson and Rodgers 2000)
- Construction of alcoves should incorporate springs, seeps or temporary streams because water flowing through the alcoves helps control the accumulation of fine sediment that tends to block the entrance (Solazzi, Nickelson, Johnson and Rodgers 2000)
- It is not recommended to anchor full-spanning structures to the substrate or to use rebar, chain-link fence or erosion cloth for restoration projects. Instead, large wood should be placed in the stream to establish itself in the channel as a function of natural processes (Solazzi, Nickelson, Johnson and Rodgers 2000)

Other

- Due to strong habitat preferences in winter and lack of ideal habitat during that time, if spawning escapement is adequate, the production of wild coho salmon smolts in most coho salmon spawning streams is probably limited by the availability of adequate winter habitat. (Nickelson, Rodgers, Johnson and Solazzi 1992, Moyle 2002, Swales, Lauzier and Levings 1986, Solazzi, Nickelson, Johnson and Rodgers 2000)
- 27% to 94% of juvenile salmonids in streams in late summer die during fall and winter (Heifetz, Murphy and Koski 1986)
- Spatial requirements of coho are different in winter than in summer – coho aggregate near the bottoms of pools in the main stream and remain close to each other (Tschaplinski and Hartman 1983, Sandercock 1991)
- Yearlings are often deeper under banks or in pools than fry (Tschaplinski and Hartman 1983)
- There are differences between inland and coastal streams winter conditions: coastal streams have high flows from heavy rainfall, whereas interior rivers freeze over and have low flows until spring snowmelt (Swales, Lauzier and Levings 1986, Bjornn and Reiser 1991)

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Coho Juvenile Outmigration and Estuary Residence

Juvenile Outmigration

- Outmigration of smolts over 10 cm in length occurs in California as early as mid-March, increases through April, and peaks about mid-May (Sandercock 1991, Moyle, 2002)
- Main peak of migration for coho occurs during a time of maximum stream discharge. A second peak of migration can occur when flows are decreasing and temperature is rising (Sandercock 1991)
- The bulk of seaward migration occurs at night (Sandercock 1991, Moyle 2002)
- Downstream movements are not continuous, but are interspersed with periods of holding and feeding in areas of low velocity (Moyle 2002)
- Coho fry move seaward earlier following winters in which stream temperatures are warmer (they presumably develop more rapidly under these conditions) (Hartman, Anderson and Scrivener 1982)

- Peaks of movement are coincident with or slightly before freshet peaks (Hartman, Anderson and Scrivener 1982)
- Coho form aggregations in pools with large woody debris during seaward migration (McMahon and Holtby 1992)
- Smolt abundance in the stream and estuary is positively related to debris volume (McMahon and Holtby 1992)
- Coho have extended periods of holding in areas of low current velocity during seaward migration (Moser, Olson and Quinn 1991)

Use of Klamath Mainstem by Fry and Smolts

- Smolts begin migrating downstream in the Klamath basin between February and the middle of June when they are about 10-12 cm long. Most smolts captured in the Orleans screw trap are taken in April and May and appear in the estuary about the same time. About 60-70% of the smolts are of hatchery origin. (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003)
- Coho emergence is believed to occur from late February through April. Coho fry were observed outmigrating from tributaries (Bogus Creek and Shasta River) from early March through late-June. Coho fry were captured at the Big Bar trap from early April through late July during spring trapping and in November during fall trapping. Yearling coho were captured during the Bogus Creek and Shasta River emigration studies from mid-January (Bogus 1990) through mid-April. In the mainstem yearlings were captured from mid-March through early August. Coho are likely to rear in the study area year round. (Shaw, Jackson, Nehler and Marshall 1997)
- Most smolts from the Scott River were captured between late March and early May (Natural Stocks Assessment Project 2003)
- Some fry are captured in outmigrant traps at the mouths of the Shasta and Scott rivers from May to early July, although most probably stay in the tributaries close to the areas in which they were spawned. (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003)
- Most natural coho production in the Klamath-Trinity basin is suspected to occur in the lower Klamath River tributaries downstream of the screw traps and Trinity River, since the natural coho component of screw trap catches on the mainstem Klamath and Trinity Rivers is usually lower than the natural component in the estuary. (Natural Stocks Assessment Project 2003)
- Hatchery yearling coho usually spend about 2 months in the main stem Klamath, and natural origin yearling coho spend a month or more in the main stem Klamath. (Natural Stocks Assessment Project 2003)

Flow and Temperature in the Klamath River Mainstem

- Increased releases from Iron Gate Dam may benefit coho salmon, but there is a considerable increase in the daily mean water temperature with distance downstream for flows that are typical of August. (Under moderate flow conditions in mid-August (1000 cfs), with typical accretions from tributaries, maximum daily temperatures increase rapidly downstream of Iron Gate Dam to a peak of 26ºC within 15 mi. Daily minimum temperatures caused by nocturnal cooling reach a minimum of 20ºC within about the same distance. By the time this water reaches Seiad Valley (RM 130), maximums are greater than 26ºC, and minimums are 22ºC; the average gain from Iron Gate Dam is 2ºC). (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003)

- Water released from Iron Gate Dam in August has a mean temperature near 22ºC, which is well above the acute tolerance threshold for coho. (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003) Temperatures in the Klamath River at 1000cfs 1000 cfs are affected substantially by the Scott River. Modification of flow and temperature regimes in these tributaries through better water management could improve mainstem temperatures. (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003)

Estuarine Residence

- Coho are vulnerable to predation once they reach the estuary
- Coho smolts often linger in the estuary, indicating that a period of estuarine residence is preferred for adjusting their osmoregulatory system to seawater (Moyle 2002)
- Coho migration through estuaries is slower than riverine migration, suggesting that a period of estuarine residence may be necessary for them to adjust their osmoregulatory capability, orient for their return migration, feed, or reduce their vulnerability to predators. (Moser, Olson and Quinn 1991)
- Coho in estuaries grow approximately 1.5% per day (depending on the estuary)
- Different species have distinct feeding habits within estuaries, but there are not consistent feeding patterns between estuaries. (Healey 1982)

Use of Klamath River Estuary

- yearling coho in the Klamath River estuary usually peaks during May, with few captured after June (Natural Stocks Assessment Project 2003)
- Smolts may feed and grow in the estuary for a month or so before entering the ocean. Smolts are largely gone from the estuary by July. (Committee on Endangered and Threatened Fishes in the Klamath River Basin, N.R.C. 2003)
- Yearling coho move quickly through the estuary without much rearing (Natural Stocks Assessment Project 2003)
- Annual relative abundance of yearling coho ranges from 0.01-0.31 fish/1000 square feet in the lower estuary and 0.24 – 0.43 fish/minute in the upper estuary (Natural Stocks Assessment Project 2003)
- 28.4% of coho in estuary are natural fish, with 65% from Trinity River Hatchery and 6.6% from Iron Gate Hatchery (Natural Stocks Assessment Project 2003)
- Mean fork length of hatchery origin coho rnages from 24 to 81 mm longer than natural origin coho in the estuary (Natural Stocks Assessment Project 2003)

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Coho Ocean Life Stage

Ocean Residence

- Smolts stay in the nearshore areas close to their home streams for several months before migrating further (Sandercock 1991, Moyle 2002)
- Coho occupy the area from the surface to a depth of 30 meters in the ocean (Sandercock 1991)
- Some Coho from California tend to follow the coastal belt northward during the summer months, as far as the northeastern section of the Gulf of Alaska (Sandercock 1991)
- Many coho spend their entire marine life in inshore waters (Sandercock 1991)
- At first, coho feed on marine invertebrates when they enter salt water, but as they grow they become more piscivorous (Sandercock 1991, Healey 1982)

- Smolts grow approximately 1.25-1.50 mm per day once they move beyond the estuary (Sandercock 1991)
- The bulk of mortality of coho at sea occurs during the first year. (Sandercock 1991)
- Of coho that survive to catchable size, approximately 50% may be taken in commercial and recreational fisheries (Sandercock 1991)
- Approxomately 5-10% of smolts will survive to return to their natal stream (Sandercock 1991)
- Coho eventually migrate northward, staying over the continental shelf (Moyle 2002)
- Most California coho stay in California and Oregon waters, though some move as far north as Alaska (Moyle 2002)
- Most coho caught off California in ocean fisheries were reared in coastal Oregon streams (Moyle 2002)
- Oceanic coho school together, but schools break apart when feeding occurs (Moyle 2002)
- One reason California coho may not move far in the ocean is the productivity of the upwelling system off the California coast, which provides high densities of food and cold temperatures (Moyle 2002)

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C. LFA Tables by Life Stage

- Spawning
- Incubation and In Gravel
- Juvenile Rearing
    - Winter/Spring
    - Summer/Fall
- Juvenile Outmigration
    - Scott River
    - Klamath River
    - Estuary
- Ocean Rearing
- Adult Migration
    - Estuary
    - Klamath River
    - Scott River

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments
Spawning	Lack of access to spawning habitat	barriers to main stem habitat		Maurer 2002 and onging spawning surveys	Documentation of when fish can acess ideal spawning areas; longitudinal profiles to determine areas expected to go dry (biannually or after significant change) - tie to well and guage data	2 (depending on climate)	connectivity is climate-dependent and varies year to year depending on when the first rain events happen; stockwater use; stormproofing methods sometimes aggravate connectivity problem	tailing pile above Sugar Creek; below Boulder Creek (in very low flows); Whitehouse Falls;
		lack of access to tributaries			Documentation of when fish can acess ideal spawning areas; longitudinal profiles to determine areas expected to go dry (biannually or after significant change) - tie to well and guage data	1	aggradation; low water table; lack of defined channel bordered by riparian plants	Moffet Creek; Kidder Creek; Patterson Creek; Shackleford
		unsuitable flow quantities (e.g. unsuitable velocities)		Reeves 1989	IFIM; assessment of gravels within bank-full mark; gauge data (run gauges during winter)	5	winter flow regime could be altered by upslope processes	guages are are at South Fork, East Fork?, Sugar Creek, and Shackleford-Mill
	Inadequate spawning habitat		Sandercock 1991; Moyle 2002					
		inadequate gravel		Habitat Typing Data (old (1989 FS) and recent); Sommarstrom 1990 and 2001	IFIM; assessment of gravels within bank-full mark; spawning gravel assessment survey	3		
		embeddedness		Habitat Typing Data (old (1989 FS) and recent)	IFIM; assessment of gravels within bank-full mark; spawning gravel assessment survey	1	road density; fire history; land use in watersheds with erosive geology	Widespread throughout Scott; Sugar Creek has especially strong problem

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments
		gravel susceptible to scour		Habitat Typing Data (old (1989 FS) and recent); Sediment Source Inventory data	IFIM; assessment of gravels within bank-full mark; spawning gravel assessment survey; scour chain study (including dredge tailings); correlate road sediment source inventory data with preferred spawning areas and likelihood of increased scour; spawning surveys in main stem	2, but need more info to verify	heavy equipment work in channels can result in gravels that seem well sorted but are unstable; possibility of high winter flows (increased peak flows)	bigger watersheds and areas with high road density - Canyon, East and South Forks; dredger tailing area near Callahan
		insufficient cover		Habitat Typing Data (old (1989 FS) and recent)	spawning gravel assessment survey; include cover assessment in existing spawning surveys	3 in general, 2 in lower parts of tribs and upper main stem	stream alteration and lack of riparian corridor	Sugar has good conditions, but East Fork and South Fork has low cover
	Insufficient spawning habitat for population - quantity and quality	superimposition of redds	Sandercock 1991		document during spawning ground surveys	3 except during some low flow years		
	Spawning in diversion ditches			spawning surveys	F&G monitoring of maintenance of diversion screens	5	unscreened ditches that are large enough to accommodate spawners can lead to juveniles getting displaced onto the fields	
	Poor water quality	temperature out of preferred range		spawning surveys	general inquiry to other professionals about issues that could be associated with temperature	3		need more information about problems associated with temperature specifically during the spawning process

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments
		lack of nutrients	Sandercock 1991, Moyle 2002		general inquiry to other professionals about issues that could be associated with nutrients	3		
		pollutants/turbidity***					can mask odors necessary for adult navigation to spawning sites	Use of Wooliver in 97 due to turbid conditions in other tributaries
	degradation of historical population structure	loss of some cohorts (2 of 3 brood years)		spawning surveys	trap adults at tributaries; correlation with outmigrants observed at screw trap	1	2 out of 3 broods are very small, causing lack of recovery source for those years	
		genetic dilution from hatchery-reared fish		spawning surveys	document hatchery clips among returning adults to Scott; DNA analysis of existing samples	5		
	insufficient number of viable adults	inability for pairs to find each other		spawning surveys	trap adults at tributaries and assess sex ratios	5		
		inadequate genetic diversity			genetic analysis of existing samples	5		

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments
Incubation	Water temperature out of preferred range	temperature too low		2001, 2002 hobo temps (have not been downloaded yet); 2003 hobo temps (have not been downloaded yet)	hobo temp capture of winter temperature regime; assessment of existing hobos that have recorded winter temperatures	5	see below (under anchor ice)	Low temperature recorded for Sugar Creek in 2003 (<.5C)
		anchor ice		observations during spawning surveys in January 2002	continued observations by spawning surveyers and landowners	3	cold conditions at higher elevations and during extremely cold events lower down, as well as lack of cover, channel simplification can lead to anchor ice development. If ice covers redds, mortality can occur due to lack of DO delivery during incubation; sedimentation can inhibit upwelling; disconnection between floodplain and stream channel can cut of sources of upwelling	Anchor ice on East Fork Scott River noted in spawning surveys in 2002; redds in areas that have had anchor ice have been observed to be in areas of upwelling of warmer water

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments
	inadequate intergravel flow through redd	sedimentation of redd		Sommarstrom 1990 and 2001; habitat typing data; SCI data; water quality control board data (e.g. French Creek)	use existing sediment data to assess habitat quality as well as survival to emergence; collect data for additional tributaries beyond those captured in existing data (various data collection methods can be used for different purposes - McNeil samples are good for long term monitoring); develop regression curve that correlates grid tosses with results from more detailed methods like McNeil or V*; fry trapping to determine actual survival to emergence; edge habitat surveys (Shaw)	5	increased hydrologic connectivity from roads	Drainages with Granitic geology or that go dry are potentially more of a problem (e.g. French, Sugar)
	redd scouring	increased peak flows (see inadequate flow in spawning table)		flow data (see inadequate flow in spawning table); precipitation data from weather stations and DWR	follow-up monitoring of known redd sites after high water events; fry trapping	5		

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments
	redd dewatering/ inadaquate flow				Scott Valley water budget; monitoring redds before and after water use for irrigation; determine timing of emergence (fry trapping)	5	during drought years, water extraction for irrigation can lead to dewatering of redds	upper tributaries with associated irrigation; Noyes Valley; East Fork Palmer Valley area; Lower parts of tribs (below diversions); Crystal Creek; Johnson Creek
	disturbance of redd			personal observations of equipment use areas	map out areas of disturbance and overlay with known redd areas	5	equipment operation over redds; human and animal disturbance of redd (e.g. cows)	potential problem to be addressed through education; Shackleford Creek
	poor water quality			toxicity tests by EPA; county records of pesticide use	research effects of pesticides, fuel and oil spills on incubating eggs; determine use of fertilizers and pesticides during incubation life stage	5	pollutants discharged into the river; persistant pollutants associated with mining sites	

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments

Rearing: Winter/Spring

Juvenile rearing	displacement and mortality caused by high flows due to reduced habitat		McMahon and Hartman 1989; Quinn and Peterson 1996; Swales, Lauzier and Levings 1986; Bjornn and Reiser 1991; Tschaplinski and Hartman 1983; Fauch 1993		CWE analysis			
winter		lack of instream habitat (cover, woody debris, beaver ponds, deep pools, overhanging banks, non-silted substrate)	Heifetz, Murhpy and Koski 1986; McMahon and Hartman 1989; Quinn and Peterson 1996; Swales, Lauzier and Levings 1986; Tschaplinski and Hartman 1983	Jay Phelps information from winter 2002 displacement due to high flows	winter habitat typing - develop protocol (including velocity measurements); habitat utilization surveys (including main stem utilization); aerial photo analysis	1	removal of riparian vegetation and instream woody debris	
		lack of off-channel habitat (alcoves, backwaters, etc.) due to lack of flood plane connectivity / channel simplification and degradation	Sandercock 1991; Moyle 2002; Swales, Lauzier and Levings 1986; Cederholm and Scarlett 1981; Nickelson, Rodgers, Johnson and Solazzi 1992	record of soil conservation district activities in 1950s; historic anecdotal descriptions of area; historic map by Meeks (in the SRWC SAP); summer habitat typing data that identifies side channels; instream flow surveys	aerial photo analysis and ground survey to create a map of potential winter rearing habitat, including channel alterations; research at historical society	1	conversion of floodplain areas to agricultural land	Kidder Creek Slough (Lighthill Road and Hwy 3 area); possible use of ditches as winter rearing (effect of screening?); Wolfard Slough?; Big Slough

Life Stage	Potential Limiting Factors	Subcategories for potential limiting factors	Available studies/information	Scott-Specific Information	Data/research Needs	Subjective opinion regarding likelihood of being a limiting factor (1=definitely, 2=likely, 3 = unlikely, 4=definitely not 5=not enough information)	Causes/Sources of Problems	Geographic reference/Comments
		altered flow regime (increased peak flow)			analysis of long term data from gauges on main stem and short term data from gauges in tributaries	2	upland road connectivity; land clearing; lack of floodplain connectivity; loss of water retention via. wetlands	
	food supply and turbidity		Bjornn and Reiser 1991; Tschaplinski and Hartman 1983; Sandercock 1991; Moyle 2002; Quinn and Peterson 1996; Bell, Duffy and Roelofs 2001					
		decreased feeding opportunities	Sandercock 1991		food source assessment	5	decrease in salmon carcasses; loss of ideal habitat conditions for winter feeding; lack of riparian vegetation; lack of benthic production; low temperatures; lack of access to prime feeding areas	Shackleford Creek
		increased sediment in run off		Sommarstrom et al. 1990; Sommarstrom 2001	measure turbidity and length of turbid periods where coho are rearing	5	increased hydrologic connectivity from roads	Moffet Creek and East Fork

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	low temperatures		Sandercock 1991; Heifetz, Murphy and Koski 1986; McMahon and Hartman 1989; Bjornn and Reiser 1991	anchor ice observations in 2002; RCD winter temperature monitoring	more winter temperature monitoring in tribs and main stem; air temperature monitoring; compare temperatures in in-channel and off-channel habitats	2	lack of deep pools and loss of riparian vegetation which leads to greater temperature fluctuations; can cause mortality in juveniles (loss of warm water refugia)	
	predation	insufficient instream cover (including substrate)	Sandercock 1991	see instream habitat section above (under displacement by high flows)	population monitoring (to determine whether predation could be a factor), including correlation to habitat types / conditions	5	lack of cover can make juveniles more vulnerable to predation	
	open diversion - non-functioning fish screens			DWR / DFG map of diversions	DWR / DFG are currently assessing diversions	2	displacement of juveniles onto land by being caught in irrigation ditches that have no headgate (fish screens may fail or have to be removed in winter)	

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Rearing: Summer/Fall

Juvenile rearing	displacement by low flows			Ron Dotson's fish rescue data; Bill Bennet's observation of dry reaches map	flow / habitat model			Ditch failure from Sugar to French
Summer		diversion		Bill Bennet's maps of diversions; adjudications for French and Shackleford Creek and for Scott	identifcation of potential rearing habitat in ditches; estimation of flow diverted	1	directly reduces flow, can cause stranding, raises temperature, reduces habitat volume and quality	widespread throughout Scott Valley (see Bill Bennet's map)
		ground water use		Bill Bennet's maps of water levels in wells; SAP section about water quantity	ground water study to assess amount and locations of ground water interconnectivity; water budget; measurement of well pumping; feasibility analysis of small dams to recharge groundwater, link diversions and groundwater use to determine surface flow; look at 70s paper (see Erich) to verify to see if it accurately defines groundwater use	2	indirectly reduces flow; can cause stranding; raises temperature; reduces habitat volume and quality	Dam at mouth of Moffett Creek; currently increasing well development and use; widespread throughout Scott Valley
		loss of pool volume	Sandercock 1991; Moyle 2002	French Creek V*; pool parameter data in habitat surveys for Scott River; USFS Habitat Surveys	expand on V* by correlating population numbers (from electrofishing data) with residual pool volume	1	increases predation; increases temperature; increases competition between juveniles; reduces habitat quality and quantity; can impact connectivity	most of the lower portions of the Scott Valley tributaries, main stem Scott

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		aggradation		Sommarstrom et al. 1990; Sommarstrom 2001; Moffet Creek upland/sediment study	aerial photo analysis (40's, 70's, 90's comparative); TMDL (in progress); follow-up study to Sommarstrom's 2000 study; CWE study with Don Elder	1	promotes earlier loss of flow and connectivity; can cause loss of pool volume; can change food source; can decrease intergravel flow	most of the lower portions of the Scott Valley tributaries; main stem Scott
	temperature out of preferred range*		Sandercock 1991; Moyle 2002; Welsh, Hodgson and Harvey 2001; Reeves et al. 1989					
		lack of intergravel flow		Sommarstrom et al. 1990; Sommarstrom 2001		2	sediment keeps water from flowing through gravels, which cools water temperature	Fine sediments below Etna Creek, in French Creek and Sugar Creek; Main stem historically was probably summer rearing habitat but is no longer.
		low surface flow		tributary gauge data	temperature modeling analysis based on gauge data	2	less priority for cooling temperatures than shading and channel structure	East Fork
		insufficient shading	Sandercock 1991	Water Temps in Scott River 2001 Report	aerial photo analysis	2	shading can be provided by canopy, hillslope, and aspect	East Fork; lower reaches of tribs
		channel degradation	Rosgen	historical photos	aerial photo analysis	1	depth-width ratio increases surface area - leads to pool volume decrease, decreased shading, increased temperatures, and slows flow velocity	
		tail water		Gary Black		3	tail water coming off the fields is generally warm	Wolford Slough

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		ground water use		Mack 1954	ground water study to assess amount and locations of ground water interconnectivity	5	groundwater flow into the river cools temperatures	
	inadaquate habitat (quality and quantity)	inadequate pool frequency	Sandercock 1991; Reeves et al. 1989; Nickelson et al. 1991; Leidholt-Bruner, Hibbs and McComb 1992; Moyle 2002	Habitat typing data (see E17); SCI Stream Condition Inventory; Forest Service LSR Administratively withdrawn area maps; SSRT Report	Habitat typing for tribs not previously surveyed (Sandy Bar part of Main Stem, Moffett Creek, Kidder Creek, Patterson Creek (Etna), Crystal Creek, Tompkins Creek (lower section))	2	channelization; lack of LWD; sedimentation	Shackleford Creek
		lack of large woody debris/cover	Sandercock 1991; Moyle 2002; Giannico 2000	Habitat typing data (see E17); SCI Stream Condition Inventory; Forest Service LSR Administratively withdrawn area maps	look at vegetation / seral stage maps and aerial photos; analyze habitat data	1 for Main Stem and alluvial tribs; 2 for other tribs	Past logging (deforestation); removal by landowners for flood control; grazing that prevents regrowth	Main Stem Scott; Kidder Creek; Shackleford Creek; Moffett Creek; Patterson Creek (Etna)
		lack of connectivity		DWR has color coded map	determine adjudicated amounts versus what is available from the natural flow	1	aggradation; diversions; channelization; lowering of water table; entrenchment; modification of natural morphology	Moffett Creek; lower portions of tributaries; Tailings reach through main stem; Shackleford Creek; Mill Creek near the mouth of Immigrant Creek
		insufficient channel complexity	Sandercock 1991	RCD habitat typing data to show present conditions; Forest Service habitat typing; NCWAP F&G survey of East Fork and E.F. tribs; Scott River Riparian Condition Inventory; F&W Service	collect and assess historical and aerial photos	1 for Main Stem, Patterson Creek (Etna), Shackleford Creek, and Moffett Creek; 2 for other tributaries	channelization for flood control and agriculture; eradication of beaver	

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		lack of cold water refugia	Nielson 1991	Scott River Main Stem Canyon 2002 Dives (Mark Pisano); TMDL Flir Data (Bryan McFadin)?	identify sites; survey tributaries	2	Lack of ground water contribution; low surface flows; aggradation; sedimentation	Main Stem Scott
		distance from emergence habitat to rearing habitat too great		fish rescue data; spawning data; habitat data	look at 2001, 2002 spawning data to determine potential areas for emergence	5	loss of habitat complexity	Shackleford Creek
		insufficient riparian vegetation	Sandercock 1991	habiat typing data (E17); aerial photos	look at aerial photos	2	grazing (prevention of willow regrowth); rip rap; channelization; lowered water tables; bank erosion; landowner removal for river access; agriculture	Main Stem Scott; alluvial portions of tributaries; some upper portions of tributaries
	predation		Sandercock 1991; Moyle 2002; Martel 1996					
		high density			population assessment of predators (mergansers, snakes, etc.); assess potential threat and location of predation	5	stranding can cause high densities and easier access by predators; can increase interspecies and intraspecies predation; simplified habitat will reduce hiding places for juveniles	
		insufficient cover (see insufficient habitat)	Gonor ?; PHABSYM models		determine potential effectiveness of restoring cover to decrease predation	5	decreases hiding places; stranding	

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	species competition		Moyle 2002; Harvey ?; Quinones 2003; Tezak et al. 1998	Dennis's French Creek e-fishing data for ratios of species, fish trap data	species composition changes over course of season; comparative growth rates; determine rearing locations of juveniles (including areas in the Klamath and tribs) and determine competition factors in those areas (including interactions with hatchery fish); assess effects of fish rescued and planted into streams; track movements of juveniles	5	simplification of channel doesn't allow for habitat partitioning; rearing of Scott River juveniles may occur outside of the subbasin due to decreased habitat quality and volume and are exposed to additional competitive interactions	
	food availibilty/supply (growth rates)		Sandercock 1991; Giannico 2000; Simenstad ? (UW); Harrington (F&G in Sacramento)	Macroinvertebrate sampling from tributaries (RCD and Timber Products, Fruit Growers, Forest Service (Jim Kilgore?)); Peter Otis' SWAMP data (Callahan)	analysis and interpretation of existing macroinvertebrate data	5	Competition decreases food supply	
		eutrophication (see section under "water quality")		Mike Deas data, hydrolabs (grab samples)				
		low nutrients (see section in "water quality")						
		insufficient riparian vegetation (see section in "inadequate habitat")			aerial photo analysis			

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	stranding (see low flow section)			Dennis Maria's e-fishing data and fish rescue information				
		diversion						
		low flow (drought)	Sandercock 1991					
		ground water use					increases water temperature	
	anthropogenic barriers			road inventories (fish passage?); County inventory of crossing restoration projects	compile information from inventories	2 but not widespread	culverts that restrict juvenile upstream passage; diversion dams	Crossing at Scott Bar Mill; Big Mill Culvert; Etna Creek
	water quality	temperature out of preferred range (see above in temp section)						
		turbidity	Moyle, 2002; Lloyd et al. 1987; Sorenson et al. 1977; Reid 1998		ask water board about collecting samples after summer storm events; install datasondes at flow gauge stations; ask Karuk tribe what they are using to monitor turbidity	2 but rare	higher turbidity decreases feeding opportunities; turbidity in summer occurs during and after storm events; can damage gills; can increase temperatures	
		pollutants and eutrophic conditions		Macroinvertebrate sampling from tributaries (RCD and Timber Products, Fruit Growers, Forest Service (Jim Kilgore?))	Analysis of macroinvertebrate indices	5		Main stem Scott has lack of macros
		lack of nutrients	Giannico 2000		Literature search and historical research	5	decrease in carcasses potentially can decrease nutrient availability to juveniles	Granitic tribs???
		suction dredging				3		Main stem Scott Bar; Wildcat; Deadwood

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		algae growth			DO measurements before dawn during hottest part of the summer	5	decreases DO levels to potentially lethal levels when stagnant	South Fork Scott; Scott River at Meamber

* preferred temps: 12-14C; upper lethal temp: 25C; do not persist with temps 22-25C for extended periods of time or with high fluctuations in the upper end of range; Denis Maria has not observed live coho juveniles in streams above 68F in the Scott River Watershed

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Outmigration: Scott River

Juvenile outmigration	suitable rearing habitat lost		Moser, Olson and Quinn 1991; McMahon and Holtby 1992					
		premature emigration		screw trap data for 0+ fish	verify that 0+ fish are leaving the system (put screw trap further downriver); analyze data from 2003; estimate quantity of 0+ fish that would naturally leave the system early	2	aggravated natural rate of premature emigration with diversions and other channel alterations	
Scott River		increased density and competition		flow data and trap data	correlate flow data with timing of outmigration (screw trap data); identification of habitat utilized during outmigration in the Scott	5	if holding habitats used along the migration route are limited, fish can be overcrowded in existing habitats	
	predation	increased density of predators			determine natural predation rates and factors; search literature and information regarding predator population fluxuations to determine if there has been an increase	5	population imbalances; concentrations of juvneiles due to less available habitat	
		harvest			creel census	5		

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		lack of cover	McMahon and Holtby1992	F&WS habtiat typing data	identify habitats used and then determine state of cover in those habitats; monitor movement of migrating juveniles (pit tags or radio tracking devices)	5		
		reduced abiltiy to evade predators due to stress		water quality data during period of outmigration	monitor conditions of outmigrants	3 for 1+ fish, 5 for 0+ fish	poor water quality lowers juveniles' vigor	
	inadequate food supply	lack of nutrients	Moyle 2002	RCD, FS macroinvertebrate samples from the canyon		5		
	lack of flow	loss of habitat			refer to above factors.			Note: lack of flow later in the outmigration season can exacerbate these listed factors
		loss of cover						
		increased density						
		increased predation						
	temperature out of preferred range	stress		datason information, HOBOS; RCD temperature report	monitor conditions of outmigrants; assessment of available thermal refugia in the main stem; determine return of adults related to outmigration	3 for 1+ fish, 5 for 0+ fish		temperature may become problematic later in the outmigration season
		disease		F&W report regarding health of chinook juveniles (Foote 2001?)	conduct health report pertaining to coho juveniles	3	gas bubble disease has been suspected in the past; could be exacerbated by increased main stem temperatures	

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		alteration of food supply		RCD, FS macroinvertebrate samples from the canyon	analyze macroinvertebrate samples for species distribution and abundance and diversity	3		
	lack of connectivity / stranding	inability to migrate			add age identification and whether smolting to fish rescue data	3 for 1+ fish, 5 for 0+ fish		Moffet Creek, Rattlesnake,
		fish rescue/relocation		fish rescue information (F&G)	determine whether smolts are being captured in the rescue program	5		

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Outmigration: Klamath River

Juvenile Outmigration	poor water quality	temperature out of preferred range		F&WS (Arcata) temperature data; Water Quality Control Board data	use rotary screw trap data and correlate with Wallace's (CDFG) estuary sampling data	3 for 1+; 2 for 0+ and some late outmigrating 1+ fish	heating and low flows throughout watershed	
Klamath River		lack of cold water refugia	Nielsen 1991	Deas reports; Summer 2002 Klamath River Thermal Refugia Study	determining carrying capacity of thermal refugia areas; determine how thermal refugia is maintained; identify stratified pools that may have been missed by FLIR (e.g. habitat typing info)	2	heating and low flows throughout watershed	
		eutrophiciation		Arcata data re: juvenile fish kills; DO measurements at Big Bar trap?; hydrolab data; Water Quality Board info on nutrient loading; Deas algae study	review and analyze existing data	2 for 0+ and 3 for 1+	increased nutrient loading from various sources	
		pollutants		locations of mining sites; county pesticide records	testing for specific pollutants	5		
		disease		Scott Foote (F&W); Gerry Bartholemew (OSU); Arcata F&W	existing species for chinook need to be expanded to include other species; determine effects from hatchery fish	2	possible influence from hatchery stocks; higher temperatures, poor water quality, and density	juvenile fish kills reported by Happy Camp and Weitchepec?
		poor DO concentrations			see above columns for eutrophication and temperature out of preferred range			

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	inadequate flow	loss of edge habitat		Tom Shaw's flow study; historical photo comparisons	determine what habitats are used by outmigrants in the Klamath	5	road construction; development of riparian corridor; recalaimation of lands for agriculture; mining tailings	
		loss of cold water refugia - tribs	[see loss of cold water refugia above]					
	blocked fish passage	lack of connectivity at trib mouths		Karuk Tribe fish barrier inventory for Mid-Klamath	determine what habitats are used by outmigrants in the Klamath; determine if there is information re: fish barriers for lower Klamath (Yurok)	5	Iron Gate; upper basin water use; roads; altered stream morphology	probably only an issue for 0+ fish
	stranding	abrupt flow changes		stranding observations; Tom Shaw's Instream Flow Study; Hydropower project studies	Need to understand effects of flow changes	5	Iron Gate; upper basin water use; altered stream morphology	
	rescue and relocation				find out if any rescue is occuring	5		
	competition	hatchery fish		rotary screw trap data; hatchery release datal; Wallace estuary sampling data	determine carrying capacity with modelling or instream flow study	2	hatchery release program's production goals; limited habitat	
		competition with non-native warm water fish		Karuk Tribe observations; creel census; screw trap data; electofishing information	census of nonnative fish and details about their locations and population numbers; educational signage	5	introductions of nonnative fish (intentional and unintentional); poor water quality that favors nonnative fish	areas around Orleans have shad, sunfish, and other nonnatives

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Outmigration: Estuary

Juvenile outmigration	loss of habitat	sedimentation		Mike Wallace - depth transect information?	Determine how river bar at the mouth has changed over time	2	upslope processes and decreased flows	
Estuary		change in estuarine configuration		Mike Wallace data?	aerial photo analysis and comparisons	2	development, land reclaimation, building of Hwy 101	
	poor water quality			Mike Wallace data?; Yurok data?; Water Quality Control Board?; pinnaped studies that include water quality information	analyze existing information	5	increased temperatures, decrease DO	
	inadequate water quantity			Mike Wallace data?; Yurok data?; Water Quality Control Board?; pinnaped studies that include water quality information; gage at Hwy 101 bridge	analyze existing information	2		can decrease edge habitat; exacerbates connectivity problem due to lack of sediment flushing
	predation		Moyle 2002	pinnaped studies; HSU wildlife department cormorant data	expand exsisting data sources	3		
	competition				determine carrying capacity and species interactions in estuary	5		

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***Note: Helicopter water dropped in fire suppression efforts from water buckets that have not been cleaned can introduce whirling disease**

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Ocean rearing	harvest	commercial and recreational	PFMC and NOAA data; CDFG Marine Fisheries Branch; ODFW; The Megatable		track coho movements with coded wire tags; determine fishing efforts from non-US sources; determine actual migratory route of salmon	5		
	poor ocean conditions		Sarah Borok (CDFG Arcata) - report on effects of oceanic conditions on salmon stocks					
		lack of food	NOAA estimates of upwelling conditions		education from existing data sources	5		
		PDO and El Nino	NOAA sources		education from existing data sources	5		
	predation		?		education from existing data sources	5	smaller smolt sizes from poor riverine rearing conditions can increase suceptibility to ocean predation	

Adult Migrations: Estuary

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Adult Migration	Water Quantity (Flows)	low flow barrier at mouth						
Estuary		increased fish density						
		longer "holding" time Increased predation increased disease						
	Water Quality	Temperature						
		Nutrients						
	Harvest	tribal fishery						
		sports fishery						
	Disease							
	Predation	mammal						

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Adult Migration: Klamath River

Adult Migration	inadequate water quantity (flow)		Sandercock 1991; Moyle 2002					
Klamath River		low flow barriers			ask fisheries programs operating on the Klamath River if there are low flow barriers during migration	3		
		longer exposure to possible -harvest, predation, disease		pinnaped studies (Stephanie Holzworth)	seek information on holding times in lower Klamath and estuary	5	increased fish "holding" time	
	insufficient holding habitat					5	loss of pool volume; low flows	
	poor water quality	temperature out of preferred range	Sandercock 1991; Nielsen 1991			5		possibly more of a factor for earlier segment of run
		eutrophic conditions		2002 fish kill reports (F&W, F&G)		5		possibly more of a factor for earlier segment of run; may be fish more suceptible to disease
	Disease	density				5		possibly more of a factor for earlier segment of run
		timing				5		possibly more of a factor for earlier segment of run
	Harvest	sport		Creel surveys; megatable		5		
		tribal			investigate tribal catch information	5		
		poaching				5		

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Adult Migration: Scott River

	Inadequate water quantity (flow)		Sandercock 1991; Moyle 2002					
Adult Migration		lack of olfactory cues for homing			literature review regarding mechanics of homing to see if flow is known to be a component elsewhere	5	low flows persisting into time of adult migration can prevent needed olfactory cues from being available	possibly a factor for observed fish holding in the Scott below Boulder Creek in 2001?
Scott River		lack of access to valley		Maurer 2002 and ongoing spawning surveys	identification and descriptions of barriers and classify by origin (anthropogenic or natural); Documentation of when fish can acess ideal spawning areas; longitudinal profiles to determine areas expected to go dry (biannually or after significant change) - tie to well and guage data	2	connectivity is climate-dependent and varies year to year depending on when the first rain events happen; stockwater use; stormproofing methods sometimes aggravate connectivity problem	Just above mouth of Boulder Creek was a barrier in 2002; occurs only under certain conditions some years; tailing pile above Sugar Creek; below Boulder Creek (in very low flows); Whitehouse Falls
		lack of holding habitat		FLIR data?; habitat typing data; radiotelemetry data from Karuk tribe	temperatures on main stem during time of migration; observational data collection	3	loss of pool volume; lack of flow from tribs; increased temperature of tribs; simplification of channel upstream	
		predation / poaching / incidental catch			poaching and incidental catch information from F&G	3		

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	Poor water quality	temperature out of preferred range	Sandercock 1991; Nielsen 1991		temperatures on main stem during time of migration (Nov and Dec); look at weir data	3		
		eutrophic conditions			monitor DO levels during migration	3		
		pollutants and turbidity masking navigational cues	Bjornn and Reiser 1991	SWAMP data?	water testing for pesticides	5		