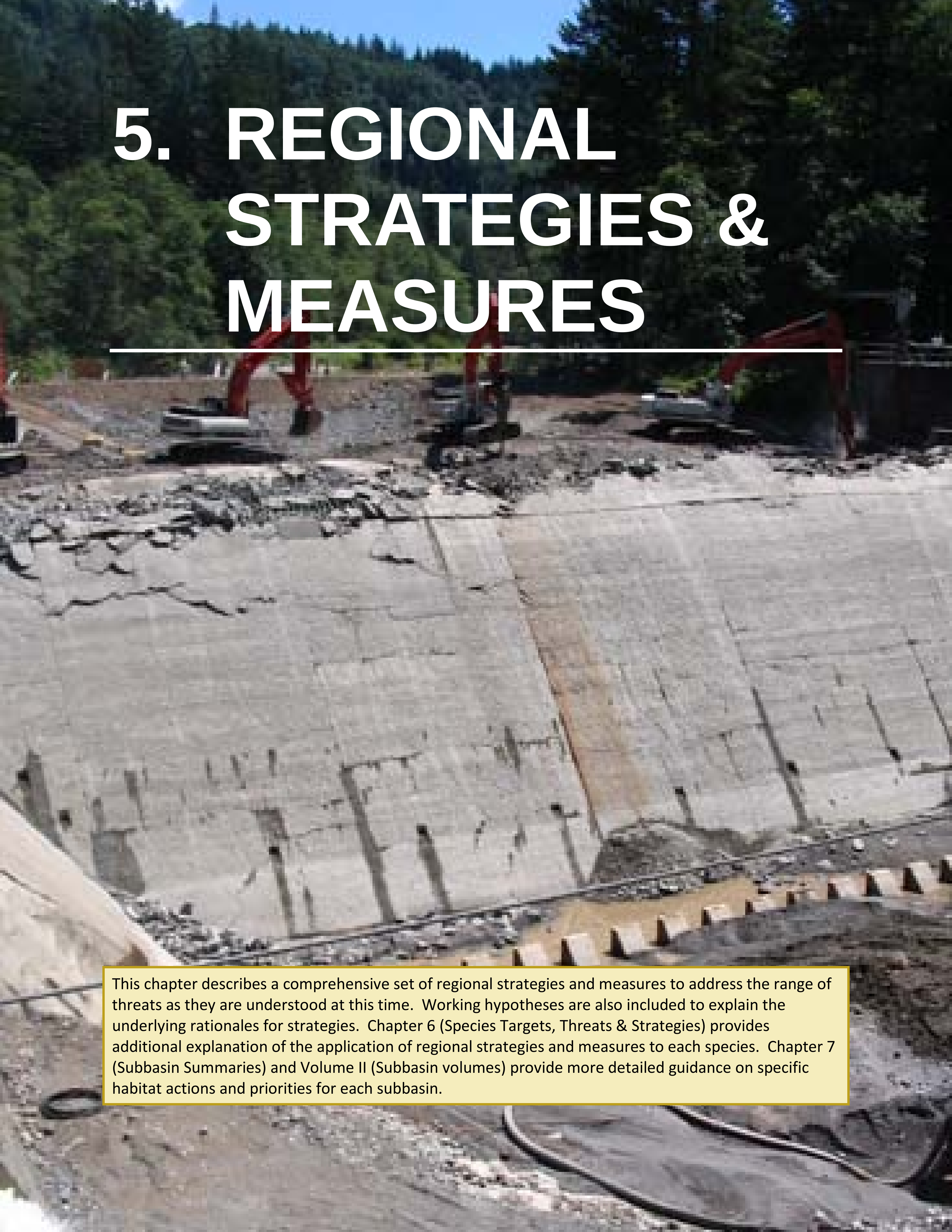

5. REGIONAL STRATEGIES & MEASURES

This chapter describes a comprehensive set of regional strategies and measures to address the range of threats as they are understood at this time. Working hypotheses are also included to explain the underlying rationales for strategies. Chapter 6 (Species Targets, Threats & Strategies) provides additional explanation of the application of regional strategies and measures to each species. Chapter 7 (Subbasin Summaries) and Volume II (Subbasin volumes) provide more detailed guidance on specific habitat actions and priorities for each subbasin.

5. REGIONAL STRATEGIES & MEASURES

Tables

5.1 Overview

This chapter describes the means by which the regional recovery vision will be achieved including:

- Strategies –provide broad guidance, and
- Measures – provide specific descriptions of the mechanisms or categories of actions needed to carry out the strategies.

Strategies and measures are fundamentally intended to produce biological results but are also based on economic, political, social, and cultural considerations. These considerations are critical to the prospects for developing and implementing an effective and equitable plan. Regional strategies and measures were developed in a series of meetings and workshops involving a working group of representatives from implementing and affected agencies. The strategies and measures included in this Plan provide initial guidance based on the current state of our understanding of limiting factors and threats. It is expected that refinements will occur during the Plan implementation process.

This Plan identifies an integrated regional strategy for affecting recovery and a series of threat-specific strategies and measures. The integrated strategy provides overarching guidance for developing complementary measures across and among each of the limiting factor/threat categories in order to balance demands and expectations among all affected parties. Threat-specific guidance addresses each of the seven categories of threat: subbasin stream habitat and watershed conditions; estuary and mainstem habitat; tributary and mainstem hydropower configuration and operation; in basin and out-of-basin harvest; mitigation and conservation hatcheries; and ecological interactions including non-native species, food web, and predation; and climate and ocean effects.

Working hypotheses describe the technical basis for the definition of strategies and measures in this Plan. Hypotheses generally describe conclusions, assumptions or beliefs based on analyses of limiting factors and threats. Many working hypotheses are conclusions based on extensive scientific evidence. Other hypotheses are consistent with scientific information but should be considered assumptions until corroborated by further testing. These assumptions represent testable hypotheses needed to bridge gaps in existing information and provide direction for Plan development.

Measures are categorized based on whether they are existing or new and whether they primarily provide protection or restoration benefits. These categories will help inform priorities and schedules for specific actions addressing these measures which will be developed during Plan implementation. Category A measures are currently being implemented and continued implementation will be critical to recovery. Category B measures expand protection of existing conditions and help ensure that species are not subjected to increased or new threats to viability. Category C measures restore degraded conditions or substantially reduce existing threats where improvement is feasible. Category C measures will help reverse baseline declining trends and establish a trajectory to future recovery.

Table 5-1. Key to labeling scheme for Recovery Plan hypotheses, strategies, measures, and actions.

	Regional	Stream	Estuary	Dams	Fisheries	Hatchery	Interaction	Climate & Ocean	Other Species	Monitoring
Hypothesis	RH	SH	EH	DH	FH	HH	IH	CH	OSH	MH
Strategy	RS	SS	ES	DS	FS	HS	IS	CS	OSS	MS
Measure	--	SM	EM	DM	FM	HM	IM	CM	OSM	MM

5.2 Integrated Regional Strategy

The integrated strategy is intended to ensure that recovery efforts are developed and implemented by using a scientifically sound and systematic approach. It strives to ensure that all recovery actions effectively complement and support each other in achieving the recovery goal: healthy, harvestable populations of salmon and steelhead. It is also intended to ensure that the cost and consequences of achieving recovery are equitable across affected constituencies. Recovery can be achieved with different combinations of actions implemented at different intensities among and on varying timelines within each limiting factor/threat category. The integrated regional strategy defines expectations and requirements for affected parties who will implement this Plan in a broader context of scientific, technical, economic, political, social, and cultural considerations.

The integrated regional strategy recognizes that salmon recovery will not be easy, quick, or inexpensive. Nor can recovery be achieved solely by addressing any single category of threat. Spreading the responsibility among each category lessens the cost to any one group, increases the certainty of success, and compounds the benefits of moderate improvements in each factor. Incomplete human understanding of biological systems, and the effects of human activities and management practices on those systems, necessarily result in uncertainty about the outcomes of the Recovery Plan. Science provides a direction for recovery, bounds the range of expectations, identifies critical first steps, and flags faulty logic and assumptions. Science does not provide a cookbook recipe that details exactly how much of each action will be required to ensure recovery. This Plan recognizes high uncertainty regarding the magnitude of effect of any given action or suite of actions by identifying a directional approach which lays out actions that target threats and identifies who should implement those actions.

5.2.1 Working Hypotheses

R.H1. It is feasible to recover naturally-spawning salmon and steelhead to healthy and harvestable levels in the Washington lower Columbia Region.

Explanation: This hypothesis presumes that conditions are not irreversibly altered such that improvements cannot reverse declining trend in salmonid numbers. This Plan assumes that recovery can realistically be achieved by marshalling a collective public will for fish and wildlife conservation and restoration.

R.H2. Substantial improvements in salmon and steelhead numbers, productivity, distribution, and diversity will be required to achieve recovery.

Explanation: As the saying goes, 200 miles into the woods and 200 miles out. The baseline threatened status of many salmonid species results from widespread and pervasive changes in their ecosystem over the last two centuries. Many of these changes will require substantive measures to address. However, improvements in multiple limiting factors will have compounding benefits to fish status.

R.H3. No single limiting factor or threat is solely responsible for the baseline viability or health of salmon and steelhead nor can all recovery goals be achieved based solely on improvements in any one factor.

Explanation: Analyses detailed in technical appendices confirm that many different factors and threats have contributed to salmon declines and that significant improvements in multiple factors will be needed for recovery.

R.H4. Substantive recovery actions have already been implemented in many areas but existing program actions are not sufficient to reach recovery goals for all species.

Explanation: There has been a long history of fish protection and restoration activities. Significant actions have been taken prior to ESA listings. These actions have provided substantial benefits but many species and populations remain at significant risk.

R.H5. Recovery of salmon and steelhead cannot be achieved solely based on local actions. Human activities throughout the extensive range and life cycle of salmon and steelhead affect their health and the habitat upon which they depend. Recovery depends on local, state, regional, national, and in the case of harvest, international action.

Explanation: In-basin and out-of-basin actions are needed to address the full spectrum of factors and threats limiting anadromous salmonids.

R.H6. Many of the actions needed for salmon will have broader ecosystem benefits but additional actions will be needed to reach and balance goals among all fish and wildlife species of interest.

Explanation: Significant habitat improvements in tributary subbasins, the Columbia mainstem, and estuary will stabilize trends and restore some conditions more similar to a historical baseline. A wide variety of native fish and wildlife species will benefit from these habitat conditions.

R.H7. Strategies and measures likely to contribute to recovery can be identified based on limiting factors and threats but estimates of the incremental improvements resulting from each specific action are generally uncertain.

Explanation: Natural systems are complex. No amount of research can resolve all uncertainties and further delay in implementing substantive recovery actions places listed species at great risk.

R.H8. Effective strategies and measures will include considerations of both biological, social and political values.

Explanation: Science can provide guidelines for the development of effective strategies and measures but successful implementation will depend on social and political considerations requiring decisions by policy makers to balance both biological and human values. The vision may involve a description of an ESUs abundance and productivity, but it will also include choices about human-induced mortality and the cost to various sectors of society. Many combinations of actions could be chosen that would lead to recovery. Yet, the decision on which specific blend of actions to take will have substantial social, economic, and cultural costs and benefits.

5.2.2 Strategies

R.S1. Meet species ESU/DPS goals for viability based on a recovery scenario that establishes priorities for population recovery consistent with TRT criteria.

Explanation: The recovery scenario identifies viability objectives for each population. The combination of populations and population status levels are designed to meet TRT recovery criteria for a viable ESU. Specific population objectives may be defined anywhere within the range between very low and very high levels of viability. The TRT criteria recognize that not every listed population needs to be restored to high or very high levels of viability to affect recovery. The recovery scenario designates individual population goals at three levels of contribution: Primary populations targeted for restoration to high or very high viability; Contributing populations are those for which some improvement will be needed to meet stratum-wide criteria; and Stabilizing populations that would be maintained at baseline levels.

R.S2. Implement strategies and measures that address each category of threat related to statutory listing factors.

Explanation: Categories include stream habitat, estuary and mainstem habitat, hydropower, harvest, hatcheries, and ecological interactions. Recovery cannot be achieved without significant improvements in each category. Recovery criteria include specific evaluations of threats related to the statutory listing factors established by the ESA.

R.S3. Establish long-term impact reduction targets for each threat category that are proportionate to approximate magnitude of the impact of each on salmon and steelhead viability.

Explanation: This plan is based on the principle that recovery of the region's salmon and steelhead is a shared responsibility and that the burden of recovery should be shared equitably over the long-term by the region's stakeholders. Long-term population-specific impact reduction targets are established for each threat category in keeping with this principle. Specifically, the targets call for the impacts of each threat category on a given population to be reduced by an equal proportion based on the productivity improvement needed to achieve the population's viability objective. For example, if a population's productivity must be improved by 40% to achieve its viability objective then the impacts of each threat category for the population must commensurately be reduced by 40%. Threat categories with large impacts can expect large but proportional reductions. Threat categories with small impacts can expect smaller but still proportional reductions. The long-term impact reduction targets are based on an equitable allocation of biological or productivity improvements needed to achieve specific population viability objectives, not on equitably allocating the challenges, level of effort, and costs of achieving those viability objectives. However, the level of effort, potential cost, and feasibility were considered in setting population viability objectives. It is expected that deliberate and aggressive action will be taken to achieve the impact reduction targets for all threat categories. The impact reduction targets may be revisited and revised periodically through the Plan's adaptive management process. In keeping with the Plan's principle of equitably allocating the burden of recovery, impact reductions should not be increased for one risk category due to the delay or failure to implement actions to address another threat category.

R.S4. Implement substantive, immediate measures where feasible to reduce near term risks in the interim until long term targets can be realized.

Explanation: While it is a goal of the Plan to ensure the equitable sharing of the recovery burden over the long-term, the Plan also recognizes that the need to manage near-term risks to population viability will temporarily result in some stakeholders bearing a disproportionate share of the burden. Many Lower Columbia salmon and steelhead populations currently have a low or very low viability or a high or very high extinction risk. The Plan is based on the premise that aggressive near-term actions will be taken to address all threats. However, the benefits of these actions are realized over different timeframes. Some actions, such as fishery reductions, can have immediate benefits. Benefits of other actions, particularly those involving habitat and hatcheries, can take years to be fully recognized. In order to reduce near-term viability or extinction risks, the front-loaded implementation strategy, as described in Chapter 4, asks fishery stakeholders to shoulder a greater share of the recovery burden until the risk reduction contributions from other recovery actions can be realized. The front-loaded strategy does not support a delay in the implementation of actions to address hatchery, habitat, estuary, dam, and ecological threats. Aggressive implementation of substantive actions to address all threats is required in the near term. It is noted that fishery reductions consistent with the front-loaded strategy have already been implemented in the first 12 years since listing. While fishery impact reductions offer the greatest opportunity to reduce near-term risks, opportunities to reduce near-term risks in other risk categories should also be implemented whenever possible.

R.S5. Use the ESA listing date as a baseline reference for identifying the improvements needed to achieve fish recovery.

Explanation: A variety of recovery actions have already been implemented and others are planned. The ESA listing date provides a common reference point for measuring the improvements needed to achieve recovery. It provides a reference date consistent with NMFS' review of population status and threats during the listing determination period. It also allows the recognition of progress that has been made over the past several years in addressing some threats and limiting factors. Many fish protection and restoration actions have been implemented prior to listing but identifying a common standard for consideration is problematic. Some beneficial actions date back decades (e.g. curtailment of splash dams and large scale commercial fishing). Contributing historical "credits" are much less important to fish recovery than the current scope for improvement.

R.S6. In evaluating the contributions of existing programs to recovery, both accrued and anticipated improvements will be considered.

Explanation: Both the accrued and expected recovery contributions of existing programs can be considered in evaluating the proportional improvements required for each factor/threat category. This will provide a more accurate indication of the additional improvements needed to achieve recovery. Existing actions are not expected to be sufficient to meet recovery goals consistent with the working hypotheses described earlier.

R.S7. Identify a suite of factor-specific recovery strategies and measures scaled to meet biological and threat reduction targets.

Explanation: The suite of strategies and measures identified in this Plan was designed consistent with the order of magnitude of needed improvements identified in the biological objectives. Considered collectively and within each category of limiting factors and threats, these strategies and measures were scaled to provide significant and measurable improvements in fish status and ecosystem health.

R.S8. Identify an appropriate balance of recovery strategies and measures that address manageable limiting factors and threats throughout the range and life cycle of salmon and steelhead.

Explanation: Salmon recovery cannot be achieved in a vacuum that does not consider threats and limiting factors throughout the range and life cycle of fish. Identifying where other activities pose risks to local populations will provide a basis for pursuing appropriate changes. Conversely, the existence of out-of-region threats does not eliminate the need to undertake substantive local actions.

R.S9. Focus near term actions on listed species while also ensuring a long term balance with other species of interest and the ecosystem.

Explanation: A fundamental strategy in this Recovery Plan is to avoid large-scale irreversible changes including species extinction. In the near term, protecting and stabilizing at-risk species can sometimes be prioritized over enhancement of healthier species as long as other species are protected from significant risk. In some cases, it may be most effective or efficient to manage other species for the benefit of at-risk species or to concentrate efforts and expenditures in favor of at-risk species. However, protection, management, and enhancement of all species and ecosystem components must be considered over the long term. A short-sighted focus only on at-risk species could inevitably doom other species that are currently healthy to a similar fate.

R.S10. Implement a recovery strategy that recognizes an inherently high degree of uncertainty in assessments of the impacts of human factors and the benefits of actions to address threats.

Explanation: Given substantial uncertainty in the effects of many limiting factors/threats and in the expected response to specific actions, this Plan does not attempt to quantify the incremental contributions toward recovery of each individual strategy and measure. Some measures address threats and produce outcomes that can be confidently quantified. Other measures address threats or produce responses that are not easily estimated. These uncertainties were recognized with other contingencies incorporated into this Plan including the biological objectives incorporated into the recovery scenario, requirements for substantive action and significant contributions for each limiting factor/threat category, and a strong monitoring, evaluation, and adaptive element. The key to effective analysis in an uncertain world is to frame an approach that recognizes that uncertainties will always remain in specific data, analyses, and assumptions. Uncertainties can be addressed by a variety of methods, all of which are incorporated into this Plan:

- Explicitly identifying uncertainties and transparently communicating methods, strengths, and limitations of each analysis.
- Incorporating known uncertainties into the risk analyses. For instance, uncertain ocean survival can be incorporated as a random variable into a population viability modeling framework for integrated fish life cycle analysis to estimate extinction risks. Uncertainty in any population process or limiting factor can be captured similarly.
- Incorporating corroborative analyses to validate key conclusions independently.
- Using analyses to identify the risks associated with key uncertainties and identifying critical uncertainties in the form of testable hypotheses that may be addressed with future monitoring and evaluation through adaptive management.
- Identifying conclusions based on the weight of all evidence, rather than any specific analytical result, and with appropriate safety margins to buffer risks.
- Including substantive measures that address every significant listing factor and threat.
- Including safety factors into the Plan to provide a buffer to offset the effects of uncertain or faulty assumptions. Safety factors may be included in biological objectives to target higher levels of recovery than minimum requirements in case efforts for some populations fall short.
- Incorporating a strong research, monitoring, and evaluation program that provides an information feedback loop for modifying prescribed actions. Future monitoring and analysis of lower Columbia salmon and steelhead populations is of utmost importance because, without sufficient data, it will be impossible to determine whether remedial actions are helping.

R.S11. Establish interim benchmarks for impact reductions and status improvement in order to guide adaptive implementation of recovery strategies and measures.

Explanation: Interim benchmarks provide near, intermediate, and long term reference points for evaluating progress toward recovery in the implementation of actions addressing each category of threat (i.e. red light/green light signals). Benchmarks are integral to the adaptive implementation approach identified in this Plan involving periodic checkpoints of progress and course corrections toward recovery goals and objectives. This adaptive implementation process is required due to the high degree of uncertainty in the scale of recovery action implementation and the benefits of specific actions.

R.S12. Identify benchmarks for actions and effects in each category of threat under the expectation that implementation partners in every sector will aggressively implement appropriate measures to restore healthy and harvestable species.

Explanation: Recovery goals, objectives, targets, benchmarks, strategies and measures identified in this plan are predicated on the premise that all partners will aggressively implement appropriate actions to address their equitable share of the recovery burden. Actions by each recovery partner are undertaken based on the assurance that all recovery partners will implement the identified Plan actions for which they are responsible. Each partner is independently accountable for meeting their responsibilities. Failure to act or achieve targets for any given threat category does not justify failure to act or achieve targets for other threat categories. At the same time, no recovery partner should be held responsible or penalized for the failure of other partners to act or achieve targets in their respective area of responsibility.

5.3 Habitat –Streams

5.3.1 Working Hypotheses

S.H1. Healthy, harvestable salmon populations depend on favorable stream habitats for migration, spawning, and rearing.

Explanation: Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity that helps maintain adequate numbers. Even during poor ocean conditions, high quality habitat will allow populations to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication.

S.H2. Baseline stream habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable naturally-spawning salmon and steelhead populations.

Explanation: Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (a.k.a. the 4-H's). Land and water use practices have contributed to large decreases in habitat quality and quantity in all subbasins. Subbasin habitat declines have been compounded in the Lewis and Cowlitz subbasins by dam construction and operation that have blocked large areas of good habitat and virtually eliminated some populations.

S.H3. Recent changes in land and water use practices are improving salmon habitat conditions in some areas and will further improve salmon habitat over time. In other areas habitat conditions continue to decline, and substantial changes are needed to support the recovery of naturally-spawning populations.

Explanation: Land use practices vary substantially between regulatory jurisdictions on the lower Columbia River. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. Recent changes in land and water use practices are improving salmon habitat conditions in some areas and will further improve salmon habitat over time but additional changes are needed in many areas to support the recovery of naturally-spawning populations. Particularly damaging practices such as splash damming to transport logs and temporary dams to divert water have been relegated to the past. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced positive effects. Others are expected to pay future dividends. Still other changes will be needed to offset the cumulative effects of years of habitat degradation.

S.H4. Recovery can be achieved without restoration of pristine historical conditions and without restoration of optimum habitat conditions in every subbasin.

Explanation: Recovery guidelines identified by the Technical Recovery Team and status assessments indicate that viable populations can typically be restored at numbers substantially less than those corresponding to properly functioning conditions. Model estimates indicate that TRT viability goals for adult abundance and productivity — produced with population change criteria modeling — are generally lower than Ecosystem Diagnosis and Treatment model numbers under properly functioning conditions for habitat.

S.H5. Some level of increased habitat protection and restoration will be required in every subbasin to arrest declining trends and ensure that population status does not decline further.

Explanation: A significant increase in habitat protection and restoration will be required in every subbasin to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The magnitude of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery goals. Projected human population growth in lower Columbia River subbasins will compound the demands for increased habitat protection and restoration just to stabilize fish populations at baseline levels. Both regulatory and non-regulatory tools exist.

S.H6. Long-term improvements in stream habitat conditions will depend on restoration of functional watershed processes.

Explanation: Salmon depend on suitable stream habitat conditions which in turn are dependent upon conditions in tributary and upstream watersheds. Local habitat activities can provide short-term benefits but long-term improvements in stream habitat conditions will depend on restoration of functional watershed processes and access to existing quality habitat. Where watershed conditions have been degraded, stream habitat forming processes will progress toward a new less functional equilibrium with their surroundings. Where watershed conditions have been restored or allowed to improve naturally, stream habitat forming processes will progress toward a more fully-functional equilibrium. Access to quality habitat can achieve immediate and lasting benefits for fish. Restoring access can include the removal of culverts, providing fish passage at dams, and reconnecting isolated side channels and wetlands.

S.H7. Restoration of functional habitat-forming processes in watersheds is a large-scale undertaking with limited prospects for immediate relief of acute extinction risks for salmon.

Explanation: Habitat forming processes are driven by the cumulative effect of conditions across the landscape of a watershed. The areas affecting conditions increase with distance downstream. Thus, restoration of functional stream habitat-forming processes in watersheds is a large-scale undertaking. Moreover, the degradation of these processes occurred incrementally over a period of decades. Effective restoration processes, even in part, will also require decades. Even where changes are implemented immediately, it may take years for benefits to fully accrue. For instance riparian protection measures might require 30-80 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited immediate relief for acute extinction risks caused by baseline low salmon population numbers.

S.H8. It is more effective and less costly to restore access to quality habitat and to protect existing high quality habitat than to attempt restoration of degraded habitat, although restoring habitat access and protecting habitat will not be sufficient to achieve recovery.

Explanation: Widespread habitat improvements can be very costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation that precludes future changes in use but does not require a change to previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional impacts. Restoring natural, habitat forming processes can also be less costly than active restoration of stream conditions, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. Protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. For example, chum salmon occupy lower reaches of watersheds that have historically been highly urbanized and developed, or that will be in the next 50 years. Active restoration in previously disturbed areas may be necessary and for this species in particular.

S.H9. Site-specific habitat improvements and access can help ameliorate acute extinction risks.

Explanation: Although effects may often be temporary, site-specific improvements in stream habitat conditions and access can help ameliorate immediate extinction risks in the interim until underlying causes of degraded stream habitat are addressed. Even where recent changes to land and water use patterns can be expected to restore population viability in the long term, more immediate actions may be required to make sure that the fish survive to reap those long term benefits. Moreover, in areas that have been extensively developed it may not be feasible or technically possible to restore habitat-forming process. In these areas, active on-going site-specific restoration actions may be the only means available to secure needed habitat conditions.

S.H10. Salmonid populations require unimpeded access to stream habitats, at all life stages, during all migration periods. Fish passage at culverts is one of the most recurrent and correctable obstacles to healthy salmon stocks. In some cases, many miles of quality salmonid spawning and rearing habitat are blocked by single barriers.

Explanation: Barriers to migration can be particularly damaging to salmon and steelhead populations. Barriers range from large mainstem hydropower dams to inadequate culverts sprinkled among the myriad of small tributaries to which anadromous species return.

S.H11. Factors and activities affecting stream habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by fish and wildlife to any given action or set of actions.

Explanation: These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The Recovery Plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

5.3.2 Strategies

S.S1. Provide habitats adequate to sustain healthy, harvestable salmon and steelhead runs in Washington lower Columbia River subbasins through access improvements, habitat protection, and restoration.

Explanation: Healthy and harvestable goals cannot be achieved without significant habitat improvements. Improvements may take the form of increased access to suitable habitats, protection of existing habitats, and restoration of suitable habitat quality for salmonids.

S.S2. Configure habitat protection and restoration activities among subbasins to support region-wide recovery goals.

Explanation: Salmon recovery will require high levels of habitat protection and restoration in many subbasins but recovery can be achieved with a mixture of high levels of improvement in some basins and more limited activities in other subbasins. Recovery scenarios identify improvements in specific populations that vary among watersheds but ultimately add up to a viable group of populations (e.g. ESU or listing unit). Primary populations need to be restored to at least a high viability level. Contributing populations need to show significant improvement. Stabilizing populations need to be protected from further declines. Not every population needs to be subjected to the same level of recovery effort. Protection and restoration activities can be concentrated in specific areas so long as the net effect considered across the region ensures that a sufficient number of unique populations are restored to or maintained at specified levels. Opportunities exist to support recovery by clearly delineating priorities for habitat protection and improvements among the regions subbasins and within subbasins. This is a substantial change from pre-Recovery Plan implementation of ESA that generally applied uniform habitat standards in all subbasins and portions of subbasins.

S.S3. Afford high levels of protection to stream and watershed habitats that currently support significant fish production for Primary and Contributing fish populations.

Explanation: As fish population and habitat productivity have declined, spatial distribution has contracted back to a limited amount of habitat that now supports a large fraction of naturally-spawning fish production. Baseline and future fish status depends on protection of these strongholds. A fundamental priority of fish recovery efforts will be to protect baseline core production areas to preserve significant remaining populations and provide the genetic material for fish restoration efforts.

S.S4. Address stream habitat conditions that limit fish as well as stream habitat forming processes in watersheds or subwatersheds that affect stream habitat in any given location.

Explanation: Stream habitat quality is often a symptom of conditions in tributary watersheds including those upstream. Sustainable long term improvements in stream habitat conditions for salmon will require restoration of functional watershed processes including those that affect water, wood, and sediment delivery to streams.

S.S5. Restore access of key populations to blocked habitats in historically accessible subbasins or portions of subbasins where necessary to support region-wide recovery goals and closely coordinate access improvements and habitat improvement activities.

Explanation: This strategy addresses local fish access issues in subbasins. Large scale loss of access due to dam construction is addressed separately in the Hydro strategy section. Lack of fish passage has eliminated access to many areas that historically supported significant fish production. Areas include upstream reaches of many subbasins where culvert construction or diversion structures impede or block passage. Habitat quality in many blocked areas continues to be suitable for salmon. Local passage improvements can restore access to significant amounts of favorable habitat. Restoring access may include removal of culverts, providing fish passage at dams, and reconnecting isolated side channels and wetlands. The amount and quality of habitat that can be opened for various populations varies considerably across the region. This strategy may involve a priority for restoring access to currently inaccessible high quality habitat for primary and contributing fish populations.

S.S6. Maximize effectiveness and efficiency of habitat restoration activities by concentrating in areas adjacent to core production areas, currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Explanation: Recovery criteria require some populations be restored to high levels of viability. All other things being equal, this is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will also require some restoration of areas that are substantially degraded but also provides significant flexibility in areas where habitat restoration efforts are distributed among and within subbasins. Restoration efforts should prioritize habitat actions that build out from and connect baseline core production areas.

S.S7. Implement habitat restoration actions sufficient to offset projected future trends in conditions such that no net loss in habitat occurs.

Explanation: Recovery criteria identified by the TRT dictates that all populations be protected from further degradation until such time as recovery goals are achieved. Baseline declining habitat trends in some areas and future development pressures result in a need for substantive habitat protection and improvement measures to maintain the baseline status.

S.S8. Utilize a combination of active and passive habitat restoration measures to provide near-term and long-term benefits.

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but only rarely provide lasting improvement unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures that protect and restore riparian zones or surrounding watersheds do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions). Habitats undergoing restoration through active and passive measures also require ongoing protection.

S.S9. Use existing procedures and programs wherever possible to take maximum advantage of opportunities for efficient implementation of habitat protection and restoration measures.

Explanation: A wide variety of regulatory and non-regulatory procedures and programs that can contribute to habitat protection and restoration are currently in place across the overlapping jurisdictions in the Washington lower Columbia region. However, in many jurisdictions, "Best Available Science" has not yet been used directly to determine appropriate habitat protection measures.

S.S10. Consider salmon recovery needs up-front in the comprehensive land use planning process, along with other social, infrastructure, and service needs.

Explanation: Implementation of salmon recovery efforts at the local government scale is driven largely by the existing land use planning and regulatory processes. However, critical areas (e.g., streams, wetlands, etc) protection has historically been addressed as an afterthought in the planning process. Infrastructure, housing, resource lands (e.g., agriculture, industrial, etc.), and service needs have been the primary drivers in determining how much, and where, growth occurs. Protection of critical areas has generally not been dealt with "up-front" in the comprehensive planning process. This approach has been inadequate in protecting existing salmonid populations from further declines. Direct consideration of salmon recovery needs in comprehensive land use planning would help steer growth to areas of the least impact, instead of the current approach of trying to mitigate impacts as an afterthought. Once a growth plan is prepared and development is proposed, critical areas are protected through regulatory means on a project-by-project, piece-meal basis.

S.S11. Undertake aggressive action including encouragement of innovative actions and incentives for habitat protection and restoration projects.

Explanation: Recovery of these listed salmon and steelhead populations almost universally demands serious improvements in stream habitat conditions that cannot be accomplished with token or timid efforts. Aggressive proactive measures are required. Aggressive habitat protection and restoration effort risking occasional missteps is appropriate where the potential benefits are also large. The best prospects for success will involve providing very strong incentives to encourage aggressive efforts. There is wide room for innovation and the recovery program needs to seek every opportunity to push the envelope in the identification and implementation of effective measures.

5.3.3 Measures

Habitat measures represent the activities that are needed to address habitat limiting factors and threats (addressing individual and/or multiple threats). In some cases, these measures may already be underway or required under existing regulations or programs. Habitat measures are often characterized as being passive restoration, active restoration, or preservation. Passive restoration refers to practices that remove the agent of degradation (stressor) and allow the system to recover naturally (e.g. levee removal). Active restoration refers to practices that are intended to accelerate the return to functioning conditions (e.g. re-establishing meander patterns, large woody debris supplementation). Preservation actions prevent degradation from occurring and protect areas and processes that have been restored (e.g. purchase of a conservation easement in a floodplain).

Habitat protection measures can take many forms across many scales. It can be site-specific or watershed-wide and can involve regulatory and programmatic approaches. Addressing watershed-wide habitat forming processes requires a scientific, data-driven understanding of each watershed and subwatershed. In the absence of such understanding, site-specific protections may not be adequate to address cumulative effects. When analyzing the level of protection in place, it is necessary to determine if habitat-forming processes are protected across the watershed. If the watershed is not protected, tighter site-specific measures may be needed. Programs should evaluate their operations against the Recovery Plan and processes at work in their service area. Protection actions must be described in terms of their scale across the watershed within which they are applied. Each watershed should then be evaluated to make sure there will be no degradation of habitat-forming processes. A listing of watershed-specific protection needs and measure's is included in the subbasin chapters of this Plan.

Habitat measures can be framed using any one of a number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration projects). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. A combined approach was used to describe the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

These measures represent all of the potential measures throughout the lower Columbia region. Some measures apply in nearly all of the subbasins, whereas others are specific only to a subset of the basins. Subbasin-specific measures are found in the subbasin chapters in Volume II of this Plan.

S.M1. Protect habitat conditions and watershed functions through land acquisition or easements where existing policy does not provide adequate protection. (Category A, B)[1]

- ***Purchase properties outright through fee acquisition and manage for resource protection***
- ***Purchase easements to protect critical areas and to limit potentially harmful uses***
- ***Lease properties or rights to protect resources for a limited period***

[1] Measures and/or actions are categorized based on whether they are existing or new and whether they primarily provide protection or restoration benefits. These categories will help inform priorities and schedules for specific actions addressing these measures which will be developed during plan implementation. Category A measures are currently being implemented and continued implementation will be critical to recovery. Category B measures expand protection of existing conditions and help ensure that species are not subjected to increased or new threats to viability. Category C measures restore degraded conditions or substantially reduce existing threats where improvement is feasible. Category C measures will help reverse current declining trends and establish a trajectory to future recovery.

- ***Designate set-asides where no use or limited uses are allowed (e.g. metro greenspaces, wilderness areas)***

Explanation: Establishing preservation areas is the most effective avenue to habitat protection. Preservation areas should ideally be located in properly functioning areas that support productive fish populations. Preservation areas can take the form of land designations (e.g. wilderness areas), private land acquisition, leases of properties or rights, or conservation easements. Land designations are established by land owners or managers and may require legislative approval in situations such as wilderness area designations. Land acquisition is conducted by public entities or private organizations (e.g. land trusts) with the purpose of preventing future degradation. Public and private entities can also purchase conservation easements or leases on critical properties, with the purpose of preventing detrimental land-uses for the contract period. Conservation easements do not purchase the land outright. Examples of conservation easement programs are the Conservation Reserve Enhancement Program (administered by the NRCS), the Riparian Open Space Program (administered by WDNR), and the Small Forest Landowner Riparian Easement Program (administered by WDNR).

S.M2. Protect habitat conditions and watershed functions through land-use planning that guides population growth and development. (Category A, B)

- ***Plan growth and development to avoid sensitive areas (e.g. wetlands, riparian zones, floodplains, unstable geology)***
- ***Encourage the use of low-impact development methods and materials***
- ***Apply mitigation measures to off-set potential impacts***

Explanation: Comprehensive land-use planning and land use controls can provide important habitat protections by regulating growth and land use so that critical areas and watershed functions are preserved. Population growth forecasts for the region identify continued heavy growth, especially in Clark County. Other population centers and rural residential development will continue to expand, with much of the growth occurring in sensitive areas. Land-use planning that limits growth, concentrates new growth in non-sensitive areas, and protects critical areas will be necessary to prevent further ecosystem degradation. Critical areas protections, such as those called for under the WA State Growth Management Act (GMA), are administered by local jurisdictions, although not all jurisdictions have adopted adequate critical areas protections. Critical areas include stream channels, riparian areas, floodplains, wetlands, aquifer recharge areas, and geologically hazardous areas. Development or other potentially harmful activities in these areas are regulated as part of critical area protections. It is crucial that all jurisdictions in the region adopt adequate critical areas protections. As required by law, the GMA specifies that critical areas protections should be based on the ‘best available science’, which will be necessary for correctly defining critical areas and identifying potential threats. Only two of the 5 major counties that make up the study area (Clark and Lewis Counties) are currently fully planning under the GMA, which involves comprehensive land-use planning that addresses natural resource impacts.

Throughout the study area, forest and crop land is being converted to urban and residential uses, which results in increased ecosystem disturbance. In these areas, preserving existing uses through zoning or other regulatory mechanisms will be necessary to prevent further habitat degradation. Limitations on land-use conversion and growth are often very politically and economically difficult to achieve, resulting in a low probability of success.

S.M3. Protect and restore instream flows. (Category B, C)

- ***Water rights closures***
- ***Purchase or lease existing water rights***
- ***Relinquishment of existing unused water rights***
- ***Enforce water withdrawal regulations***

- ***Implement water conservation, use efficiency, and water re-use measures to decrease consumption***

Explanation: These instream flow measures relate to depleted stream flows resulting from water withdrawals, and not to alterations to stream flows due to changes in watershed runoff processes or hydro-regulation, which are covered under separate measures. Instream flow measures are aimed at retaining water in streams for protection of aquatic resources. Low flow concerns exist in most streams at certain times of the year, especially where surface and groundwater withdrawals contribute to depletion of stream flows. These measures include closures (administrative or formal rule closures) that restrict the allocation of new water rights, purchasing or leasing water rights, ensuring the relinquishment of unused water rights, enforcing withdrawal regulations, and implementing water conservation measures. These measures are often difficult to implement because of existing water rights and continual increases in demands. Some of these measures have a potential cost to land-users due to foregone use (e.g. loss in crop production) or costs associated with obtaining alternative water sources. If implemented, however, withdrawal reductions can begin to yield benefits immediately.

Purchasing or leasing existing water rights can be an effective method for reducing existing use or preventing additional water withdrawals. This approach has the advantage of being conducted within the current legal framework with compensation provided to water rights holders. It has been used in portions of WA State but not to any significant degree in the study area.

Relinquishment of water rights refers to the "use it or lose it" policy that is common in Western water law. As the policy now stands in WA State, if a water right is not used for a consecutive 5-year period, the water right is relinquished back to the state. Municipal uses are exempt from this policy and water rights holders can apply for exemptions based on a number of criteria. The primary drawbacks to this policy include the difficulty with monitoring whether water rights are being exercised or not and the lack of enforcement.

Water rights regulations enforcement is lacking in most stream systems in the lower Columbia region and the actual extent of illegal withdrawals is unknown. In some stream systems, illegal withdrawals are believed to contribute to low flow problems at certain times of the year. Increased monitoring and enforcement will be necessary to prevent potentially detrimental illegal withdrawals.

Water conservation and water use efficiency are important aspects of addressing water withdrawal concerns. During critical times of the year or during drought conditions, water use can be curbed through community education or water use limits. Water conservation and water use efficiency can also be increased through upgrades to water delivery systems, water re-use, and development of alternative water sources.

S.M4. Protect and restore fish access to channel habitats. (Category B, C)

Explanation: Restoring access to critical spawning and rearing habitats can be one of the simplest and most effective restoration strategies. Restoration of habitat connectivity in streams typically involves correction of a passage obstruction that is restricting access to a portion of the stream channel. The most common passage barriers in stream channels include dams and culverts. Other types of barriers include tide gates, fish ladders, and diversion structures. In some cases, barriers may also be created by alterations to channel morphology or stream temperature.

The biological benefits of passage restoration are often realized within a couple of years, since re-colonization can occur relatively rapidly. Project success is often high, especially given the considerable amount of research that has been conducted on passage requirements for salmonids. The costs of culvert replacement are often relatively minor, although establishing passage at dams can be very expensive and politically challenging. There is considerable effort underway to inventory and upgrade culverts across the region. These efforts are being conducted by the USFS, WDOT, the LCFRB, and other cooperators. Passage has been provided around the Cowlitz River mainstem dams for years. Passage around the Lewis River hydro-system is currently being evaluated and is expected to occur within the next few years.

Protection of fish passage is generally provided for under existing regulations and agency policy. Construction standards for forest and non-forest roads on private, state, and federal lands prohibit the creation of passage obstructions.

S.M5. Manage regulated stream flows to provide for critical components of the natural flow regime. (Category B, C)

- ***Provide adequate flows for specific life stage requirements (e.g. migration, summer rearing)***
- ***Address geomorphic effects of hydro-regulation (e.g. channel-forming flows, sediment transport)***

Explanation: Addressing regulated flows will confront some of the threats posed by hydropower operations. The annual hydrograph of the Lewis and Cowlitz Rivers has been altered from pre-dam conditions due to hydro-regulation. In general, spring flows have been reduced, summer base flows and fall flows have been increased, portions of some channels have been de-watered, and frequently occurring peak flows have been reduced. Some of these alterations may directly benefit certain life stages of fish (e.g. increased base flows benefit summer rearing), but may have indirect long-term negative consequences to fish due to impacts to channel form, sediment/substrate conditions, floodplain function, and riparian vegetation. Restoration emphasis should be placed on critical components of the natural flow regime, such as providing for occasional channel forming flows and providing for adequate flows for smolt migration. Sediment transport through dams should also be addressed where possible, with substrate enhancement below dams if necessary.

Many limiting factors are addressed through regulated flow restoration. These include primarily stream flow impacts (e.g. habitat dewatering), habitat diversity (e.g. channel-forming flows), and riparian function. Restoring stream flows has a relatively high probability of success, although power and recreation demands may out-compete natural resource needs in drought years. Re-establishing channel-forming flows may be difficult in some cases due to real or perceived flood impacts. Costs of flow restoration range from relatively low to quite high, especially if significant power generation is forgone. The benefits of regulated flow restoration accrue very quickly in some cases (e.g. flushing flows for smolt migration) and more slowly in other cases such as channel-forming flows, since a period of channel adjustment may be necessary before habitats become suitable.

S.M6. Protect and restore floodplain function and channel migration processes. (Category B, C)

- ***Set back, breach, or remove artificial channel confinement structures***

Explanation: Floodplain degradation occurs as a result of a variety of land uses and can impact many limiting factors including stream flow, substrate and sediment, water quality, habitat diversity, and channel stability. The lower reaches of many lower Columbia streams have been straightened, channelized, and diked in order to create useable land, protect land-uses, and to increase flood conveyance. Restoration of a stream's access to its floodplain is achieved through partial or full removal of confining structures or through channel grade-control. Floodplain restoration addresses limiting factors related to stream flow, channel stability, habitat connectivity, and biological processes (e.g. nutrient exchange). These projects have a moderate-to-high probability of success and address important limiting factors, but they are typically expensive and politically challenging, especially if infrastructure is potentially at risk (e.g. risk to floodplain development if levees are breached). Floodplain reconnection projects have occurred infrequently in the study area and are typically only partially implemented (e.g. levee set-backs as opposed to levee removal). Nevertheless, some significant floodplain and estuarine reconnection / restoration projects have begun on the Chinook and Grays Rivers.

S.M7. Protect and restore off-channel and side-channel habitats. (Category B, C)

- ***Restore historical off-channel and side-channel habitats where they have been eliminated***
- ***Provide access to blocked off-channel habitats***
- ***Create new off-channel or side-channel habitats (e.g. spawning channels)***

Explanation: Off-channel and side-channel habitats serve important roles for anadromous fish, resident fish, and wildlife. These habitat types provide important spawning areas, rearing sites, and refuges from disturbance. These habitats are dynamically created and maintained in unconfined alluvial channels. Examples of off-channel habitats include oxbow lakes, wetlands, and backwater sloughs. Off-channel and side-channel habitats are lost as a result of many of the same practices that reduce floodplain function, including channel straightening, floodplain filling, and artificial confinement. In some instances, off-channel habitats exist but access to them is blocked by barriers such as levees, roadways, or tide-gates. With the exception of barrier removal, restoration of off-channels and side-channels is best accomplished passively, through restoration of floodplain connections and channel migration zone processes. Active restoration approaches, such as excavating fill from historical off-channels, may be necessary in some cases where full function cannot be restored. Where populations have suffered from severe loss of critical off-channel habitats and where existing infrastructure limits restoration options, the creation of new habitats (e.g. spawning channels) may be necessary. This approach has been used in the creation of chum spawning channels in the Grays River and Bonneville Tributaries basins.

S.M8. Protect and restore instream habitat complexity. (Category B, C)

- ***Place stable woody debris in streams to enhance cover, pool formation, bank stability, and sediment sorting***
- ***Structurally modify stream channels to create suitable habitat types***

Explanation: In-stream habitat complexity is necessary to create the diversity of habitats and structural features utilized by fish at their various life stages. Important components of habitat complexity include large woody debris, boulders, spawning substrate, and a patchwork of habitat unit types (e.g. pools, riffles, glides). Habitat complexity is created and maintained by natural processes including channel migration, channel adjustment, sediment transport, and large woody debris recruitment. Restoration of habitat complexity is best accomplished through passive measures that restore watershed processes, riparian function, and floodplain connections. Active approaches to restoring habitat complexity include placement of in-stream structural components (i.e. large woody debris), substrate supplementation, and structurally modifying stream channels (e.g. re-meandering).

Many limiting factors are addressed by restoration of in-stream habitat complexity; however, active channel restoration often only addresses the symptoms and not the causes of limiting factors. To be successful, active channel restoration must be paired with restoration of the habitat-forming processes that served to create the limiting factors in the first place. Because habitat-forming processes are often not adequately addressed, active channel restoration varies widely in probability of success. It can also be very costly. An advantage to active channel restoration is that if implemented successfully, the benefits can be realized within a few years, an important consideration when faced with urgent risks to species.

Many active channel restoration projects have been conducted in the study area. The most common projects are large woody debris supplementation efforts. Changes to channel meander patterns and direct creation of habitat units have also occurred in some streams. The long-term benefits of many of these projects have not been fully evaluated because of their recent implementation.

S.M9. Protect and restore stream-bank stability. (Category B, C)

- ***Restore eroding stream banks***
- ***Restore mass wasting (landslides, debris flows) within river corridors***

Explanation: Projects that protect or restore stream-bank stability address habitat diversity, channel stability, and substrate and sediment limiting factors. Stream-bank erosion and mass wasting are natural processes that are necessary for habitat formation, large woody debris recruitment, and substrate delivery; however, land-use practices that artificially compromise bank stability can contribute to impaired channel adjustment and sediment delivery processes. Stream-bank instability occurs in two primary forms: 1) erosion of the bed and banks of stream channels, and 2) mass wasting within the river corridor. Bed and bank erosion occurs as bed scour or lateral bank erosion. Mass wasting occurs as landslides, gully formation, or debris flows. Stream-bank stability impairments are related to hillslope conditions (i.e. runoff, sediment supply) or to conditions within channels, riparian areas, and floodplains.

The most effective restoration measures include passive measures that restore the channel conditions or watershed processes that are contributing to the instability. Examples of passive measures include riparian reforestation, restoration of the natural runoff regime, and reductions in artificial confinement.

Active restoration measures include structural stabilization or vegetative plantings. The best approaches often utilize a combination of structural and vegetative measures known as bio-engineering techniques. To be successful, active channel restoration must be paired with restoration of the habitat-forming processes that served to create the limiting factors in the first place. Because habitat-forming processes are often not adequately addressed, active channel restoration varies widely in probability of success.

S.M10. Protect and restore riparian function. (Category B, C)

- ***Reforest riparian zones***
- ***Allow for the passive restoration of riparian vegetation***
- ***Livestock exclusion fencing***
- ***Invasive species eradication***
- ***Hardwood-to-conifer conversion***

Explanation: Riparian degradation occurs as a result of a variety of land uses and can impact many limiting factors including stream flow, substrate and sediment, water quality, habitat diversity, and channel stability. Riparian restoration can take many forms. The most common type of riparian restoration is re-vegetation, which is a quasi-active restoration strategy, since plantings are initially conducted as a jump start, but the system is then left to recover on its own. Recovery of riparian vegetation is a critical step in system recovery as it addresses many of the habitat threats and in-stream limiting factors. As with other active restoration approaches, environmental stressors (e.g. livestock grazing) must be addressed for riparian plantings to be successful. Re-vegetation projects are very cheap and have a moderate-to-high probability of success. Benefits, however, take a long time to accrue. Stream shading, bank stability, and large woody debris improvements may not be realized for 30 to 80 years or more. These time lags should not deter the implementation of these projects, which can be a great investment in future watershed function. Due to the ease, cost, and community involvement potential, many re-vegetation projects have been conducted throughout the study area.

One of the most common restoration strategies on grazing lands is riparian exclusion fencing for livestock. This passive restoration strategy allows for trampled soils to stabilize, decreases animal waste delivery to streams, and allows the riparian plant community to recover. Riparian fencing is relatively inexpensive and has a high probability of success, if maintained properly. Some benefits, such as reductions in trampling and animal waste generation, accrue within the first few years. Other benefits, such as the benefits resulting from recovery of vegetation, may take many years to accrue. Riparian fencing has occurred along many streams in the study area, particularly through the efforts of the NRCS and local Conservation Districts (CDs).

Although significant riparian timber harvest occurred in the past, riparian areas currently receive protection from forest practices. Forest practices policies on private, state, and federal lands are geared towards riparian protections that maintain stream shade, wood recruitment, and stream bank stability.

S.M11. Protect and restore natural sediment supply processes. (Category B, C)

- ***Address forest road related sources***
- ***Address timber harvest related sources***
- ***Address agricultural sources***
- ***Address developed land sources***

Explanation: Restoration and protection of sediment supply processes addresses the substrate and sediment limiting factors. Sediment supply process restoration on forest lands includes road abandonment, road maintenance, ditch-line disconnect from stream channels, forest re-vegetation, and implementation of proper forest harvest practices. Protections of sediment supply processes are provided for in private, state, and federal forest practices policy. Road construction and maintenance standards are aimed at ensuring that no degradation to fish habitat occurs due to erosion or stream bank destabilization. Restrictions are placed on upland harvests that have a potentially adverse impact on unstable slopes and landforms.

In the last several years, the USFS has actively removed roads and upgraded problem roads on federal lands. On private lands, the new Forest Practices Rules (FPRs) contain strict standards for road construction and require timberland owners to submit road maintenance and abandonment plans. As these programs continue to be implemented, corresponding improvements to limiting factors are expected.

Road abandonment is very expensive and carries a risk of fill failure and continued erosion if not conducted and maintained properly. Proper maintenance and upgrades of existing roads can accomplish some of the same objectives as removal, but to a lesser degree. The social costs (e.g. limited human access) and economic costs of maintenance/upgrades are considerably less than abandonment, at least in the near term. The benefits from forest road restoration projects are likely to be realized in less than a decade.

Forest re-vegetation and wildfire risk reduction projects can help to protect and restore sediment supply processes. Re-vegetation of harvested areas is inexpensive and highly successful. Stabilization of harvest-related mass wasting sites is often less successful until a mature forest is re-established. Forest re-vegetation is standard practice on public and private lands and is required under the new FPRs for harvests greater than 50% of the timber volume.

Restoration of sediment supply processes on agricultural lands is accomplished through the application of agricultural Best Management Practices (BMPs) with respect to erosion control. These include activities such as conservation tillage and cover cropping. Tax incentives and cost-free technical assistance programs (e.g. through the NRCS) have resulted in many farmers implementing conservation measures on their lands.

S.M12. Protect and restore runoff processes. (Category B, C)

- ***Address forest road impacts***
- ***Address timber harvest impacts***
- ***Limit impacts from forest fires***
- ***Limit additional watershed imperviousness***
- ***Manage storm water runoff***
- ***Protect and restore wetlands***

Explanation: Restoration and protection of runoff processes addresses stream flow, water quality, critical habitat, channel stability, and substrate and sediment limiting factors. Runoff impairment throughout the lower Columbia basin is related to forest practices, urban development, and channel / floodplain alterations. Land-use impacts have the greatest effect on frequent interval (2-10 year) floods and little effect on extreme flood events. Elevated peak flow volumes can increase the risk of redd scour and sedimentation.

Protections of runoff processes are provided for in private, state, and federal forest practices policy. Forest road construction and maintenance standards are aimed at ensuring that no degradation to fish habitat occurs due to ground water capture or surface water diversion. There are also restrictions placed on upland harvests in order to reduce the potential for increased snow accumulation and melt rates that can potentially increase runoff volumes during storm events. The adequacy of these restrictions has not been fully evaluated.

In the last several years, the USFS has actively removed roads and upgraded problem roads on federal lands. On private lands, the new FPRs contain strict standards for road construction and require timberland owners to submit road maintenance and abandonment plans. Road abandonment can reduce flow concentration and reduce conversion of stream flows from subsurface to surface flows (groundwater capture). Benefits and risks associated with road abandonment projects are discussed under the sediment supply measure. As these programs continue to be implemented, corresponding improvements to limiting factors are expected.

Forest re-vegetation and wildfire risk reduction projects can help to restore stream flow limiting factors. Re-vegetation of harvested areas is inexpensive and highly successful; however, hydrologic benefits of re-vegetation are not seen until after 25 years or more. Forest re-vegetation is standard practice on public and private lands and is required under the new FPRs for harvests greater than 50% of the timber volume. Wildfires in forested watersheds can also severely impact watershed and stream conditions. Wildfire risk reduction projects including timber harvest and thinning can thus have significant benefits where other detrimental effects are controlled.

Runoff preservation and restoration on developed lands includes storm water retention/infiltration measures, urban storm water BMPs (e.g. pervious pavement, on-sight runoff control, living roofs, etc), reductions in watershed imperviousness (e.g. fewer hard surfaces, more natural vegetation, less compacted soils), and changes to uniform building codes and development regulations (UBCs and the Fire Marshall often require excessive paving, wide roads and cul-de-sacs, and place restrictions on alternative low-impact building methods).

Due to the permanent infrastructure of developed lands, which is unlikely to be restored to pre-disturbance conditions, runoff restoration in these areas is more accurately classified as rehabilitation or mitigation as opposed to restoration. The existing infrastructure also makes for a low probability for success and great expense. For example, even though expensive storm water attenuation projects are required for most major developments, there is little evidence that they are sufficient enough to reduce harmful impacts to stream flows. Rehabilitation of watershed processes in developed lands will require aggressive measures at local (e.g. residential storm water infiltration) and municipal (e.g. storm water retention) scales. Efforts on developed lands in the study area should focus on the expanding Vancouver metropolitan area and on rural development that is encroaching on many of the lowland river valleys.

Wetlands are critical for attenuating stream flows, providing for nutrient exchange, and for creating complex habitats. Wetlands restoration can address several limiting factors, including habitat connectivity, stream flow, water quality, habitat diversity, and biological processes. Wetland areas have been reduced by a host of land-use practices, with agriculture and development having the greatest impacts. Wetlands restoration involves restoring historical wetlands or creating new wetlands to mitigate for loss of historical wetlands. Wetlands mitigation is often required by local jurisdictions when development results in irreversible wetlands loss. Restoring historical wetlands has a high probability of success if the agent of degradation is removed from the site. Mitigation wetlands have a much lower probability of success because natural conditions at the site may not be able to sustain wetland processes. Wetlands restoration can be very expensive, especially if an active approach is taken to create the appropriate structure and function. Passive approaches, such as letting an historical wetland recover on its own, are less expensive but may take decades. Wetland mitigation occurs frequently in developing areas in the study area, especially in the expanding urban areas within Clark County. Wetlands mitigation and restoration is especially important in these areas, which historically consisted of abundant wetlands throughout the broad Columbia River floodplain. Wetland restoration has also occurred in many other locations in the study area, often associated with riparian restoration efforts. Restoring wetlands in riparian and floodplain areas can yield important benefits to fish, including habitat creation and increased nutrient / food resources.

S.M13. Protect and restore water quality. (Category B, C)

- ***Restore the natural stream temperature regime***
- ***Reduce fecal coliform bacteria levels***
- ***Reduce turbidity sources***
- ***Restore dissolved oxygen concentrations***
- ***Reduce delivery of chemical contaminants to streams***
- ***Reduce sub lethal effects of contaminants***

Explanation: Water quality restoration and preservation measures address water quality limiting factors. Restoration can take many forms, including restoration of channel, riparian, and hillslope watershed processes that are discussed in other measures. These include riparian re-forestation, livestock exclusion fencing, recreation management, and restoration of sediment supply processes.

Water quality restoration and preservation on agricultural lands includes livestock exclusion fencing to reduce bacteria and erosion, on-sight manure management to prevent nutrient/bacteria loading, and application of agricultural BMPs with respect to pesticide, herbicide, and fertilizer use. These practices have a moderate probability of success and can be fairly expensive, especially for small-scale farmers. Tax incentives and cost-free technical assistance programs (e.g. through the NRCS) have resulted in many farmers implementing water quality related measures on their lands throughout the lower Columbia region.

Water quality restoration and preservation on forest lands involves sediment supply measures (turbidity), riparian measures (temperature, turbidity, dissolved oxygen, nutrients), and forestry BMPs that address pesticide, herbicide, and fertilizer use (chemical contaminants). Water quality protections on forest lands are generally covered under existing private, state, and federal forest practices policy.

Water quality restoration and preservation on developed lands involves managing industrial point sources of pollution, eliminating urban and rural sewage discharge to streams (e.g. urban sewage overflows, leaking septic systems), and treating storm runoff before it is discharged to streams. Chronic, sub lethal effects of contaminants are a source of particular concern.

Water Quality Standards are the basis for protecting and regulating the quality of surface waters in Washington (http://www.ecy.wa.gov/programs/wq/swqs/index.html). The standards implement portions of the federal Clean Water Act by specifying the designated and potential uses of water bodies in Washington State. They set water quality criteria to protect those uses and acknowledge limitations. The standards also contain policies to protect high quality waters (anti-degradation) and in many cases specify how criteria are to be implemented, for example in permits.

S.M14. Restore channel and floodplain areas damaged as a result of streamside gravel mining and reduce risks of future impairment due to these activities. (Category C)

- ***Prevent potentially harmful mining wastes, high temperature water, and turbidity from entering streams***
- ***Prevent fish stranding in processing areas***
- ***Stabilize surface mining sites to prevent erosion***
- ***Reduce the risk of gravel pond capture, while providing for natural channel migration processes***
- ***Restore channel morphology where streams have avulsed into mining areas***

Explanation: Mining site restoration includes stabilization of exposed substrate, re-vegetation, reduction in water quality impacts, reductions in channel avulsion risks, re-habilitation of degraded stream channels, and adequate fish screening. The primary limiting factors that are addressed include water quality, substrate and sediment, channel stability, riparian function, and floodplain function. Restoration aimed at decreasing erosion and sedimentation can occur through stabilizing dredge material and through measures that sever connections between processing areas and stream channels. Abatement of water quality impacts requires alterations to processing techniques, treatment of water prior to stream discharge, or effectively severing connections between processing areas and stream channels. On a few streams in the study area (e.g. East Fork Lewis River), restoration activities will need to focus on restoring the natural channel morphology where streams have avulsed into gravel mining/processing ponds. Future avulsion risk will also need to be addressed. In some instances, recovery of mining areas may provide an opportunity for floodplain, wetland, and channel migration zone restoration.

The success of mining site restoration will vary widely depending on the problems and techniques used to solve them. Efforts such as altering processing techniques or screening processing ponds can be very successful, whereas stabilizing dredge material or decreasing avulsion risk may prove very challenging, especially considering that many of these sites are located within the 100 year floodplain or geomorphic floodplain. There is also great variation associated with the time that is needed until benefits are realized. Water quality impacts could potentially be curbed within a few years, whereas channel migration zone recovery could take decades.

S.M15. Protect and restore sensitive areas through recreation management. (Category B)

- ***Limit intensive recreational use where there is harassment potential***
- ***Actively rehabilitate areas damaged by intensive recreational use***

Explanation: Recreation-related restoration efforts include rehabilitating damaged terrain, limiting use, and waste management. Rehabilitation efforts are sometimes necessary to reduce erosion and re-establish native vegetation, especially in areas where intensive motorized recreation occurs (e.g. all-terrain vehicles). Limiting recreation use will be necessary in some cases to allow the system to recover. Limiting use can also reduce direct harassment effects on aquatic biota. Such activities include swimming and boating in salmonid spawning, juvenile rearing, or adult holding areas during critical periods. Human waste management is a concern in areas of intensive use. Providing waste management or disposal facilities can reduce impacts.

The success of recreation management and restoration depends on the specific problems and the techniques applied. Success is often hampered by a user group's resistance to recreation limitations or by a lack of adequate enforcement. Recreation has been intensively managed on state and federal lands in the past, but funding cuts, combined with increasing population pressures, are making it increasingly difficult to manage recreation adequately.

S.M16. Maintain and/or establish adequate resources, priorities, regulatory frameworks, and coordination mechanisms for effective enforcement of land and water use regulations for the protection and restoration of habitats significant to fish and wildlife resources. (Category B, C)

Explanation: Establish cooperative enforcement partnerships among agencies, public, land owners, and industry. Establish priorities to emphasize protection in key areas and facilities where recovery efforts are focused.

5.4 Habitat—Estuary & Columbia Mainstem

5.4.1 Working Hypotheses

E.H1. Complex and dynamic interactions between physical river and oceanographic processes, as modulated by climate and human activities affect the general features of fish and wildlife habitat in the Columbia River estuary and lower mainstem.

Explanation: Habitat formation in the lower Columbia River mainstem and estuary is controlled by opposing hydrologic forces; ocean processes (tides) and river processes (discharge). Both hydrologic processes are affected by anthropogenic factors and climate cycles and variability. These processes control estuary bathymetry, water turbidity, salinity, nutrients, and woody debris, which in turn determine the location and type of habitats that form and persist throughout the estuary and lower mainstem.

E.H2. Human activities have altered how the natural processes interact, changing habitat conditions in the Columbia River estuary and lower mainstem.

Explanation: Anthropogenic factors have substantially influenced the current habitat conditions in the lower Columbia River mainstem and estuary. The primary anthropogenic factors that have determined estuary and lower mainstem habitat conditions include hydro system construction and operation (i.e., water regulation), channel confinement (primarily diking), channel manipulation (primarily dredging), and floodplain development and water withdrawal for urbanization and agriculture. Generally, these anthropogenic factors have influenced estuary and lower mainstem habitat conditions by altering hydrologic conditions, sediment transport mechanisms, and/or salinity and nutrient circulation processes. Projected population growth and land use conversion will continue to pressure habitat conditions and habitat-forming processes for salmon and steelhead in the estuary and lower mainstem.

E.H3. Changes in the Columbia River estuary and lower mainstem habitat are the result of local activities as well as activities throughout the Columbia and Snake River basins.

Explanation: This hypothesis exemplifies the idea that 'everything flows downstream'. Because of the location within the Columbia River basin, lower mainstem and estuary habitats are affected by both local and basin-scale activities.

E.H4. Rates of obvious physical habitat change in the Columbia River estuary and lower mainstem have slowed in recent years, baseline physical and biological processes are likely still changing such that habitat conditions represent a degraded state of equilibrium.

Explanation: The habitat alterations that have occurred since pre-development times have degraded the quality and quantity of habitat in the estuary and lower mainstem. Because this historical trend in habitat loss appears to have slowed recently, the estuary and lower mainstem habitat conditions are in a degraded state of equilibrium. This emphasizes the urgency of the current need to implement habitat restoration actions to reverse the trend of habitat loss.

E.H5. Our current understanding of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and introduces substantial uncertainty in decisions intended to benefit recovery and sustainability of natural resources.

Explanation: Our current understanding of causal relationships between salmonids, non-salmonid fishes, and wildlife and the habitat conditions or habitat-forming processes in the Columbia River estuary or lower mainstem are unclear. Much of what we know about the effects of changing habitat conditions on salmonid habitat requirements in the estuary is based on limited estuary-specific research or is speculative based on known salmon and habitat relationships in non-tidal freshwater. Continued research is vital to the progress and success of restoration and recovery efforts in the Columbia River estuary and lower mainstem.

E.H6. Exotic species are capitalizing on the Columbia River estuary and lower mainstem habitats and they have impacted ecosystem processes and relationships.

Explanation: The current biotic community in the Columbia River estuary and lower mainstem is fundamentally different today than it was historically because of the introduction of exotic species. All exotic species introductions in the lower Columbia River represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites. Altered habitats in the Columbia River estuary and lower mainstem ecosystem as a result of hydro system development and water regulation have facilitated the successful establishment of aquatic non-indigenous species.

E.H7. Of all fish and wildlife species utilizing the Columbia River estuary and lower mainstem habitat, salmonids appear to be one of the most distressed.

Explanation: Declining salmonid trends in the Columbia River basin are reflected in the prevalence of ESA-listings throughout the basin. The same trend does not hold true for many fish and wildlife species. Despite substantial changes to the Columbia River estuary and lower mainstem ecosystem, many species have stable or increasing abundance trends. This statement must be qualified by the lack of information on many fish and wildlife species. However, salmon are clearly among those at serious risk.

E.H8. The Columbia River estuary and lower mainstem ecosystem is critical to the expression of salmon life history diversity and spatial structure which support population resilience and production basin wide.

Explanation: Estuaries have important impacts on juvenile and subsequent adult salmonid survival. Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean, as well as the olfactory cues needed for successful homing and migration. Juxtaposition of high-energy areas with ample food availability and sufficient refuge habitat is a key habitat structure necessary for high salmonid production in the estuary. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids.

E.H9. Changes in the Columbia River estuary and lower mainstem habitat have decreased the productivity of the ecosystem and contributed to the imperiled status of salmon and steelhead.

Explanation: Salmonid production in estuaries is supported by detrital food chains; habitats that produce and/or retain detritus are particularly important. Diking and filling activities have eliminated the emergent and forested wetlands and floodplain habitats that many juvenile salmonids rely on for food and refugia, as well as eliminating the primary recruitment source of large woody debris that served as the base of the historical macro detritus-based food web. The current estuary food web is micro detritus based, primarily in the form of imported phytoplankton production from upriver reservoirs. This current food web is primarily available to pelagic feeders and is a disadvantage to epibenthic feeders, such as salmonids. Additionally, the decreased habitat diversity and modified food web has decreased the ability of the lower Columbia River mainstem and estuary to support the historical diversity of salmonid life history types.

E.H10. Density dependent factors may affect salmonid productivity in the Columbia River estuary and lower mainstem under some conditions, but their significance is unclear.

Explanation: At our current level of understanding, the importance of density dependent mechanisms in the estuary, if they exist, are not clear. Research in other Pacific Northwest estuaries points toward density dependent mechanisms, although applicability to the Columbia River estuary is unknown. Food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large numbers of salmonids (hatchery or natural) enter the estuary.

E.H11. Habitat restoration efforts are capable of significantly improving conditions for fish and wildlife species in the Columbia River estuary and lower mainstem.

Explanation: Restoration of tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River has been identified as an important component of current and future salmon restoration efforts. These important peripheral habitats could be returned to the lower Columbia River ecosystem via dike removal and restoration of historical flow regimes. Management actions that seek to alter anthropogenic factors and restore natural habitat-forming processes need to be evaluated based on their impact on biological diversity and not simply on production of juvenile salmonids.

E.H12. Estuary and lower Columbia River mainstem habitat restoration efforts would provide substantial benefits for anadromous fish species throughout the Columbia and Snake River basins.

Explanation: All anadromous salmonids in the Columbia and Snake River basins must pass through the estuary twice to complete their life cycle. The estuary is critical to juvenile salmonid survival and smoltification, and it provides the necessary cues for successful return migrations. Improvements to lower mainstem and estuary habitat conditions will improve survival for all salmonids throughout the entire Columbia River basin.

5.4.2 Strategies

E.S1. Avoid large-scale habitat changes where risks to salmon and steelhead are uncertain.

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

E.S2. Mitigate small-scale local habitat impacts such that no net loss occurs.

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site or off site efforts that provide benefits equal to or greater than the losses.

E.S3. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Explanation: Important habitats in the Columbia River estuary and lower mainstem that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats such as tidal swamps and marshes that are isolated or impaired should be restored when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving. Ocean-type juvenile salmonids, in particular, depend on tidal swamp and marsh habitats for food and cover. Since the 1800s, the acreage of these two habitat types in the estuary has declined by 62% and 94%, respectively.

E.S4. Strive to understand, protect, and restore habitat-forming processes in the Columbia River estuary and lower mainstem.

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes are due to natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

E.S5. Improve understanding of how salmonids utilize estuary and lower mainstem habitats and develop a scientific basis for estimating species responses to habitat quantity and quality.

Explanation: Current understanding of how physical processes affect habitat conditions for salmonids in the estuary and lower mainstem is limited because the interrelationships among fish, wildlife, and habitat conditions in the estuary and lower mainstem have been largely understudied. Recent research is beginning to fill this knowledge gap, but additional research—including tagging studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations—could significantly improve our understanding of how salmonid populations use and respond to changing habitat conditions in the estuary and lower mainstem.

E.S6. Recognize the significance of all species to the productivity of the lower mainstem and estuary ecosystem.

Explanation: All species within the lower Columbia and estuary are an integral part of a complex food web. Variable abundance of one species affects the productivity of other species. For example, eulachon are an important prey species of birds and marine mammals. American shad have increased in abundance, becoming an important sturgeon food source. Conversely, juvenile American shad abundance may result in competition with juvenile salmonids for food and habitat.

5.4.3 Measures

E.M1. Protect intact riparian areas in the estuary and its tributaries and restore riparian areas that are degraded.

Explanation: Riparian areas provide key ecological functions that affect water temperature, the availability of insects, and macro detrital inputs to the ecosystem. Riparian areas in the lower Columbia River have been degraded by a number of factors, including shoreline modifications, diking and dike maintenance practices, and activities related to the disposal of dredged material. Protecting intact riparian areas and restoring degraded areas would provide significant benefits to salmonids by reducing water temperatures and increasing macro detrital inputs to the system.

E.M2. Operate the hydro system to reduce the effects of reservoir surface heating, or conduct mitigation measures.

Explanation: Low-velocity flows and broad surface area exposure in reservoirs increase the temperature of flows in the estuary. As cool-water fish, salmonids need stream temperatures of 20º C or lower for normal metabolism, growth, disease resistance, and timing of important life functions such as smoltification and adult migration. Currently salmonids in the estuary are experiencing water temperatures at the upper limit of their tolerance for longer periods and more frequently than they did historically. Modifying hydro system operations to lower water temperatures would aid salmonids in carrying out their essential physiological processes and life functions.

E.M3. Establish minimum instream flows for the Lower Columbia River mainstem that would help prevent further degradation of the ecosystem.

Explanation: Instream flows in the estuary maintain habitat-forming processes and conditions in the estuary and plume. Although some legal instream flows have been established in the Columbia River basin, others are needed, especially with the growing human population in the basin. Establishing legal instream flows for the estuary would protect minimum flow levels in the estuary and plume and support associated habitat-forming processes.

E.M4. Adjust the timing, magnitude, and frequency of flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats and provide better transport of coarse sediments and nutrients in the estuary, plume, and littoral cell.

Explanation: The magnitude, frequency, and timing of flows are an important determinant of habitat opportunity for salmonids in the estuary, who have adapted to historical flows and depend on them to complete their life cycles. Spring freshets in particular are important habitat-shaping events, in part because they aid in the transport of sand and gravel from upstream and estuary sources to the estuary, plume, and littoral cell. This influx of sand and gravel helps maintain salmonid habitats, contributes to turbidity that shelters salmonids from predation, and influences food sources in the plume. Freshets also help juveniles access floodplain habitats that provide traditional insect food sources and contribute macro detritus to the food web. Returning to a more natural hydrograph would have significant ecosystem benefits and affect all facets of salmonid life histories expressed in the estuary and plume.

E.M5. Study and mitigate the effects of entrapment of sediment in reservoirs, to improve nourishment of the littoral cell.

Explanation: The deposition of fine sediment, sand, and gravel behind slow-velocity impoundments in the Columbia River reduces the transport of these materials into the estuary, plume, and littoral cell, thus altering habitat-forming processes and reducing turbidity that otherwise would shelter salmonids from predation. Effectively mitigating the effects of sediment entrapment would provide shallow-water habitats, reduce predation of salmonids in the main channel and plume, and strengthen habitat-forming processes.

E.M6. Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.

Explanation: The transport of sand and gravel from upstream and estuary sources helps maintain salmonid habitats, contributes to turbidity that shelters salmonids from predation, and influences food sources in the plume. Although there are many competing uses for dredged materials, beneficial use of uncontaminated sand and gravel from dredge operations could play an important role in restoring habitat capacity and habitat opportunity in the estuary. Providing sand nourishment in the estuary, plume, and littoral cell would reduce the effects of ship wake stranding, improve habitat for *Corphium* (a food source for salmonids), and be beneficial in the development of emergent marshes and other salmonid habitat features. Sand entering the plume also would provide important ecological benefits.

E.M7. Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.

Explanation: Dredge operations maintain a navigational channel in the Columbia River that concentrates flows, alters tidal influences, reduces circulation patterns around the estuary, and releases toxic contaminants from substrates; once disturbed, these deposited contaminants can be redistributed throughout the estuary and littoral cell. Reducing or mitigating the effects of dredging would reduce salmonids' exposure to contaminants and improve habitat-forming processes.

E.M8. Remove or modify pile dikes that have low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.

Explanation: Extensive use of pile dikes and navigational structures has altered sediment accretion and erosion processes, reduced flow circulation through shallow-water habitats in the estuary, and created favorable conditions for predators of salmonids. Removing many instream structures would improve circulation in shallow-water habitats and eliminate some salmonid predator habitats.

E.M9. Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.

Explanation: Many juvenile salmonids rely on off-channel habitats for feeding and refuge opportunities. Reduced floodplain inundation has limited juvenile salmonids' access to historical wetland and swamp habitat, much of which has been converted to other land uses. Protecting remaining intact and accessible off-channel habitats is critical to maintaining key habitat and food sources for juvenile salmonids.

E.M10. Breach or lower dikes and levees to improve access to off-channel habitats.

Explanation: Many juvenile salmonids rely on off-channel habitats for feeding and refuge opportunities. Historically, insects and macro detritus from these habitats were important inputs to the estuarine food web. Currently, the amount and accessibility of key off-channel habitats has been limited by dikes, levees, tide gates, and filling, which have reduced floodplain inundation and allowed conversion of land to agricultural, residential, and industrial uses. Restoring off-channel areas would reclaim habitat that is important to salmonids.

E.M11. Reduce the square footage of over-water structures in the estuary.

Explanation: Over-water structures may provide habitats for predators and affect instream and shoreline plant communities. However, the total surface area of over-water structures in the estuary has not been quantified, and the structures' case-by-case functions have not been analyzed. Additional research is needed to understand how much salmonids would benefit from reducing over-water structures in the estuary.

E.M12. Reduce the effects of vessel wake stranding in the estuary.

Explanation: Wakes from deep-draft vessels traveling through the estuary wash sub yearling salmonids onto shore, leaving them stranded. Factors that affect stranding include beach slope and time of day as well as vessel draft, speed, and hull design. The extent of mortality caused by ship wake stranding is uncertain, but a study soon to be released by the University of Washington and U.S. Army Corps of Engineers may provide further clarification of the issue.

E.M13. Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.

Explanation: Water-soluble contaminants such as atrazine, chlorpyrifos, and diazinon enter the estuary as a result of tributary and upstream agricultural practices, and DDT has been detected at elevated levels in the estuary. Agricultural contaminants such as these can cause salmonid mortality through bioaccumulation or short-term toxicity.

E.M14. Identify and reduce terrestrially- and marine-based industrial, commercial, and public sources of pollutants.

Explanation: The estuary has been affected by historical and current releases of toxic contaminants, including industrial and commercial pollutants such as PCBs and PAHs, which have been found near Portland, Vancouver, Longview, and Astoria. Recent studies have demonstrated significant juvenile mortality in the estuary as a result of toxic contaminants. Reducing sources of pollutants would lower not just the amount of toxic contaminants in the estuary but also water temperature and nutrient loading. This would improve both habitat capacity in the estuary and the fitness level of salmonids.

E.M15. Monitor the estuary for contaminants and restore or mitigate contaminated sites.

Explanation: This action is intended to address the need to monitor the entire estuary for contaminants; however, actual restoration activities are feasible only in specific reaches. Reducing toxic contaminants in the estuary would improve both habitat capacity and the fitness level of salmonids.

E.M16. Implement storm water best management practices in cities and towns.

Explanation: Municipal storm water runoff can convey toxic contaminants to the estuary, reduce groundwater recharge, and increase the "flashiness" of stream flows. Although many municipalities in the Columbia River basin take steps to reduce the impacts of storm water, wider use of storm water best management practices would markedly improve conditions and provide a net benefit to salmonids in the estuary through a more normal hydrograph, reduced exposure to contaminants, and lower water temperatures.

5.5 Dams

5.5.1 Working Hypotheses

D.H1. Tributary hydropower development and operation has eliminated access to large areas of productive habitat in some lower Columbia subbasins and has also affected habitat suitability downstream.

Explanation: Dam construction in the Cowlitz, Lewis, and White Salmon subbasins has eliminated access of anadromous fishes to large areas of habitat that historically supported productive populations and remains suitable for these species. In the Cowlitz basin, dam construction has blocked 90-100% of the available habitat for Upper Cowlitz, Cispus, and Tilton winter steelhead, coho, and spring Chinook, as well as habitat for fall Chinook and chum. North Fork Lewis dams have similarly blocked 95% of winter steelhead, 50% of summer steelhead, 50% of Fall Chinook, 90% of spring Chinook, and 10% of chum habitat in that system. Inundation of habitats due to dam construction has also affected chum and fall Chinook.

D.H2. Effects on migration and passage mortality of juvenile and adult salmon from gorge populations caused by the configuration and operation of Bonneville Dam has reduced population resilience and inhibits recovery.

Explanation: Most lower Columbia River salmon populations originate from areas downstream of Bonneville Dam and are not subject to passage concerns. However, significant mortality of juveniles from gorge populations continues to occur through turbine passage and to a lesser extent from spillway or turbine bypass systems. Adult Chinook are typically delayed for a short period in the tailrace, but most eventually find and use fish ladders; other species such as steelhead ascend more rapidly. Varying percentages of adults (i.e. by species) do not pass successfully or pass but then fall back over the spillway. Inundation of habitats due to dam construction has also affected chum and fall Chinook, particularly upstream of Bonneville Dam.

D.H3. Construction and operation of the Columbia River hydropower system has contributed to changes in Columbia River estuary and lower mainstem habitat conditions and habitat forming processes that have reduced salmonid population resilience and inhibits recovery.

Explanation: Construction and operation of the Columbia River hydropower system has significantly altered flow, temperature, and sediment transport patterns in the lower mainstem and estuary. The combination of these changes and other local activities has substantially altered habitat conditions for lower Columbia fish and wildlife species. These include direct local effects such as dewatering of chum and fall Chinook redds in the mainstem downstream from Bonneville Dam. Also included are large-scale changes in habitat forming processes.

5.5.2 Strategies

D.S1. Restore access of key populations to blocked habitats in historically accessible subbasins or portions of subbasins where necessary to support region-wide recovery goals.

Explanation: Lack of fish passage has eliminated access to upper Cowlitz, Lewis, and White Salmon rivers where dams were constructed without adequate passage facilities. Habitat quality in many blocked areas continues to be suitable for salmon. Recovery of some salmon runs (e.g. spring Chinook) may not be feasible, according to TRT criteria, without restoration of effective passage upstream and effective juvenile passage downstream of some large tributary dams once populations are reestablished.

D.S2. Assure that the Columbia River and tributary hydropower systems are managed to contribute to recovery of lower river as well as upstream populations.

Explanation: The hydropower systems must be managed to complement and support the recovery of threatened lower Columbia River salmon and steelhead populations. Concerns with mainstem Columbia and tributary dams include passage efficiency, local effects of operations on tailrace habitats, and widespread ecosystem effects of changes in flow, temperature, and sediment transport patterns. Effects on watershed processes must be considered (blockage of marine-derived nutrients to areas above dams, blocked movement of large wood and sediment, changes in historical hydrology and changes in hydro geomorphic processes).

5.5.3 Measures

D.M1. Evaluate and adaptively implement anadromous fish reintroduction upstream of Cowlitz, Lewis, and White Salmon dams and facilities as part of relicensing processes or requirements. (Category C)

Explanation: Evaluations of the implementation of fish reintroductions are already are already underway in the Cowlitz subbasin. Similar efforts are planned as part of the Lewis relicensing agreement and are under consideration in the White Salmon relicensing processes. Uncertainty exists regarding the most effective way to restore passage through dam and reservoir complexes in the Cowlitz and Lewis systems. Dam heights and reservoir sizes make juvenile passage particularly problematic.

D.M2. Develop, maintain and operate effective juvenile and adult passage facilities (including facilities, flow, and spill) at Bonneville Dam and tributary dams when populations are reestablished. (Category B)

Explanation: Effective passage facilities are crucial for Upper Gorge salmon populations as well as every other upstream anadromous fish population. Additionally, effective passage will be crucial in tributaries where populations are reestablished to historic spawning and rearing habitat located above tributary dams. Measure implementation will involve evaluations of proposed passage programs.

D.M3. Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation and rearing periods. (Category A, B)

Explanation: Prevents dewatering and decreased flows in redds during incubation, as well as increasing the potential spawning sites available for adults. Prevents migration barriers, reduces high temperatures in late summer and reduces predation losses.

D.M4. Operate the tributary hydro systems to provide appropriate flows for salmon spawning and rearing habitat in the areas downstream of the hydro system. (Category A, B)

Explanation: The quantity and quality of spawning and rearing habitat for salmon, in particular fall Chinook and chum in the North Fork Lewis and Cowlitz, is affected by the water flow discharged at Merwin and Mayfield dams respectively. The operational plans for the Lewis and Cowlitz dams, in conjunction with fish management plans, should include flow regimes, including minimum flow and ramping rate requirements, which enhance the lower river habitat for fall Chinook and chum.

D.M5. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary. (Category C)

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes. Habitat for salmonids, other resident fish, and wildlife in the Columbia River estuary and lower mainstem would benefit from a more natural regime. However, most regional parties argue for refill of storage projects during spring for augmenting summer flows during juvenile emigration from interior basin ESUs.

D.M6. Implement and monitor effects of hydropower license agreements. (Category C)

Explanation: Monitor and notify Federal Energy Regulatory Commission (FERC) of significant license violations, enforce terms and conditions of section 7 consultations on FERC licensing agreements, and encourage implementation of section 7 conservation recommendations on FERC Relicensing agreements. This is a regulatory measure related to operations of facilities licensed by the FERC, including tributary hydropower facilities.

5.6 Fisheries

5.6.1 Working Hypotheses

F.H1. Salmon recovery is predicated on restoration of healthy, harvestable naturally-spawning populations.

Explanation: Fishing is both part of the problem in protecting salmon populations from extinction and part of the goal of recovering naturally-spawning populations to harvestable levels. On the one hand, harvest of naturally-spawning fish reduces numbers of fish escaping to spawn. Significant harvest rates of naturally-spawning fish may thus increase risks of extinction. Reductions in fisheries may reduce the risk of extinction. On the other hand, the recovery goal has been defined to include sustainable harvest of naturally-spawning populations. As life cycle modeling indicates, recovery cannot be achieved merely by eliminating all fishing effects or removing all hatchery fish that sustain baseline fisheries. The intent of this Plan is to strike an appropriate balance between fishing and other land and water uses to recover lower Columbia salmon and steelhead.

F.H2. Historic fishing rates in conjunction with other factors posed significant risks to the continued existence of many naturally-spawning populations and were not sustainable.

Explanation: Columbia River salmon are subject to harvest in the Canada/Alaska ocean, U.S. West Coast ocean, lower Columbia River, and tributary recreational, commercial and treaty Indian fisheries. Historic harvest rates in combined fisheries ranged from species averages of 60% to 85% per year. These rates are sustainable by only the most robust salmon populations in the most productive habitats. Fishery restrictions have substantially reduced impacts to wild fish from historical levels but in some cases remain well above the rebuilding exploitation rates for some populations.

F.H3. Changes in fishery management to protect weak stocks have reduced harvest of some naturally-spawning populations in recent years.

Explanation: Fisheries from the Columbia Basin to Alaska have been widely restricted to limit impacts on listed and other weak stocks of fish. Listed populations are generally not targeted by fisheries but are caught incidental to the harvest of healthy hatchery and naturally-spawning populations (e.g. Hanford upriver bright fall Chinook). Changes have been made to ocean and in-river sport, commercial, and tribal fisheries to reduce risks to listed populations. Restrictions have been the most severe on in-basin fisheries.

Weak stock management (the practice of limiting fisheries based on annual abundance of particular stocks of concern) of Columbia River fisheries has evolved in response to decades of declining trends in naturally-spawning salmon viability that culminated in ESA listings of 26 species of for Pacific salmon and steelhead. Weak stock management became increasingly prevalent in the 1970s in response to continuing declines of upriver runs affected by mainstem dam construction. In the 1980s coordinated ocean and freshwater weak stock management commenced. More fishery restrictions followed ESA listings in the 1990s. Fishery reductions were one of the first areas of focus following ESA listing and a wide variety of protective measures were quickly implemented by NMFS in the ESA section 7 process. These included elimination of some fisheries, reductions in allowable fishing impacts for naturally-spawning stocks, abundance-based management criteria to further reduce impacts in years of low abundance, and selective fisheries for marked hatchery fish.

F.H4. Additional fishery management opportunities exist for reducing near term population risks for some species such as fall Chinook but opportunities for others such as chum salmon and steelhead are limited.

Explanation: For those populations affected significantly by harvest and are at risk due to low spawner abundance, fishery reductions can be used to reduce near-term viability risks until benefits of habitat improvements can be realized. Harvest management should work in conjunction with habitat actions to adequately seed the available properly functioning habitat. Habitat improvements typically require many years to implement, whereas, fishery reductions can have a more immediate effect. For instance, changes in forestry practices adopted by Washington are expected to substantially improve watershed and stream habitat conditions in the future but many improvements based on current actions will require 50 to 150 years to accrue. This is the time it takes for forests to mature and reestablish functional watershed processes that create healthy stream habitat conditions for salmon. These habitat measures will restore conditions conducive to long term population viability but do not address the immediate problems of small populations and high extinction risks. Fisheries, by contrast, are subject to annual management decisions allowing for the benefits of fishery reductions to be realized immediately.

F.H5. Additional fishery restrictions involve tradeoffs in foregone catch of healthy hatchery and naturally-spawning stocks in freshwater and ocean fisheries.

Explanation: Opportunities for additional fishery reductions exist but will increasingly depend on ocean fisheries where Columbia River fish comprise only a small portion of the catch and priorities are driven by a number of considerations in addition to the status of Columbia River fish. Access to harvestable surpluses of strong stocks in the Columbia River and ocean is regularly constrained by impact limits on weak stocks mixed with the strong (for instance harvest of strong runs of upriver bright fall Chinook may be limited by restrictions to protect lower Columbia River tule Fall Chinook). As a result of weak stock constraints, surpluses of hatchery and strong naturally-spawning runs often go unharvested. Small reductions in fishing rates on listed populations can translate to large reductions in catch of other stocks as well as reductions in recreational trips to communities that provide access to fishing, resulting in significant economic consequences. In addition, fishery restrictions to protect naturally-spawning populations can also limit the harvest of surplus hatchery fish which can result in a high incidence of hatchery strays in natural spawning areas.

F.H6. Reductions in fishing rates gradually reach a point of diminishing returns where further reductions do not significantly affect population risks.

Explanation: Reductions in fishing produce decreasing benefits as impact rates decline from high to medium to low. Risks are extremely sensitive to moderate to high fishing rates but further reductions eventually reach a point of diminishing returns. Not enough fish are saved, at low fishing impact rates on small populations, to make a significant biological difference. For instance, reducing a 50% harvest or exploitation rate by half on a run size of 100 fish would escape an additional 25 fish and increase the population size by one third (75 vs. 50 spawners). However, reducing a 10% harvest rate by half on the same run size would save only 5 fish and increase the population size by only 6%. Populations that remain at risk despite reductions in fisheries are constrained by other factors that will ultimately determine the population's fate. This is not to argue that harvest no longer matters at a certain level, but merely to illustrate that substantial improvements in fish numbers and reductions in risks are no longer biologically feasible after fishing impacts have been reduced beyond a certain point. (See Technical Appendix E for risk analysis of the effects of fishing rates.)

F.H7. Restoration of healthy, harvestable naturally-spawning populations will ultimately depend on a combination of actions involving harvest management, hatchery operations, habitat protection and restoration, and ecological interactions.

Explanation: Effects of fisheries and habitat on fish population viability and harvest potential are intimately related. Sustainable fisheries ultimately depend on protection and restoration of significant amounts of high quality habitat. Population viability and the potential for sustainable harvests are ultimately determined by the inherent productivity of a population, which is a function of habitat quality and utilization. Productive populations in good habitat produce fish in excess of those needed for replacement. These additional fish provide resiliency that lets the population bounce back quickly following years of poor ocean survival. Additional fish disperse from core areas and help sustain adjacent or marginal populations. Additional fish are also available for harvest in many years. The viability of a productive population may remain high even where the habitat is not filled to capacity in every year. Thus, it is not necessary to regulate fisheries to achieve maximum seeding of productive habitats to ensure population viability. Unproductive populations in poor quality or over-utilized habitat operate at or below replacement where average numbers of offspring in subsequent generations are less than or equal to the spawners that produced them. Consequently, poor quality habitats may not support viable populations even when filled to capacity because fish replacement rates are low and populations lack the resiliency to rebound from the inevitable poor ocean cycles.

Long-term population viability depends on both spawning escapement as affected by fisheries and productivity as affected by habitat and hatcheries. To reap the benefits of habitat improvements, fisheries must be regulated to allow sufficient escapement to take advantage of the available habitat. Where currently lacking, weak stock management practices must be developed to support progress towards recovery of listed populations. Recovery will fail if fisheries are not properly managed to complement other recovery efforts and synchronized with increases in fish productivity due to habitat improvements.

5.6.2 Strategies

F.S1. Assure fishery impacts to lower Columbia naturally-spawning populations are managed to contribute to recovery.

Explanation: Fisheries must be managed to complement and support the recovery of threatened lower Columbia River salmon and steelhead populations. For those populations significantly affected by harvest, fishery limitations can provide immediate reduction in extinction risks, buying time until habitat improvement measures can become effective. Fisheries must be managed fundamentally to protect naturally-spawning escapement and ensure that incidental catches of naturally-spawning fish do not reduce near-term persistence probabilities or compromise prospects for recovery. Fisheries must also be managed to limit escapement of hatchery-origin fish into natural spawning areas and to protect fish from adverse genetic and ecological effects. Further fisheries management must help ensure that sufficient fish return to take optimum advantage of the productivity of existing habitat and to sustain functional ecological processes. Implement an all-threat strategy including changes in fishery management to protect weak stocks and reduce harvest rates.

F.S2. Preserve fishery opportunity focused on hatchery fish and strong naturally-spawning stocks in a manner that does not adversely affect recovery efforts.

Explanation: The long-term goal for salmon recovery is to restore harvestable populations but this goal will require substantial habitat improvements in tributaries, the mainstem, and estuary. Even if effective habitat measures are implemented immediately, benefits will accrue slowly. It took a long time to degrade the habitat to the baseline state and it will take a long time to restore it. In the interim, carefully controlled fishing opportunities can be provided for hatchery fish and strong naturally-spawning stocks.

F.S3. Revise or adjust Fishery Management Plans for lower Columbia ESUs as needed to support the Lower Columbia Recovery goals and priorities.

Explanation: Integrate the Lower Columbia Fish Recovery Plan and fishery management processes. Modify ESA harvest limits, weak stock management regulations, and fishery conservation practices as needed to ensure consistency with Lower Columbia Recovery goals, objectives, and priorities.

F.S4. Consider recovery goals for lower Columbia salmon and steelhead populations as identified in the Lower Columbia Recovery Plan in annual fishery management processes.

Explanation: Lower Columbia populations (as directly represented or represented by appropriate index populations within the ESA based on the recovery scenario) will be considered in pre-season planning, technical review and assessments, in-season monitoring, and in the development of management strategies. Processes include PFMC, PSC, NOF, Compact, U.S. v. Oregon, F&W Commissions, and NMFS's ESA analysis of fishery actions. Specific index populations or stocks will be identified through these management processes.

F.S5. Ensure that scientific review of Lower Columbia Recovery Plan harvest objectives and current ESA management objectives occurs as part of the process in fishery management forums.

Explanation: Incorporate specific biological objectives for recovery of lower Columbia populations into processes established for PFMC, PSC, and U.S. v. Oregon technical committees to review, assess, and synthesize for regulatory decisions. Analysis will include effects of fisheries on listed species and how fisheries will impact recovery goals and objectives outlined in the Plan. Goals and objectives will include consideration of the role of salmon in ecological interactions.

F.S6. Research and employ best available technology to reduce incidental mortality of non-target fish in selective fisheries.

Explanation: Studies would be implemented to better estimate and control mortality of naturally-spawning fish released or encountered in selective fisheries as a function of gear types, environmental conditions, handling techniques, and revival methods. Use of mark-selective harvest (along with weirs, habitat improvement, etc.) is a key strategy in the goal of achieving conservation and harvest objectives, but there are important uncertainties as to the ultimate effectiveness of this strategy. Research should evaluate the need for high encounter rates of marked hatchery fish to make mark-selective harvest succeed, and reduce potential impacts of this on the juvenile and spawning life stages. Work should include testing and implementation of alternative selective gears for commercial fishers.

F.S7. Seek to maintain and/or establish programs, priorities, regulatory frameworks, and coordination mechanisms for effective enforcement of fishery rules and regulations for the protection of fish and wildlife resources.

Explanation: Effective enforcement requires a dedicated effort.

5.6.3 Measures

Fall Chinook

F.M1 Implement actions to limit the exploitation rate of lower Columbia River tule Fall Chinook in order to protect weak populations. (Category B)

Explanation: Fishery impact limits on tule Fall Chinook were reduced from the pre-listing baseline of approximately 65% to 49% starting in 2002 and to 38% in 2009. Recent limits were based on a Restoration Exploitation Rate (RER) analyses conducted by NMFS derived from Coweeman fall Chinook numbers which may not provide adequate protection for other, weaker populations targeted for recovery. Nor do baseline impact rates adequately capitalize on the potential for using fishery reductions to reduce near-term risks in the interim until benefits of other actions are realized (particularly those addressing habitat and hatchery threats). Interim benchmarks established in this Plan and consistent with other fishery measures identified for fall Chinook establish the need for further near term reductions in fishery impacts for fall Chinook. Increases in fishing rates would occur at a future date when harvestable numbers of naturally-produced fish are restored.

Responsible Parties: NMFS, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

F.M2. Define appropriate fishery impact rates for fall Chinook based on assessments of near- and long-term risks to species viability and considerations of the needs to preserve fishery viability, manage hatchery surpluses, and promote implementation of other recovery measures. (Category B)

Explanation: This Plan establishes benchmark ranges which identify appropriate fishery impact rates during the recovery period. Fishery impact rates are based on a balance of considerations. Foremost among these is the effect on population viability and the need to manage near-term risks. However, interactions with other recovery goals and strategies must also be taken into account. For instance, this Plan also identifies harvestability goals which include considerations of the effects of impact limits on the sustainability of fisheries. Beyond a certain level, risk analyses have shown that small changes in impact rates have limited benefit in terms of risk reduction. However, small changes in fishery impact allowances can have very large implications for fishery sustainability. Impact limits also recognize the utility of fisheries as a tool to limit escapement of hatchery surpluses into natural production areas in large return years. Continuing fishery opportunities provide a strong incentive for implementation of other recovery measures.

Responsible Parties: NMFS, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

F.M3. Consider and expressly evaluate the potential for a sliding scale harvest plan based on annual abundance indicators for representative tule fall Chinook populations. (Category C)

Explanation: An abundance-based approach to annual fishery management has been implemented for many other stocks including upriver spring Chinook, Willamette spring Chinook, Oregon coast natural coho, and Oregon lower Columbia coho. An abundance based management approach reduces fishing rates in years of low abundance to decrease risks of low escapements. Such an approach should be considered for the management of Lower Columbia fall Chinook. Specific harvest rates, population status, and survival indexes would need to be derived after a thorough scientific analysis is conducted. Additionally, this measure would include a comparison of the proposed sliding scale approach with the current abundance based approach utilized per the PST Agreement (as further limited by the RER) to determine if outcomes would be substantially different and if there were advantages of one approach over the other in respect to meeting recovery objectives. The abundance-based approach could also be considered in conjunction with the RER approach to account for variable abundance of hatchery fish.

Box 5-1 is displayed as a conceptual illustration of how an abundance-based management plan with a sliding scale could be used. Evaluations of the potential for a variable annual harvest rate strategy will consider the potential benefits and risks associated with a range of alternatives for abundance-based management. It is likely not feasible to implement abundance-based management on a population by population basis due to limited data on wild escapements and forecasted returns. However, abundance-based management using aggregate ocean survival indicators and recent escapements might prove to be an effective alternative to population-level management. Any periodic reduction in fishery impacts can be expected to translate into some risk reduction benefit due to a lower effective average impact rate over time. Yet another potential alternative might be to simply reduce impacts in years following poor escapements to reduce the chances of multiple compounding production cycles.

Responsible Parties: NMFS, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

Box 5-1. Example of a sliding-scale abundance-based management approach for Coweeman fall Chinook.

Features

- Harvest rates reduced from baseline levels in years of low returns to protect naturally-spawning escapement in the Coweeman and reduce risks to population viability.
- Allowable impacts scaled to habitat capacity and marine survival.
- Provides access to other healthy salmon runs at variable rates dependent on condition of the Coweeman population and marine survival.

		Marine survival index[3]			
		Very low (<0.15%)	Low (0.15-0.25%)	Medium (0.25-0.40%)	High (>0.4%)
Parent spawner status[1]	Number[2]	Harvest Rate			
High (>75% of capacity	>1,270	Low	Med(-)	Med(+)	High
Medium (>50% of capacity)	850-1,270	Low	Med(-)	Med	Med(+)
Low (<50% of capacity)	170-849	Low	Low(+)	Med(-)	Med
Very Low (<10% of capacity)	<170	Low(-)	Low(-)	Low(-)	Low(-)
Total tule run size (1,000s)		<40	40-75	75-100	>100

[1] Parent index = 3 year average of parent broods. (e.g., 2004 return based on 1999, 2000, 2001 parents)
[2] Based on baseline EDT capacity estimate.
[3] Survival based on LRH forecast adults vs. hatchery releases

F.M4. Conduct periodic reviews of fall Chinook harvest relative to habitat productivity and capacity to assure harvest objectives are synchronized with habitat changes. (Category C)

Explanation: The RER exploitation rate assumes a rate of improvement associated with baseline habitat conditions. As habitat conditions improve, a greater rate of improvement will be achieved with the RER harvest plan. Conversely, the rate of improvement will be less if habitat degrades. An adaptive Management Plan would include a review of the relationship between a RER harvest plan and habitat conditions in basins that produce tule fall Chinook indicator populations. This review could be coordinated through NMFS, WDFW, and the Technical Committees of the fishery management forums.

Responsible Parties: NMFS, WDFW

Programs: PFMC (Salmon Technical Team (STT))

F.M5. Seek commitment from agencies and tribes in the Pacific Fisheries Management Council, North of Falcon, and Columbia River Compact processes to specifically manage annually for lower Columbia naturally-spawning fall Chinook and to establish a collaborative U.S. policy position for the international table at the Pacific Salmon Commission. (Category B)

Explanation: Implementing a revised harvest management plan for lower Columbia fall Chinook would involve coordinated allocation of harvest impacts across ocean and freshwater fisheries. Lower Columbia tules are currently managed directly in PFMC and Columbia River fisheries and indirectly through the 1999 Abundance Based Management Agreement affecting PSC fisheries. This process would involve allocation agreements between Indian and non-Indian, commercial, and recreational interests, and in some years may require international management response if future harvest assessments conclude that refinement in the current 1999 Agreement is needed to meet the needs of lower Columbia Chinook. A collaborative U.S. approach would be necessary to negotiate with Canada. The 1999 Pacific Salmon Treaty Agreement expired after 2008. A new bilateral agreement was adopted in 2008. This agreement included additional protections for lower Columbia River fall Chinook.

Responsible Parties: NMFS, WDFW, ODFW, Col. Tribes, WA Tribes, USFWS

Programs: PFMC, N of Col. Compact

F.M6. Improve tools to monitor and evaluate fishery catch to assure impacts to naturally-spawning fall Chinook are maintained within agreed limits. (Category B)

Explanation: The pre-season fishery Chinook assessment models utilized in PFMC, PSC, and in U.S. v. Oregon should be evaluated to determine if they adequately represent harvest of lower Columbia tule fall Chinook. In-season methods for monitoring catch by species should be evaluated and improved where possible.

Responsible Parties: NMFS, WDFW, ODFW, Col. Tribes, WA Tribes

Programs: PFMC, PSC, U.S. vs. Oregon (Tech Advisory Committee (TAC))

F. M7. Manage ocean, Columbia River, and tributary fisheries to meet the spawning escapement goal for lower Columbia bright fall Chinook. (Category A)

Explanation: The baseline escapement goal for lower river bright fall Chinook is 5,700 natural adult fall Chinook returning to the North Fork Lewis River to spawn. Ocean and freshwater fisheries would continue to employ escapement goal management for Lewis River fall Chinook. The escapement goal may be reassessed as new data is acquired and Lower Columbia Recovery objectives are established for lower Columbia bright fall Chinook.

Responsible Parties: NMFS, WDFW, ODFW, ADFG, Canadian DFO

Programs: PFMC (STT), PSC, U.S. vs. Oregon (TAC)

F.M8. Develop a more detailed process for in-season monitoring of stock specific harvest of fall Chinook in the Columbia River. (Category B)

Explanation: Evaluate process and resources used by management agencies to monitor in-season harvest of listed species. Assure monitoring and coded-wire tag analysis is adequate for accurate and timely estimates of stock specific impacts to enable in-season recovery and regulatory adjustments as necessary. Assure that monitoring of mark-selective fisheries can effectively estimate fishery impacts on unmarked fish. Assure that investments into in-season monitoring programs are long term to match recovery timelines.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

F.M9. Implement basin wide marking for hatchery tule fall Chinook that is adequate for monitoring interception rates in specific fisheries, tributary harvest management, and monitoring escapement of naturally-spawning fish. (Category C)

Explanation: This measure would involve adipose fin marking of hatchery tule fall Chinook in order to enable mark-selective fisheries for hatchery fish and to account for and/or control first generation hatchery fish in the natural spawning escapement. Legislation passed by Congress mandates marking of all Chinook, coho, and steelhead produced in federally-funded hatcheries that are intended for harvest. Since 2006, virtually all hatchery fall Chinook released in the lower Columbia River have been marked. By 2011, all returning LCR hatchery fall Chinook should be marked.

Responsible Parties: NMFS, USFWS, WDFW, Col. Tribes

Programs: PFMC (STT), U.S. vs. Oregon (TAC), PSC (Chinook Tech Team), U.S. Congress, WA F&W Commission

F.M10. Address technical and policy issues regarding mass marking and help develop programs to mark and monitor recoveries of fall Chinook in fisheries and escapement. (Category B)

Explanation: This measure addresses technical conflicts between the Chinook coded-wire tag stock identification program and mass marking of Columbia River hatchery fall Chinook. This measure would require assessment of those impacts associated with mass marking selected hatchery programs and would require technical and policy resolution in the fishery forums. Funding for marking and sampling would need to be addressed.

Responsible Parties: WDFW, ODFW, NMFS, USFWS, Col. Tribes, Canadian DFO, ADFG, WA Tribes

Programs: PFMC (STT), PSC (Chinook Tech Team), U.S. vs. Oregon (TAC)

Chum

F.M11. Columbia River Compact agencies will evaluate effectiveness of the current time and area management strategy for chum protection in the commercial fishery. (Category B)

Explanation: Late fall commercial fisheries target late stock hatchery coho and sturgeon. Chum impacts are limited by gear mesh size restrictions in sturgeon fisheries and by curtailing coho fisheries by November before significant numbers of chum are present. The Compact agencies would evaluate the effectiveness of this management strategy based on information acquired in recent years.

Responsible Parties: WDFW, ODFW

Programs: U.S. vs. Oregon (TAC)

F.M12. Develop more specific chum management details for pre-season and in-season management of the late fall commercial fishery. (Category B)

Explanation: The Compact agencies would develop specific criteria for in-season fishery adjustments (e.g. early closures, gear adjustments, area closures) based on chum encounter rates in the fishery. These criteria would be established as part of the chum management plan.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact

F.M13. Monitor chum handle rate in tributary winter steelhead and late coho sport fisheries. (Category B)

Explanation: State agencies would include chum incidental handle assessments as part of their annual tributary sport fishery sampling plan. The sampling effort would be focused in areas where chum rebuilding is a priority and there is significant sport fishing effort for other species occurring during November and December.

Responsible Party: WDFW

Programs: WDFW Creel Program

Steelhead

F.M14. Define appropriate fishery impact rates for steelhead based on assessments of near- and long-term risks to species viability and considerations of the needs to preserve fishery viability, manage hatchery surpluses, and promote implementation of other recovery measures.

Explanation: This Plan establishes benchmark ranges which identify appropriate fishery impact rates during the recovery period. Fishery impact rates are based on a balance of considerations. Foremost among these is the effect on population viability and the need to manage near-term risks. However, interactions with other recovery goals and strategies must also be taken into account. For instance, this Plan also identifies harvestability goals which include considerations of the effects of impact limits on the sustainability of fisheries. Beyond a certain level, risk analyses have shown that small changes in impact rates have limited benefit in terms of risk reduction. However, small changes in fishery impact allowances can have very large implications for fishery sustainability. Impact limits also recognize the utility of fisheries as a tool to limit escapement of hatchery surpluses into natural production areas in large return years. Continuing fishery opportunities provide a strong incentive for implementation of other recovery measures.

Responsible Parties: NMFS, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

F.M15. Monitor and evaluate commercial and sport impacts to naturally-spawning steelhead in salmon and hatchery steelhead target fisheries. (Category A)

Explanation: Includes monitoring of naturally-spawning steelhead encounter rates in fisheries and refinement of long-term catch and release handling mortality estimates. This would also include assessment of the baseline monitoring programs and determining their adequacy in formulating naturally-spawning steelhead incidental mortality estimates. Application of advances in methodologies such as genetic stock identification may also be included in this measure.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

F.M16. Continue to improve gear and regulations to minimize incidental impacts to naturally-spawning steelhead. (Category B)

Explanation: The effectiveness of large-mesh commercial gear to target Chinook salmon and avoid steelhead is well documented. However, recent live capture spring Chinook fisheries strategy includes a smaller mesh size to improve survival of released naturally-spawning spring Chinook. The smaller mesh size can increase encounters with winter steelhead. Regulatory agencies should continue to refine gear, handle and release methods, and seasonal options to minimize mortality of naturally-spawning steelhead in commercial and sport fisheries.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

F.M17. Establish specific naturally-spawning steelhead encounter triggers for in-season Columbia River fishery adjustments needed to support lower Columbia recovery goals and strategies. (Category B)

Explanation: Encounter rates of naturally-spawning steelhead should be monitored in Columbia River fisheries with specific criteria established to trigger season adjustments, which could include delays, closures, gear requirement changes, or fishing area adjustments. This measure would require a long term monitoring program for Columbia River fisheries.

Responsible Parties: WDFW, ODFW

Programs: BPA F&W Program

F.M18. Work through U.S. v. Oregon and with Columbia River treaty Indian tribes to develop harvest plans for Wind River summer steelhead. (Category B)

Explanation: Wind River summer steelhead are destined for above Bonneville Dam and therefore are subject to U.S. v. Oregon agreements regarding treaty Indian harvest. Wind River summer steelhead is a priority population for recovery. Discussions with the Columbia River treaty Indian tribes could include options to minimize harvest of Wind River steelhead in Zone 6 fisheries (e.g., expanded Wind River mouth sanctuary during early fall season treaty Indian fisheries).

Responsible Parties: WDFW, ODFW, NMFS, Col. Tribes, USFWS

Programs: U.S. vs. Oregon (Policy and TAC)

F.M19. Monitor naturally-spawning steelhead handle rate in tributary salmon and steelhead fisheries. (Category B)

Explanation: State agencies include naturally-spawning steelhead encounter rates as part of their future tributary sport fishery sampling plans. Efforts would be focused in areas with significant effort on hatchery steelhead and salmon, and prioritized in areas where priority populations are in the process of rebuilding. WDFW has modeled naturally-spawning steelhead encounter rates for Kalama winter and summer steelhead, and SF Toutle winter steelhead.

Responsible Parties: WDFW

Programs: WDFW Creel Surveys

F.M20 Manage Columbia River commercial fisheries by time, area and gear to target hatchery fish and minimize impacts to naturally spawning steelhead. (Category A)

Explanation: Commercial fisheries should utilize "Select Area" off-channel sites to harvest net pen-reared hatchery spring Chinook. Mainstem commercial fisheries should continue to regulate by mesh size, time, and area to reduce impacts to naturally-spawning steelhead.

Responsible Parties: WDFW, ODFW

Programs: U.S. vs. Oregon (TAC)

Coho

F.M21. Define appropriate fishery impact rates for coho based on assessments of near- and long-term risks to species viability and considerations of the needs to preserve fishery viability, manage hatchery surpluses, and promote implementation of other recovery measures.

Explanation: This Plan establishes benchmark ranges which identify appropriate fishery impact rates during the recovery period. Fishery impact rates are based on a balance of considerations. Foremost among these is the effect on population viability and the need to manage near-term risks. However, interactions with other recovery goals and strategies must also be taken into account. For instance, this Plan also identifies harvestability goals which include considerations of the effects of impact limits on the sustainability of fisheries. Beyond a certain level, risk analyses have shown that small changes in impact rates have limited benefit in terms of risk reduction. However, small changes in fishery impact allowances can have very large implications for fishery sustainability. Impact limits also recognize the utility of fisheries as a tool to limit escapement of hatchery surpluses into natural production areas in large return years. Continuing fishery opportunities provide a strong incentive for implementation of other recovery measures.

Responsible Parties: NMFS, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

F.M22. Implement actions to regulate the fishery impact rate on naturally-spawning lower Columbia River coho in order to protect weak indeed populations and reduce risks using a sliding scale harvest based on annual abundance indicators. (Category C)

Explanation: Establish an abundance-based Ocean/Columbia River harvest matrix for naturally-spawning lower Columbia coho. Consider harvest matrices established for Oregon Coastal Natural Coho and Oregon lower Columbia coho and determine if a different harvest matrix is needed for lower Columbia coho. Indicators must accurately represent the status of populations targeted for recovery including both strong and weak populations. Interim benchmarks established in this Plan and consistent with other fishery measures identified for coho establish the need for significant near term reductions in fishery impacts. Greater fishing rates would be restored at a future date as harvestable numbers of naturally-produced fish are restored.

Responsible Parties: WDFW, NMFS

Programs: Col. Compact, PFMC (STT)

F.M23. Maintain selective sport fisheries in ocean, Columbia River, and tributaries and monitor impacts on naturally-spawning coho stocks. (Category B)

Explanation: Mass marking of lower Columbia River coho has enabled successful ocean and freshwater selective fisheries to be implemented since 1998. Fin-marking programs should be continued and fisheries monitored to provide improved estimates of naturally-spawning coho release mortality.

Responsible Parties: WDFW, NMFS, ODFW, USFWS

Programs: PFMC, Col. Compact, BPA F&W Program, WDFW Creel Survey

F.M24. Manage Columbia River commercial fisheries by time area, and gear to target hatchery fish and to minimize impacts to naturally-spawning coho. (Category A)

Explanation: Commercial fisheries should utilize Select Area off-channel sites to harvest net pen reared hatchery coho. Continue to regulate mainstem commercial fisheries by time, and area to reduce early naturally-spawning coho impacts and regulate commercial fisheries targeting late hatchery coho by time and area to avoid impacts to the latest timed (Clackamas type) naturally-spawning coho.

Responsible Parties: WDFW, ODFW, NMFS

Programs: Col. Compact, U.S. vs. Oregon (TAC)

F.M25. Review and evaluate the harvest management strategy developed to protect naturally-spawning Clackamas late coho in terms of its ability to protect naturally-spawning Washington late coho. (Category B)

Explanation: If rebuilding strategies for late coho in Washington streams prioritize the November-January returning naturally-spawning fish, then separation from the October timed late coho produced in hatcheries for harvest will be achieved. The Clackamas late coho fishery management strategy may also protect Washington naturally-spawning coho. Technical review would include review of harvest impact rates and would consider timing of Washington stocks.

Responsible Parties: WDFW, NMFS

Programs: U.S. vs. Oregon (TAC), PFMC (STT)

Spring Chinook

F.M26. Define appropriate fishery impact rates for spring Chinook based on assessments of near- and long-term risks to species viability and considerations of the needs to preserve fishery viability, manage hatchery surpluses, and promote implementation of other recovery measures.

Explanation: This Plan establishes benchmark ranges which identify appropriate fishery impact rates during the recovery period. Fishery impact rates are based on a balance of considerations. Foremost among these is the effect on population viability and the need to manage near-term risks. However, interactions with other recovery goals and strategies must also be taken into account. For instance, this Plan also identifies harvestability goals which include considerations of the effects of impact limits on the sustainability of fisheries. Beyond a certain level, risk analyses have shown that small changes in impact rates have limited benefit in terms of risk reduction. However, small changes in fishery impact allowances can have very large implications for fishery sustainability. Impact limits also recognize the utility of fisheries as a tool to limit escapement of hatchery surpluses into natural production areas in large return years. Continuing fishery opportunities provide a strong incentive for implementation of other recovery measures.

Responsible Parties: NMFS, WDFW, ODFW

Programs: PFMC, Col-Compact, PSC, WA F&W Commission

F.M27. Continue to monitor Columbia River selective fisheries and provide estimates of impacts to naturally produced lower Columbia spring Chinook. (Category A)

Explanation: Baseline Columbia River management includes ESA harvest limits for upper Columbia, Snake River, and Willamette naturally-spawning spring Chinook. This measure would include specific estimates of impacts to lower Columbia naturally-spawning spring Chinook as part of the pre-season and in-season management process.

Responsible Parties: WDFW, ODFW, NMFS

Programs: Col. Compact, U.S. vs. Oregon (TAC)

F.M28. Monitor and evaluate handling mortality impacts to released naturally-spawning spring Chinook in Columbia River fisheries. (Category A)

Explanation: Columbia River selective fisheries for marked hatchery spring Chinook commenced in 2001. Studies should continue to increase precision of long-term mortality estimates of naturally-spawning spring Chinook captured and released in selective fisheries.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, U.S. vs. Oregon (TAC), BPA F&W Program

F.M29. Develop gear and handling techniques, as well as regulatory options in both commercial and sport fisheries, to minimize selective fishery impacts to naturally-spawning spring Chinook. (Category B)

Explanation: Continue alternative gear experiments in the commercial fishery to provide effective harvest of hatchery spring Chinook and high survival of released naturally-spawning spring Chinook. Also, experiment with methods to increase handling survival with improved revival methods and consider regulatory actions to reduce stress on released fish.

Responsible Parties: WDFW, ODFW

Programs: Col. Compact, BPA F&W Program

F.M30. Develop a lower Columbia naturally-spawning spring Chinook harvest rate plan for management of Columbia River fisheries at such time as significant populations are re-established. (Category C)

Explanation: This measure would provide specific harvest limits for lower Columbia naturally-spawning spring Chinook. This harvest plan would consider existing populations and reintroduced populations as they are reestablished in historical habitats. This measure would include an assessment of the baseline harvest constraints for other Columbia River spring Chinook stocks (Willamette, upper Columbia, and Snake River) and their adequacy for lower Columbia spring Chinook recovery.

Responsible Parties: WDFW, ODFW

Programs: WA F&W Commission, Col. Compact (TAC)

F.M31. Manage Columbia River commercial fisheries by time, area and mark-selective requirements to target hatchery fish and minimize impacts to naturally spawning spring Chinook. (Category A)

Explanation: Commercial fisheries should utilize “Select Area” off-channel sites to harvest net pen-reared hatchery spring Chinook. Continue to regulate mainstem commercial fisheries by mesh size, time, and area to reduce impacts to naturally-spawning spring Chinook.

Responsible Parties: WDFW, ODFW

Programs: U.S. vs. Oregon (TAC)

5.7 Hatcheries

5.7.1 Working Hypotheses

H.H1. Historic hatchery operations in conjunction with other factors posed significant risks to the continued existence of many naturally-spawning populations.

Explanation: Hatcheries have proven to be a powerful tool for producing salmon and steelhead but the benefits are accompanied by risks. On the one hand, high survival of eggs and juveniles in hatcheries enables large-scale production of fish. Dozens of hatcheries have been built throughout the Columbia Basin and especially in the lower Columbia, primarily to produce fish for harvest and to offset declines in natural salmon production. Harvest hatchery programs are located in the lower Columbia to mitigate for local watershed loss of fish access to habitat as well as to provide the means to fully mitigate for Columbia River dam construction. Hatcheries are also useful conservation tools for temporarily preserving populations where habitat has been lost, bolstering numbers through bottlenecks caused by poor ocean conditions, and supplementing naturally-spawning production where mortality factors are severe. On the other hand, hatcheries may also contribute to increased extinction risks by several mechanisms. Inadvertent hatchery selection can result in domesticated fish that do not reproduce or survive as well as naturally-spawning fish. Introduction or straying of significant numbers of naturally-spawning hatchery fish, that are genetically dissimilar from naturally-spawning fish, may reduce the productivity of the naturally-spawning population. Large numbers of hatchery fish can reduce naturally-spawning fish numbers through competition, predation, or disease. Large numbers of hatchery fish can also make it difficult to accurately estimate naturally-spawning fish numbers and productivity.

H.H2. Changes in hatchery operations have and will continue to contribute to reduced risks to naturally-spawning populations.

Explanation: Widespread hatchery reforms have been implemented over the last 20 years with the recognition of potential risks. Example reforms have included elimination of releases in priority wild production areas, elimination of inter-basin brood stock transfers, development of integrated brood stock management programs, acclimation of smolts to reduce straying, lower basin releases to reduce inter-species predation, and differential management of fisheries for wild and hatchery fish. Additional refinements can be expected in the future.

H.H3. Additional reductions in hatchery impacts are needed to support the recovery of naturally-spawning populations.

Explanation: Interim conservation measures and continued use of hatcheries to enhance fisheries requires fundamental changes in operations to reduce risk, protect naturally-spawning populations, and ensure progress toward recovery. A series of comprehensive regional reviews have been completed that identify conservation hatchery strategies, hatchery reform principles, and recommendations for changes to Columbia River programs. Many changes are being implemented and are reflected in Hatchery Genetic Management Plans (HGMPs) prepared for every hatchery program as part of ESA compliance. The HGMPs are currently being developed and have not formally been submitted to NMFS for authorization. This Recovery Plan identifies hatchery measures needed to support recovery of lower Columbia River salmon populations. These measures are expected to be integrated with the final lower Columbia hatchery program HGMPs.

H.H4. Conservation hatchery programs can contribute to recovery through the preservation, reintroduction, and supplementation of naturally-spawning populations.

Explanation: Because recovery ultimately depends on naturally-produced spawners spawning naturally, hatcheries by themselves are not the answer to salmon recovery. However, hatcheries can make near term contributions to the conservation and restoration of some naturally-spawning populations. For instance, the remnant native genetic material for lower Columbia River spring Chinook, coho, and some steelhead populations currently resides solely in the hatchery system. These hatchery fish may be building blocks for reintroduction and rebuilding of extirpated or weak populations. Hatcheries can also be used to jump start other populations and reduce use of naturally-spawning brood stock needed to seed extirpated populations (chum for example).

H.H5. Hatcheries can provide harvest opportunities consistent with measures to restore and maintain healthy, harvestable naturally-spawning populations.

Explanation: Hatcheries can help provide continuing fishing opportunity while habitat restoration measures are implemented. With few exceptions, baseline habitats are not able to produce sufficient numbers of fish to sustain meaningful fisheries. Current fisheries are focused almost entirely on hatchery fish. Abrupt closures of all existing hatchery programs would essentially terminate significant salmon and steelhead fisheries in large parts of the Columbia Basin and along Oregon and Washington coasts. Analyses of hatchery impacts also indicate that hatchery closures by themselves would not be sufficient to restore viable salmon or steelhead populations throughout the Washington lower Columbia recovery area. Naturally-spawning production levels foreseeable in the near future would fall far short of meeting mitigation responsibilities for eliminating anadromous access to habitat in large parts of the upper Columbia and Snake basins. (However, use of hatcheries to provide interim harvest opportunities will require significant reforms for consistency with recovery requirements.)

H.H6. Some hatchery programs have legal obligations to provide fish for mitigation purposes and those obligations will likely be offset to varying degrees by increases in natural production.

Explanation: Large-scale hatchery production exists primarily to mitigate for effects of habitat changes, particularly related to hydropower development and operation. For instance, programs in the Cowlitz and Lewis rivers are mitigation for dams which block access to historically productive areas in the lower basin. Other lower Columbia hatchery programs in Washington and Oregon help mitigate for the effects of Columbia and Snake river mainstem dam construction and operation. Hatchery production levels in many facilities are obligated by a series of inter-jurisdictional agreements, for instance, with Columbia River treaty Indian tribes, other states, and between the U.S. and Canada. Habitat improvements prescribed by this Recovery Plan are not likely to provide sufficient levels of natural production to meet other obligations within the foreseeable future.

H.H7. Returning adults from some hatchery programs currently sustain some natural populations.

Explanation: In the lower Columbia, much of the native genetic material now exists only in the hatchery system. Upper Cowlitz and Lewis spring Chinook, winter steelhead, and coho were removed to hatcheries after dams blocked those rivers. Although some indigenous populations have been minimally influenced by hatchery programs, many hatchery and naturally-spawning populations of coho and fall Chinook are now indistinguishable. In these populations, domestication may have reduced the diversity and productivity of natural spawners. Conversely, returning adults from some hatchery programs currently supplement natural production in many marginal habitats that might no longer sustain a viable naturally-spawning population.

H.H8. Conservation and harvest benefits from hatchery programs can be realized with acceptable risks to naturally-spawning populations through effective integrated or segregated hatchery programs.

Explanation: Hatchery programs can be evaluated and scored by the operating agencies and NMFS based on levels of benefits provided and risks posed to naturally-spawning populations. Conservation programs would be expected to provide benefits to naturally-spawning population recovery while fishery mitigation programs would be expected to implement measures which neutralize or reduce risks to low levels. Each hatchery program would be considered in the context of affects on specific naturally-spawning populations in the watershed in which the program is implemented. The program would be evaluated and scored relative to the measures and strategies contained in this hatchery strategy as they apply to the needs of the naturally-spawning populations present in the subbasins.

H.H9. Restoration of healthy, harvestable naturally-spawning populations cannot be achieved solely by eliminating the effects of hatcheries either by closing all existing facilities or by replacing all production programs with conservation programs.

Explanation: Widespread hatchery closures will not address the fundamental habitat problems that have placed wild salmon and steelhead populations at risk. Nor are hatcheries a long term solution for the loss of naturally-spawning populations. Hatcheries may not be sustainable in the long term if the natural biological diversity that supports the success of anadromous salmon and steelhead across the breadth of habitat and environmental conditions encountered throughout their life cycle is lost. Survival gradually declines and the cost of supplying benefits increases.

5.7.2 Strategies

H.S1. Expand use of hatchery reintroduction and supplementation programs to conserve and recover naturally-spawning fish when and where appropriate.

Explanation: Conservation hatchery programs will be a critical tool in salmon recovery throughout the lower Columbia River. Hatchery programs historically concentrated on production for harvest but recent experience has demonstrated that hatcheries can make substantial contributions to naturally-spawning salmon conservation. Conservation hatchery programs will be a key to reintroduction efforts in areas where access or suitable habitat is restored. Carefully designed supplementation programs can also be used to maintain viable naturally-spawning populations in the interim until adequate habitat improvements occur or in cases where the appropriate brood stock is chronically under-seeding the habitat. Many conservation programs have already been initiated but additional modifications of existing hatchery programs and new programs will be needed.

The contribution of specific hatchery stocks to ESU viability and recovery will depend on the source of each stock, the history of hatchery practices which may have altered the genetic or life history characteristics relative to the native population, and the demands of recovery. In some cases, hatchery influences are minimal and wild fish may be used in a hatchery to jump start natural populations through supplementation in particular areas where habitat restoration has been effective (e.g. Grays River and Duncan Creek chum). Some hatchery stocks are highly domesticated or from out-of-subbasin sources and are not appropriate for production enhancement but may continue to be used for fisheries enhancement where consistent with natural production goals. Several hatchery stocks represent the only significant native genetic material still existing in the ESU and will be critical for production enhancement. This is the case for Lewis and Cowlitz River hatchery stocks being used for reintroduction efforts above dams in the Cowlitz and Lewis rivers. Other hatchery stocks, including many tule fall Chinook and coho, are practically the same as their naturally-spawning counterparts. This is common where natural stock productivity is no longer sufficient to support a self-sustaining natural population in the face of habitat degradation. These stocks will play a significant role in recovery as habitat is restored.

Supplementation programs may be appropriate when habitat is underutilized. Reintroduction is appropriate when access to habitat is restored. Use of appropriate brood stock will assure fitness of fish for enhancement. Innovative rearing practices, which simulate natural conditions, can be used to maintain some of the naturally-spawning fish behavior attributes in hatchery reared fish. However, the efficacy of conservation hatchery programs remains unclear and additional research and experimentation will be required for refinement toward optimum application. Experimental conservation hatchery programs may require adaptation of existing facilities (e.g. Abernathy Hatchery) or the development of new facilities to conduct research that supports the Recovery Plan through an improved understanding of salmon genetics, life cycle diversity, habitat utilization, and effective management practices.

H.S2. Reconfigure production-based hatchery programs for harvest to support populations and region-wide recovery goals while limiting or eliminating detrimental impacts on naturally-spawning populations.

Explanation: The hatchery strategy included in this Plan identifies some areas that will be free of hatchery influence and other areas where hatchery programs are distributed to serve specific conservation and harvest purposes in specific watersheds, consistent with goals for populations using each watershed. This mosaic of programs is designed to ensure that overall each ESU will be naturally self-sustaining. Every hatchery program should either benefit natural production or not adversely affect recovery. Detrimental hatchery effects can be reduced with integrated programs intended to minimize the divergence of the hatchery population from its natural counterpart and segregated programs where interactions (within species and inter-specific) between naturally-spawning and hatchery fish are minimized. Recovery scenarios identified in this Plan provide the opportunity to operate different types of programs in different subbasins for different purposes. Programs will be evaluated and scored based on their ability to meet complementary hatchery and naturally-spawning fish objectives. This evaluation would be connected to and involve the parties associated with the HGMP process.

Recovery scenarios identify improvements in specific populations that add up to a viable group of populations (e.g., ESU or listing unit). Priority populations need to be restored to a high level. Contributing populations need to show significant improvement. Stabilizing populations need to be protected from further declines. Thus, not every population needs to be subjected to the same level of recovery effort. Hatchery impacts will be considered in selecting recovery scenarios. Hatchery programs should be assessed in terms of their feasibility in meeting recovery goals under current programs, the trade-offs identified, and the changes needed to meet recovery goals. Opportunities exist to support recovery by distributing hatchery programs to serve specific conservation and harvest purposes in specific watersheds, consistent with goals for the populations using each watershed.

It is important to maintain representative areas independent of hatchery influences in order to determine population viability levels and the recovery status of naturally-spawning populations. Natural spawning by significant numbers of hatchery fish can mask true naturally-spawning population status, making it difficult to accurately assess the condition of naturally-spawning fish. This calls for a carefully-stratified approach where hatchery conservation measures are applied to some populations, protection measures are applied to other populations, and yet other populations are kept free of hatchery influences. By definition, most primary populations will serve as sanctuaries free from significant contributions of hatchery fish because of restrictive diversity criteria. This approach recognizes the inherent uncertainties in the relative risks and benefits of different hatchery approaches and optimizes opportunities for learning and future adaptive management.

H.S3. Until harvestable naturally-spawning populations are restored, many lower Columbia River hatchery programs will continue to be operated to produce fish for harvest purposes in a manner consistent with restoring and maintaining healthy, harvestable naturally-spawning populations.

Explanation: Harvestable surpluses from naturally-spawning populations require high quality habitats that produce fish in excess of those needed for replacement. Habitat recovery is a long process, hence, harvestable surpluses for most naturally-spawning populations will not be available in the near future. Fishing opportunity currently depends almost entirely on hatchery fish. Elimination of production hatchery programs in the lower Columbia River would essentially end significant sport and commercial salmon and steelhead fisheries in the lower Columbia and large portions of the ocean. Further, mitigation responsibilities for irreversible habitat losses to hydro development would be unfulfilled. Production scale hatchery programs and the need for hatchery fish for fisheries should decrease as naturally-spawning populations become healthy and can support fisheries. However, the need for hatchery programs at some level is not expected to be eliminated.

H.S4. Base hatchery reform on a comprehensive assessment of the risks and benefits posed by artificial production programs.

Explanation: An evaluation of hatchery programs and implementation of hatchery reform in the lower Columbia will occur through several processes. These include: 1) the LCFRB recovery planning process; 2) Hatchery Genetic Management Plan (HGMP) preparation for ESA permitting; 3) FERC-related plans on the Cowlitz River and Lewis River; 4) the federally mandated Artificial Production Review and Evaluation (APRE) process, 5) the Pacific Northwest Hatchery Reform Project implemented by the Hatchery Scientific Review Group, and 6) an Environmental Impact Statement for funding and operation of Columbia River hatcheries.

H.S5. Operate hatcheries to promote region-wide recovery through the application of appropriate risk containment measures for: 1) hatchery origin adults returning to natural spawning areas, 2) release of hatchery juveniles, 3) handling of natural origin adults at hatchery facilities, 4) water quality and effective disease control, and 5) mixed stock fisheries.

Explanation: Programs which are not specifically designed for naturally-spawning fish enhancement will be operated in a manner that is consistent with achieving region-wide recovery through appropriate risk containment measures. Negative impacts from natural spawning hatchery fish are reduced by segregated programs or increased by efficiency in removing hatchery adults. Juvenile releases may be modified by timing, area, or magnitude to reduce both intra-specific and inter-specific risks. Naturally-spawning adult handling impacts may be improved with modified collection or improved handling techniques. Brood stock guidelines may address genetic fitness risks. Water treatment methods can minimize disease. Marking programs enable catch and release of naturally-spawning fish in mixed stock fisheries. The Hatchery Scientific Review Group (HSRG 2009) identified a series of recommendations and criteria for reform of Columbia Basin hatchery programs consistent with this Recovery Plan. As of the 2010 adoption date for this revised Recovery Plan, WDFW is in the process of developing and implementing a Conservation and Sustainable Fisheries Plan that includes significant reforms to hatchery programs consistent with this guidance.

H.S6. Assist in the design of hatchery programs to be consistent with recovery goals for lower Columbia ESUs and the ecological context of the watershed, including the characteristics of the habitat and the natural fish populations.

Explanation: Each hatchery program may be visualized as following a trajectory from the baseline operation to the expected operations at recovery. The speed and direction of the trajectory will depend on the baseline characteristics of the population, the baseline productivity of the habitat, and policy decisions that define region-wide recovery. Although watershed-specific considerations will ultimately shape each hatchery program, default hatchery programs for each of the four combinations of population and habitat conditions can be roughly characterized as follows: 1) High population integrity, low habitat productivity-hatchery program used as egg bank, brood stock development source, or captive brood source to preserve the unique qualities of the stock until habitat restoration occurs; 2) High population integrity, high habitat productivity-hatchery program operated to minimize impacts to naturally-spawning fish; no supplementation needed; 3) Low population integrity, low habitat productivity-hatchery program used to provide mitigation for lost habitat without impeding achievements of region-wide recovery; and 4) Low population integrity, high habitat productivity--hatchery program operated to improve stock integrity.

H.S7. Promote local adaptation of natural and hatchery populations by managing hatchery broodstock to achieve proper genetic integration with, or segregation from, natural populations.

Explanation: This strategy, as identified by the HSRG (2009), is intended to reduce genetic and ecological hatchery risk to natural populations. Integrated programs are intended to maintain the genetic characteristics of a local, natural population among hatchery-origin fish by incorporating natural-origin fish into the hatchery broodstock in order to avoid domestication. Segregated programs protect the wild population by maintaining a genetically separate hatchery population and limiting natural spawning of those hatchery fish. The HSRG has developed criteria for integrated and segregated populations based on the proportion of hatchery origin spawners in the wild (pHOS) and the proportionate natural influence (PNI) of hatchery-origin spawners. As of the 2010 adoption date for this revised Recovery Plan, WDFW is in the process of developing and implementing a Conservation and Sustainable Fisheries Plan that includes significant reforms to hatchery programs consistent with guidance by the HSRG and this Recovery Plan.

H.S8. Minimize adverse ecosystem effects of and ecological interactions with hatchery-origin fish.

Explanation: This strategy is as identified by the HSRG (2009). Ecosystem effects may result from the operation of facilities in support of hatchery programs (traps, weirs, water intake screens and hatchery effluent discharges). Adverse ecological interactions between hatchery- and natural-origin fish may result from competition, predation, or disease. Numbers, size, time, location and method of release all affect the potential for ecological interaction. Disease risks are affected by hatchery practices related to water supply, rearing density, fish transfers between facilities, and fish health management measures.

H.S9. Develop marking programs to assure that hatchery-produced fish are identifiable for harvest management and escapement accounting.

Explanation: Marking of juvenile hatchery fish with an adipose fin-clip prior to release enables future identification of adult fish encountered in a fishery or in the escapement areas. Selective fisheries which allow the retention of hatchery fish and require the release of naturally-spawning fish are an effective tool for reducing fishery impacts of naturally-spawning stocks. Identifying individual fish as hatchery or naturally-spawning produced on the spawning grounds enables accurate enumeration of naturally-spawning production which is essential for monitoring recovery progress. In some cases, marks other than an adipose fin-clip (e.g., thermal or chemical marks) may be required when differentiation of natural and hatchery-origin adults is required for brood stock management but not to provide fishing opportunities.

H.S10. Use adaptive management to ensure that hatchery programs respond to new knowledge of how to further protect and enhance natural production and improve operational efficiencies.

Explanation: Innovative rearing methods, brood stock development, improved water quality, release strategies, improved rearing facilities, etc. will be researched and implemented where possible to improve survival and contribution of hatchery fish and to reduce impacts to natural fish in the watershed. Methods to improve efficiency of operations to enable attainment of complementary hatchery and natural objectives within funding constraints should be explored. Hatcheries programs will be reviewed for consistency with lower Columbia recovery objectives in the HGMP review process, including annual reports and 5-year comprehensive reviews.

H.S11. Promote public education concerning the role of hatcheries in the protection of natural populations.

Explanation: Hatcheries are often a first contact point for public exposure to fish management. Many hatcheries are organized with public education programs concerning hatchery operations. A new public education program would be developed for each hatchery to emphasize the importance of naturally-spawning fish populations in the watershed including information concerning recovery efforts and the role the hatchery is playing in the recovery mission. The intent of the public education programs would be to promote naturally-spawning fish stewardship and support for responsible hatchery programs. This measure is but one component of a comprehensive integrated education and outreach program that is described in further detail elsewhere in this Plan.

H.S12. Document and formalize hatchery operations through the use of the existing Hatchery Genetic Management Plans (HGMPs).

Explanation: HGMPs provide a systematic means to step down from the population-scale hatchery strategies and measures to a detailed documentation of hatchery programs, including operations, performance standards, and performance indicators. Preparation and submittal of HGMPs by resource management agencies through the existing permitting process facilitates transparency, accountability, and regulatory certainty of program consistency with Lower Columbia Recovery Plan measures. Draft HGMPs currently under development will need to incorporate specific measures and actions identified in this Recovery Plan.

H.S13. Seek flexibility in current funding to assure hatcheries have the resources to achieve complementary harvest and natural production objectives.

Explanation: Current funding sources for lower Columbia hatchery operations are primarily the 1938 Mitchell Act, requiring federal mitigation for the development of the mainstem Columbia federal hydro system, and FERC Licenses, requiring private utilities to mitigate for operation of dams in lower Columbia tributaries. These funds are attached to specific production levels for specific hatcheries and in some cases with legal requirements to rear fish in the lower Columbia hatcheries for release into upper Columbia tributaries. There has been some limited investments in recent years by BPA to enhance naturally-spawning fish through hatchery programs and the re-license requirements for private utilities has included complementary investments for naturally-spawning enhancement as well as hatchery production. These investments will need to be significantly expanded to meet complementary naturally-spawning and production objectives in the hatchery programs. Additional funding sources or re-distribution of current funding will need to be considered. Mitchell Act fund flexibility may be limited because most of the funding is directed by congressional appropriations.

5.7.3 Measures

Fall Chinook

H.M1. Reconfigure and reform hatchery programs for Fall Chinook consistent with responsibilities identified in this Recovery Plan and standards established by the Hatchery Scientific Review Group. (Category B)

Explanation: This Recovery Plan identifies a series of goals, objectives, targets, benchmarks, and strategies which establish the need for changes in hatchery programs to support the needs of recovery. The HSRG (2009) identified a series of recommendations and criteria for reform of Columbia Basin hatchery programs consistent with this Recovery Plan. As of the 2010 adoption date for this revised Recovery Plan, WDFW is in the process of developing and implementing a Conservation and Sustainable Fisheries Plan that includes significant reforms to hatchery programs consistent with this guidance. Anticipated changes will involve changes in the size and location of production, reform of hatchery activities and practices, expanded monitoring of hatchery effects on natural populations, and evaluations of the effectiveness of corresponding actions.

H.M2. Maintain or establish wild fish refuges for fall Chinook in selected watersheds by eliminating or limiting release and escapement of hatchery-origin fish into natural spawning areas. (Category B)

Explanation: Baseline fall Chinook hatchery programs include on-site releases into the Cowlitz, Green (NF Toutle), Kalama, Washougal, Big Creek, Youngs Bay, Little White Salmon, and mainstem Columbia. Releases of hatchery Fall Chinook into the Elochoman River were terminated in 1980. Fall Chinook reared and released at Little White Salmon and Bonneville hatcheries are upriver bright stock and not part of the lower Columbia ESU. This measure would preclude off-site releases in other watersheds for harvest purposes. Fall Chinook hatchery releases into watersheds that currently have no fall Chinook hatchery programs may only be considered as part of a supplementation program or a brood stock risk reduction program when determined to be necessary to preserve and/or recover the population. Escapement of hatchery-origin strays into natural spawning areas would be limited in wild fish refuge systems by a combination of hatchery practices and weir operation. Hatchery fish will not be released into selected populations targeted for restoration to high levels of viability. Numbers of naturally-spawning hatchery adults may be reduced by trapping and removing from the stream. This approach might encompass the entire watershed or involve a targeted effort to provide significant reductions of hatchery fish in the majority of the natural spawning area. This measure may also involve a reduction in total releases of hatchery fall Chinook in the lower Columbia River region.

H.M3. Implement hatchery reforms for fall Chinook in phases in order to limit demographic risks of the reduction in hatchery supplementation of natural abundance in the interim until natural habitat and population productivity is sufficient to sustain local populations. (Category B)

Explanation: Many natural tule fall Chinook populations are currently sustained by a continuing subsidy of hatchery fish. Abrupt removal of this subsidy could result in the natural population “bottoming out” before it has a chance to benefit from increased fitness that is expected to result from the removal of hatchery fish. Many tule populations are also currently limited by habitat conditions which may not be adequate to support a sustainable wild population in the absence of hatchery subsidy until effective habitat restoration measures have been implemented. This measure will require the development and application of criteria to establish an appropriate mix of first generation hatchery spawners and naturally-spawning spawners for each population with hatchery and naturally-spawning fall Chinook production, and reduce first generation spawners. In some watersheds, integrated hatchery and naturally-spawning programs may be developed with a matrix/sliding scale approach to guide the appropriate number of naturally-spawning brood stock in the hatchery program and the appropriate number of hatchery fish on the spawning grounds, based on the number of naturally produced adults returning each year. Adjustments to the initial strategies may be considered as an adaptive management measure in response to monitoring and evaluation results. The ability for natural fish to be sustained without hatchery supplementation should increase as habitat productivity improves. Implementation of this action will require marking of hatchery fall Chinook production which could be expensive depending on how many programs were included. In addition to the marking, weirs and traps would need to be upgraded to meet NMFS adult handling criteria that will minimize adverse effects on natural origin adults. Disposition of surplus hatchery fish that are removed from the population will also need to be considered.

H.M4. Use local watershed brood stock and integrated production strategies in fall Chinook hatchery programs in order to promote local adaptation and natural productivity. (Category B)

Explanation: This measure involves implementation of integrated hatchery programs identified by the HSRG (2009). Implementation requires increased use of natural-origin adults in the hatchery broodstock and avoidance of interbasin transfers of hatchery broodstock. Broodstock composition is established in each program based on criteria for proportionate natural influence established by the HSRG for integrated hatchery programs. Very limited outside watershed transfers have occurred in the Kalama and Cowlitz fall Chinook hatchery programs and, although domestication has occurred, the baseline hatchery and natural populations are similar and derived from the original natural runs produced in these watersheds. Fall Chinook transfer limits have included the remainder of the lower Columbia fall Chinook hatchery programs in recent years and are addressed in the draft "Fall Chinook Management Guidelines" developed by WDFW. Transfer limits would be upheld in the Recovery Plan to assure hatchery fall Chinook programs are consistent with development of natural and hatchery populations with attributes adapted to the unique characteristics of the watershed. Local brood stock in the hatcheries will reduce the risks associated with interactions between natural and hatchery fish.

H.M5. Use fall Chinook juvenile release strategies to minimize ecosystem effects and ecological interactions. (Category A)

Explanation: Hatchery fall Chinook are released in their first year as sub yearlings and do not pose a major predation risk to rearing naturally-spawning fish in the same watershed. However, if hatchery fall Chinook spend significant resident time in the stream before migrating to the Columbia, they may compete for space with smaller naturally-spawning fall Chinook, displacing the naturally-produced fish to marginal habitat or influence premature migration, which will reduce naturally-spawning fish survival. Options to reduce these risks include; release fish at an optimum time when the majority have smolted and are prepared to leave the system quickly, release fish off-site and downstream of the majority of the naturally-spawning fish rearing area, or reduce numbers of hatchery juveniles released into the stream.

H.M6. Use hatchery operation strategies to protect Lewis River naturally-spawning fall Chinook from ecosystem effects and ecological interactions. (Category A)

Explanation: Lewis River naturally-spawning (bright) fall Chinook are the healthiest Chinook population in the lower Columbia basin. The majority of the Lewis River naturally-spawning fall Chinook juveniles rear in the lower North Fork Lewis and utilize several miles of habitat located immediately downstream of the Lewis River Salmon Hatchery. Hatchery fall Chinook are not released into the North Lewis River and should not be considered in the future. Steelhead, coho, and spring Chinook yearling releases, either from the hatchery harvest program or from the upper Lewis natural reintroduction program, must include strategies to minimize impacts to rearing naturally-produced fall Chinook. Release options include; volitional releases to assure fish are smolted and migrate rapidly, release locations downstream of the majority of fall Chinook rearing area, rearing methods to reduce residual fish, and the inclusion of stress relief ponds for reintroduced smolts. Hatchery operations should include adequate water quality treatment methods to minimize chance of disease transmittal to natural fall Chinook. Monitoring of naturally-produced Lewis River fall Chinook status and evaluation of hatchery operation impacts should be included in a monitoring and evaluation plan.

H.M7. Mark hatchery fall Chinook in priority watersheds to promote fishery utilization, facilitate the utilization of natural-origin fish in integrated programs, and enumerate hatchery fish in natural spawning areas. (Category C)

Explanation: This measure enables a more accurate enumeration of naturally-spawning fall Chinook spawning escapement in the priority populations and provides the means to control the number of hatchery adults spawning naturally, integrates hatchery and naturally-spawning programs, and provides selective fishing options where appropriate. Identification of naturally-spawning fish in important areas with mixed hatchery and naturally-spawning returns is a crucial element of a monitoring and evaluation program. Legislation passed by Congress mandates marking of all Chinook, coho, and steelhead produced in federally-funded hatcheries that are intended for harvest. Since 2006, virtually all hatchery fall Chinook released in the lower Columbia River have been marked. By 2011, all returning Lower Columbia River hatchery fall Chinook should be marked.

H.M8. Continue to produce, in a manner consistent with other recovery strategies and measures, sufficient numbers of hatchery fall Chinook to sustain significant fishery opportunities until harvestable naturally-spawning populations are restored. (Category A)

Explanation: This measure is consistent with strategy H.S3 which refocuses fisheries on hatchery fish until recovery is achieved. This measure addresses the need to sustain fisheries as an essential element of the short and long-term harvestability goals included in this Plan. It is also noted that significant portions of current hatchery production, including programs funded under the Federal Mitchell Act and some subbasin programs, were established as mitigation for altered environments. This mitigation will continue to affect fisheries even if other recovery goals are met. Therefore it is likely there will be a continuing need for hatchery mitigation to sustain viable fisheries.

Spring Chinook

H.M9. Reconfigure and reform hatchery programs for Spring Chinook consistent with responsibilities identified in this Recovery Plan and standards established by the Hatchery Scientific Review Group. (Category B)

Explanation: This Recovery Plan identifies a series of goals, objectives, targets, benchmarks, and strategies which establish the need for changes in hatchery programs to support the needs of recovery. The HSRG (2009) identified a series of recommendations and criteria for reform of Columbia Basin hatchery programs consistent with this Recovery Plan. As of the 2010 adoption date for this revised Recovery Plan, WDFW is in the process of developing and implementing a Conservation and Sustainable Fisheries Plan that includes significant reforms to hatchery programs consistent with this guidance. Anticipated changes will involve changes in the size and location of production, reform of hatchery activities and practices, expanded monitoring of hatchery effects on natural populations, and evaluations of the effectiveness of corresponding actions.

H.M10. Reintroduce spring Chinook in upper Cowlitz and Lewis beginning with hatchery supplementation. (Category A, C)

Explanation: The majority of the spring Chinook habitat in the lower Columbia basin is located upstream of the hydro dams in the Lewis and Cowlitz rivers. Facilities and operational strategies for hatchery programs in these basins must address space, brood stock development, rearing methods, transfer of fish, marking strategies, and monitoring and evaluation which adequately supports a spring Chinook reintroduction program. Successful reintroduction above these lower river tributary dams is critical to recovering lower Columbia spring Chinook, and hatchery support is a key element of the rebuilding program. Supplementation of juvenile and adult hatchery spring Chinook above the dams represents the initial stage of reintroduction of spring Chinook into the upper Cowlitz and Lewis habitats. Brood stock choices for reintroduction are currently limited to the hatchery stocks. The Cowlitz hatchery brood stock has had negligible outside basin influence and is considered consistent with the original Cowlitz naturally-spawning stock. The Lewis hatchery spring Chinook program was developed from outside stocks, principally Cowlitz spring Chinook, but the Lewis program is currently sustained without transfers from other hatcheries. The success of this reintroduction effort will ultimately hinge on achieving adequate juvenile collection efficiencies for downstream passage of outmigrants.

H.M11. Develop plans for future hatchery programs with reestablished natural-origin spring Chinook populations, including integrated and segregated options. (Category A, C)

Explanation: As natural production is established above the dams, natural brood stock may be incorporated into the hatchery program to reduce risks to reestablished natural populations, and to improve fitness of the hatchery stock in an integrated program. However, the future relationship of the hatchery and natural-origin spring Chinook in the FERC license basins of the lower Columbia may be dependent on the success of reintroduction and the final configuration of a dam passage system. Under some circumstances, a segregated hatchery program may be considered. An integrated program would first provide appropriate brood stock for natural supplementation as needed and, as a secondary priority, improve the fitness of the hatchery base program stock as well. The natural brood stock hatchery program would be initiated at variable levels based on criteria established for natural adult return levels and hatchery: naturally-spawning ratios on the spawning grounds and in the hatchery. A matrix approach would be developed to manage naturally-spawning fish in the brood stock, adult escapement to natural production areas and to the hatcheries, and hatchery fish on the spawning grounds

H.M12. Develop and apply hatchery brood stock watershed transfer policies for spring Chinook. (Category B)

Explanation: Cowlitz and Kalama hatcheries should maintain their baseline stock integrity and avoid outside watershed transfers. The Lewis program should use the current Cowlitz-type hatchery stock from the Lewis Hatchery to begin the reintroduction effort and establish an adaptive Lewis stock over time. Transfers would only be considered for the Lewis from the Cowlitz program in emergency situations where brood stock was not available to meet reintroduction and harvest mitigation objectives. However, under these circumstances, transfers would only be considered for the harvest program. As the Lewis stock is developed over time, transfers under any conditions would not be acceptable. Reintroduction of the extirpated spring Chinook stocks in the upper Gorge (Big White Salmon and Hood rivers) require supplementation from spring Chinook programs outside these watersheds (e.g. Klickitat, Deschutes). As reintroduced spring Chinook become sustainable in these upper Gorge watersheds, the supplementation programs would be phased out.

H.M13. Use spring Chinook juvenile release strategies to minimize ecosystem effects and ecological interactions. (Category B)

Explanation: Hatchery produced spring Chinook are released as yearlings into the lower Cowlitz, Lewis, and Kalama rivers and pass through principal rearing areas for naturally-spawning fall Chinook and chum on their way to the Columbia River. To minimize potential predation on sub-yearling fall Chinook and chum, hatchery spring Chinook release strategies which encourage rapid migration through the lower Cowlitz and Lewis should be implemented; including volitional release, optimum release size, and release downstream of principal chum rearing areas. Rearing practices should avoid producing large numbers of immature mini-jacks which remain in the lower Columbia freshwater environment during the spring before returning in the summer. Rearing practice adjustments which increase smolt to adult survival rates would enable adult return mitigation requirements to be attained with less hatchery smolts released.

H.M14. Mark spring Chinook hatchery production for identification and harvest. (Category A)

Explanation: Spring Chinook, which are reared as part of the hatchery base harvest program, should continue to be adipose fin-clipped to enable selective fisheries and identification of hatchery fish in natural spawning areas and at collection facilities. Distinguishing the origin of returning adults will be necessary for the reintroduction of spring Chinook upstream of the hydro systems in the Lewis and Cowlitz, and will also provide the means to develop integrated brood stock programs in the hatcheries.

H.M15. Continue to produce, in a manner consistent with other recovery strategies and measures, sufficient numbers of hatchery spring Chinook to sustain significant fishery opportunities until harvestable naturally-spawning populations are restored. (Category A)

Explanation: This measure is consistent with strategy H.S3 which refocuses fisheries on hatchery fish until recovery is achieved. This measure addresses the need to sustain fisheries as an essential element of the short and long-term harvestability goals included in this Plan. It is also noted that significant portions of current hatchery production, including programs funded under the Federal Mitchell Act and some subbasin programs, were established as mitigation for altered environments. This mitigation will continue to affect fisheries even if other recovery goals are met. Therefore it is likely there will be a continuing need for hatchery mitigation to sustain viable fisheries.

Chum

H.M16. Implement and expand hatchery programs for chum consistent with responsibilities identified in this Recovery Plan and standards established by the Hatchery Scientific Review Group. (Category B)

Explanation: This Recovery Plan identifies a series of goals, objectives, targets, benchmarks, and strategies which establish the need for changes in hatchery programs to support the needs of recovery. The HSRG (2009) identified a series of recommendations and criteria for reform of Columbia Basin hatchery programs consistent with this Recovery Plan. The HSRG viewed chum conservation programs as an important short-term risk strategy to preserve the genetic legacy of depressed chum populations. However, the HSRG also cautioned that managers should avoid maintaining this ESU only through artificial propagation due to long-term hatchery risks of domestication and fitness loss. As of the 2010 adoption date for this revised Recovery Plan, WDFW is in the process of developing and implementing a Conservation and Sustainable Fisheries Plan that includes significant reforms to hatchery programs consistent with this guidance. Anticipated changes will involve changes in the size and location of production, reform of hatchery activities and practices, expanded monitoring of hatchery effects on natural populations, and evaluations of the effectiveness of corresponding actions.

H.M17. Continue to enhance local chum populations using Grays and Chinook hatcheries. (Category A)

Explanation: Grays River chum stock is currently utilized to rebuild the chum population in the Chinook River and as a risk management tool for the Grays River population. The HSRG had no recommendations to improve the Grays chum program and recommended its continued operation as an important safety net in the lower Columbia. The Grays River brood stock program might also be expanded to include supplementation of other coastal stream populations, consistent with HSRG recommendations to develop one or two additional safety net populations in each of the three lower Columbia strata. Appropriateness of the Grays broodstock for use in other areas will depend on genetic similarities between Grays River and other chum populations as well as the availability of other sources of broodstock. Expanding the Grays supplementation program should only be considered if sufficient

Grays River brood stock were available to support the hatchery program without risking the Grays River natural population.

H.M18. Initiate additional conservation propagation programs for chum in order to restore depleted or extirpated populations and to reduce demographic risk. (Category C)

Explanation: This measure is consistent with recommendations by the HSRG (2009). The HSRG recommends promptly initiating chum programs in each of the ESU's three geographic strata. Hatcheries will play a key role in rebuilding lower Columbia chum populations. Recent year spawning surveys indicate remnant chum populations present in many tributary streams of the lower Columbia River. However, the majority of these populations are critically low in numbers. The unique attributes of the lower Columbia chum populations will be preserved and maintained with hatchery program support. Supplementation programs would be developed on a parallel track with habitat enhancement programs in the watersheds. Enhancement programs might be implemented in concert with the development of chum spawning channels which have been found to be very effective in other regions. Effective actions will depend on the ability of chum to naturally colonize new access areas and respond quickly to improved habitat. Hatchery Genetic Management Plans will need to be developed and brood stock sources identified for many of these proposed supplementation programs. The HSRG recommended implementing chum conservation programs at existing facilities using fry releases of 100,000 to 200,000 for up to three generations.

H.M19. Use DNA data to select appropriate chum brood stock. (Category B)

Explanation: DNA samples from chum spawning in the mainstem lower Columbia and tributaries have been collected in recent years. Results from DNA analysis will inform strategies for developing specific hatchery programs which are consistent with specific traits of individual populations.

H.M20. Develop and apply hatchery brood stock watershed transfer policies for chum. (Category B)

Explanation: Chum releases into the Grays and Chinook rivers would only include Grays River stock, and chum releases into lower Gorge streams would only include lower Gorge stocks. Transfer policies would be further developed based on DNA analysis results and would be adaptive over time as sustainable populations are established in more watersheds and more hatcheries are used for chum supplementation and risk management programs.

Steelhead

H.M21. Reconfigure and reform hatchery programs for steelhead consistent with responsibilities identified in this Recovery Plan and standards established by the Hatchery Scientific Review Group. (Category B)

Explanation: This Recovery Plan identifies a series of goals, objectives, targets, benchmarks, and strategies which establish the need for changes in hatchery programs to support the needs of recovery. The HSRG (2009) identified a series of recommendations and criteria for reform of Columbia Basin hatchery programs consistent with this Recovery Plan. As of the 2010 adoption date for this revised Recovery Plan, WDFW is in the process of developing and implementing a Conservation and Sustainable Fisheries Plan that includes significant reforms to hatchery programs consistent with this guidance. Anticipated changes will involve changes in the size and location of production, reform of hatchery activities and practices, expanded monitoring of hatchery effects on natural populations, and evaluations of the effectiveness of corresponding actions.

H.M22. Maintain or establish wild fish refuges for steelhead in selected watersheds by limiting or eliminating release and escapement of hatchery-origin fish into natural spawning areas. (Category B)

Explanation: Escapement of hatchery-origin strays into natural spawning areas would be limited in wild fish refuge systems by a combination of hatchery practices and weir operation. Hatchery fish will not be released into selected populations targeted for restoration to high levels of viability. Numbers of naturally-spawning hatchery adults may be reduced by trapping and removing from the stream. This approach might encompass the entire watershed or involve a targeted effort to provide significant reductions of hatchery fish in the majority of the natural spawning area. This measure may also involve a reduction in total releases of hatchery steelhead in the lower Columbia River region.

H.M23. Expand use of local watershed brood stock and integrated production strategies in selected steelhead hatchery programs in order to promote local adaptation and natural productivity. (Category B)

Explanation: This measure involves increased use of integrated hatchery programs identified by the HSRG (2009). Implementation increased proportions of natural-origin fish in existing integrated programs using native wild stock and conversion of a number of programs from segregated to integrated operations. Broodstock composition is established in each program based on criteria for proportionate natural influence established by the HSRG for integrated hatchery programs. Integrated programs involve the use of complementary conservation/harvest programs with local steelhead stocks. Natural steelhead populations in the lower Columbia are generally stable at low or moderate levels and utilize much of the available habitat. With the exception of habitats upstream of tributary dams, and above Bonneville Dam, hatchery supplementation of winter steelhead would not be included as part of a hatchery program. However, development of local late winter stocks in the hatchery can be used as a naturally-spawning stock risk management tool as well as providing an expanded selective fishing opportunity on marked hatchery production.

H.M24. Improve segregated programs for steelhead, where appropriate, to meet established wild population protection criteria. (Category B)

Explanation: The HSRG recommended conversion of a number of programs from segregated to integrated and the improvement of several remaining segregated programs by controlling the number of hatchery-origin fish in natural spawning areas. This can involve reductions in hatchery production in some areas and changes in hatchery practices. Effective monitoring of the numbers of hatchery fish in the natural environment will be essential in the adaptive management of these segregated programs to ensure that wild fish protection objectives are achieved.

H.M25. Use steelhead juvenile release strategies to minimize detrimental ecosystem impacts and ecological interactions. (Category A)

Explanation: Hatchery steelhead are released as yearling smolts. Release strategies include; on-site hatchery releases, fish trucked away from the hatchery in the same watershed and released, fish acclimated in net-pen sites or acclimation ponds before release, and fish trucked to other watersheds and directly released. Potential for predation on naturally-spawning sub yearling fall Chinook, chum, or coho should be reduced through development of steelhead release strategies. Release strategies should also be adopted to minimize residualism of steelhead smolts. Strategies would be developed for each watershed, with options including; release downstream of significant naturally-spawning fish rearing areas, volitional release methods, release fish when smolted and at optimum size for rapid movement out of the tributary, avoid release of residual fish, and reduce the numbers of fish released into a particular watershed.

H.M26. Utilize hatchery production to reintroduce winter steelhead in upper Cowlitz and Lewis rivers. (Category A, C)

Explanation: Re-licensing of Cowlitz and Lewis river dams will include provisions to reintroduce natural production of winter steelhead into the habitats upstream of the dams. Passage through these hydro systems, particularly including juvenile collection efficiencies, will be critical to the success of the programs. Hatchery facilities and operations must also be adapted to accommodate the reintroduction effort; including rearing space, brood stock development, marking programs, collection and sorting facilities, transfer equipment, and adequate monitoring and evaluation plans.

H.M27. Continue to mark steelhead hatchery production. (Category A)

Explanation: Continue to provide resources to mass mark hatchery steelhead with an adipose fin-clip to enable selective fisheries and to distinguish hatchery fish and naturally-spawning fish at collection sites and other escapement sampling areas, Mass marking is also important for identifying and removing hatchery fish from the watershed prior to spawning.

H.M28. Maximize harvest and removal of non-local summer and early winter steelhead produced from segregated hatchery programs. (Category B)

Explanation: The summer and winter steelhead harvest programs include steelhead smolts released from hatcheries within the watersheds as well as fish transferred from Skamania or Merwin hatcheries and released into several watersheds. The winter steelhead hatchery stocks return as adults to the tributaries in late fall and early winter and spawn in mid-winter. Summer steelhead hatchery stocks return to the tributaries during spring and summer and also spawn in the winter. The local naturally-spawning winter steelhead arrive later then the hatchery fish and spawn in the spring. The naturally-spawning summer steelhead spawn in the spring also. The timing and spatial differences between the earlier spawning hatchery fish and the naturally-spawning fish minimize the opportunity for spawning interaction between the hatchery and naturally-spawning fish. However, because some overlap in spawning is possible, and surviving juveniles from natural spawning hatchery parents may compete with naturally-spawning juveniles, hatchery steelhead programs will improve methods to efficiently remove hatchery adults from the watershed prior to spawning. These methods would include efficient trapping, maximizing harvest of marked hatchery fish, limiting the duration of adult recycling programs, and transferring collected adults to lakes or ponds instead of returning them to the river.

H.M29. Continue to produce, in a manner consistent with other recovery strategies and measures, sufficient numbers of hatchery steelhead to sustain significant fishery opportunities until harvestable naturally-spawning populations are restored. (Category A)

Explanation: This measure is consistent with strategy H.S3 which refocuses fisheries on hatchery fish until recovery is achieved. This measure addresses the need to sustain fisheries as an essential element of the short and long-term harvestability goals included in this Plan. It is also noted that significant portions of current hatchery production, including programs funded under the Federal Mitchell Act and some subbasin programs, were established as mitigation for altered environments. This mitigation will continue to affect fisheries even if other recovery goals are met. Therefore it is likely there will be a continuing need for hatchery mitigation to sustain viable fisheries.

Coho

H.M30. Reconfigure and reform hatchery programs for coho consistent with responsibilities identified in this Recovery Plan and standards established by the Hatchery Scientific Review Group. (Category B)

Explanation: This Recovery Plan identifies a series of goals, objectives, targets, benchmarks, and strategies which establish the need for changes in hatchery programs to support the needs of recovery.

The HSRG (2009) identified a series of recommendations and criteria for reform of Columbia Basin hatchery programs consistent with this Recovery Plan. The HSRG concluded that current coho production programs provide significant harvest benefits and help preserve genetic resources in the ESU but most are inconsistent with current conservation objectives. The ESU is dominated by many poorly segregated and a few poorly integrated programs. As of the 2010 adoption date for this revised Recovery Plan, WDFW is in the process of developing and implementing a Conservation and Sustainable Fisheries Plan that includes significant reforms to hatchery programs consistent with this guidance. Anticipated changes will involve changes in the size and location of production, reform of hatchery activities and practices, expanded monitoring of hatchery effects on natural populations, and evaluations of the effectiveness of corresponding actions.

H.M31. Maintain or establish wild fish refuges for coho in selected watersheds by limiting or eliminating release and escapement of hatchery-origin fish into natural spawning areas. (Category B)

Explanation: Escapement of hatchery-origin strays into natural spawning areas would be limited in wild fish refuge systems by a combination of hatchery practices and weir operation. Hatchery fish will not be released into selected populations targeted for restoration to high levels of viability. Numbers of naturally-spawning hatchery adults may be reduced by trapping and removing from the stream. This approach might encompass the entire watershed or involve a targeted effort to provide significant reductions of hatchery fish in the majority of the natural spawning area. This measure may also involve a reduction in total releases of hatchery coho in the lower Columbia River region. Selective fisheries for hatchery coho will also be key to reducing numbers of naturally spawning hatchery coho.

H.M32. Expand use of local watershed brood stock and integrated production strategies in selected coho hatchery programs in order to promote local adaptation and natural productivity. (Category B)

Explanation: This measure involves increased use of integrated hatchery programs identified by the HSRG (2009). Implementation increased proportions of natural-origin fish in existing integrated programs using native natural stock. Broodstock composition is established in each program based on criteria for proportionate natural influence established by the HSRG. In some cases, meeting criteria for population objectives will require reducing program size (HSRG 2009). In some programs, harvest benefits could be maintained and conservation improved by developing highly integrated conservation programs with associated segregated harvest programs. With the exceptions of Clackamas and Sandy river natural coho populations, it is believed there are little differences between the hatchery coho populations and the natural coho populations in the lower Columbia River. A significant number of the natural spawning coho are first generation hatchery fish. Re-establishing natural populations with attributes adapted to the local watershed will be connected to development of local brood stock in the hatchery programs. This measure will include development of brood stock with return and spawn timing characteristics which are similar to historical natural populations. Presently, Cowlitz and North Toutle hatchery coho are considered local brood stock with little outside basin influence. Late coho brood stock for naturally-spawning fish enhancement would include later spawning coho returning in December and January, which is consistent with the timing of the majority of the historical late coho populations.

H.M33. Improve segregated programs for coho, where appropriate, to meet established wild population protection criteria. (Category B)

Explanation: The HSRG recommended improvement of segregated programs by controlling the number of hatchery-origin fish in natural spawning areas. This can involve reductions in hatchery production in some areas and changes in hatchery practices. Effective monitoring of the numbers of hatchery fish in the natural environment will be essential in the adaptive management of these segregated programs to ensure that wild fish protection objectives are achieved.

H.M34. Develop conservation hatchery programs to restore native for coho in selected populations. (Category C)

Explanation: Hatchery production with appropriate stock will be an important step in rebuilding natural coho production in lower Columbia tributaries. The program sites and magnitude would be determined by assessing the status of individual populations relative to available habitat, as well as availability of appropriate brood stock. Hatchery supplementation levels would be reduced over time as sustainable natural populations are developed.

H.M35. Reintroduce coho in upper Cowlitz and upper Lewis rivers. (Category A, C)

Explanation: Re-licensing of Cowlitz and Lewis river dams will include provisions to reintroduce natural production of coho into the habitats upstream of the dams. Passage through these hydro systems, particularly including juvenile collection efficiencies, will be critical to the success of the programs. Hatchery facilities and operations must also be adjusted to accommodate the reintroduction effort; including rearing space, brood stock development, marking programs, collection and sorting facilities, transfer equipment, and adequate monitoring and evaluation plans.

H.M36. Develop coho transfer policies as local brood stock is developed. (Category B)

Explanation: After local natural and hatchery coho populations are developed, brood stock transfer policies will be developed and implemented to assure the stock integrity of coho in a particular watershed is maintained. Transfer guidelines would not preclude meeting legal obligations to transfer lower Columbia coho to release areas in upper Columbia tributaries. Transfer exceptions may also include transfer of harvest program fish if appropriate measures are in place to protect the integrity of the locally developed natural stock.

H.M37. Use coho juvenile release strategies to minimize detrimental ecosystem impacts and ecological interactions. (Category A)

Explanation: Hatchery coho for the harvest program are released as yearling smolts. Release of yearling coho occur at the hatchery site, from net pens, and from acclimation ponds. Potential for predation on naturally-spawning sub yearling fall Chinook, chum, coho, or steelhead should be reduced and addressed through development of coho release strategies. Strategies would be developed for each watershed, with options including; release downstream of significant naturally-spawning fish rearing areas, volitional release methods, release fish when smolted and at optimum size to assure rapid movement out of the tributary, and reduce the numbers of fish released in a particular watershed. Supplementation may occur with adult hatchery fish, yearling, or sub yearling coho. The magnitude, life stage, and areas for supplementation releases would consider interactions and impacts to existing naturally-spawning populations.

H.M38. Mark coho hatchery harvest production. (Category A)

Explanation: Coho released as part of the hatchery base harvest program would continue to be adipose fin-clipped. Distinguishing the origin of returning adults will be a critical aspect of the reintroduction of coho upstream of the hydro systems in the Lewis and Cowlitz basins, and in monitoring natural production in other lower Columbia tributaries. This measure would enable a more accurate enumeration of naturally-spawning coho spawning escapement in the sub-basins, provide the means to control the number of hatchery adults spawning naturally, integrate hatchery and naturally-spawning programs, and provide selective fishing options where appropriate. Identification of naturally-spawning fish in important areas with mixed hatchery and naturally-spawning returns will be an important element of a monitoring and evaluation program.

H.M39. Establish naturally-spawning production sanctuary areas to be used for coho indicator stock programs. (Category B)

Explanation: Establishes key naturally-spawning coho production areas as sanctuaries where significant numbers of hatchery fish are not present or where stray hatchery fish would be removed prior to spawning. These areas would be used to index natural production of naturally-spawning fish in the lower Columbia basins. Intensive monitoring and evaluation would occur in these indicator stock streams. This measure would provide the means for future estimates of annual naturally-spawning coho smolt production in the lower Columbia and also to compare coho production between streams with and without hatchery spawner influence.

H.M40. Continue to produce, in a manner consistent with other recovery strategies and measures, sufficient numbers of hatchery coho to sustain significant fishery opportunities harvestable naturally-spawning populations are restored. (Category A)

Explanation: This measure is consistent with strategy H.S3 which refocuses fisheries on hatchery fish until recovery is achieved. This measure addresses the need to sustain fisheries as an essential element of the short and long-term harvestability goals included in this Plan. It is also noted that significant portions of current hatchery production, including programs funded under the Federal Mitchell Act and some subbasin programs, were established as mitigation for altered environments. This mitigation will continue to affect fisheries even if other recovery goals are met. Therefore it is likely there will be a continuing need for hatchery mitigation to sustain viable fisheries.

5.8 Ecological Interactions

5.8.1 Working Hypotheses

I.H1. Non-native, invasive, and exotic species often reduce or displace native species, particularly where habitats have been altered by human activities.

Explanation: Native species have co-evolved and typically experience some level of balance with each other. They are often co-adapted and depend on each other. Non-native and invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Altered habitats provide opportunities for introduced species to thrive and displace native species. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems.

I.H2. Salmon are but one element in a complex ecosystem where each part affects and is affected both directly and indirectly by all the other parts. Salmon have been a significant source of nutrients in freshwater systems and are both predator and prey.

Explanation: Salmon contribute a food source for other species, nutrients, and habitat forming processes in freshwater systems. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the abundance of salmon. Many significant salmon predators and scavengers, including bull trout and eagles, benefit from healthy salmon populations. Large numbers of salmon returning to spawning streams also introduces significant amounts of marine derived nutrients into nutrient-poor freshwater systems. These nutrients stimulate primary and secondary productivity that in turn increases food abundance in the entire stream system, and in particular for juvenile salmon. Finally, salmon affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

I.H3. Predation has always been a source of juvenile salmonid mortality in the lower Columbia River mainstem and estuary, but habitat changes resulting from human activities have substantially increased predation by some species including Caspian terns and northern pikeminnow.

Explanation: Native predator species are an integral part of the naturally functioning system. Their abundance follows the abundant cycles of prey populations, and in healthy systems, prey numbers often limit predator numbers, rather than the reverse. At times predators can exploit altered habitats in ways that compromise the achievements of specific management goals, and may require management themselves to reduce prey mortality. These cases are rare and can require input of significant amounts of energy to maintain the system in a state that is essentially out of balance. Such management is only fruitful where it can be established that the predator management benefits are not offset by other limiting factors, predator population viability remains intact, effects of predator removal do not cause other unintended perturbations, and predation losses are not outweighed by benefits. (Predation benefits might include predation on competitors, stabilizing selective pressure, or prevention of habitat over-utilization.) Predator-prey interactions are also complex and difficult to understand or control.

5.8.2 Strategies

I.S1. Do not intentionally introduce new exotic species. Take aggressive measures to avoid inadvertent introductions of new species and to control or reduce the potential adverse effects of existing non-native species or their effects.

Explanation: The impacts of introduced or invasive species are unpredictable and may be severe. Once established, introduced or invasive species can be virtually impossible to control or eliminate.

I.S2. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Explanation: This Recovery Plan focuses on salmon but recovery measures must also consider the contribution of salmon to other parts of the ecosystem, as well as the balance among salmon-centric recovery measures and the health of other system components. Salmon recovery will likely benefit other parts of the native ecosystem. Salmon recovery cannot occur at the expense of the viability of other native species. Because of the complex nature of ecological relationships, attempts to recover salmon without consideration of their role in the ecosystem will inevitably fail.

I.S3. As an interim recovery strategy, until more suitable habitat conditions are restored for salmon, manage predation by selected species while also maintaining a viable balance of predator populations.

Explanation: In selected cases it is possible to provide temporary benefits to selected species through management of predators or predation. Predation management need not rely on predator control. A variety of predation management alternatives exist, which can reduce the vulnerability of selected prey without jeopardizing predator or prey populations and compromising the health of the ecosystem.

5.8.3 Measures

Non native Species

I.M1. Implement regulatory, control, and education measures to prevent additional species invasions. (Category B)

Explanation: The lower Columbia ecosystem currently contains a variety of invasive, non-native species including fish, clams, shrimp, crabs, crayfish, snails, plankton, and plants. Once established, it can be virtually impossible to control or eliminate these species. By far the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits. Recently adopted regulations for ballast water are one example of this measure.

I.M2. Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations. (Category B)

Explanation: Ship ballast water is responsible for the introduction of exotic invertebrates in the estuary. The magnitude of the effect of specific introductions is difficult to quantify, but it is likely that exotic invertebrates disrupt food webs and out-compete juvenile salmonids' native food sources. Reducing the impacts of exotic invertebrates would help maintain traditional salmonid food sources and the trophic relationships that salmon have adapted to.

I.M3. Establish a moratorium on intentional introductions of aquatic species and importation of high-risk species. (Category B)

Explanation: Intentional species introductions typically do not achieve intended benefits and cause more problems than they solve.

I.M4. Take proactive steps to control or reduce the impacts of introduced, invasive, or exotic species. (Category C)

Explanation: Once established, it can be difficult to eliminate introduced, invasive, or exotic species. However, a variety of direct or indirect methods can be employed to control or reduce their impacts. Local populations of introduced species can sometimes be removed prior to becoming firmly established. Vegetation control can be used to affect predator-prey interactions. Habitat modifications (coves, docks, levees, etc.) that favor introduced, invasive, or exotic species can also be designed to reduce impacts.

I.M5. Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants. (Category B)

Explanation: Exotic plants in the estuary often out-compete native plants and change the structure of plant communities such that they do not provide the same food or shelter that native species have adapted to. Preventing and controlling noxious weeds would help maintain the estuarine food web and habitats that juvenile salmonids rely on.

I.M6. Manage established populations of introduced game fish to limit or reduce significant predation or competition risks to salmon, and to optimize fishery benefits within these constraints. (Category A)

Explanation: Significant populations of introduced game fish including walleye, smallmouth bass, and channel catfish are firmly established and cannot be feasibly removed. In some cases, introduced game fish populations might be managed to reduce risks to sensitive native species including salmon. Established populations can sometimes be managed to shape fishery benefits, as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. However, walleye fisheries might be managed with size regulations for trophy fishery benefits with no effect on salmonids.

I.M7. Reduce the abundance of shad in the estuary. (Category C)

Explanation: Shad returns to the Columbia River number approximately 4 million annually. Shad's effects on the estuary ecosystem and salmonids are poorly understood. However, shad are an introduced species and their biomass alone represents a threat to trophic relationships in the Columbia River.

I.M8. Evaluate positive and negative impacts of American shad on salmon, sturgeon, and other species as well as the feasibility and advisability of shad management measures. (Category C)

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts from competition for habitat or food. Elimination or control of shad is not a panacea for salmon recovery but the potential significance of shad interactions with salmon, sturgeon or other species and options for management warrant closer consideration. Ill-considered attempts at intervention may produce unanticipated consequences.

Food Web

I.M9. Experimentally evaluate nutrient enrichment programs (LLT) and risks using fish from hatcheries or suitable analogs. (Category C)

Explanation: Under some circumstances, inputs of marine-derived nutrients from salmon carcasses have been shown to substantially increase system productivity. Additional research and experimentation is needed to determine where additional nutrient inputs can provide significant benefits and what alternatives for nutrient augmentation may be effective.

I.M10. Consider ecological functions of salmon, including nutrients in establishing escapement goals. (Category C)

Explanation: Nutrient benefits of large spawning escapements are theoretically already represented in escapement goals where based on spawner-recruit analyses. However, existing data may not effectively determine the incremental benefits of nutrients independent of other factors such as spawning density. This measure proposes more explicit consideration of nutrient benefits in establishing escapement goals based on results of other evaluations.

Predators

I.M11. Continue to manage the northern pikeminnow fishery to help offset increased predation on salmon that resulted from habitat alteration. (Category A)

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikeminnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

I.M12. Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids. (Category C)

Explanation: Introductions of smallmouth bass, walleye, and channel catfish in the freshwater reaches of the estuary have increased predation on juvenile salmonids, as have in-water structures that offer predation opportunities for pikeminnow. Ecosystem alterations in the estuary as a result of these species are uncertain; however, maintaining warm-water species at or below baseline levels would likely benefit salmonids by reducing predation and competition.

I.M13. Continue to manage predation by avian predators, such as Caspian terns, to avoid large increases in salmon predation while also protecting the viability of predator populations. (Category A)

Explanation: Transplanting the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where increased predation might pose added risks. Additional alternatives for management of predation by avian predators will be included in an Environmental Impact Statement currently being prepared by the U.S. Fish and Wildlife Service.

I.M14. Identify and implement actions to reduce salmonid predation by pinnipeds. (Category A)

Explanation: Pinniped predation on salmonids at Bonneville Dam has been estimated at from 0.5 percent to 3.4 percent of the winter steelhead and spring Chinook runs. Estuary wide estimates are unsubstantiated, but it is likely that losses exceed 10 percent of the runs each spring. The extent of predation needs further study and documentation. The impact on salmonid survival because of actions to reduce predation by pinnipeds, would depend on how many adults are actually being eaten by pinnipeds—a question that remains controversial.

I.M15. Implement projects to redistribute part of the Caspian Tern colony currently nesting on East Sand Island. (Category A)

Explanation: Caspian Tern predation represents a significant source of mortality for winter stream-type juveniles migrating to saltwater. Stream-type salmonids are particularly vulnerable because of the timing of their out-migration (during tern nesting season) and their preference for deep-channel habitats near tern nesting sites. Terns have been documented to consume as much as 3 percent of stream-type juveniles migrating through the estuary.

I.M16. Implement projects to reduce Double-crested Cormorant habitats and encourage dispersal to other locations. (Category B)

Explanation: Predation by Double-crested Cormorants represents a significant source of mortality for stream-type juveniles migrating to saltwater. Recent studies indicate that Double-crested Cormorants prey on salmonid juveniles in the estuary at a rate equal to or greater than the rate by Caspian Terns. In some years cormorants may consume as many as 6 million juveniles.

5.9 Climate and Ocean Effects

5.9.1 Working Hypotheses

C.H1. Recovery planning analyses must consider variable ocean conditions as an uncontrollable backdrop to the effects of human activities on salmon.

Explanation: The comprehensive treatment of factors limiting fish recovery also warrants careful consideration of other influences that are beyond our control. These include environmental conditions such as ocean and climate cycles that can cause dramatic variation in natural mortality rates. The effects of human-caused mortality and restoration measures must be considered in the context of these significant and highly variable survival rates. Periodic poor ocean cycles are the stressor that bottoms out populations compromised by habitat degradation and overuse. Downturns challenge the persistence and health of impaired salmon populations and can precipitate irreversible consequences where fish have been heavily impacted by human-induced factors. Healthy populations are able to ride out the periodic declines without lingering effects. Large numbers, high inherent productivity, high diversity, wide distribution all help sustain viable populations in the face of normal environmental variability.

C.H2. Global warming trends are likely to produce detrimental long-term changes to the productivity and viability of lower Columbia River salmon and steelhead.

Explanation: Evidence for global warming is unequivocal. While there is some uncertainty of the magnitude of future trends and corresponding impacts on salmonids, there is little doubt that impacts will be significant.

5.9.2 Strategies

C.S1. Develop recovery objectives, strategies, and measures that adequately consider the risk and uncertainty in the normal variability in ocean productivity for anadromous species.

Explanation: Ocean conditions have always varied and always will. High returns in good ocean years do not mean that threatened or endangered fish are recovered. Recent large salmon runs suggest that we may have entered a period of better-than-average ocean survival conditions. Rather than relaxing the need for salmon recovery, this pattern provides an opportunity to implement substantive changes for population rebuilding needed to withstand the next down cycle. Habitat and demographic improvements require time to become effective and may come too late if the next period of decline is the one from which the population cannot recover.

C.S2. Develop recovery objectives, strategies, and measures that adequately consider the likely long term impacts of climate change on viability and habitat of anadromous species.

Explanation: Declining future trends in fish production due to climate change will require substantive measures to protect refuge areas, avoid substantial investments in marginal areas likely to become increasing unsuitable, and to undertake additional impact reduction and restoration actions than would otherwise be required if climate trends were stable.

5.9.3 Measures

C.M1. Establish fish population recovery objectives that explicitly consider the effects of variable ocean productivity on extinction risks and improvements necessary to ensure future viability.

Explanation: While it is obviously not possible to control ocean variability, it is possible to design recovery scenarios and strategies that will ensure populations are not driven to extinction during periods of low ocean productivity. This was accomplished in this Plan by the use of the population viability analysis framework as the analytical basis for the population status and objective identified in this Plan.

C.M2. Consider likely future habitat trends in relation to global warming in establishing protection and recovery priorities for fish populations, watersheds or stream reaches, and recovery measures.

Explanation: Investments in marginal areas that are likely to become increasingly unsuitable will produce fewer long term benefits than investments in areas with better long term prospects.