SKAGIT CHINOOK RECOVERY PLAN

2005

Skagit River System Cooperative
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Washington Department of FISH and WILDLIFE

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FORWARD

The Skagit Chinook Recovery Plan is a document that strives to achieve one thing: provide a detailed pathway by which Skagit Chinook populations can recover to sustained numbers that meet recovery goals established, by agreement, between fisheries co-managers. The authors accomplish this task first by presenting a framework by which restoration and protection actions can be evaluated in relation to recovery goals, and secondly by making specific recommendations that can, if implemented, move us progressively toward our mutual objective of meeting those goals. As such, this document represents the best effort of area co-managers to describe one pathway that will meet the regional expectations of Chinook recovery.

By recommending proposed actions, describing expected results, showing how results will be monitored against established benchmarks, and suggesting what to do if benchmarks are not met, the authors are simply attempting to provide one means to meet desired ends. By no means should this be construed as the only pathway by which those ends can be achieved. We recognize the complexities of implementing recovery actions and the importance of securing support from a host of stakeholders. Furthermore, we acknowledge the importance of building agreement one step at a time. This said, the co-managers offer this document in the spirit of providing leadership and direction. In doing so, we challenge the reader to be critical, but to do so constructively. Each recommendation that is rejected or modified should be replaced with another recommendation for action.[1]

This document will provide the basis of the Skagit Basin chapter of the greater Puget Sound wide Chinook recovery. In each significant discreet watershed of importance to the recovery of Puget Sound Chinook a recovery plan has been drafted. Puget Sound Shared Strategy has compiled them to create the Puget Sound Chinook recovery plan in response to the listing of Puget Sound Chinook as threatened by the Endangered Species Act.

[1] In submitting this recovery plan, the Swinomish Indian Tribal Community and the Sauk-Suiattle Indian Tribe neither identify or define the maximum extent of legal right, entitlement and authority of the tribes under the Treaty of Point Elliott, 12 Stat. 927, or existing law. The tribes reserve all rights and claims of legal right, entitlement or authority they may have against any party with respect to any issue arising from the Treaty of Point Elliott or existing law, and nothing in this recovery plan shall limit, prejudice, or otherwise affect the assertion of such rights or claims, or create any precedent regarding any such issue. By submitting this recovery plan, no Tribe intends to, or does, acknowledge, admit, or concede that the recovery of salmonids pursuant to this plan satisfies or is consistent with the Tribes' treaty fishing rights. Any use or construction of this recovery plan, or of any agreement, limitation on harvest, or other arrangement or accommodation made in accordance with this plan, to limit, prejudice, or otherwise affect such rights or claims or to use such as precedent is unauthorized or improper and is not intended for use and may not be used in any judicial, quasi-judicial, administrative or other proceeding for such purpose.

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CONTEXT OF THIS PLAN

Working on behalf of the Swinomish Indian Tribal Community and the Sauk-Suiattle Indian Tribe, Skagit River System Cooperative (SRSC) and Washington Department of Fish and Wildlife (WDFW), in consultation with other interested groups, have developed the Skagit Chinook Recovery Plan through a process that was initiated in 1994. While not all of these groups have expressly issued their support for the plan, the area co-managers represented by WDFW and SRSC have concurrence on the elements contained herein.

If implemented, this plan will meet recovery goals established by area co-managers for each of the six stocks of Chinook found in the Skagit Basin. The plan is based on empirical data collected over the past fifteen years. Through the use of these data, we have developed quantitative methods supporting our contention that recovery can be reached with Skagit Chinook stocks if recommended actions are implemented. However, our ability to quantify the magnitude of benefit for every recommended action is limited, especially in regard to actions that are regulatory. For those to which we can apply a value, the cumulative restoration benefit will result in meeting approximately 70-80% of what is necessary for recovery of adult recruitment (depending on marine survival and whether you look at equilibrium or maximum sustained yield [MSY] escapement levels). In addition to these quantifiable actions, there are a number of recommended actions that will provide some contribution to recovery efforts. The co-managers believe that through the combination of quantified and unquantified benefits we will achieve 100% of the recovery goals.

PURPOSE

The purposes of the plan are to:

- Define biologically-based recovery goals
- Identify what is known or assumed about factors that limit production of Skagit River Chinook
- Propose scientifically-based actions that will restore Skagit River Chinook to optimum levels, including fisheries management, artificial production, habitat protection, habitat restoration, effectiveness monitoring, and applied research

The reader should recognize this plan as representing only one pathway to reach recovery, and that the co-managers welcome discussions to improve or revise the plan. By no means should this be construed as the only pathway by which the desired ends can be achieved. We recognize the complexities of implementing recovery actions and the importance of securing support from a host of stakeholders. Furthermore, we acknowledge the importance of building agreements one step at a time. This said, the co-managers offer this document in the spirit of providing leadership and direction. In doing so, we challenge the reader to be constructively critical, while keeping in mind that proposed changes will need to be similarly quantitatively supported to demonstrate that recovery goals as established in this plan can be achieved.

RECOVERY GOALS

There are four measures of recovery that must be met to comply with the National Oceanic and Atmospheric Administration (NOAA)'s definition of recovery:

1) **Abundance**, expressed as both escapement, which is the number of spawners, and recruitment, which is the number of returning adults harvested in Alaska, Canada and the U.S., plus the number of unharvested fish that return to the Skagit River
2) **Productivity**, or the ratio of the number of fish produced by each spawner
3) **Diversity** of habitats and genetic traits that support Chinook production
4) **Connectivity** between these habitats

Tribal parties to this plan have defined harvest goals that are consistent with the over-all recovery goals adopted by the co-managers. Productivity, in practical terms, is a measure of the number of fish that are produced in excess of those necessary to equal replacement. In a healthy and properly managed population, each pair of spawning fish will produce three or more pairs of returning adults. All fish in excess of a single pair of fish are available to go towards either escapement or harvest, based on what is necessary to meet recovery goals, and on the condition of the watershed.

Skagit Chinook fall into six different populations: Upper Cascade springs, Suiattle springs, Upper Sauk springs, Lower Skagit falls, Upper Skagit summers, and Lower Sauk summers. The following two tables show where we are today, and what the recovery goals are at the point of MSY.

Percent of adult recruitment goals at MSY for wild Skagit Chinook salmon achieved by implementing all proposed restoration actions.

Marine Survival	Recovery Goal (Adults per Year)	Before Plan Actions		After Plan Actions		Percent Change
		Adults per Year	Percent of Goal	Adults per Year	Percent of Goal	
Low Regime	40,600	20,369	50.2%	29,991	**73.9%**	+23.7%
High Regime	124,000	59,774	48.2%	88,012	**71.0%**	+22.8%

Percent of productivity goals at MSY for wild Skagit Chinook salmon achieved by implementing all proposed restoration actions.

Marine Survival	Recovery Goal for Recruits (Adults per Spawner)	Before Plan Actions		After Plan Actions		Percent Change
		Adults per Spawner	Percent of goal	Adults per Spawner	Percent of goal	
Low Regime	3.4	1.7	50.2%	2.5	**73.9%**	+23.7%
High Regime	5.8	5.1	86.8%	7.4	**127.8%**	+41.0%

The next two tables demonstrate that recovery goals cannot be met through harvest management actions alone.

1999-2005 Mean Exploitation Rates			
Mgmt Unit	**Marine Survival Scenario**	**Recovery Criterion**	**Percent of Goal**
Skagit Spring Chinook	Avg Low	Escapement	87%
		Recruitment	40%
		Productivity	46%
	Avg High	Escapement	146%
		Recruitment	47%
		Productivity	32%
Skagit Summer/Fall Chinook	Avg Low	Escapement	116%
		Recruitment	53%
		Productivity	45%
	Avg High	Escapement	189%
		Recruitment	50%
		Productivity	26%

While escapements may be met under certain circumstances, both recruitment and productivity cannot be met by harvest management actions alone. Near-term tribal harvest goals are 500 spring Chinook and 20,000 summer and fall Chinook. Long-term goals are 1000 springs and 30,000 summers and falls. These harvest goals are consistent with the recovery goals described in this plan. As can be seen from the following table, tribal harvest goals cannot be met as a result of harvest management activities alone.

Percent of harvest goals achieved through harvest management actions, assuming no other restoration actions and current adult capacity.				
	Avg Survival, Low Regime		**Avg Survival, High Regime**	
	Spring MU	**Sum/Fall MU**	**Spring MU**	**Sum/Fall MU**
Long-Term Harvest Goal	1,000	30,000	1,000	30,000
Current Adult Capacity	1,430	19,573	4,194	57,440
Terminal Exploitation Rate	1%	5%	12%	18%
Resulting Harvest	14	979	503	10,339
Percent of Harvest Goal	1%	3%	50%	35%

Therefore, as a result of the analyses identified above, restoration efforts directed at specific life history strategies, in portions of the watershed specific to those strategies, were developed as part of the plan.

Benefits of hatchery practices as a result of plan implementation can be seen in the following table, which assumes the same recruitment at both low and high marine survival:

Number of additional fish resulting from Artificial Production Actions		
	Low marine survival (% recovery)	High marine survival (% recovery)
Summer/Fall Recruits	1850	1850
Escapement	1150 (11%)	900 (5%)
Harvest	100 (0.3%)	300 (1%)

APPROACH TO RECOVERY PLANNING

Four different juvenile Chinook salmon life history strategies have been identified in the Skagit: yearlings, parr migrants, tidal delta rearing migrants, and fry migrants. Because of differences in habitat use, yearlings and parr migrants depend more on abundant and high quality freshwater habitat, while tidal delta rearing migrants and fry migrants depend more on estuarine habitats (tidal delta and pocket estuaries). This difference in habitat utilization by individual life history strategies helps shape the habitat recovery actions proposed in this plan. Habitat recovery actions are proposed that benefit each life history strategy in an effort to maintain and strengthen Chinook population diversity, as well as to achieve the spatial connectivity, abundance and productivity goals.

FACTORS LIMITING CHINOOK PRODUCTION

This recovery plan lists a number of factors currently limiting Chinook production based on best available science. Limiting factors were considered within a salmon life cycle framework that considers all life stages, life history strategies and the various habitats upon which salmon depend in those various life stages. Production is a function of all life stages and habitats encountered throughout a salmon's life.

We did not consider the ocean as a limiting factor, but did evaluation actions based on favorable, unfavorable, and worst-case ocean conditions. Factors identified as limiting production are: (1) seeding level (density of spawners or juveniles) is adequate for Upper Skagit summers, Lower Skagit falls, and Suiattle springs, and indeterminate for Lower Sauk summers, Upper Sauk springs, and Upper Cascade springs; (2) degraded riparian zones; (3) poaching; (4) current hydroelectric operations; (5) sedimentation and mass wasting; (6) flooding; (7) high water temperatures; (8) hydromodification; (9) water withdrawals; (10) loss of delta habitat and connectivity; (11) loss of pocket estuary habitat and connectivity; (12) availability of prey species; and (13) illegal habitat destruction and degradation. This plan recommends actions to address these factors limiting production. A number of factors were also evaluated and assumed not significant.

RECOVERY ACTIONS

This plan lays out recovery actions as follows:

- Harvest management
- Habitat protection
- Habitat restoration, including restoration in habitats for each life cycle stage:
    - Spawning habitat
    - Freshwater rearing habitat
    - Tidal delta rearing habitat
    - Nearshore rearing habitat
- Artificial production
- Research
- Monitoring

HARVEST MANAGEMENT ACTIONS

Harvest management regimes will be guided by the principles of the Puget Sound Salmon Management Plan and other legal mandates pursuant to U.S. *v* Washington and U.S. *v* Oregon. Fisheries will be managed according to the 2004 Comprehensive Management Plan for Puget Sound: Harvest Management Component. Actions described in the Skagit Plan were developed through the Comprehensive Management Planning process in an effort to constrain fisheries such that exploitation rates, which is percent of adult returning fish harvested by Alaska, Canada, and U.S. Treaty and non-treaty sports and commercial fishers, will be low enough to allow for stock rebuilding during years of low run size, and to ensure that harvest will only take place if it will not impede achievement of recovery goals. As such, fisheries are structured to achieve ESA jeopardy standards, and agreed-upon U.S.-Canada Pacific Salmon Treaty harvest rates, while at the same time allowing fisheries on stocks of fish with harvestable surplus.

In actual application, since 1999, these constraints have successfully limited impacts on Skagit Chinook to well under the ceiling exploitation rates. From 1999–2005, with a ceiling rate of 50%, predicted exploitation rates on Skagit summer/fall Chinook have averaged 37%; for Skagit spring Chinook, which had a ceiling rate of 42% from 1999–2004 (lowered to 38% beginning in 2005), predicted exploitation rates have averaged 27%. These rates are low enough to allow achievement of the spawning escapement levels associated with recovery, but harvest management actions alone will not achieve the recovery goals for recruitment and productivity.

A more robust and coordinated enforcement program is proposed as part of the harvest management plan. Poaching can be addressed by increasing the presence of enforcement officers, either by adding to existing staff or through improved coordination with other agencies, by coordinating with volunteer groups or individuals who may be willing to observe poaching hot spots, and by improving community education about salmon issues.

HABITAT PROTECTION

The authority and responsibility for habitat as it pertains to salmon recovery ultimately rests with every individual landowner and permitting authority charged with making decisions regarding how a piece of land will be developed and managed.

The ability to reach recovery as proposed in this plan is based on taking the appropriate steps towards restoration, while not reducing the current productivity of the system. We do recognize that, as a result of ongoing land uses and additional population pressures, habitat will continue to degrade. However, we cannot predict how much or how fast this degradation will occur. Therefore, this plan provides recommendations regarding those measures necessary to insure that there will be no loss of productivity and that current habitat conditions will get no worse. We recognize that: (1) there are other pathways to recovery, and that we are open to evaluating different protection options if they can be demonstrated to maintain current productivity; and (2) if other parties or jurisdictions seek to provide a lesser degree of protection, that commensurate additions in restoration measures must be provided.

The habitat protection plan provides for recommended protection measures in the following areas:

- Stream Flow
- Basin Hydrology

- Water and Sediment Quality and Sediment Transport
- Stream Channel Complexity
- Riparian Areas and Wetlands
- Estuary and Nearshore
- Fish Passage and Access

Fifty-six recommendations have been made to address the above-mentioned areas. In many instances, to provide for certainty of protection if implemented, enforcement and modification of or additions to existing regulations are proposed.

Also proposed within this section of the plan is a long-term monitoring strategy that looks at how well existing habitat is protected during plan implementation. These measures are linked to quantitative criteria identified as part of the recommendations.

RESTORATION ACTIONS

The restoration strategy for this plan is based on an understanding of the limiting factors for each of the Skagit Chinook salmon stocks, and the specific location of existing or potentially restorable habitat. These factors largely determine the relative importance of a specific habitat in our salmon recovery plan. Restoration actions improving conditions for spawning and incubation will increase seeding for all juvenile Chinook life history strategies. Large river floodplain restoration seeks to improve freshwater conditions for all Chinook salmon fry, but more expressly for those life history strategies that depend on freshwater habitat for extended rearing, such as parr migrants and yearlings. Delta restoration will benefit delta rearing life history strategies, while pocket estuary restoration will benefit fry migrants. The plan proposes restoration in the following areas:

Spawning habitat and egg incubation conditions. Proposed actions focus on: (1) areas that have been isolated or impaired as a result of human disturbance (e.g., road crossings); and (2) actions that address physical processes that are impaired, such as sediment transport or hydrology, that lead to degradation or loss of spawning habitats. Most isolated Chinook spawning habitat has been identified and projects completed that address the problem; therefore, projects emphasized are primarily road storm proofing, upgrades and decommissioning.

Freshwater rearing habitat in large river floodplains, tributaries, and non-tidal delta. Projects include restoring freshwater rearing habitat by removing or upgrading hydromodifications on the main channel, planting riparian vegetation, restoring natural floodplain processes by removing or relocating floodplain modifications, and/or re-connecting historic floodplain channels.

Tidal delta rearing habitat. Restoration actions include reestablishment of historic estuarine wetlands through dike and levee removal or setbacks, and the reestablishment of downstream migration corridors that provide for dispersion of juvenile Chinook to spatially diverse habitats.

Nearshore rearing habitat (primarily pocket estuary restoration). The plan focuses efforts in three major areas: (1) increase opportunity for juvenile Chinook salmon to utilize pocket estuary habitat close to their natal rivers so that outmigrants can make a safer transition from the river to the marine environment; (2) increase opportunity for juvenile Chinook salmon to utilize pocket estuaries throughout the Whidbey Basin for safe rearing and traveling through the nearshore; and (3) ensure healthy and functioning nearshore beaches connecting pocket estuaries for the benefit of forage fish and larger Chinook life history strategies that do not directly utilize pocket estuaries. Activities include the restoration of lost pocket estuary marsh, channels and impoundments; reestablishing tidal connectivity and volume within pocket estuaries; restoring armored sediment source beaches in littoral cells that create and maintain spits, forming pocket estuaries; restoring lost or degraded freshwater inputs to pocket estuaries and known forage fish habitats; and removing impediments to fluvial and coastal sediment transport processes.

ARTIFICIAL PRODUCTION

Two resource management plans (RMP) that cover artificial production are currently under review by NOAA Fisheries. One RMP focuses on hatchery Chinook releases and their potential effects on listed Chinook and summer chum salmon. The other RMP deals with non-Chinook hatchery releases, which include coho, chum, pink, sockeye and steelhead hatchery programs, and their effects on the listed species. Together, these hatchery RMPs provide the proposed frameworks through which co-managers would jointly manage Puget Sound salmon and steelhead hatchery programs, while meeting conservation requirements specified under the Endangered Species Act (ESA). Principles developed by the Hatchery Scientific Review Group (HSRG) (2004), or those that are part of the RMP, will guide hatchery operations.

Current hatchery Chinook programs within the Skagit River have been established for indicator stock purposes. The objective of these indicator-stock programs is to obtain representative data on harvest impacts and marine survival of Chinook salmon that the co-managers can use to apply to management of wild Chinook populations. Under this Chinook Restoration Plan, hatchery Chinook programs will continue, initially, as currently programmed. No new hatchery Chinook programs are proposed for the Skagit at this time, and existing programs will continue as configured. However, if predefined circumstances occur, one or more programs may be modified or eliminated. In addition, the co-managers will develop a contingency conservation plan that describes the actions that will be taken in the event that wild production of one or more populations declines to a specified level. Non-Chinook programs will be modified in accordance with the RMP.

The co-managers' adaptive management framework combines passive adaptive management and evolutionary problem solving. It has seven key elements:

1) An integrated strategy for the ESU
2) Defined goals and objectives for hatchery programs
3) A framework of artificial production strategies for reaching goals and objectives
4) Strategy-specific guidelines for operating hatchery programs
5) Scientific tools for evaluating hatchery operations, including statistical analyses, risk-benefit assessments, and independent scientific review
6) A decision-making framework for considering in-season, annual, and long-term changes in hatchery objectives and standard operating modes described in Hatchery and Genetic Management Plans (HGMPs) and resolving disputes
7) Implementation using available resources

RESEARCH ACTIONS

Research efforts in the Skagit Basin over the past ten years, in combination with applicable research from other basins, have informed the development of this recovery plan. The goals of continuing research actions are to test and refine the working hypotheses upon which restoration and protection actions are based. Because this plan is intended to be adaptive, it is critical to carry out the research necessary to fill data gaps and to determine whether the assumptions that guide our recovery actions are valid.

Some of the currently identified data gaps for our ongoing work include: sources of sediments impacting egg to fry survival; the role of beavers in the tidal delta; the ecology of forage fish, as it relates to salmon during nearshore rearing; the role of predation by seals and birds in limiting Chinook productivity; and further refinement of our understanding of Chinook rearing and survival in nearshore habitats, including the impacts of specific land uses.

Proposed research actions include investigating:

- Life histories and habitats used by yearling Chinook
- Hatchery fish predation in rivers
- Nutrient and carcass cycling
- Sediment and scour
- Impacts of global warming on delta habitats
- Impacts of beavers on delta habitats
- Juvenile Chinook use of nearshore habitats
- Hatchery/wild interactions in the delta and nearshore
- Impacts of boat harbors on Chinook salmon
- Impacts of diking on eelgrass
- Forage fish ecology
- Pinniped predation
- Predatory birds
- Life history strategies and marine survival
- Juvenile Chinook salmon origin and use of habitats within Puget Sound, Straits of Juan de Fuca, and Georgia Straits basins

MONITORING ACTIONS

Monitoring actions arise from the need to evaluate the effectiveness of restoration, protection, and harvest actions in reaching our recovery goals. Reach-scale monitoring generally follows methodologies described in Monitoring Stream and Watershed Restoration (Roni 2005). In the cases of tidal delta and nearshore restoration, basin-scale monitoring is implemented according to the Intensively Monitored Watersheds Plan included in Appendix E. Recovery success is evaluated both on the individual action (project) scale, and at the basin-wide scale.

Monitoring efforts will focus on evaluating process function and biotic response. The biological component of monitoring quantifies population characteristics for outmigrating juveniles and returning spawners at the basin scale. At the project scale biological monitoring includes Chinook salmon presence or absence, fish density, community compositions, Chinook size, and predation and prey potential. The process component of monitoring quantifies habitat characteristics indicative of landscape process function. At the project scale, monitoring will include river flow, sediment supply, driftwood accumulation, tidal extent, etc. At the basin scale where processes are generally beyond local control, we monitor conditions such as flooding, drought, relative sea level, salinity, and ambient air temperature.

Specific monitoring proposals within the plan include:
- Spawner surveys
- Catch sampling and reporting
- Test fishery
- Hatchery indicator stock programs
- Monitoring compliance with minimum flow and downramping requirements
- Redd stranding studies
- Mainstem smolt trap
- Fish trapping in the estuary delta
- Bay seining
- Effects of land uses on Chinook and Chinook habitat

The co-managers believe that the development of this Chinook recovery plan is only the first step in a long path towards salmon recovery. We believe it provides a blueprint for implementing those actions necessary to insure that Chinook salmon, and the ecosystems upon which they depend, will be a permanent part of the landscape and legacy of Washington State and specifically the Skagit River Basin. We look forward to collaborative engagement with all those that seek to achieve this worthy goal.

Location map. The Skagit River System.

1. INTRODUCTION

The Skagit River Basin represents the largest and one of the most unspoiled strongholds of fish and wildlife habitat in the Puget Sound. The Skagit system is comprised of the mainstem Skagit and tributaries as well as four secondary river basins: the Baker, the Cascade, the Sauk, and the Suiattle. It encompasses over 3,100 square miles (8,030 square kilometers) of watershed area and 80,728 acres (32,670 hectares) of delta connecting the river to Skagit Bay and Whidbey Basin. The Skagit drainage includes 2,989 identified streams totaling approximately 4,540 linear miles. Stakeholders and governing bodies in the Skagit system include three treaty Indian tribes; two federal and three state land management agencies; Canadian federal, provincial and municipal governments; three county governments; various local municipal governments; and private property owners.

Anadromous forms of ten salmonid species, and several more racial sub-groups or stocks, exist within the Skagit Basin. These include six Chinook stocks (spring, summer, and fall); pink salmon; chum salmon; sockeye salmon; summer and winter run steelhead; sea run cutthroat trout; and Dolly Varden and bull trout. Of these stocks, all season-specific Chinook, sockeye, coho, and steelhead species are under review by state and federal agencies for potential listing under the Endangered Species Act (ESA). The Puget Sound Chinook salmon Evolutionarily Significant Unit (ESU) was listed as a threatened species on March 24, 1999 by the National Marine Fisheries Service (NMFS). The U.S. Fish & Wildlife Service (USFWS) has proposed Puget Sound coastal bull trout as threatened. Coastal/Puget Sound sea-run cutthroat trout are listed as candidate species by NMFS.

Chinook salmon stocks originating from the Skagit River have been in a long-term decline. Chinook catches in the Skagit terminal area have declined since at least 1935; ranging from 40,000 to 50,000 in the 1930s, dwindling down to annual catches of a few thousand or even hundreds during the 1990s (Figure 1.1). Return/spawner rates have been below average since brood year (BY) 1983 and have been less than or equal to one in most years since BY 1985.

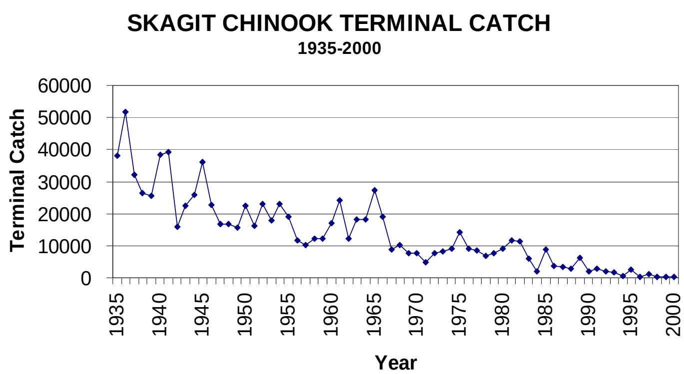

Figure 1.1. *Chinook net catch since 1935 in Skagit Bay and River.*

An equally alarming observation in the population profile indicates that, although spawning escapements have been relatively stable over the period of record, total adult recruitment has decreased significantly from the levels of the mid-1980s (Figure 1.2), which indicates there may have been a loss in habitat productivity. By 1994, it was evident that piecemeal management strategies enacted since 1977 had been unsuccessful at reversing this trend. A more comprehensive, proactive, and

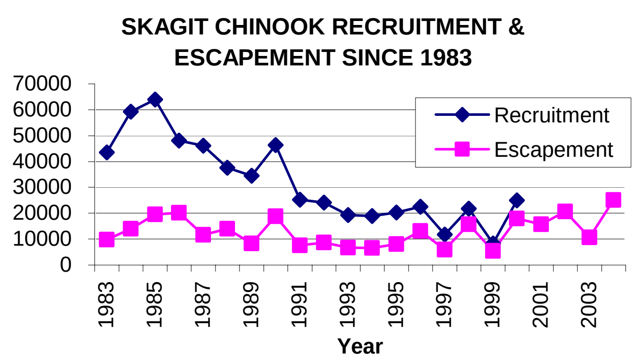

Figure 1.2. *Trends in total (spring, summer, and fall) Chinook recruitment and escapement since 1983.* Recruitment numbers are from post-season runs using FRAM.

adaptive approach was needed, resulting in a cooperative effort by the stakeholders to develop what was then called the Skagit Chinook Restoration Plan. Since that time, the listing of Puget Sound Chinook as "threatened" under the ESA has accentuated the need for recovery planning. This is a planning document for recovery of Skagit Chinook stocks.

1.1. PURPOSES OF THIS PLAN

The purposes of this plan are to:

- Describe our assumptions about Skagit River Chinook stocks
- Define biologically based recovery goals
- Identify scientifically based limitations to recovery
- Propose scientifically based recovery actions, including: fisheries management, habitat protection, habitat restoration, artificial supplementation, effectiveness monitoring, and applied research

This plan is designed to be both deterministic and adaptive. That is, for a given set of assumed constraints on production, specific restoration actions are proposed. Proposed actions are based upon science, and do not incorporate political or economic factors. If the proposed actions are implemented and expected results are not achieved, then different actions will be proposed after an evaluation of initial assumptions and science. Predicted outcomes will serve as performance criteria against which the observed results will be compared. If the performance criteria are achieved, the assumptions will be considered valid; if the performance criteria are not achieved, those assumptions must be reviewed and revised, as well as any protection and/or restoration action that was based on those assumptions. To help guide this evaluation we have described methods to be used to monitor the results of the restoration actions, such that the results can be compared to the performance criteria. Ongoing research will also be conducted to test and improve our assumptions about the connections between limiting factors and Chinook recovery.

Therefore, the authors have explicitly listed the assumptions used by the parties to this plan. Current assumptions about constraints on Chinook production, and the basis for these assumptions, are listed in Appendix E as a memo that summarizes the discussion and initial assumptions about constraints generated through the Skagit Chinook Workgroup. While this memo is concerned specifically with upper Skagit summer Chinook, most of the assumptions apply for all stocks.

Nothing in this plan is intended to define or limit tribal fishing rights as secured by the 1855 Treaty of Point Elliot, and further affirmed by federal court orders and decisions. Implementation of this plan does not imply fulfillment of the tribal right to take fish, or to meet the Trust obligations of the federal government and its subdivisions.

1.2. PARTIES TO THIS PLAN

The parties to this plan are the State of Washington, represented by the Washington Department of Fish and Wildlife (WDFW), and the Swinomish Indian Tribal Community and the Sauk-Suiattle Indian Tribe, represented by the Skagit River System Cooperative (SRSC).

1.3. HISTORY OF THE SKAGIT RECOVERY PLAN

The foundation for this plan was initially developed pursuant to the terms of the May 13, 1994 Memorandum Of Understanding (MOU) on Skagit spring Chinook between WDFW and the Skagit Basin tribes (Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, and Sauk-Suiattle Tribe), which provides that the parties will conduct workshops aimed at determining:

- What is known about the factors that affect Skagit Chinook
- What needs to be accomplished over the next year(s) to design effective supplementation, habitat protection and restoration, harvest management, enforcement, and other strategies that will restore Skagit River Chinook to optimum levels

The MOU also provides that, guided by the results of these workshops, the parties will:

- Develop a plan that specifies, in detail, the strategies that will be used to restore Skagit Chinook to optimum levels
- Commit to funding the elements of this plan

From this agreement arose the Skagit Chinook Workgroup that began meeting in the summer of 1994. Over the years, the Skagit Chinook Workgroup continued to meet in an effort to fulfill the initial intent of this agreement between the co-managers. The following organizations and individuals have been involved in the Skagit Chinook Workgroup deliberations over the years (and if we omitted anyone, we apologize):

Washington Department of Fish and Wildlife
Chuck Baranski
Pete Castle
Bill Hebner
Kathy Hopper
Curt Kraemer
Chuck Lavier
Sandy Moore
Chuck Phillips
Jim Scott
Dave Seiler
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The nucleus of the work provided by the Skagit Chinook Workgroup, and the continued implementation of their initial vision, provides much of the foundation for this plan.

2. TERMS AND DEFINITIONS

303(d) list: List of impaired waters. The federal Clean Water Act (CWA) requires states to maintain a list of stream segments that do not meet water quality standards. The list is called the 303(d) list because of the section of the CWA that makes the requirement.

Allele: One or more forms of a protein or DNA sequence at a particular gene locus.

Allele frequency: Frequencies of alleles for all loci are calculated per population sample.

Allozyme analysis: Alternative forms of enzymes, which are proteins, differentiated by net charge of the molecule and detectable by electrical separation on gel matrices combined with biochemical staining methods. Proteins result directly from DNA coding and thus represent genetic characteristics of organisms.

Area-under-the-curve: Used in salmonid spawning ground surveys to estimate escapement. The area-under-the-curve is calculated, in the case of Skagit Chinook, by multiplying the mean number of redds counted over time (usually weekly or bi-weekly) in an index area or spawning stream, by the number of days in that time segment, and summing for the entire season. This total area (the graphed data), is then divided by redd life (usually 21 days) to estimate total number of redds. The estimated total number of redds is then multiplied by 2.5 (assumed number of spawners per redd) to calculate the total number of spawners for the estimate of escapement.

Bed load: The part of a load moved by a stream along or near its bed (the bottom of a body of water), because this fraction of the load consists of particles too large or heavy (boulders, pebbles, gravel) to be carried in suspension. Movement of bed load is a function of the stream gradient, velocity, and friction of the grains between each other and between grains and bed.

Broodstock: Fish returning to the hatchery, or taken from the wild that will contribute that year’s hatchery production.

Criteria for ESA listing: Must determine if a species should be listed as endangered or threatened because of any of the following five factors: 1) present or threatened destruction, modification, or curtailment of its habitat or ranges; 2) over-utilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) inadequacy of existing regulatory mechanisms; 5) other natural or manmade factors affecting its continued existence (NOAA definition).

Directed fisheries: For the purposes of this plan, directed fisheries are defined as those in which more than 50 percent of the total fishery-related mortality is made up of listed Puget Sound-origin Chinook. Total mortality includes all landed and non-landed mortality (as defined in the Comprehensive Chinook Plan, Section 5.1).

Distinct population segment: A population segment that is discrete in relation to the remainder of the species to which it belongs, and significant to the species to which it belongs. An Evolutionarily Significant Unit (ESU) of Pacific salmon is considered a DPS.

Endangered species: A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range.

ESA jeopardy standards: Standards that determine whether an action would be reasonably expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species (Section 7(a) (2) and Implementing Regulations 50 C.F.R. § 402). The quantitative standards that were used for Skagit Chinook are described in PSIT and WDFW 2004 (p. 108-109).

Essential fish habitat: Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (Magnuson-Stevens Conservation Act, 16 U.S.C. 1802(10)).

> **Waters** include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate (50 C.F.R. 600.10); **substrate** includes sediment, hard bottom, structures underlying the waters, and associated biological communities (50 C.F.R. 600.10); **necessary** means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem (50 C.F.R. 600.10); and **healthy ecosystem** means an ecosystem where ecological productive capacity is maintained, diversity of the flora and fauna is preserved, and the ecosystem retains the ability to regulate itself. Such an ecosystem should be similar to comparable, undisturbed ecosystems with regard to standing crop, productivity, nutrient dynamics, trophic structure, species richness, stability, resilience, contamination levels, and the frequency of diseased organisms (50 C.F.R. 600.10). See U.S. Dept. of Commerce 1997a and 2002.

Estuary: Body of water where the river meets the sea. Salinity of estuaries is somewhere between that of the ocean (about 34 parts per thousand) and that of fresh water (almost zero) and acts as a transition zone for juvenile salmon before migrating to the ocean, and for adult salmon as they return to freshwater to spawn.

Evolutionarily significant unit: A population or group of populations that is considered distinct for purposes of conservation under the Endangered Species Act. An ESU is a population or group of populations that is substantially reproductively isolated from other conspecific populations and represents an important component in the evolutionary legacy of the species.

Fishery management plan: A plan to achieve specified management goals for a fishery. It includes data, analyses, and management measures (including guidelines for harvest) for a fishery.

Fitness: The ability of an organism to persist in its environment.

Habitat areas of particular concern: Subsets of EFH identified based on one or more of the following considerations: 1) importance of the ecological function, 2) extent to which the habitat is sensitive to human-induced degradation, 3) whether and to what extent development activities are stressing the habitat type, and 4) rarity of habitat type (50 CFR 600.815(a)(8)).

Hydrograph: A graph showing time-related variation in flow. The variation may be shown in terms of yearly, monthly, daily, or instantaneous change.

Impaired riparian zone: Riparian refers to the land directly adjacent to a stream, lake, or estuary. A healthy riparian area has vegetation that harbors insects, contributes nutrients, and provides shade and cover for fish. "Impaired" is a regulatory term indicating the riparian zone does not function as necessary for fish habitat. (See 303(d) List of impaired streams.)

Indicator stock: A stock or release group that is used to monitor trends for larger associated units. In PSC application, there are escapement indicator stocks, which are used to monitor escapement trends for production regions, and exploitation rate indicator stocks, which are CWT release groups that are used to monitor survival rates and exploitation rates for associated untagged production. In the case of Skagit Chinook, there are currently three exploitation rate indicator stock programs, which are used to represent the fisheries distribution of Skagit spring Chinook, Skagit summer Chinook, and Skagit fall Chinook.

Lithologies: The description and study of rocks, as seen in hand-specimens and outcrops, on the basis of color, grain size, and composition.

Mainstem: The highest order portion of a river into which lower order tributaries flow.

Maximum sustainable yield: This is equivalent to Maximum Sustained Harvest (MSH), which, under the Puget Sound Salmon Management Plan, is the maximum number of fish of a management unit that can be harvested on a sustained (or long-term) basis, in Washington fisheries. Because survival rates vary from year to year, this level is more accurately expressed as a long-term average.

Maximum sustainable yield escapement: The spawning escapement level that produces MSY under average environmental conditions.

Nearshore: Marine water area between the uppermost extent of saltwater influence (the back shore), extending down to the shallow subtidal to the edge of the photic zone (approximately 40 meters).

North of Falcon process: The negotiation process through which the state and tribal co-managers set the annual regulations for salmon fisheries in Western Washington and the Pacific Ocean north of Cape Falcon, Oregon.

Operculum: The thin and flexible bony plate covering the outside of the gills on either side of the fish's head. The operculum is an important component to the "two-pump" respiratory system possessed by most fish. The operculum is routinely marked (hole punched) to identify sampled fish.

Pacific decadal oscillation: The PDO (Hare 1996) is often described as a long-lived El Niño-like pattern of Pacific climate variability (Zhang et al. 1997). As seen with the better-known El Niño/Southern Oscillation (ENSO), extremes in the PDO pattern are marked by widespread variations in Pacific Basin and North American climate. In parallel with the ENSO phenomenon, the extreme phases of the PDO have been classified as being either warm or cool, as defined by ocean temperature anomalies in the northeast and tropical Pacific Ocean. When sea surface temperatures (SST) are anomalously cool in the interior North Pacific and warm along the Pacific Coast, and when sea level pressures are below average over the North Pacific, the PDO has a positive value. When the climate anomaly patterns are reversed, with warm SST anomalies in the interior and cool SST anomalies along the North American coast, or above average sea level pressures over the North Pacific, the PDO has a negative value (Mantua 1999). See Mantua et al. (1997) for specific impacts on salmon.

Pocket estuary: Partially enclosed, measurably diluted marine body of water that is smaller in scale than and discontinuous from Chinook natal river systems.

Population: The fish spawning in a particular lake(s) or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season (WDF et al. 1993).

Properly functioning conditions: The spawning and rearing habitat conditions necessary for the long-term survival of Pacific salmon populations. See U.S. Dept. of Commerce 1996.

Seeded: Used in this document to describe the distribution and density of fish throughout the available habitat.

Species: Any subspecies of fish or wildlife or plants, and any DPS of any species of vertebrate fish or wildlife which interbreeds when mature (Endangered Species Act, Sec. 3 (15)). For Pacific salmon, this includes any DPS that meets the qualifications of an ESU (Waples 1991b).

Stock: An anadromous salmonid population of a single species migrating during a particular season to a specific fish production facility and/or to a freshwater system which flows into saltwater (PSSMP definition).

Stream reach: A section of a body of water that is defined either by the morphology of the stream, the geology of the stream, the hydrology of the stream, a predefined length, or a legal boundary. In most cases used in this document, all reaches of the Skagit Basin are identified by alpha-numeric designations: SK## for the Skagit River, SU## for the Suiattle River, SA## for the Sauk River, CA## for the Cascade River.

Threatened species: A species is considered threatened if it is likely to become an endangered species within the foreseeable future.

Acronyms Used in This Document

AABM	Aggregate Abundance Based Management
AUC	Area-Under-the-Curve
BMP	Best Management Practices
BY	Brood Year
CREP	Conservation Reserve Enhancement Program
C&S	Ceremonial and Subsistence
CAO	Critical Areas Ordinance
cfs	cubic feet per second
CWA	Clean Water Act
CWT	Coded Wire Tag
DDT	Dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Statement
DIT	Double Index Tag
DPS	Distinct Population Segment
EDT	Ecosystem Diagnosis and Treatment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act of 1973, as amended
ESU	Evolutionarily Significant Unit
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
fPR	forced Pool-Riffle
FMP	Fishery Management Plan
FRAM	Fishery Regulation Assessment Model
GIS	Geographic Information Systems

HAPC	Habitat Areas of Particular Concern
HCP	Habitat Conservation Plan
HGMP	Hatchery and Genetic Management Plans
HPA	Hydraulic Project Approval
HSRG	Hatchery Scientific Review Group
ISBM	Individual Stock Based Management
JOG	Joint Objectives and Goals
LWD	Large Woody Debris
MMPA	Marine Mammal Protection Act of 1972, as amended
MOU	Memorandum of Understanding
MSY	Maximum Sustainable Yield
MWL	Mean Water Line
MU	Management Unit
NBS	National Biological Survey
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWFSC	Northwest Fisheries Science Center (NMFS-NOAA)
NWIFC	Northwest Indian Fisheries Commission
OCPI	Overriding Consideration of Public Interest
PDO	Pacific Decadal Oscillation
PFC	Properly Functioning Conditions
PFMC	Pacific Fisheries Management Council
PR	Pool-Riffle
PSC	Pacific Salmon Commission (implementing body for Pacific Salmon Treaty)
PSE	Puget Sound Energy
PSIT	Puget Sound Indian Tribes
PSSMP	Puget Sound Salmon Management Plan
PST	Pacific Salmon Treaty
PUD	Public Utility District
RM	River Mile
RMAP	Road Maintenance and Abandonment Plan
RMP	Resource Management Plan
SCD	Skagit Conservation District
SCL	Seattle City Light
SRFB	Salmon Recovery Funding Board
SRSC	Skagit River System Cooperative (2003 to present)
SSC	Skagit System Cooperative (1975–2002)
SUS	Southern United States
SWC	Skagit Watershed Council
SWSL	Surface Water Source Limited
TMDL	Total Maximum Daily Load
TRT	Technical Review Team (Pacific Salmon)
UET	Upper Escapement Threshold

USACE	United States Army Corps of Engineers
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USCG	United States Coast Guard
USGS	United States Geological Survey
WAU	Watershed Administrative Unit (WDNR)
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WCVI	West Coast Vancouver Island
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WDOT	Washington Department of Transportation
WRIA	Water Resource Inventory Area (WDOE)

3. ASSUMPTIONS ABOUT SKAGIT CHINOOK SALMON

In defining recovery goals, we have made several general assumptions about the biology of Skagit Basin Chinook salmon populations. These assumptions are scientifically based, and are used to develop hypotheses about production constraints. This chapter outlines these general assumptions. More in-depth scientific discussion is included in the appendices of this plan, and actions to monitor the validity of these assumptions are described in Chapters 14 and 15.

3.1. SIX SKAGIT CHINOOK STOCKS

We are assuming that six separate Chinook populations naturally inhabit the Skagit Basin (Washington Department of Fisheries et al. 1993). Each of these stocks utilizes stock-specific spawning grounds (Figure 3.1). The stocks are defined as follows:

Upper Skagit Summers

Upper Skagit summer Chinook are those that spawn in the Skagit mainstem and its tributaries upstream of the Sauk River, primarily from September through early October. Genetic analyses have shown that upper Skagit summer Chinook are significantly differentiated from other Skagit Basin Chinook populations, including the hatchery summer Chinook stock formerly released at Marblemount Hatchery (terminated in 1992) (Marshall et al. 1995; Puget Sound Technical Recovery Team 2004).

Lower Skagit Falls

Lower Skagit fall Chinook are those that spawn in the Skagit mainstem and its tributaries downstream of the Sauk River. Most of these fish spawn between Sedro Woolley and the Sauk River primarily in October, generally later than upper Skagit summer spawners (WDF et al. 1993). Peak redd counts are in mid-October. Updated allozyme-based genetic analyses showed that lower Skagit fall Chinook are significantly differentiated from other Skagit Basin Chinook populations (Puget Sound TRT 2004).

Lower Sauk Summers

Lower Sauk spring Chinook are those that spawn in the Sauk mainstem and its tributaries (excluding the Suiattle system) downstream of the Darrington bridge at river mile (RM) 21.2. Most of these fish spawn between the town of Darrington and the mouth of the Suiattle River, from September through early October. Lower Sauk spring Chinook have statistically significant genetic differences from all other Skagit Basin Chinook populations, but they are more similar to other Skagit populations than to Puget Sound Chinook populations.

Upper Sauk Springs

Upper Sauk spring Chinook are those that spawn in the Sauk mainstem and its tributaries upstream of the Darrington bridge at RM 21.2. Most of these fish spawn between the mouth of the Whitechuck River and the confluence of the North and South Forks of the Sauk, from late July through early September. Updated allozyme-based genetic analyses showed that upper Sauk spring Chinook are significantly differentiated from other Skagit Basin Chinook populations (Puget Sound TRT 2004).

Suiattle Springs

Suiattle spring Chinook are those that spawn in the tributaries to the Suiattle River. Most of these fish spawn from late July through early September. Statistical analysis of allozyme allele frequency data indicate that Suiattle spring Chinook are genetically distinct from all other Skagit Basin Chinook populations, as well as hatchery spring Chinook produced at Marblemount Hatchery, which were first derived from Suiattle-origin spring Chinook broodstock (Marshall et al. 1995; Marshall 2001).

Upper Cascade Springs

Upper Cascade spring Chinook are those that spawn in the Cascade River and its larger tributaries upstream of the canyon, beginning at about RM 7.8. Statistical analysis of allozyme allele frequency data indicate that upper Cascade spring Chinook are genetically distinct from all other Skagit Basin Chinook populations, including the Marblemount Hatchery spring Chinook stock (Marshall et al. 1995; Puget Sound TRT 2004). As with other Skagit spring populations, upper Cascade springs are more similar genetically to Skagit summer and fall Chinook populations than they are to spring Chinook populations that spawn in other Puget Sound systems. Figure 3.1 shows the spawning ranges of the six stocks.

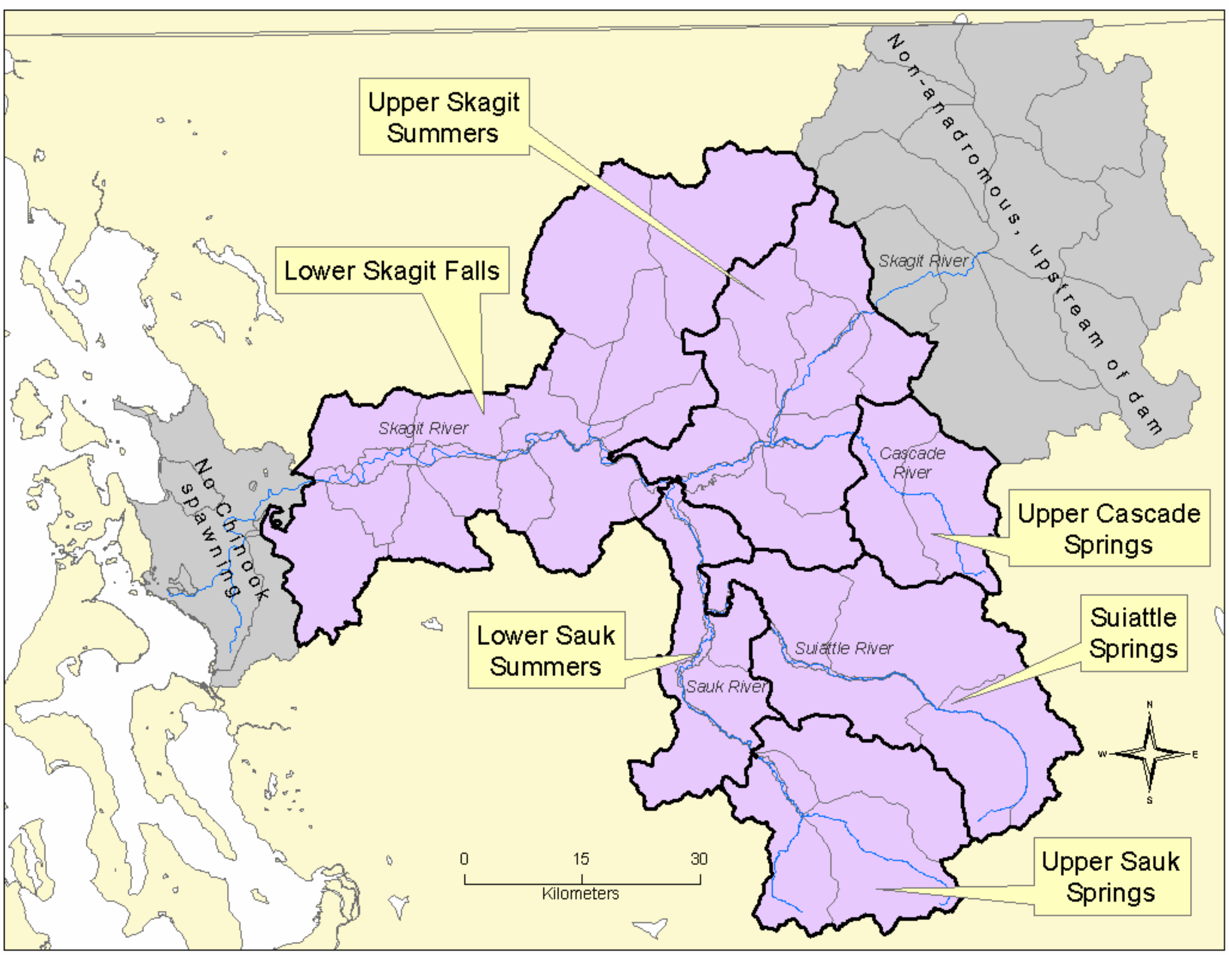

Figure 3.1. *Spawning ranges of the six Skagit Chinook stocks.*

Genetic analysis of allozyme data indicate that lower Sauk summer, upper Cascade spring, and Suiattle spring Chinook are genetically distinct populations, but genetic distinctions are ambiguous for the other populations. Lower Skagit falls and upper Sauk springs are genetically distinct from each other, but neither is distinct from upper Skagit summers (Marshall et al. 1995, cited in WDFW 2003). An updated genetic analysis performed for purposes of the Puget Sound Technical Recovery Team (TRT) showed that genetic similarities among putative Skagit Basin Chinook populations are relatively high, but that allele frequency differences between populations are highly significant in statistical tests (Puget Sound TRT 2004). Upper Sauk springs are assumed to be a separate population because they are genetically distinct from their nearest neighbors, lower Sauk spring and Suiattle spring Chinook, and they are spatially and temporally separated from upper Skagit summer and lower Skagit fall Chinook. Upper Skagit summer and lower Skagit fall Chinook are assumed to be separate because of their different spawning timing (WDF et al. 1993), and some differences in hydro region and lithologies (Puget Sound TRT 2004).

3.2. POPULATION FITNESS

We assume the intrinsic ability of Skagit Chinook salmon populations to produce and survive (independent of density and habitat quality) is not declining. Average fecundities of upper Skagit summer broodstock used for coded wire tagging (CWT) of indicator stocks (5,600 in 1994; 5,800 in 1995; 5,400 in 1996; 6,400 in 1997; 5,900 in 1998; 6,100 in 1999; and 5,600 to 6,600 for 2000-2003) (Henderson and Hayman 2003) are higher than those observed in the late 1970s (5,200) (Baranski 1994); and the mesh size used from 1994-1999 (7.5 inches) is smaller than the 8-inch mesh used during the 1970s. This indicates that average fecundities have not decreased for this population over the last 20 years. River entry timing also remains distributed over the entire period from May to September. Continued monitoring of fecundity, egg size, and fish size in broodstock collection programs, and distribution of run timing and spawning timing, will further test this assumption and its validity in the future.

3.3. JUVENILE LIFE HISTORY TYPES AND STRATEGIES

Chinook salmon exhibit two distinct life history types: stream type (yearling or older at the age of seaward migration) and ocean type (sub-yearling at the age of seaward migration) (Healey 1991). Within each life history type there is the potential for many sub-types – or what we define as life history strategies. Chinook salmon populations with variation in life history type and strategy diversify their population by separating the risk of mortality for progeny from the same brood year to different parts of the river-ocean continuum.

Researchers have observed these variations of life history types and strategies among Skagit Chinook salmon. Stream and ocean type Chinook salmon have been known to comprise the Skagit Chinook salmon populations since the 1960s, when scales were used to identify the juvenile smolt ages from returning adults. More recent smolt trap work in the mainstem of the lower Skagit River suggests that ocean type populations dominate the juvenile outmigration (Seiler et al. 1995). Hayman et al. (1996) were the first to identify three different juvenile life history strategies for wild Skagit ocean type Chinook salmon. Hayman's differentiations were based purely on juvenile fish timing and size patterns observed in freshwater and estuarine habitats throughout the Skagit River and its estuary. Beamer et al. (2000a) later confirmed the presence of these same juvenile life history strategies based on otolith microstructure observations. Table 3.1 describes Skagit Chinook life history strategies.

Table 3.1. *Description of known juvenile life history strategies for wild Skagit Chinook salmon.*

Life History Type	Life History Strategy Description
Ocean Type	*Fry Migrants* – These fry emerge from egg pockets and migrate quickly downstream to Skagit Bay. Fry migrants do not rear extensively in delta habitat, so no delta rearing structure is observed on their otolith. They enter Skagit Bay usually in February and March, at an average fork length (FL) of 39 mm (observed range from otoliths is 30–46 mm FL). Some fry migrants take up residence in pocket estuary habitat (Beamer et al. 2003). These areas are thought to provide fry migrants with a survival or growth advantage over other nearshore habitats.
	Delta Rearing Migrants – Delta rearing fry emerge from egg pockets and migrate downstream at the same time as fry migrants. Instead of directly entering Skagit Bay, they reside in tidal delta habitat for a period ranging from several weeks up to several months, reaching an average size of 74 mm FL (observed range from otoliths is 49–126 mm FL). The average delta residence period for delta rearing Chinook salmon in 1995 and 1996, combined, was 34.2 days (Beamer et al. 2000a). Following the delta rearing period, these fish migrate to Skagit Bay, usually starting in late May or June. We observe a delta rearing region on their otolith. Beamer and Larsen (2004) further defined several life history sub-strategies for delta rearing Chinook salmon based on movement patterns and overall residence period within the delta
	Parr Migrants – These fry emerge from egg pockets and rear for a couple of months in freshwater to achieve a similar size as their delta rearing cohorts over the same time period. Following freshwater residence, parr migrants move through the delta and into Skagit Bay, usually starting in late May or June, at the average size of 75 mm FL (observed range from mainstem trapping is 57–92 mm FL). Parr migrants do not reside in tidal delta habitats. We observe an extended freshwater rearing region and no delta rearing region on their otolith. Some of these fish may reside in off channel habitat within the large river floodplain areas of the Skagit River (Hayman et al. 1996)
Stream Type	*Yearlings* – These fry emerge from egg pockets and rear in freshwater for a period of over one year. Movement patterns and habitat preferences within freshwater are largely unknown. Yearlings migrate to the estuary generally from late March through May, at an average size of 120 mm FL (observed range is 92–154 mm FL). Yearlings do not reside in tidal delta habitats for an extended period of time like delta rearing migrants. Yearlings seem to pass through delta habitats, possibly lingering briefly, before they move on to nearshore areas. Yearlings are rarely found in shallow intertidal environments, and are most commonly detected in deeper subtidal or offshore habitats. Residence in nearshore areas of Skagit Bay by yearlings appears to be shorter than ocean type life histories

These life history strategy definitions continue to be tested and revised by on-going research and monitoring efforts. Primary questions to answer include identifying all life history strategies and which stocks are represented by these different strategies. Otolith and genetic data collected from spawners throughout the basin, starting with the 1995 brood, could further refine these assumptions by identifying geographic locations of fish that exhibit specific life history strategies.

3.4. LIFE HISTORY TYPES AND STRATEGIES BY SKAGIT CHINOOK STOCK

Genetic and fish scale sample results confirm that all six Skagit Chinook salmon stocks have stream and ocean type life histories present in their populations. Otolith and genetic sample results confirm that five of six Skagit Chinook salmon stocks have all three ocean type life history strategies (fry migrant, parr migrant, and delta rearing) present in their populations. Lower Sauk summers were not observed in a limited number of genetic samples of known parr migrants. See Appendix D for details.

We assume upper Skagit summers, lower Skagit falls, and lower Sauk summers are predominately comprised of ocean-type life history strategies, while Suiattle spring, upper Sauk spring, and upper Cascade spring populations have significant yearling life history components that vary in proportion from year to year. We base this assumption on fish scale sample data from spawning grounds. Collections since 1992 from summer and fall spawning grounds (not near the hatchery), and since 1986 from spring spawning grounds, give the following mean percent yearlings by population: lower Skagit falls = 17.8%; upper Skagit summers = 2.6% (BY 1994 or later); Suiattle springs = 51.2%; upper Cascade springs (since 1992) = 50.3%; upper Sauk springs = 44.5%; and lower Sauk samples = 9.1% in one year (BY 1997) with sufficient samples. Some of the upper Skagit samples before BY 1994 may have included hatchery yearlings because there were 300,000 to 1,000,000 unmarked hatchery yearlings released in these brood years that may confound our estimate of wild yearlings in the spawning population. However, all hatchery releases after BY 1993 have been 100% tagged, and the small incidence of yearling adults has remained fairly constant. Refer to Appendix C for details.

3.5. MAXIMUM SUSTAINED YIELD ESCAPEMENT LEVELS

As Chinook salmon density increases, Chinook, like other organisms, become less productive, due to competition for food and space, predation, disease, etc. It's like cramming workers into an office: the size of the building is fixed, as is the number of electrical outlets, toilets, and space for desks and chairs. As workers are added, the office as a whole does more and more work until it reaches a point where the maximum amount of work is being done. Above that point, as more workers are added, workers are competing for the same resources, making more noise, and getting in each others' way, so that less and less work gets done, until, finally, there are so many workers getting in each others' way that no work at all is being done. This is analogous to Chinook salmon populations, with the population growth rate (i.e., the harvestable surplus) analogous to the amount of work getting done in the office. Maximum sustainable yield (MSY) is analogous to the amount of work that gets done when the office is staffed at the level that produces the maximum amount of work; and the number of workers needed to produce that maximum amount of work is analogous to the MSY escapement

Estimates of MSY escapement for Skagit summer and fall Chinook have ranged between 7,500 and 20,000. MSY escapement estimates for Skagit spring Chinook have ranged between 1,000 and 3,000. MSY exploitation rate estimates for Skagit Chinook under recent survival conditions are between 35% and 70%. These values vary according to marine survival rates and habitat conditions. The actions described in this plan are proposed under the assumption that, under current survival conditions, MSY escapement for Skagit summer and fall Chinook is between 10,000 and 15,000; MSY escapement for Skagit spring Chinook is between 1,500 and 2,000; MSY exploitation rate for summer and falls is about 50%; and MSY exploitation rate for springs is slightly less than 40%.

Over the last 30 years, several estimates of MSY escapement and exploitation rate have been generated for Skagit Chinook. The first estimate, WDFW Technical Report 29 (Ames and Phinney 1977), assumed MSY escapement for Skagit summer and fall Chinook was the mean of the 1968–1977 escapements (14,900) and the MSY escapement for Skagit spring Chinook was the mean of the 1959–1968 escapements (3,000). Surplus production analyses conducted in 1984 indicated maximum surplus production of summer and fall Chinook would be obtained, depending on the analysis used, with escapements of 8,000 to 12,000 (Hayman 1984), and maximum surplus production of spring Chinook would be obtained with escapements slightly less than 2,000 (SRSC, unpublished data).

Analyses by the Skagit Chinook Workgroup yielded several estimates of MSY exploitation rate for summer and fall Chinook, which ranged from 42% to 67% (Hayman 1997). For brood years 1985–1993, this analysis estimated MSY escapement to all fisheries is 14,800, and MSY escapement to U.S. fisheries is 12,300, with 95% confidence limits as low as 6,500. In the late 1990's, the Chinook Technical Committee (Pacific Salmon Commission) estimated MSY escapement for Skagit summer and fall Chinook at about 8,000, but this has not yet been published (J. Scott, WDFW, personal communication). This estimate is close to those generated from Ecosystem Diagnosis and Treatment (EDT), which estimated MSY escapement at 7,700 for Skagit summer and falls, and 900 for Skagit springs, assuming current survival rates and habitat conditions (G. Blair, Mobrand Biometrics, personal communicatio*n*). EDT also estimated that, under long-term average (higher) marine survival rates and current habitat conditions, MSY escapement would be 15,800 for summer and falls, and 1,600 for springs. If habitat conditions improve, these estimates would be higher. Under pristine conditions and long-term marine survival rates, EDT estimated that MSY escapement would be 20,800 for summer and falls, and 2,300 for springs.

The most recent analysis, which is assumed to provide the most accurate estimates of MSY under current conditions, is a repetitive simulation analysis that included management error and environmental variability. This analysis estimated that, for target exploitation rates that achieve ESA jeopardy standards, long-term mean harvest was most likely to be maximized by using a target exploitation rate of 54%[2] for summer and falls (Hayman 1999; Hayman 2000a; Puget Sound Indian Tribes [PSIT] and WDFW 2001; PSIT and WDFW 2004), and 47%[3] for springs (PSIT and WDFW 2004). When this simulation was modified to allow incidental harvest only below an upper escapement threshold, and additional harvest up to those exploitation rate targets when escapement exceeds that threshold, then long-term mean harvest was maximized by using a preseason escapement threshold of 14,500 for summer and falls and 2,000 for springs (Hayman 2003; PSIT and WDFW 2004). In this analysis, the mean escapements that resulted from using these upper escapement thresholds were 10,600 for summer and falls, and 1,800 for springs.

SRSC and National Oceanic and Atmospheric Administration (NOAA) scientists are currently compiling inputs to a Chinook life history model that can be used to model and evaluate the long-term productivity of specific habitats. This study examines different levels of habitat capacity and productivity. The model outputs will be verified by comparing them to spawner-smolt and spawner-recruit observations. In the shorter term, relatively high spawner and smolt outmigration levels in recent years should provide information about the capacity of the system for producing harvestable Chinook salmon, and the relation between MSY escapement and these higher spawner and smolt outmigration levels.

[2] The equivalent rate in our fishery management model, Fisheries Regulation Assessment Model (FRAM), is 50% for summer and falls.

[3] The equivalent rate in the 2004 version of FRAM is 38%.

3.6. MARINE SURVIVAL

We assume that the ocean environment is not at carrying capacity. Therefore changes in freshwater and estuarine habitat quality and juvenile production will result in corresponding changes in adult recruitment, despite variability in marine survival rates. Acceptance of the hypothesis that ocean carrying capacity is not limiting suggests that simply increasing juvenile production can increase adult recruitment. Even in periods when marine survival is poor, adult recruitment can be maintained by increasing juvenile production to compensate, at least until some upper ceiling is reached. Conversely, the hypothesis that ocean carrying capacity is the primary limiting factor in adult recruitment suggests that this carrying capacity should be managed as a scarce resource. In this scenario, adult recruitment could be maximized by careful allocation of ocean resources. Management actions might emphasize preserving diversity of life history strategies to cope with variable marine conditions. Emphasis would be on the fitness, rather than number, of juveniles produced in freshwater habitats, insuring that they can best compete for food and avoid predation.

The question of whether the ocean's carrying capacity has or has not been reached is likely not a meaningful one. A more accurate concept is that of the ocean ecosystem as being in constant flux and subjected to many complex influences, which are difficult or impossible for managers to account (Pearcy 1992). Failure to consider the role of ocean conditions in marine survival is illustrated in the massive hatchery production, which has in some cases displaced wild stocks, at least in years with unfavorable marine conditions (Levin et al. 2001). These failures have led to a call for improved understanding and consideration of marine conditions when making fisheries management decisions (e.g., Beamish et al. 2004; Brodeur et al. 2000).

A growing volume of work has been exploring the role of ocean conditions in the abundance and survival of various salmonid populations. For example, salmon production in the Pacific Northwest and Alaska has been related to large-scale shifts in climate and circulation in the Gulf of Alaska (Beamish and Bouillon 1993; Hare and Francis 1995). A developing appreciation of the role of ocean conditions in salmon ecology has led some to conclude that salmon abundance and survival are primarily driven by marine processes (Coronado and Hilborn 1998). This has led some to a paradigm that emphasizes "marine dominance" of salmon ecology; in contrast to the "freshwater dominance" that has driven salmon management for decades (Bisbal and McConnaha 1999).

A "marine dominance" perspective would discount the importance of freshwater habitat and life history stages when compared to the effects of marine conditions that are largely beyond human control. The marine dominance view may erroneously overemphasize the marine environment, in much the same way that previous fisheries managers overemphasized the freshwater environment. The oversimplification of marine survival as a percentage rate fails to take into account the adaptations that salmon have made to their dynamic environment. For example, Beamer and Larsen (2004) showed how the delta residence period of ocean type Chinook salmon in the Skagit influenced performance at a later life stage. This means that the consequences of poor habitat conditions in an earlier life stage (e.g., a limitation in delta capacity for delta rearing juvenile Chinook), may be observed later in the salmon's life cycle (see Appendix D). This is local evidence refuting the marine dominance idea. Higher or more dynamic mortality rates in marine environments may be caused or exacerbated by poor or limiting habitat conditions occurring earlier in the salmon life cycle.

The freshwater, estuarine, and marine environments of salmon are variable and diverse. In response to the demands of their environment, Skagit Chinook salmon have developed a variety of life history strategies that utilize different parts of their freshwater, estuarine, and marine environments in different ways. Changes in the environment may favor one life history strategy over others, making conservation of diversity an important component of protecting the population as a whole. This is especially true in the face of possible environmental shifts due to global climate change. Thus, maintaining or increasing juvenile production over the range of life history strategies would allow Skagit Chinook to both exploit favorable ocean conditions when they occur, and provide a buffer against environmental variability when ocean conditions are unfavorable. In the past 30 years we have observed two different climate regimes, and average marine survival between regimes has varied by a factor of three. Skagit Chinook salmon population recovery planning must consider possible shifts in marine survival and ensure population recovery is achieved under a variety of conditions, including the worst-case scenario (see Appendix D for full discussion).

4. RECOVERY GOALS

The May 13, 1994 MOU that initiated the development of this plan (see Chapter 1.3) specifies that the goal of this plan is 'to restore Skagit Chinook to optimum levels'. *Optimum levels* will be defined as levels that provide sufficient harvestable Chinook salmon to the parties to this plan to meet incidental harvest provisions, provide meaningful directed harvests at levels consistent with treaty-reserved fishing rights, and meet treaty and non-treaty allocation objectives, while protecting and enhancing the diversity, abundance, and productivity of wild Skagit Chinook and their ecosystems. Thus, the overall recovery goal of this plan has two components: harvest goals, which can be met with a combination of hatchery and wild fish; and wild Chinook production goals.

4.1. PRODUCTION GOALS

Wild Chinook salmon production goals are defined as those levels of abundance, productivity, connectivity, and diversity that would result from maintaining functioning habitat in its current condition and restoring degraded habitat at least to properly functioning conditions (PFC). The abundance and productivity levels that represent PFC have been determined by projecting the expected production when habitat is at PFC, and calculating two points on the resulting spawner-recruit curve: 1) the point of equilibrium (the level at which each spawner produces, on average, one adult recruit); and 2) the point of maximum surplus production (also known as MSY, this is the level at which average adult recruitment exceeds its number of parent spawners by the greatest amount; this is also the point at which the population growth rate is the greatest). In order to declare that a stock's wild Chinook production goals have been met, its escapement must be at least as high as the escapement at the calculated point of maximum surplus production, and the average adult recruitment that results from that escapement must be at least as high as the recruitment value on the spawner-recruit curve that is drawn through those two aforementioned points.

In order to calculate the production levels at PFC, we used EDT modeling (Mobrand Biometrics 2000b). Workshops were held to develop the physical and biological inputs for the EDT model under current, PFC, and historical conditions. We compared the initial EDT-generated outputs of adult production under current conditions to those that have actually been observed, and, because the EDT current outputs were generally significantly lower than observed levels, we then engaged in an iterative feedback loop over a period of several months, tweaking the EDT input parameters until the EDT estimates of current production matched reasonably closely to observed levels (Appendix H). Under the assumption that if EDT current estimates are reasonably close to reality (and thus EDT estimates of production under PFC are also close to reality) we adopted the EDT-generated estimates of productivity and capacity at PFC as our recovery goals.

These levels of production are generally in the range of production levels that have been estimated for past decades, and the EDT-generated estimates of historical production are also tolerably close to historical levels estimated from the NMFS status review of Puget Sound Chinook. See Appendix H for details on the comparative analyses of EDT outputs versus observed production, the assumptions used, and the qualifiers on those analyses.

Because recovery must be robust to naturally occurring fluctuations in marine survival (i.e., we can't declare a stock "recovered" just because of a fortuitously-high natural fluctuation in marine survival, and then face extinction again when marine survival returns to a more normal level), these standards will change in accordance with naturally occurring fluctuations in marine survival. At the average marine survival rates that existed during the 1990s, these recovery standards are listed in Table 4.1

Table 4.1. *Recovery goals at average marine survival rates during the 1990s.*

	At Point of Maximum Surplus Production			At Point of Equilibrium	
Population/MU	Escapement	Resulting Recruitment	Recruits Per Spawner	Escapement	Resulting Recruitment
Upper Cascade	290	870	3.0	1,160	1,160
Suiattle	160	450	2.8	610	610
Upper Sauk	750	2,270	3.0	3,030	3,030
Skagit spring MU	1,200	3,600	3.0	4,800	4,800
Lower Skagit	3,900	11,900	3.0	15,800	15,800
Upper Skagit	5,380	20,600	3.8	26,000	26,000
Lower Sauk	1,400	4,200	3.0	5,580	5,580
Summer/fall MU	10,630	37,000	3.5	47,630	47,630

These standards will be adjusted as marine survival changes. Adjustments will be calculated by using the ratio between marine survival during the years for which production is being examined and the 1990s average marine survival[4]. For example, at the higher average marine survival rates that existed during the 1970s and 1980s (which were more than double the 1990s rates), these standards would change to those listed in Table 4.2.

Table 4.2. *Recovery goals at high marine survival rates.*

	At Point of Maximum Surplus Production			At Point of Equilibrium	
Population/MU	Escapement	Resulting Recruitment	Recruits Per Spawner	Escapement	Resulting Recruitment
Upper Cascade	510	2,340	4.6	2,860	2,860
Suiattle	270	1,150	4.2	1,420	1,420
Upper Sauk	1,340	5,530	4.1	6,900	6,900
Skagit spring MU	2,100	9,000	4.3	11,100	11,100
Lower Skagit	7,400	39,700	5.4	47,100	47,100
Upper Skagit	9,400	61,800	6.6	71,200	71,200
Lower Sauk	2,700	12,700	4.8	15,400	15,400
Summer/fall MU	19,200	115,000	6.0	134,000	134,000

In addition to the above-listed abundance and productivity goals, actions taken under this plan must address life history diversity and the spatial structure of habitat opportunity for the six Chinook salmon stocks present in the Skagit. While we do not have quantitative goals for these parameters, our plan's habitat restoration actions were developed with these concepts in mind. The basis for this is explained in Chapter 8 (General Approach to Habitat Restoration).

[4] "Marine survival" in this case refers to survival after leaving the nearshore environment, where fluctuations in survival are due almost entirely to natural events.

4.2. HARVEST GOALS

The tribal parties to this plan have also specifically quantified annual terminal area harvest goals, which were presented in the 1992 Joint Objectives and Goals (JOG) Statement, a position paper adopted by the United States Section of the Pacific Salmon Commission, as:

- Near-Term: 500 springs, 20,000 summer and falls
- Longer-term: 1,000 springs, 30,000 summer and falls

It is the purpose of this plan to outline the actions that will achieve these harvest and wild Chinook production goals.

5. FACTORS LIMITING CHINOOK PRODUCTION

To systematically and scientifically determine the limitations to Skagit Chinook salmon populations, we have utilized a life cycle model to evaluate each Chinook salmon life stage and each life history strategy. We have described limiting factors for each of the six Chinook stocks within the life cycle model framework. Poor recruitment or seeding levels, limited habitat capacity, and poor survival at a given life stage have been identified on a stock-by-stock basis and are summarized in following sections. Details about various life stages are discussed in Appendices A, B, C, and D.

5.1. THE LIFE HISTORY MODEL FRAMEWORK

We know that current Skagit Chinook salmon populations are not adequate to achieve our recovery goals. Chinook salmon productivity depends not on a single habitat or life stage, but on all the habitats used by salmon throughout the various life stages in their life cycle.

Successful recovery of Chinook salmon populations will depend in part on an ability to quantify the relative effects of different land uses and harvest management activities on habitat and salmon populations, as well as the benefits of different restoration and regulatory actions on salmon survival and productivity. In order to evaluate potential factors that limit Skagit Chinook salmon populations, we use a life cycle model framework that links the various life history stages of wild Chinook salmon with habitat conditions (Figure 5.1). We use this life cycle model approach to evaluate potential limiting factors for each of the six stocks of wild Chinook salmon in the Skagit River basin.

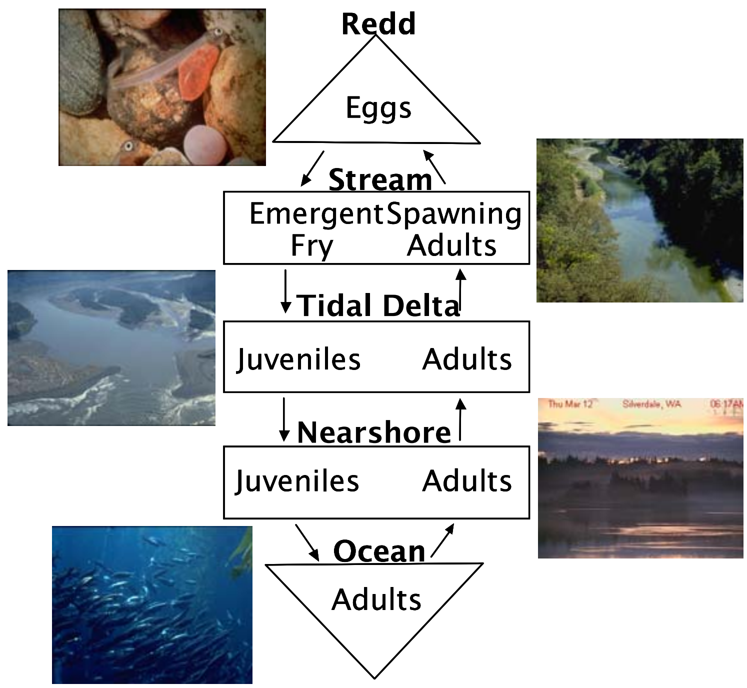

Figure 5.1. *Chinook life cycle model.* Each life stage produces recruits for the next stage.

5.2. LIMITING FACTOR ANALYSIS

We have analyzed Chinook production in terms of three limiting factors: seeding or recruitment, habitat capacity, and fish survival. Each of these factors has been applied to the five life history stages (eggs in redds, freshwater rearing juveniles, estuary rearing juveniles, nearshore rearing juveniles, and returning spawners). We did not consider the ocean as limiting in terms of our analysis of potential recovery actions (see section 3.6 on assumptions for marine survival). Rather, we assume that the ocean is not at capacity and is therefore not limiting. However, we know ocean conditions will strongly influence the number of Chinook salmon recruits, depending on differences in juvenile life history strategies and climate regimes. Therefore, our analysis of limiting factors considers the potential differences of ocean survival by estimating recruitment results for three different potential marine survival rates (average survival during a favorable climate, average survival during an unfavorable climate, and worst case survival) for each affected juvenile life history type.

Production is limited by seeding (the number of initial recruits for a given life stage) if habitats are not seeded to average MSY density. In this case, an increase in seeding will increase production.

Production is limited by habitat capacity if one of the four life cycle model habitats (redd, river, tidal delta, or nearshore, assuming ocean habitat is not limiting), is seeded to average MSY density (occupied to capacity) and increasing habitat quantity would increase production. This does not mean that managing for MSY escapement is the goal for each separate population.

A stock is survival-limited if: 1) empirical estimates of survival rate at some life history stage are less than literature values; or 2) recruits per spawner rates at a given level of spawning escapement have either decreased from previously estimated levels, or are less than literature values on comparable streams at similar spawner densities; or 3) a theorized or measured relationship exists between survival rates and a constraining factor, and measured or estimated levels of that constraining factor are above the levels that reduce survival rates (or below those levels, if the constraint is a requirement for survival).

Limiting factors thus point to recovery actions that:

- Increase seeding or recruits for the next life stage, or, if habitats are seeded to MSY;
- Increase the capacity and amount of the constraining habitats; and/or
- Increase survival for any life stage by addressing specific survival issues.

Listed below are the current constraints on Skagit Chinook salmon stocks, as determined by available scientific resources and our understanding of the body of scientific evidence. In all cases we believe production for each population is not currently high enough to achieve the recovery goals of this plan under existing levels of habitat and management (fishery harvest and hatchery). We believe this to be the case because even if there were no interceptions of Skagit Chinook salmon in Canadian fisheries, achievement of recovery and harvest goals of this plan would require a total recruitment (all Skagit populations) of at least 55,000. Pacific Salmon Treaty (PST) model run reconstruction indicates that this level has not been approached in any of the last ten completed broods, including the recruitments resulting from the three broods that exceeded the then-existing escapement goal (Puget Sound Salmon Stock Review Group 1997).

For each limiting factor identified, we list the impacts of the limiting factor (quantified if possible), the stocks impacted, and the application of these findings for general recovery actions within the Skagit basin. Assessing constraints by stock does not imply that, under this plan, the separate stocks will become separate fishery management units. Again, we present the ideal scenario according to best available science, applied for maximum benefit, without regard to economic, political, or social constraints. This is the starting point for reaching consensus on implementation of Chinook recovery actions.

5.3. LIMITING FACTORS

5.3.1 Seeding Levels

Description and Effect

Without spawners, unlimited restoration actions won't restore the runs; thus, a fundamental action in Chinook recovery is to provide sufficient spawners to seed the most limiting habitat type to a desired density of spawners. Under the federal court-ordered Puget Sound Salmon Management Plan (PSSMP), the desired density is the density that provides the maximum long-term average surplus production to U.S. fisheries (referred to as the "MSY density"), and the spawning escapement level that produces that density is the "MSY escapement". MSY escapement is usually estimated from observations of spawners and resulting production, or from habitat modeling, and is the level above which an increase in the number of spawners produces fewer additional adults than that increase in the number of spawners. This level is always less than or equal to the habitat capacity. While it may be difficult to measure MSY density directly in the field, if the habitat is at capacity, one could conclude that it is seeded at least to MSY density. Indications of MSY density are the following:

- Changes in a habitat quantity parallel changes in Chinook abundance; or
- Survival rates to a life history stage decrease as abundance increases above current levels (this is a flag—if there is a survival rate decrease, it must be sufficient to reduce surplus production to U.S. fisheries); or
- Production flattens out over a wide range of spawning escapements; or
- Length-frequencies are skewed toward smaller Chinook; or
- Spawner densities (or juvenile densities), approximate literature values of non-underseeded habitat.

In the Skagit basin research indicates that, in most of the recent years, the system is at capacity for at least three age-0+ life history strategies: freshwater parr, estuary delta-rearing smolts, and pocket estuary-rearing smolts (Appendices C and D). There are some indications that yearling production may also be limited. Since these life history types appear to be by far the predominant types found in the adult returns, the system as a whole must not be under seeded. Since each of the six Skagit Chinook populations appear to produce these four life history strategies, one might conclude that none of the populations is under seeded, however, that is not necessarily true. It's possible that one population might be underrepresented relative to the other populations and that increasing the seeding for that population would result in increases in adult returns (for that population) that exceed the increase in its seeding level. The overall system production may not increase, meaning that production of the other populations would decrease, but the distribution of production between the populations would be more robust. Thus, even though it appears that the Skagit system as a whole is not underseeded, we must examine seeding levels for each population separately. Note, however, that while this evaluation is done for each population separately in order to determine whether increasing the seeding for that population will increase the surplus production, this does not mean that managing for MSY escapement is the goal for each separate population (see Harvest Management Actions, Chapter 6).

Impacts on Populations

Lower Skagit Falls: Likely adequately seeded. Our assessment of the seeding level of lower Skagit falls in 2005 is different from what our assessment would have been ten years ago. While the seeding levels achieved during most of the 1990s (summer and fall escapements of 5,000–7,000, with lower Skagit fall escapements ranging from 400–1,500), appear to be below the MSY density, average escapements more than tripled during the last seven years, exceeding 2,000 in five of those seven years. Increased escapements are likely a response to recent fishery restrictions and harvest management actions taken in the United States and Canada.

While we have not yet made estimates of smolt production for just the lower Skagit fall population, this population is unique among Skagit Chinook populations, in that most of its rearing habitat is shared with all the other populations. Thus, if there is a habitat limitation on production of upper Skagit parr migrants (see Upper Skagit Summers, below), it might be assumed that that same limitation applies to the lower Skagit fall population. It is possible that the bottleneck on upper Skagit summer Chinook parr production could occur upstream of the lower Skagit River. However, if there were unused rearing capacity in the lower river, one would expect a lower percentage of fry migrants than has been observed in recent years (Appendix C). Additionally, since pattern-C otoliths (which are found in fry and adults collected from the lower Skagit River), are also found in estuary delta habitat, this same reasoning applies to assumptions about limitations on lower Skagit fall Chinook in estuary delta habitat (Appendix D). It is likely that there is competition for rearing space between the different Skagit Chinook populations, and that if the other populations were less abundant, there would be greater capacity for the lower Skagit fall population. At current abundance levels it might be assumed that the lower Skagit fall population is nearing its capacity for the parr migrant and estuary delta rearing life history types. Moreover, calculations done using EDT methods (Mobrand Biometrics 1998, 1999, and 2000a), estimate that, under current habitat conditions, the MSY escapement for lower Skagit falls is about 2,600. The average escapement over the last five years, 3,000, exceeds that level. Thus, it is likely that current lower Skagit fall Chinook habitat is seeded to MSY density.

Upper Skagit Summers: Likely adequately seeded. As with lower Skagit falls, our assessment of the seeding level of upper Skagit summers in 2005 is different from what our assessment would have been ten years ago. While the seeding levels achieved during most of the 1990s (summer and fall escapements of 5,000–7,000, with upper Skagit summer escapements ranging from 3,500–6,000) appear to be below the MSY density, average escapements more than doubled during the last five years due almost entirely to harvest management actions taken in the United States and Canada. Escapement levels exceeded 10,000 spawners in four of those five years, with the 2005 escapement higher than any level ever estimated (estimates go back to 1952). Reasons for assuming that these escapement levels have seeded current habitat to average MSY density at some life history stage are as follows:

1) These more recent escapements are within the range of estimates of MSY escapement (see Chapter 3.5).
2) While spawning escapement levels have increased, the fact that there has not been a corresponding increase in production of parr migrants, and estuary delta rearing and pocket estuary rearing juveniles also indicates that habitat is seeded to average MSY density at these life history stages (Appendices C and D). While the number of fry migrants who don't rear in the tidal delta has correspondingly increased, the contribution of fry migrants that

don't rear in estuary delta habitat may be nearly negligible; if the other two life history types are approaching capacity, it is likely that the entire population is approaching capacity.

3) While these observations actually apply to the aggregate of all Skagit Chinook populations, not just to the upper Skagit summers, because the upper Skagit summers are by far the largest component of this aggregate (70% to 80% of the total), they would have the most effect on system-wide trends. Therefore, it is likely that these observations are also applicable to the Upper Skagit summer population.

4) Adult return data also indicate that current seeding levels may be at average MSY density for some life history stage. As noted above, the recent increases in escapement have occurred largely because the portion of the run caught in fisheries has been reduced, not because of an increase in production. The broods produced by these increased escapements have not yet fully recruited, but initial observations indicate that despite the increase in parent spawning escapement there will not be corresponding increases in total recruitment after accounting for changes in marine survival. Using the Fishery Regulation Assessment Model (FRAM), total adult run sizes of Skagit summer and fall Chinook were forecasted to be 22,000 in 2002 and 23,000 in 2003. These run sizes compare to an average recruitment of 16,000 (range 7,500–23,000) for return years 1996–2000, as estimated from post-season runs using FRAM (LaVoy 2003). This increase is not proportionate to the increase in escapement, particularly if we factor in the higher marine survival conditions in recent years. This leveling out in adult recruitment as escapement increased is further indication that current habitat is seeded to MSY density.

5) According to EDT calculations the MSY escapement level for the entire Skagit summer and fall Chinook management unit under current habitat conditions is about 7,600. Recent spawning escapements for the upper Skagit summer population alone have exceeded that level in four of the last five years.

6) In recent years Chinook redds have been distributed throughout the spawning range of upper Skagit summers. While there has been no documentation of redd superimposition by Chinook, and thus no evidence that upper Skagit summer Chinook production is limited by a lack of spawning area, the wide distribution of spawning indicates that upper Skagit summer Chinook are seeding all the habitat available to them.

Taken together, these observations indicate it is likely that current upper Skagit summer Chinook habitat is seeded at least to MSY density.

Lower Sauk Summers: Indeterminate status. While incubation survival rates for this population are generally poor due to recent heavy siltation and bedload movement in the mainstem and some mass wasting and loss of pool-riffle sections in the tributaries, these impacts are limited mostly to the area downstream of the Suiattle River. In the area upstream of the Suiattle River, which is less degraded, escapement numbers have also declined since the 1970s. In this area it appears that the decline in escapement is not paralleled by a decline in spawning or rearing habitat quantity. For example, there are side channels in this area that are of sufficient quality to be used by coho, but Chinook have not been found in them, which indicates that, at current seeding levels, Chinook production is probably not limited by side channel area in the lower Sauk River. In addition, the current MSY escapement for lower Sauk Chinook, estimated from EDT, is about 1,100 (G. Blair, Mobrand Biometrics, personal communication). This escapement level was achieved in 1996, 2001, and

2003, but the mean escapement over the last cycle has only been about 900. There is some empirical data that both supports and refutes the EDT estimate: the 1996 brood escapement was about 1,100, or about 430 greater than the 1985–96 average, and the resulting terminal run size, when adjusted for marine survival and preterminal interceptions, would have been about 2,500, which was 1,680 greater than the 1985–1996 adjusted average (SRSC, unpublished data). Thus, increasing the escapement by 430 increased the adjusted terminal run size by nearly 1,700, which means surplus to the terminal area increased by about 1,250. However, this is only a preliminary analysis of one brood, and the same conclusions did not apply to the 1986, 1988, and 1990 broods, which had similar escapement levels but did not provide increased surplus production. In these cases increasing the escapement by 400–600 spawners resulted in decreased surpluses (of between 100 and 1,400) after adjusting for marine survival and preterminal interceptions (SRSC, unpublished data). Thus, while there is some evidence that escapements less than 1,100 may be below MSY density, there is also evidence that contradicts that assessment. It may be that the capacity of the habitat varies due to the fluctuating impacts of sediment from Glacier Peak.

As with all Skagit Chinook populations, a limit on production likely exists at a later life history stage, downstream of the lower Sauk River (Appendices C and D). It is possible, however, that this population is underrepresented in proportion to the other populations, and that increasing the escapement of this particular population may increase its adult returns by more than the increase in its spawning escapement and by more than the compensating losses that might accrue to other populations. That answer can be determined only through further monitoring. The status of the seeding level of the lower Sauk summer population is therefore indeterminate.

Upper Sauk Springs: Indeterminate status. The escapement data since 1952 for upper Sauk springs show wide fluctuations, with lows of around 600 occurring in 1954, 1958, and 1964, a peak above 3,300 occurring in 1959 and 1960, a sharp decline, with some peaks (between 100 and 1,200) for years 1967–1973, generally low escapements (between 100 and 600) from 1974–1984, generally increased escapements (between 600 and 900, with a peak of 1,800) from 1985–1991, and then lower escapements (between 100 and 500) since then. Thus, it might be concluded that while upper Sauk spring Chinook escapements have fluctuated widely, current levels are, nonetheless, generally below those of the 1950s and early 1960s, implying underseeding. However, the pre-1994 escapement estimates for the upper Sauk springs are probably the least accurate in the system, which limits their value for comparing current escapement levels and trends to those of the past.

Prior to 1994 escapement was estimated by floating a 7.8-mile index section, calculating the peak live plus dead, then the fish per mile value for that section, and expanding that fish per mile value to 32.6 miles. However, there are well under 32.6 miles of spawning habitat in the upper Sauk (current estimates range from ten to 14.3 miles), which means that past estimates were probably biased high. Those estimates could still be meaningful as indicators of relative trends if they are consistent relative to each other, but it does not appear that they are. Since 1994, there has been no correlation between the peak fish per mile values and the number of redds (a more accurate indicator of escapement) counted in the upper Sauk River. In fact, since 1994, the highest observed fish per mile value was in 1995 and corresponded to one of the lowest estimated escapements (and the peak live plus dead count, 267, even exceeded the total escapement estimate of 190). Thus, it is not necessarily true that current escapement levels are below those of the 1950s and early 1960s, and any conclusions based on such comparisons of abundance levels would be highly tenuous.

So, how do we assess whether the upper Sauk spring Chinook population is underseeded or not? Estimated spawning escapements since 1994 have ranged from 100 to 700 (mean of 340) and escapements during the last five years have averaged about 450. With between 16.8 km and 23.8 km of spawning habitat (PR or fPR habitat) in the upper Sauk River and an assumed spawner capacity of 30 redds per km in PR or fPR habitat, which was the average density observed in other parts of the Skagit under higher escapement levels (Hayman et al. 1996), the theoretical spawner capacity in the upper Sauk River would be about 500 to 700 redds, or about 1,200 to 1,800 spawners (spawners are assumed to be 2.5 times the number of redds observed). Since recent escapements have been well under that level, data imply that, if spawning grounds area is a limiting factor, capacity has not been reached. Subjective observations of redd densities where there is good gravel also indicate that redds appear sparse. However, because escapement trends in the upper Sauk River are significantly correlated to those of every other Skagit Chinook population (Appendix A) except Suiattle springs (which nearly has a significant correlation) and lower Sauk summers (which might be limited by factors distinct from every other population), production of upper Sauk springs is probably limited by factors that also limit the other populations. Because the other populations, except possibly Suiattle springs, are not limited by spawning area, it is, therefore, likely that upper Sauk springs are also not limited by spawning area. EDT estimates that the current MSY escapement for the upper Sauk is about 600, which is well under the 1,200 to 1,800 that could be accommodated by the spawning area, but is only somewhat higher than recent observed mean escapement levels. Also, some empirical results do support the assumption that current seeding levels are less than the MSY level. Limited observations (two brood years) of spawner ages indicate that the number of yearlings that spawned was not a constant number (a constant number of yearlings might indicate that yearling rearing capacity in the upper Sauk River was reached). In addition, the 1994 escapement of 130 returned considerably more spawners (290) in 1998, which indicates capacity to handle at least the 130 spawners that spawned in 1994. The 1995 escapement of 190 only approximately replaced itself, but there was a major flood in 1995 that probably reduced significantly the effective number of spawners (i.e., if the flood effects are accounted for, the 1995 escapement did more than replace itself). Thus, the admittedly sparse data that are available provide some indication that, if seeding levels were increased above the 1994–1995 levels, adult run sizes could be noticeably larger, but it is unclear whether this would be true of the recent-year escapements that were in the 400-700 range. Moreover, the important juvenile rearing sites for upper Sauk spring Chinook are not clearly known, especially for yearling Chinook, and it is possible that these habitats may constitute constraints on the capacity of upper Sauk Chinook at current seeding levels. Because of these unknowns, the status of the seeding level of the upper Sauk population is indeterminate.

Suiattle Springs: Likely adequately seeded. Since redd counts began in the Suiattle in 1994, escapement estimates have ranged from a low of 167 in 1994, to a high of 688 in 2001, with a mean of 390. The mean escapement during the last five years has been about 430 (Appendix A). Several estimates of MSY escapement were calculated for Suiattle springs. EDT modeling indicated that the equilibrium spawner abundance for Suiattle Chinook under current marine survival rates, with no fishing, is about 500 spawners, and that the corresponding MSY escapement level is slightly over 100 spawners (G. Blair, Mobrand Biometrics, personal communication). Dynamic spawner-recruit modeling developed by NMFS for brood years 1986–1997, using the maximum daily average flow on the Sauk from October to February as a variable (and no marine survival variable), yielded an MSY escapement estimate of about 400 (Bishop et al. 2003). As Suiattle springs are only known to spawn in low-gradient reaches above the mouths of ten Suiattle tributaries, it's possible that this population may be limited by spawning area. It has been estimated that only 1.4 to 7.4 km of these tributaries have suitable gradient for Chinook spawning (E. Beamer, SRSC), personal communication). Thus, at a density of 30 redds per km, the theoretical spawner capacity in the Suiattle would be only 105 to 555 spawners. The range exists because the gradient of 6.0 km of the 7.4 km is steep enough to provide suitable spawning habitat only if there are channel obstructions (e.g., logs) that create fPR habitat. It is unknown how much of these six km are fPR habitat, and how much is less-spawnable plane-bed habitat.

In addition, empirical observations of escapements since 1994 and the resulting escapements four years later (Appendix A) indicated that escapements higher than about 400 have not consistently produced surplus returns. While the 1994 escapement (167) produced a return rate four years later that exceeded 2:1, the 1996–1998 broods, which experienced similar incubation conditions and no greater fishing levels, did not. The expectation would be that if the 1996–1998 escapements were below the MSY level, the average Suiattle spring Chinook escapements from 2000–2002 would have been in the 700–800 range—they were instead 360, 688, and 265, respectively. Thus, the MSY escapement for Suiattle springs is probably in the 100 to 400 range. The recent average escapement of 430 is at or above the upper end of this range, so we will assume that recent average escapements have seeded the habitat to MSY density.

On the other hand, estimated escapements prior to 1991 were generally higher than those of recent years, which would indicate a greater capacity than the current spawning numbers[5]. However, there are several problems with comparing recent numbers to those of earlier years:

- Spawning habitat has been lost. Floods affected Sulphur Creek in the 1970s and removed a spawning bar in 1995; Tenas Creek lost about 0.5 miles of spawning due to poor flows; Downey Creek had a spawning area filled in with sediment; Circle Creek has accumulated considerable sediment; and Big and Straight Creeks were heavily affected by floods in the 1970s, may have lost access due to debris blockages or coarse sediment deposition. These areas are only beginning to recover again.
- Except for brood years 1965–1968, none of the broods with escapements above about 600 has replaced itself. This may have been caused by high preterminal harvest rates, but it does indicate that productivity is lower at the higher spawning levels, and that the higher spawning levels were not stable equilibria.
- As noted above, escapement estimation methods have changed. Escapement is now estimated by walking the entire spawnable length and counting all the new redds dug in the system. Prior to 1994, escapement was estimated by walking a combined total of 2.0 miles in Big, Tenas, Buck, and Sulphur Creeks, calculating the peak live plus dead fish per mile value for those sections, and expanding that fish per mile value to 8.5 miles. However, there are well under 8.5 miles of spawning habitat in the Suiattle River (the maximum estimate is

[5]Some anecdotal accounts report more fish. Years ago, a Darrington resident named Boroseth reportedly interviewed tribal elders, who reported much higher fish abundance in the Sauk and Suiattle Rivers. We have not located this report, and don't know the specifics. Smith and Anderson (1921) were less effusive, and provided only presence or absence information, without numbers. They described Chinook in Buck and Downey Creeks as "fairly abundant"; said "salmon have been seen" in Tenas Creek and Big Creek; said Sulphur Creek is not as good as Buck Creek; Lime Creek has no salmon much above the mouth; and that Milk Creek and the other streams are "of no importance" for salmon. This low-key assessment does not establish that Suiattle springs were more abundant back then than they are now.

4.6 miles), so the past estimates may have been biased high. In addition, as with upper Sauk springs, there has been no correlation since 1994 between the peak fish per mile values and the number of redds (which is the basis for recent escapement estimates).

It may be that, if there is any underseeding in the Suiattle River, it is confined to specific tributaries. Of the four index tributaries, over the entire period of record (which is continuous since 1958, with some observations from 1946–1952) Buck Creek has shown no decline, while Big Creek and Tenas Creek showed no decline until after the flood of 1990. In Sulphur Creek (which has the highest number of spawners) there was a precipitous decline between 1972 and 1973. The number of spawners has stayed at that lower level since then. In fact, almost all of the perceived decline in Suiattle Chinook escapement estimates up to 1990 can be attributed to the lower numbers in Sulphur Creek.

In addition to questions about spawning habitat capacity, there are also questions about whether rearing habitat of yearlings is fully seeded. As with upper Sauk spring Chinook, Suiattle springs have a significant yearling component, which could be limited by constraints different from those that limit fingerling production. There are few field observations of rearing yearling Suiattle spring Chinook and little data on specific constraints. Analyses of whether yearling production is limited at current escapement levels are inconclusive: from the limited data, it appears that the contribution of yearling smolts to the mainstem trap does not increase as the age-0+ outmigration decreases, and the percentage of yearling adults in the escapement does not decrease as the brood escapement increases. Both of these observations indicate that yearling production at current escapement levels is not density-dependent. Conversely, the data also indicate that the percentage of yearling adults in the escapement does decrease as the age-0+ outmigration of that brood increases. This is evidence of the opposite conclusion: that yearling production is density-dependent and is therefore habitat-limited at current spawning levels. Since these sets of observations are contradictory, no clear conclusion can be drawn about whether yearling production is habitat-limited at current escapement levels.

It should be noted that we would expect spawning habitat conditions to change both naturally due to flood disturbance and land use intensity. Since most of the spawning habitat of the Suiattle springs is located within low gradient sections of tributary watersheds, on alluvial fans or in the Suiattle River floodplain, there is a high potential for channel alignments to greatly increase or decrease the amount of spawning habitat in individual tributaries over time. Such data may help explain escapement patterns and provide a context to recent changes to spawning conditions (reported as bullets above).

Upper Cascade Springs: Indeterminate status. Consistent escapement estimates for upper Cascade springs exist only since 1992, and these estimates are all in the 100 to 400 range except for the 2001 escapement of 625. These are all much less than the estimated spawner capacity, which, with 17 to 21 km of PR habitat, at 30 redds per km, is about 1,200–1,600 spawners (E. Beamer, SSC, personal communication). In addition, excluding the flood-ravaged return of 1999, the escapement trend for the last nine years has been increasing, which could indicate that there was unused capacity during at least the first part of that period.

On the other hand, there is no documented evidence that upper Cascade Chinook escapements were ever as high as 1200–1600 fish. Recent EDT modeling estimated that MSY escapement for upper

Cascade springs under current environmental conditions is only about 200 spawners, and that even under historic conditions the MSY escapement would have been less than 600 (G. Blair, Mobrand Biometrics, personal communication). Smith and Anderson (1921), who surveyed the system in 1921 and interviewed people at that time who might have seen the River Basin under historic conditions, did say that abundance of Cascade River salmon in general used to be higher (than it was in 1921), stating that salmon and steelhead in the upper Cascade River "formerly ran in very large numbers but now the numbers are comparatively small", but it is unclear whether this statement applies to Chinook, or how those numbers would compare to current abundance.

Moreover, upper Cascade spring Chinook do have a significant yearling component (about half the adult age samples had a yearling life history type). The same questions about yearling capacity that apply to Suiattle and upper Sauk spring Chinook populations also apply to upper Cascade Chinook. It has been speculated that, if the yearling life history type was not environmentally constrained, all spring Chinook would become yearlings. So, theoretically, the fingerling life history type could be below its freshwater capacity level, while the yearling life history type is not, particularly for yearlings that rear in riverine side channel habitat. However, because Chinook fingerling parr production appears to be limited for the Skagit system as a whole (Appendix C), it seems unlikely that upper Cascade parr would not be subject to the same limitation. As with lower Sauk and upper Sauk Chinook populations, it is possible that the upper Cascade spring Chinook population could be underrepresented in proportion to the other populations, but that can only be determined through further monitoring. Because of these unknowns and contradictory observations, the status of the seeding level of the upper Cascade population is indeterminate. At any rate, with the increased escapements in recent years and the tight fisheries restrictions required under the Puget Sound Comprehensive Chinook Plan, seeding level assumptions will be tested in the next few years.

Restoration Actions

Underseeding can be addressed by: restricting fisheries to increase the number of fish that spawn; by taking habitat restoration actions that increase survival rates, such as reducing sediment inputs and mass wasting by retiring roads; or by supplementing natural seeding levels with artificially produced juveniles. This plan addresses fisheries restrictions by limiting exploitation rates to levels less than the calculated equilibrium rates at MSY, which should allow underseeded populations to increase until they achieve MSY density (Chapter 6). This plan also proposes several actions intended to improve survival rates in spawning areas (Chapter 9) and the nearshore (Chapter 12). There are no hatchery supplementation projects proposed in this plan, but there is a requirement to develop a contingency conservation plan to deal with catastrophically low abundance. Criteria for considering supplementation projects are listed (Chapter 13). These actions should address the underseeding constraint, but they will advance us toward reaching recovery goals only if MSY seeded habitats have the capacity and support the survival rates necessary to meet recovery production goals.

5.3.2 Degraded Riparian Zones

Description and Effect

Riparian wood is necessary to create PR habitat, which is the preferred spawning and early rearing habitat of Chinook salmon. Maturation of these riparian areas will increase the pool-riffle habitat and bank cover for rearing juveniles, and can provide additional capacity not just for spawners, but also for producing parr migrants for which existing capacity is limited (Appendix C). Large woody debris recruited from mature riparian zones is necessary to convert a plane-bed channel to a forced pool-riffle channel. Land use activities that eliminate riparian habitats disrupt the natural recruitment process, limiting spawning and rearing habitat.

Impacts on Populations

Lower Skagit Falls: Heavily degraded riparian areas. Loss of riparian trees has reduced suitable PR spawning habitat in some tributaries and the resulting increase in temperatures has blocked Chinook access. Riparian management can also increase spawning habitat (e.g., converting a plane-bed channel to a forced pool-riffle channel) by allowing the natural processes present in the watershed to restore habitat. Beamer et al. (2000b) estimated that 75% of the Carpenter Creek Watershed Administrative Unit (WAU), 52% of the Alder Creek WAU, 38% of the Day Creek WAU, 50% of the Finney Creek WAU, 57% of the Gilligan Creek WAU, 66% of the Grandy Creek WAU, 80% of the Hansen Creek WAU, 72% of the Jackman Creek WAU, 46% of the Loretta Creek WAU, 69% of the Nookachamps Creek WAU, and 39% of the Pressentin Creek WAU have at least moderately impaired riparian function.

In the mainstem reaches 72% of floodplain reach SK060A (near Day Island), 68% of reach SK060B (Cottonwood area), 76% of reach SK070A and 47% of reach SK070B (Loretta Creek area), 49% of reach SK080A (downstream of Baker River), 62% of reach SK080B and 51% of reach SK080C (upstream of Baker River), and 53% of reach SK090 (downstream of the Sauk River) have at least moderately impaired riparian function. Field inventories to identify riparian planting and restoration projects have been completed in the Nookachamps and Hansen Creek WAUs.

Upper Skagit Summers: Significantly degraded riparian areas. An analysis for the Skagit Watershed Council (SDC) that rated the quality of each WAU in the Skagit system with respect to riparian function indicates that all the upper Skagit WAUs (except Illabot Creek) have significant impairment of riparian function. Beamer et al. (2000b) estimated that 27% of the Bacon Creek WAU, 60% of the Corkindale Creek WAU, 43% of the Damnation Creek WAU, 41% of the Diobsud Creek WAU, 38% of the Goodell Creek WAU, 10% of the Illabot Creek WAU, 15% of the Jordan-Boulder WAU, and 20% of the Newhalem Creek WAU have at least moderately impaired riparian function. In the mainstem reaches, 61% of reach SK100 (near the Sauk River), 49% of reach SK100A (Illabot Creek area), 54% of reach SK110 (Marblemount area), 29% of reach SK130 (Newhalem area), and 42% of reach CA010 (lower Cascade River) have at least moderately impaired riparian function. While there has been no documentation of redd superimposition by Chinook in the mainstem spawning areas of the upper Skagit River, which indicates that riparian projects may provide limited benefits to mainstem spawning for this population, the wood cover that results from riparian projects does provide additional protected rearing habitat, which should allow additional space to produce parr migrants.

Lower Sauk Summers: Heavily degraded in some areas. Wood has been lost from the lower Sauk River because of heavy logging and ongoing agricultural practices. Beamer et al. (2000b) estimated that 17% of the Clear Creek WAU, 55% of the Dan Creek WAU, 6% of the Hilt Creek WAU, 72% of the Sauk Prairie Creek WAU, and 38% of the Rinker Creek WAU have at least moderately impaired riparian function. In the mainstem reaches, between 11% (reach SA020B) and 53% (reach SA010) of each reach has at least moderately impaired riparian function. Furthermore, in the immediately upstream mainstem reaches, up to 92% (reach SA060D) of the reach has at least moderately impaired riparian function, and this greatly inhibits wood recruitment to the lower Sauk River.

Upper Sauk Springs: Moderate riparian degradation. The SWC Application Strategy estimated that riparian wood growth has been removed from about 30% of the mainstem Sauk River reach SA070, about 15% to 20% of the Monte Cristo Creek WAU, about 5% of the Whitechuck River WAU, and about 1% of the Sloan Creek WAU.

Suiattle Springs: Significant riparian degradation, especially in the mainstem. In the Suiattle River mainstem, wood has been removed from the riparian zone in about 30% of reach SU020A, 42% of reach SU030, 65% of reach SU040A, 60% of reach SU040B, and 25% of reach SU040C. Big Creek in the Tenas Creek WAU, which has an impaired riparian zone, has been replanted. Big Creek might have some need for interim actions (i.e., large woody debris (LWD), fan restoration) as the riparian area matures.

Upper Cascade Springs: Little riparian degradation. The SWC's Application Strategy did document some degraded riparian areas in the upper Cascade, but these are almost entirely limited to coho tributaries, and have little effect on Chinook.

Restoration Actions

Restore natural riparian structure and processes. Riparian areas can be protected by fencing off farm animals, and by leaving adequate un-logged buffers. Once degraded, riparian areas can be restored by planting trees along riverbanks and protecting those trees from removal, but it takes decades before the benefits are realized. Large woody debris placement can provide a short-term fix until the planted areas mature, but LW

D projects should be limited to sites where pool-riffle habitat may once have existed and where the LWD won't be washed away. This plan does not specify any riparian planting or LWD placement projects. Instead, it addresses riparian degradation through protection actions and maintenance of buffers (Chapter 8). It should be noted that the benefits of riparian management will, however, be limited without addressing hydromodification.

5.3.3 Poaching

Description and Effect

Illegal taking of fish reduces seeding levels and spawner survival. State, tribal, and federal biologists have historic information and data that report and document the illegal take of salmon in the Skagit River, and it appears that, for several species, significant numbers are killed by illegal fishing activities (P. Castle, personal communication).

Impacts on Populations

All populations have significant impacts from illegal fishing activities, although some stocks, such as Suiattle springs, are believed to suffer greater impacts than others.

While the nature of the problem (illegal behavior), makes it difficult to quantify the impacts of poaching, it is roughly estimated that illegal takes may account for 10% or more (possibly up to 50% for Suiattle River Chinook in some years), of the Chinook escapement, depending on the stock (Capt. W. Hebner, WDFD Enforcement, personal communication). At current legal exploitation rates (20% to 50%), this would mean that 5% to 40% of the total recruitment is taken illegally, depending on the stock, and that total exploitation rates could actually range from about 28% to 75%.

Restoration Actions

Poaching can be addressed by increasing the presence of enforcement officers, either by adding to existing staff or through improved coordination with other agencies, by coordinating with volunteer groups or individuals who may be willing to observe poaching hot spots, and by improving community education about salmon issues. A proposal for carrying out these actions is described in Chapter 6.8 of this plan. If the illegal take could be eliminated, escapements would be expected to increase by 10% to 100%, depending on the stock. This would help to address underseeding problems for those populations that are believed to be underseeded (see above). Note that while enforcement actions may help to address underseeding problems for some populations, this is not a sufficient action by itself to insure Chinook recovery—as with harvest management actions (see above). Such actions will advance us toward reaching recovery goals only if the seeded habitats have the capacity and support the survival rates necessary to meet recovery production goals.

5.3.4 Dam Operations

Description and Effects

The Skagit has mainstem hydroelectric dams on the Baker River and on the Skagit mainstem upstream of Newhalem. The Skagit mainstem dams completely block salmon migration, while trap and haul facilities are used at the Baker dams to transport adult salmon over the dams, and to transport juvenile salmon out of the reservoir.

Construction of the Baker River dam inundated spawning habitat, decreasing total habitat, and thus habitat capacity. Fry stranding studies conducted in the 1970s and 1980s in conjunction with re-licensing the mainstem Skagit River dams (Seattle City Light Projects) demonstrated that downramping (reducing river flows) can strand large numbers of Chinook fry. This problem was addressed by restricting the downramping rate for the mainstem Skagit River dams to less than two inches per hour. This downramp rate, now adopted as a Washington State standard, cannot be met at the Baker River Project with the current project configuration of one turbine. An additional impact of hydropower operations is an increase in potential Chinook redd stranding over natural rates. This can occur when project flow releases are increased over natural basin inflow during spawning and minimum flow releases are at or below natural inflows during egg incubation and fry emergence. At the Baker River Project, flow release patterns essentially surcharge spawning flows while providing very little egg incubation and alevin emergence flow. Again, the single turbine configuration of the Baker Project limits how flows can be released, and this potential for stranding cannot be greatly reduced with the current configuration.

The Baker River Project is currently undergoing relicensing by the Federal Energy Regulatory Commission (FERC). A settlement agreement has been reached between Puget Sound Energy and all relicense stakeholders, including state and federal resource agencies and Tribes. If FERC issues a license that includes flow provisions in the settlement agreement, construction will be completed in 2012 that will add two additional turbines, providing greater flexibility in flow releases. Washington State downramp rates will be met in the Skagit River downstream of the Baker River, greatly reducing the potential for Chinook fry stranding due to Baker River Project operations. There will be maximum flow release restrictions while Chinook are spawning downstream of the Baker Project, and new minimum flow releases that greatly reduce or eliminate the potential for Chinook egg or alevin stranding from project operations.

While dam operations can reduce the impacts of flooding, which improves salmon egg incubation survival during that year, these actions might also have unintended negative effects. Before construction of the mainstem dams, major flood events were unregulated and had the potential to reduce salmon production for brood years that experienced large flood events. However, flooding also changes the river channel and creates new side channels, which tends to diversify aquatic habitat opportunities and increase salmon productivity for multiple species and life histories. With the amelioration of these major flood events, there is less new channel formation, hence a potential to decrease rearing and spawning habitats necessary for Chinook production. This loss of habitat has been documented in the upper Skagit River reaches (Smith, 2005). However, the specific role that mainstem Skagit River dam operations have played in the loss of side channel habitat is unknown. Isolation of floodplain areas (primarily from State Highway 20) has also played a significant role in the loss of side channel habitat. Mitigation funds from Seattle City Light have been used to reconstruct side channel habitat in this part of the river basin.

Dam operations can also change the temperature regime in the river, which may affect emergence timing or food availability for juvenile salmon; however, our assessment is that this factor is not having a significant effect on Skagit Chinook (see Chapter 5.4.2).

Impacts on Populations

Lower Skagit Falls: There is a total of 68.8 miles of anadromous habitat inundated by the Baker Lake Hydroelectric Dam (R2 Resource Consultants 2004), but not all was historically Chinook habitat. Of this total, 47.95 miles would be 2% gradient or less. Another 13.3 miles would be available at the 2–4% gradient range. In addition to the area inundated by the Baker reservoirs there is 0.6 miles of the Baker River downstream of the project that is anadromously accessible but not effective as Chinook habitat. Projects located on the lower Baker River would be exposed to scouring flows during flood control operations.

While trap and haul facilities exist on the Baker River for both upstream (adult) and downstream (juvenile) migration, outmigrating smolt survival rates are very low for Chinook salmon in the Baker River. Total Chinook smolt outmigration numbers from the Baker River have seldom exceeded a few hundred, even when over 1,000 adults per year were planted into the Baker River from 1999–2002. The reasons for the poor survival of Chinook in the Baker system are unclear, but it may be related to poor passage efficiency at the upper dam.

Operations of the Baker dams have also dewatered lower Skagit Chinook redds in the mainstem Skagit downstream of the Baker River. During the winter of 2000–2001, WDFW personnel observed hundreds of Chinook redds dewatered (P. Castle, WDFW, personal communication). Since then, no other dewatered Chinook redds have been observed but dewatered chum redds have been observed. In addition, downramping from the Baker dams may cause water levels to drop in the mainstem Skagit River faster than seven inches per hour (WDFW maximum guideline is two inches per hour with some seasonal considerations, see Hunter 1992), which would be expected to strand fry along river edges. This would reduce fry survival in the Skagit mainstem downstream of the Baker River.

Upper Skagit Summers: The mainstem Skagit dams have largely dealt with redd-dewatering as a potential source of mortality through the establishment of minimum flows appropriate for each species. Since 1990, when improved flows were put into effect, redd dewatering caused by mainstem dam operations has become uncommon. In terms of impacts on fry, stranding studies have documented that, while residual impacts from ramping have been reduced to the extent possible for the mainstem dams, they do still occur to some degree.

Riverine side channels, a preferred rearing habitat for Chinook, have a natural life expectancy of only about 50 to 100 years, after which they eutrophy and die. New side channels would be created to replace them during big floods, but the mainstem dams have reduced the magnitude of these side-channel-creating floods, resulting in a net loss of side channel area. This loss of habitat has been documented in the upper Skagit River reaches (Smith 2005). However, the specific role that mainstem Skagit River dam operations have played in the loss of side channel habitat is unknown. Isolation of floodplain areas (primarily from State Highway 20) has also played a significant role in the loss of side channel habitat. Mitigation funds from Seattle City Light have been used to reconstruct side channel habitat in this part of the river basin.

All Other Stocks: Activity at the Baker dam mainly affects lower Skagit falls, since part of their spawning area is downstream of the Baker River. Operation of the mainstem Skagit dams primarily affects upper Skagit summers, but operations of these dams also affect fry from all other stocks as they migrate and rear in the Skagit mainstem.

Restoration Actions

An agreement that limits flow fluctuations on the mainstem Skagit dams minimizes impacts to the extent possible (impacts to other salmonids must still be studied), and a similar flow agreement has recently been concluded for the Baker dams. These impacts will continue to be monitored to insure that both major hydro projects adequately address mortalities due to redd dewatering and fry stranding. An important part of the Baker River agreement will be finding ways to improve the outmigration efficiency for Chinook in the Baker River.

5.3.5 Sedimentation and Mass Wasting

Description and Effects

The major, management-related, increases in sediment levels in freshwater Chinook habitat are due to mass wasting events associated with logging roads and timber harvest units (Hansen Ck Watershed Analysis, 1995; Jordan Boulder Watershed Analysis, 1996). The increases in the rates of mass wasting associated with forest practices in the Skagit River Watershed are also documented in other watershed analyses in western Washington (see http://www.dnr.wa.gov/forestpractices /watershedanalysis/ for additional analyses). Increased sediment in spawning areas destabilizes the channel bed so that high flow events move more bedload causing localized increases in bed scour or fill. Hence, salmon eggs are more easily and more frequency dislodged (scoured), or buried (filled), with a given flow event than before increased sedimentation. Also, increased fine sediment through mass wasting, or surface erosion can suffocate salmon eggs or block emergence of hatched salmon fry. For freshwater rearing fry, increased sediment reduces benthic invertebrate production and the value of edge habitat cover by filling the spaces between cobbles, boulders, and large woody debris.

Sedimentation from glacial melt on Glacier Peak affects egg to fry survival as well as freshwater rearing. During several recent years Glacier Peak has put out large amounts of sediment during the late spring and summer. This sediment flow is heaviest during spawning, and its effects on the value of edge habitat may persist long enough to affect the fry to smolt stage unless something first flushes out the accumulated sediment.

A sediment budget created for the Skagit watershed has shown that sediment levels are greater than historic levels in many WAUs, which contributes to increasing scour and fill of the channel bed. An analysis for the SWC (Beamer et al. 2000b) rated the quality of each WAU in the Skagit system with respect to sediment supply, and identified creeks that are impaired with respect to sediment supply, primarily due to logging and road construction.

Impacts on Populations

Lower Skagit Falls: It is believed that, in general, spawning habitat in the lower Skagit River is very poor for incubation survival. Beamer et al. (2000b) rated the Carpenter Creek, Nookachamps Creek, Gilligan Creek, Hansen Creek, Day Creek, Loretta Creek, Grandy Creek, Finney Creek, Jackman Creek, and West Lake Shannon WAUs (i.e., all lower Skagit WAUs except Alder Creek, Pressentin Creek, and East Lake Shannon) “impaired” with respect to sediment supply. Finney Creek, in particular, has become an example of degraded tributary habitat. Aerial surveys of the mainstem have shown areas of extensive fine sedimentation that were formerly graveled. The recent heavy accumulation of silt in the mainstem and mass wasting and loss of pool-riffle sections in the tributaries has caused both a loss of spawning area and poor egg-to-fry survival.

Upper Skagit Summers: Beamer et al. (2000b) concluded that incubation habitat in the upper Skagit River is generally relatively good, albeit with some areas where function is impaired. Of the upper Skagit River WAUs, he found that the Corkindale Creek, Diobsud Creek, Damnation Creek, and Jordan-Boulder WAUs are impaired with respect to sediment supply.

Lower Sauk Summers: Due to recent heavy accumulation of silt in the mainstem, and mass wasting and loss of PR sections in the tributaries, it is generally believed that spawning habitat in the lower Sauk River is among the poorest in the system for incubation survival. Sediment levels are generally high throughout the lower Sauk River. All of the lower Sauk River WAUs (Hilt Creek, Rinker Creek, Sauk Prairie Creek, Dan Creek, and Clear Creek) are rated “impaired” with respect to sediment supply due to forest management activities(Beamer et al. 2000b). Clear Creek is probably the only tributary with much Chinook potential, but all the tributaries contribute sediment to the mainstem. This problem is compounded by accelerating glacial melt from Glacier Peak, which, since about 1991, has deposited huge amounts of silt on the spawning grounds downstream of the Suiattle River, which further reduces incubation survival.

The distribution of pink salmon spawning provides additional evidence that spawning habitat quality is poor in the lower Sauk River—probably because of high sediment levels. In 1999, it was estimated that several thousand pink salmon spawned in the Sauk River upstream of the Whitechuck River, and that a couple thousand spawned between the town of Darrington and the Suiattle River. In contrast, downstream of the Suiattle River, where sediment levels are particularly heavy, very few pink salmon were observed spawning (P. Castle, WDFW, personal communication). Since pink salmon are not believed to be under-escaped, not selecting the Sauk River downstream of the Suiattle River for spawning indicates that the scarcity of Chinook in the same area is likely due to poor habitat quality and not to the low numbers of Chinook. Because this is also the area with the greatest sediment load, it is probable that the sediment load is at least partly the reason for the poor habitat quality.

Upper Sauk Springs: The Application of the SWC's Strategy (Beamer et al. 2000b) rated the Monte Cristo Creek WAU, in which much of the spawning area of the upper Sauk springs lies, “impaired” in terms of sediment supply. This WAU, which includes the Sauk slide location, is rated impaired because of forest management activities and geology. In addition, while it is unclear where upper Sauk River juvenile Chinook rear, they necessarily migrate through the lower Sauk River during rearing, or outmigration, subject to the siltation and turbidity problems noted above for lower Sauk summers.

Suiattle Springs: There is acknowledgment that freshwater survival rates of Suiattle Chinook will probably always be less than literature averages, due in part to the periodic high natural levels of glacial sediment in the mainstem. Although most streams in the Suiattle River system are in relatively pristine condition, Beamer et al. (2000b) rated the Tenas Creek WAU (which also includes Big Creek), “impaired” in terms of sediment supply. The sediment supply is impaired in the Tenas Creek WAU because of past forest practices and it is geologically unstable, composed primarily of metamorphic and surficial deposits. As a result, the 1990 and 1995 floods had major impacts on incubation survival in this WAU. Survival appears to have been poor since the 1990 flood. Other than in this WAU, incubation survival should not be a problem for Suiattle Chinook.

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impacts on incubation survival in this WAU. Survival appears to have been poor since the 1990 flood. Other than in this WAU, incubation survival should not be a problem for Suiattle Chinook.

Restoration Actions

Decommissioning logging roads, replacing culverts, and replacing unstable fills with stable fills will reduce the sediment levels that physically scour out or smother incubating eggs. Analysis methods exist that can identify the specific roads, culverts, and fills that need to be replaced.

5.3.6 Flooding

Description and Effect

The limiting factor with the greatest impact on egg to migrant fry survival is flooding during egg incubation. Analyses by Seiler et al. (2001), and Seiler et al. (2004), have shown a very strong negative correlation between egg to migrant fry survival (estimated at the Skagit mainstem smolt traps located in the town of Burlington and operated by WDFW), and peak flow during incubation (i.e., flooding reduces survival). It is assumed that this negative correlation is caused by increased mortality rates due to streambed movement (e.g., scour and fill) that occurs during floods. The severe floods, 15 to 20-year events or greater, reduce egg to migrant fry survival by an estimated 75% to 80% when compared to 1-year floods, and the 10-year events reduce freshwater survival by about one-third (Beamer and Pess 1999). While floods are natural events, human activities, such as increasing impervious surfaces, land clearing, and extending drainage networks associated with roads can increase the severity and frequency of floods. There is evidence that this increase in severity and frequency has been occurring—Kunzler (1991) documented that floods at Mount Vernon during salmon incubation (defined as exceeding 28.0 feet at the USGS gauge #12200500 Skagit River near Mount Vernon), have occurred much more frequently since 1979 than in prior years; floods occurring only three out of 11 years from 1968¯1978, versus eight out of 12 years from 1979¯1990, and with higher peak flows. Flooding frequency and magnitude is also expected to increase over the next century due to predicted global warming (University of Washington Climate Impacts Group 2005).

While overall system production of Chinook is usually limited at life stages that occur subsequent to incubation (i.e., parr, estuary delta, and pocket estuary—see Appendices C and D), this is not the case in severe flood years. In years where floods occurred during incubation time significantly reducing the survival rate, Chinook density becomes so low that those habitat types are no longer capacity-limited. Thus, actions that increase incubation survival, by reducing the effects of these floods, will increase adult production.

Impacts on Populations

Lower Skagit Falls: The flooding problem is especially severe in the lower Skagit, which absorbs the full brunt of floods, and where stresses due to flooding are amplified because of the ubiquitous alterations to lower basin hydrology. Due to increases in impervious surfaces, land clearing, and extensions of drainage networks due to roads, all the WAUs in the lower Skagit are rated "impaired" or "likely impaired" with respect to peak flow hydrology, except for Pressentin, which is rated "sensitive to land use" (Beamer et al. 2000b). This impairment has contributed to the increased flood frequency noted by Kunzler (1991), as well as the fact that there has also been an increase in the frequency of severe flood events (15-year or greater floods) since 1979; there have been five such flood years since 1979, but only one severe flood year (1975) in the 20 years prior to 1979.

Upper Skagit Summers: By converting the survival relation in Seiler et al. (2001) to flood return frequency, Beamer (SSC, unpublished data) calculated that incubation survival in the upper Skagit mainstem was significantly reduced (according to the USGS gauge #12181000 Skagit River at Marblemount) due to flooding in 1980, 1983, 1990, 1995, and 2003, and was significantly reduced in the tributaries (according to the USGS gauge #12178000 Skagit River at Newhalem) due to flooding in 1979, 1980, and 1983, 1995, and 2003. Fry surveys after the 1995 flood indicted very low counts in the upper Skagit River and sedimentation problems have been documented in some of the tributaries, including the Cascade basin (Jordan-Boulder WAUs), where flood events are not regulated by mainstem dams.

While Beamer et al. (2000b) found that none of the upper Skagit WAUs are impaired with respect to peak flow (although the Corkindale Creek and Jordan-Boulder WAUs are sensitive to land use), and these occurrences of reduced survival were less frequent than for other Skagit Chinook populations (possibly because the mainstem dams can restrict flooding to some extent in this population's spawning areas—average spawning levels in the upper Skagit have increased since 1979), reduced survival has occurred more frequently since 1979 than in the years prior to 1979. For years prior to 1979, the Newhalem gauge, which has operated since 1960, showed only one year, 1962, in which tributary incubation survival would have been significantly reduced; the Marblemount gauge, unfortunately, did not operate consistently before 1976.

Lower Sauk Summers: The lower Sauk River is the region with the best correlation between flood return frequency and return rates of spawners four years later (E. Beamer, SRSC, personal communication), so it appears to be the population most affected by flooding and incubation survival. This may be a response to sedimentation, where increased sedimentation (the cause of lower survival) is observed after high flow events (the triggering mechanism). A steep decline in lower Sauk River escapement started with the 1983 return, which experienced a significant flood (a 9-year event that would reduce incubation survival by about 30%). Since 1979, the lower Sauk River, which does not have flow controls, has experienced an increased frequency of 5-year and greater floods (every 2.4 years, versus the 5-year average), which will move bedload. There have been three severe (greater than 20-year events), in 1980, 1990, and 2003, and two 10-year events, in 1989 and 1995. These observations are consistent with the hydrology ratings listed in Beamer et al. (2000b): Hilt Creek, Rinker Creek, Sauk Prairie Creek, and Dan Creek WAUs are all rated "likely impaired" with respect to peak flow hydrology, and Clear Creek is rated "sensitive to land use".

Upper Sauk Springs: None of the upper Sauk River WAUs are rated “impaired” or “sensitive to land use” with respect to peak flow hydrology—it is estimated that less than 20% of both the tributary and mainstem watersheds in the upper Sauk River are hydrologically immature, and that road densities are less than one km/km^2 (Beamer et al. 2000b).

Suiattle Springs: Beamer et al. (2000b) rated the Tenas Creek WAU (which also includes Big Creek) "functioning, but sensitive to land use" in terms of peak-flow hydrology. All other WAUs in the Suiattle are rated “functioning”. As with the upper Sauk springs, less than 20% of both the tributary and mainstem watersheds in the upper Sauk River are hydrologically immature and road densities are less than one km/km^2 (Beamer et al. 2000b).

Upper Cascade Springs: Both upper Cascade WAUs are rated "functioning" with respect to peak flow hydrology (Beamer et al. 2000b). Approximately 24% of the tributary watershed is hydrologically immature, and road density is about 0.33 km/km^2.

Restoration Actions
Floods are natural events that form and maintain important Chinook habitat, especially for rearing. However, higher peak flow magnitudes might be a consequence of immature forests, high road densities in mountain basins, and/or high levels of impermeable surfaces in lowland basins. This plan mitigates the effects of flooding with actions that protect or restore mature forests, decommissions or reconstructs road networks, and address impervious surfaces that collectively alter the hydrologic character of the basin (Chapters 7 and 9). We also advocate floodplain restoration as an action that mitigates the impacts of flood flows on Chinook salmon (Chapter 10). Healthy floodplains allow floods to dissipate energy and store sediment that otherwise might destabilize streambeds. Hydraulically sheltered habitat can form within floodplains, protecting deposited eggs and providing juvenile salmon with refuge habitat.

5.3.7 High Water Temperatures

Description and Effect
High water temperatures put stress on Chinook, and reduce their survival. High temperatures can also block access to tributaries for spawning or rearing, and can promote the growth of minnow fish species that compete with Chinook. In the Skagit River tributaries, high water temperatures are generally caused by removal of riparian trees and reductions in stream flow.

Impacts on Populations

Lower Skagit Falls:
The following lower Skagit tributaries where Chinook have been observed have been put on the WDOE's 303(d) list of impaired waters[6] because of high temperatures: Carpenter, Cumberland, Day, Fisher, Finney, Hansen, Jones, Nookachamps, East Fork, Nookachamps, Grandy, and Jackman

Of those 303(d) listed streams, Nookachamps, East Fork Nookachamps, Grandy, Day, Finney, and Jackman are likely to have significant Chinook production potential, but Chinook are now scarce to non-existent in all of these, except Day and Finney Creeks.

High temperatures are generally recorded in July and August (R. LaRock, SRSC, personal communication), which is after age-0+ juveniles have outmigrated and before adult Chinook enter the streams, but it is possible that temperatures could remain high and serve as a barrier to upstream migration during the spawning season.

Upper Sauk Springs: There have been anecdotal reports of relatively high temperatures in the upper Sauk River—exceeding 19ºC in August in the mainstem downstream of Falls Creek. Since upper

[6] Washington Department of Ecology, 303(d) list of impaired waters, Washington State Water Quality Standards, Washington Administrative Code (WAC) 173-201A-130.

Sauk spring Chinook have a yearling component, high summer temperatures or low flows can affect survival of this population. However, these reports have not been verified.

Restoration Actions
Riparian planting and maintenance of riparian buffers provide the shade necessary to reduce water temperatures in the summer and fall in the lower Skagit River tributaries. This plan does not specify any riparian planting projects, but does address this problem through protection actions and maintenance of buffers (Chapter 7). The high temperatures reported for the upper Sauk River would need to be verified by field measurements before any restoration actions could be considered.

5.3.8 Hydromodification

Description and Effects
Hydromodification consists of armoring riverbanks or roads with riprap to prevent erosion and channel migration. While this may protect the road or the land behind the bank, it has negative effects on Chinook production, both by reducing the productivity of riverbanks, and by preventing channel migration and the opening of new channels and backwaters.

Beamer and Henderson (1998) showed that subyearling juvenile Chinook use natural banks at a density five times greater than riprap (hydromodified) banks. Natural banks may be preferred to hydromodified banks because they are better at sheltering Chinook from predators, providing food, and stabilizing temperatures. Natural bank cover shades shoreline areas and prevents high temperatures in these areas and root wads and other woody material in the water provide hiding places for Chinook and substrate for prey. Natural banks, with their associated LWD and backwaters, also provide refuge for presmolts during high flow events where they would otherwise wash out into the bay before they were physiologically adapted to saltwater. For these reasons, this lower river "grubstake" habitat is considered among the most productive in the system for coho and Chinook.

In addition, the Skagit was naturally a highly dynamic system, in which floods periodically created new channels, which are much more productive, for both spawning and rearing, than older channels. However, high levels of hydromodification prevent the formation of new channels. Hayman et al. (1996) showed that juvenile Chinook (probably parr migrants), were consistently found in the lower ends of off channel habitat along the Skagit River, and that backwaters were used by subyearling Chinook in higher densities than other mainstem edge habitats. Floodplain disturbances that hinder river movement such as riprap, dikes, unneeded roads and fills reduce the formation of backwaters and other complex natural habitats.

Since the quantity of freshwater rearing habitat appears to be limiting the parr migrant production from the Skagit River (Appendix C), activities that reduce the capacity of that habitat, such as bank hardening and prevention of new channel formation, reduce Chinook production from the Skagit.

Impacts on Populations
Lower Skagit Falls: High levels of hydromodification in the lower Skagit have reduced the area of natural banks and backwaters by about 60%, and have prevented the formation of new channels.

Upper Skagit Summers: Beamer et al. (2000b) identified extensive hydromodification throughout all reaches in the upper Skagit (especially in the Marblemount area) as well as in the lower Skagit River reaches that upper Skagit Chinook migrate through.

Lower Sauk Summers: The Sauk River is still highly dynamic, but hydromodification has in some cases limited the opening of old channels and new channel formation. In the lower Sauk River, Dan Creek has been greatly hydromodified, essentially eliminating the spawning area in that creek. Parts of the mainstem, mainly between Darrington and the Suiattle River, have also been hydromodified, resulting in a loss of preferred spawning habitat.

Upper Sauk Springs: In the upper Sauk River Beamer et al. (2000b) identified three locations in the Sauk mainstem above the Whitechuck River where the channel is impaired due to stream bank hardening. Two of these sites, a road in the floodplain and a riprapped bank, are now plane-bed reaches, but could become forced pool-riffle habitat with floodplain management.

Suiattle Springs: In the Suiattle River Beamer et al. (2000b) identified four locations in the mainstem Suiattle where the channel is impaired due to stream bank hardening—three in reach SU030 and one in reach SU040A. There is a great deal more bank hardening in the lower Sauk River and lower Skagit River, through which Suiattle springs migrate and potentially rear for extended periods. However, because Suiattle Chinook escapements are not significantly correlated to those of lower Sauk and lower Skagit Chinook, and our research indicates that hydromodification significantly affects these populations, it is possible that the level of bank hardening in these lower mainstems does not significantly affect the abundance of Suiattle springs.

Upper Cascade Springs: There is no known hydromodification in the upper Cascade River. The impacts of hydromodification on upper Cascade springs occur only in hydromodified reaches downstream of the upper Cascade River through which upper Cascade Chinook must migrate.

Restoration Actions

Floodplain management consists of addressing the effects of both hydromodification and degraded riparian areas (Chapter 5.3.2). Actions that address hydromodification include removing or relocating dikes and riprap. Actions that address degraded riparian areas, as described in Chapter 5.3.2 above, consist of riparian fencing and planting, LWD placement, and limiting land use and development in streamside areas. Taken together, these floodplain management actions provide cover, stabilize banks, create more gentle gradients in the tributaries, allow new channel formation, and open additional off-channel habitat. Floodplain management actions are described in Chapter 10 of this plan and include such projects as Gilligan Floodplain Restoration, Salem LC Floodplain, Skiyou Slough, Car Body Hole, Marblemount Bridge, Government Bridge, Downey Creek Crossing, Boundary Bridge, and Dearinger Campground Road.

5.3.9 Water Withdrawals

Description and Effects

Salmon need a continuous supply of cool, oxygen-rich water to survive. People and fish considerations compete for the limited supply of water in the Skagit Basin. A 1996 MOU between the Skagit tribes and several other government entities and a 2001 instream flow rule are intended to limit water withdrawals so that fish are protected. However, instream flow studies demonstrate that existing flows are often below optimum for Chinook, and there are pressures for additional withdrawals from exempt wells, over-appropriation of water rights, and illegal withdrawals. Such withdrawals, in addition to those due to dam operations (which are described in Chapter 5.3.4 above) can cause dewatering of off channel habitat, exacerbation of water quality problems—particularly temperature, increased predation, reduction of available rearing habitat, and amplification of simplified habitat. Summer low flows may also be impacted by predicted global warming over the next century (University of Washington Climate Impacts Group 2005)

Impacts on Populations

The primary impact is on lower Skagit falls. Unregulated, increased water withdrawals have the potential for increasing effects on upper Skagit and Sauk River populations as well.

Restoration Actions

Continue to enforce the 1996 MOU, the 2001 instream flow rule, and existing water code provisions. Issue permits only in accordance with these rules. Investigate evidence of illegal withdrawals. (See Chapter 7.4 for specific actions.)

5.3.10 Loss of Delta Habitat

Description and Effects

Post settlement diking, dredging, and filling in the delta have severely limited the historic extent of delta habitat. Under present day conditions, the contiguous habitat area of the Skagit River delta that is exposed to tidal and river hydrology totals about 3,118 hectares. This consists mostly of the delta area in the vicinity of Fir Island, but it also includes a fringe of estuarine habitat extending from the town of LaConner to the north end of Camano Island. Historically, the contiguous habitat area of the Skagit delta included the same area, but also included the Swinomish Channel corridor and extended to the southern end of Padilla Bay (Collins 2000). The historic area equaled 11,483 hectares. This results in a seventy-three percent (73%) loss of tidal delta wetlands and channels (i.e., delta footprint). In total, we estimate an 87% net loss of delta channel edge and blind channel habitats preferred by juvenile Chinook salmon for rearing since the 1860's (Appendix D). Natural formation of delta habitat outside of diked areas occurs by the deposition of riverine sediments. These estimates of delta habitat loss do account for gains in delta habitat caused by progradation occurring between the 1860s and 1991.

Using remote sensing techniques, Hood (2005) estimated that the Skagit delta is prograding at a rate of approximately 1.66 hectares per year since 1956 in the North Fork region of the delta, and losing an average of 0.3 hectares per year over the same period in the South Fork. These numbers suggest a net addition of tidal delta habitat of 68.0 hectares over the last 50-year period. However, if only the last 15 years timeframe is analyzed, we see the North Fork region prograding at roughly the same rate (average of 1.4 hectares per year), and the South Fork region showing an average loss of 2.65 hectares per year — yielding a net loss of 18.75 hectares since 1991. The causes of this decline are not clear; however, projections for sea level rise in conjunction with global warming trends lead us to believe the South Fork will continue to lose ground for the foreseeable future.

At contemporary Chinook salmon population levels, current delta habitat conditions are limiting the number and size of juvenile Chinook salmon rearing in delta habitat. Otolith data indicate that delta residence is important for the success of juvenile Chinook salmon surviving later in their life cycle. Restoration of delta habitat should increase capacity for delta rearing Chinook salmon and improve survival in later life stages. Limitations in current delta habitat conditions are also displacing juvenile Chinook salmon from delta habitat to Skagit Bay habitat, and forcing a change in their life history strategy from delta rearing to fry migrants. Literature values show that fry migrant survival is one order of magnitude lower than delta rearing individuals.

Impacts on Populations

All six wild Skagit Chinook salmon stocks include delta rearing life history strategies in their populations. These life history strategies currently rear in Skagit delta estuary habitats. Skagit delta habitats are much smaller and more fragmented than historically, therefore rearing opportunity of estuarine rearing Chinook salmon has been greatly reduced (see Appendix D for a full discussion).

Restoration Actions

Restore large areas of delta habitat. Delta restoration projects are described in Chapter 11 of this plan, and include Wiley Slough, Milltown Island, Telegraph Slough, Fisher Slough, Davis Slough, Dry Slough, Smokehouse, and additions to Deepwater Slough.

5.3.11 Loss of Delta Habitat Connectivity

Description and Effects

Connectivity is a function of both the pathways and distance that fish must travel to find habitat (Appendix D). Lost habitat connectivity reduces capacity and fish survival. Daily average juvenile Chinook salmon density increases as a function of landscape connectivity (Appendix D). From this we infer that habitat fragmentation, in addition to lost habitat area, has been detrimental to Skagit Chinook populations.

Impacts on Populations

All Skagit Chinook populations are affected by loss of delta habitat connectivity.

Restoration Actions

Restoration of connectivity should be a component of delta restoration. Restoration of connectivity is an objective of the delta restoration projects listed above, as well as such projects as McGlinn Island, South Fork Dike Setback, Blake's Bottleneck, Cross Island Connector, Sullivan's Hacienda, and North Fork Levee Setback (Chapter 11).

5.3.12 Loss of Pocket Estuary Habitat

Description and Effect

Pocket estuaries are partially enclosed, measurably diluted marine bodies of water that are smaller in scale and discontinuous from Chinook natal river systems. All six wild Skagit Chinook salmon stocks include delta rearing and fry migrant life history strategies in their populations that currently rear in Skagit Bay nearshore habitat, including pocket estuaries (see Appendix D for a full discussion) (Beamer et al. 2003). Some of these pocket estuary rearing fish are displaced from delta rearing due to overcrowding in the tidal delta (Beamer et al. 2003). Approximately 80% of Whidbey Basin pocket estuaries have been lost. Historical pocket estuaries in close proximity to the Skagit delta have seen a net loss of 86%. Lost pocket estuary habitat limits nearshore habitat capacity and juvenile Chinook survival (Beamer et al. 2003).

Juvenile Chinook salmon are over 100 times and 10 times more abundant in pocket estuary habitat than in offshore or nearshore habitat, respectively, during the period from February through May (see Appendix D for a complete discussion). Pocket estuaries are preferred nearshore rearing habitat and provide refuge from predators for Chinook salmon. We found that rearing in pocket estuaries exposes fry migrant Chinook salmon to a much lower risk of predation by fish than rearing in exposed nearshore habitat. While sculpins are very abundant in pocket estuary habitat, they are not large enough to prey on averaged-sized Chinook salmon. Conversely, though predator density is lower in adjacent nearshore habitat than in pocket estuaries, a high percentage of the predators are large enough to prey on average-sized juvenile Chinook salmon.

Impacts on Populations

Loss of pocket estuary habitat reduces the capacity of nearshore rearing habitat and decreases survival of juvenile Chinook during nearshore rearing for all six stocks (Beamer et al. 2003).

Restoration Actions

At contemporary Chinook salmon population levels, limitations in current delta habitat conditions are displacing juvenile Chinook salmon from delta habitat to Skagit Bay habitat, and forcing a change in their life history type from delta rearing to fry migrants. Literature values show that fry migrant survival is one order of magnitude lower than delta rearing individuals. Some fry migrant Chinook salmon rear and take refuge in pocket estuaries. Restoration of pocket estuary habitat can be a strategy to partially mitigate delta density dependence and improve survival of naturally occurring fry migrants. Pocket estuary restoration projects are described in the Nearshore Restoration chapter (Chapter 12), and include Lone Tree, SneeOosh, Kiket, and Dugualla estuaries.

5.3.13 Loss of Pocket Estuary Habitat Connectivity

Description and Effect

Currently, pocket estuaries are smaller and sparser in the landscape than they were historically. We describe and quantify these impacts as habitat connectivity. We define pocket estuary connectivity at the landscape scale as the migratory pathways connecting the natal river delta to proximal pocket estuaries, and the pathways between pocket estuaries. At the local scale we define connectivity as the pathways into pocket estuaries from the adjacent nearshore habitat.

Lost pocket estuary connectivity, at the local and landscape scale, impact habitat capacity and fish survival. The scarcity of pocket estuaries decreases the opportunity that juvenile Chinook salmon have to utilize this preferred habitat as a transition step from their natal rivers to the marine environment, or as refuge and rearing habitat as they migrate through Whidbey basin to the open ocean. Our research has determined that an increase in local scale connectivity corresponds to increasing juvenile Chinook salmon abundance in pocket estuary habitats (Appendix D). Pocket estuary use by Chinook salmon correlates to higher growth rates and lower predation (inferred from lower predator densities), (Appendix D).

Impacts on Populations
All Skagit Chinook populations are affected by loss of pocket estuary connectivity.

Restoration Action
Restoring tidal volume to pocket estuaries will also improve the opportunity for Chinook salmon to utilize pocket estuaries by increasing tidal channel depth and width. A general plan needs to be developed to restore pocket estuary rearing opportunity throughout the Whidbey basin shoreline providing a corridor of important nearshore habitats as juvenile Chinook salmon migrate seaward. Pocket estuary connectivity projects are described in Chapter 12.

5.3.14 Availability of Prey Fish Species

Description and Effect
Healthy herring, smelt, and other forage fish stocks are necessary to support the ecology of Chinook salmon in nearshore rearing habitats. The nearshore habitat requirements for supporting healthy forage fish stocks are a research need.

Understanding the relationships between forage fish and nearshore habitats requires understanding the life cycle of the different forage fish species and how those species use nearshore habitats at all life stages. Evaluating current and historic forage fish population levels can also be used to determine if there has been a change in forage fish abundance, and if so, whether that change is affecting the survival of wild Chinook salmon populations.

Impacts on Populations
All Skagit Chinook populations are believed to be affected by forage fish abundance.

Restoration Actions
Whether forage fish availability is a constraint on Skagit Chinook production is unknown, and the action called for in this plan is to conduct research to determine whether it is, and if so, what to do about it. The research project is described in Chapter 14.5.1.

5.3.15 Illegal Habitat Destruction and Degradation

Description and Effect
Multiple land use actions have contributed to habitat destruction and loss: urban, agricultural, and other non-point pollution entering directly into streams; bulldozers operating on spawning grounds; illegal and unpermitted development and land use practices along the Skagit River and its tributaries; wood removed from gravel bars. These actions are under jurisdictions of Skagit County, WDOE, Washington Department of Natural Resources (WDNR), and WDFW, but because the enforcement branches of these agencies are under funded and understaffed, enforcement actions are limited.

Illegal activity that affects Chinook salmon habitat has impacts on habitat capacity and fish survival. As a result, the benefits that should result from the significant and painful restrictions enacted on legal fisheries, land use activities, individuals, and other industry throughout the Skagit River basin are potentially negated by illegal takings and further deterioration of fish habitat. Chinook recovery depends on maintaining fishing impacts below a level that would impede recovery. Accordingly, legal fisheries are managed to insure that this level is not exceeded. However, with significant, uncounted, concealed, and probable increasing impacts of illegal habitat violations, it is possible that total impacts may exceed the level that impedes recovery. The unknown incidences of illegal habitat activities are at conflict with recovery activities where it is difficult, or impossible to block account for those illegal activities and evaluate, or conclude whether the recovery activities were effective or not.

Impacts on Populations
All Skagit Chinook populations are affected by illegal habitat destruction and degradation.

Restoration Actions
Increase and improve fisheries enforcement and community education about salmon issues. Chapter 7 of this plan includes a proposal to address both poaching, as described in Chapter 5.3.3 above, and illegal habitat destruction.

5.3.16 High Seas Survival

Description and Effects
Large-scale climatic processes influence survival of salmon in marine habitats. Changes in marine survival rates have a directly proportional effect on Chinook abundance (e.g., if marine survival is cut in half, so is adult abundance). Therefore, evaluating the consequences of marine survival on adult recruitment is critical to determine the long-term benefits of restoration. Marine survival estimates for wild Skagit Chinook salmon were generated by Greene et al. (2005), who estimated that, during the 1974–1997 period, there were two different climate regimes influencing marine survival (see Appendix D, Figure 3.7), corresponding to Pacific Decadal Oscillation (PDO) shifts in the region (Hare et al. 1999). During the 1974–1984 period marine survival (from estuary residence through adult recruitment) averaged about 1.5%, while during the subsequent years (1985–1997) it was about one-third of that level. The causes of the recent lower marine survival rates are not clearly known and the changes that are due to natural fluctuations in large-scale climatic processes that act on the high seas are not controllable. Controllable causes of low marine survival rates are limited to nearshore or estuarine areas and have been described previously (Chapters 5.3.10 through 5.3.14).

Stocks Impacted
All Skagit Chinook populations are affected by fluctuations in high seas survival.

Restoration Actions
Direct actions that can be taken to affect high seas marine survival are unknown. Consequently, we must plan for these changes in survival rates and account for them in our restoration actions. Therefore assessments of recovery and harvest management objectives must account for natural fluctuations in survival rates. Outside of the high seas area, actions to improve survival in nearshore and estuary delta habitat are described in Chapters 11 and 12. Research projects to determine whether additional controllable factors are significantly affecting Skagit Chinook, such as forage fish abundance, pinnipeds, and birds, are described in Chapter 14.

5.4. FACTORS EVALUATED AND ASSUMED NOT SIGNIFICANT

The following were considered as possible limiting factors and dismissed as not substantially limiting, based on the rationale provided. This does not mean that these limiting factors can never be considered again. However, it does mean that, before reconsidering these factors, someone will have to collect new data, which has not yet been presented, and which should be fairly convincing.

5.4.1 Hatchery Fish Predation in Rivers

Life History Stage
Freshwater rearing

Basis
The hatchery releases of concern are coho, yearling spring Chinook, and steelhead. Mainstem smolt trap data indicate that these fish spend little time in the river. The fastest traveling outmigrants begin to appear at the Burlington smolt trap almost on the day of release, with the largest portion of the release passing within a few days. The last outmigrants pass the trap within a month after release. This limits their exposure to wild Chinook fingerlings, which begin outmigrating several months before the hatchery fish are released and finish outmigrating several months after the hatchery fish have passed. In addition, the mainstem trap data do not indicate a depression in the outmigration timing curve of wild Chinook at the time hatchery fish are released that might be expected if hatchery fish predation was having a substantial effect on the wild Chinook. This may be explained by wide dispersal, both spatial and temporal, of wild Chinook making them less vulnerable to hatchery fish predation. It might be more useful to evaluate the degree of predation in the transition zone, where wild Chinook tend to concentrate in schools, and dismiss in-river predation as an important limiting factor. Nonetheless, predation on delayed release Chinook (in other areas) can be considerable. In one study in California on the Feather River, it was estimated that 532,000 hatchery Chinook yearlings ate an estimated 7.5 million wild age-0+ Chinook before leaving the system (Sholes and Hallock 1979). To verify directly whether hatchery fish predation on wild Chinook in the Skagit River occurs and whether such occurrence is a major factor limiting wild Chinook production, stomach contents of hatchery Chinook were examined at the Burlington smolt trap in 1999. Of the stomach contents examined, little evidence could be found that hatchery fish preyed upon wild, age-0+ Chinook.

Kraemer et al. 2005 found that Chinook salmon egg-to-migrant survival was relatively unchanged over a 12-year period on the Skagit River where hatchery steelhead smolt releases varied from 196,000 to 583,000 fish. Compared to the Lewis River (Washington) where steelhead predation on Chinook salmon juveniles was frequent (Hawkins and Tipping 1999), Kraemer et al. postulated that steelhead predation on Skagit River Chinook salmon juveniles was relatively minor due to the lower adult salmon spawner densities, earlier Chinook salmon juvenile emigration timing, larger size of Chinook juveniles when steelhead were released, and lower densities of steelhead smolts released, but it might be useful to repeat this examination with a larger sample size.

Predation of hatchery steelhead on Chinook salmon juveniles is probably a function of abundance of prey and spatial and temporal overlap between predator and prey. This may explain why steelhead predation on the Skagit River is probably not as prevalent as on the Lewis River. Not only was the Skagit River Chinook salmon potential egg density (103,100 eggs/km) considerably less than that on the Lewis River (878,200 eggs/km), emigration of Chinook salmon juveniles substantially decreased the availability of Chinook salmon fry in the Skagit River as steelhead prey. About 68% of the Skagit origin Chinook juveniles emigrate prior to the release of hatchery steelhead smolts on May 1 (Seiler et al. 2002). On the Lewis River, peak juvenile emigration occurs in late June and early July (McIsaac 1990). Most Chinook salmon juveniles were probably present in the Lewis River when hatchery steelhead smolts were released from mid-April to early May. Thus, not only were more Chinook salmon juveniles present in the Lewis River than on the Skagit River when hatchery steelhead were released, but the Chinook salmon juveniles were smaller in size in the Lewis River.

Presumably, Chinook salmon egg-to-migrant survival will be impaired by predation at some level of hatchery steelhead released in a river basin. The release number threshold may be river specific and will require considerable research to determine. Recent hatchery steelhead releases in the Skagit range from 196,000–583,000 and do not appear influence wild Chinook egg to migrant fry survival over that range. We therefore assume this factor is not a significant constraint on wild Skagit Chinook populations.

Increased numbers of steelhead released, changes in the timing of hatchery releases (e.g., earlier in the year when more Chinook fry are present) or release locations may change the spatial and temporal overlap between hatchery steelhead and wild Chinook salmon. These kinds of changes may increase predation potential causing us to re-evaluate this factor.

We assume that under current hatchery programs (with practices specified in Chapter 13), predation by hatchery-raised salmonids on wild juvenile Chinook salmon is not substantial in riverine habitat of the Skagit River watershed. However, the limited local data supporting this assumption is refuted by the Feather River reference. Therefore, we should revisit this potential constraint and have listed this issue as a research action in Chapter 14 of this plan.

5.4.2 River Temperatures During Incubation (Dam-caused Changes)

Life History Stage
Egg to fry survival, freshwater rearing

Basis
It was hypothesized that the mainstem dams, due to thermal inertia in the reservoirs and temperature gradients at the depths from which spill is withdrawn, have changed the temperatures downstream from what they were pre-dam. Specifically, temperatures would be warmer during incubation, and colder in the summer. The effect of the temperature shift would be to speed up larval development, with the possibility that salmon would emerge earlier than their food is available.

For this hypothesis to be accepted, we have to establish that: 1) the current river temperatures are different from what they were pre-dam; 2) this temperature change has changed the timing of emergence from the gravel; and 3) this change in timing has reduced Chinook survival.

Regarding condition #1, there are not sufficient measurements of pre-dam river temperatures to establish directly what mean incubation temperatures were during pre-dam conditions. However, under the assumption that pre-dam temperatures were similar to current temperatures in the Sauk and Cascade Rivers (both of which are free-flowing), there is strong evidence that that the mainstem Skagit is now warmer in the fall and early winter, colder from mid-February to May, intermediate in the late spring, and colder in the summer. As such, it appears that condition number one has been met.

Regarding condition number two, lab experiments indicated that, even though there is some compensation for temperature units, the postulated difference in temperatures should still speed up hatching by up to two months. However, field sampling and otolith reading indicated that emergence of upper Skagit summers occurs approximately the same time as emergence of Sauk Chinook and is consistent with literature estimates of peak emergence timing for four other Chinook stocks (none of which, however, was in Puget Sound) (Graybill et al. 1979). If emergence timing of Sauk River Chinook (and of these other four stocks) is representative of pre-dam emergence timing of upper Skagit Chinook, then the emergence timing of upper Skagit Chinook has not changed significantly. Why would it not, particularly since there is no evidence that spawning timing has changed? One possible explanation is that hatching does occur earlier, but, because of colder temperatures in late winter, emergence is delayed. If this is true, fry may starve in the gravel after they absorb their yolk sacs. However, measurements collected in 1975 indicated that upper Skagit emergent fry had fairly robust condition factors, so they were not starving intra-gravel. At any rate, it appears that condition number two has not been met.

If condition number two has not been met, condition number three becomes moot. We therefore agreed to assume that changes in incubation temperatures are not a significant constraint on upper Skagit Chinook. However, by using otolith analysis of the stock composition at the mainstem trap, we should be able, within the next few years, to estimate egg to smolt survival and outmigration timing by stock. This will allow us to examine whether survival and outmigration timing of upper Skagit summers are different from those of other stocks. Even if emergence timing has changed (and the timing of food availability has not), it is also likely that the existing upper Skagit summer Chinook stock consists of fish that have adapted to that change. If we were somehow to change the temperature regime in the river back to pre-dam conditions, there is no assurance that survival would increase. In addition, short of dam removal, there is little that can be done to decrease incubation temperatures—withdrawals from Ross Lake, the uppermost (third), mainstem dam, are already taken from below the thermocline, limiting the availability of colder water.

5.4.3 Small Hydro

Life History Stage

Egg to fry survival

Basis

Small hydro project could cause mass wasting if pipelines fail at a small hydro site. This constraint is already addressed under “Sedimentation and Mass Wasting” (Chapter 5.3.5 above). However, we need to determine whether there are any existing small hydro projects that may potentially fail.

We don’t know of any existing projects that have failure risk potential. The Komo Kulshan project above Lake Shannon had undergone repairs, but it wasn’t in an area that affected Chinook. There were, however, several proposed sites at risk of failure identified on Diobsud Creek, Boulder and Jordan Creeks in the Cascade, Irene Creek in the mid-Cascade, Rocky Creek near Corkindale, Rocky Creek in the Day Creek system, and Anderson Creek in the Baker system. All the proposed sites above have been dismissed, with re-hearings denied or not requested, so they are unlikely to be built.

Therefore, small hydro does not currently appear to be a significant constraint on Skagit Chinook. For now, actions would consist of tracking applications and documenting concerns to the Federal Energy Regulatory Commission (FERC) if the proposed project site could be identified as unstable or inappropriate. These actions would not increase Chinook production, but they could prevent a decrease in the future. Water supply pipelines may carry similar risks to those of small hydro, but we did not investigate that topic.

5.4.4 Nutrient and Carcass and Productivity Levels

Life History Stage
Freshwater rearing

Basis
Recent research has shown that marine-derived nutrients, provided by salmon carcasses, comprise a high proportion of the production in stream ecosystems. It has been theorized that in places where there are fewer salmon carcasses, productivity has been reduced, resulting in lower return rates to those streams. We tested the assumption that increasing the number of carcasses[7] in the Skagit, would increase the harvestable surplus of Skagit Chinook.

Our analysis was hampered by the lack of controlled studies that relate an increase in carcass levels to an increase in adult returns. There were inferential results from other areas, but these were not necessarily transferable or unambiguous. There exists Skagit specific data on escapements (carcass levels), coho and Chinook smolt outmigrations, adult returns for the system as a whole, and a long-term data series on escapements for a smaller stream, Illabot Creek. Analysis of these data (memo dated May 13, 1999, from R. Hayman, SSC, to H. Michael, WDFW), indicated the following:

- While there is considerable interannual variation, mean carcass biomass levels in the Skagit have been fairly constant, with a slight *increasing* trend, since 1968;
- During that time, Skagit Chinook run sizes have been *negatively* correlated to carcass biomass levels four years previously;
- Skagit Chinook smolt outmigration and smolts per spawner values (since BY 1989) have been *negatively* correlated to brood year carcass biomass levels, even after flow is accounted for;
- The same is true of coho smolts and smolts per spawner values (since BY 1982)
- On Illabot Creek, counts of peak Chinook per mile and Chinook per parent spawner are *negatively* correlated to peak carcass biomass four years previously;

[7] Primarily pink and chum carcasses, which are the biggest contributors to the carcass biomass, and are the only species still on fixed escapement goals.

- The same is true of Illabot coho three years previously.

While none of these negative correlations was statistically significant, rejecting the hypothesis that increasing the number of carcasses reduces Chinook or coho production, there was also no basis to make the assumption that increasing the number of carcasses on the Skagit River would be expected to increase Chinook production. Consequently, we will initially assume that current carcass levels are not a significant constraint on Skagit Chinook production. However, we also believe that further research on this potentially limiting factor is needed.

5.4.5 Bird Predation

Life History Stage
Freshwater, tidal delta, and nearshore rearing

Basis
Initial screening indicated that only two bird species, common mergansers and double-crested cormorants, might be significant predators on Chinook in the Skagit (S. Neuhauser, WDFW, personal communication). Other species might be a nuisance in localized situations (e.g., great blue herons getting into hatchery ponds), and Western grebes do eat salmon (Wood 1987a, 1987b), but their numbers have declined (D. Nysewander, WDFW, personal communication) and their predation rates are probably not greater than pre-development levels.

Predatory birds have been a natural part of the regional ecosystem. Understanding their role, and population trends over time will help us understand if bird predation is an issue for Chinook salmon.

Past regional work has demonstrated predation on Chinook salmon outmigrants by these cormorants. Or goals are to:

- Determine if double-crested cormorants are major predators on Skagit Chinook and if their population numbers are increasing.
- Develop model from data to estimate percentage of outmigration lost to cormorant predation. Determine if particular Chinook stocks and life history types are vulnerable to bird predation.
- Determine if there is a particular section of the river where Chinook are vulnerable to cormorant predation.

We do not know the extent that cormorants forage on salmonids. A study on the Snohomish showed that cormorants mainly forage on whitefish and peamouth chubs, and that they prefer fish the size of age-1+ Chinook, rather than age-0+s. In Skagit Bay, cormorants do not appear to forage near schools of pink and chum smolts (which are close in size to Chinook), but appear to target larger fish, such as smelt and herring (which could have an ecological effect on salmon, but we don’t have enough data to even begin to speculate on that). Also, there appears to be no consensus among local biologists whether cormorants are present or not during much of the Chinook outmigration. We concluded that the data on abundance (relative to pre-development days), and Chinook consumption are less compelling for cormorants than they are for marine mammals. Marine mammal predation was initially assumed to not be substantial (see below), so we concluded the same thing for double-crested cormorants. Further research is needed, especially on cormorant forage habits.

5.4.6 Competition and Predation by Other Fish

Life History Stage
Freshwater rearing, tidal delta rearing, nearshore rearing

Basis
SRSC has collected and analyzed stomach contents of fish species in Skagit Bay and River. The analyses indicate whitefish, sculpins, bull trout, cutthroat trout, and rainbow trout forage on Chinook fry. While there may be significant impact on fry, there was no evidence that predation is any greater now than it was pre-development. While temperatures downstream of the dams are warmer in fall and early winter, they are not warm enough to change the number of warm water, non-native fish predators in the upper river or at the mainstem trap site.

Other fish species are found in conjunction with Chinook fry and fingerlings during sampling in the lower river and tidal delta. Dominant species caught include sculpins, peamouth chub, and stickleback. Sculpins do prey on juvenile Chinook salmon, while peamouth and stickleback could be considered competitors (Simenstad and Kinney 1978). Literature indicate that at temperatures above 22°C chubs begin to out-compete Chinook smolts. Thermograph readings collected by SRSC from various tidal delta sites indicated that temperatures rarely exceeded 22°C while Chinook were present, though they vacated the estuary sites after mid-July. Our density dependence analysis of tidal delta habitat (part of Appendix D) for juvenile Chinook salmon did not identify predation or competition with other fish as a significant variable when we included the density of potential predator species or competitor species in our analyses. Some non-native fish (e.g., bass, yellow perch, pumpkinseed sunfish) have been found in lower river and tidal delta habitat, although generally at low densities and small body sizes. Control of these non-native fish should be considered in Chinook recovery efforts.

Predation may be significant in nearshore habitats, especially on fry migrant Chinook salmon. Beamer et al. (2003) showed that predation risk was significantly lower in pocket estuary habitat compared to adjacent nearshore areas. Nearshore habitats armored with riprap may provide habitat for ambush predators such as sculpins. These areas are found in dredged navigation channels and boat harbors. We have listed this issue as a research topic in Chapter 14.

5.4.7 Disease

Life History Stage
All life stages

Basis
There has been speculation that the changed temperature regime downstream of the dams may increase the occurrence of some diseases, but no data or evidence have been presented to indicate that this is so or that disease is a significant constraint on Skagit Chinook.

5.4.8 Hatchery Fish Predation and Competition in Estuary and Bay

Life History Stage:
Nearshore rearing and marine survival

Basis
Yearling hatchery releases of coho, Chinook, and steelhead have appeared only sporadically in tidal delta samples taken since 1992 and bay samples taken since 1995. For subyearling Chinook salmon we have more quantitative data on habitat occupation for both hatchery and wild fish. Wild (unmarked) juvenile Chinook salmon are consistently found in estuarine habitats from February through October (See Figure 1.2 in Appendix D). Conversely, juvenile hatchery Chinook salmon exhibit a narrower temporal distribution in all four estuarine habitat types sampled, compared to wild fish. The significant overlap in habitat occupation only occurs in the nearshore environment in deeper habitats or offshore areas. It appears that hatchery origin subyearling Chinook do not take up extended residence in tidal delta habitats or in the shallow intertidal areas. This is possibly due to the size and time of year that hatchery subyearling Chinook reach nearshore habitats.

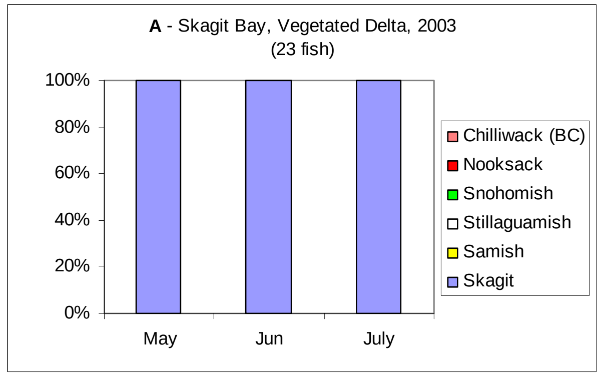
In tidal delta habitat, most recoveries of yearling hatchery Chinook occurred in only a few samples, and most samples of subyearling Chinook had few associated hatchery fish. The one exception occurred in 1992, when hatchery coho were released into the South Fork near Conway. Subsequently, large numbers of hatchery coho (marked with a right ventral fin clip) were recovered at two sites downstream from the release point. As long as this practice is not repeated, hatchery coho do not appear to be associated with wild subyearling Chinook in the tidal delta and bay frequently enough to create a significant constraint on survival.

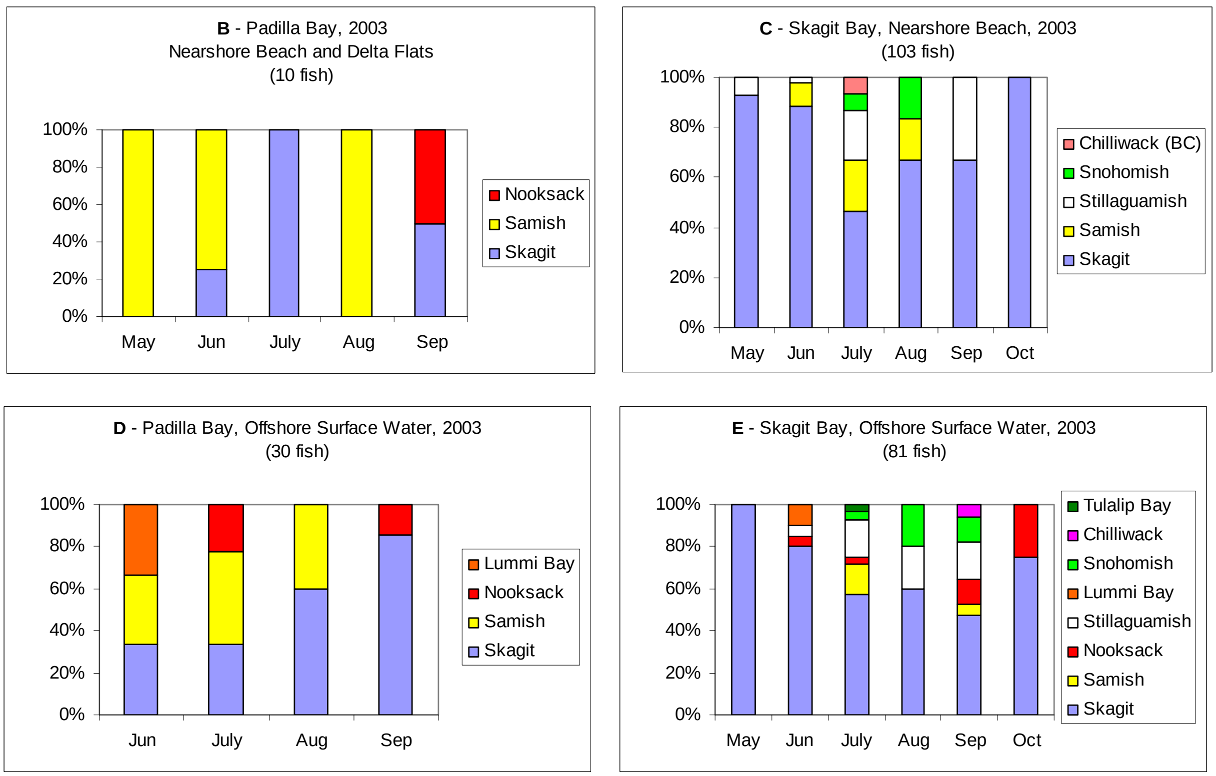
Concern has also been expressed about the possible effect of delayed-release Chinook raised in regions outside the Skagit. A recent review of Chinook stomach samples (Buckley 1999), used to assess the effect on wild Chinook of the delayed-release Chinook program in Puget Sound, found that Chinook rarely eat other Chinook. During sampling in Puget Sound in 1997 and 1998 the majority (580) of 783 Chinook sampled had only (unidentified) "invertebrates" in their stomachs. Those Chinook that had fish in their stomachs had primarily consumed herring, sand lance, and (unidentified) "marine fish larvae". No salmon were identified in those Chinook whose stomachs were sampled.

Understanding whether competition of hatchery fish on wild Chinook is significant has not been determined. The potential for interaction appears to be greatest in nearshore habitat areas starting in June where both hatchery and wild Chinook co-mingle. The potential for interaction is also a function of overall population sizes of both hatchery and wild Chinook. Hatchery Chinook releases in the Skagit are small compared to other nearby river basins and out-of-system origin hatchery fish should be considered when analyzing this issue. We do have evidence of hatchery fish from other rivers being present in Skagit Bay but not the Skagit Tidal Delta (Figure 5.2).

This topic is a research need listed in Chapter 14.

Figure 5.2. *Percentage of coded wire tagged Chinook salmon by basin of origin.* For (A) Skagit delta channels, (B) Padilla Bay nearshore beach and delta flats combined, (C) Skagit Bay nearshore beach, (D) Padilla Bay offshore surface water, and (E) Skagit Bay offshore surface water. Results from 2003.





5.4.9 Marine Mammal Predation

<u>Life History Stage</u>
Nearshore rearing and marine survival

<u>Basis</u>
There are about 15 marine mammal species in the North Pacific Ocean that reportedly eat salmon, but only two, the California sea lion and the Pacific harbor seal, have increased in abundance sufficiently that they might be considered more numerous now than in pre-development days.

California sea lions have increased in abundance since the Marine Mammal Protection Act (MMPA) was passed in 1973 (Barlow et al. 1995). Counts of pups have increased at a rate of 5.4%

per year since 1975, and counts at some haul-out sites in Puget Sound have increased about tenfold. Current levels may even be greater than pre-development levels (Calambokidis and Baird 1994; NMFS–SWFSC–248 1996; U.S. Department of Commerce 1999), particularly in Puget Sound, which, judging from the lack of encounters recorded by early surveyors, may have been outside their range. California sea lions have been observed eating both adult and outmigrating juvenile salmon at the Ballard Locks, and spring Chinook returning to Marblemount Hatchery have been increasingly scarred with marine mammal attacks in recent years (C. Lavier, WDFW, personal communication). However, it is unclear that the overall increased impact of sea lions is a significant constraint on Skagit Chinook. While California sea lion numbers are high, they may only be filling a niche vacated by other species (such as Stellar sea lions) that have dropped in abundance. In addition, they are opportunistic, and tend to congregate where foraging is successful, such as near the major hake spawning area in Port Gardner Bay, and near the Ballard Locks. In areas where human disturbances have concentrated their prey such as the Ballard Locks, the increased impact of sea lions on salmonid species may now be significantly greater than in the past, and it would be legitimate to consider them a major constraint to recovery efforts, though similar sea lion concentrations are not known to exist in Skagit Bay or the nearby waters. Moreover, sea lions are generally present in the Skagit area for only part of the year. Most of them arrive in the fall and leave in the spring, which means that they are absent for a significant part of the smolt outmigration, and much of the adult return timing. They are present when adult spring Chinook enter the river, and they probably return in time to intercept the later part of the fall Chinook run, but they are probably gone for most, or all of the summer Chinook run.

Pacific harbor seals have also increased in abundance in Puget Sound since the MMPA was passed (Barlow et al. 1995). One estimate cites their increase at about 7.7% per from 1978–1993 (Huber 1995). Unlike sea lions, they remain resident in Puget Sound continuously. Salmon, both juveniles and adults, are reportedly a minor part of their diet (NMFS–NWFSC–28, 1997), but because harbor seals are abundant even if 5% of their diet was salmon, that would account for about 350,000 adults per year. Since harbor seal abundance in Skagit Bay, as well as the river (they have been observed eating Chinook), their potential impact to Chinook populations can be substantial (Everitt et al. 1981; Gearin et al. 1988). However, as with sea lions, the magnitude of their impact, and the change from pre-development days, has not been sufficiently quantified to determine whether controlling this factor would result in a noticeable increase in Chinook production.

In assessing marine mammals, we are faced with a practical problem: 1) we aren't sure that this factor is a significant constraint, relative to pre-development days; 2) if we decide that marine mammal predation negatively impacts Chinook recovery, the most effective option would probably be lethal removal; and 3) given the ESA and the public's popular appeal with marine mammals, lethal remedy may not be an option even if their foraging substantially constrained Chinook recovery. It is possible that landscape level habitat simplification allows for greater predation opportunity and thus habitat restoration efforts to increase complexity would be the corrective action. In addition, federal funding will probably be needed to address this problem, but unlikely unless we first verify and quantify the extent of the problem.

There are three hypotheses to explore:

1) Marine mammal populations are higher than normal and therefore are having a higher than normal impact on the prey populations that support them, including salmon.

2) Habitats supporting salmon at the landscape scale have been so degraded and simplified that opportunities for marine mammal predation on salmon are greater and therefore marine mammal predation is having a significant adverse impact on salmon populations.
3) There is not a significant adverse impact on salmon populations from marine mammal predation. It is only a perception by humans because we see them eating salmon.

Each hypothesis might be true to some degree and they could interrelate.

For situations like this, NMFS provides the following guidance:

> "In situations where California sea lions or Pacific harbor seals are preying on salmonids that are listed or are proposed or candidates for listing under the ESA, immediate use of lethal removal by state or federal resource agency officials would be authorized. This authorization would only apply to those areas where resource agencies have determined that there is an urgency to immediately remove pinnipeds lethally, without having to expend resources on non-lethal methods that are not likely to provide immediate resolution to the conflict. This authority would be exercised only if (1) salmonid conservation or recovery plans are in place or in development, (2) recovery efforts on other factors affecting salmonid status are underway, and (3) lethal removal of pinnipeds is consistent with salmonid conservation/recovery plans. Under this authorization, lethal removal would occur only in specific areas where the conflicts occur, such as locations where salmonid passage is restricted or impeded and only during the period when affected salmonids are migrating through the area. It would be inappropriate to use this approach, for example, to remove pinnipeds in lower estuary areas when the actual predation problem clearly occurs upstream at a fish passage restriction. In addition, this immediate lethal authorization should not apply uniformly to every river system within the range of a listed salmonid population. Lethal removal would be inappropriate in cases where a particular salmonid run in a river system within the listed salmonid population is doing relatively well, and resolving predation at that site is not a recovery need." (U.S. Department of Commerce 1999).

Since we have not yet "determined that there is an urgency to immediately remove pinnipeds lethally, without having to expend resources on non-lethal methods", and we have not identified specific locations of high conflict "where salmonid passage is restricted or impeded", we decided that the orderly path to take is: 1) assume that marine mammals are not a significant constraint; 2) study them more closely to determine whether (and where) they are; and 3) act accordingly. At the present time, research proposals consist of recording the incidence of scarring on adult Chinook at Marblemount Hatchery, and collecting scat samples at haul-out sites to try to quantify the percent Chinook in the diet of California sea lions and Pacific harbor seals (Chapter 14.5.6).

6. HARVEST MANAGEMENT ACTIONS

6.1. INTENT

The co-managers' primary intent is to control impacts on weak, listed Chinook populations, in order to avoid impeding their rebuilding, while providing sufficient opportunity for the harvest of other species, abundant returns of hatchery-origin Chinook, and available surpluses from stronger natural Chinook stocks. Where such surpluses of natural Chinook exist, the intent of the harvest management actions is to prevent exploitation rates from exceeding the rates that are most likely to maximize harvest over the long term, to allocate as much as possible of those rates to U.S. commercial and recreational fisheries, and, for the tribal parties to this plan, to allocate as much as possible of the Treaty share to the terminal area. For the duration of this plan, directed fisheries (see Terms and Definitions for the definition of *directed fisheries*) that target listed Chinook runs are precluded, unless a harvestable surplus exists, except for very small-scale tribal ceremonial and subsistence harvest, and research-related fisheries in a few areas. This section of the plan is not intended to circumvent the annual planning processes conducted through the PSC, Pacific Fisheries Management Council (PFMC), and the North of Falcon process (see Terms and Definitions).

The management regime will be guided by the principles of the PSSMP, and other legal mandates pursuant to *U.S. v. Washington* (384 F. Supp. 312 (W.D. Wash. 1974)), and *U.S. v. Oregon*, in equitable sharing of harvest opportunity among tribes, and among treaty and non-treaty fishers. The PSSMP is the framework for planning and managing harvest so that treaty rights will be upheld and equitable sharing of harvest opportunity and benefits are realized. The fishing rights of individual tribes are geographically limited to 'usual and accustomed' areas that were specifically described by subproceedings of *U.S. v. Washington*. The harvest management actions described in this Skagit Chinook Recovery Plan are based on the principles of the PSSMP that assure that the rights of all tribes are addressed.

6.2. IMPLEMENTATION

Fisheries will be managed according to the 2004 *Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component* (Puget Sound Indian Tribes and WDFW 2004). Under this plan, fisheries are managed according to four parameters: 1) total exploitation rate ceilings; 2) Southern U.S. (SUS) exploitation rate ceilings; 3) upper escapement thresholds (UET); and 4) floor escapement levels. As long as spawning escapement of a management unit and all its component populations is predicted to be above the floor level, fisheries must be managed such that either the predicted total exploitation rate does not exceed that management unit's ceiling, or the predicted SUS exploitation rate does not exceed the management unit's SUS ceiling; moreover, fisheries directed at wild Skagit Chinook may be conducted only if, after accounting for all incidental impacts, the spawning escapement is expected to exceed its UET. If spawning escapement is predicted to be below a floor level for either a management unit or a population, the SUS exploitation rate ceiling applies.

This strategy will be applied to two management units: the Skagit summer and fall management unit (which combines the upper Skagit, lower Skagit, and lower Sauk populations), and the Skagit spring management unit (which combines the Suiattle, upper Sauk, and upper Cascade populations), except in the case of floor escapements, which, as noted above, are also applied to each separate population.

The ceiling total exploitation rate is the exploitation rate that accounts for management error and environmental variation such that, when used as the target every year, it provides the highest expected long-term catch to U.S. fisheries, consistent with ESA jeopardy standards (Hayman 1999; Hayman 2000a). Because modeling analyses indicate that this ceiling is set low enough to allow abundance to increase to the MSY recovery level (a level that should maximize long-term harvest), while also achieving ESA jeopardy standards, harvest should not impede recovery, even if this exploitation rate ceiling were used as the target rate every year. However, because the plan also does not allow directed fisheries if the projected escapement is less than the UET, annual exploitation rates have averaged significantly less than the ceiling rate, which provides further conservatism to insure that harvest will not impede recovery, as long as habitat does not deteriorate.

The UET is the preseason escapement target that is most likely to maximize the long-term catch of that unit, under the Comprehensive Chinook Management framework (Hayman 2003). These numbers are currently 14,500 for summer and falls and 2,000 for springs, but they are being reviewed by the Pacific Salmon Commission's Joint Chinook Technical Committee, and they may be adjusted to be consistent with the results of that review, following review by the co-managers.

The floor escapement level, as noted above, has been calculated for both the management unit and its component populations, and is the predicted escapement for which there is a 95% probability that the post-season observed escapement will be above a point of instability (Hayman 2000a). If escapement is predicted to be below the floor, further management actions would be taken (see U.S. Fisheries [General], below, for examples of actions that might be taken to meet the SUS exploitation rate ceiling). Thus, this plan is designed to allow the abundance of management units to increase to MSY recovery levels, while also taking actions to prevent the extinction of individual populations.

The ceiling total exploitation rate can be expressed as an absolute rate, but, due to uncertainties about the escapement levels used to generate the spawner-recruit parameters, is most consistently expressed as a percentage of the 1989–1993 fishing year mean exploitation rate.

For summer and fall Chinook, Hayman (1999), used spawner-recruit parameters (J. Scott WDFW, personal communication), calculated that the exploitation rate ceiling most likely to maximize long-term harvest, consistent with ESA jeopardy standards, is an absolute rate of 54%. This rate is 82% of the observed 1989–1993 mean exploitation (i.e., exploitation rates in 1989–1993 were higher than MSY rates), (Hayman 2000b), and, under the current FRAM calibration, translates to a FRAM rate of 50%. This rate would change as marine survival rates change (it would go up if long-term marine survival increases, and down if long-term marine survival decreases), and as any other measurable density-independent survival rates change. The actions prescribed in this Chinook recovery plan are expected to increase density-independent survival rates—at recovery, according to EDT analysis, the MSY exploitation rate under current marine survival rates is expected to increase to 71%.

The corresponding floor escapement for the summer and fall Chinook management unit is currently 4,800 (Hayman 1999). The population-specific floor escapement levels are: upper Skagit summers

= 2,200; lower Sauk summers = 400; and lower Skagit falls = 900 (Hayman 2000c). The SUS exploitation rate ceilings that apply if escapements are projected to be less than any of these floors are 15% in even years, and 17% in odd years.

For Skagit springs, Hayman (2000a) calculated that the exploitation rate ceiling most likely to maximize long-term harvest, consistent with ESA jeopardy standards, was also an absolute rate of 54% (it was coincidental that the absolute rates for Skagit summer and falls and springs were the same number—they were calculated independently), which was 76% of the observed 1989-1993 mean exploitation rate on Skagit spring Chinook (i.e., exploitation rates on springs in 1989–1993 were also higher than MSY rates, by somewhat more than for summer and falls), (Hayman 2000b). Upon subsequent review, this rate was recalculated as an absolute rate of 47%, which translates to 38% in the current FRAM calibration (PSIT and WDFW 2004, Appendix A, Skagit Management Unit (MU) Profile). The proposed floor escapement for the Skagit spring Chinook management unit is 576 spawners (Hayman 2000a); population-specific floors are: Suiattle springs = 170; upper Sauk springs = 130; and upper Cascade springs = 170 (PSIT and WDFW 2004). The SUS exploitation rate ceiling that applies if escapements are projected to be less than any of these floors is 18%.

6.3. FISHING REGIMES

There is no single fishing regime that may be used each year to achieve these rates, but there are a variety of actions that might be taken in any given year in each fishery that catches Skagit Chinook. Various combinations of these actions may be applied in any given year, as necessary to insure that the combined exploitation rate for all fisheries does not exceed the ceiling rate. These actions may include, but are not necessarily limited to those outlined below; provided, however, that some of these actions may be required by federal law or international treaties:

6.3.1 Canadian AABM Fisheries

The Canadian aggregate abundance-based management (AABM) fisheries are the Northern British Columbia troll, Queen Charlotte Islands sport, and West Coast Vancouver Island (WCVI) troll and sport fisheries. These fisheries will be managed according to Annex IV, Chapter 3 of the 1999 PSC agreement. Under the terms of this chapter, fishing levels will change as the aggregate abundance available to a fishery changes.

Populations Affected
Upper Skagit summers; lower Skagit falls. Other populations also benefit.

Expected Direct Results
Catch levels in the AABM fisheries would vary annually according to overall Chinook abundance in these areas. Exploitation rates on Skagit stocks in WCVI and North/Central B.C. would be reduced from 1988–93 rates, and should approximate (perhaps slightly lower), the rates projected for 1999. The projected 1999 exploitation rates (FRAM 0799) on spring populations were about 4% in WCVI and 2% in North/Central B.C., and on summer and fall populations were about 7% in WCVI and 12% in North/Central B.C. Model runs would be needed each year to quantify the expected exploitation rates.

Verification of Direct Results
Monitor catch levels in each AABM fishery, and exploitation rates of CWT indicator stocks. Unless otherwise noted, these verification actions apply to each of the harvest management actions.

Backup Actions (if Direct Results not achieved)
The 1999 Annex specifies payback provisions if the AABM fisheries exceed their ceilings. If the catch ceilings are not exceeded, but exploitation rates on Skagit stocks consistently exceed expected levels, then the models that predict exploitation rates may be biased, and should be corrected. It would then be necessary to determine whether the objectives of this plan can be achieved at the corrected (higher), exploitation rates. If the objectives cannot be achieved at the corrected exploitation rates, then the parties to this plan will advocate renegotiation of the AABM ceiling schedules. This might be possible if exploitation rates on Canadian Chinook are also higher than expected. Otherwise, we will be stuck with these exploitation rates at least until the Chinook Annex expires in 2008, and will need to compensate for the higher rates by reducing rates in other fisheries, or by taking other actions to improve survival rates.

6.3.2 Canadian ISBM Fisheries:

All other Canadian fisheries, which include North/Central B.C. net, Georgia and Johnstone Strait sport and net, and Area 20 (Strait of Juan de Fuca), net fisheries, are Individual Stock-Based Management (ISBM) fisheries. These fisheries will also be managed in accordance with Annex IV, Chapter 3 of the 1999 PSC agreement. Under the terms of this chapter, until escapement objectives are achieved, the aggregate of exploitation rates in these fisheries will be reduced by at least 36.5% from the 1979–82 average rates.

Populations Affected
All spring populations. Summer and fall populations also benefit.

Expected Direct Results
Catch levels in the ISBM fisheries would vary annually according to overall Chinook abundance in these areas. Exploitation rates on Skagit stocks in Georgia Strait and Area 20 would be reduced from 1988–93 rates, and should approximate (perhaps slightly higher,) the rates projected for 1999. The projected 1999 exploitation rate (FRAM 0799) on spring stocks was about 4% in Georgia Strait (including Johnstone Strait), and Area 20, and on summer and fall stocks was about 2% in Georgia Strait and Area 20. Model runs would be needed each year to quantify the expected exploitation rates.

Backup Actions
The 1999 Annex specifies payback provisions if the AABM fisheries exceed their allowed impacts. Because these impacts are expressed in terms of exploitation rates (not catch ceilings), the potential problem of agreed catch levels allowing higher-than-predicted exploitation rates (see Canadian AABM fisheries, above), would not apply here. However, exploitation rate ceilings could still be exceeded if the preseason models underestimate the exploitation rate that will result from a given catch level, or if predicted catch levels are consistently exceeded. If the impacts are being consistently exceeded because the preseason models are biased (i.e., for a given catch level, they consistently predict a lower exploitation rate than actually occurs), then the models need to be adjusted to predict exploitation rates more accurately, and fisheries must be reduced to stay within

the allowed impacts. If predicted catch levels are consistently exceeded, then the seasons need to be set more conservatively, or with tighter monitoring.

6.3.3 U.S. Fisheries (General)

U.S. fisheries will also be managed so as to meet the requirements of Annex IV, Chapter 3 of the 1999 PSC agreement. Under the terms of this chapter, until escapement objectives are achieved, the aggregate of exploitation rates in all U.S. fisheries will be reduced by at least 40% from the 1979–82 average rates, or to the average exploitation rates observed from 1991–1996, whichever is lower. Listed below are examples of fishery-specific actions that might be taken in any given year to achieve these targets. In addition, whenever the preseason forecast of spawning escapement for a Puget Sound Chinook management unit or wild population is below its floor escapement level, then the impacts in SUS fisheries on that management unit or population will be reduced until either the forecast of escapement exceeds the floor, or until the SUS exploitation rate is no greater than the SUS exploitation rate ceiling. This section of the plan is not intended to circumvent the annual planning processes conducted through the PFMC, and the North of Falcon process.

Populations Affected
Unless otherwise noted, these actions are aimed at all Skagit populations.

Expected Direct Results
Expected exploitation rates will be calculated from FRAM. In the 2000 FRAM, with a package of actions very similar to those listed below in place, the predicted total exploitation rate on Skagit summer and fall Chinook was 29% (46% of the 1989–93 level), with 12% in SUS fisheries, and the predicted rate on Skagit spring Chinook was 22% (40% of the 1989–93 level), with 16% in SUS fisheries. Predicted rates in subsequent years (through 2005), have ranged from 21%–33% for Skagit springs, and 26%–48% for Skagit summer and falls.

Actual SUS rates may be considerably less than those predicted in FRAM. Recent analyses of BY 1998 CWT groups indicates that only 1% of the Skagit summer and fall Chinook tags, and only 4% of the spring Chinook tags, were recovered in SUS fisheries[8]. In contrast, 33% of the summer and fall Chinook tags, and 34% of the spring Chinook tags, were recovered in Canadian and Alaskan fisheries (the remainder went to spawning escapement). Because BY 1998 fish contributed to fisheries in 2001–2003, when SUS fisheries were at levels typical of those described in this plan, these SUS impacts are probably typical of those that would be expected under this plan. These low impact levels also indicate that, not only is the Comprehensive Chinook framework highly effective in reducing SUS impacts on Skagit Chinook, but also that there are negligible benefits to be gained from any further restrictions on SUS fisheries.

Backup Actions
Insure that ceilings and fishing restrictions are being followed. If ceilings and restrictions are being followed, but overall exploitation rates are still higher than expected (and are higher than the ceiling rate), or escapement floors are not being met, then:

- Determine which fisheries have the higher-than-expected rates;

[8] Recoveries not adjusted for adult equivalents.

- Adjust the forecasting models to account for that difference;
- Determine whether the difference resulted from a recent change in distribution relative to other modeled stocks, or from an error in calculating the distribution in the previous years that were used to calculate the target exploitation rate and the 1989–93 base rate;
- If the former, then negotiate fisheries reductions sufficient to satisfy the ceiling exploitation rate, starting with the fisheries where impacts have increased;
- If the latter, then recalculate the ceiling exploitation rates, using corrected data for previous years.

These backup actions necessitate completion of the modeling analyses (the first three bullets listed above) prior to implementation of the corrective actions (the final two bullets above)

6.4. EXAMPLES OF SPECIFIC ACTIONS IN U.S. FISHERIES

Listed below are examples of possible fishery-specific actions, from the Minimum Fisheries Regime that is found in PSIT and WDFW (2004). These fishery specific actions, may, in a given year, in some combination, be implemented to limit exploitation rates to ceiling levels, or to exceed floor escapements. These examples are given to denote the minimum fisheries levels that may be used in any given year, as envisioned by the co-managers in conjunction with their agreement to the 1999 PSC Chinook Annex—they must take into account variations in stock abundance during any given year, but are not to be viewed as absolute required actions in any particular year (Note: these actions are intended to address all Puget Sound wild Chinook, not just Skagit Chinook. This list is not intended to be exhaustive).

6.4.1 Non-Treaty Ocean Troll and Recreational Fisheries

- Chinook and coho quotas and seasons adopted by the PFMC.
- Exploitation rates on critical Puget Sound Chinook management units will not exceed the range projected to occur for management years 2000–2003 (see Chapter 5).

6.4.2 Treaty Ocean Troll Fishery

- Chinook and coho quotas and seasons adopted by the PFMC.
- Exploitation rates on critical Puget Sound Chinook management units will not exceed the range projected to occur for management years 2000–2003 (see Chapter 5).

6.4.3 Strait of Juan De Fuca Treaty Troll Fisheries

- Open June 15–April 15.
- Use barbless hooks only.

6.4.4 Strait of Juan De Fuca Treaty Net Fisheries

- Set net fishery for Chinook open June 16–August 15. 1,000-foot closures around river mouths.
- Gillnet fisheries for sockeye, pink, and chum managed according to PST Annex.
- Gillnet fisheries for coho from the end of the Fraser Panel management period to the start of

These backup actions necessitate completion of the modeling analyses (the first three bullets listed above), prior to implementation of the corrective actions (the final two bullets above).

fall chum fisheries (approximately October. 10).
- Closed mid-November–mid-June.

6.4.5 Strait of Juan De Fuca Non-treaty Net Fisheries

Closed year-around.

6.4.6 Areas 5/6 Recreational Fishery

- May 1–June 30 closed.
- July 1–September 30 Chinook mark selective fishery not to exceed two months, and not to exceed 3,500 landed catch in 2004. In subsequent years, this may be extended by agreement of the co-managers, else, Chinook non-retention.
- October closed
- 1-Chinook bag limit in November.
- December 1–February 15 closed
- 1-fish bag limit February 16–April 10
- April 11–30 closed

6.4.7 Strait of Juan De Fuca Terminal Treaty Net Fisheries

- Hoko, Pysht, and Freshwater Bays closed May 1–October 15.
- Elwha River closed April 1–mid-September, except for minimal ceremonial harvests.
- Dungeness Bay (6D) closed March 1–mid-September; Chinook non-retention mid-September–October 10.
- Dungeness River closed March 1–September 30. Chinook non-retention when open, except for minimal ceremonial harvests.
- Miscellaneous JDF streams closed March 1–November 30.

6.4.8 Strait of Juan De Fuca River Recreational Fishery

- June 1–September 30 Elwha River closed to all fishing from river mouth to WDFW channel. At all other times and places, Chinook non-retention.
- Dungeness closed to salmon January 1–October 15.
- Dungeness Chinook non-retention October 16–November 30.
- Close other streams.

6.4.9 Areas 6/7/7A Treaty and Non-treaty Net Fisheries

- Sockeye, pink, and chum fisheries managed according to PST Annex.
- Net fisheries closed from mid-November–mid-June.
- Area 6A Closed.
- Non-treaty purse seine and reef net fisheries Chinook non-retention.
- Non-treaty gill net fishery Chinook ceiling of 700.

- Non-treaty closure within 1,500 feet of Fidalgo Island between Deception Pass and Shannon Pt; and within 1,500 feet of Lopez and Decatur Islands between Point Colville and James Island.

6.4.10 Area 7 Recreational Fishery

- May 1-June 30 closed.
- July 1–July31 fish limit, Rosario Strait and Eastern Strait of Juan de Fuca
- Closed; Bellingham Bay closed.
- August 1–September 30 one fish limit, Southern Rosario Strait and Eastern Strait Juan de
- Fuca closed Bellingham Bay closed.
- August 1-August 15, Samish Bay closed.
- Chinook non-retention October 1-October 31
- November 1-November 30, one fish limit.
- December-February 15 closed
- 1-fish bag limit February 16-April 10
- April 11-30 closed

6.4.11 Areas 7B/7C Bellingham/Samish Bay Net Fisheries

Note: Actions in this area are primarily aimed at Nooksack early Chinook, but this area also has significant impacts on Skagit summer and fall stocks, and occasional catches of Skagit spring stocks.

- Bellingham Bay (7B) and Samish Bay (7C) closed to commercial fishing from April 15-July 31.
- Areas 7B and 7C hatchery fall Chinook fishery opens August 1.
- Pink fishery opens August 1.
- Ceremonial fishery in late May limited to ten natural-origin Chinook.
- Subsistence fishery limited to 20 natural-origin Chinook from July 1-4.
- Ceremonial and subsistence harvest to be taken in the lower river, and between the confluence of the South Fork and the confluence of the Middle Fork.
- Nooksack River commercial fishery for hatchery fall Chinook opens August 1 in the lower river section; and staggered openings in up-river sections will occur over four successive weekly periods (see Appendix A).
- Bellingham Bay recreational fishery closed in July.
- Samish Bay recreational fishery closed August 1-15.
- Chinook non-retention in Nooksack River recreational fisheries.
- 2-Chinook bag limit after October 1 in Nooksack River.
- 2-fish bag limit from July 1-December 31 in Samish River.

6.4.12 Areas 8/78C/78D Skagit Terminal Area Net Fisheries

- Skagit Bay (8) and lower Skagit River (78C) closed to commercial net fishing from mid-February-August 22 in pink years, and until Week 37 (~September 10) in non-pink years.

[Note 1: since the Comprehensive Chinook Plan was written, the non-pink years closure has actually extended to week 39].

- Upper Skagit River (78D) closed to commercial net fishing from mid-March-August 22 in pink years, and until Week 42 (~October 10) in non-pink years, unless there is an opening for Baker sockeye in July. [Note 1 applies here also.]
- No Chinook update fishery, or directed commercial Chinook fishery ["directed Chinook fishery" is as defined in the Comprehensive Chinook Plan, Section 5.1], unless there is a good likelihood of a harvestable number in the terminal area.
- Upper Skagit and Sauk-Suiattle fisheries on Baker sockeye may require 5.5-inch maximum mesh, and Chinook non-retention. Note: This action is aimed primarily at summer stocks.
- Half of the Upper Skagit and Sauk-Suiattle Tribes' share of Baker River sockeye may be taken at the Baker River Trap, rather than in river fisheries. [Note: This action is aimed primarily at summer stocks. Swinomish may also conduct fisheries on Baker sockeye in the future.]
- Chinook test fisheries limited to one boat, six hours per week.
- Treaty pink update fishery may be limited to two days per week during Weeks 35 and 36, and Non-treaty update may be limited to one day a week, gill nets only. [Note: this action, and the other Skagit terminal area net actions listed below, are aimed primarily at lower Skagit falls.]
- Pink fisheries gill net openings in the Skagit River may be limited to a maximum of three days per week, regardless of pink numbers. Beach seines may be used on other days, with Chinook non-retention.
- Chinook non-retention may be required in pink gillnet fisheries in the upper river [Note: since the Comprehensive Chinook Plan was written, this provision has been applied to certain weeks].
- Release Chinook from beach seines in Skagit Bay.
- Tribal coho openings may be delayed until Week 39 in the Bay and lower river, and until Week 42 in the upper river.

6.4.13 Skagit River Recreational Fisheries

- Chinook non-retention.

6.4.14 Areas 8A and 8D Net Fisheries

Note: Actions in this area are primarily aimed at Stillaguamish and Snohomish Chinook, but this area also has significant impacts on Skagit spring stocks, and lower impacts on Skagit summer and fall stocks. Area 8A Treaty fishery Chinook impacts incidental to fisheries directed at coho, pink, chum, and steelhead.

- Effort in the Treaty pink fishery will be adjusted in-season to maintain Chinook impacts at, or below those modeled during the pink management period.
- Area 8D Treaty Chinook fisheries is limited to Ceremonial and Subsistence (C&S) beginning in May, and to three days per week during the Chinook management period.
- Non-treaty pink fishery limited to one day per week for each gear.
- Non-treaty purse seine fishery Chinook non-retention.
- Area 8D non-treaty Chinook impacts incidental to fisheries directed at coho and chum.

6.4.15 Stillaguamish River Net Fisheries

- Treaty net fishery Chinook impacts incidental to fisheries directed at pink, chum, and steelhead.
- Treaty pink fishery schedule limited to maintain Chinook impacts at or below the modeled rate.

6.4.16 Stillaguamish River Recreational Fisheries

- Chinook non-retention.
- Use barbless hooks from September 1-December 31.

6.4.17 Snohomish River Fisheries

- Net fisheries closed.
- Chinook non-retention in river recreational fisheries.

6.4.18 Area 8-1 Recreational Fisheries

- May 1-August 31closed.
- Chinook non-retention September 1-October 31.
- November 1-November 30 one fish limit.
- December 1-February 15 closed.
- One fish bag limit February 16-April 10.
- April 11-April 30 closed.

6.4.19 Area 8-2 Recreational Fisheries

- May 1-July 31 closed.
- Chinook non-retention August 1-October 31.
- November 1-November 30 one fish limit.
- December 1-February 15 closed.
- One fish bag limit February 16-April 10.
- 4/11-4/30 closed.
- One Chinook bag limit in Tulalip Bay in August and September.
- Tulalip Bay openings limited to 12:01 AM Friday to 11:59 AM Monday each week.

6.4.20 Area 9 Net Fisheries

Net fisheries limited to research purposes.

6.4.21 Area 9 Recreational Fisheries

- May 1-July 31 closed.
- Chinook non-retention August 1-October 31.
- November 1-November 30 one fish limit.
- December 1-February 15 closed.

- One fish bag limit February 16-April 10.
- April 11-April 30 closed.

6.4.22 Area 10 Net Fisheries

- Closed from mid-November-June and August.
- Sockeye net fishery during first three weeks of July when ISU indicates harvestable surplus of Lake Washington stock.
- Net fisheries for coho and chum salmon will be determined based on in-season abundance estimates of those species. Limited test fisheries will begin the 2nd week of September. Commercial fisheries schedules will be based on effort and abundance estimates. Marine waters east of line from West Point to Meadow Point shall remain closed during the month of September for Chinook protection. Chinook live release regulations will be in effect

6.4.23 Lake Washington Terminal Area Fisheries

- Chinook run size update from lock count to re-evaluate forecasted status.
- No Chinook directed commercial fishery in the Ship Canal or Lake Washington.
- Net fishery impacts incidental to fisheries directed at sockeye and coho. Sockeye and coho fisheries dependant on lock count ISU. Incidental Chinook impact minimized by time and area, and live Chinook-release restrictions. Sockeye fisheries scheduled as early as possible. Coho fishery delayed until September 15th when 95.2% of the Chinook run has cleared the locks.
- Possible directed Chinook fishery in Lake Sammamish for Issaquah Hatchery surplus.
- Cedar River and Issaquah Creek closed to recreational fishing.
- Chinook non-retention in Sammamish River, Lake Washington, Lake Union, Portage Bay, and Ship Canal recreational fisheries

6.4.24 Area 10A Treaty Net Fisheries

Note: This fishery occasionally catches Skagit spring Chinook stocks.

- Chinook gillnet test fishery 12 hours/week, three weeks, beginning mid-July to re-evaluate forecasted status.
- No Chinook directed commercial fishery.
- Net fishery impacts incidental to fisheries directed at coho. Coho opening delayed until September 15th.

6.4.25 Duwamish and Green River Fisheries

- Commercial Chinook fishery dependant on Area 10A test fishery results.
- No Chinook directed commercial fishery.
- Net fishery impacts incidental to fisheries directed at coho. Coho opening delayed until September 15th and restricted to waters below the 16th Ave Bridge. Coho opening above the 16th Avenue Bridge to the turning basin delayed until September 22nd. Coho opening above the turning basin up to the Highway 99 Bridge delayed until September 29th.
- Chinook non-retention in river recreational fisheries

6.4.26 Area 10E Treaty Net Fisheries

- Closed from mid November until last week of July.
- Chinook net fishery five days per week, the last week of July-September 15.
- Chinook impacts incidental to net fisheries directed at coho and chum, from mid-September-November

6.4.27 Area 10 Recreational Fisheries

- May 1-June 31 closed.
- Chinook non-retention July 1-October 31.
- November 1-November 30 one fish limit.
- 12/1-2/15 closed.
- One fish bag limit February 16-April 10.
- April 11-April 30 closed.

6.4.28 Area 11 Net Fisheries

- Closed from end of November to beginning of September.
- No Chinook-directed fishery
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.
- Non-treaty purse seine fishery Chinook non-retention.

6.4.29 Area 11A Net Fisheries

- Closed from beginning of November to end of August.
- Net fishery Chinook impacts incidental to fisheries directed at coho.

6.4.30 Puyallup River System Fisheries

- Net fisheries closed from beginning of February to beginning of August.
- Limit gill net test fishery for Chinook to one day a week, scheduled from mid-July-August 15.
- Chinook net fisheries limited to one day per week, August 15-September 10 (delayed to protect White River spring Chinook.
- Muckleshoot on-reservation fisheries on White River limited to hook and line C&S fishing for seniors, with a limit of 25 Chinook.
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.
- Two Chinook bag limit in river sport fisheries.
- Chinook non-retention before August 1 in Puyallup River sport fishery.
- Chinook non-retention before September 1 in Carbon River sport fishery.
- Chinook non-retention in White River.

6.4.31 Area 11 Recreational Fisheries

- May 1-May 30 closed.

- One fish limit June 1-November 30.
- 12/1-2/15 closed.
- One fish limit February 16-April 10.
- April 11-April 30 closed.

6.4.32 Area 13 Fox Island and Ketron Island Net Fisheries

Note: There may be occasional catches of Skagit summer and fall stocks in this fishery.

- Closed from end of October-August 1.
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.

6.4.33 Area 13 Sequalitchew Net Fisheries

Net fishery Chinook impacts incidental to fisheries directed at coho.

6.4.34 Area 13A Carr Inlet Net Fisheries

- Closed from beginning of October-August 1.
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.

6.4.35 Area 13C Chambers Bay Net Fisheries

- Closed from end of mid-October-August 1.
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.

6.4.36 Area 13D Net Fisheries

- Closed from mid-September-August 1.
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.

6.4.37 Area 13E Henderson Inlet Net Fisheries

Closed year-around.

6.4.38 Area 13F Budd Inlet Net Fisheries

- Closed from mid-September-July 15.
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.

6.4.39 Areas 13G–13K Net Fisheries

- Closed Mid-September-August 1.
- Net fishery Chinook impacts incidental to fisheries directed at coho and chum.

6.4.40 Areas 83D and 83F Nisqually River and McAllister Creek Fisheries

- Chinook fishery late-July-September, up to three days per week dependent on in-season abundance assessment (see Appendix A).
- Coho fishery October through mid-November.
- Late chum fishery mid-December-mid-January.
- Nisqually River recreational closed February 1-May 31.
- McAllister Creek recreational closed December 1-May 31.
- Chinook non-retention in June recreational fishery.
- Two Chinook bag limit.

6.4.41 Area 13 Recreational Fisheries

- One fish bag limit May 1-November 30.
- December 1-February 15 closed.
- One fish bag limit February 16-April 10.
- April 11-April 30 closed.

6.4.42 Areas 12/12B/12C/12D Hood Canal Treaty Net Fisheries

(Also see: Skokomish and Mid-Hood Canal Management Unit profiles in Appendix A)

- Chinook directed treaty fishery limited to Areas 12C and 12H.
- Coho directed fisheries in Areas 12 and 12B delayed to Sept. 24, and in Area 12C, delayed to October 1. Beach seines release Chinook through October. 15.
- 1,000-foot closures around river mouths, when rivers are closed to fishing.
- Net fisheries closed from mid-December-mid-July

6.4.43 Area 9A Treaty Net Fisheries:

- Closed from end of January-mid-August (dependent upon pink fishery).
- Beach seines release Chinook through October 15.

6.4.44 Area 12A Treaty Net Fisheries:

- Closed from mid-December-mid-August.
- During coho and chum fisheries, beach seines release Chinook through October 15.

6.4.45 Hood Canal Freshwater Treaty Net Fisheries

- Dosewallips, Duckabush, and Hamma Hamma rivers closed.
- Skokomish River Chinook fishery August 1-September 30, limited to two to five days per week.
- Skokomish River closed March-July 31(also see: Skokomish MU profile in Appendix A).

6.4.46 Area 12 Recreational Fishery

- May 1-June 30 closed.

- Chinook non-retention July 1-October 15.
- October 16-December 31, one fish limit.
- January 1-February 15 closed.
- One fish bag limit February 16-April 10.
- April 11-April 30 closed.

6.4.47 Hood Canal Freshwater Recreational Fisheries

- Closed March 1-May 31.
- Chinook non-retention from June 1-February 29 in all rivers.
- Dosewallips, Duckabush, and Hamma Hamma closed in September and October.

The above actions are intended to reduce impacts from 1989-1993 levels on Skagit wild Chinook. The next action is a new fishery intended to increase harvests of hatchery Chinook.

6.4.48 Area 78D Cascade River Net Fishery

During August, the Skagit River tribes may experiment with gear that allows the live release of unmarked hatchery spring Chinook in the lower Cascade River at the mouth of the hatchery.

The targeted population is Skagit hatchery springs.

6.5. EXPECTED POPULATION RESULTS

The above actions (except the Cascade River fishery), were intended to increase the number of spawners from the levels that existed prior to ESA listing, under the assumption that, at those escapement levels, production was constrained by a lack of spawners, and Chinook habitat was not seeded to average MSY density at any life history stage. These actions have increased the number of spawners in the Skagit River, and it is expected that the average increase in run size (by BY) will be greater than the average increase in brood year spawning escapement, when calibrated for marine survival and preterminal interceptions.

6.6. EFFECTIVENESS MONITORING

Five separate research and data-gathering programs will be done to monitor whether the expected fish production results are being achieved

- Spawning grounds surveys and escapement estimation for each population separately;
- Indicator stock coded-wire-tagging and sampling, for groups representing lower Skagit falls, upper Skagit summers, and Skagit springs;
- Smolt outmigration population estimation;
- Flow monitoring; and
- Stock identification analysis that estimates the percentage of the smolt outmigration composed of each population.

The first two programs will provide estimates of brood escapement, preterminal interceptions, total recruitment, and marine survival of each population. From these estimates, the parties will analyze the relations between recruitment (calibrated for a standardized marine survival rate), and brood escapement, as well as the relation between run size (calibrated for expected preterminal interceptions), and brood escapement in order to determine whether the average increase in run size (by brood year), has been greater than the average increase in brood year spawning escapement, when calibrated for marine survival and preterminal interceptions. These analyses will incorporate consideration of measurement error and management imprecision.

The last three programs, combined with the escapement estimates, will provide estimates of egg-to-smolt survival of each population as a function of peak incubation flows. These functions will be analyzed separately for escapement levels that are the same approximate magnitude, as a rough screen to determine whether egg-to-smolt survival, calibrated for flow, is higher at the lower observed escapements than at the higher escapements. If it isn't, then we can assume that the higher observed escapements are below the MSY escapement level[9], and that the population will benefit from higher escapements (or decreases in exploitation rates). If it is, then the egg-to-fry survival rates will be multiplied by the average marine survival rates and preterminal interception rates (derived from the first two programs), to determine egg-to-terminal adult return rates, at each escapement range, as a function of flow. These rates will be multiplied by the estimated egg deposition at each escapement level, to determine whether the expected increase in terminal run size is greater than the increase in escapement. This analysis is similar to the spawner-recruit analysis described in the above paragraph, but it allows for the rough screen, and it allows for the possibility that a given escapement level will be below the MSY escapement level at one flow level, but not at a higher flow level. In such a case, peak flow frequencies will be analyzed, and simulations will be run that model peak flows occurring according to that frequency, to determine the probability that a given escapement level will provide greater benefits than a different escapement level. The monitoring programs are described in more detail in Chapter 15.

6.7. BACKUP ACTIONS

If the monitoring indicates that increasing the spawning escapement from the levels that existed prior to ESA listing to levels consistent with application of the UET is not likely to provide increases in harvestable surplus to the parties to this plan, the parties will first examine whether this can be accomplished by a reallocation of harvest from fisheries outside the parties' jurisdiction.

If this cannot be done, then it must be concluded that the UET is higher than the MSY escapement level, and the UET should be reduced to the new estimate of MSY escapement, adjusted as necessary to take advantage of any increase in production from contemporary habitat restoration activities.

Doing this means that the parties would be assuming that Chinook habitat is being seeded to average MSY density for some life history stage at lower escapement levels than are initially assumed in this plan. If revising the UET does not achieve the goals of the plan, the parties must focus on additional actions that increase Chinook capacity and survival rates. If density-independent survival is assumed to be less than normal for any freshwater life history stage (e.g., incubation survival is particularly low for some population), these actions could include undertaking or increasing supplementation programs that release juveniles after completion of that life history

[9] However, survival rates may be so low that the returns/spawner rate is less than 1.0 (i.e., below replacement). In such a case, there is no MSY escapement level, and the stock is headed towards extinction. Harvest management actions may delay extinction, but they will not prevent it. To prevent extinction, other actions must be taken to increase the survival rates.

stage (see Chapter 11). This would be done as a short-term temporary measure to artificially increase survival rates until habitat restoration actions have improved the natural survival rates to normal levels.

6.8. HARVEST ENFORCEMENT

Chinook salmon recovery in the Skagit River system depends on, among other things, curtailing, eliminating, or both the illegal harvest of native Chinook stocks and reducing the assaults on fish habitat through effective enforcement of existing take and habitat protection regulations.

While the nature of the illegal harvest problem is difficult to determine, WDFW Officers detect and apprehend individuals annually who illegally harvest/kill Chinook salmon in the Skagit River. Although WDFW and the County prosecutor have successfully prosecuted these individuals, resulting in excessive and highly publicized sentencing (e.g., substantial fines, vessel forfeitures, license revocations), the illegal harvest will no doubt continue possibly thwarting well intended and last chance recovery efforts. The following enforcement recommendations will aid in reducing both illegal Chinook salmon harvest and illegal habitat degradation:

Recommendation 6.8.1

The parties will continue to seek funding to staff additional state and tribal enforcement officers in Skagit, Whatcom, and Snohomish Counties to focus on the protection of fish life and fish habitat within the Skagit River and its tributaries. It is expected that the additional enforcement officers would expend their time in the field addressing the protection of fish life and fish habitat in the Skagit River Basin.

Recommendation 6.8.2

Demand on existing enforcement staff is expected to increase, necessitating the need for increased cooperation through the development of effective partnerships. Improved partnerships will ensure the fullest utilization of enforcement efforts, coordination, and communication. Entities expected to be included in the enhanced partnerships would include, but are not necessarily limited to: Swinomish Indian Tribal Community, Sauk-Suiattle Indian Tribe, Upper Skagit Indian Tribe, WDFW, USFS, USFW, USACE, WDNR, WDOE, NMFS, Skagit County Sheriff's Office, Whatcom County Sheriff's Office, and Snohomish County Sheriff's Office.

Recommendation 6.8.3

Future state and tribal compliance priorities will focus on illegal harvest and take for both anadromous and native resident salmonid species as well as habitat protection to provide "gravel to gravel" protection by vigorously enforcing current state, tribal, and local protection regulations.

Recommendation 6.8.4

Increase state and tribal law enforcement effectiveness and cooperation by directing staff to schedule and conduct cooperative patrols of both state and tribal closed and open harvest seasons. The sharing of information and maintaining the confidentiality of that information, for law enforcement purposes, is absolutely essential.

Recommendation 6.8.5
Develop and publish a map that lists (by species), particular poaching and habitat area problems for listed or candidate species. This not only identifies what we know now of poaching and problem areas, but will also provide a guide for effective countermeasures and enforcement patrol planning.

Recommendation 6.8.6
Implement an aggressive enforcement program (using key enforcement staff from the newly developed enforcement partnership but particularly with state and tribal officers), to target the illegal take (habitat loss and illegal loss), of fish stocks. Uniformed officer presence will be prioritized and directed into areas where listed or candidate fish species are present within the Skagit River Drainage Basin and its associated estuary and nearshore areas. Patrols will be conducted by foot, car, boat, aircraft, off-road vehicle, snowmobile, mountain bike, and horseback, and stakeouts (both physical and electronic).

Recommendation 6.8.7
Develop a fish and habitat law enforcement educational program to present to members of the criminal justice system (other law enforcement entities, county prosecutors, judges, court commissioners, probation and parole officers), within the Skagit Basin to enhance their understanding of their authority and the significance of the issues.

Recommendation 6.8.8
Enhance voluntary compliance with a coordinated state and tribal public outreach program featuring both state and tribal fish and wildlife protection statutes and regulations to maximize law enforcement effectiveness. WDFW and tribal officers will be an integral part of the co-managers' team approach to education by working with biologists, other enforcement officers, policy makers, and interested public to develop and distribute education and outreach materials directed at illegal take, regulations, understanding of ESA and the needs of the resource. Potential presentation opportunities include sport shows, fairs, schools, landowners, local government, industrial groups, agricultural groups, and with other stakeholders to discuss ESA issues.

Recommendation 6.8.9
Develop or use existing reporting systems of the involved agencies (e.g., tribes, WDFW, NMFS) to track enforcement activities (i.e., programs serviced, mode of patrol, hours expended, type of contacts). The reporting system used should be compatible to allow easy exchange of information between the parties.

Recommendation 6.8.10
The parties' enforcement officers should participate in the fishing regulations-setting processes, including PFMC and North of Falcon, and provide input regarding the feasibility of enforcing the regulations packages being considered by the fishery managers.

7. HABITAT PROTECTION

7.1. INTRODUCTION

Successful habitat protection depends on three important components. First is a public that recognizes the importance of salmon habitat protection, and that does not condone actions by others that do harm to these resources. This sentiment should be nurtured through a vigorous public information effort, and by providing the technical information to assist landowners and others in their efforts to comply with existing regulations. Technical and financial resources should also be made available to those who voluntarily want to do even more to protect and restore salmon habitat if they so choose. Providing people with the information to make informed decisions that will be protective of salmon habitat when working in and around streams is the first step towards habitat protection. To summarize, providing people the tools to “do the right thing” capitalizes on the vast majority of the public that wants to provide for a future for Skagit River Chinook.

A second factor and one that needs to be implemented concurrently with the first step is an unambiguous regulatory framework that insures that the habitat needs of the fisheries resource are fully protected, either through avoidance of impacts or through the full mitigation of unavoidable impacts. The regulations should provide sufficient clarity to landowners and other project proponents about what standards need to be met, and what actions are unacceptable. These regulations must be applied equally to all, with assistance from implementing agencies so that people can understand the necessity of the regulated actions, and how they can comply.

Finally, there needs to be an enforcement presence to insure that those that choose not to follow the rules will be held accountable. This is important for a number of reasons. First and foremost, vigorous enforcement provides a deterrence to those that might otherwise try to circumvent or ignore existing regulations. Also important is that an active enforcement process indicates to those that are abiding by the rules that others will be held to a similar standard, and that there is an even playing field for everyone that needs to work in an around streams. Finally, a vigorous enforcement presence indicates to the public that these matters are an important public policy, and that the authorities with jurisdiction take their responsibilities seriously and are committed to ensuring that salmon protection is an important priority.

Habitat actions taken to recover and protect Chinook salmon must be based on the biological and ecological requirements of the species. While science forms the primary basis for protection and recovery actions, scientific knowledge is incomplete, and therefore monitoring and adaptive management will be necessary as habitat preservation and restoration actions are implemented. Some of the recommended actions in this chapter may need to be refined or altered as recovery progresses, and new actions not yet apparent may become necessary.

In contrast to the relatively specific scope of responsibility regarding hatcheries, harvest, and hydropower, the authority and responsibility for habitat as it pertains to salmon recovery is widespread. Ultimately, this authority and responsibility rests with every individual landowner and permitting authority that makes a decision regarding how a piece of land will be developed and managed.

Because responsibility for addressing habitat issues affecting salmon is so widespread among Washington citizens and governments, recovery and protection of Chinook salmon will require involvement and collaboration of many stakeholders. This collaboration will be successful only if all parties are willing and able to understand the economic, political, and social constraints of other stakeholders and work together to address these constraints within the realm of sound science and at the same time meet the Chinook recovery goals within this plan.

In the face of increased human population growth and the impact of ongoing land use activities, the ability to recover Chinook salmon can only occur if the fish productivity necessary to meet recovery goals is met through a combination of habitat restoration and protection actions. Any further reductions in current habitat capacity and fish productivity will result in the necessity for additional restoration measures, which may result in greater economic challenges in the future

Given this assumption, we offer the following specific recommendations that could, and should, be taken by federal, state, tribal, and local governments and stakeholders in an effort to realize viable recovery efforts. Furthermore, we believe the following recommendations represent only one pathway to ensure the continued freshwater and estuarine productivity of Skagit Chinook. Other combinations of habitat protection and restoration actions may also achieve recovery, and the authors of this document look forward to considering other pathways to meet the Chinook recovery goals. The authors recognize that elements may be changed in order to account for anticipated or desired impacts, and we trust proponents for such changes will be willing to measure their actions with the same or similar quantitative assessments of potential fish productivity and abundance as we present herein.

It is important to understand that these recommendations apply only to those areas of the Skagit River watershed that are currently or historically occupied by Chinook, or areas that influence Chinook habitat. A further refinement of this plan will result in the development of site-specific maps where these recommendations should apply.

Protection and restoration of habitat critical to maintaining Chinook production and productivity is dependant on seven factors:

1) Application of best available science and implementation of adaptive management practices to deal with uncertainty
2) Local collaborative planning that fully incorporates the needs of salmon in the recovery planning process
3) Adequate regulatory safeguards that meet the required certainty of fish and habitat protection
4) Adequate technical assistance to aid parties with the compliance of regulations
5) The vigorous enforcement of these regulatory safeguards
6) Adequate incentives to promote voluntary involvement of the public in the restoration and protection of salmon habitat
7) A desire on the part of the public and elected officials to provide for those habitat elements necessary to sustain salmon populations sufficient to meet the recovery goals

This document will focus primarily on state and local governmental agencies because they have the largest regulatory impact at the watershed level and therefore play a fundamental role in the expression and implementation of habitat recovery efforts. These agencies include: WDNR, through its implementation of Forest Practices rules and through the management of aquatic lands; WDOE, through implementation of the Clean Water and Shorelines Management Acts and administration of the water code; WDFW, through administration of the Hydraulics Code; and local city and county governments.

This document recognizes the fact that co-managers of the fisheries resources have their primary jurisdictional authority over hatchery and harvest activities. Therefore, the protection elements within this recovery plan are recommendations to local, state and federal entities. Implementation of these recommendations will be the prerogative of these governments, and the ability to reach Chinook recovery goals will in large part be determined by the extent to which these or equally effective recommendations are implemented.

The recommendations in this chapter highlight actions that must be addressed with expediency. The involvement of jurisdictional stakeholders is, in fact, imperative. Towards such end we strongly recommend a decision-making process that builds upon local voluntary efforts already underway, and also incorporates other non-voluntary elements as described herein. The co-authors of this plan resolutely believe our ability to reach recovery goals will in large part be determined by the extent of successful implementation of these or other equally effective measures.

Protection elements within this chapter (restoration elements will be found in Chapters 9-12) are arranged according to salmonid life history needs, and the physical processes and habitat types affecting them. The primary components consist of, in part:

- Stream Flow
- Basin Hydrology
- Water Quality, Sediment Quality, and Sediment Transport
- Stream Channel Complexity
- Riparian Areas and Wetlands
- Estuary and Nearshore
- Fish Passage and Access

7.2. STREAM FLOW

Washington State's Governor's Salmon Recovery Office's "Statewide Strategy to Salmon Recovery, Extinction is Not an Option", dated September 1999, states as a goal:

> "Retain or provide adequate amounts of water to protect and restore fish habitat. Objectives include: Establish stream flows for watersheds that support important fish stocks, and Protect and/or restore instream flows by keeping existing flows and putting water back into streams where flows are diminished by existing uses-especially illegal or wasteful uses or by poor land use practices." (p. IV.57)

The following discussion examines progress toward meeting the Strategy's goal in the Skagit Basin, and then offers specific recommendations that will measurably facilitate the recovery of Chinook salmon:

Instream flows for the Skagit River were established by rule in 2001 (WDOE 2001). Instream flow studies have demonstrated that existing flows are frequently below optimum for spawning and rearing Chinook. Additional growth pressures, along with illegal use of water throughout portions of the basin, can have adverse effects on Chinook productivity. Stream flow is affected by basin hydrology as well as withdrawals (either permitted, permit-exempt, or illegal) for:

- Individual residential use (e.g., wells)
- Municipal water systems
- Agricultural use
- Hydropower
- Commercial and industrial use

To protect stream flows from over-appropriation through withdrawals and diversions, we offer the following recommendations:

7.2.1 Individual Residential Use

The use of exempt wells has had an adverse impact on stream flows, particularly in tributaries that experience low flows during the summer months. A number of these streams within the Skagit Basin have been identified by state and local agencies for listing on WDOE's Surface Water Source Limited (SWSL) list. The Chinook streams identified are:

- Nookachamps Creek
- Diobsud Creek
- Carpenter Creek

Recommendation 1

Issue new water right permits only when there will be no new impairment of current instream flows as established by rule or when appropriately mitigated.

Mechanism: Mitigation possibilities include the use of Skagit PUD or the City of Anacortes' inchoate water rights, through extension of service, or of municipal water systems that have been in place prior to new rulemaking. Many of these alternative sources are within established service areas and consistent with the purposes for which the water rights were originally issued. Additional basin-specific storage, the use of "pump and dump" systems, and the use of groundwater not in hydraulic connectivity to surface flows might be considered as alternative sources of water to accommodate new growth without reducing instream flows. The use of Overriding Consideration of Public Interest (OCPI) to allow for additional diversions and withdrawals should not come at the expense of instream flows, but should utilize existing out of stream sources to meet future needs.

Recommendation 2

Enforce the provisions of the Skagit Instream Flow rule such that there will be no use of exempt wells that are in hydraulic continuity with surface waters in cases where instream flows will be impaired.

Recommendation 3

Provide Washington State Department of Ecology with the resources needed to apply and enforce the instream flow rules.

Recommendation 4
Enforce RCW 90.14.160 for the relinquishing of unused water rights.

Recommendation 5
Issue new building permits only when water rights have been secured.

Mechanism: Building permits should not be issued unless there is an adequate supply of potable water, which in this instance, at a minimum, means that use of this water will not impair instream flows. The Growth Management Act requires that an adequate supply of potable water must be available prior to the issuance of building permits, perhaps via PUD extensions or transfers of valid existing rights.

Recommendation 6
Use available municipal water rights to service unmet domestic and industrial and other needs.

Mechanism: Skagit PUD and Anacortes water systems should work to serve current unmet needs. These systems draw from the Skagit River and are consistent with both the Skagit Instream Flow Rule and the 1996 MOU between the Swinomish, Sauk-Suiattle, and Upper Skagit Indian Tribes; Skagit County; Skagit PUD #1; the City of Anacortes; WDOE; and WDFW. This will minimize the impacts of additional diversions to Skagit Chinook stocks.

Recommendation 7
Develop coordinated mitigation plans to offset new ground and surface water developments.

Mechanism: Local, state and federal relief could be made available to local landowners to provide funding and technical capability to develop mitigation plans and programs to offset the impact of new groundwater developments. All stakeholders, in conjunction with WDOE, should develop a consensus request to the Washington state legislature that addresses this issue; contingency plans must be available if state funding is not provided.

7.2.2 Public Water Systems

The passage of HB1338 provides for an expansion of the original place-of-use of previously issued water rights without regarding impacts to instream resources. It also expands the definition of municipal water systems to provide for the use of inchoate water rights that otherwise would go unused or be relinquished. The bill eliminates restrictions on existing water permits. All of this will result in additional use of water that will further impair instream flows.

Instream flow agreements already established in the Skagit Basin have secured water rights for the major water purveyors within the county, Skagit PUD, and Anacortes. These water rights will appropriately be used to meet future growth needs while at the same time reducing the impacts of individual exempt wells.

Recommendation 8
The expansion of service areas or the use of inchoate rights for areas outside of original place- or purposes-of-use should be prohibited (which is inconsistent with current law as expressed in HB1338). The definition of public water systems should not be expanded to include what were formerly private or non-municipal water systems.

7.2.3 Hydropower

We believe current operations at Skagit River mainstem dams operated by Seattle City Light have been adequately mitigated through the relicense process concluded in the 1995 Settlement Agreement.

The Baker River Project, operated by Puget Sound Energy, is currently undergoing relicensing by the Federal Energy Regulatory Commission (FERC). A settlement agreement has been reached between Puget Sound Energy and all relicense stakeholders, including state and federal resource agencies and Tribes. If FERC issues a license that includes flow provisions in the settlement agreement, construction will be completed in 2012 that will add two additional turbines, providing greater flexibility in flow releases. Washington State downramp rates will be met in the Skagit River downstream of the Baker River, greatly reducing the potential for Chinook fry stranding due to Baker River Project operations. There will be maximum flow release restrictions while Chinook are spawning downstream of the Baker Project, and new minimum flow releases that greatly reduce or eliminate the potential for Chinook egg and alevin stranding from project operations.

Recommendation 9
Implement the license articles proposed by the parties to the PSE Baker Relicense Agreement.

Recommendation 10
Additional flood control needs must be consistent with instream flows established and agreed upon in the Baker River license agreement. Any new flood control operations agreed upon by USACE will need to be consistent with these flows as well.

7.2.4 Agricultural Use

The use of water for irrigation of crops is becoming increasingly important in the Skagit Valley. Current recorded water rights greatly exceed the actual beneficial use of legally authorized water rights. In addition, there is evidence that unpermitted water use for agricultural purposes is taking place in the basin.

Recommendation 11
Define current and future irrigation needs. Conduct landscape-level planning to implement coordinated water management in the Skagit Basin. Consider development of a water bank to ensure the most efficient use of water rights.

Recommendation 12
Enforce existing provisions of the water code such that water is utilized consistently with the purpose, place, and quantity of use authorized on permits, certificates and claims. Rights to water that is not put to beneficial use should be relinquished.

7.2.5 Commercial and Industrial Use

Most industrial water use in the Skagit Valley is served by municipal water systems. Recent State Court decisions have expanded the use of exempt wells for commercial use, such that additional water withdrawals will likely occur if WDOE does not enforce the existing Skagit Instream Flow

Rule, and if Skagit and Snohomish Counties continue to issue building permits when adequate water supplies are not available.

Recommendation 13

Hold commercial water users to the provisions of the Skagit Instream Flow Rule. Prohibit the use of exempt wells by commercial enterprises, as this is in direct conflict with exempt well provisions of the State water code.

7.3. BASIN HYDROLOGY

Basin hydrology is affected by a number of land uses, including forest practices, increased area of impervious surfaces, and flood control. Each of these can degrade stream channel morphology and adversely affect the physical processes of sediment transport, channel development, wood loading, and stream bank integrity.

7.3.1 Impervious Surfaces

Studies in King County have demonstrated that watersheds with increased impervious surfaces can have altered basin hydrology such that channel capacities are exceeded during storm events. This often results in the down-cutting and degradation of streams. Few watersheds within the Skagit Valley exceed 7% impervious surface, but some watersheds will exceed this capacity at full build-out based on current comprehensive plan documents.

Recommendation 14

Develop and implement regulations that will limit impervious surfaces to levels that are below a threshold of 7% total impervious surfaces in any tributary watershed.

Mechanism: Low impact development techniques should be evaluated and approved by local jurisdictions and written into local building codes. Incentives should be sought for the application of innovative techniques that mitigate for new impervious surfaces. Comprehensive plans should be adjusted if necessary to insure that full build out will not result in impervious surfaces exceeding 7% unless other equally effective measures in maintaining hydrologic stability are put in place.

7.3.2 Flood Control Measures

In the past 15 years, numerous flood control measures have been proposed for addressing the serious issue of flood protection. Some of these measures would result in significant changes in the hydrology of the Skagit Basin. Currently, the USACE, in conjunction with Skagit County, is conducting a major flood control study to assess various alternatives for meeting the flood control needs of the basin. Changes to basin hydrology may result from implementation of any one of the alternatives developed.

Recommendation 15

Implementation of any measures identified in the Skagit Flood Control study should seek to maintain the hydrological and physical integrity of the mainstem Skagit River and its tributaries as well as the Skagit Delta.

Mechanism: The construction of new dikes and levees should be prohibited unless mitigated for, resulting in no net increase in isolated floodplain area nor additional loss of floodplain habitat.

Operations of flood control structures at both the Baker River and Seattle City Light dam projects must be consistent with and subordinate to instream flows adopted as a result of the agreed-upon license articles of the Baker River relicensing process, as well as currently established license provisions of the Seattle City Light projects.

7.3.3 Global Warming

Issues of global warming should be recognized as a current reality, but details necessary to ameliorate the impacts of climate change are beyond the scope of this plan.

Recommendation 16
Assess the potential impacts of global warming on flood frequencies and durations, and on stream flows. Upon completion of these assessments, integrate the conclusions with ongoing permitting and planning processes.

7.4. WATER QUALITY, SEDIMENT QUALITY, AND SEDIMENT TRANSPORT

Nearly twenty Skagit Basin streams are currently listed on the Clean Water Act Section 303(d) list of waters with impaired water quality. Most are listed as a result of not meeting water quality standards for fecal coliform, temperature, or dissolved oxygen, although White Creek and Hansen Creek are listed based on a narrative standard for inadequate habitat. Human-caused sources of elevated sediments come primarily as a result of several land uses including agriculture, urban development, forestry, stormwater and road systems.

7.4.1 Forest Practices

Management-related landslides and road-surface runoff have been identified as contributing to accelerated sedimentation rates in streams. Landslides related to timber harvesting and road construction have been addressed in WAC 222-16-050 that requires forest practice activities taking place on unstable landforms are in compliance with the State Environmental Policy Act guidelines and will require an environmental checklist and additional review, at a minimum. In addition, forest Practices Rules further specify that road maintenance and abandonment plans (RMAPs) are to be completed by June 30, 2006 (assessment portion), and all of the work finished by June 30, 2016. Existing roads are to be brought up to new construction standards unless there is “little risk to public resources” (fish are considered to be a public resource). Much of the work involves replacement of undersized or poorly installed culverts. Culverts need to be able to allow passage of the debris likely to accompany 100-year flood events. The work will also include installation of additional culverts as needed, and side cast pullback in high-hazard areas.

Recommendation 17
Secure funding for maintenance, storm-proofing or decommissioning of roads.

Mechanism: The RMAP provisions of Forests and Fish Agreement are being implemented. Complete inventory of orphan and high-risk roads on roads not covered by Forest and Fish. Prioritize and schedule identified roads for closure and decommissioning. Timber interests, U.S. Forest Service (USFS) and WDNR should provide background and outline issues regarding roads that directly and indirectly affect fish habitat.

Recommendation 18

Reduce sediment from road-surface runoff.

Mechanism: Accomplished through the RMAP process by disconnecting the runoff from the stream networks. New roads will have ditch relief pipes placed close to streams that will direct ditch water onto the forest floor before it reaches the streams. Existing roads will be brought up to the new standards over the 15-year life of each plan. Construction of new stream-adjacent parallel roads is strongly discouraged and requires, at a minimum, an on-site interdisciplinary team review (WAC 222-24-020 (2)). Existing stream-adjacent parallel roads receive high priority for repair and maintenance in road maintenance plans (WAC 222-24-051 (7 (e))). Recommend that timber interests and WDNR provide background and outline issues regarding roads that directly and indirectly affect fish habitat. Successful resolution of this issue may require a detailed, basin-wide inventory of salmon streams and roads, along with priorities (or a process to determine priorities) for implementing road management plans.

Recommendation 19

Small landowners, as defined by the current Forest Practices Act, own a disproportionately large number of salmon-bearing stream miles. Measures need to be put in place to protect water quality regardless of size of land ownership.

Mechanism: Appropriate water quality protection measures may be achieved by legislative changes to Forest Practices Rules or by other measures that will provide for equivalent levels of protection

7.4.2 Agricultural Practices

The Statewide Strategy to Recover Salmon summarizes the current situation with respect to salmon and agricultural practices in Washington. Approximately 37,000 farms cover 15.7 million acres and produce more than 200 commodities that contribute significantly to the state's economy. Although it is acknowledged that current farm practices are necessary for the profitability and the existence of farming in Skagit County, it is also recognized that some farm practices are harmful to salmon and salmon habitat (Appendix F)

Recommendation 20

Governor Locke's Extinction is not an Option (1999) called for a collaborative process to develop an agricultural strategy within three years, and delineated default actions if that strategy was not developed among interested parties. These default actions include a regulatory framework in the form of an Agricultural Practices Act, a Riparian Protection Act, or the mandatory use of Farm Plans based on Best Management Practices (BMP) based on Best Available Science (BAS). The commitment to enforce these regulations, is a necessary component to protect water quality within the Skagit Basin. A Water Quality based agricultural strategy has yet to be developed.

Mechanism: Implement the default actions or develop an institutional mechanism through which water quality issues can be discussed, prioritized and study designs developed for focused investigations. Utilize existing institutional resources such as WSU research, UW fisheries or Western Washington University to broker objective investigations and implement agreed upon work plans in areas of acknowledged expertise.

Recommendation 21

Assist and support development of Total Maximum Daily Load (TMDL)s for each of the Chinook streams listed on the 303(d) list in the Skagit River Basin. Identify and implement the measures necessary to meet water quality standards. These measures should become part of either local or state regulations to ensure their implementation.

Recommendation 22

Develop and implement drainage maintenance plans pursuant to the Skagit Drainage and Fish Initiative.

Recommendation 23

Provide access for review of site-specific water quality improvement measures of Farm Plans, Conservation Reserve Enhancement Program (CREP) buffers, and the expenditure of EQIP funds implemented by the Skagit Conservation District (SCD) and NRCS to ensure that appropriate BMPs and Farm Plan elements are being employed to protect water quality. On-going monitoring and reports of results regarding the efficacy of these programs should be undertaken.

Recommendation 24

The Shorelines Management Act currently exempts agricultural practices, which inadequately protects essential Chinook habitat. Protecting this habitat requires modification of the Shorelines Management Act to eliminate the exemption for agricultural practices, or to develop alternative mechanisms that provide equivalent levels of protection.

Recommendation 25

Increase funding level for water quality improvement grants, and ensure that funding is targeted to actions that will demonstrably improve water quality.

Recommendations 26

Ensure that changes to State water quality standards reflect the actual as well as the potential use of Skagit Basin streams by anadromous fish, rather than the core and non-core areas that is currently being proposed.

Recommendation 27

The Clean Water Act (CWA) does not adequately provide for non-point source water quality protection. Adequate protection requires modification of the CWA or establishment of other mechanisms that provide for levels of protection equivalent to those required for point sources of pollution.

Recommendation 28

Ensure the adequacy of water quality violation investigations and follow up, and review the adequacy of BMPs as implemented.

7.5. STREAM CHANNEL COMPLEXITY

Stream channel complexity needs to be protected from further degradation. Much of the Skagit River below Sedro Woolley has been modified as a result of stream bank hardening and the construction of dikes and levees. Compared to historical conditions, the complexity of the mainstem Skagit River and many of its tributaries has been significantly compromised. On the Skagit delta the watercourses consist of a complex network of natural streams, dredged and straightened natural drainages and artificially constructed agriculture ditches. In order to prevent further damage to these streams, additional bank protection and dredging of salmon-bearing waters should be prohibited, unless it is possible to mitigate for such actions, resulting in no net impact to habitat.

Recommendation 29
Acquire floodplain parcels for conservation and/or restoration in priority areas, through willing sellers. Priority should be given to those areas subject to recurring flood damage, and those that require streambank hardening for protection of life or capital investments.

Mechanism: Based on priorities identified in the floodplain section of this document secure where possible those parcels that realize recurring flood damage. Recommend that the Federal Emergency Management Agency (FEMA) define current criteria for purchase of flood-prone land parcels. Land purchases by local entities might be based, in part, on alternative mitigation programs.

Recommendation 30
Prohibit new development within active floodplains.

Mechanism: Floodplain development that will require the use of bank hardening or other long-term maintenance or protection measures for capital investments pose a risk to human life and siphon public resources. Incentives to avoid floodplain development such as development right transfers should be encouraged.

Recommendation 31
Construction of any new capital facilities should be prohibited within the channel migration zones of the Skagit, Sauk, Suiattle, and Cascade Rivers.

Recommendation 32
Allow wood entrained on bridge pilings or abutments to stay within the river system.

Mechanism: County contractors, maintenance crews, USACE, and Washington Department of Transportation (WDOT) should be trained and empowered to float entrained wood downstream to maximize the functions of wood introduced into streams as a result of natural riparian and upslope processes. The incorporation of this wood along the bed and banks of streams at downstream locations could assist in the preservation of stream bank integrity.

Recommendation 33
Consistent with recent WDFW legislative recommendations, modify statutes governing the administration of the hydraulic code such that violations would be treated as civil penalties rather than criminal offenses.

Recommendation 34
The current system of depending upon the willingness of local prosecutors to prosecute hydraulics violations is inadequate, due to a higher-priority afforded to criminal workloads involving human safety. This results in few cases going to court. A special prosecutor's office should be established to be responsible for handling hydraulic code violations, or an equivalent mechanism should be developed to allow for adequate priority to ensure that hydraulic violations are prosecuted.

Recommendation 35

No new riprap, levees, or bank hardening should be permitted within the Skagit Basin, except where mitigation is adequately provided.

Mechanism: New construction within the high water mark should occur only after an analysis of site-specific and reach level impacts associated with new bank hardening projects is completed, and fully mitigated for with proven techniques. Physical processes that allow for the losses of existing side channels and floodplain functions should be prohibited. It is recommended that USACE initiate discussion of this issue by outlining the legal foundation and current implementation process regarding riprap, levees, and bank hardening. The relationship between USACE and WDFW regarding their separate regulatory authorities should also be discussed and reconciled as much as possible.

Recommendation 36

Exemptions for emergency actions on the part of USACE should be limited to a period immediately following the flood events. In instances where emergencies have been declared, a specific declaration determining the end of the emergency period should be declared as well. Any work to be conducted subsequent to this date should not be entitled to exemptions from USACE review processes.

Recommendation 37

The impacts of emergency dike and levee construction and maintenance should be fully mitigated per review of each project by appropriate federal, state, or local regulatory agencies.

Mechanism: For each project constructed or modified during emergency actions, a proportion of the costs of the project should be deposited into a fund to be used to mitigate for the effects of these activities. The recommendation is for 20% of the project costs to be deposited into the fund. The details of a funding mechanism will need to be developed.

Recommendation 38

The USACE or local diking districts should provide yearly analysis of dike and levee maintenance needs in order to ensure that only damage associated with floods will be exempt from normal CWA and ESA review and requirements.

Recommendation 39

Develop a Sauk River Flood Management Plan that identifies structures and properties at risk.

Mechanism: This plan should identify site-specific actions, such as property purchases, road relocations, habitat improvements, and bank protection such that habitat is protected. The intent of this plan is to provide certainty to landowners regarding what actions may be available to address property concerns, and which actions will not be allowed. This plan should provide for funding sources for implementation. All stakeholders, led by Snohomish and Skagit Counties, should contribute to the implementation of this recommendation.

Recommendation 40

Adequate funding for enforcement and a priority for enforcing habitat violations is necessary. The WDFW enforcement program should regard the application of the hydraulic code as among their highest priorities.

Recommendation 41
Adequate funding for technical assistance and permit processing is necessary to provide assistance in the development and design of hydraulic projects.

Recommendation 42
The co-managers will, pursuant to adequate funding, will develop mitigation techniques to assist landowners in the implementation of activities to provide for the protection of habitat and salmon productivity

Recommendation 43
Enhance the Hydraulic Project Approval (HPA) information-sharing process with Skagit Basin Tribes in order to increase the level of collaboration between the co-managers.

Recommendation 44
Develop long-term funding sources for the purchase of lands or easements in order to reduce the loss of channel complexity caused by human activities.

7.6. RIPARIAN AREAS AND WETLANDS

The riparian strategies of the Forests and Fish Agreement acknowledged that significant changes in riparian management were needed and laid out a series of recommendations. At the center of the recommendations is the concept that a "healthy" riparian forest is a mature forest stand of 140 years of age and that any management in the riparian zone must not inhibit or prevent the accomplishment of this condition. Key components of the riparian strategies include a 50-foot no-harvest core zone, a moderate-management inner zone ranging from an additional 30 to 84 feet in width, and finally an outer zone consisting of extensive management activity extending out to the "site potential tree height" for a total riparian width of between 90 and 200 feet, depending on site conditions. This agreement represents a major increase in the riparian zone protection for forest practices regulated by WDNR.

The new riparian rules should enable the riparian zones to sufficiently recover over time to conditions that approach pre-management levels. This will provide for needed bank stability, large wood recruitment, and a variety of other riparian functions. In cases where riparian degradation is especially severe, active riparian restoration may be required. Activities such as brush clearing, removal of hardwoods, and planting of desired species can help reverse the damage and reduce the length of time required to return to a fully functioning riparian system.

Recommendation 44
Adopt by regulation the stream buffer measures consistent with the BAS. Include a provision that site-specific alterations are possible, based on information that demonstrates a comparable level of resource protection can be attained.

Recommendation 45
City and county Critical Areas Ordinances (CAO), under the Growth Management Act (GMA) and local Shorelines Master Plans (SMP), are critical elements in protection of riparian areas and wetlands. The GMA requires that local jurisdictions protect wetlands and riparian areas by including BAS, and that they give special consideration to conservation or protection measures

necessary to preserve or enhance anadromous fisheries. Apply BAS relative to protection for fish provided by buffers contained in WDFW's Priority Habitats and Species document (WDFW 1997) (See Appendix G) or by other means that provide for equivalent levels of protection within CAO and SMP.

Recommendation 46
The CREP and NRCS Farm Plans can be useful programs for protecting habitat along critical Chinook salmon streams. CREP and riparian elements of Farm Plans need to apply BAS relative to protections for fish provided by WDFW Priority Habitats and Species document or by other means that provide for equivalent levels of protection.

Recommendation 47
Exemptions for small forest landowners from provisions of the Forests and Fish Agreement is not consistent with the original Forests and Fish Agreement. To be consistent, remove riparian exemptions for small forest landowners from the Habitat Conservation Plan (HCP) under consideration by NOAA Fisheries.

Mechanism: Provisions must be made to ensure that all forest landowners will not be allowed to impact riparian buffer functions and values.

7.7. ESTUARY AND NEARSHORE

7.7.1 Shoreline Modifications

The construction of bulkheads along marine shorelines has had a significant impact on the productivity of the nearshore environment. The loss of gravels necessary for beach enrichment has resulted in a loss of habitat to support the production of forage fish upon which juvenile and adult salmon are dependent. The loss of eelgrass resulting from dredging operations has had a similar effect. Recent research has shown pocket estuaries to be a vital component of habitat necessary to support juvenile Chinook on their seaward journey, and these have been adversely affected or lost due to land use changes.

Recommendation 48
Prohibit any new infrastructure (i.e., roads, drainage systems) proposing to limit access or reduce the productivity of existing pocket estuaries.

Recommendation 49
Prohibit the net expansion of bulkhead length, or increase in elevation, in nearshore areas. Bulkhead maintenance should not provide a mechanism to expand footprint, length or elevation.

Mechanism: Any new construction of bulkheads along the marine shoreline should be permitted only when mitigated for by the removal of other marine bulkheads, resulting in no net expansion of bulkhead length. Based on recent site-specific information, mitigation should be based on an analysis at the littoral cell level so that impacts can be mitigated for on-site and in-kind.

Recommendation 50
Limit the size of eelgrass impacts to less than 0.5 acre and mitigate impacts to eelgrass beds prior to construction.

7.7.2 Oil Spill Response

A catastrophic spill located within Puget Sound, or more specifically within the Whidbey Basin and Admiralty Inlet, can have devastating effects upon Skagit Chinook stocks, along with other stocks within the area. These effects can come from two major sources: impact-related spills that occur as a result of hull breaches or lack of containment during transport of hazardous materials, and spills that occur during off-loading of materials. Protection activities involve reduction in the likelihood of impact losses and increase in the effectiveness of spill response.

Recommendation 51
Require advance notification by tanker operators to WDOE and U.S. Coast Guard (USCG), and ensure implementation of effective booming during ship and barge fueling and oil transfers.

Recommendation 52
Fund, maintain and train a support network of citizen response groups throughout Puget Sound that are adequately trained and outfitted to provide emergency response to spills.

7.8. FISH PASSAGE AND ACCESS

There are numerous fish passage barriers throughout the Skagit River Basin that prevent access of Chinook to waters that were historically productive watercourses. In addition, impassable barriers for other salmonids exist on federal, state, county, and private roads throughout the watershed.

Performance measures for fish passage should be as follows:

Hydrology- The allowance for a range of flows and flow conditions appropriate to the watershed and location within the watershed where a stream or water body crossing structure is located. Flow conditions should be maintained upstream, downstream, and within the crossing structure.

Sediment Transport and Deposition- Provision for sediment generated upstream (and potentially downstream in tidal areas) to be transported and stored in a natural manner conducive to creating and maintaining natural habitat conditions in the watershed. These storage and transport conditions must be maintained above and below any structure.

Woody Debris Transport and Storage- Provision for the transport and storage of wood of the size appropriate for the watershed and location in question. Transport capacity required will be a function of stream power, stream size (bankfull width), and vegetation. Large Woody Debris transport may be critical in many tidal areas.

Alluvial Fan Processes- Processes active on alluvial fans include sediment and LWD recruitment, transport and storage; channel creation, maintenance, and avulsion and associated habitat functions. Crossing structures must not disrupt these processes and habitat conditions.

Floodplain Processes- Processes include hydrologic connections to, as well as the ability to create and maintain, off-channel and side channel habitats including channels, other open water habitats, and wetlands. Processes also include connections to the hyporheic zone, and connections to sources of large woody debris, other organic materials, and nutrients.

Habitat Connectivity- Providing the appropriate level of habitat connectivity at the crossing location, including hydrologic connections for wetland areas, connection of off-channel habitats with floodplain areas, and connects to sources of LWD and other organic inputs.

Tidal Influence- Provision for the full natural extent of tidal influence, including tidal inundation and natural salinity levels, as well as woody debris transport and sediment import and export to areas on the landward side of tidal channel-crossing structures.

Fish Passage- Provision for the passage of native fishes, particularly anadromous salmonids, at all life stages at appropriate times and flows in appropriate locations. Current WDFW requirements reasonably represent conditions for adult anadromous salmonids in terms of passage flows and maximum upstream habitat limits. However, passage criteria for Juvenile salmonids should continue to be incorporated and implemented.

Recommendation 53
The construction of any new fish passage structures should be required to meet the performance measures stated above.

Recommendation 54
Current federal regulatory requirements regarding fish passage and access should be enforced at all structures within the legal definition of USACE' jurisdiction.

Recommendation 55
Enforce the current State statute that requires fish passage at all obstructions including road crossings. For the purposes of this recovery plan only, the enforcement priority related to impassable culverts shall be within those tributaries that currently do or have the potential to support Chinook use.

Recommendation 56
Each governmental entity should identify each culvert on their lands or under their jurisdiction that have man-made barriers to Chinook salmon. Their barriers should be eliminated based on the performance measures stated above.

7.9. MONITORING

Since the protection element of this recovery plan is based on the assumption that full implementation will result in no additional loss of productivity, it is vital to determine the degree to which this element is being carried out. For the protection element of this recovery plan, monitoring should consist of quantitative measurements of the physical and chemical changes associated with land use practices. These changes will be evaluated within the larger monitoring program of this plan in order to assess the loss of productivity (if any) that can be attributed to the associated land use practices.

The following parameters should be incorporated into a long-term monitoring strategy. At this time, these are the general parameters that need to be evaluated. Site-specific monitoring protocols for each parameter will need to be established upon plan implementation. Each measurement must contain specific information regarding location of impacts, quantity of physical changes, and, if possible, the cause of the impact.

Instream Flows

- How many new water rights have been issued, what are the quantities of flow reduction associated with these rights, and what has the mitigation been? A quantitative investigation of the adequacy of the mitigation measures should be undertaken.
- Have exempt wells been permitted that effect instream flows where Chinook reside? If so, what is the quantity of water that has been withdrawn, and in which locations?
- Have there been any water rights relinquished, and if so, what is the quantity of water that has been made available for instream flows?
- What additional quantity of water has been withdrawn or diverted as a result of the use of inchoate water rights?
- Has there been an enforcement element associated with the illegal use of water, and if so, has additional water been made available to meet instream flow needs?
- Has a water bank been established, and has this resulted in water savings or additional water use?

Basin Hydrology

- What level of impervious surface exists in each Skagit tributary that supports Chinook, and have the levels remained below 7%?
- Have new flood control measures been instituted, and if so, have they resulted in habitat gains or losses? Have physical impacts been fully mitigated?
- Have there been changes in peak flows associated with land use practices?
- Have there been changes to water quality, sediment quality, and sediment transport?
- Has there been an increase or decrease in road-related sediment inputs, and have they occurred as a result of road building?
- Have water quality standards been met, and have measurements of water quality shown an increasing or decreasing trend?
- Upon what percentage of the landscape have BMPs been employed?

Stream Channel Complexity

- How many acres of new development have occurred in the floodplain?
- What areas and in what locations have new capital facilities and bank-hardening activities taken place?
- Has the amount of woody debris increased or decreased with the Skagit River and its Chinook-bearing tributaries?
- Has stream channel morphology changed as a result of land use practices?
- If mitigation has been employed as a result of the need for new bank-hardening structures, has the mitigation been demonstrated to adequately offset the impacts?
- Has unpermitted bank hardening and instream work been done, and has there been an enforcement effort that has resulted in mitigation of the impacts?

Riparian Areas and Wetlands

- Have shoreline activities that impact the recovery of riparian functions been eliminated? How many miles of riparian habitat have been established, and what is the condition of this habitat?
- How many additional acres of wetlands have been lost, and in what locations? What functional values have been lost?
- Have riparian areas been damaged as a result of timber harvest and road construction activities?

Estuary and Nearshore

- What has been the additional footprint associated with new bulkheads and infrastructure constructed along marine shorelines?
- What is the total acreage of eelgrass lost as a result of new development activities?

Fish Passage

- How many additional miles of fish-bearing streams have been blocked as a result of inadequate culvert and tide gate maintenance or construction?
- How much additional fish habitat has been degraded as a result of poorly designed culverts?

8. GENERAL APPROACH TO HABITAT RESTORATION

8.1. RESTORATION WITHIN THE CHINOOK LIFE CYCLE FRAMEWORK

Salmon productivity depends not on a single habitat or life stage but on all the habitats used by salmon throughout their life. Thus, recovery plans for any species or population must consider a broad range of habitats, from spawning grounds to the ocean. Research shows that Skagit Chinook salmon have multiple juvenile life history strategies. Further, the environment, shaped by both habitat conditions and salmon population size, experienced by an individual fish is largely responsible for determining its actual life history strategy. From this research we conclude that improvements to a variety of habitat types (freshwater rearing and incubation areas, tidal delta, and nearshore pocket estuaries) will benefit all known juvenile life history strategies of wild Skagit Chinook salmon.

Many of the projects within this plan have been developed or identified as part of past and ongoing restoration efforts on the part of numerous interested parties throughout the Skagit Watershed.

8.2. RESTORATION OF LIFE HISTORY AND HABITAT DIVERSITY

Wild Chinook salmon life history diversity and existing habitat conditions in the Skagit Basin and estuary necessitate restoration within many types of habitat to achieve the recovery goals stated in Chapter 4. Not all habitat areas (spawning and egg incubation, freshwater rearing, tidal delta rearing, and nearshore rearing) are similar in their intrinsic fish productivity or geomorphic size. There are areas within the river basin and estuary that are more strategic for Chinook salmon populations than other areas. The limiting factors for each of the Skagit Chinook salmon stocks, and the specific location of existing or potentially restorable habitat largely determine the relative importance of a specific habitat in our salmon recovery plan. For example, our research indicates that existing tidal delta habitat capacity is limiting all Skagit Chinook stocks (see Chapter 5 and Appendix D). Opportunities may exist to restore large areas of tidal delta habitat in Samish Bay, but our plan does not advocate restoration of tidal delta habitat in Samish Bay because Samish Bay is not strategically located for wild Skagit Chinook salmon during the limiting tidal delta rearing life stage. The migratory pathways from the Skagit River to Samish Bay simply do not exist that would allow many juvenile Skagit Chinook to take advantage of tidal delta rearing opportunity in Samish Bay. Our habitat restoration plan must consider the relative value of habitats across the landscape in terms of their strategic importance to wild Skagit Chinook.

8.3. GEOMORPHIC LIMITS TO RESTORATION

Geomorphologically, the Skagit system consists of the river and tributary systems, the lower river floodplain of the geomorphic delta (non-tidal delta—the portion of the geomorphic delta not currently influenced by tidal processes), the tidal delta (currently influenced by tidal hydraulics and mixing), and adjoining nearshore areas (Figure 8.1). These zones are divided based on topography and geomorphic process of formation. The extent of each of these zones and the mode and magnitude of geomorphic processes within these zones determines the natural habitat potential of the system. Restoration potential is ultimately limited by the natural potential of the system.

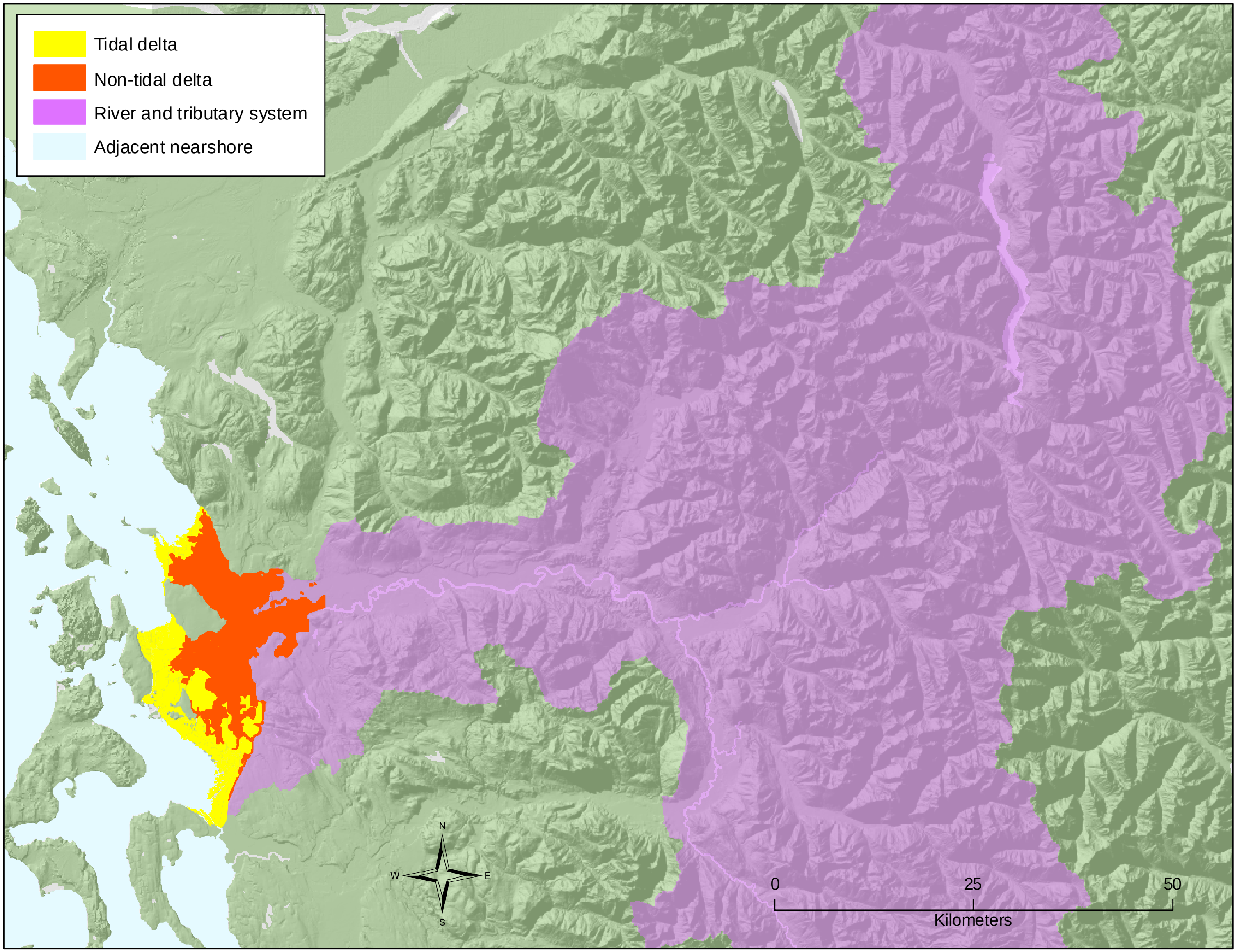


Figure 8.1. *Geomorphic regions of the Skagit Basin.*

The River System

The total area of large river floodplain is approximately 14,293 hectares. This is the area where mainstem and off-channel habitats are formed and maintained by natural riverine processes. Thirty-one percent (31%) the total floodplain area is either isolated or shadowed from natural riverine processes. These are areas where roads or dikes completely cutoff river interaction with its floodplain or roads and hardened stream banks shadow the floodplain from riverine processes. This inventory gives us an initial assessment of the area where process-based restoration could be applied to improve freshwater habitat conditions for Chinook salmon.

The Non-Tidal Delta

For the non-tidal part of the delta, historic wetland area was approximately 5,733 hectares. Current non-tidal delta wetland area is only 67 hectares. Similarly, lower floodplain forest area was approximately 12,297 hectares, while current floodplain forest area is only 314 hectares. Together, this is a net loss of 98% of non-tidal delta area, influenced by lower riverine processes, within which freshwater rearing and refuge habitat could form and persist.

The Tidal Delta

Under present day conditions, the contiguous habitat area of the Skagit delta that is exposed to tidal and river hydrology totals about 3,118 hectares. This represents the area where tidal channels and slough exist for delta rearing life history strategies. This area is mostly the delta area in the vicinity of Fir Island, but it also includes a fringe of estuarine habitat extending from La Conner to the north end of Camano Island. Historically, the contiguous habitat area of the Skagit delta included the same area, but also included the Swinomish Channel corridor and extended to the southern end of Padilla Bay (Collins 2000). The historic area equaled 11,483 hectares. This result in a seventy-three percent (73%) loss of tidal delta footprint.

The Nearshore

In contrast to freshwater and tidal delta rearing habitat opportunity, the intertidal and subtidal footprint of historic pocket estuary area was only 340.7 hectares. These are pocket estuaries in close proximity to the Skagit delta and are largely within Skagit Bay. Under present day conditions these same sites are only 47.5 hectares, resulting in an eighty-six percent (86%) loss. This represents the current pocket estuary rearing opportunity for fry migrant Chinook salmon.

Strictly considering limitations from natural processes and geomorphic controls, tidal delta and freshwater rearing habitat restoration potential may roughly be equal. That is, there are thousands of hectares where tidal delta or freshwater habitats could be restored if disturbances to natural processes were eliminated. However, this is not the case for pocket estuaries. There are only several hundred hectares of habitat that could be pocket estuary habitat.

8.4. HUMAN LIMITS TO HABITAT RESTORATION

We recognize that restoring Chinook salmon productivity within the Skagit Basin and its estuary is further complicated by human disturbances to the natural landscape of which only a portion can reasonably be removed through restoration. We have not quantified the area within the Skagit River Basin or its estuary that can be changed from existing human land uses that exclude Chinook salmon to natural habitat because this is not a scientific question. The answer to this question is a matter of policy and political will that can change as society values or de-values the natural habitats needed for Chinook salmon.

In this plan we have chosen to quantify the amount of habitat needed to achieve the recovery goals presented based on the biological factors known to influence wild Skagit Chinook salmon.

8.5. IDENTIFYING HABITAT RESTORATION OPPORTUNITIES

It is for these above reasons we advocate a diversified habitat restoration approach to recover wild Skagit Chinook salmon populations. We do this based on our understanding of the limits for each Chinook salmon stock and their corresponding life history strategies, but also to present a plan that is balanced across the landscape to not burden any specific land use or governmental jurisdiction. For example, it makes no ecological sense to attempt to achieve the recovery goals by restoration habitat for only one life history strategy – we would risk the entire population with a single catastrophic disturbance. Likewise, it makes no sense to burden one land use or jurisdiction with the majority of the restoration burden. This pathway would limit the ability of a biologically sound recovery plan to be implemented. Therefore, the restoration components of our plan include actions throughout the basin that restore:

1. Spawning habitat and egg incubation conditions
2. Freshwater rearing habitat in large river floodplains, tributaries, and non-tidal delta
3. Tidal delta rearing habitat
4. Nearshore rearing habitat (primarily pocket estuary restoration)

These recovery actions will together increase overall wild Chinook salmon population size and improve the population's resilience to a variety of natural and human caused disturbances. Therefore, this plan attempts to identify a balanced portfolio of actions, selected from areas of identified opportunity across the basin and estuary landscape. Restoration actions improving conditions for spawning and incubation will increase seeding for all juvenile Chinook life history strategies. Large river floodplain restoration seeks to improve freshwater conditions for all Chinook salmon fry, but more expressly for those life history strategies that depend on freshwater habitat for extended rearing such as parr migrants and yearlings. Delta restoration will benefit delta rearing life history strategies while pocket estuary restoration will benefit fry migrants.

Given the broad and diverse landscape, restoration efforts are typically confronted with the very real problem of assessing, identifying and prioritizing restoration opportunities in such a way that account for the realities of existing landscape uses, limited resources, and expanding pressures from human populations. The authors of this plan have attempted to address these realities while accounting for existing landscape processes and geomorphic limitations. While striving to select a balanced portfolio of actions that will address all known juvenile Skagit Chinook life history strategies across a variety of landscape settings. Potential restoration actions are described herein for four broad habitat types that are spatially diverse (both within its type and across types) so all Skagit Chinook populations will be more protected from disturbances that influence only specific habitat types or areas within the river basin and its estuary.

To accomplish our objectives we first evaluated habitat on the basis of its geomorphic site potential. Employing a variety of "screens" that evaluate the relative merits of specific habitats helps to achieve this. With each project described, we attempted to account for landscape processes at work in the Skagit Basin, and identify features that shape those processes. By providing for the geomorphic limitations within the landscape we hope to focus our restoration efforts toward those actions that have the highest probability of achieving recovery.

We have attempted to sequence projects based on 1) known technical feasibility, 2) land ownership, use and or landowner willingness, 3) logistic complexities, 4) synergistic effects and 5) spatial location and connectivity. Projects that are well developed in regard to these criteria have been sequenced for early implementation. Those less well developed are placed in out years. Sequencing is generally described on a twenty year planning horizon with five year increments for implementation.

Beginning with freshwater spawning habitat and moving in downstream order to nearshore rearing habitat, each of the following habitat restoration action sections of this plan (Chapters 9-12) will present a brief description of the tools employed in the evaluation. Specific details concerning these tools and methods can be found in the appendices. Each evaluation summary will be followed by specific habitat restoration actions. Together, implementation of these habitat actions along with the other actions listed in this plan (harvest management - Chapter 6, habitat protection -Chapter 7, and artificial production - Chapter 13) will achieve the recovery goals stated in Chapter 4.

9. RESTORATION ACTIONS IN SPAWNING HABITAT

Restoration actions directed at improving the quality and quantity of available spawning habitat are generally focused toward achieving one of the following objectives:

- Identifying spawning habitats that have been isolated or impaired via anthropogenic disturbance (e.g., road crossings) and restoring connectivity (both physical and biological) to these locations
- Identifying and addressing causal mechanisms for impairment to watershed processes (such as sediment transport or hydrology) that lead to degradation or loss of spawning habitats

9.1. GENERAL SPAWNING HABITAT RESTORATION STRATEGY

Identifying and prioritizing habitats that have been isolated from the spawning range of Skagit Chinook populations has been a priority restoration activity for many groups working in the basin. State agencies funded work in the late 1990s to survey and evaluate all known road crossings within the basin for partial and complete barriers to fish passage. This survey work was completed in the year 2000 and identified over 600 barriers to fish passage (SSC 2000). Analysis of these data indicates that nearly all of these barriers isolate little Chinook spawning habitat but do affect large areas of rearing habitats (SRSC, unpublished). This is likely due to Chinook spawning being concentrated in mainstem channels, and large stream systems and those known to have value for Chinook were often targeted early for restoration. However, in addition to affected rearing habitats, these surveys also identified several inadequate road crossings that limit or restrict the connectivity of physical processes that shape and supply spawning habitats frequented by Chinook. Subsequently, these locations have been targeted for restoration actions and will be described either in this or the rearing habitat section.

Our strategy for addressing the causal mechanisms of watershed impairment focuses on those mechanisms that affect two key processes: hydrology and sediment delivery. Degradation of these two processes are typically related to land use activities that either 1) alter the hydrograph such that the magnitude, timing and/or frequency of flows are significantly changed, or 2) alter the delivery and routing of water and/or sediment through hydromodifications that reduce the habitat quality by such things as increasing gradient, altering channel type, and directing scouring flows. Typical examples of such land uses are road building and development. In those watersheds that are still managed primarily for natural resource productivity (i.e., forestry or agriculture) we are focused on first protecting the landscape from further impairment, and subsequently addressing identified mechanisms of impairment. In forested landscapes these mechanisms are related to logging activities, particularly construction and maintenance of forest roads. In agricultural landscapes these mechanisms are typically related to tilling and drainage activities. In watersheds that have large areas of rural or residential development, impervious surface area from roads and buildings can alter hydrology.

In addition to restoration efforts targeted at forest road systems, special attention has been directed toward locations where alluvial fan geomorphic units have been interrupted by anthropogenic disturbances. We believe restoration projects in these locations could increase spawning capacity by an order of magnitude by converting areas of plane bed channel (caused by hydromodification or LWD removal) to forced pool riffle or pool riffle channel (Montgomery et al. 1999). These projects are also expected to increase egg to fry survival for Chinook salmon that spawn in the restored alluvial fan, because these areas are more hydraulically sheltered than unrestored fans that are dominated by hydromodified mainstem habitat (Montgomery et al. 1999; Hyatt 2003).

If theses strategies can be fully implemented on the landscape, we predict an overall increase in productivity from 341 to 435 migrant fry per Chinook spawner (if all watersheds shown in Figure 9.1 are converted from impaired to functioning). We base the estimated productivity increase on the premise that 100% of the watersheds can be treated given the necessary resources and given this strategy does not propose displacement of existing land uses.

9.2. IMPLEMENTATION

Presently, the spawning range of Chinook is limited in lowland watersheds by intrinsic habitat suitability. Therefore the focus for our priority restoration actions related to spawning habitats is largely on those causal mechanisms related to forested landscapes and the management of forest road networks in mountain basins. Forest roads are the primary concern for habitat restoration for several reasons: 1) roads occupy a relatively small area in a watershed, but can cause substantial increases in sediment supply and impacts to hydrology if poorly designed or maintained; 2) it is possible to greatly reduce sediment impacts and restore natural hydrology in a watershed by upgrading, maintaining, and decommissioning roads; 3) impacts related to timber harvest from other activities (e.g., logging on steep slopes) have been more recently addressed through regulatory controls rather than through active restoration efforts. Implementation of road-related sediment reduction and hydrology improvement projects rests with two primary vehicles: 1) the Road Maintenance and Abandonment Plan (RMAP) process established through the Forest and Fish Agreement, and 2) targeted actions on USFS lands.

The RMAP process, if implemented as directed by the Forest and Fish Agreement, should ultimately result in significant improvements to road systems on private industrial forestlands. However, there are significant road problems on federal lands that are not subject to that Agreement and the USFS does not have sufficient funding to address these problems, so active habitat restoration will be needed. Small landowner exemptions will also need to be addressed through regulatory actions

In work conducted while developing the Skagit watershed Council Strategy and Application, each WAU in the Skagit River Basin was rated as either "functioning" or "impaired" based on sediment supply. Functioning was applied to those WAUs where average sediment supply is <100 m^3 per km^2 per year, or where average sediment supply is >100 m^3 per km^2 per year, but is <1.5 times the natural rate. Where average sediment supply is >100 m^3 per km^2 per year and is >1.5 times the natural rate, the sediment supply process was rated as "impaired". The sediment supply map developed from this evaluation (Figure 9.1) shows the ratings for sediment supply averaged across WAUs. Areas shown in red are rated "impaired"; areas shown in green are rated functioning.

Using this analysis as our basis we applied an assumption that RMAP requirements detailed in the Forest and Fish Agreement would be implemented within the planning horizon used by this document. In those watersheds in which a majority of existing unpaved roads were covered by the RMAP requirements we reviewed the sediment supply call under this new "restored" condition. In a number of WAUs greater than 50% of the forestland holdings were exempt from the RMAP requirements by virtue of being in Federal Ownership, or small landowner exemptions. In these watersheds additional restoration actions would need to be taken to upgrade or decommission forest roads to meet our functioning sediment supply rating of <100m^3 per km^2 per year. Table 9.1 shows the results of our analysis, depicting those WAUs that were converted to functioning as a result of the RMAP requirements.

Projects involving road storm proofing, upgrades and decommissioning have been extensively implemented in several Skagit Basin watersheds. USFS roads have been targeted and funded in the Finney, Sauk Prairie, Dan Creek, Murphy, Goodman, and O'Brien watersheds, and much of the work has been completed. Additional projects on USFS lands have been identified in the Tenas Creek, Day and Lime Creek WAUs. These actions coupled with RMAP implementation should result in improvements to watershed sediment supplies and peak flows. Figure 9.2 summarizes the changes to sediment supply predicted and included as a part of this recovery plan.

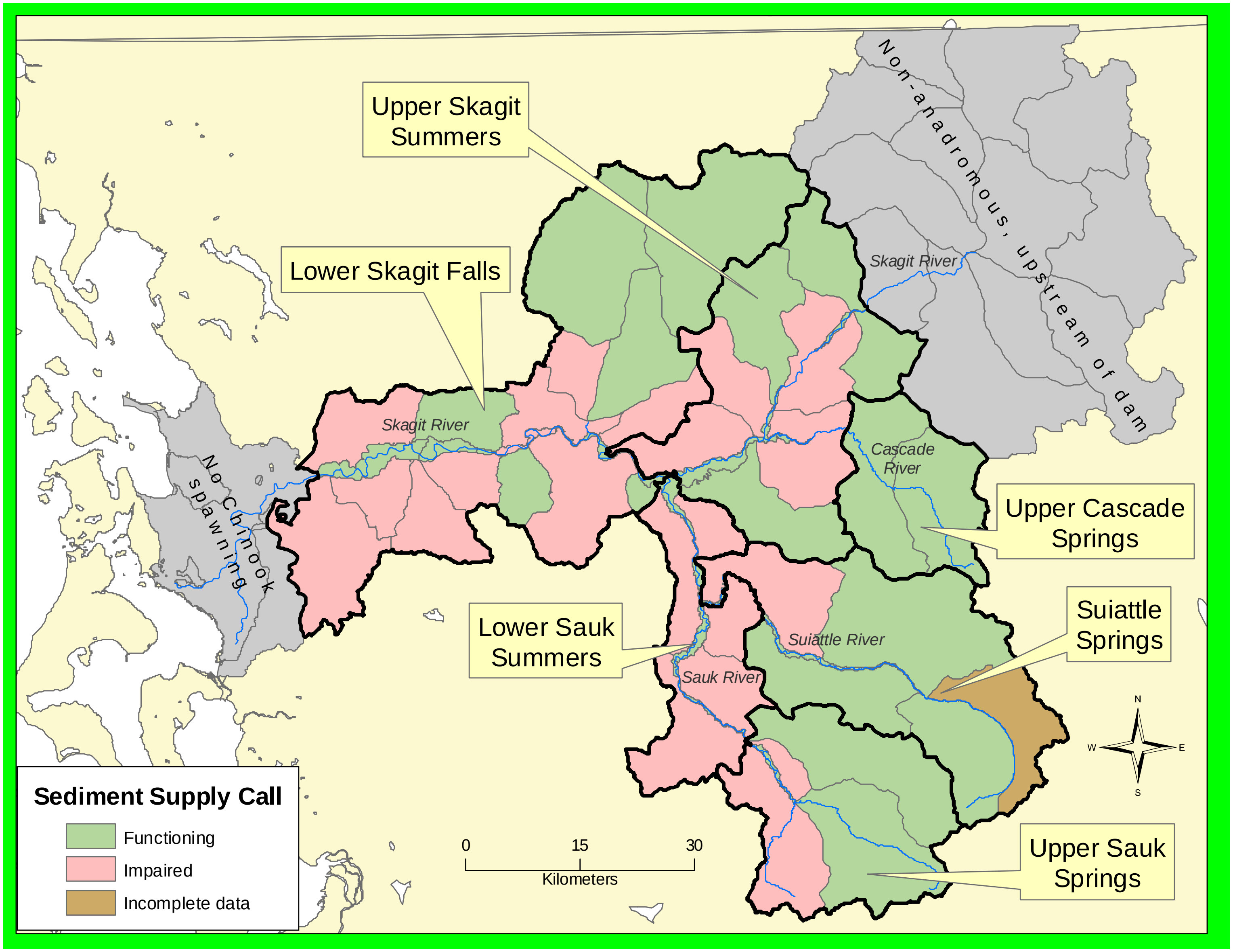


Figure 9.1. *Sediment supply call.* Sediment supply call by WAU shown as being impaired or functioning based on partial sediment budgets completed by Paulson, 1997.

Table 9.1. *Sediment supply call under restored conditions.* Percentage of unpaved roads likely to be improved through the RMAP provisions of the Forest & Fish Agreement.

WAU Name	Area Sq Miles	Unpaved Roads	Miles of Road/square mile	USFS Roads	Percent	RMAP Roads	Percent	Current Call	Change
ALDER	34.4	116.3	3.4		0.0%	98.0	84.2%	Functioning	
BACON CREEK	51.59	31.1	0.6	7.8	25.2%		0.0%	Functioning	
BUCK-DOWNEY-SULPHUR	110.83	16.3	0.1	4.6	28.3%		0.0%	Functioning	
CARPENTER	46.67	155.5	3.3		0.0%	24.5	15.8%	N/A	
CASCADE PASS	66.43	14.2	0.2	1.7	12.1%		0.0%	Functioning	
CASCADE, MIDDLE	71.44	30.8	0.4	7.6	24.8%		0.0%	Functioning	
CHOCOLATE GLACIER	62.84	0.6	0.0	0.1	22.1%		0.0%	Functioning	
CLEAR CREEK	48.45	65.2	1.3	14.8	22.7%	5.0	7.7%	Impaired	no
CORKINDALE	34.42	66.7	1.9	1.1	1.7%	20.0	30.0%	Impaired	no
DAMFINO CREEK	49.93	38.2	0.8	0.2	0.5%	0.9	2.5%	Impaired	no
DAN CREEK	32.01	104.5	3.3	28.2	27.0%	3.3	3.1%	Impaired	no
DAY CREEK	37.22	118.8	3.2	1.6	1.4%	108.8	91.5%	Impaired	yes
DIOBSUD CREEK	36.82	29.1	0.8	2.3	7.8%	0.5	1.9%	Impaired	no
FINNEY	53.8	204.3	3.8	24.9	12.2%	96.9	47.4%	Impaired	yes
FIR IS	45.12	30.7	0.7		0.0%		0.0%	N/A	
FRIDAY CREEK	34.28	147.9	4.3		0.0%	43.8	29.6%	N/A	
GILLIGAN	26.7	70.2	2.6		0.0%	54.9	78.2%	Impaired	yes
GRANDY	30.16	140.8	4.7		0.0%	101.0	71.7%	Impaired	yes
HANSEN CREEK	43.82	137.6	3.1		0.0%	104.1	75.7%	Impaired	yes
HILT	20.17	71.1	3.5	6.7	9.5%	33.5	47.1%	Impaired	no
ILLABOT	60.43	115.2	1.9	7.7	6.6%	33.1	28.8%	Functioning	
IMAGE LAKE	50.2	0.5	0.0	0.2	33.8%		0.0%	Functioning	
JACKMAN	26.26	79.7	3.0	4.5	5.6%	53.4	67.1%	Impaired	yes
JORDAN-BOULDER	51.49	139.2	2.7	1.3	0.9%	89.4	64.2%	Impaired	yes
LIME CREEK	58.69	62.3	1.1	18.4	29.5%	9.8	15.8%	Functioning	
LORETTA	23.3	64.0	2.7	5.3	8.3%	42.4	66.3%	Impaired	yes
MILLER CREEK	15.91	75.9	4.8		0.0%	47.7	62.8%	N/A	
MONTE CRISTO	72.7	56.4	0.8	13.2	23.4%		0.0%	Impaired	no
MT BAKER	105.07	118.8	1.1	35.8	30.1%	2.2	1.8%	Functioning	
NOOKACHAMPS	72.77	295.0	4.1		0.0%	137.8	46.7%	Impaired	no
PADILLA BAY	47.07	74.6	1.6		0.0%		0.0%	N/A	
PRESSENTIN	21.33	33.2	1.6	1.2	3.5%	29.9	89.9%	Functioning	
RINKER	34.09	144.2	4.2	3.9	2.7%	93.4	64.8%	Impaired	yes
SAMISH RIVER	125.87	224.9	1.8		0.0%	100.5	44.7%	N/A	
SAUK PRAIRIE	21.61	90.0	4.2	3.1	3.4%	62.8	69.8%	Impaired	yes
SHANNON, E	57.7	121.4	2.1	7.0	5.8%	78.7	64.8%	Functioning	
SHANNON, W	20.99	77.3	3.7	0.4	0.5%	68.3	88.4%	Impaired	yes
SKAGIT FLATS, LOWER	44.25	178.0	4.0		0.0%		0.0%	N/A	
SLOAN CREEK	81.31	23.4	0.3	5.7	24.3%		0.0%	N/A	
TENAS	57.06	109.7	1.9	13.5	12.3%	52.9	48.2%	Impaired	yes
THUNDER CREEK	125.53	4.0	0.0		0.0%		0.0%	Functioning	
WHITE CHUCK	85.54	47.7	0.6	12.4	26.0%		0.0%	Functioning	

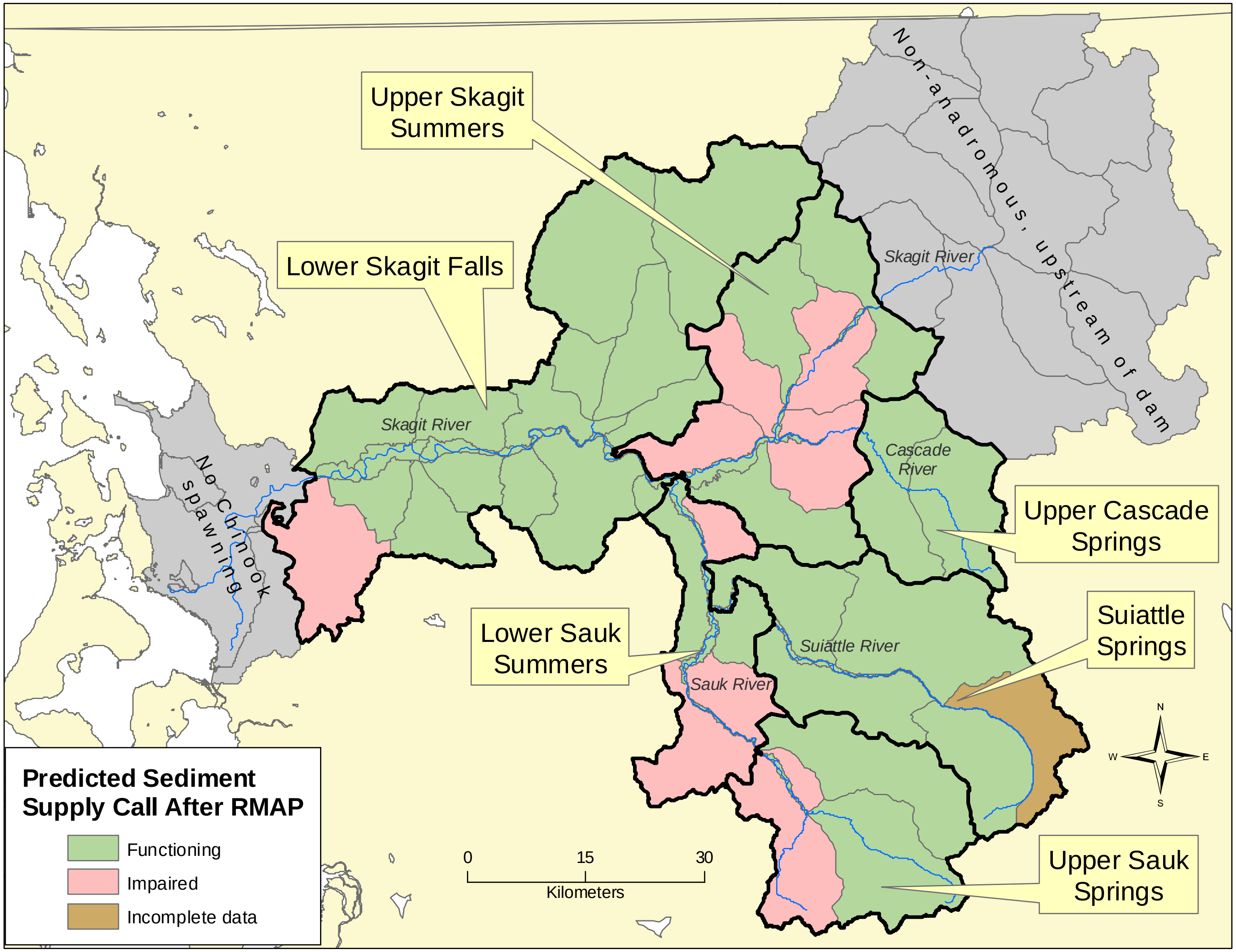


Figure 9.2. *Predicted sediment supply call after RMAP*. Sediment supply call under predicted conditions with RMAP implementation and selected projects on federal lands.

9.3. SPAWNING HABITAT PROJECTS

9.3.1 Sediment Reduction – Sauk Prairie and Dan Creek Watersheds

Project Summary

Poorly designed or maintained forest roads can reduce spawning and rearing habitat quality by increasing sediment delivered to streams through surface erosion and mass wasting processes. Approximately 50 miles of Forest Service roads were identified in the Sauk Prairie and Dan Creek watersheds in the Sauk River Basin that are poorly designed or maintained and have the potential to increase sediment to fish-bearing streams. This project will address sediment impacts by upgrading roads that are needed for access and by decommissioning roads that are no longer needed. Upgrading roads involves increasing the size and number of cross-drain culverts, increasing the size of stream crossings to convey high flows, sediment, and woody debris, dipping and armoring fill material over larger culverts, and reducing or removing fill material on unstable slopes located adjacent to or upslope from streams. Decommissioning roads involves removing culverts, removing fill material from drainage crossings and on unstable slopes located adjacent to or upslope from streams, and restoring natural drainage patterns by excavating drainage crossings in the road fill.

Purpose

The purpose of this project is to reduce or eliminate sediment impacts to streams related to forest roads in the Sauk Prairie and Dan Creek watersheds.

Populations Targeted

Lower Sauk summers

Estimated Cost

The Salmon Recovery Funding Board has already provided $350,000 to decommission and upgrade 25 miles of Forest Service roads in the Sauk Prairie and Dan Creek watersheds. Another $300,000 or more will be needed to complete all of the roadwork in these two watersheds.

Timeframe

With the existing grant, eight miles of road were treated in 2003 and an additional 17 miles will be treated in the summer of 2005. After this is completed additional grants will be needed for the remaining roadwork in these two watersheds. Some work will be completed by the Forest Service in the summer of 2005 in response to flood damage to the road network from the October 2003 flood.

Contingencies

The biggest contingency has to do with permitting and project administration with the Forest Service. The Forest Service has limited staff, so habitat restoration projects often take a long time to move forward. The October 2003 flood event greatly slowed progress on this project because Forest Service staff needed to spend time responding to emergency road damage. This caused some delays, but so far this project has continued to move forward.

Expected Direct Results

Physical: It is expected that improving road drainage conditions will reduce or eliminate sediment delivered to streams from forest roads, which is expected to reduce the amount of fine sediment in spawning gravel, increase pool depth and volume, and reduce channel width and bed instability in downstream areas.
Biological: It is expected that reducing bed instability and fine sediment in spawning gravels should improve the rate of survival-to-emergence for juvenile salmon and that increasing pool depth and volume will increase rearing capacity.

Effectiveness Monitoring

After roadwork is completed, the treated segments will be monitored to ensure that drainage treatments function as designed. Roads will also be monitored after major storm events to evaluate the effectiveness of the treatments in minimizing catastrophic failures.

Backup Actions (if direct results are not achieved)

None identified at this time

9.3.2 Suiattle Sediment Reduction

Project Summary

Poorly designed or maintained forest roads can reduce spawning and rearing habitat quality by increasing sediment delivered to streams through surface erosion and mass wasting processes. This is especially problematic for spawning conditions in the Suiattle River Basin, where the majority of Chinook spawning occurs in the lower reaches of a few larger tributary streams because the mainstem has such a very large fine sediment load as a result of extensive glaciers upstream.

The watersheds in the upper reaches of the Suiattle River Basin have low road densities and so are not likely at risk from road-related sediment impacts. The Circle, Straight, Tenas, and Big Creek watersheds in the lower reaches of the Suiattle River all support at least some Chinook spawning and have higher densities of forest roads. Roads in these watersheds need to be inventoried to evaluate potential impacts to fish habitat and the high hazard roads need to be upgraded or decommissioned. Upgrading roads involves increasing the size and number of cross-drain culverts, increasing the size of stream crossings to convey high flows, sediment, and woody debris, dipping and armoring fill material over larger culverts, and reducing or removing fill material on unstable slopes adjacent to or upslope from streams. Decommissioning roads involves removing culverts, removing fill material from drainage crossings and on unstable slopes adjacent to or upslope from streams, and restoring natural drainage patterns by excavating drainage crossings in the road fill.

Purpose

The purpose of this project is to first identify and then reduce or eliminate sediment impacts to streams related to forest roads in the lower reaches of the Suiattle River Basin.

Populations Targeted

Suiattle springs

Estimated Cost

The Bureau of Indian Affairs (BIA) has provided $60,000 to inventory Forest Service roads in the Circle, Straight, Tenas Creek and Big Creek watersheds and to evaluate the potential for sediment impacts to fish-bearing streams. Once roads with a high risk of sediment delivery are identified, then a budget can be developed and grant funds can be pursued to implement treatments on those roads. It is not known how much this will cost because the road inventory has not yet been completed, but it is expected somewhere between $500,000 and $1.5 million will be needed.

Timeframe

With the existing grant, a forest road inventory will be completed in the summer of 2005. Future grants will be needed to implement treatments on roads that have a high risk of sediment delivery. It is expected that this could be completed by 2010.

Contingencies

The biggest contingency has to do with permitting and project administration with the Forest Service. The Forest Service has limited staff, so habitat restoration projects often take a long time to move forward. Hopefully this project will move forward quickly once the road inventory work in the Suiattle River Basin and road treatment work in the Sauk River Basin are completed.

Expected Direct Results

Physical: It is expected that improving road drainage conditions will reduce or eliminate sediment delivered to streams from forest roads, which is expected to reduce the amount of fine sediment in spawning gravel, increase pool depth and volume, and reduce channel width and bed instability in downstream areas.
Biological: It is expected that reducing bed instability and fine sediment in spawning gravels should improve the rate of survival-to-emergence for juvenile salmon and that increasing pool depth and volume will increase rearing capacity.

Effectiveness Monitoring
After roadwork is completed, the treated segments will be monitored to ensure that drainage treatments function as designed. Roads will also be monitored after major storm events to evaluate the effectiveness of the treatments in minimizing catastrophic failures.

Backup Actions (if direct results are not achieved)
None identified at this time

10. RESTORATION ACTIONS IN FRESHWATER REARING HABITAT

The purpose of this chapter is to catalogue specific freshwater habitat restoration actions that will increase the production of Chinook salmon in the Skagit River Basin. There is recent evidence of limited freshwater habitat rearing capacity for Chinook salmon in the Skagit– fish sampling efforts show an upper limit on the number of parr migrants the river basin produces (~1,300,000 annually), while the rest of the ocean type component head downstream as delta rearing or fry migrants. This appears to be a density-dependent migration response. Therefore, increasing the availability of freshwater rearing habitat should increase the number of parr migrants. The assumption here is that floodplain habitat is critical to the success of parr migrant and stream type life histories because of the length of their residency in freshwater and the growth that occurs during that time. Parr migrants spend several months in freshwater and grow to an average size of 75 mm fork length before migrating seaward. Stream type Chinook salmon spend over one year in freshwater habitat before migrating seaward at an average size of 120 mm fork length.

Floodplain areas are especially important for freshwater rearing because the availability of complex mainstem edge habitat, backwaters, and off-channel habitat is essential for the foraging and refugia of all freshwater life history phases. These habitats can be degraded or eliminated by; 1) hydromodifications (such as dikes and riprap bank armoring structures) that reduce mainstem edge habitat complexity, and 2) hydromodifications or any other structures in the floodplain (such as roads, houses and fills) that limit lateral channel migration and the formation of backwaters and off-channel habitat. For this reason, restoring freshwater rearing habitat generally focuses on removing or upgrading hydromodifications on the main channel, planting riparian vegetation, restoring natural floodplain processes by removing or relocating floodplain modifications, and/or re-connecting historic floodplain channels.

In order to better understand the freshwater rearing habitat restoration opportunities for each Chinook stock, the Skagit River Basin was delineated into rearing ranges based on which stocks could occupy a given area of the system assuming downstream migration of juveniles only. Starting with six different stocks that have unique spawning ranges, the freshwater rearing areas were divided into eight unique rearing ranges. Figure 10.1 shows the mainstem channel and the geomorphic floodplain for each rearing range, which provides an overall footprint for where freshwater rearing habitat restoration could occur in the Skagit River Basin. This figure also shows where gaps were identified in floodplain habitat availability (methods described below and in Appendix C) and the locations of specific restoration projects that are identified in this chapter. Each rearing range was divided into smaller floodplain reaches for more detailed analysis. Table 10.1 shows floodplain characteristics, floodplain impairment, and mainstem edge, backwater, and off-channel habitat conditions for each floodplain reach and Chinook rearing range (methods described below and in Appendix C).

These results show that there is a total of 14,618 hectares of floodplain area in the Skagit River Basin, but that 31% of that area is disconnected from natural river processes. This information will be used in the sections that follow, which describe specific impacts to Chinook salmon from hydromodifications and floodplain impairments, present a general strategy for addressing these impacts to increase Chinook production, discuss a specific implementation plan, and include summaries of floodplain and habitat conditions and specific restoration projects for each rearing range.

Figure 10.1. *Index to rearing range maps.* Location map of figures showing floodplain areas grouped by the freshwater rearing ranges of Skagit Chinook salmon stocks throughout the Skagit River Basin. Also shows location of habitat restoration projects, and where gaps in habitat opportunity have been identified. Figure insets labeled A-E show the freshwater rearing range for all stocks. Figure insets labeled F and G shows the freshwater rearing range for Upper Skagit summers and Upper Cascade springs. Figure insets labeled H and I show the freshwater rearing range for Upper Skagit summers. Figure inset labeled J shows the freshwater rearing range for Upper Cascade springs. Figure insets labeled K and L shows the freshwater rearing range for all Sauk and Suiattle stocks. Figure insets labeled M and N shows the freshwater rearing range for Lower Sauk summers and Upper Sauk springs. Figure inset labeled O shows the freshwater rearing range for Upper Sauk springs. Figure insets labeled P and Q shows the freshwater rearing range for Suiattle springs.

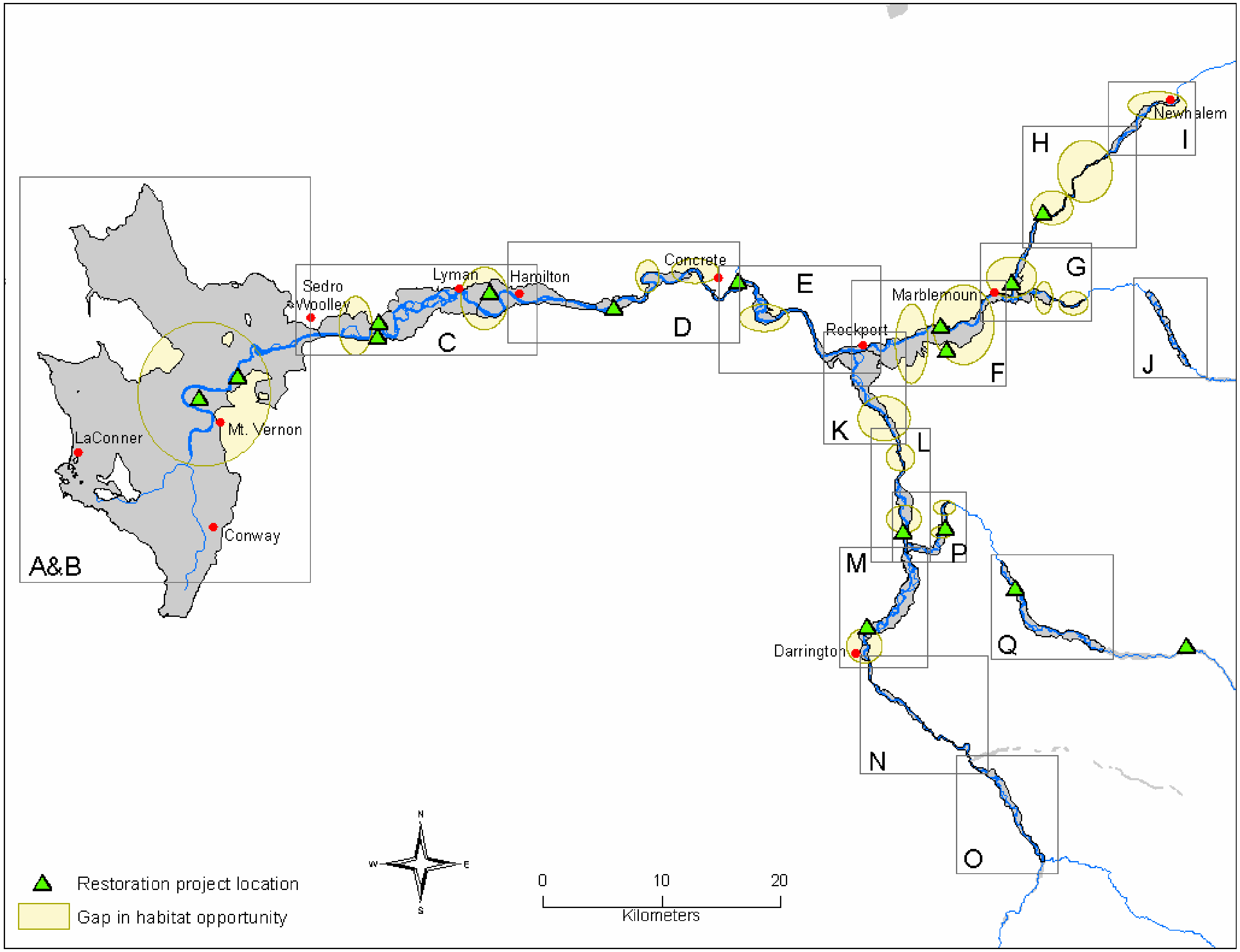


Table 10.1. *Summary of large river floodplain and habitat conditions for Skagit River Basin.*

Spawning Range	Rearing Range	Floodplain Reach	Total Flood-plain Area (ha)	FP Area Dis-connected From River Hydrology (ha)	% Impaired	Average FP Width (m)	Average Effective FP Width (m)	Mainstem Channel Length (m)	Mainstem Channel Area (ha)	Off-channel Habitat Length (m)	Off-channel Length/ Main-stem Length	Back-water Per-imeter (m)
	All Stocks	Non-tidal delta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lower Skagit fall		SK060A	3312.6	1152.7	35%	2,284	1,567	18,972	287.1	76,665	4.04	13,349
		SK060B	1275.2	862.5	68%	1,766	571	10,201	170.3	16,258	1.59	2,204
		SK070A	136.6	38.9	29%	547	391	2,546	43.5	627	0.25	292
		SK070B	341.3	85.5	25%	761	570	5,026	78.7	6,490	1.29	642
		SK080A	409.1	135.5	33%	916	613	7,686	103.2	3,467	0.45	1,076
		SK080B	332.3	47.7	14%	827	708	5,764	91.7	2,302	0.40	1,295
		SK080C	225.4	27.8	12%	302	265	7,843	103.4	2,038	0.26	379
		SK090	151.4	12.7	8%	301	276	5,133	72.0	598	0.12	1,760
U Skagit summer		SK100	267.6	27.4	10%	505	453	5,513	65.8	10,075	1.74	2,546
		Total	**6451.6**	**2390.7**	**37%**	**1,173**	**739**	**68,685**	**1,016**	**118,521**	**1.73**	**23,542**
Upper Skagit summer	Upper Skagit summer & upper Cascade spring	SK100A	1685.0	890.7	53%	1,537	724	12,230	121.9	33,724	2.76	5,152
		SK110	530.1	187.5	35%	482	311	11,692	96.3	4,089	0.32	2,238
		CA010	206.5	106.7	52%	664	321	3,740	11.5	4,611	1.23	1,287
		CA020	51.1	9.9	19%	164	132	3,234	10.3	1,397	0.43	0
		Total	**2472.7**	**1194.9**	**48%**	**877**	**453**	**30,896**	**240.1**	**43,822**	**1.42**	**8,678**
Upper Skagit summer	Upper Skagit summer	SK120A	53.0	1.5	3%	130	126	4,338	30.0	960	0.22	203
		SK120B	15.9	0.8	5%	62	59	2,547	11.5	0	0.00	0
		SK130A	35.5	1.2	3%	145	140	2,514	14.1	43	0.02	254
		SK130B	300.2	109.1	36%	490	312	6,892	46.0	9,558	1.39	1,867
		Total	**405**	**112**	**28%**	**266**	**192**	**16,292**	**102**	**10,561**	**0.65**	**2,325**
U Cascade spring	U Cascade spring	CA40A-40D	330.3	14.8	4%	453	433	10,114	NA	NA	NA	NA
		Total	**330.3**	**14.8**	**4%**	**453**	**433**	**10,114**	**NA**	**NA**	**NA**	**NA**

Spawning Range	Rearing Range	Floodplain Reach	Total Flood-plain Area (ha)	FP Area Dis-connected From River Hydrology (ha)	% Impaired	Average FP Width (m)	Average Effective FP Width (m)	Mainstem Channel Length (m)	Mainstem Channel Area (ha)	Off-channel Habitat Length (m)	Off-channel Length/ Main-stem Length	Back-water Per-imeter (m)
Lower Sauk summer	All Sauk and Suiattle	SA010	1055.7	364.2	34%	1,732	1,134	6,981	55.7	33,151	4.75	3,758
		SA020A	132.1	65.1	49%	398	202	3,470	27.3	1,155	0.33	200
		SA020B	51.3	1.9	4%	185	178	2,846	18.2	1,315	0.46	279
		SA030	353.4	1.0	0%	864	862	4,935	45.8	15,541	3.15	963
		SA040	64.1	12.6	20%	294	236	2,227	18.8	1,989	0.82	491
		Total	**1656.6**	**444.7**	**27%**	**897**	**657**	**20,459**	**166**	**53,150**	**2.60**	**5,691**
Lower Sauk summer	Lower Sauk summer and upper Sauk spring	SA050	918.2	154.9	17%	1,020	848	11,651	73.4	51,032	4.38	8,407
		SA060A	81.7	10.1	12%	545	477	1,854	9.8	851	0.46	664
		SA060B	333.3	22.9	7%	246	229	14,681	74.1	15,190	1.03	2,120
		SA060C	11.6	2.4	21%	108	86	1,149	4.2	116	0.10	2
		SA060D	47.1	30.9	66%	551	190	977	7.4	135	0.14	0
		Total	**1391.9**	**221.2**	**16%**	**536**	**451**	**30,312**	**169**	**67,324**	**2.22**	**11,192**
U Sauk spring	U Sauk spring	SA070	475.2	26.5	6%	471	444	12,873	43.9	25,368	1.97	2,979
		Total	**475.2**	**26.5**	**6%**	**471**	**444**	**12,873**	**44**	**25,368**	**1.97**	**2,979**
Suiattle spring	Suiattle spring	SU010	239.7	6.6	3%	559	543	5,615	26.2	17,084	3.04	2,599
		SU020A	101.2	10.8	11%	339	302	3,484	18.3	2,178	0.63	507
		SU030	744.4	65.5	9%	586	535	15,593	69.6	33,082	2.12	5,727
		SU040A	215.4	0.0	0%	386	386	6,312	NA	NA	NA	NA
		SU040B	36.7	0.0	0%	205	205	1,972	NA	NA	NA	NA
		SU040C	52.7	0.0	0%	180	180	3,317	NA	NA	NA	NA
		SU050	45.5	0.0	0%	116	116	4,297	NA	NA	NA	NA
		Total	**1435.6**	**83.0**	**6%**	**420**	**395**	**40,588**	**114**	**52,343**	**1.29**	**8,832**
Grand Total			***14,618***	***4,489***	***31%***	***752***	***521***	***230,219***	***1,850***	***371,089***	***1.69***	***63,239***

10.1. GENERAL FRESHWATER HABITAT RESTORATION STRATEGY

A study of hydromodifications in the Skagit (Beamer and Henderson 1998) showed that subyearling juvenile Chinook use natural banks at a density five times greater than riprap (hydromodified) banks. The salmon recovery inference from this study is that wherever riprap banks exist, they should be converted to natural banks (either through removal or mitigation measures like adding complex wood to riprap areas). The projects as recommended should increase capacity for parr migrant and stream type life history strategies. They should also improve habitat quality for fry of other life history strategies that are migrating seaward yet are still using these habitats on a more temporary basis.

Hayman et al. (1996) showed that backwaters were also preferred habitat by sub-yearling Chinook and was used in higher densities than other mainstem edge habitats. Hydromodifications and floodplain disturbances that reduce lateral channel migration (riprap, dikes, floodplain roads and fills) reduce the formation of backwaters and other complex natural habitats. Projects that remove or relocate these kinds of structures should increase parr migrant capacity.

Hayman et al. (1996) also showed that juvenile Chinook (probably parr migrants) were consistently found in the lower ends of off-channel habitat along the Skagit River. This phenomenon was not found in off-channel habitat along the Sauk and Suiattle Rivers. The data were opportunistically collected at coho smolt trapping sites run during the 1980s and early 1990s so caution should be used in drawing conclusions. The implication of the finding for Chinook recovery might be support for reconnecting off-channel habitat, especially along the Skagit River for the benefit of parr migrants.

For the purpose of this report, aerial photographs and Geographic Information Systems (GIS) were used to estimate the total area of floodplain reaches and the area of each floodplain reach that was isolated or shadowed by roads and hydromodifications (see Appendix C). Effective floodplain width was calculated for each floodplain reach, which is the average width of the floodplain that was *not* isolated or shadowed by roads and hydromodifications. The length of off-channel habitat, shoreline perimeter of backwater habitat, length of bank and bar habitat on mainstem edges, and total area of mainstem habitat were also measured for each floodplain reach. Off-channel habitat was classified as flowing in a connected, isolated or shadowed portion of the floodplain.

These data were used to compare total amount of habitat in floodplain reaches with differing characteristics and levels of impairment and to compare the amount of habitat found in connected versus isolated or shadowed floodplain areas. This analysis showed there was significantly more habitat in floodplain reaches that were connected with the river than in reaches that were isolated or shadowed by floodplain modifications. Multiple regression analysis showed that floodplain gradient and effective floodplain width were significant in determining how much habitat was available in each reach (see Appendix C). These results suggest that removing or relocating roads and hydromodifications in large river floodplains should increase the amount of rearing habitat available to Chinook salmon.

As a result of this research, the strategy for floodplain restoration emphasizes reconnecting isolated floodplain areas and restoring mainstem edge habitat and by removing, relocating, or improving hydromodifications and floodplain structures. Hydromodifications that are disconnecting or isolating a portion of the floodplain anywhere in the Skagit River Basin should be removed or relocated unless they are protecting permanent infrastructure that would be too expensive or difficult to relocate. Where hydromodifications are protecting permanent infrastructure or are located near the outside edge of the floodplain, they should be modified to improve mainstem edge habitat conditions with the use of woody debris, complex structures and riparian vegetation. Floodplain areas that currently have functioning floodplain conditions should be acquired or protected though regulatory actions to prevent future isolation or habitat degradation.

In the following sections we have described selected projects that will increase capacity for out migrating salmonids. For each of these projects benefits have been quantified in terms of parr migrants. However, all of these projects have other significant benefits for the survival of out migrating Chinook salmon that were not quantified. These benefits come primarily from two pathways; flood refuge and increased productivity.

<u>Flood refuge conceptual benefit</u>: The freshwater rearing projects that are along the main river corridor will restore a diversity of habitats that include low velocity areas like off channel and backwater habitats. These areas provide Chinook fry with a refuge opportunity during times of high river flow. Research has shown that high stream flow events can displace age 0+ salmonids downstream by reducing the availability of preferred or suitable slow water habitats and increasing competition for space (Seegrist and Gard 1972, Erman et al. 1988, Latterell et al. 1998) causing lower survival. We expect a significant flood refuge benefit from floodplain restoration projects yet we have not attempted quantification of this benefit in the current draft of this plan.

<u>Increased productivity benefit</u>: Floodplain restoration that focuses on reconnection of floodplains to fluvial processes will allow for less restricted movement and deposition of physical elements such as water, wood and sediment. Along with these physically elements, other biological processes are allowed to work within the new floodplain area not only allowing for the formation and maintenance of habitats that Chinook salmon directly live in but also an increased base level of productivity for those habitats. Some of the important smaller scale processes that increase productivity of aquatic habitats within restored floodplain areas include: increased primary production within increased vegetative footprint in the floodplain; increased detritus retention leading to increased secondary productivity; increase hyporheic flow and biotic processes occurring within the hyporheic zone that make nutrients more available to the aquatic system.

10.2. IMPLEMENTATION

A number of projects have already been developed to restore floodplain processes and mainstem edge habitat at various sites in the Skagit River Basin. For the most part, these projects target significant portions of isolated floodplain habitat that have either been recently acquired by conservation interests or have existing support from local political interests. These are described below in the sections for each rearing range.

10.2.1 General Restoration of Hardened Streambanks

In addition to specific projects that are already identified, a more general implementation strategy is to address every hydromodification in the Skagit River Basin due to the benefits from restoring natural mainstem edge habitat conditions for Chinook salmon. Table 10.2 includes information on edge habitat and hydromodification conditions. The location of each hydromodification is included on maps below in the sections for each rearing range. The best alternative for fish would be to restore natural bank conditions by removing these hydromodifications entirely because this would also restore off-channel habitat development. However, where hydromodifications are located near the outside edge of the geomorphic floodplain or are protecting important infrastructure that would be too costly to relocate, then they should be modified to improve mainstem edge habitat conditions with the use of woody debris, complex structures, and riparian vegetation.

Table 10.2**.** *Summary of edge habitat conditions and hydromodifications for each rearing range.*

Rearing Range	Floodplain Reach	Mainstem Channel Length (m)	Total Edge Habitat Length (m)	Hydro-modified Length (m)
All stocks	Non-tidal delta	22,779	57,390	48,796
	SK060A - SK100	68,685	195,606	30,308
Upper Skagit summer and upper Cascade spring	SK100A -SK110 and CA010 -CA020	30,896	76,061	7,884
Upper Skagit summer	SK120A -SK130B	16,292	39,244	3,460
Upper Cascade spring	CA40A - 40D	10,114	NA	48
All Sauk and Suiattle	SA010 - SA040	20,459	49,359	3,160
L Sauk summer & U Sauk spring	SA050 - SA060D	30,312	78,541	2,998
Upper Sauk spring	SA070	12,873	30,137	504
Suiattle spring	SU010 - SU030	24,692	63,068	1,118
	SU040A - SU050	15,898	NA	282
Totals		***230,219***	***589,407***	***98,559***

The net benefit is a gain of 135,000parr migrants per year if all hardened stream banks are removed or modified such that their restored capacity is equal to that of a natural stream bank.

10.2.2 Gaps in Rearing Habitat Opportunity

In order to identify high priority areas for restoration of off-channel habitat, it was assumed that reaches of the river that have gaps in the availability of backwaters or floodplain channels should be considered priority areas for restoration. The spatial distribution of habitat availability was determined by measuring the distance between each backwater and floodplain channel outlet and quantifying the amount of habitat available to fish from each outlet point (described in Appendix C). Gaps in habitat availability were defined as at least one kilometer of mainstem length that provides access to less than 1,000 meters of floodplain channel length or backwater perimeter. Areas with five kilometers or more of contiguous mainstem length with less than 1,000 m of habitat per kilometer of mainstem length are identified as the highest priority. A visual analysis of these gaps was completed to identify priority areas based on these criteria and the results are summarized in Table 10.3. Some of the gaps in habitat that were originally identified were eliminated and not included on this list because they were in areas where the floodplain was naturally relatively narrow and the habitat gap was likely to be a result of natural conditions. It is expected that this habitat gap analysis will help identify new floodplain reaches that are not already targeted for restoration, but it is not intended to exclude other reaches for restoration or protection if good projects are identified in those areas.

Table 10.3. *Priority river reaches identified in floodplain habitat based on gaps in backwater and off channel habitat opportunity.*

River/Rearing Range	Downstream River KM*	Upstream River KM	Possible Actions
Skagit River: all stocks	14.3	26.3	Cottonwood Is., Britt Sl., Nookachamps, Sterling Reach, River Bend, Salem LC
	26.3	28.6	Gilligan Floodplain, Skiyou
	41.6	48.2	Cockreham Island
	61.9	65.5	
	67.9	70.5	
	79.3	85.7	
Skagit River: upper Skagit summers and upper Cascade springs	96.6	98.9	
	100.3	106.6	Car Body Hole
	109.5	113.4	Marblemount Bridge
Skagit River: upper Skagit summers	116.8	120.4	Bacon Creek
	120.5	126.3	
	131.5	135.5	
Cascade River: upper Skagit summers	2.9	4.6	
	6.4	7.9	
Sauk River: All Sauk and Suiattle stocks	5.4	9.3	
	10.1	12.4	
	16.6	19.0	Government Bridge
Sauk River: L. Sauk summers and upper Sauk springs	31.7	35.2	Darrington and vicinity
Suiattle River: Suiattle springs	5.2	6.2	Dearinger Park
	7.9	9.3	

*Note: River KM on the Skagit River is measured upstream from the bifurcation of the North and South Forks located in the delta near Mount Vernon

The data collected on floodplain and habitat conditions has been summarized for each floodplain reach and Chinook rearing range in Table 10.1. These data can be used to prioritize areas for further investigation of floodplain restoration and protection projects. In addition, maps were generated to show the spatial distribution of floodplain conditions in terms of their connection with river hydrology (connected, isolated, or shadowed by roads or hydromodifications), length and location of mainstem, backwater, and off-channel habitat, the location of hydromodifications, and the specific reaches that were identified in the floodplain habitat gap analysis. These maps are provided for each Chinook rearing reach in the sections below to help guide restoration actions. Each section also includes specific restoration actions intended to restore floodplain habitat.

10.3. RESTORATION PROJECTS IN THE NON-TIDAL DELTA (ALL STOCKS)

10.3.1 Habitat Conditions

The non-tidal delta includes the Skagit River and floodplain between the tidal delta and Sedro-Woolley. Detailed channel mapping and measurements of floodplain characteristics were not completed for this section of the river, although available information suggests that the floodplain has been highly impaired and that essentially the entire section is a gap in habitat availability. For the non-tidal part of the delta, historic wetland area was 5,733 hectares while current wetland area is only 67 hectares (Figure 10.2). Similarly, floodplain forest area was 12,297 hectares while current floodplain forest area is 314 hectares. Together, this is a net loss of 98% of the area where lower river delta habitat could form and exist. There are not good estimates for all channels within each area. However, almost all floodplain channels have been isolated from the mainstem and essentially 100% of the mainstem is hydromodified under current conditions.

10.3.2 Restoration Strategy

Other regions can be used to infer something about potentially lost or severely depressed life history strategies due to complete or nearly complete loss of the habitats used by these life history strategies. For example, Burke and Jones (2001) showed that current juvenile Chinook salmon life history strategies differ dramatically from those documented in the early 1900s by Rich (1920). Juvenile Chinook salmon populations historically possessed more complex population structure and showed a broader temporal distribution in the estuary. However, the different cohorts that showed up in the estuary throughout the year show varying degree of estuarine and fluvial residence. It appears that historically there was a life history strategy to occupy essentially every habitat opportunity available in the river basin and its estuary. Of particular note is the fact that historically juvenile Chinook salmon used the lower Columbia River for overwintering. Taking this conclusion as a paradigm for the Skagit, we find historically that the Skagit River had extensive lower river non-tidal wetlands and floodplain channels. Now these extensive habitats are largely gone or are isolated from the mainstem river (Figure 10.2) creating a large gap in habitat opportunity between Sedro-Woolley and the tidal delta. Because freshwater rearing habitat diversity and area is so limited in the non-tidal delta of the Skagit, it is possible we have lost juvenile life history strategies that used this area. These life history strategies were probably some form of stream type or parr migrant. Ongoing research has already shown a significant number of the wild Chinook salmon fry move downstream from egg incubation areas as a response to increasing population size. Flood refuge opportunity for all juvenile life history types has also been lost in this part of the basin. If habitat can be restored in the non-tidal delta, fish will likely attempt to colonize it, thus providing opportunity for historic life history strategies again.

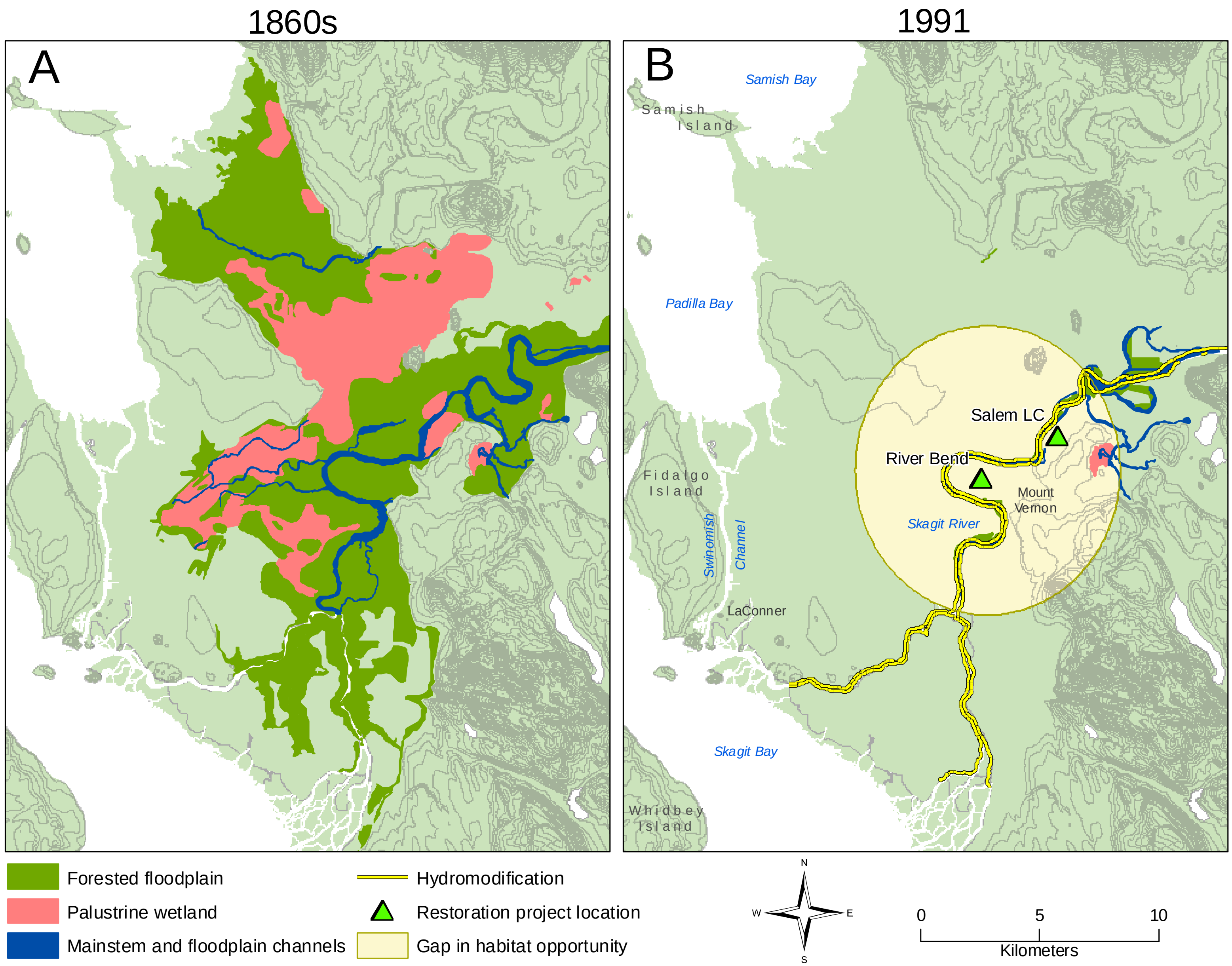


Figure 10.2. *Floodplain areas for the non-tidal delta portion of the Skagit River.* The map shows changes to floodplain and mainstem habitats. Historic conditions (A) were reconstructed by Collins (2000) and current conditions (B) were assessed using 1991 orthophotos by Beamer et al. (2000b).

10.3.3 Salem LC Floodplain

Project Summary
In addition to a hydromodified bank, the site has three anthropogenic features that limit this unit's site potential. A blocking floodgate, a dike located near the confluence with a small stream on site, and the fill associated with Francis Road. All of these anthropogenic features prevent connectivity throughout the unit. The relatively high floodplain levels suggest the site is somewhat limited in its potential to develop more off-channel complexity. However, the existing channel and its relationship with degraded wetlands suggest significant potential related to the development of a riverine wetland complex. This is supported by historic evidence that a riverine wetland was present at this location in 1889.

Populations Targeted
All

Estimated Cost
This site has been recently purchased by Wildlands Incorporated for development as a wetland mitigation bank. Unfortunately, there is no mechanism or incentive for wetland mitigation banks to develop restoration features that are targeted at fish species. Any restoration work commensurate with fisheries goals would necessarily be by design. In the case of Salem LC, Wildlands has no current plans to remove blockages to fish access. However, they will be developing on-site wetland values. If incentives can be provided, there is a high likelihood that fish access to the site could be reestablished.

Timeframe
This site has a high probability of implementation within a five-year timeframe. Restoration actions are already being evaluated through a mitigation bank design and permitting process. Incentives for fish related actions may take some time to develop.

Contingencies
Two properties located at the northern end of the site will restrict the development of the full site potential. If these properties can be included or have localized flooding issues addressed, then restoration can proceed relatively unfettered.

Expected Direct Results
Physical: As reported by the Big Bend Feasibility Study conducted for the City of Mount Vernon (Miller Consulting, 2004) the site has a proposed footprint of 118 hectares (291 ac). Presently it is largely unconstrained by levees. However a small dike does exist at the downstream end of the property that restricts the backwater flow from the Skagit River during flood events. The site is also artificially smaller than it would potentially be if not bisected by Francis Road. There is evidence of past high-water channels eroded from high water events. These subtle channels can be detected in aerial photographs and with ground surveys. However, the relief within these narrow bands is such that water does not appear to be concentrated for any significant length of time. The orientation of these channels suggests that they may represent relic side channels, or perhaps erosion that occurred during a specific major historic flood event, such as the 1921 flood. Most of the site is floodplain terrace, generally six meters above the Mean Water Line (MWL), with some undulations in elevation visible at ground level and on aerial photographs. The swale that supports the stream and associated wetlands appears to be at elevations between 4.5-6.0 meters. Figure 10.3 shows a DEM

contour map of the site. Approximately 18 hectares (45 ac) of the site is in lower elevations that should be conducive to riverine wetlands.
Biological: 17,198 parr migrants per year.

Effectiveness Monitoring
Will be developed as project is advanced

Backup Actions (if direct results are not achieved)
None identified at this time

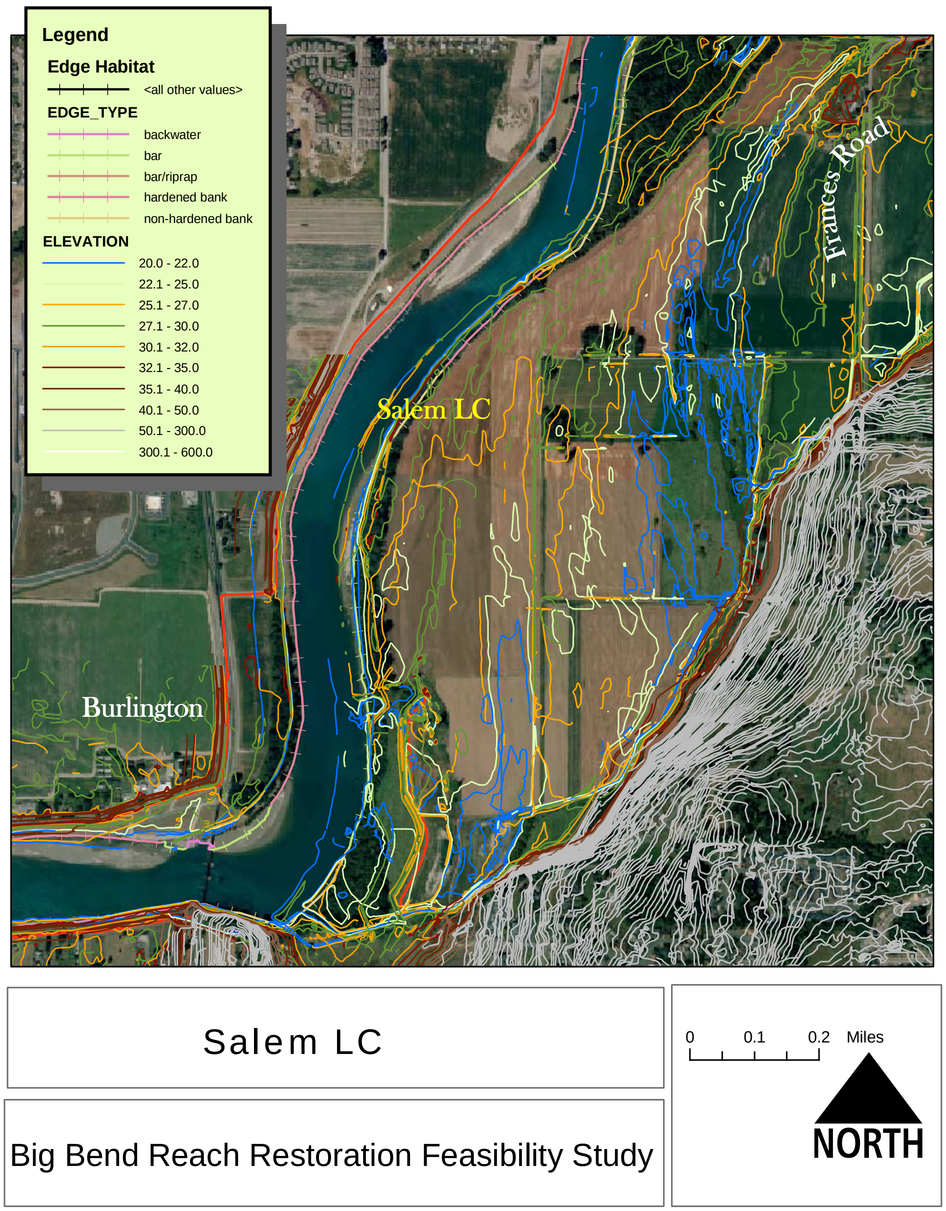


Figure 10.3. *Salem LC floodplain site.* Shows DEM topography as presented in the Big Bend Restoration Feasibility Study by Miller Consulting (2004).

10.3.4 River Bend

Project Summary
Conceptual restoration actions at this site focused on actions that would take advantage of the low topographic depressions, classic oxbow shape and position in the river continuum. River Bend is an area that is extremely prone to flooding and regionally recognized as a high hazard area during large-scale flood events. This high hazard exposure to river forces generally deters development in the area, and marginalizes agricultural productivity in low lying areas, thereby making this location uniquely situated to offer substantial opportunity for fish, wildlife, open space, or recreational uses.

Understanding the need for flood protection, the design considers engineered inlet and outlet structures that will allow passage of both fish and a designed range of flows into a large riverine wetland complex as shown in Figure 10.4. A cross-bend containment levee is also considered. This levee would provide protection to commercial development at the east end of the bend. One important design question is if low flow connections can be maintained in the summer months thereby allowing the site to provide suitable rearing habitat year around.

Populations Targeted
All

Estimated Cost
This project would take considerable resources to implement in terms of engineering, infrastructure relocation and property acquisitions. Costs are not being estimated given the long time horizon for implementation.

Timeframe
Long time horizon because of complexities. This project has numerous social and political hurdles, but does have promise in that it offers some social and community benefits in addition to its value for restoration. We have included this project as a prospect for the 15-20 year time horizon.

Contingencies
Flood protection for greater Mount Vernon would need to be addressed. Also protection of the Anacortes water supply is critical for project consideration. The project would essentially need to be integrated into Flood Management Plans in order to become reality. Large-scale agreement from municipalities and landowners is required.

Expected Direct Results
Physical: Conceptual designs estimate the recoverable habitat at approximately 97 hectares (240 ac). Because this habitat is just above the influence of tidal hydrology we would expect it to function as a floodplain riverine wetland.
Biological: 65,028 parr migrants per year.

Effectiveness Monitoring
Will be developed as project is advanced

Backup Actions (if direct results are not achieved)
None identified at this time

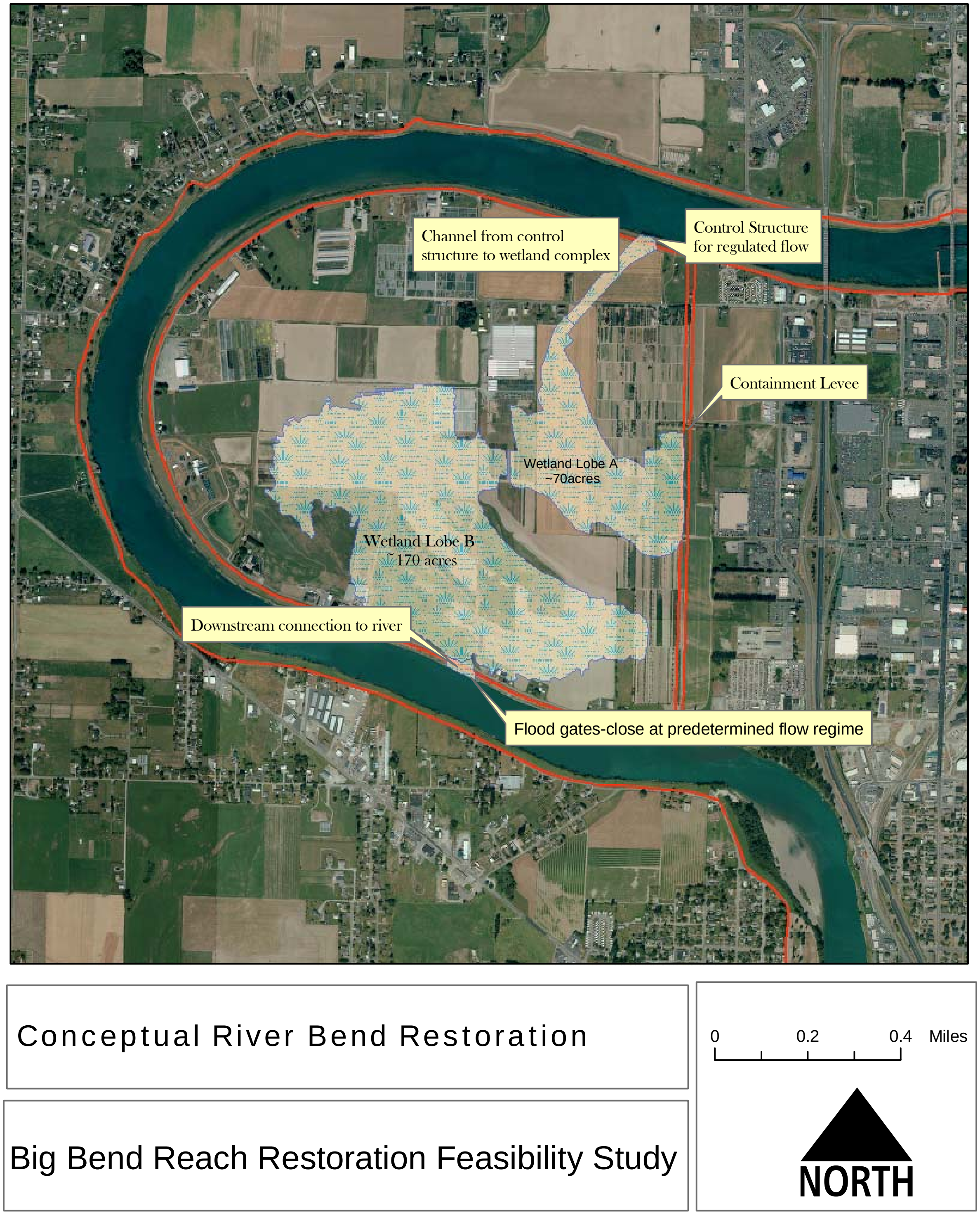


Figure 10.4. *River Bend.* Conceptual River Bend restoration design. Presented in the Big Bend Restoration Feasibility Study by Miller Consulting (2004).

10.3.5 Sterling Reach Restoration

Project Summary:
This project would reestablish hydraulic connections to the mainstem river throughout the historic oxbows in the vicinity of Sterling. These oxbows, now known as Debay's and Hart's sloughs would be reconnected such that mainstem flows could re-establish historic channel networks. Conceptually this would require partial removal of a training levee established by the Army Corps of Engineers south of Highway 9 and the excavation of historic channels in the present day floodplain.
Feasibility studies have reviewed potential site reconnections. In addition, land acquisition programs have purchased significant easements and title in the area for fish and wildlife values.

Populations Targeted
All

Estimated Cost
3-5 Million

Timeframe
10-15 years for the entire project. Portions could be phased in starting with Hart's slough restoration within five years. Limited connectivity within Debay's Slough could also be explored.

Contingencies
Competing modern day land uses include some agriculture, urban infrastructure and wildlife management areas. Debay's slough is publicly owned but currently managed as a Swan reserve. Efforts to re-establish flow within this relic oxbow would counter current management techniques that favor quiescent waters. Replacement lands would be required to meet wildlife objectives.

Impacts to flood management strategies would also need to be considered. Especially in the vicinity of Hart's Slough and its interface with urban infrastructure. The northern end of Harts slough meets Highway 20 at a location that historically fed the development of Gages Slough during flood events. Albeit atrophied, this intersection between Hart's Slough and Gages Slough is still a focal point of flood management efforts is large events. Restoration efforts could increase the likelihood of risk to infrastructure unless management of gages slough is considered as well.

Expected Direct Results
Physical: 370.5 hectares of habitat that should yield ~177,700 square meters of off channel area.
Biological: 16,311 parr migrants per year.

Effectiveness Monitoring
Will be developed as project is advanced

Backup Actions (if direct results are not achieved)
None identified at this time

10.3.6 Nookachamps Confluence

Project Summary:
This project would split mainstem flow by excavating a channel through the oxbow at the Nookachamps confluence

Populations Targeted
All

Estimated Cost
$2.5 Million

Timeframe
5 years if owner consent could be secured

Contingencies
Landowner agreement & potential impacts to county roadways. Floodplain area could be improved if county road was realigned.

Expected Direct Results
Physical: 57.5 hectares of habitat
Biological: 8,155 parr migrants per year.

Effectiveness Monitoring
Will be developed as project is advanced

Backup Actions (if direct results are not achieved)
None identified at this time

10.3.7 Britt Slough

Project Summary:

Located on site is the outlet of the relic Britt slough channel. Because this channel has been disconnected from the mainstem river near Eagle Nest bar it no longer functions as an ephemeral distributary. The channel now acts as the drainage system for the watershed area around the old channel. Therefore, this proposal seeks to re-establish what appears to be a historic riverine wetland near the southern portion of the site and examine to potential for a distributary connection to the mainstem using the remaining portion of the historic Britt slough channel.

Populations Targeted

All

Estimated Cost

$500,000

Timeframe

2-3 years if owner consent could be secured

Contingencies

Landowner agreement. Impacts to drainage system if distributary connection is pursued. Levee setback options should be considered.

Expected Direct Results

Physical: 56.8 hectares of floodplain habitat yielding approximately 9,280 square meters of habitat.
Biological: 7,155 parr migrants per year.

Effectiveness Monitoring

Will be developed as project is advanced

Backup Actions (if direct results are not achieved)

None identified at this time

10.3.8 Cottonwood Island

Project Summary:
This project proposes to set back a section of levee located near the WDFW boat ramp access at what is locally known as the "spud house". This project would increase the hydraulic connectivity to the historic Cottonwood channel located at the forks.

Populations Targeted
All

Estimated Cost
$2 million

Timeframe
5 year if owner consent could be secured

Contingencies
Landowner agreement. Relocation of public access point by WDFW. Potential hydraulic impacts to the upper end of Dry Slough.

Expected Direct Results
Physical: 169.8 hectares of floodplain habitat yielding approximately 45,720 square meters of habitat.
Biological: 10,148 parr migrants per year.

Effectiveness Monitoring
Will be developed as project is advanced

Backup Actions (if direct results are not achieved)
None identified at this time

10.4. RESTORATION PROJECTS FROM SEDRO-WOOLLEY TO ROCKPORT (ALL STOCKS)

10.4.1 Habitat Conditions

This rearing range has 6,451 hectares of floodplain with 37% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 68.7 km, and the off-channel habitat length is 118.5 km, which is approximately 1.73 km of off-channel habitat length per km of mainstem length. The average floodplain width in this rearing range is relatively high at 1,173 m, but the effective width is only 739 m due to extensive floodplain impairment.

Figure 10.5 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, along with the location of hydromodifications that may be impairing habitat conditions. Lastly, gaps in habitat availability are marked on the maps as likely areas to emphasize habitat restoration along with the location of specific projects described in this section. There are five gaps that were identified in this rearing range for a total of 21.5 km mainstem channel length.

10.4.2 Restoration Strategy

For the most part, this rearing range is characterized by a relatively wide floodplain and a high level of floodplain disturbance in the section between Sedro-Woolley and Hamilton and a much narrower floodplain but still a high level of floodplain disturbance upstream of Hamilton. Floodplain disturbances are associated with bridges, roads, towns and private property developments. For this reason, it is expected that significant gains can be made in off-channel habitat by removing hydromodifications and floodplain disturbances. The difficulty is that development and infrastructure is relatively high throughout this range, so projects of this nature may be expensive or complex to implement.

The strategy for this rearing range is to extend bridge crossings where they cross the floodplain, remove hydromodifications where they interfere with floodplain functions, and soften hydromodifications with the use of wood and complex structures where they are on the edge of the floodplain. In the lower section, downstream from Hamilton, there are a number of opportunities to provide function to large areas of floodplain with relatively low impact to infrastructure developments by removing hydromodifications. In the upper section, there are quite a few hydromodifications at the outer edge of the floodplain that could be softened without needing to be removed. There are also a number of roads that could be relocated outside or to the edge of the floodplain, although some of them are major highways so the expense may be high. Lastly, it is important to protect existing habitat by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

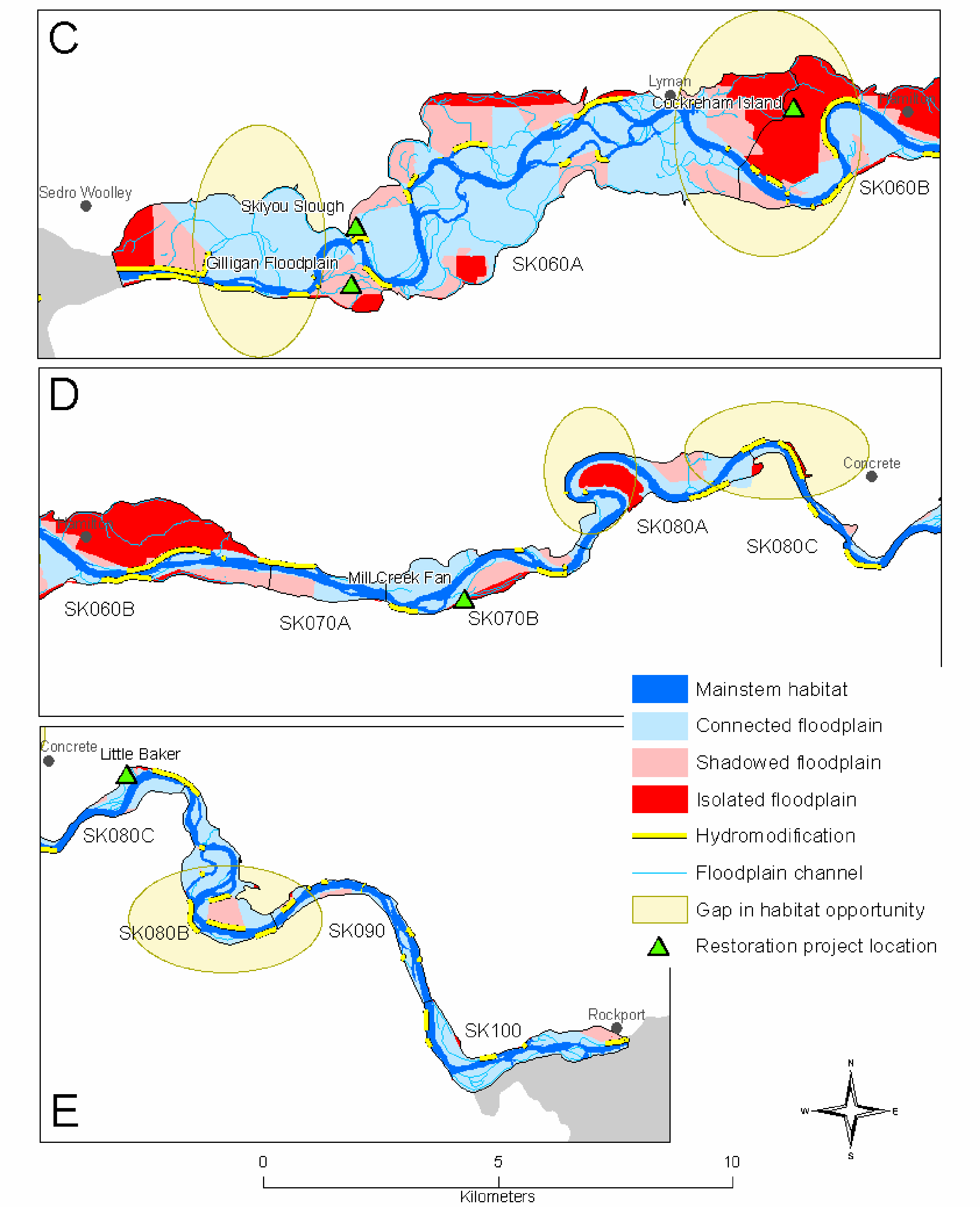


Figure 10.5. *Floodplain and habitat conditions for the Skagit River from Sedro-Woolley to Rockport.* (C) Sedro-Woolley to Hamilton, (D) Hamilton to Concrete, (E) Concrete to Rockport.

10.4.3 Gilligan Floodplain Restoration

Project Summary
Restore side channel and floodplain habitat in the Skagit River downstream from Gilligan Creek by removing 170 linear meters of a flood control dike and associated riprap bank protection, which will restore function to approximately 69 hectares (170 acres) of floodplain. Floodplain vegetation will be improved by removing non-native vegetation and planting native trees.

Populations Targeted
All

Estimated Cost
The cost will be approximately $375,000 and grants have already been secured for approximately half of that cost from the Fraser Panel Southern Fund.

Timeframe
If the project is funded, the planning and design work should take approximately one year, so implementation could occur as early as summer 2006.

Contingencies
Sufficient funding and institutional commitment to relocate infrastructure and acquire floodplain holdings.

Expected Direct Results
Physical: This project is expected to improve edge habitat conditions in the mainstem that have been degraded by rock armoring and to restore natural flows to a significant side channel that was blocked off by the construction of a flood control dike.
Biological: 5,688 parr migrants per year. It is expected that there will be some increase in fish use immediately after project completion as a result of improved edge habitat conditions in the mainstem. It is expected that significant use of side channel and floodplain habitats will take from a few months to a decade or more as these habitats are restored and developed through the process of erosion and channel migration.

Effectiveness Monitoring
Flow conditions and fish utilization will be monitored in the mainstem and the side channel after the dike is removed.

Backup Actions (if Direct Results not achieved)
Removing the dike is expected to restore natural floodplain processes, so there is not a specific flow or habitat target to achieve. However, if the side channel is not wetted as often as it could be due to poor project design, or if fish stranding is occurring, then some additional excavation may be undertaken to improve habitat conditions.

10.4.4 Skiyou Slough

Project Summary

Skiyou Island was recently acquired by the USFS as a part of the Wild and Scenic River Corridor. Over 243 hectares (600 ac) in size, the island was intensively farmed and managed for agricultural purposes. Surrounded by a relic slough channel the site has been the focus of considerable restoration activity aimed at re-establishing the riparian functions of the floodplain and channel corridor. However, little attention has been focused on removing hydraulic restrictions near the upstream inlet to the slough channel. Much of this armoring work has been a direct by product of the Gilligan Dike construction, which forced hydraulic forces toward established landowners at the slough inlet. If the levee at Gilligan can be removed, then hydraulic controls at the inlet of Skiyou should be considered for removal.

Populations Targeted

All.

Estimated Cost

A good candidate for Salmon Recovery Funding Board (SRFB) or NRCS funding. Could be possible to achieve results for less than $200,000

Timeframe

Would need to be sequenced after the Gilligan project. Assuming Gilligan can go forward within a near term time frame we could expect to submit this project for construction in 2008.

Contingencies

Landowner agreement might require additional acquisition. If active restoration cannot be implemented at the site, then natural forces will eventually provide the mechanism. However, this could be long term.

Expected Direct Results

Physical: This action would result in channel forming flows being able to help shape and maintain a more active and healthy rearing environment.
Biological: 8,549 parr migrants per year.

Effectiveness Monitoring

Will be developed as project is advanced

Backup Actions (if direct results are not achieved)

None identified at this time

10.4.5 Cockreham Island

Project Summary

Evaluate and implement habitat restoration for Etach Slough and Cockreham Island on the right bank of the Skagit River between just downstream from the town of Hamilton. Approximately 2,470 linear meters of bank armoring on the right bank limits connectivity between the river and floodplain on the north side. There are a number of houses in this area that are prone to flooding, and the large bank protection structures are routinely damaged or threatened by the river, so Skagit County is completing assessment work that may lead to relocating homes and infrastructure.

The floodplain between Lyman-Hamilton Highway and the river in this location is 540 hectares (1,334 ac) and there are over five kilometers of sloughs and channels that would benefit from increased connectivity with the river. Restoration actions could include removing or setting back bank protection structures, relocating homes, removing or relocating roads, and planting native vegetation in the floodplain. These may be expensive and difficult measures, but it makes sense to pursue ambitious restoration in this area because the habitat value is very high, flood risks and associated costs are high, and the overall density of houses and infrastructure is relatively low.

Populations Targeted

All

Estimated Cost

Exact costs have yet to be determined, but there may be funds available for buying property, relocating infrastructure, and restoring habitat from the Federal Emergency Management Agency (FEMA) due to past flood damage in this area. It is expected that full restoration of this floodplain reach would take 3-5 million dollars.

Timeframe

Currently Skagit County hired a consultant to complete assessment work to evaluate alternatives that might reduce the flooding risks in this area. At this point it is not clear what the specific alternatives will look like and how much habitat restoration will be considered. In any case, it will be several years before any kind of restoration work could be completed.

Contingencies

These will be worked out as part of the assessment, design, and permitting process.

Expected Direct Results

Physical: When implemented, this project is expected to restore connectivity between the Skagit River and its floodplain.
Biological: 10,702 parr migrants per year.

Effectiveness Monitoring

A monitoring plan needs to be developed once a specific restoration alternative has been selected and designed.

Backup Actions (if direct results are not achieved)

None identified at this time

10.4.6 Little Baker Channel

Project Summary

The purpose of this project is to increase freshwater rearing habitat by constructing a side channel on the right bank of the Baker River, connected to the Skagit River through the relic Little Baker channel. Approximately 600 meters of new channel will be constructed with an approximate width of six meters and 400 meters of existing channel will benefit from increased flow conditions. Preliminary investigations on this project have been completed by the Skagit Fisheries Enhancement Group and the U.S. Army Corps of Engineers. The project will likely receive water from a controlled surface connection with the Baker River or groundwater flow that will be enhanced with excavation work in the channel.

Populations Targeted

All

Estimated Cost

The cost will be approximately from $150,000 to $1,000,000 depending on the final design that is chosen. Funding will likely be available from the U.S. Army Corps of Engineers or through mitigation funds from Puget Sound Energy.

Timeframe

Planning and design work is still being completed and will likely take at least another year. After this is completed and funding is secured, the project could be completed in 2007 or 2008.

Contingencies

If the design work indicates that a constructed channel in the former Little Baker channel is not viable, then this project will not move forward.

Expected Direct Results

Physical: This project will not restore natural processes but will result in a discrete constructed channel that will provide rearing habitat for Chinook salmon.

Biological: 233 parr migrants per year. This is very low is fish spawn from within the habitat. It is expected that there will be an increase in fish use immediately after project completion as a result of new habitat being available.

Effectiveness Monitoring

Flow conditions and fish utilization will be monitored in the side channel after it is constructed.

Backup Actions (if Direct Results not achieved)

If flow conditions or fish use in the channel do not occur as expected, then further work will be conducted to evaluate how the project could be altered to improve flow conditions.

10.5. RESTORATION PROJECTS IN THE REARING RANGE OF UPPER SKAGIT SUMMERS AND UPPER CASCADE SPRINGS

10.5.1 Habitat Conditions

This rearing range has 2,473 hectares of floodplain with 48% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 30.9 km, and the off-channel habitat length is 43.8 km, which is approximately 1.42 km of off-channel habitat length per km of mainstem length. The average floodplain width in this rearing range is relatively high at 877 m, but the effective width is only 453 m due to extensive floodplain impairment.

Figure 10.6 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, along with the location of hydromodifications that may be impairing habitat conditions. Lastly, gaps in habitat availability are marked on the maps as likely areas to emphasize habitat restoration along with the location of specific projects described in this section. There are five gaps that were identified in this rearing range for a total of 15.7 km mainstem channel length

10.5.2 Restoration Strategy

This rearing range is characterized in the lower section by a relatively wide floodplain and a high level of floodplain disturbance, while in the upper section the floodplain is significantly narrower, but still has a high level of disturbance from hydromodifications and floodplain impacts, mostly associated with bridges, roads, and private property developments. For this reason, it is expected that significant gains can be made in off-channel habitat by removing hydromodifications and floodplain disturbances. The difficulty is that development and infrastructure is relatively high throughout this range, so projects of this nature may be expensive or complex to implement.

The overall length of off-channel habitat per mainstem channel length is moderately high, but this is mostly a result of substantial amounts of habitat in the very wide floodplain area at the lower end of the rearing range (Barnaby and Lucas Slough complexes and also near the mouth of Illabot Creek). However, the remainder of the range has a much lower quantity of off-channel habitat because of a large number of hydromodifications and floodplain impairments or possibly because of flow regulation from several major dams upstream which has reduced off-channel habitat formation. For these reasons, there were a number of gaps identified in this range despite the large quantity of habitat at the downstream end.

The strategy for this rearing range is to extend bridge crossings where they cross the floodplain, remove hydromodifications where they interfere with floodplain functions, and soften hydromodifications with the use of wood and complex structures where they are on the edge of the floodplain. There are also a number of roads that could be relocated outside or to the edge of the floodplain, although some of them are major highways so the expense may be high. Lastly, it is important to protect existing habitat by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

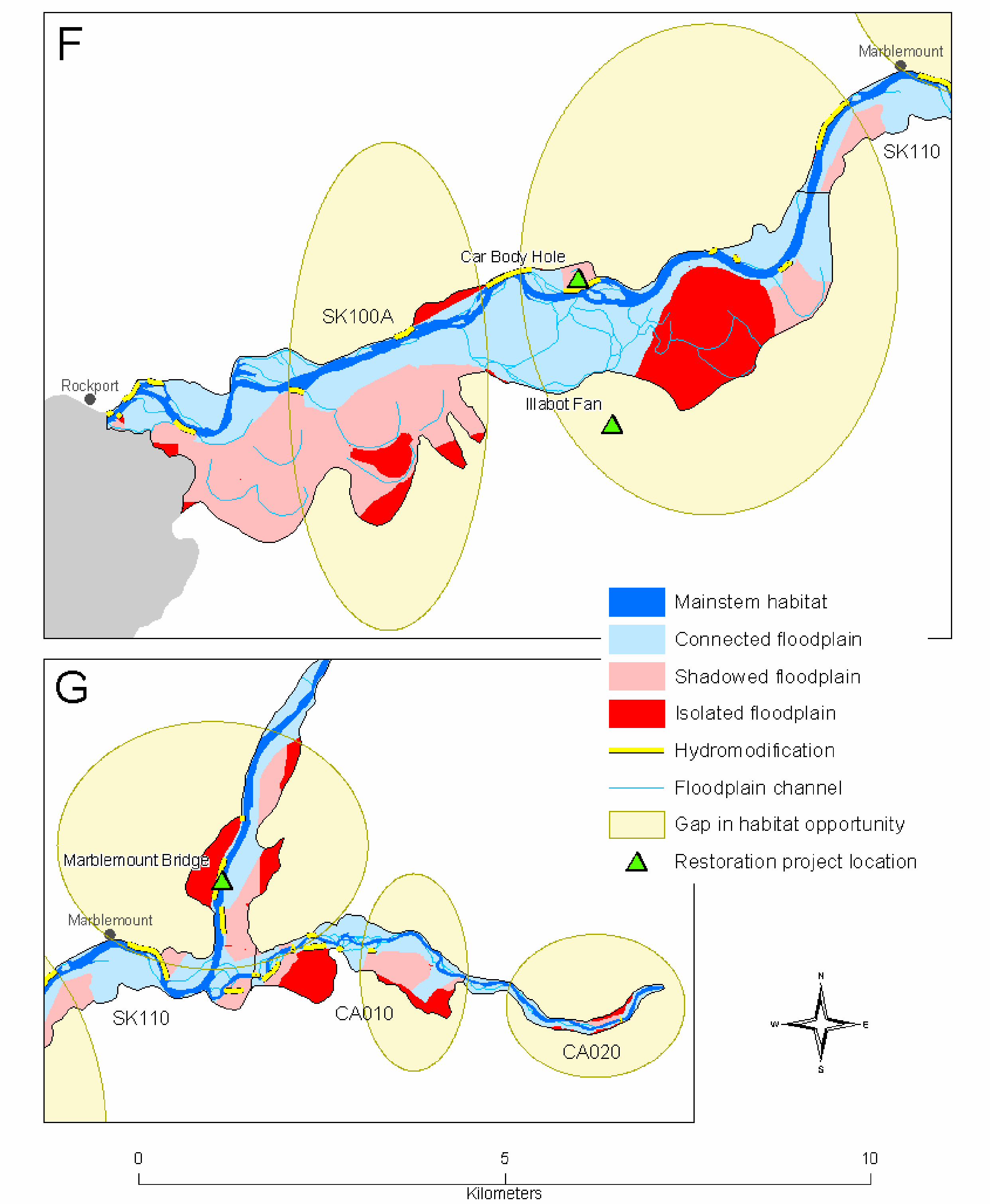


Figure 10.6. *Floodplain and habitat conditions for the upper Skagit River from Rockport to Diobsud Creek and the lower Cascade River*. (F) Rockport to Marblemount, (G) Marblemount to Diobsud Creek and the lower Cascade River.

10.5.3 Illabot Creek

Project Summary

Illabot Creek is a highly productive tributary that enters the left bank of the Skagit River shortly upstream from Rockport. The associated alluvial fan and floodplain area totals over 520 hectares (1300 acres). Over 400 meters of Illabot Creek have been straightened and armored with riprap to protect a bridge crossing and powerline corridor. As a result, a historic secondary channel was abandoned and current primary channel is steeper, shorter, and disconnected from the surrounding floodplain. Riprap bank armoring and channel straightening have decreased channel complexity and changed the channel type from a forced pool-riffle reach to a plane-bed reach, decreasing the available habitat. Adjacent riparian vegetation has also been removed, eliminating potential shade and a source of large woody debris.

A feasibility study to be completed by the end of 2005 will examine the effect of human modifications to the alluvial fan and floodplain of Illabot Creek. This study will identify multiple alternatives that will restore channel complexity to the compromised reach and select one based on potential costs and benefit to habitat. Restoration alternatives include: 1) relocating the road and bridge to the historic crossing further upstream on Illabot Creek and removing all riprap bank armoring in the floodplain reach, 2) constructing an additional bridge span at its present location to accommodate an historic secondary channel and removing most of the riprap upstream and downstream of the bridge, or 3) removing some of the excess riprap (270 m in length) downstream of the current bridge crossing.

Populations Targeted

Upper Skagit summers

Estimated Cost

Estimated project cost depends upon the chosen restoration alternative and will be finalized in the feasibility study. Alternative 1), replacing the road and bridge to its historic location will cost approximately $3.5 million. Alternative 2), adding an additional bridge span to the current crossing would cost between $500,000 and $1,000,000. Alternative 3), leaving the bridge in place and removing the excess riprap downstream (270 m in length), would cost $30,000 to $50,000. In all cases, the powerline structure must be protected for a cost of $40,000.

Timeframe

The Illabot Creek Feasibility Study will be completed by the end of 2005. At that time a preferred restoration alternative will be selected and project funding will be pursued. It will likely take several years to secure funding and implement a project.

Contingencies

Currently it seems very likely that it will be possible to implement at least one of the alternatives, however there is not a specific contingency plan. If it is not possible to remove riprap bank armoring, then the site will remain in its currently degraded state.

Expected Direct Results

Physical: Removing riprap and channel constrictions on Illabot Creek will increase channel edge complexity, decrease channel gradient and possibly convert it to a forced pool-riffle channel type,

and allow the development of new secondary channels. The amount of habitat restored will depend upon the chosen restoration alternative. Alternatives 1 and 2 will allow the most habitat to be restored, as all 440 m length of riprap will be removed and channel complexity and migration will be restored to the entire modified reach. An analysis of historical photos shows that the modified reach in Illabot Creek had *over three times* the channel area before it was channelized compared to current conditions. Alternative 3 will only restore channel complexity to approximately 270 m of channel and may only allow some additional secondary channels to develop.
Biological: 8,232 parr migrants per year.

Effectiveness Monitoring
A monitoring plan will be developed as part of the feasibility study.

Backup Actions (if direct results are not achieved)
None identified at this time

10.5.4 Car Body Hole

Project Summary
This project would be to remove approximately 550 linear meters of riprap bank armoring (and associated car bodies) at Car Body Hole, which is located on the right bank of the Skagit River across from Illabot Creek. This section of the Skagit River was identified in the floodplain analysis as having a gap in off-channel habitat and there are a number of historic channels on this parcel that would likely become wetted if the bank armoring were removed. Riparian and floodplain vegetation has been cleared on most of the parcel, so this project would also restore native vegetation to the site. The purpose of this project is to restore natural channel migration and the development of off-channel habitat and also to restore native vegetation on approximately 20 hectares (50 ac) in the floodplain of the Skagit River.

Populations Targeted
All

Estimated Cost
If the parcel is purchased in order to complete habitat restoration, then the cost of acquisition would be market value at time of purchase; removal of riprap is $200,000, and riparian and floodplain planting $75,000.

Timeframe
The landowner Ezra Buller has been approached a number of times by different agencies seeking to do habitat restoration on this parcel. He has expressed some interest in this idea, but a successful agreement has never been reached. Most recently, Mr. Buller has indicated that the agencies should work with his heirs to negotiate future restoration efforts. Since it is unknown when this parcel will change owners and whether future negotiations will be successful, there is no specific time frame for this project.

Contingencies
Currently there is no contingency plan. If it is not possible to remove riprap bank armoring or restore native vegetation, then the site will remain in its currently degraded state.

Expected Direct Results

Physical: In the main channel, habitat complexity would be increased and the process of lateral channel migration would be restored. It is expected that new off-channel habitat will be formed over time as the Skagit River migrates across its floodplain. Native vegetation will improve riparian and floodplain conditions by providing edge complexity and a source for future large woody debris.
Biological: 1,996 parr migrants per year.

Effectiveness Monitoring
Monitoring design will be developed in conjunction with feasibility and baseline analysis.

Backup Actions (if Direct Results not achieved)
This project would restore natural processes, so there is little risk that it will not succeed. However, we could choose to move to more active restoration actions if passive approach is under performing.

10.5.5 Marblemount Bridge

Project Summary

The habitat gap analysis indicated that there is very little natural off-channel or backwater habitat in the two kilometer reach of the Skagit River just upstream from the bridge in Marblemount, and that almost 81 hectares (200 ac) of the floodplain is isolated or shadowed by roads and riprap bank protection. No specific project has been identified for this area, but the analysis indicates that re-connecting channels or floodplain in this area to the river should be a high priority. This could be accomplished through acquisitions, setting back dikes, and relocating roads.

Populations Targeted

All

Estimated Cost

There is no cost estimate at this time.

Timeframe

Further field investigation is needed to identify projects and evaluate the feasibility of projects in this reach.

Contingencies

Currently there is no contingency plan. If no projects are possible, then this reach will remain in its currently degraded state.

Expected Direct Results

Physical: In the main channel, habitat complexity would be increased and the process of lateral channel migration would be restored. It is expected that new off-channel habitat will be formed over time as the Skagit River migrates across its floodplain.
Biological: 9,182 parr migrants per year.

Effectiveness Monitoring

Monitoring design will be developed in conjunction with feasibility and baseline analysis.

Backup Actions (if Direct Results not achieved)

There is not a specific project at this time, so no backup actions are indicated.

10.6. RESTORATION PROJECTS IN THE REARING RANGE FOR THE UPPER SKAGIT SUMMER STOCK ONLY

10.6.1 Habitat Conditions

This rearing range has 405 hectares of floodplain with 28% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 16.3 km, and the off-channel habitat length is 10.6 km, which is approximately 0.65 km of off-channel habitat length per km of mainstem length. The average floodplain width in this rearing range is relatively narrow at 266 m, and the effective width is only 192 m due to moderate floodplain impairment.

Figure 10.7 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, along with the location of hydromodifications that may be impairing habitat conditions. Lastly, gaps in habitat availability are marked on the maps as likely areas to emphasize habitat restoration along with the location of specific projects described in this section. There are five gaps that were identified in this rearing range for a total of 15.7 km mainstem channel length

10.6.2 Restoration Strategy

This rearing range is characterized by a relatively narrow floodplain and a moderately high level of disturbance. The length of off-channel habitat in this rearing range is the lowest of any of the rearing ranges, likely due to a relatively narrow floodplain, moderate floodplain impairment and possibly because flow regulation from several major dams upstream has reduced off-channel habitat formation.

Due to the narrow floodplain, there is limited opportunity to form off-channel habitat, so it is especially important in this reach to restore floodplain function where there are opportunities to do so. Restoring the alluvial fan at Bacon Creek and removing hydromodifications and floodplain impairments at the upstream end of the rearing range near Newhalem provide some of the only opportunities to accomplish this, so should be high priorities. For the remainder of the range, it is important to soften existing hydromodification with the use of wood and complex structures to benefit mainstem edge complexity. Lastly, it is important to protect existing habitat by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

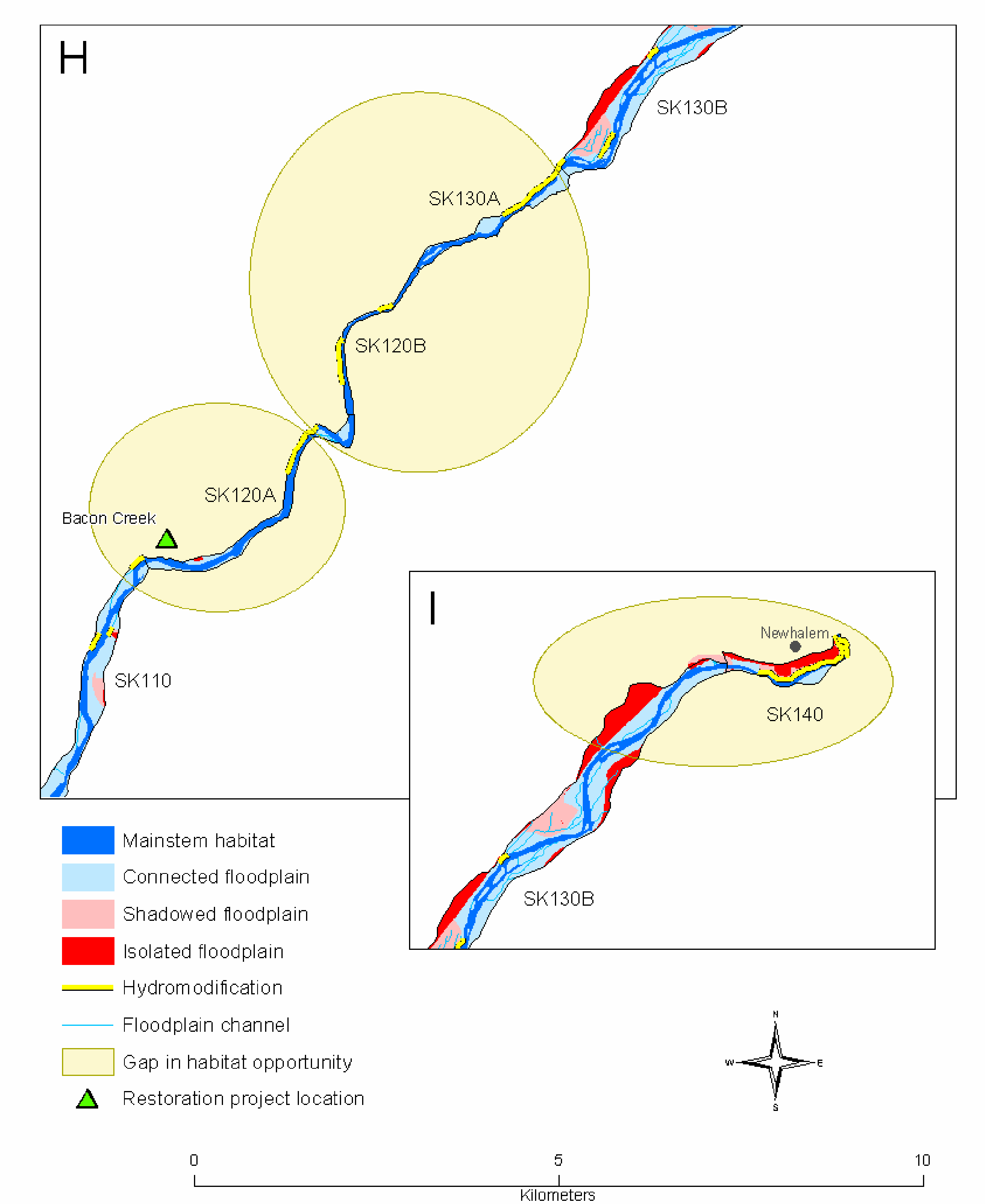


Figure 10.7. *Floodplain and habitat conditions for the Skagit River from Diobsud Creek to Newhalem.* (H) Diobsud Creek to Skagit/Whatcom county line, (I) Skagit/Whatcom county line to Newhalem.

10.6.3 Bacon Creek

Project Summary

The SR 20 road fill spans the alluvial fan and floodplain along the lower mile of Bacon Creek, which is a large tributary on the right bank of the Skagit River. The road fill crosses a small but productive groundwater tributary (Cub Creek) with a culvert that creates a barrier to juvenile fish during higher flows. In addition, the road fill reduces channel complexity in the main Bacon Creek channel and limits the development of off-channel habitat by constraining lateral channel migration. Constructing a full-spanning bridge at the Cub Creek crossing would restore fish passage and provide substantially more opportunity for channel migration and habitat development. A project was recently completed shortly upstream of SR 20 to restore lateral channel migration by relocating approximately one mile of a Forest Service road outside of the floodplain and alluvial fan of Bacon Creek, so improving the SR 20 road crossing would add value to this existing project by removing the largest remaining impact in this area. The purpose of this project is to restore complete fish passage to Cub Creek and restore the development of off-channel habitat on 11 hectares (27 ac) in the floodplain and alluvial fan of Bacon Creek.

Populations Targeted

All

Estimated Cost

Installing an additional bridge crossing structure at Bacon Creek would cost approximately one million dollars according to estimates from the Washington State Department of Transportation. This project may also require that a Seattle City Light utility tower located between SR 20 and the Skagit River be protected from erosion from Bacon Creek.

Timeframe

WSDOT has agreed to do this project if funding can be secured for the bridge, but there is currently no funding source. Once funding is secured, a project could be completed within two years.

Contingencies

Currently there is no contingency plan. If a new bridge is not constructed at the site, then the site will remain in its currently degraded state.

Expected Direct Results

Physical: In the main channel, habitat complexity would be increased and the process of lateral channel migration would be restored. It is expected that new off-channel habitat will be formed over time as Bacon Creek migrates across its floodplain and alluvial fan. Fish passage would be restored to Cub Creek.
Biological: 9,182 parr migrants per year

Effectiveness Monitoring:

Monitoring design will be developed in conjunction with feasibility and baseline analysis.

Backup Actions

Move from passive to active strategies. Identify additional bank armoring for removal

10.7. RESTORATION PROJECTS IN THE REARING RANGE OF UPPER CASCADE SPRINGS ONLY

10.7.1 Habitat Conditions

This rearing range has 330 hectares of floodplain with 4% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 10.1 km, but the off-channel habitat length or other habitat parameters were not available. The average floodplain width in this rearing range is moderately wide at 453 m, and the effective width is 433 m with only minimal floodplain impairments.

Figure 10.8 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, although the habitat inventory was not completed for this rearing reach. The location of hydromodifications that may be impairing habitat conditions is also shown. The habitat gap analysis was not completed for this rearing range due to insufficient data.

10.7.2 Restoration Strategy

A moderately wide floodplain and a minimal level of floodplain disturbance characterize this rearing range. Habitat data were not available, but field observations indicate that this rearing range has a large quantity of off-channel habitat.

The only habitat restoration project that would benefit this rearing range would be to remove or extend the bridge crossing for Forest Road 1570 to span the entire floodplain. This would increase mainstem edge complexity and restore processes that create of off-channel habitat. It is also especially important in this rearing range to protect existing habitat by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

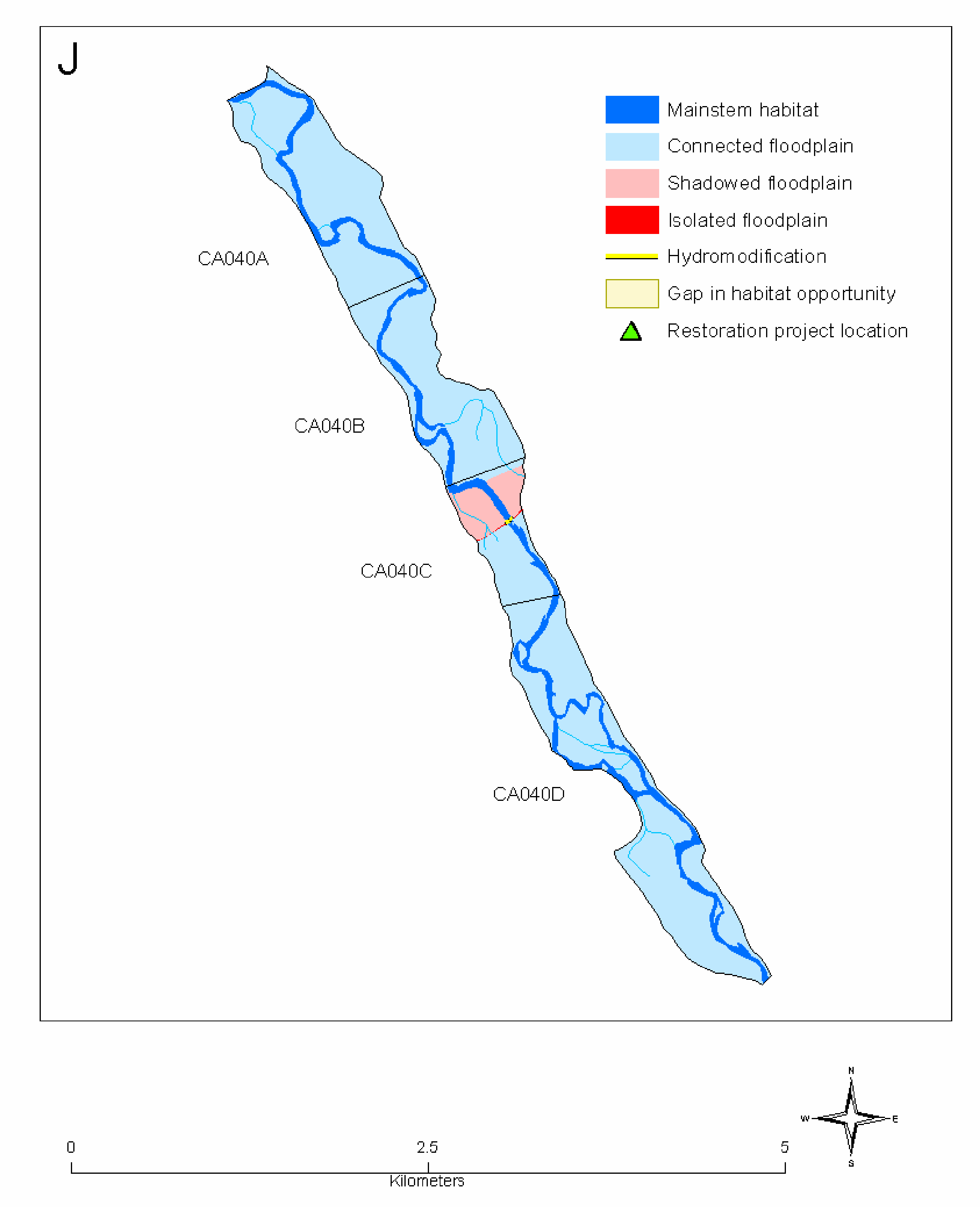


Figure 10.8. *Floodplain and habitat conditions for the upper Cascade River from Marble Creek to Kindy Creek.* (J) Marble Creek to Kindy Creek.

10.8. RESTORATION PROJECTS IN THE REARING RANGE OF ALL SAUK AND SUIATTLE STOCKS

10.8.1 Habitat Conditions

This rearing range has 1,657 hectares of floodplain with 27% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 20.5 km, and the off-channel habitat length is 53.2 km, which is approximately 2.6 km of off-channel habitat length per km of mainstem length. The average floodplain width in this rearing range is relatively wide at 897 m, and the effective width is only 657 m due to moderate floodplain impairment.

Figure 10.9 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, along with the location of hydromodifications that may be impairing habitat conditions. Lastly, gaps in habitat availability are marked on the maps as likely areas to emphasize habitat restoration along with the location of specific projects described in this section. There are three gaps that were identified in this rearing range for a total of 8.6 km mainstem channel length.

10.8.2 Restoration Strategy

This rearing range is characterized by alternating sections of wide and narrow floodplains and has a moderately high level of floodplain disturbance. As a whole, this rearing range has the largest length of off-channel habitat per mainstem length of any of the rearing ranges, primarily because of the very wide floodplain and large amount of habitat near the mouth of the river.

However, there are a number of hydromodifications and floodplain impacts, mostly associated with bridges, roads, and also some private property developments. The strategy for this rearing range is to extend bridge crossings where they cross the floodplain, remove hydromodifications where they interfere with floodplain functions, and soften hydromodifications with the use of wood and complex structures where they are on the edge of the floodplain. There are also a number of roads that could be relocated outside or to the edge of the floodplain, although some of them are major highways so the expense may be high. Lastly, it is important to protect existing habitat by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

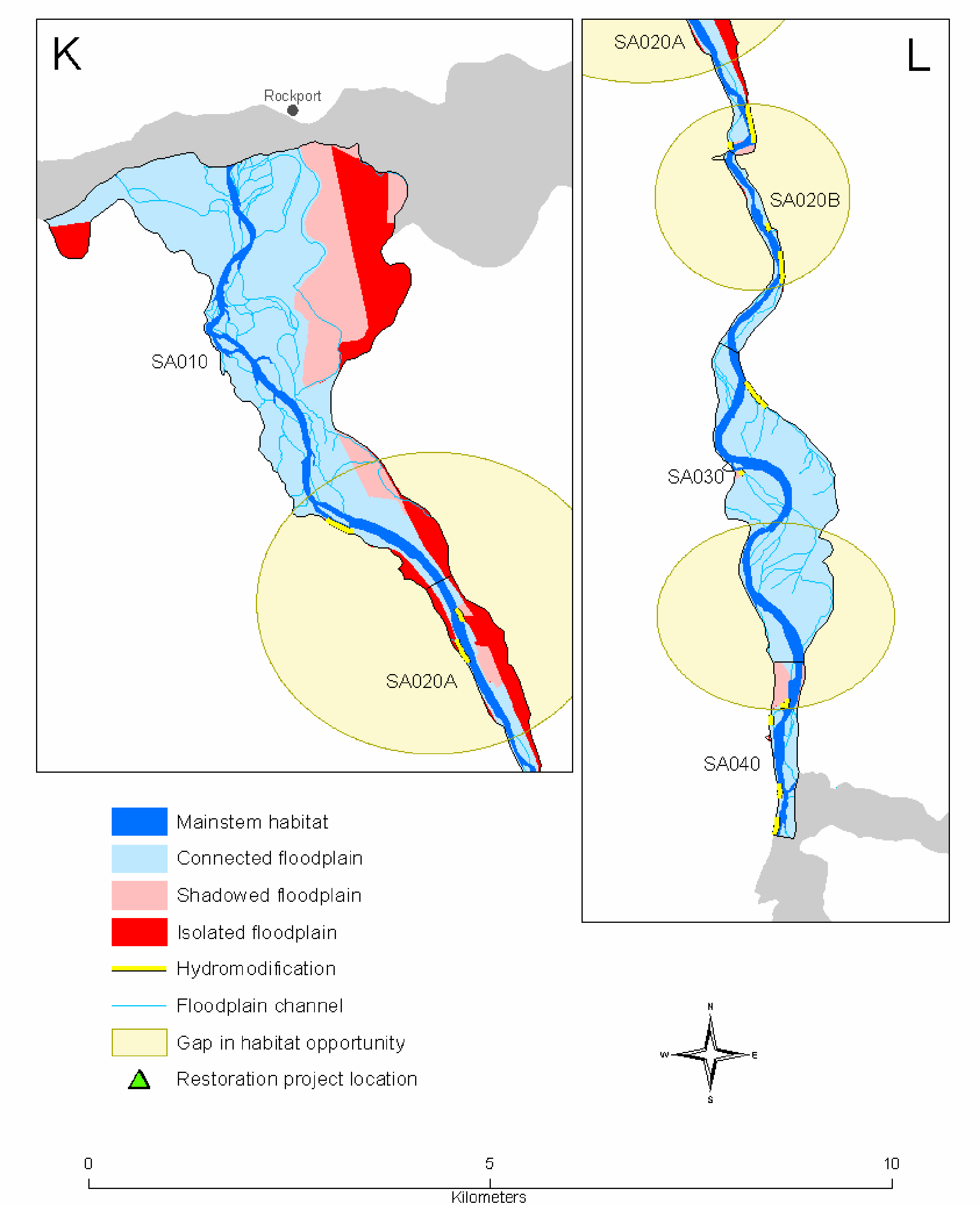


Figure 10.9. *Floodplain and habitat conditions for the Sauk River from the Skagit River to the Suiattle River.* (K) south of the Skagit, (L) north of the Suiattle.

10.8.3 Government Bridge

Project Summary
The habitat gap analysis showed that the Sauk River downstream from the Suiattle River between River KM 16.6-19.0 is lacking in off-channel and backwater habitat. The primary floodplain modification in this area is the Government Bridge and associated bank protection projects. The road fill associated with this bridge blocks connection to a historic floodplain channel and function for approximately 22 hectares (54 ac) of floodplain. A project in this location would involve constructing a bridge to span at least a portion of the floodplain, which extends approximately 215 meters on the left bank side of the Sauk River. The purpose of this project is to restore mainstem channel complexity and the development of off-channel habitat through the natural process of channel migration on the Sauk River.

Populations Targeted
All Sauk and Suiattle stocks

Estimated Cost
A larger bridge span would cost a minimum of $1,000,000.

Timeframe
There is no specific timeframe, but it makes sense to pursue habitat restoration in this reach as part of the Sauk River Reach Study, which is currently proposed and will hopefully be funded.

Contingencies
Currently there is no contingency plan. If it is not possible to expand the bridge span or remove riprap bank armoring, then this reach will remain in its currently degraded state.

Expected Direct Results
Physical: In the main channel, habitat complexity would be increased and the process of lateral channel migration would be restored. It is expected that new off-channel habitat will be formed over time as the Sauk River migrates across its floodplain.
Biological: 5,507 parr migrants per year.

Effectiveness Monitoring
Monitoring design will be developed in conjunction with feasibility and baseline analysis.

Backup Actions (if Direct Results not achieved)
This project would restore natural processes, so there is little risk that it will not succeed.

10.9. RESTORATION PROJECTS IN THE REARING RANGE OF LOWER AND UPPER SAUK STOCKS

10.9.1 Habitat Conditions

This rearing range has 1,392 hectares of floodplain with 16% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 30.3 km, and the off-channel habitat length is 67.3 km, which is approximately 2.22 km of off-channel habitat length per km of mainstem length. The average floodplain width in this rearing range is moderately wide at 536 m, and the effective width is 451 m with only moderate floodplain impairment.

Figure 10.10 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, along with the location of hydromodifications that may be impairing habitat conditions. Lastly, gaps in habitat availability are marked on the maps as likely areas to emphasize habitat restoration along with the location of specific projects described in this section. There was one gap that was identified in this rearing range for a total of 3.5 km mainstem channel length.

10.9.2 Restoration Strategy

This rearing range is characterized in the lower section (from Darrington downstream) by a relatively wide floodplain and a moderate level of floodplain disturbance, while in the upper section (upstream of Darrington) the floodplain is significantly narrower, and has a relatively low level of disturbance. The lower section has a much larger amount of off-channel habitat than the upper section, primarily because of the lower gradient and wider floodplain. The lower section has one of the largest lengths of off-channel habitat per unit mainstem length of any of the rearing ranges.

The lower section has a number of hydromodifications and floodplain disturbances that should be addressed, particularly in the area near the town of Darrington and several kilometers downstream. It is important for both sections in this range to protect the current conditions by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

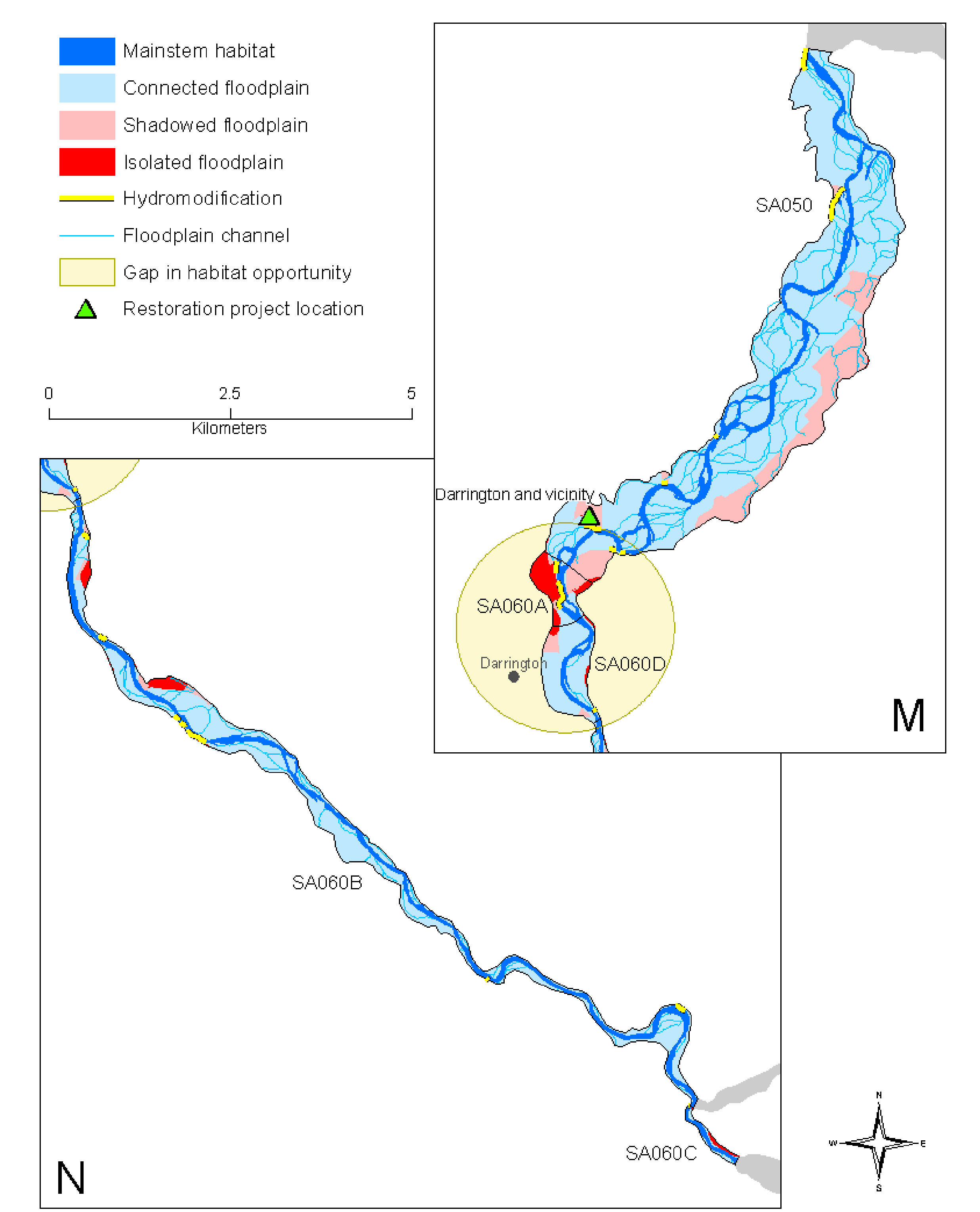


Figure 10.10. *Floodplain and habitat conditions for the Sauk River from the Suiattle River to the Whitechuck River.* (M) Suiattle River to Darrington, (N) Darrington to the Whitechuck River.

10.9.3 Darrington and Vicinity

Project Summary

The habitat gap analysis showed that the Sauk River between River KM 31.7-35.2 is lacking in off-channel and backwater habitat. This reach includes the town of Darrington, the Sauk Prairie Bridge, the Hampton timber mill, and private property owners. Significant portions of the floodplain are isolated or shadowed by roads or hydromodifications (approximately 67 ha or 164 ac), but restoration may not be costly or not possible due to the high value of some of the developments in this area. However, this reach should be evaluated in more detail, and some practical restoration actions might include increasing the span length for the bridge and removing hydromodifications on some of the properties downstream from the Hampton Mill. The purpose of this project is to restore mainstem channel complexity and the development of off-channel habitat through the process of natural channel migration on the Sauk River.

Populations Targeted

Lower Sauk summers and upper Sauk springs

Estimated Cost

No cost estimate at this time.

Timeframe

There is no specific timeframe, but it makes sense to pursue habitat restoration in this reach as part of the Sauk River Reach Study, which is currently proposed and will hopefully be funded.

Contingencies

Currently there is no contingency plan. If it is not possible to expand the bridge span or remove riprap bank armoring, then this reach will remain in its currently degraded state.

Expected Direct Results

Physical: In the main channel, habitat complexity would be increased and the process of lateral channel migration would be restored. It is expected that new off-channel habitat will be formed over time as the Sauk River migrates across its floodplain.

Biological: 9,394 parr migrants per year.

Effectiveness Monitoring

Monitoring design will be developed in conjunction with feasibility and baseline analysis.

Backup Actions (if Direct Results not achieved)

This project would restore natural processes, so there is little risk that it will not succeed.

10.10. RESTORATION PROJECTS IN THE REARING RANGE OF UPPER SAUK SPRINGS ONLY

10.10.1 Habitat Conditions

This rearing range has 475 hectares of floodplain with 6% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 12.9 km, and the off-channel habitat length is 25.4 km, which is approximately 1.97 km of off-channel habitat length per km of mainstem length. The average floodplain width in this rearing range is moderately wide at 471 m, and the effective width is 444 m with only minimal floodplain impairment.

Figure 10.11 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, along with the location of hydromodifications that may be impairing habitat conditions. Lastly, gaps in habitat availability are marked on the maps as likely areas to emphasize habitat restoration along with the location of specific projects described in this section. There were no gaps that were identified in this rearing range.

10.10.2 Restoration Strategy

This rearing range is characterized by a moderate width floodplain and a minimum of floodplain disturbance. For this reason, there is extensive off-channel habitat development and overall a high level of freshwater rearing habitat. There are a few hydromodifications that could be softened or removed, but the most important actions to take in this range is to protect the current conditions by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

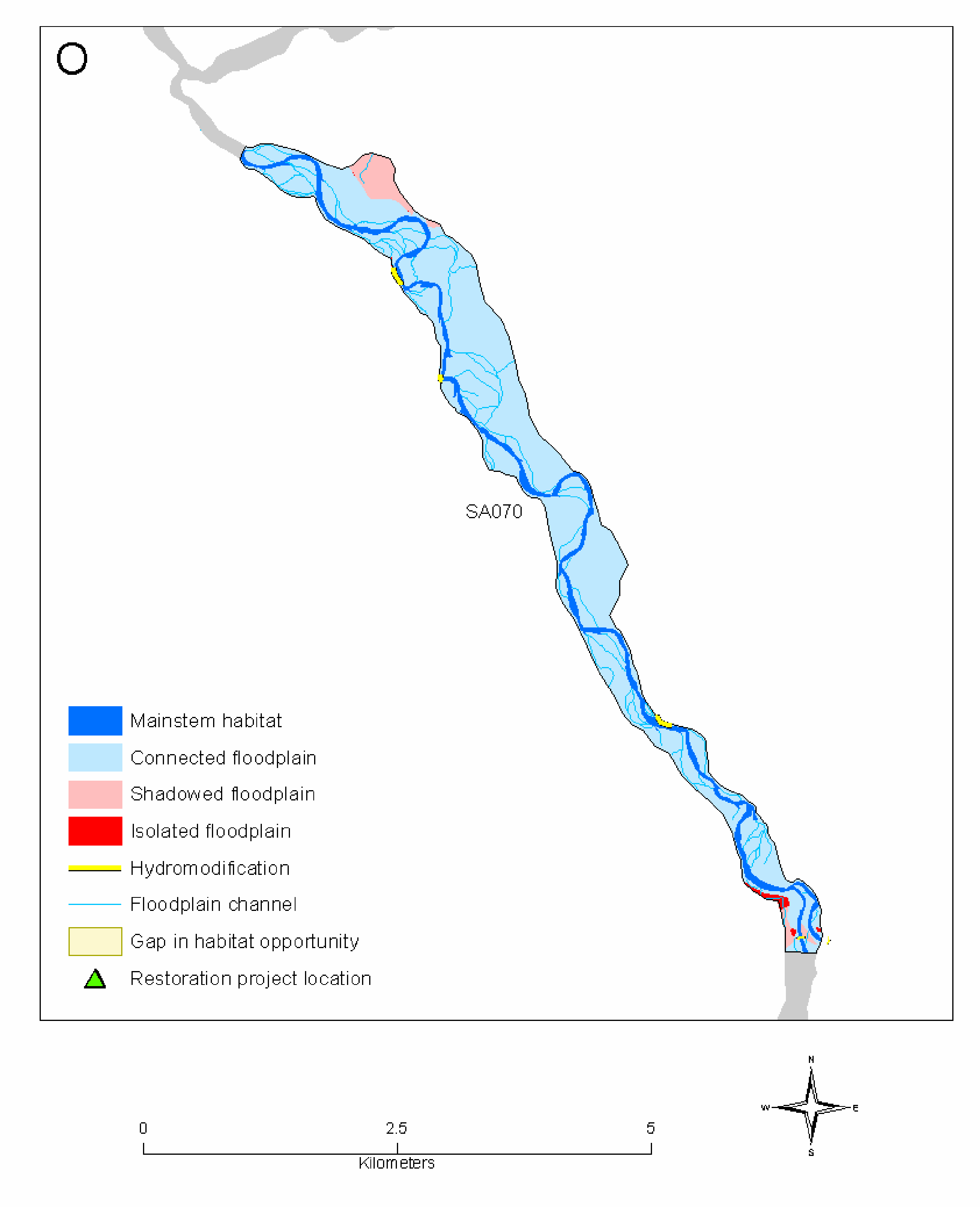


Figure 10.11. *Floodplain and habitat conditions for the Sauk River from the Whitechuck River to the Forks.* (O) Whitechuck River to the Forks.

10.11. RESTORATION PROJECTS IN THE REARING RANGE OF SUIATTLE SPRINGS ONLY

10.11.1 Habitat Conditions

This rearing range has 1,436 hectares of floodplain with 6% isolated or impaired from roads, hydromodifications, or other floodplain structures (Figure 10.1). The mainstem channel length in this reach is 40.6 km, and the off-channel habitat length is 52.3 km, which is approximately 1.29 km of off-channel habitat length per km of mainstem length. The average floodplain width in this rearing range is moderately wide at 420 m, and the effective width is 395 m with only minimal floodplain impairment.

Figure 10.12 shows floodplain characteristics and habitat conditions. Floodplain boundaries are presented and areas that are isolated or shadowed by roads, hydromodifications, or other floodplain impairments are shown. Mainstem channels, backwaters, and off-channel habitats are all shown, along with the location of hydromodifications that may be impairing habitat conditions. Lastly, gaps in habitat availability are marked on the maps as likely areas to emphasize habitat restoration along with the location of specific projects described in this section. There were two gaps that were identified in this rearing range for a total of 2.4 km mainstem channel length.

10.11.2 Restoration Strategy

This rearing range is characterized by a moderate floodplain width and a relatively low level of floodplain disturbance. However, the Suiattle has a lower off-channel habitat length per mainstem length than the upper Sauk River, which has a similar floodplain width. There were a few gaps in habitat that were identified in the analysis. There are several hydromodifications and floodplain roads that could be removed or upgraded to increase rearing habitat. However it is also important to protect the current conditions by keeping roads, hydromodifications and developments out of the floodplain and avoiding timber harvest in the floodplain.

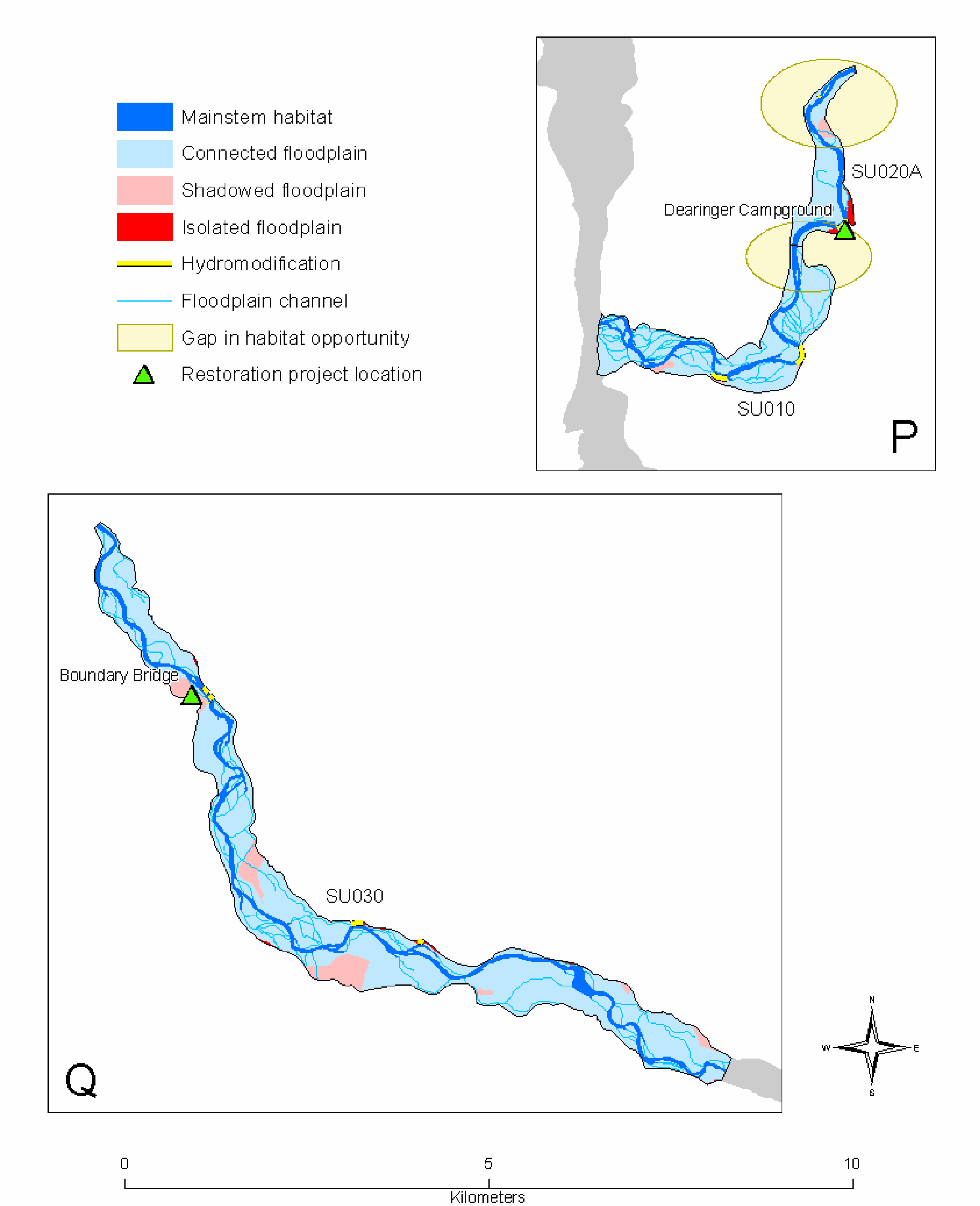


Figure 10.12. *Floodplain and habitat conditions for the Suiattle River*. (P) The mouth to the bottom of the canyon reach, (Q) the top of the canyon reach to Milk Creek.

10.11.3 Dearinger Campground Road

Project Summary

The habitat gap analysis showed that the Sauk River between River KM 5.2-6.2 is lacking in off-channel and backwater habitat. The primary floodplain modification in this area includes several riprap bank protection structures along a road that leads to Dearinger Campground. The one on the left bank of the Suiattle River at approximately River KM 6.8 was damaged during the flood of 2003 and is currently being considered for repairs. This is outside the identified reach, but the floodplain in this area is large enough that restoration at this site could benefit the identified reach. A project at this site would involve removing the riprap bank protection and relocating the road outside the floodplain. Although this project has not been scoped in detail, it would be relatively straightforward to relocate this road because it is not paved and the surrounding land use is entirely timber with no houses, structures, or other developments.

The purpose of this project is to restore mainstem channel complexity and the development of off-channel habitat through the process of natural channel migration on the Suiattle River.

Populations Targeted

All

Estimated Cost

Removal of riprap bank armoring and relocating the road would cost between $150,000 and $300,000. It is possible that some acquisition or easement exchanges would be necessary to construct a new road, which could cost up to $250,000.

Timeframe

This project has not been scoped in detail, but it would make sense to pursue this project in the context of repair work that is currently being planned for the road.

Contingencies

Currently there is no contingency plan. If it is not possible to remove riprap bank armoring, this reach will remain in its currently degraded state.

Expected Direct Results

Physical: In the main channel, habitat complexity would be increased and the process of lateral channel migration would be restored. It is expected that new off-channel habitat will be formed over time as the Suiattle River migrates across its floodplain.

Biological: No estimate at this time.

Effectiveness Monitoring

Monitoring design will be developed in conjunction with feasibility and baseline analysis.

Backup Actions (if Direct Results not achieved)

This project would restore natural processes, so there is little risk that it will not succeed.

10.11.4 Boundary Bridge

Project Summary

Restore floodplain connectivity by removing road and fill material associated with Boundary Bridge on the south side of the Suiattle River. Approximately 260 linear meters of road crosses the floodplain in this location. This road blocks several historic channels and isolates approximately 17 hectares (43 ac) of floodplain. The bridge currently does not provide access because the river eroded approximately 25 meters of the approach on the south side in October 2003. Habitat restoration options include removing the bridge and all of the associated roadfill in the floodplain or extending a new bridge span across a portion of the floodplain and replacing fill material with large culverts in historic channel crossings.

Populations Targeted

All

Estimated Cost

Exact costs have yet to be determined, but removing the road fill would cost approximately $300,000 plus the cost of removing the bridge. Adding a new bridge span and putting culverts in the existing road fill would cost between $1- $2.5 million. Some funds could come from emergency money provided to the Forest Service by the Federal Highways Administration, but habitat restoration elements may needed to be funded by another source.

Timeframe

Currently the federal agencies are completing environmental assessment work and will be making a decision on the preferred alternative sometime in 2005. This alternative may or may not include significant habitat restoration elements. Once that is completed, design, permitting, and implementation could take an additional two to three years.

Contingencies

These will be worked out as part of the assessment, design, and permitting process.

Expected Direct Results

Physical: If implemented, this project is expected to restore connectivity between the Suiattle River and its floodplain and increase the development of off-channel habitat in the floodplain as a result of channel migration after the road fill is removed.
Biological: 6,868 parr migrants per year.

Effectiveness Monitoring

Flow conditions, side channel formation, and fish utilization will be monitored in the floodplain habitats after the bridge is removed or improved.

Backup Actions (if Direct Results not achieved)

These will be worked out as part of the assessment, design, and permitting process.

10.11.5 Downey Creek Crossing

Project Summary
This project involves closing the Suiattle River Road at the Downey Creek Crossing, or expanding the bridge crossing over Downey Creek to a length that would minimize impacts to approximately 1.2 hectares (3 ac) of the alluvial fan associated with the Downey Creek near the confluence with the Suiattle River.

Populations Targeted
Suiattle springs

Estimated Cost
Road Closure would be the least costly since the crossing is currently washed out from the October 2003 flood event. Costs with this option could be as low as $200,000 for decommissioning and/or movement of the camping area and trail upgrades. The second option, which would restore vehicle passage to the Sulphur Creek Campground and Suiattle River trailheads could cost in excess of $1.5 million depending on crossing design and load rating.

Timeframe
Public pressure to re-open access to the Suiattle River trailheads is very high. USFS teams are currently reviewing options for re-development of this stream crossing. Preferred options will likely be identified (already identified) and implemented in 2006 (or maybe this summer)

Contingencies
Off-channel habitats associated with the Downey Creek alluvial fan will again be isolated and impaired if crossing is redeveloped to its original footprint. Road fill associated with the crossing could be retrofitted with a culvert if no other option is selected. However, this would likely lead to limited habitat value for Chinook.

Expected Direct Results
Physical: If natural processes are allowed to work over the entire available floodplain of this fan, then we would expect the development of one or more new channels through this transitional section of Downey Creek. Presently, sediments and hydrology are concentrated in the channel passing under the bridge, thereby limiting the suitability of habitat within this reach for Chinook due to swift flows and large substrates.
Biological: 4,897 parr migrants per year.

Effectiveness Monitoring
Monitoring design will be developed in conjunction with feasibility and baseline analysis.

Backup Actions (if Direct Results not achieved):
These will be worked out as part of the assessment, design, and permitting process.

11. RESTORATION ACTIONS IN TIDAL DELTA REARING HABITAT

The tidal delta is the lower portion of the Skagit geomorphic delta that is influenced by tidal hydraulics and saltwater mixing (Figure 8.1). Biological evidence indicates a significant need for improvements in both estuarine habitat capacity and connectivity in order to achieve recovery of wild Skagit Chinook salmon populations. Appendix D contains detailed information regarding studies that have been conducted within the Skagit Basin that led us to this conclusion. All six Skagit Chinook stocks benefit from restoration of tidally influenced delta habitat.

11.1. GENERAL TIDAL DELTA RESTORATION STRATEGY

Estuarine habitat can be divided into three major types based upon vegetation. The outer edge is emergent marsh habitat, characterized by sedges and grasses. Upstream of this zone is an area of transition habitat between the emergent vegetation and the upstream-forested zone. The vegetation in the transition area consists of scrub-shrub: small trees and bushes. The upper extent of estuarine habitat is the forested riverine tidal zone, which supports trees. The functions of each of these zones and how they relate to salmon rearing are not well understood. However, in the Skagit, Chinook juveniles grow fastest in the emergent marsh habitat with growth rates averaging 1.68 mm per day, compared to a rate of 0.53 mm per day in the transitional and forested zones (SSC and USGS 1999). Tidal marsh habitat produces an average annual standing crop of five tons of vegetation per hectare, supporting a vast array of insects and crustaceans that serve as prey for juvenile salmon (Kistritz 1996).

Under present day conditions, the contiguous habitat area of the Skagit delta that is exposed to tidal and river hydrology totals about 3,118 hectares (Figure 11.1). This is mostly the delta area in the vicinity of Fir Island, but it also includes a fringe of estuarine habitat extending from La Conner to the north end of Camano Island. Historically, the contiguous habitat area of the Skagit delta included the same area, but also included the Swinomish Channel corridor and extended to the southern end of Padilla Bay (Collins 2000). The historic area equaled 11,483 hectares. This results in a seventy-three percent (73%) loss of tidal delta footprint.

Based on the arrangement of existing delta habitat and the need for more of it, it is unlikely that we could achieve Skagit Chinook recovery without at least two delta restoration projects that strongly improve the pathways that juvenile Chinook salmon can find and occupy delta habitat. Therefore, we have included two connectivity projects, one for central Fir Island and another for Swinomish Channel. The Swinomish Channel project would to take advantage of the large restoration potential along Swinomish Channel and southern Padilla Bay as well as improve pathways to existing under utilized nearshore habitat within Padilla Bay. Potential delta restoration sites are shown in Figure 11.2.

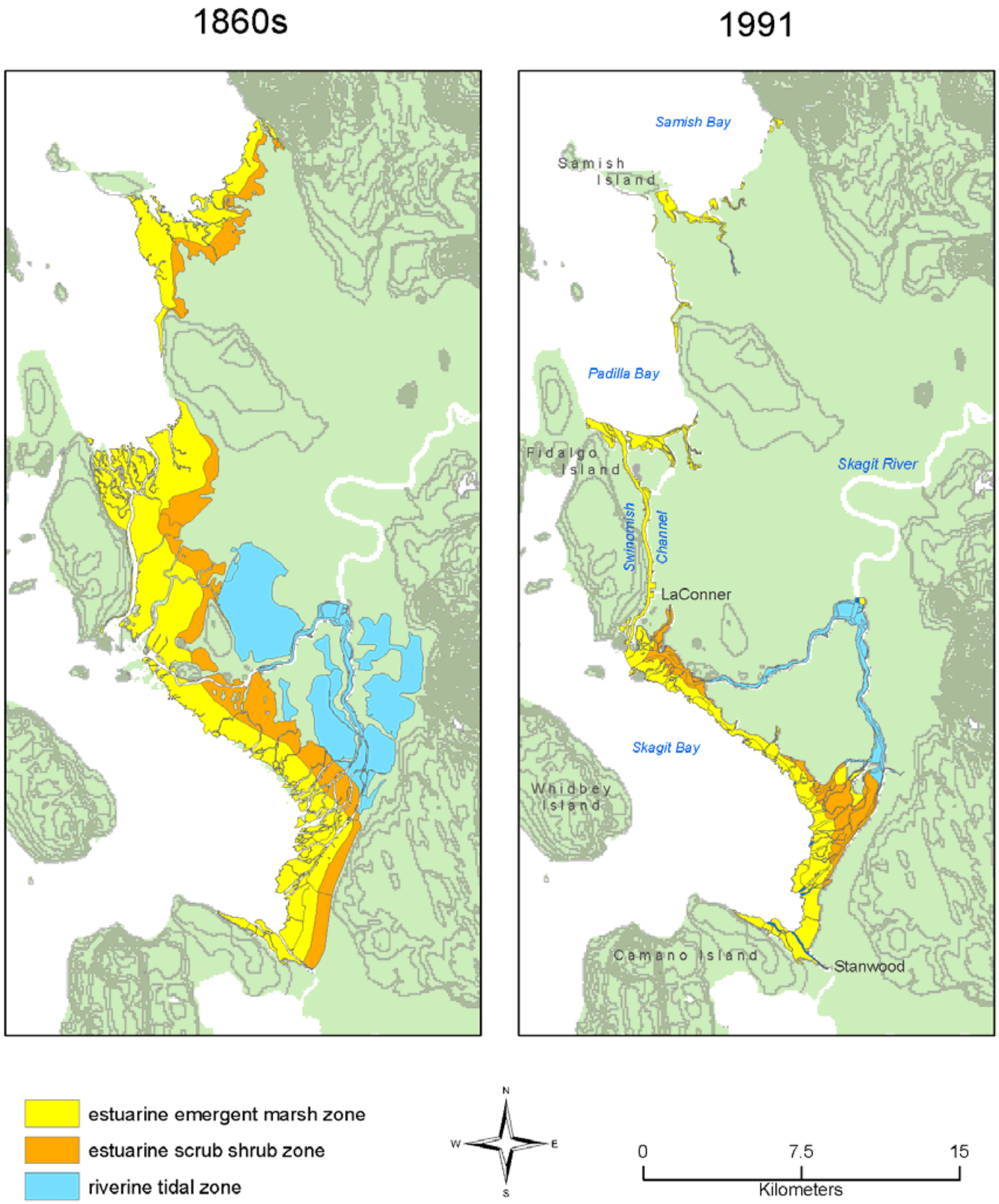


Figure 11.1. *Changes to the estuarine habitat zones within the geomorphic Skagit Delta.* Historic (circa. 1860s) conditions were reconstructed by Collins (2000) using archival maps and survey notes. Current habitat zones were mapped by Beamer et al. (2000b) using 1991 orthophotos.

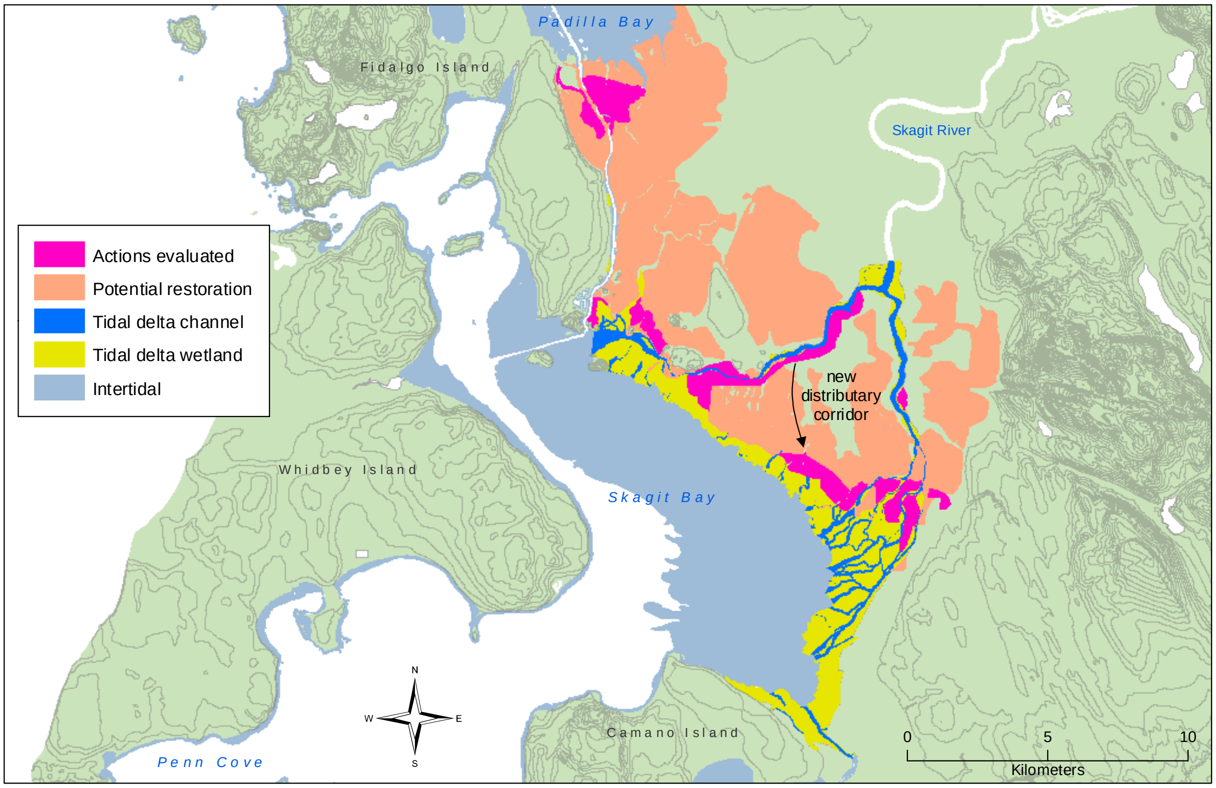


Figure 11.2. *Existing delta habitats and potential restoration.* Location of existing delta habitats that are easily accessible to delta rearing Chinook salmon (yellow and blue polygons) and the location of potential delta restoration (pink polygons).

11.2. IMPLEMENTATION

Recognizing the logistic complexities, scientific and engineering challenges, funding constraints and social barriers to implementing restoration actions we propose establishing specific implementation goals based on four five year incremental milestones. We have grouped our specific restoration recommendations into each of three milestone sequences: the years 2010, 2015 and 2020.

Projects listed under the long-term restoration horizon are generally less well developed and have a host of uncertainties or complexities that must be addressed before implementation could be expected to proceed. All of these projects are socially complex and resource intensive so will need to include some elements of mutually understood benefits for most, if not all, interest groups involved. For example, The North Fork levee setback project must have a demonstrable flood protection benefit to the residents of Fir Island before we would expect community acceptance of such a project. Furthermore, projects identified here would have very direct implications for particular landowners. For this reason alone many of these proposed projects will hinge on the success of projects implemented in the 5-10 year phases. The necessary incentive and institutional programs will need to be in place and working before landowner agreement can be reached. Projects identified in the 15 year implementation horizon will be informed by the relative success or failure of projects implemented in the first two phases of this plan. In this respect, the projects listed here are expected to be real time elements of our adaptive management strategy as they move toward further development and prospective implementation.

11.3. NEAR-TERM TIDAL DELTA RESTORATION PROJECTS

11.3.1 Wiley Slough

Project Summary
Set back dikes to the pre-1956 footprint of the levee system along Wiley Slough. The property is currently in public ownership. Details are available in a recently published design report (SRSC 2005) (Figure 11.3).

Purpose
Improve habitat connectivity and capacity.

Populations Targeted
All

Estimated Cost
Project design is currently underway having been funded by the Salmon Recovery Funding Board and matched with funds from Seattle City Light and in-kind contributions from WDFW and several other organizations. Design funding cost approximately $150,000. Preliminary cost estimates from the design phase place implementation costs near $2.5 Million.

Timeframe
High level of probability. Project design will be completed in early 2005. Assuming agency concurrence project funding and permitting can begin almost immediately. Successful funding can potentially lead to project implementation as early as 2006. However, 2007 implementation will likely be more realistic given the size of the funding need and the potential for delays from challenges by user groups.

Contingencies
Hunting groups are adamantly opposed to this project and will make every effort to prevent its implementation. Legal challenges are a possibility and could delay implementation for several years if the challenges are considered meritorious by the judicial system.

Expected Results
Physical: 65.0 ha of estuarine marsh area reconnected to tidal processes. Allometry predictions suggest this area can sustain 2.0 hectares of channel habitat with a connectivity rating of .040.
Biological: The resulting Chinook production is estimated to increase by approximately 38,492 smolts.

Effectiveness Monitoring
See Chapter 15 for details on estuarine monitoring strategy.

Backup Actions (if Direct Results not achieved)
Outmigrant rearing is strongly dependent on the development of channel area. However, a variety of factors could impede or retard channel development. Dense mats of established invasive vegetation is one such factor. If invasive species become a problem active management techniques will need to be employed to open channel corridors and control invasive spread.

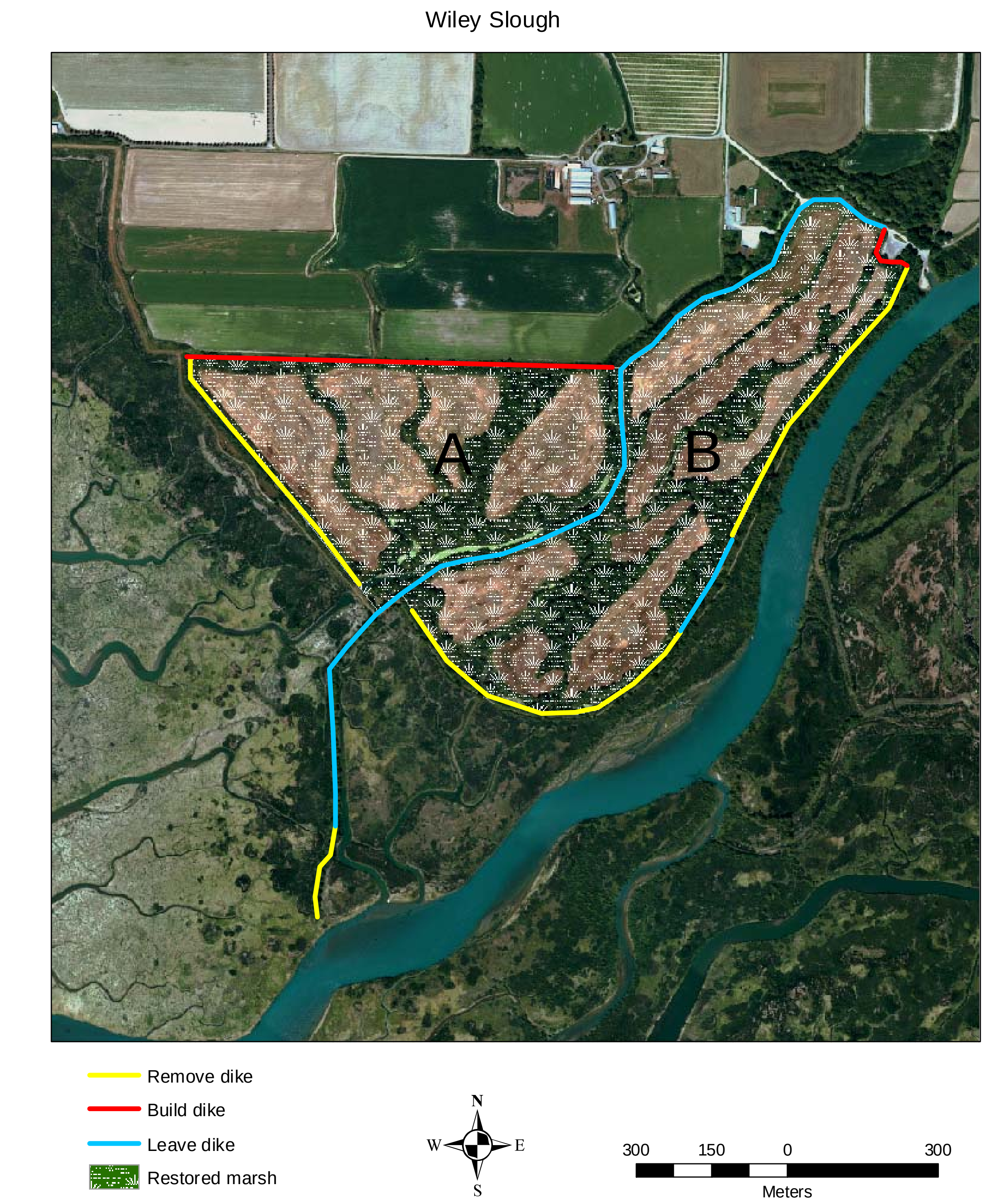


Figure 11.3. *Wiley Slough.* Wiley Slough site potential. Current on-site channels (red), including borrow ditches. Historical channels (black; observed from 1937 photos) often coincide with current channel remnants. The northeastern portion of the site was diked by 1889. The remainder was not diked until the early 1960s, so detailed reconstruction of historical channels on much of the site is possible through reference to historical (1937 and 1956) photos.

11.3.2 Milltown Island

Project Summary
Milltown Island (212 diked acres) was sold to WDFW after farming was deemed impractical in this area. The site has lain fallow and restoration efforts have been minimal, consisting of several *ad hoc* dike breaches in 2000. On-site tidal channel abundance is much less than in nearby reference areas. We propose to extensively breach dikes to restore tidal and riverine processes that will scour and maintain on-site tidal channels (Figure 11.4).

Purpose
To remove hydraulic controls on Milltown island that limit the development of channel networks and native vegetation.

Populations Targeted
All

Estimated Cost
$100,000 has been secured through Seattle City Light's ESA program. This money has been used as matching funds to secure a $350,000 commitment from the SRFB in 2004.

Timeframe
Planning and permitting work is now underway. These should be finished in 2005, allowing implementation work to proceed in 2006 and 2007.

Contingencies
Methods for project implementation are not settled. Explosives have been used in the past to breach the levees in selected locations. This method is also being considered again, however, ESA constraints could restrict the use of ordinances so other methods such as barging, hauling or spreading are being considered. Costs are expected to vary depending on methods approved.

Restoring shrub habitat to this site and eliminating or greatly reducing reed canary grass in the process will be difficult. While control of RCG is generally problematic, competition and shading by shrubs can be effective (Apfelbaum and Sams 1987). The topographic elevation in the Milltown area is appropriate to scrub-shrub growth (Hood 2004); a mowing and planting program is needed to bypass early life stage competition between shrubs and RCG.

Expected Direct Results
Physical: Tidal channel density relationships in undiked reference tidal marshes in the South Fork Skagit delta indicate that marsh area of 212 acres (the amount of area directly influenced by Milltown Island dikes) should support approximately 19 tidal channels amounting to a total of 14.8 acres and approximately 12.2 miles length (Hood, In Prep.). Instead, only five tidal channels amounting to 5.3 acres and 2.9 miles length are observed in the portion of Milltown Island behind dikes (Fig. 11.4), far less than predicted by the model. In comparison, the southern portion of Milltown Island, which was never farmed or diked and consists of 96 acres of tidal shrub wetlands, is predicted to support 11 tidal channels amounting 4.8 acres total. In fact, ten tidal channels totaling 3.9 acres are observed, which is in good agreement with model predictions. The contrast between predicted and observed tidal channel geometry for the diked versus undiked portions of

Milltown Island suggests that there is potential for significant restoration of tidal channels to the diked portion of Milltown Island. The limited amount of existing dike breaches probably constrains tidal channel development. More extensive dike removal may allow greater tidal channel development.
Biological: Juvenile salmon (40-110mm fork length) currently have access to the site. Restoration actions on this site could result in additional tidal channel habitat (following a period of channel network development) and higher quality tidal marsh vegetation. Restoration actions assume by this analysis include removal of at least 6,000 feet of dike. Under this scenario we expect the site to produce opportunity for an additional 57,179 smolts.

Effectiveness Monitoring
See Chapter 15 for details on estuarine monitoring strategy.

Backup Actions (if Direct Results not achieved)
Under the proposed restoration scenario not all remnant levee will be removed. Because of the extraordinary cost associated with levee removal at this remote location we have only targeted those levee sections have the greatest influence on hydraulic forces. If removal of these levee sections fails to produce desired results additional levee sections should be evaluated for removal.

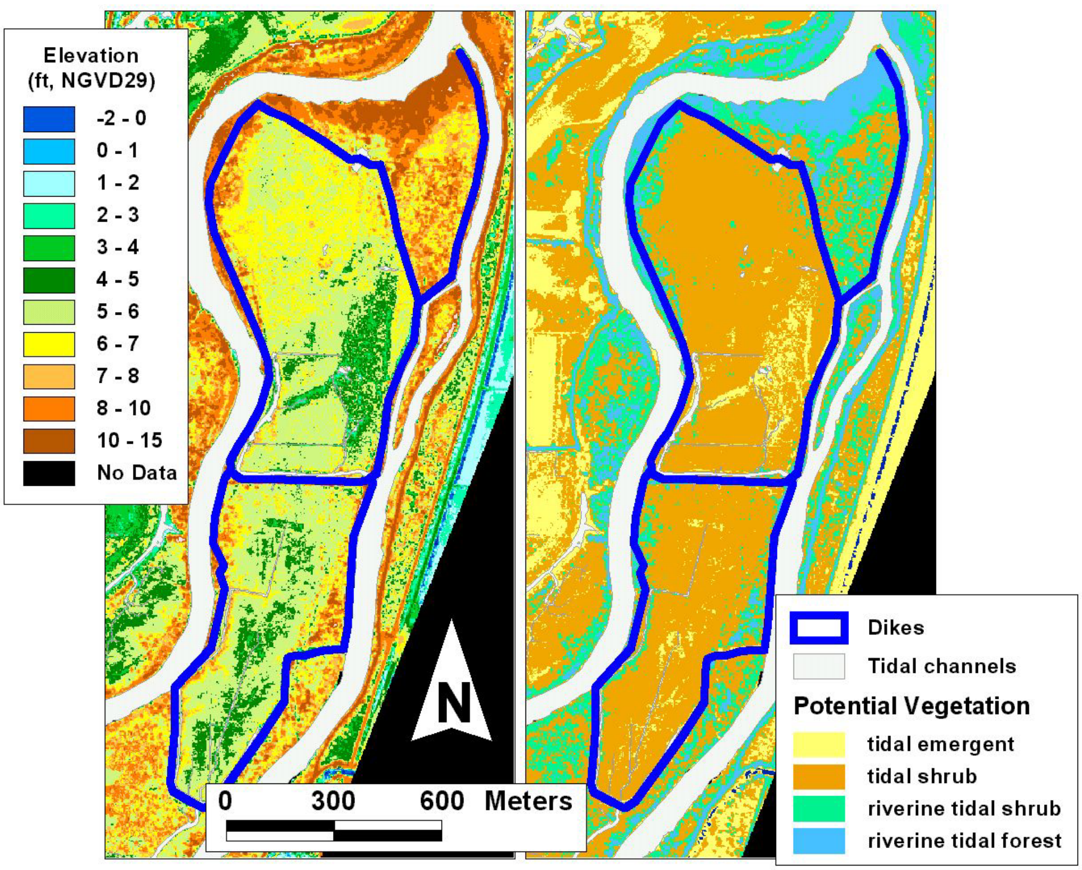


Figure 11.4 *Milltown Island.* Milltown Island site potential. Topography from LIDAR imagery (left). Potential vegetation, assuming elevation control (right).

11.3.3 Telegraph Slough-Phase 1

Project Summary
Dike setback project located at the north end of the Swinomish channel. This phase of the project would implement approximately 90 hectares of marsh restoration. The second phase would add an additional 100 hectares of marsh and a distributary connection following the historic Telegraph Slough (Figure 11.5).

Purpose
To expand estuarine emergent marsh rearing habitat in conjunction with improvements at McGlinn Island.

Populations Targeted
All

Estimated Cost
Funded in 2004 by the SRFB for $400,000 and matched by Ducks Unlimited (DU). Total project cost estimated at $750,000

Timeframe
This project has a moderate likelihood of implementation. Implementation is expected by 2007 is landowner agreement can be finalized.

Contingencies
A private citizen, who has expressed his desire to see the property restored under the guidance of DU, is acquiring Properties being restored. Written agreement has not been secured from the private party who acquired the property. Until such agreement is in place there is some possibility that the property can remain behind the levee system. Hunting organizations are likely to test the resolve of DU to opt, or advise for full restoration.

Expected Direct Results
Physical: Phase 1 would restore tidal influences to an estimated 90 hectares of potential habitat. This habitat could support just under seven hectares of channel with a connectivity index of .0087. If the causeway project is implemented the connectivity value goes to .016 and production estimates increase accordingly.
Biological: Phase 1 implementation yields a site potential capacity of just under 50,000 smolts when connectivity is improved at the Causeway. The productivity drops to about half this value without improved connectivity (see discussion in Appendix D).

Effectiveness Monitoring
This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions
If invasive species become a problem active management techniques will need to be employed to open channel corridors and control invasive spread.

Figure 11.5 *Telegraph Slough – Phase 1*. Levee set back alignment shown in red with potential emergent marsh area highlighted.

11.3.4 McGlinn Island Causeway

Project Summary
Improve hydraulic connection between the North Fork of the Skagit and Swinomish Channel north of McGlinn Island. This action is expected to improve access by juveniles to estuarine rearing habitat in Padilla Bay. The current access, through a small opening in the rock jetty (known as the "Fish Hole") is limited because river flow is directed away from Swinomish Channel, and the opening is inaccessible at low tides (Figure 11.6).

Purpose
To improve hydraulic and fish passage connectivity between the Swinomish Channel and the North Fork of the Skagit River, thereby alleviating an identified barrier to Chinook migration.

Populations Targeted
All

Estimated Cost
Feasibility level investigations have been funded by the Salmon Recovery Funding Board for approximately $150,000 including match monies and services being supplied by the U. S. Geological Survey (USGS) who will take lead on hydraulic modeling tasks. Actual project implementation will depend on feasibility outcomes, but are expected to run in the $500,000-$700,000 range.

Timeframe
Feasibility work and preferred alternatives will completed by the end of 2006. Implementation can be as early as 2007 if funding is made readily available. However, a 2008 start date would be more likely given the complexities of the project.

Contingencies
Key questions regarding impacts on population distribution and effect on fisheries allocations remain. If this action causes an increase in Canadian interceptions or other negative management ramifications it will be reconsidered or dropped. The question of how this project could impact harvest management or be impacted by harvest not currently being realized by the stocks (i.e., Canadian fisheries) needs to be answered during the feasibility planning.

Expected Direct Results
Physical: Water will flow from the Skagit River into Swinomish Channel at a depth and velocity that allows fish migration. This will increase connectivity to existing habitat throughout the Swinomish channel and Padilla Bay. This will also increase the benefits of projects being considered at the North end of the Swinomish channel.
Biological: Significant restoration potential exists along the northern end of Swinomish Channel. Two projects are included in our five-year implementation schedule-smokehouse floodplain and Telegraph Slough. The smolt benefit for these projects is highly dependent on the Swinomish Channel Causeway project that improves connectivity between the North Fork and Swinomish Channel. Without the causeway project, the combined benefit for these two projects is 72,622 smolts annually. With the causeway project, the combined benefit for these two projects almost doubles to 133,616 smolts annually. The Swinomish Channel causeway project also improves the

value of existing habitat along Swinomish Channel and in southern Padilla Bay. The increase in productivity to existing habitat is estimated to be 40,898 smolts annually. Another important part the causeway project is that it could improve migratory pathways to eelgrass habitat within Padilla Bay that is under-utilized. Because data on habitat values for eelgrass in Padilla were not readily available this habitat contribution was not modeled.

Effectiveness Monitoring

Monitoring will focus on evaluating the relationship between modeled flows and actual flows once project is implemented. Fish migration will need to be monitored as well to evaluate the effectiveness of predicted outcomes. A fyke net will be installed at the passage gate for limited periods of time, and will sample throughout the outmigration at different tidal stages and times of day, to estimate total fish use through the season. This number will be estimated for different smolt outmigration levels, and compared to rearing densities observed in different estuary habitat types.

Backup Actions (if Direct Results not achieved)

It's expected that feasibility investigations will address this issue in detail. It's likely that contingency alternatives will be included in final recommendations that will allow for some adaptive management once the project has been implemented.

Figure 11.6 *McGlinn Island.* Causeway conceptual design showing potential breech location. This action would likely be accompanied by work at the existing jetty fish way.

11.3.5 South Fork Dike Setback

Project Summary
2500' of existing levee will be removed and re-graded down to the existing "bank top level" at the top end and the lower end will be graded for off-channel connectivity. The main river levee will be relocated and constructed approximately 700' maximum from the riverbank at the mid-point of the project. 1800' of new levee will be built adjacent to the County road with the keyway located along the riverward toe slope of the levee.

Purpose
To restore riverine tidal habitats for Chinook rearing.

Populations Targeted
All

Estimated Cost
Approximately $1,000,000. This includes property acquisition. $850,000 has been funded by the SRFB. $160,000 was provided as matching funds from Dike District 3 tax revenues.

Timeframe
Project was implemented in 2004 under the direction of Skagit County.

Contingencies
The project has been funded and implemented. Some site alterations might still be needed depending on the results of site monitoring. For example: re-grading the "upper" end of the project reach to restore "flow through" hydrology will be included if the need is demonstrated. Additional conifer plantings could be included as time and maturity of the site warrants

Expected Direct Results
Physical: If implemented so that hydrology can naturally influence the project site (i.e., upstream floodplain connectivity is not altered by armoring or fill) the site has over 16 hectares of site potential area. This could yield .374 hectares of channel habitat with a .081 connectivity rating.
Biological: Modeling suggests the site has potential to increase Chinook production by ~14,588 smolts.

Effectiveness Monitoring
The project has been implemented by Skagit County, through the use of SRFB funds, in late 2004. It is not clear if a monitoring plan has been developed for the site. We are assuming the IMW monitoring plan will be applicable in the absence of anything more detailed. Chapter 15 has more detail on the Skagit IMW estuarine monitoring strategy.

Backup Actions
Channel development could be impeded by toe rock remaining in place after construction. Channel development could also be impeded by topography of upstream end of the site (floodplain fill was retained to protect newly constructed levee). If channel development is limited these features should be evaluated for removal.

11.3.6 Fisher Slough

Project Summary

This project acquires ~50-80 acres of farmland within the riverine tidal zone and restores agricultural land to channel, scrub-shrub, forested wetland, and tributary junction habitats. In addition, this project assesses ecosystem functions supplied by the Fisher Slough subbasin, including hydrology and geomorphology, and provides conceptual alternatives for addressing high priority problems (Figure 11.7).

Purpose

To restore riverine tidal wetland habitats for juvenile rearing

Populations Targeted

All

Estimated Cost

Initial project elements have been funded by SRFB. Feasibility costs are approximately $150,000. Acquisition costs are approximately $250,000. Project costs will vary, but estimates are between $1,000,000 and $1,500,000

Timeframe

The feasibility and acquisition phase of this project are now underway. Probability of project implementation is very high. Expect implementation in 2007.

Contingencies

The most significant constraint on the project is the Big Ditch siphon culvert underneath Fisher Slough. The degree of Chinook benefit achieved on these parcels will depend on the degree to which hydrological connectivity can be maximized. Alternatives for passing Big Ditch flows without impeding drainage on farmland will be a principle part of the assessment. Selection of an alternative will depend on the financial cost relative to the ecological benefit provided.

Expected Direct Results

Physical: Our estimate of restoration potential indicates and area of 27.5 hectares of habitat could be realized at this location. This subsequently would result in about .81 hectares of channel area with a connectivity rating of .042.

Biological: If implemented such that tidal wetland is allowed to redevelop over the area of what is now locally known as the Poor Farm, this project should improve Chinook production by an estimated 16,431 smolts within 2-3 years after implementation.

Effectiveness Monitoring

A monitoring plan is being developed as a part of the feasibility project. Expected study plan will be commensurate with estuary monitoring strategy outlined in Chapter 15.

Backup Actions

Evaluate additional actions related to the Carpenter Creek system. If invasive species become a problem active management techniques will need to be employed to open channel corridors and control invasive spread.

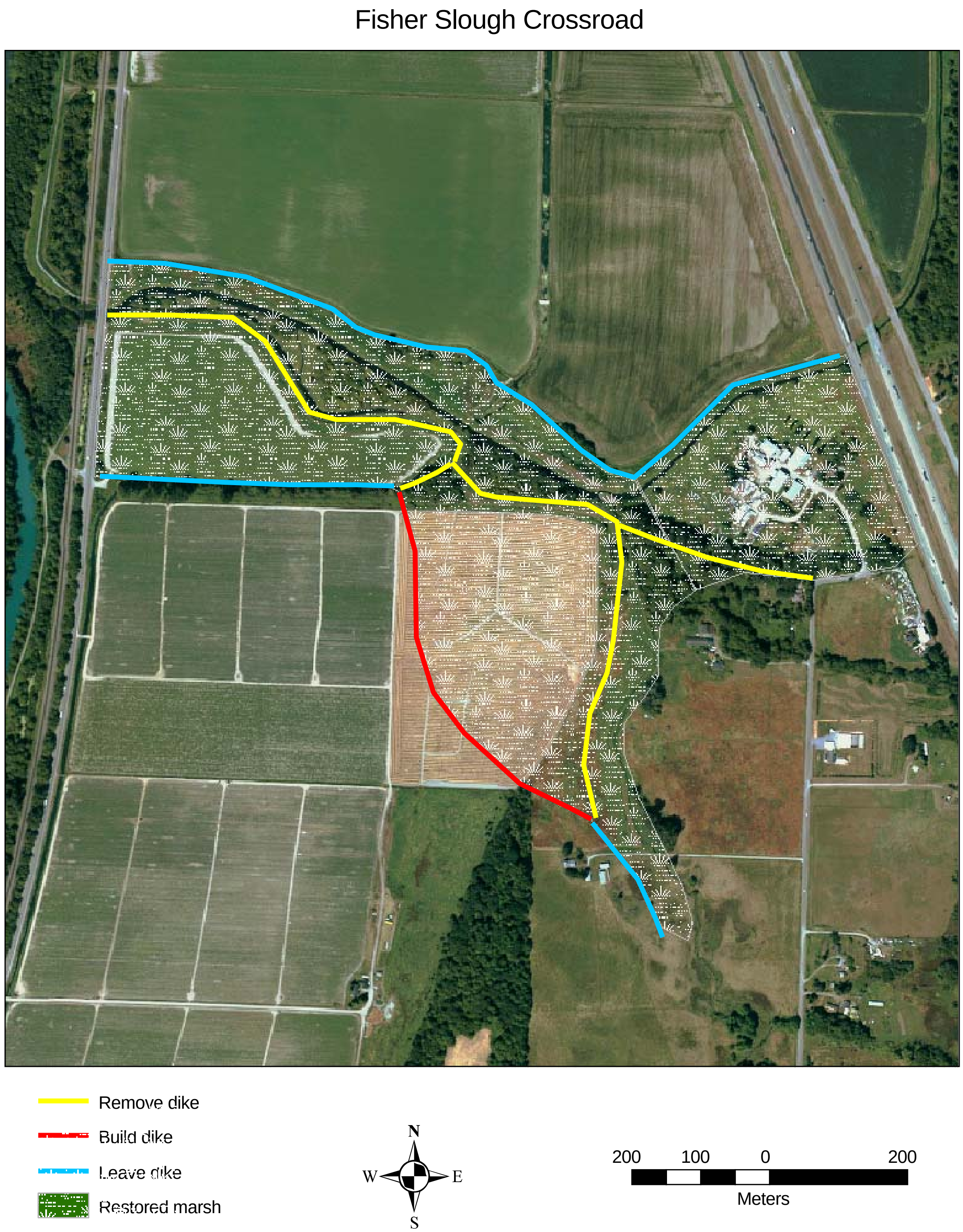


Figure 11.7. *Fisher Slough.* Fisher Slough conceptual restoration footprint.

11.3.7 Davis and Dry Slough

Project summary
Levee setback project in the vicinity of Claude Davis and Dry Slough. The project as described here proposes to involve approximately 90 acres of WDFW lands and 30 acres of private land in the first

Purpose
To restore estuarine emergent marsh habitats for improved juvenile Chinook rearing.

Populations Targeted
All

Estimated Cost
Funds for this project could be secured readily through established funding sources. Expected cost would run approximately $1.5 million

Timeframe
The site has been the subject of intense discussions between WDFW, private landowners, the Dike District and Tribes. If a reasonable settlement could be struck this project could move forward in less than five years.

Contingencies
The site is the subject of potential legal challenges regarding fish passage at tidegates. If this issue goes to court we cannot predict the outcome or timeline for a decision.

Expected Direct Results
Physical: The site potential is for 48.05 hectares of marsh habitat. This equates to 1.105 hectares of channel habitat under the current levels of connectivity, which is valued at .0221.
Biological: This project could yield 11,660 smolts per year.

Effectiveness Monitoring
This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions (if Direct Results not achieved):
These will be worked out as part of the assessment, design, and permitting process.

11.3.8 Smokehouse Floodplain

Project Summary

The Fornsby Creek SRT project is a fish passage and habitat restoration project located along the Swinomish Channel of the Skagit River delta. The site was once an expansive estuarine emergent marsh over 900 acres in size (Collins and Sheik, 2002). Hydraulic modifications including installation of flap-style tide gates converted this emergent marsh to arable uplands. The modern site still contains a significant network of remnant slough channels, albeit simplified by decades of agriculture. These remnant channels are presently influenced by small freshwater tributary streams and seeps but isolated from tidal influence.

The project will replace existing impassible tide gates with self-regulating tidegates (SRTs). Tide gate replacement will restore tidal influence to the channels, enable fish passage, and increase the amount of available blind channel, distributary, and tributary habitat for all salmonid species. Allowing a wide range of tidal influence to interact with the remnant channels' freshwater flows on the floodplain will create estuary-type freshwater and salt water mixing zones. These mixing zones are critical rearing habitat for juvenile salmonids. The project will also implement habitat restoration actions on 1.3 miles of the re-opened channel habitat. In total, the project will re-open more than five miles of channel to fish and improve over 50 acres of aquatic habitat (Figure 11.8).

Purpose

To increase estuarine marsh habitats available to juvenile Chinook through improved passage at tide gates and riparian corridor development.

Populations Targeted

All

Estimated Cost

A total of $700,000 has been secured for this project.

Timeframe

Implementation will begin in 2005. Final project elements for the first phase will be in place in 2007.

Contingencies

This site will not be able to realize its full site potential until the McGlinn Island Causeway project is constructed. The salinity barrier present in the Swinomish Channel will continue to limit the utility of the area to migrating Chinook.

Also, The complexity of individual land allotments (or Individual Indian Trust Lands) currently constrains the project scope. These allotments are often owned jointly by dozens, and in some cases hundreds, of related individuals. Securing permission to conduct project work on these lands is extremely difficult and time consuming. Therefore this project does not propose work on these lands. Work on individual allotment lands will be pursued in later phases and as agreements can be secured.

Expected Direct Results
Physical: In total, the project will re-open more than five miles of channel to fish and improve over 25 hectares of aquatic habitat. We believe this will result in approximately 2.594 hectares of newly available channel.
Biological: Prior to the completion of the McGlinn Causeway project the connectivity rating will be significantly lower than afterwards. Pre McGlinn connectivity is estimated at .0091 and post connectivity .016.This will result in and 20,471 smolts respectively.

Effectiveness Monitoring
The goal of the Smokehouse monitoring plan is to determine: (1) the effectiveness of the new tide gates in controlling the quantity of the water passing into and out of the reopened channels; (2) the change, if any, in water quality within the reopened channels; (3) the effect, if any, of saltwater on nearby agricultural lands; and (4) the amount of fish use within the reopened channels. The monitoring goals will be accomplished by comparing the data gathered before, during, and after the new tide gate installation (Table 11.1). The effects of the tide gate installations will be evaluated against pre-installation baseline data and results from a control site. The south fork of Fornsby Creek will retain the old style flap tide gate and function as this control site. This site is situated on Individual Indian Trust land, with restoration constraints as noted above. Future restoration may include this area as permissions are gained.

Table 11.1. *Monitoring objectives and size allocation.*

	PROJECT AREA		**CONTROL AREA**		
	New Tidegate Sites	Re-opened Channel Sites	Tidegate Sites	Channel Sites	TOTAL
Surface Water Level	4	6	2	1	13
Flow Velocity	0	6	0	1	7
Water Quality	4*	6	2*	1	13
Monitoring Wells	0	12	0	2	14
Soil Salinity Transects	0	6	0	1	7

The water quality monitoring plan will consist of 13 monitoring sites within the project area (see vicinity map). Paired sites (salt water side and freshwater side) are located at each of three tide gates (one existing tide gate to be replaced with a SRT, one new SRT, and one existing tide gate not replaced in this project phase (control site)) for a total of six tide gate monitoring sites. An additional seven sites are located along the upstream channels re-opened as part of this project.

*Ambient water quality is currently monitored at these sites under a separate program. Data will be shared with this project, but funding is not sought to support current monitoring.

Several approaches will be taken to evaluate the effectiveness of the new tide gates in controlling the quantity of the water passing into and out of the reopened channels. The surface water level will be recorded with electronic dataloggers at 13 locations. Surface water level data will assess the functionality of the tide gates in preventing excess water from entering the system (flooding) or allowing de-watering. Flow velocity will be measured at seven locations using a standard flow meter at locations of measured channel profile. Flow velocity data will allow determination of water flow volume within the system as well as the magnitude of tidal flushing. This will allow project proponents to fine-tune tide gate function to optimize flushing within the re-opened channel habitat and optimize the fish passage window.

Surface water quality monitoring will be performed at 13 sites (three paired stations on either side of each tide gate and seven individual stations at upstream monitoring sites). Conventional water quality parameters will be recorded including pH, temperature, conductivity, salinity, dissolved oxygen, turbidity, and chloride. These sites will be monitored weekly to biweekly with a regular field probe (Hydrolab Surveyor/Sonde4). A second water quality probe, a continuously recording long-term deployment probe (Hydrolab Surveyor/Sonde4a), will be deployed at each station on a rotational basis. With this data, we will be able to monitor the affects of increased tidal influence on water quality and identified water quality problems, including high temperatures and low dissolved oxygen.

Water levels and water quality parameters including conductivity, salinity, and chloride will also be measured in 14 monitoring wells at seven upstream monitoring stations. Water levels will be continuously monitored, allowing evaluation of the effects of the SRTs on local water table elevations. Combined analysis of water quality data from the main channels and the wells will allow the evaluation of saltwater influence on the adjacent agricultural lands. The use of a soil moisture and salinity probe along transects perpendicular to the channels will provide an application-based assessment of any saltwater impact on the adjacent agricultural lands.

This project will assess juvenile salmon access to habitat upstream of standard tide gates and self-regulating tide gates using beach seining methodology. Monthly beach seine and habitat sampling will occur at sites at both high and low tidal stages from February through June. Conclusions about accessibility will be partially inferred by comparing catches immediately upstream and downstream of the tide gate structure. The probability of detecting salmon upstream of a tide gate structure by our sampling methods will be put in context by using an extensive database of beach seine results collected at Browns Slough and reported in Beamer and LaRock (1998). Catches will be analyzed for fish community composition and juvenile salmon size and abundance by species and age class.

A sample of juvenile Chinook will be collected and analyzed for diet composition three different times representing periods when Chinook (1) just arrive in estuarine habitat, (2) peak of estuarine rearing, and (3) decline in estuarine rearing. The study will put the biological results into an ecological context for salmon habitat quality by using bioenergetics modeling for juvenile Chinook. Comparison of results from tide gate sites to reference sites to will indicate the possible influence of differences in habitat quality at each site on corresponding fish catch results.

Backup Actions

Increase tidal connections or expand project to include levee setback.

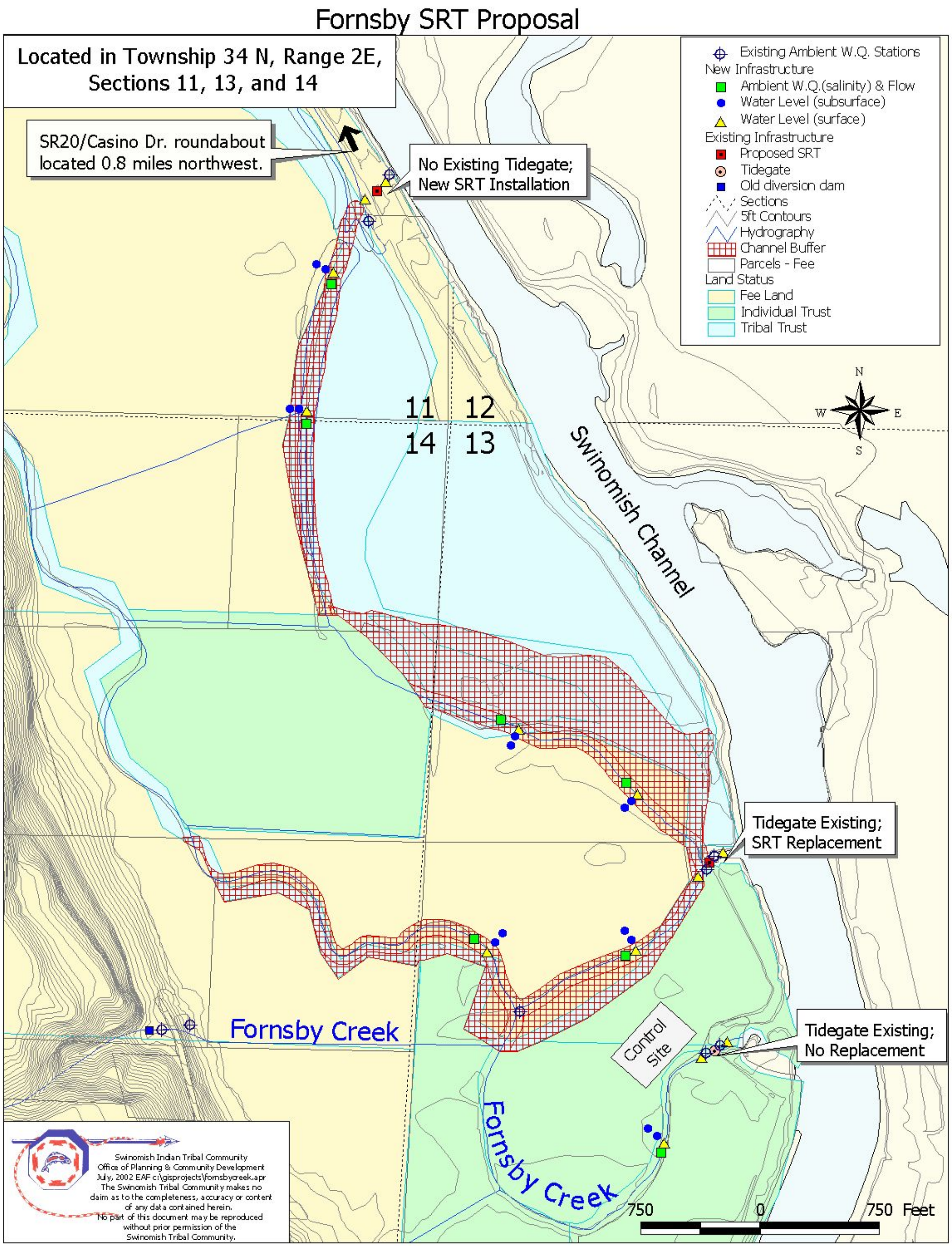


Figure 11.8 *Fornsby Creek and Smokehouse Floodplain – Phase 1.* Fornsby Creek and Smokehouse floodplain SRT replacement project - phase 1.

11.4. LONGER-RANGE DELTA RESTORATION PROJECTS

Projects in the mid term implementation horizon are those that have a significant degree of uncertainty that involve resolution by a new or established institutional mechanism. For example, the complexities involving the creation of a cross-island connector potentially involves many different individuals and a hand full of organizations. The incentive mechanisms for each of these parties differ. With these types of projects we are faced with identifying the incentive mechanisms that exist, or the mechanisms that could exist.

Therefore, this plan recognizes the need for an incentive framework that balances the needs of the individual with those of society. The mechanism by which such a balance is struck must rest with an institution that adequately represents the social and political will of local Skagit communities, relative to their responsibilities to the welfare of the region and State. Successful implementation of complex projects will require that first the appropriate institution is identified, and then the required ways and means are made available to such an institution. These requirements, by nature will require mandates by legislative bodies charged with meeting the will and the intent of public interest.

The following projects are likely candidates for the application of institutional ways and means.

11.4.1 Blake's Bottleneck

Project Summary

This project encompasses several alternative actions that can be implemented in the vicinity of the terminus of Rawlins Road and Blake's marina complex. Each action seeks to setback levees in such a way as to create additional emergent marsh and riverine wetlands. There is potential synergy between this project and the concept of a North Fork Levee setback. The projects footprint would vary substantially based on the willingness of private landowners to engage and the institutional incentives provided for their consideration. The alternatives evaluated include: Thein Farm (Figure 11.9), Rawlins Road Dike Setback (Figure 11.10), and Blake's Bottleneck.

Purpose

To restore riverine tidal habitats for Chinook rearing.

Populations Targeted

All

Estimated Cost

Feasibility studies have been funded through the SRFB in 2004. These studies will lead to more specific cost estimates and viable alternatives. Gross planning estimates place this project in the $3 million range including acquisition costs for full restoration for the Blake's Bottleneck and Rawlins Road Dike setbacks together. Add another $1 million for Thein farm project.

Timeframe

This project is being discussed with representatives from the Agricultural community and local landowners. The timeframe for implementation hinges on the ability of restoration planners and government officials to institutionalize long-term incentives that respect stewardship of the respective properties post project implementation.

Contingencies
As with all long-term project areas we expect numerous variables subject to resolution. This project can still take a variety of forms based on landowner willingness and institutional incentives.

Expected Direct Results
Physical: Thein Farm could yield 84.5 acres or 34.2 hectares of marsh area with a 1.039 connectivity rating. Channel allometry modeling indicates this could yield 1.04 hectares of channel area. Rawlins Dike Setback could yield 72 hectares of marsh area yielding 3.96 hectares of channel habitat. Blake's Bottleneck could yield 7.48 hectares of marsh and .067 hectares of channel habitat.
Biological: Thein Farm would be expected to yield 30,000 smolts per season. Rawlins setback 95,000, and Blake's Bottleneck 1,780.

Effectiveness Monitoring
This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions
Riverine hydrology in the area could raise topography over time and limit the long term persistence of channels. Channel development must be closely monitored along with succession of vegetation. Invasive plants would need to monitored and controlled. If levee removal is not possible consider application of SRT technology.

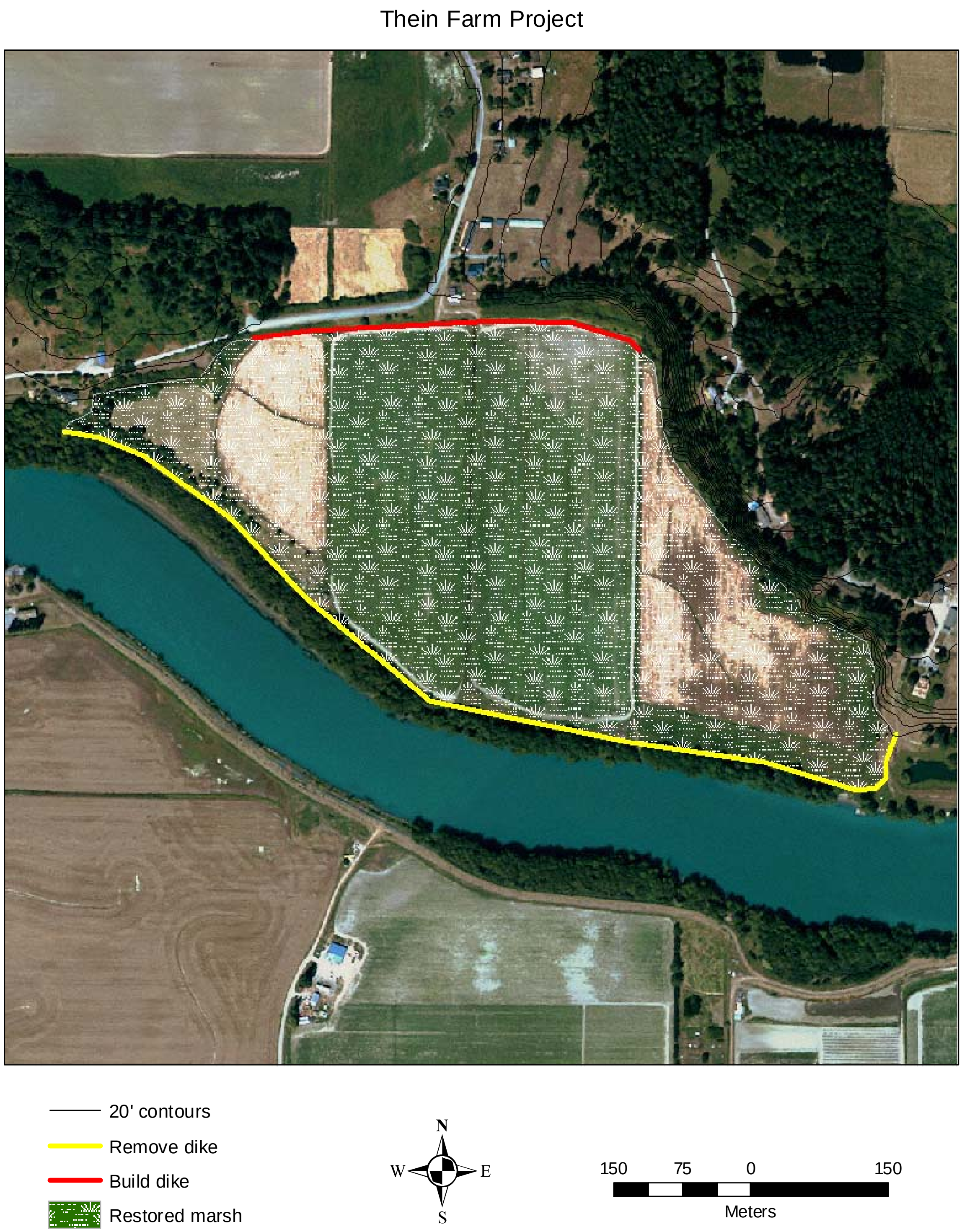


Figure 11.9. *Thein Farm.* Conceptual restoration design for Thein farm project. Dike reinforcement is shown in red. Dike removal is shown in yellow.

Rawlins Road Levee Setback

Figure 11.10. *Rawlins Road.* Conceptual restoration footprint for the Rawlins Road levee setback project.

11.4.2 Telegraph-Phase 2

Project Summary

Following restoration actions described in Telegraph Phase 1 this project seeks to re-establish connectivity and estuarine marsh habitat through the historic footprint of the former Telegraph slough corridor. This project will necessitate concurrence from the WSDOT and local landowners. Isolation of this historic slough pathway was the direct result of State actions through the construction of the Highway 20 corridor. Therefore, restoration will require significant resources to address the barrier created by Highway 20 (Figure 11.11).

Purpose

To expand restoration of estuarine emergent marsh habitats in the Swinomish Channel corridor once Chinook passage is improved through the McGlinn Island project.

Populations Targeted

All

Estimated Cost

This project does require concurrence from local landowners. Key property owners are few, but will likely need to evaluate incentives and success of Telegraph-Phase 1 before committing to further restoration objectives. Initial estimates place this potential action at between $3-5 million.

Timeframe

Again this project hinges on the success and/or failure of the phase 1 project proposal. Assuming that the phase 1 project can be implemented on a schedule that results in tidal influences throughout the phase 1 site by 2007, then we might assume favorable reaction and potential implementation by 2011.

Contingencies

Passage through Highway 20 is a costly necessity for this project. If this cannot be accomplished the value of the additional action would be diminished. We strongly recommend WDOT review of the proposal and determination of preliminary feasibility. Expected results are based on Causeway project implementation. Agreement from the primary landowners - the Bell family - would also be required. Flood feasibility studies are evaluating the potential for developing a flood bypass through the vicinity. This may or may not affect the project and should be evaluated if the bypass option is pursued by USACE.

Expected Direct Results

Physical: Restored habitat connectivity (0.016 connectivity index) and 197 ha of restored estuarine habitat with 15 ha of channel and openwater habitat.
Biological: Increase habitat capacity by 113,145 smolts.

Effectiveness Monitoring

This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions

Vegetation: Move from passive to active restoration strategies. Channels: Assess surface runoff and/or withdrawals. WQ: Monitor effluents for deleterious effects

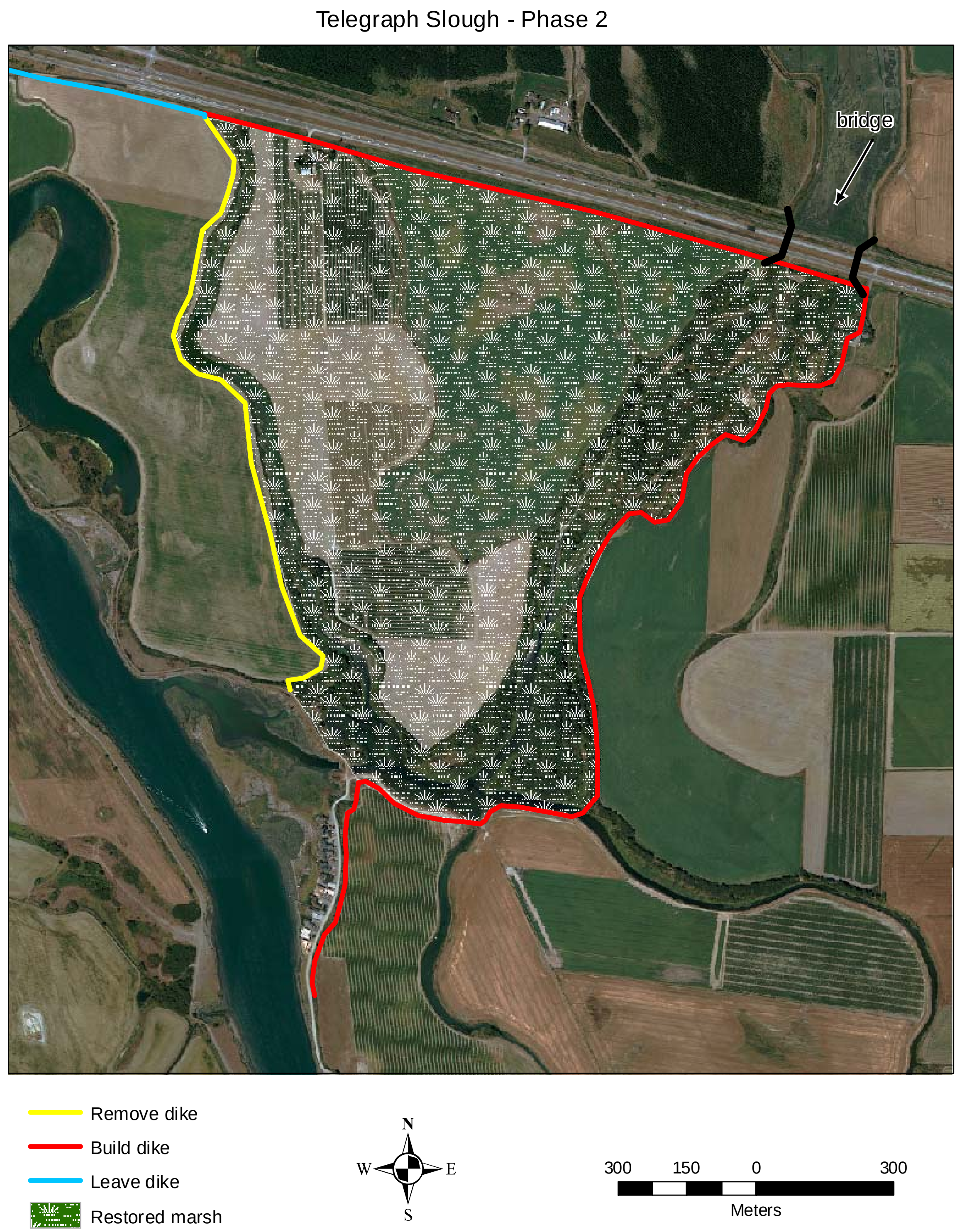


Figure 11.11. *Telegraph Slough - Phase 2.* Conceptual restoration design showing levee setback and additional marsh area that would complement the area created in phase 1.

11.4.3 Smokehouse-Phase 2

Project Summary:
The phase 1 project opens the Smokehouse floodplain to fish access. This project seeks to set back levees through key areas of the Smokehouse floodplain, allowing expression of larger emergent marsh communities and associated blind channel networks.

Purpose
Increase the availability of emergent marsh habitats in the Swinomish channel corridor once Chinook passage is improved through the McGlinn Island project.

Populations Targeted
All

Preliminary Cost Estimates
Costs again will depend on the actual alternatives proposed. Preliminary estimates predict dike setbacks of over 5500 lineal feet. Overall project cost is expected top be in the $2,000,000 to $3,000,000 range.

Timeframe
Assuming successful completion of elements of the first phase of estuarine projects we would expect this project to come on line in 2010.

Contingencies
Unsuccessful development of Phase 1 projects would lead to a break down of commitment from the Swinomish Indian Tribal Community. This would result in postponement until previous commitments have been delivered.

Expected Direct Results
Physical: This project would be expected to yield 37.46 hectares of additional marsh area, which would in turn provide 1.38 hectares of channel area at a .0166 connectivity rating.
Biological: The biological yield would be ~10,890 smolts per year or 56 adults per year with average survival on a low regime.

Effectiveness Monitoring
This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions
Review functionality of causeway connections. Consider NF pathways. Examine the functionality of habitats between North and South ends of the channel. Pursue active vegetation restoration if needed to compete with invasive species.

11.4.4 Cross Island Connector

Project Summary:
This project looks to re-establish connectivity between the North Fork of the Skagit and the central bay front along Fir Island. This is most likely through the development of a connecting corridor that follows one of two historic pathways (Browns Slough and/or Dry Slough) or through low-lying farmlands.

Purpose
Restore historic distributary connections that will improve connectivity for fish, water and sediments to underutilized, and eroding, emergent marsh habitats in central delta.

Populations Targeted
All

Estimated Cost
Costs are difficult to ascertain given the complexities and wide array of engineering solutions that are part and parcel to this project proposal. Conservative estimates place this project in the $2-5 million range.

Timeframe
This element of the recovery plan is viewed as a critical element that serves to increase productivity within established emergent marshes. Central Fir Island marshes are currently under performing due to the loss of sediment and water pathways through the central core of the island. Therefore, this element has been targeted as a key element of the ten-year work plan. Its probability is considered moderate depending largely upon the culmination of political will, funding and landowner incentives.

Contingencies
A number of potential pathways exist and have been described in some detail in the Fir Island Feasibility Study completed for the Skagit Watershed Council in 2004 (SRSC and PWA 2004). Each of these pathways possesses its own merits and drawbacks. A number of technical issues must be addressed with local communities such as issues with flood protection and drainage infrastructure function. If solutions can be found and engineered this project could be implemented.

Expected Direct Results
Biological: Chinook model estimates place the value of this action at approximately 240,000 smolts, making it one of the most significant single measures that could be undertaken to recover Skagit Chinook populations.
Physical: Increased tidal influence and mixing and improved migration pathways in the delta.

Effectiveness Monitoring
This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions
Backup actions will depend on approved design. We will assume that flood and tidal regulation will be a required feature by local landowners. Facilitating the development of drainage infrastructure will be required. In addition water management issues could be addressed. Monitoring of fisheries benefits will inform management plan.

11.4.5 Sullivan's Hacienda

Project Summary

This project proposes to setback levees to a pre 1956 footprint. Thereby, allowing for the re-establishment of emergent marsh and blind channel networks in the vicinity of Sullivan's Slough (Figure 11.12).

Purpose

Increase emergent marsh rearing habitat in tidal delta

Populations Targeted

All

Timeframe

If incentive programs can be established and drainage infrastructure needs addressed, this project could potentially be implemented within the 10-year time horizon if landowner agreement can be secured. This in part will be informed by the success or failure of efforts to establish institutional mechanisms for long term landowner incentive programs.

Estimated Cost

Allow $3 million for completion of this project.

Contingencies

Landowner agreement and drainage infrastructure. Significant drainage questions need to be addressed.

Expected Direct Results

Physical: Currently, 2.6 acres or 1.0 miles of ditches or vestigial tidal channels exist landward of dikes on the study site (Fig. 11.12). Restoration of tidal inundation could result in the redevelopment of 5.8 acres or 4.8 miles blind tidal channels. Seaward of the dikes there are currently 1.3 acres or 0.8 miles of blind tidal channel. Photos from 1937 show 3.4 acres or 0.7 miles of blind tidal channel seaward of the dikes. Modeling indicates the possibility of sustaining 1.9 acres, 1.6 miles of blind tidal channel. This amount is less than historical because the study site is half the size of the amount of marsh present in this area in 1937 (later diked by 1965).
Biological: The Chinook production benefit under this scenario is ~36,517 smolts annually.

Effectiveness Monitoring

This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions

Vegetation: Move from passive to active restoration strategies
Channels: Assess surface runoff and/or withdrawals
WQ: Monitor effluents for deleterious effects

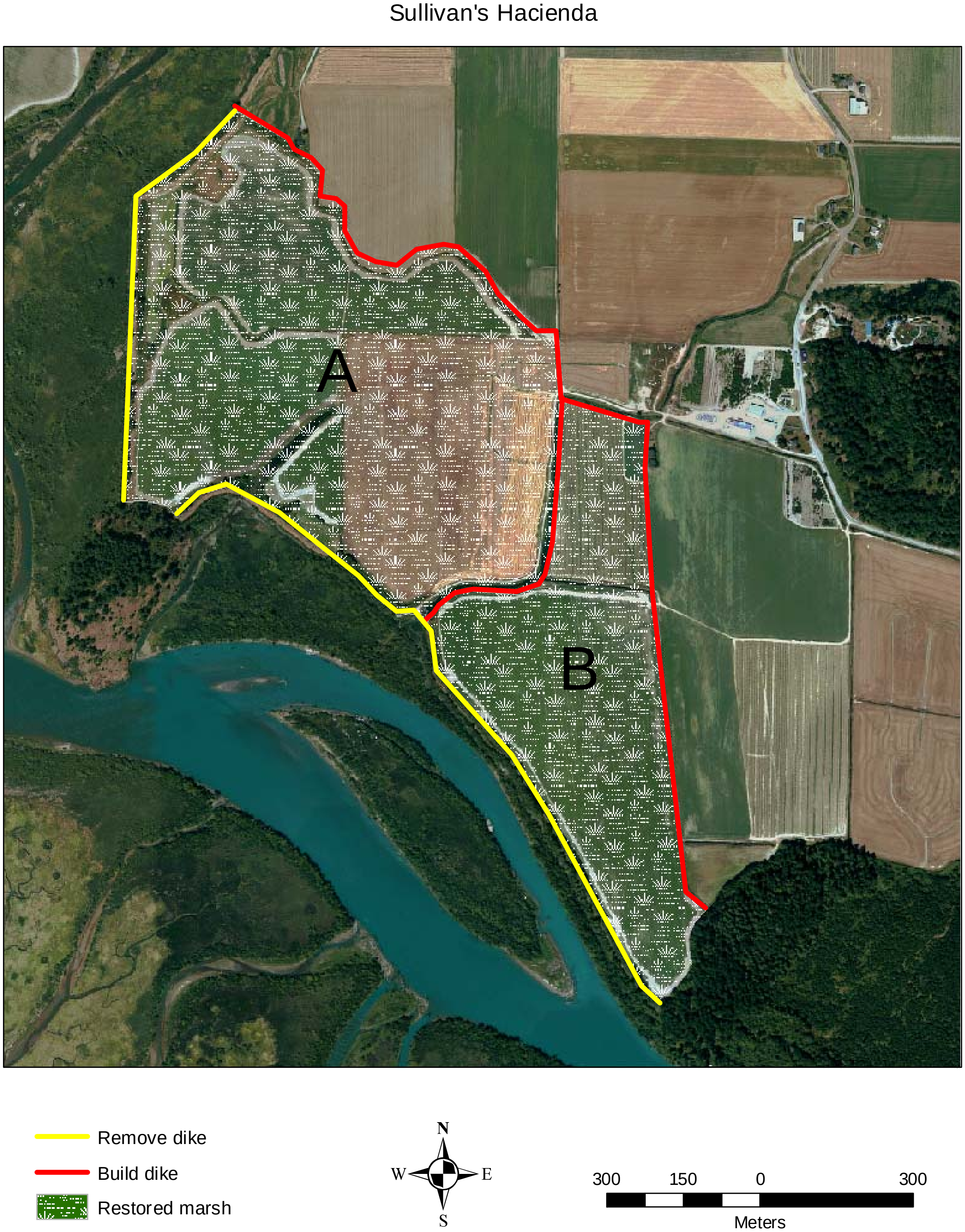


Figure 11.12. *Sullivan's Hacienda.* Channels interior (green) and exterior (dark blue [2000] and light blue [1937]) to the dikes. Light blue areas have filled in with sediments since 1937 and been transformed to marsh (outside the dikes) or agricultural land (inside the dikes). Note that the 1937 aerial photo was in black and white and had considerably lower resolution than the 2000 color aerial photo. Consequently, 1937 channel abundance is likely underestimated.

11.4.6 Deepwater Slough-Phase 2

Project Summary
If recovery goals are still not being achieved after the ten-year time horizon the WDFW will come under increasing pressure to restore the remaining habitat at the Deepwater Slough site. This would likely involve the complete removal of levees around each of the two lobes left after the first Deepwater project (Figure 11.13).

Purpose
Increase tidal delta rearing habitats in scrub-shrub zone

Populations Targeted
All

Estimated Cost
Estimate 2-3 million depending on the extent of levee removal.

Contingencies
Pressure from private landowners could press this project site into an earlier phase of restoration. Presently the site services a single user group. Making it a potential target by other user groups who would prefer to see restoration pressures realized by WDFW.

Expected Direct Results
Physical: Restored habitat connectivity (0.026 connectivity index) and 108.5 ha of restored estuarine habitat with 4.5 ha of channel and openwater habitat.
Biological: Increase habitat capacity by 95,5165 smolts.

Effectiveness Monitoring
This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions
Vegetation: Move from passive to active restoration strategies
Hydrology: Disconnect or fill remnants of drainage network
Complexity: Add roughness to floodplain
Channels: Move from passive to active restoration strategies (e.g., identify site level opportunities for channel excavation)

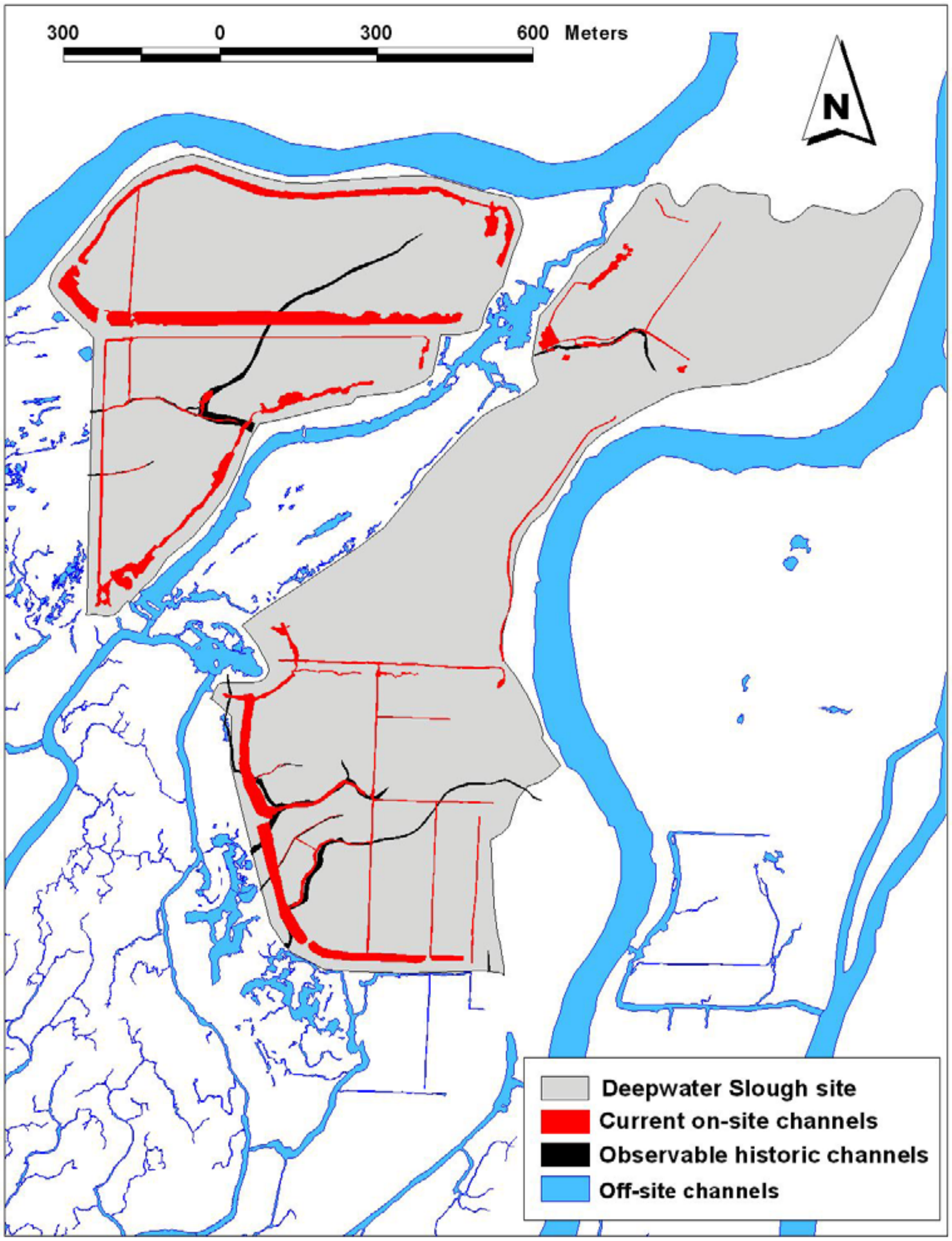


Figure 11.13. *Deepwater Slough - Phase 2*. Current on-site channels (red), including borrow ditches. Historical channels (black; observed from maps or historical photos) often coincide with current channel remnants or topographic swales visible in LIDAR imagery. Most of the site was already diked by 1889, so detailed reconstruction of historical channels is not possible.

11.4.7 North Fork Levee Setback

Project Summary
This project proposes to setback levees along the North Fork of the Skagit from the former inlet of Dry Slough to the Western terminus of the levee system near Rawlins Road. The proposed project could be phased in four distinct phases depending on its merit as a flood control project (Figure 11.14).

Purpose
Increase available floodplain for riverine tidal rearing habitats

Populations Targeted
All

Estimated Cost
This project could be over $15 million depending on choices made for phasing. The relationship to flood control for Fir Island is a keystone to this project, so USACE involvement is paramount.

Timeframe
If flood control benefits can be realized this project has a reasonable chance to be implemented. The timeframe for implementation would be long term given the planning complexities.

Contingencies
Its relationship to flood control, wide spread public support, and subsequent investment.

Expected Direct Results
Physical: If implemented in its entirety this project could yield 266.215 hectares of tidally influenced habitat. This habitat would have the added benefit of being a contiguous corridor cutting across several different habitat types. Channel potential is approximately 12.196 hectares with a high connectivity of .092.
Biological: Total smolt contribution could be 625,032.

Effectiveness Monitoring
This project would be monitored as described in estuary monitoring strategy outlined in Chapter 15.

Backup Actions
Vegetation: Move from passive to active restoration strategies
Hydrology: Lower floodplain topography.
Complexity: Add roughness to floodplain
Channels: Move from passive to active restoration strategies (e.g., identify site level opportunities for channel excavation)

North Fork Levee Setback

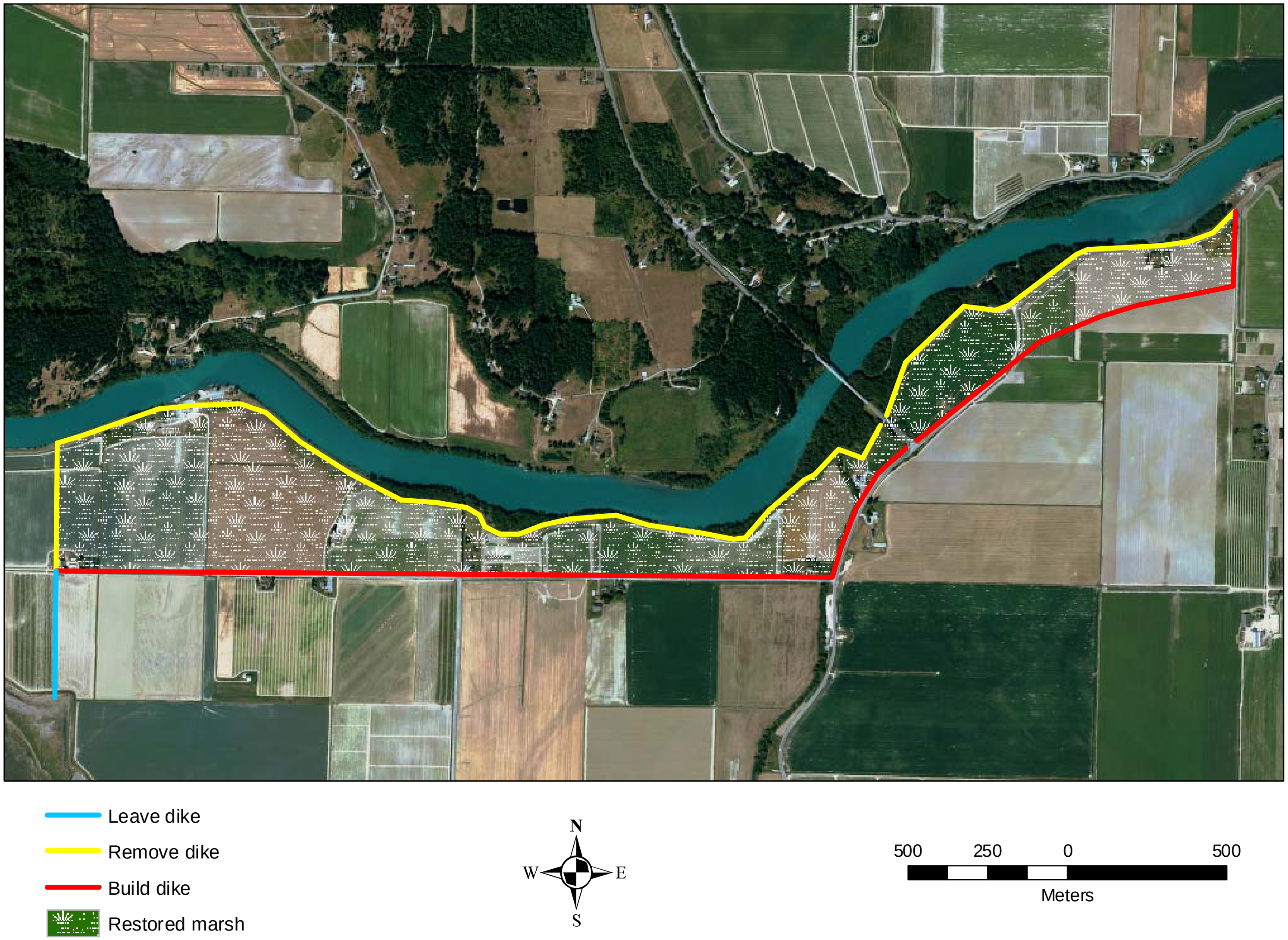


Figure 11.14. *North Fork Levee.* North Fork Levee setback showing extent of the first section of levee setback.

12. RESTORATION ACTIONS IN NEARSHORE REARING HABITAT

12.1. GENERAL NEARSHORE RESTORATION STRATEGY

Our nearshore restoration strategy focuses first on general precepts that can be applied throughout nearshore habitats in the Puget Basin that could be utilized by Skagit Chinook salmon as well as all Puget Sound and British Columbia stocks. Then, in more detail, we focus on restoration objectives in habitats specifically identified by our research in Skagit Bay: pocket estuaries utilized and preferred by Skagit-origin Chinook salmon.

Juvenile Chinook salmon utilize inland coastal waters such as the greater Puget Sound extensively, and survival during this residence period has been correlated with the overall success of their respective populations (Greene et al. 2005, Beamish et al. 2004). Chinook salmon using this area are exposed to different levels of survival risk due to differences in their migration timing, location, and duration of habitat use. Moreover, the greater Puget Sound environment is not homogeneous in habitat type or quality due to both natural and human causes. Thus Chinook salmon rearing potential varies across the landscape. A more specific understanding of the origins of juvenile Chinook salmon using this landscape will fill a glaring data gap needed for Puget Sound Chinook salmon population recovery by linking specific populations to specific areas within the greater Puget Sound and specific habitat types (see Chapter xx). The nearshore (intertidal and shallow subtidal) portions of the "salmonscape" can be influenced by human caused disturbances and thus can be improved by our management actions. A process-based restoration strategy is fundamental to long-term recovery because nearshore processes interacting with the landscape at a local scale determine and maintain the characteristics of habitats available to salmon and other species upon which salmon depend for their survival in the nearshore environment,

A Process based strategy requires that coastal and watershed processes influencing nearshore habitats remain or are restored to functional levels. These nearshore processes are both geomorphic and chemical. They include:

- Longshore sediment erosion, transport, and deposition within littoral cells;
- Tidal erosion;
- Tidal range, volume, and bathymetry;
- Fluvial deposition;
- Freshwater inflow and estuarine mixing; and
- Water and sediment quality.

12.1.1 Landscape Process Restoration

Restoration at the landscape process scale ensures the sustainability of existing habitats and facilitates the recreation of lost historic habitat. Specific objectives of our strategy include:

1. Protect existing and restore lost pocket estuary emergent marsh, channels and impoundments.
2. Protect existing and restore lost tidal connectivity and volume within pocket estuaries.

3. Preserve unarmored and restore armored sediment source beaches in littoral cells that create and maintain spits forming pocket estuaries.
4. Restore lost pocket estuary sites over a large spatial scale to protect and restore regional scale connectivity between pocket estuaries and between deltas and pocket estuaries.
5. Protect existing and restore lost or degraded freshwater inputs (quantity and quality) to pocket estuaries.
6. Restore pocket estuaries of various geomorphic types to maintain habitat diversity and functionality throughout variable long-term climatic and oceanographic conditions.
7. Protect existing and restore armored coastal landforms, like spits and cusps, which form pocket estuaries such that these landforms can change and function naturally to protect and maintain pocket estuary habitat.
8. Remove impediments to fluvial and coastal sediment transport processes.
9. Protect and restore known forage fish habitats, including intertidal and subtidal spawning habitats for smelt, sandlance and herring as well as larval rearing areas (known to include pocket estuaries at least for smelt) and eelgrass meadows;
10. Identify and implement protocols that protect juvenile salmon in boat harbors and other industrialized or modified shorelines. Boat harbors are a common habitat in the current nearshore landscape. They are relatively protected from the natural coastal energy regime and therefore do attract juvenile salmon and other estuarine fishes. However, they are not natural habitats so we can expect the fish community to be different, possibly with the introduction of more predators or a changed food chain. Also, fish within these areas are exposed to risks such as direct pollution spills not present in natural habitats.
11. Plan for predicted sea level rise in all nearshore restoration projects.

In addition to landscape process restoration, part of ensuring safer transition of Chinook salmon from natal rivers to the open ocean is protecting “choke points” within the Puget Sound ecosystem from catastrophic human disturbances such as oil and toxic spills. Choke points are those places where large proportions of salmon populations must travel through. For Puget Sound Chinook salmon this would include Admiralty Inlet. For Skagit Chinook salmon, it would include Deception Pass, Swinomish Channel, and Saratoga Passage. One catastrophic disturbance in a choke point could destroy a very high percentage of an individual salmon population.

12.1.2 Pocket Estuary Restoration

The biological evidence from our research near the Skagit River indicates that restoration of pocket estuaries within the Skagit’s nearshore environment will help improve the abundance and resilience of Skagit Chinook salmon populations. Our nearshore restoration strategy is three fold: 1) increase opportunity for juvenile Chinook salmon to utilize pocket estuary habitat close to their natal rivers so that outmigrants can make a safer transition from the river to the marine environment; 2) increase opportunity for juvenile Chinook salmon to utilize pocket estuaries throughout the Whidbey Basin for safe rearing and traveling through the nearshore; and 3) ensure healthy and functioning nearshore beaches connecting pocket estuaries for the benefit of forage fish and Chinook life history strategies that do not directly utilize pocket estuaries.

To maximize recovery benefits for Skagit Chinook salmon of any pocket estuary restoration, we first prioritize restoring and protecting pocket estuaries with a high degree of connectivity to the Skagit Delta. We have based our prioritization on existing fish migration pathways estimated from the drift buoy study (Appendix D.VI). We hypothesize that habitats "downstream" of tidal currents originating at river mouths are more important to fry migrant Chinook salmon populations than habitats "upstream" or distant from the same tidal currents. We base this hypothesis on our data suggesting pocket estuary habitats provide a rearing and refuge opportunity to fry migrants (Beamer et al. 2003) and on the idea that providing pocket estuary opportunity soon after fry leave delta or river habitats will reduce risk of mortality by reducing the time individual fish spend in the exposed nearshore or offshore environment at a small size.

12.2. IMPLEMENTATION

Potential pocket estuary restoration sites are shown in Figure 12.1. We have targeted as a priority the pocket estuaries in close proximity to the river. Each site listed in Figure12.1 has existing habitat, restoration potential, or both. Based on our understanding of fish migration pathways from the delta to nearshore areas within Skagit Bay, juvenile salmon could reach any of these pocket estuary sites quickly, often within five or six hours after leaving the delta. Because fish can find these sites within a day or less of when they leave the river, we believe they are a restoration priority for fry migrants that experience delta density dependence or are flushed out of the river during a high flow event.

In the following sections individual pocket estuary projects will be described in some detail, depending on the relative level of restoration project development. The follow descriptions provide details of specific pocket estuary projects that have been identified throughout Skagit Bay. While not exhaustive or inclusive, the identified projects would result in a total of 311.5 hectares (769.6 acres) of intertidal and subtidal pocket estuary habitat available to fry migrant Chinook salmon within a day's migration from the Skagit River delta (Table 12.1). This prediction is based on the assumption that the collective pocket estuary footprint when restored will result in 31.1 hectares (76.8 acres) of additional channel habitat (e.g., tidal channels or impoundments, subtidal channels or open water). Therefore, this particular end state would yield a pocket estuary capacity for fry migrant Chinook salmon that would increase from 73,393 to 221,264 smolts annually.

Of these, Dugualla Bay potentially provides the single largest contribution. This is in part because of its high level of connectivity and size. This site is near the mouth of the North Fork Skagit River, the distributary pathway where density dependent migration of fry migrant Chinook salmon is highest within the Skagit Delta.

In the descriptions that follow we will be separating projects into five, ten and fifteen year time horizons based on their relative complexity and uncertainty. Those that are described in the five-year time horizon all relatively well underway in terms of planning and feasibility. Those further in the future, such as Dugualla Bay, depend on several unknown variables that are more difficult to predict. The first seven projects listed are in the 5-year Implementation Horizon. These projects are underway, have significant local support, or have been developed to a level of refinement that would allow for potential implementation within a five-year time horizon are described in the following sections. The following 12 projects have been identified through preliminary evaluations as potential projects with moderate likelihood of success, but have not been developed well enough to be implemented in the near term horizon. Dugualla Bay in particular has enough complexity to require at least several more years of planning and development before implementation can be pursued.

Figure 12.1. *Pocket estuary sites within one day's migration from the Skagit River delta by fry migrant Chinook salmon.*

Table 12.1. *Summary of potential habitat area, connectivity, and annual Chinook smolt benefit by pocket estuary sites after restoration.*

Project Area	Potential estuarine area (ha)	Potential channel or openwater area (ha)	Connectivity index	Smolt capacity
Ala Lagoon	10.012	1.789	0.017	14,122
Arrowhead Lagoon	4.773	0.691	0.011	3,671
Crescent Harbor	83.366	5.168	0.007	15,983
Dugualla Lagoon	156.939	9.730	0.020	93,758
Dugualla Bay Heights	2.550	2.398	0.023	26,025
English Boom Lagoon	9.551	0.563	0.013	3,418
Kiket Lagoon	1.416	0.900	0.014	6,219
Lone Tree Lagoon	2.590	1.318	0.017	11,038
Mariners Cove	8.007	5.394	0.011	27,448
Similk Beach	9.551	0.592	0.013	3,782
SneeOosh Lagoon	1.093	0.068	0.018	593
Turners Bay	21.610	2.469	0.013	15,203
Total	311.457	31.080		221,264

12.3. NEARSHORE RESTORATION PROJECTS

12.3.1 Lone Tree Lagoon

Project Summary
1) Pocket Estuary Restoration: Replace a 24-inch tidally inundated culvert with a 50-foot bridge to reconnect and restore tidal marsh. Remove road and campsite fill in the historic marsh above the culvert. Protect and restore sediment source beaches in adjacent drift cells that maintain the lagoon spit. 2) Stream Restoration: Restore in-stream habitat in the lower 700 feet of Lone Tree Creek, which flows into Lone Tree Lagoon. Replace four undersized culverts with channel spanning squashed culverts. Line all new culverts with streambed material. Eliminate one undersized culvert and restore channel in its location. Remove riprap and enhance buffer in lower riparian corridor. 3) Water Quality: Reduce water quality impacts by addressing key sediment and fecal contaminant sources in lower 700 feet of the creek. Restore watershed hydrology and in-stream flow (Figure 12.2).

Purpose
Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted
Restoration will benefit the fry migrant life history type from all six Skagit stocks. Chinook, coho, and steelhead juveniles will benefit directly due to their utilization of the lower creek corridor.

Cost
Characterization and Feasibility were funded through EPA PPG Section 319 for $90,476. Pre-project fish utilization monitoring was completed in 2004 through a Marine Resource Committee grant for $7,500. Marsh and stream restoration (Actions 1 and 3) are funded through the Swinomish Indian Tribal Community and NRCS Environmental Quality Incentives Program grant for $85,000. Post project monitoring is expected to cost approximately the same amount as pre-project monitoring and is anticipated through the same funding source. Costs for Actions 2, 4, and 5 have not been determined.

Probability and Timeframe
Site characterization and feasibility are complete for marsh and stream restoration. Project design is in progress for the bridge and culverts. Construction plans and permitting are targeted to be completed in time for construction in late summer 2005.

Contingencies
There are five alternative conceptual designs. If the preferred alternative is not implemented, one of the remaining four designs, or a combination of these will be implemented. The proposed actions are proven restoration measures for estuarine marsh. If water quality improvement measures don't reduce sediment and fecal coliform input to the stream, additional measures may be implemented.

Expected Direct Results
Physical: This project will restore 0.22 ha of tidal marsh and 130 m^2 of in-stream habitat that has been eliminated by filling, ditching, rock armoring, and culverting. However, project components will protect the entire 2.59 ha pocket estuary from threats that risk the productivity of the entire

lagoon. Water quality improvement measures will reduce sediment and fecal coliform input to the stream.
Biological: Completed restoration will increase nearshore habitat fish capacity by an estimated 613 smolts annually. Protection components of this project should preserve the capacity of the entire lagoon (11,038 fish). Fish use is expected to increase in the restored area immediately after project completion. Increased utilization should occur as the disturbed project areas stabilize and in-stream habitat increases.

Effectiveness Monitoring
Post-project fish utilization will be monitored and compared with pre-project data. Habitat formation, culvert function, buffer re-establishment, bank stability, and water quality will also be monitored.

Backup Actions (if Direct Results not achieved):
These will be worked out as part of the assessment, design, and permitting process.

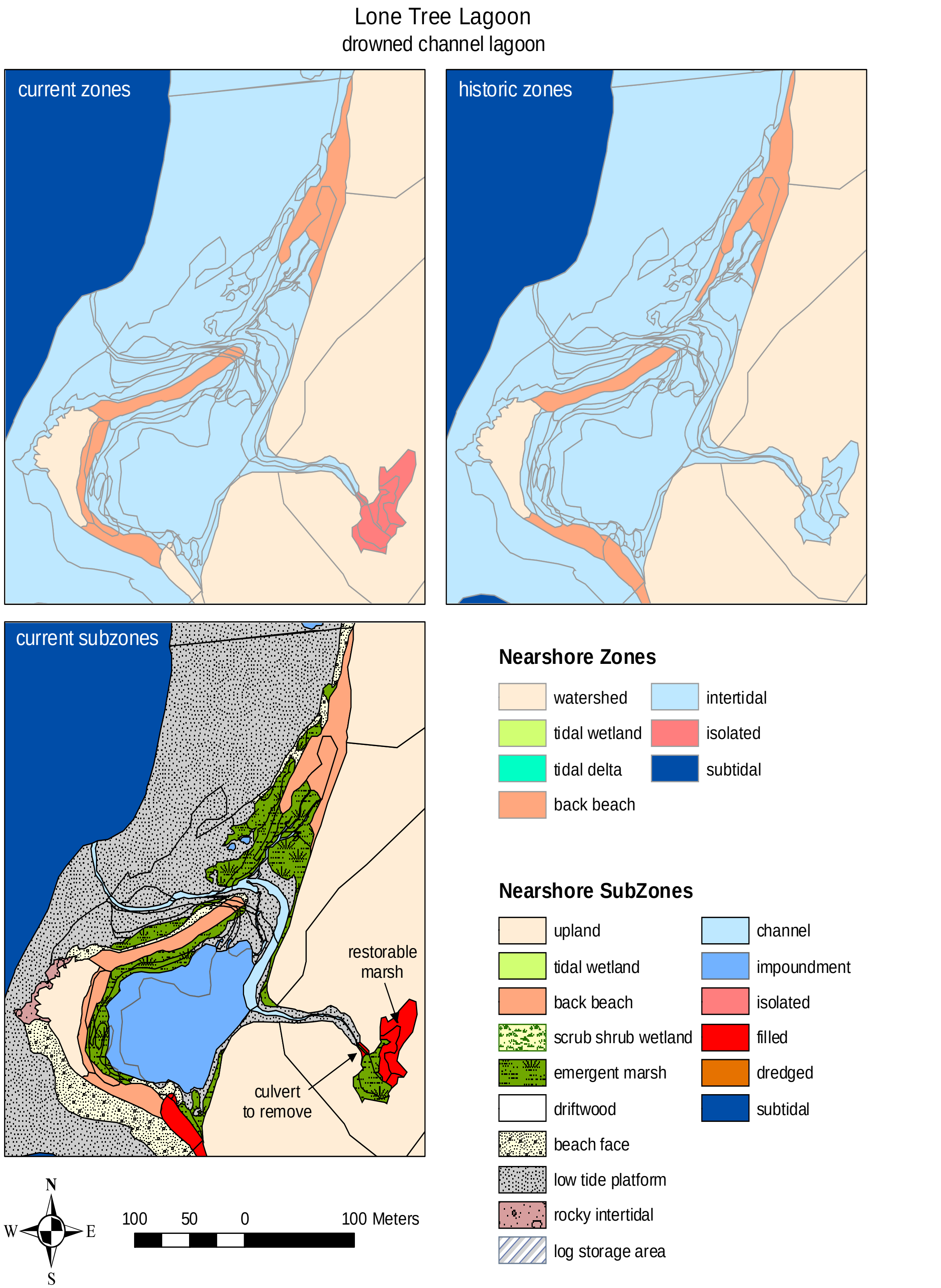


Figure 12.2. *Lone Tree Lagoon.* Lone Tree Lagoon is mostly intact. However, its watershed is severely impacted by paving and hydrologic modifications. This site is currently being studied for restoration. The culvert and tidal marsh to be restored are labeled.

12.3.2 Arrowhead Lagoon

Project Summary
1) Restore intertidal pocket estuary habitat by: a) Increasing the lagoon opening by approximately 60% by removing a hydraulic restriction caused by trail fill. b) Restoring natural tidal processes including tidal prism to the entire western portion of the lagoon by removing approximately two acres of fill, for a 30% to 40% increase in habitat capacity. 2) Protect and restore sediment source beaches in adjacent drift cells that maintain the lagoon spit. 3) Address water quality issues related to septic fields adjacent to the marsh (Figure 12.3).

Purpose
Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted
Restoration will benefit the fry migrant life history type from all six Skagit stocks.

Cost
The cost for marsh restoration (Action 1) will be approximately $260,000. Match funding has been approved through the SRFB. The BIA will provide the remaining funding. Costs of Actions 2 and 3 have not been evaluated.

Timeframe
Planning, design, and permitting work should take approximately one year. Construction is anticipated to begin summer 2006 due to seasonal work windows.

Contingencies
The project includes construction of a bridge to span the intertidal channel that is currently plugged by trail fill. This will require coordination with and approval from the property owners. Numerous bridge options will be explored. Fill removal may increase or decrease based on soil investigation findings within the fill areas. Additional fill removal from adjacent inner shoreline may be considered to offset a reduction in channel opening created by bridge limitations.

Expected Direct Results
Physical: This project will restore approximately 2.43 hectares of tidal marsh habitat that has been eliminated by filling and diking. Channel area will increase by approximately 0.7 hectares. Local connectivity for this pocket estuary should improve significantly due to increased channel entrance cross-section area and depth. Project components will protect the entire 4.78 ha pocket estuary from threats that risk the productivity of the entire lagoon.
Biological: Completed restoration will increase nearshore habitat fish capacity by and estimated 799 smolts annually. It is expected that there will be an immediate increase in fish use above the lagoon restriction following project completion. Protection components of this project should preserve the capacity of the entire lagoon (3,671 fish).

Effectiveness Monitoring
Habitat restoration, buffer re-establishment, fish utilization, lagoon outlet bank stability, and water quality will be monitored. Fish utilization will be monitored by SRSC and SRFB.

Backup Actions (if Direct Results not achieved):
These will be worked out as part of the assessment, design, and permitting process.

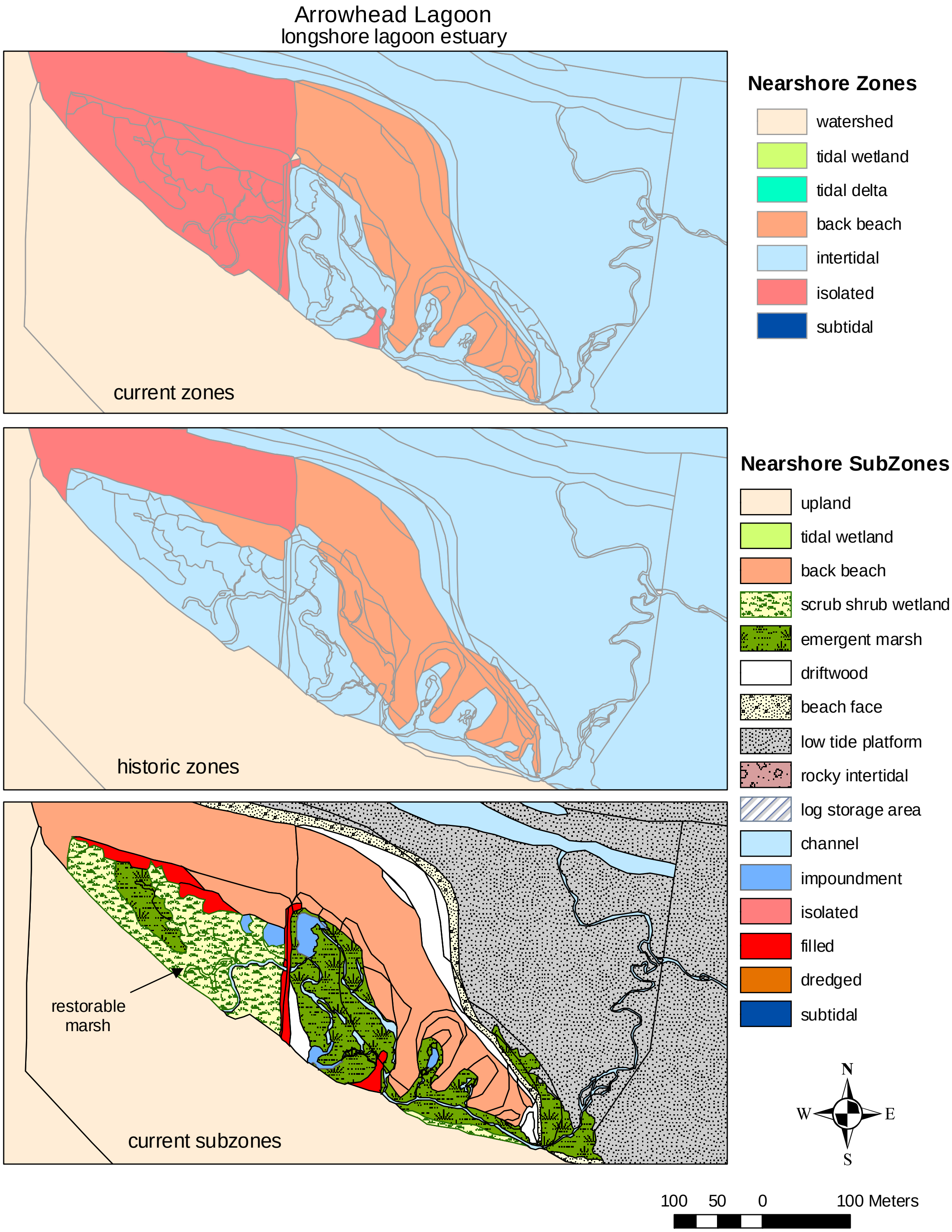


Figure 12.3. *Arrowhead Lagoon.* Arrowhead Lagoon has been diked and filled to isolate its western half. The outer beach of the spit is armored and the inner edge of the spit is partially armored and filled. This spit appears to have grown steadily to the east, with easterly curved fingers extending into the marsh as the spit has prograded. Maintaining sediment sources for this spit will be an important part of restoration and habitat protection.

12.3.3 Turners Bay Lagoon

Project Summary
1) Restore connectivity for the upper marsh area by removing road fill. 2) Address water quality and ditching in the headwater wetlands. 3)Protect existing sediment source beaches in adjacent the drift cell (Figure 12.4).

Purpose
Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted
Restoration will benefit the fry migrant life history type from all six Skagit stocks.

Cost
Proposed for feasibility work under EPA funding in 2005. Cost estimates are not available at this time

Probability and Timeframe
This project is in the early stages of investigation. The area is under tribal jurisdiction. Talks with adjacent landowners are now underway. There is mutual interest in completing a project at the site so probability is high

Contingencies
There are several businesses located along the stream and marsh feeding this lagoon. A composting business may need some evaluation in relation to its contributions to degraded water quality. Water quality monitoring will need to be stepped up to inform restoration alternatives and costs. In instances were violations are detected, enforcement actions will be pursued.

Expected Direct Results
Physical: Total estuarine habitat will increase by 3.52 hectares. Channel habitat will increase by 0.77 hectares. Project components will protect the entire 21.61 ha pocket estuary from threats that risk the productivity of the entire lagoon.
Biological: Completed restoration will increase nearshore habitat fish capacity by an estimated 4,735 smolts annually. It is expected that there will be notable increase in fish use within the lagoon immediately following project completion. Protection components of this project should preserve the capacity of the entire lagoon (15,203 fish).

Effectiveness Monitoring
SRSC will continue to monitor fish use at this site as part of ongoing research. The Swinomish Indian Tribal Community will continue to monitor water quality as part of ongoing baseline monitoring.

Backup Actions (if Direct Results not achieved):
These will be worked out as part of the assessment, design, and permitting process.

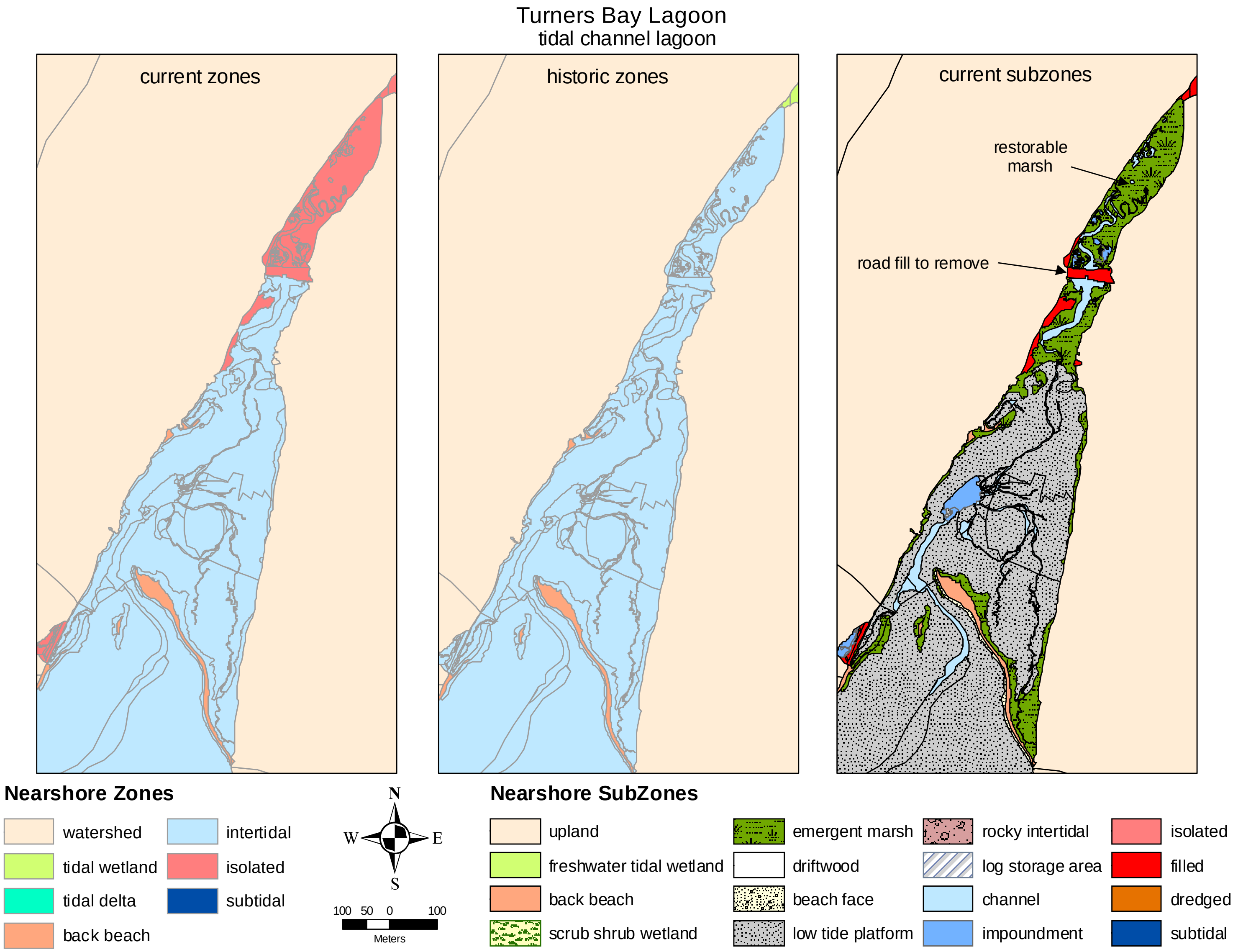


Figure 12.4. *Turners Bay Lagoon.* Turners Bay Lagoon is a tidal channel lagoon system with a small creek and wetland at its head. It is probable that the pocket estuary connected to Padilla Bay at some point during its evolution. A tide gate and road fill has isolated the upper wetland of Turners Bay Lagoon.

12.3.4 Crescent Harbor

Project Summary

Proposed restoration, developed by Island County, would include:

- Breaching the existing beach berm at the current culvert location
- Replacing the culvert with a spanning bridge
- Removing fill within the marsh at the south edge of the WWTP
- Filling existing dredged ditches and replacing them with excavated channels to mimic historic natural drainages
- Creating or improving connections between the three marsh segments (Figure 12.5)

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost and Funding Sources

Feasibility work is complete. Island County Public Works received $406,424 from the SRFB in 2000 to develop the above described restoration plan. Complete project costs are not available at this time.

Probability and Timeframe

This project is in process. Whidbey Naval Air Station is the willing landowner. An exact timeline has not been developed. Completion is probable.

Contingencies

Water quality issues stemming from the WWTP may complicate this project.

Expected Direct Results

Physical: Total estuarine habitat will increase by 83.37 hectares. Channel habitat will increase by 5.17 hectares.
Biological: Completed restoration will increase nearshore habitat fish capacity by an estimated 15,938 smolts annually. It is expected that there will be juvenile salmon within the lagoon immediately following project completion.

Effectiveness Monitoring

It is expected that fish utilization would be monitored by SRSC and NOAA fisheries as part of the on-going research.

Backup Actions (if Direct Results not achieved):

These will be worked out as part of the assessment, design, and permitting process.

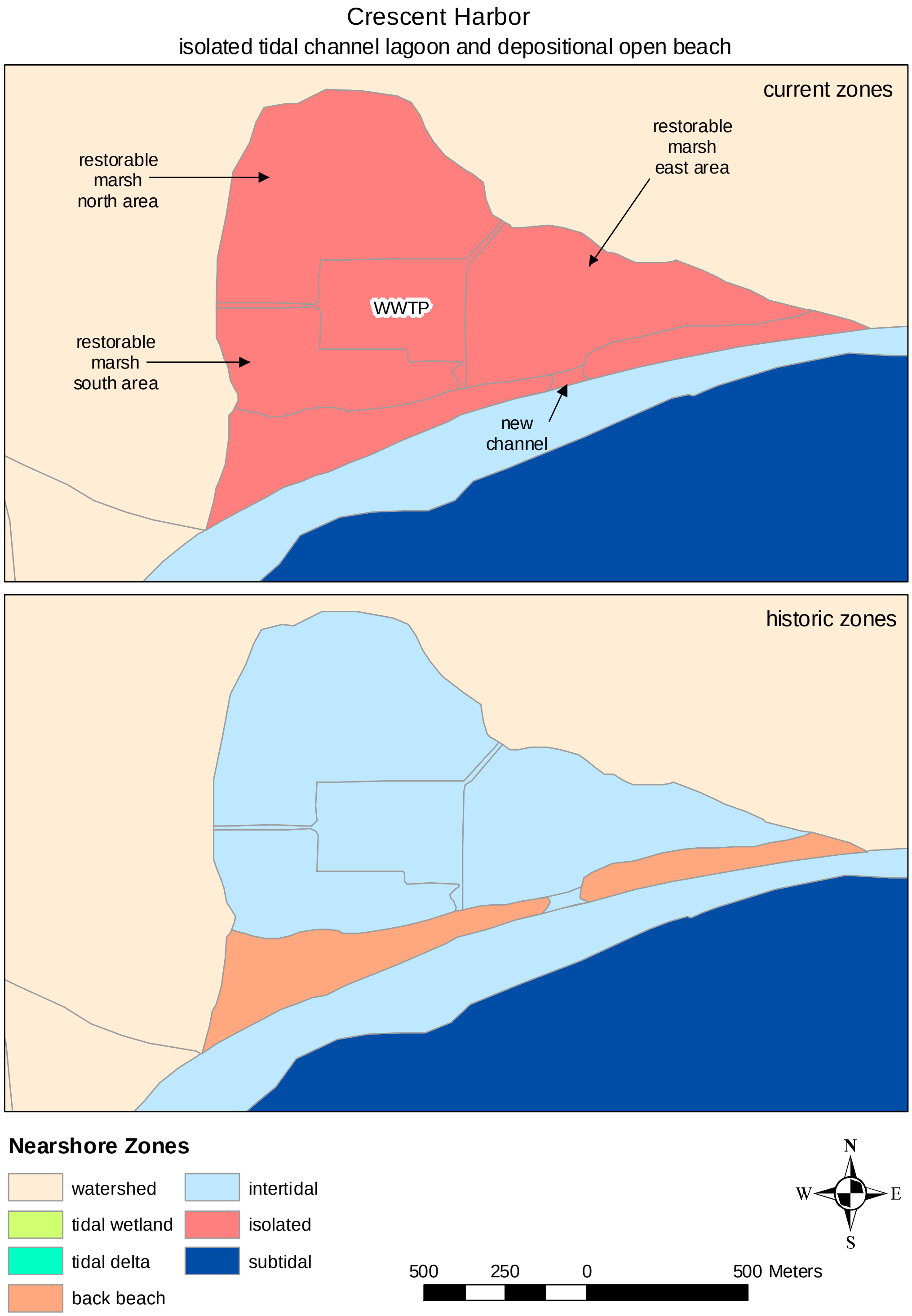


Figure 12.5. *Crescent Harbor.* Crescent Harbor pocket estuary has been completely cut off from tidal exchange except through ground water. The former spit is armored along its eastern half and filled with a road along the crest of the berm. The isolated marsh system, associated with a creek, is ditched and piped to the beach via a tide-gated culvert. Most of this system is restorable, minus a wastewater treatment pond (WWTP) and intake pipes in the middle of the marsh. The restorable marsh is in three separate segments, divided by the WWTP and intake pipes.

12.3.5 English Boom Lagoon

Project Summary

- Restore historic marsh and channels by removing dikes and fill from old log storage operation.
- Reroute the creek, which has been diverted away from the pocket estuary to flow into the pocket estuary (Figure 12.6).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost and Funding Sources

Likely SRFB proposal for 2005. Additional match monies are available through USFWS Coastal accounts, Ducks Unlimited, and WDFW. Complete project costs have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation. Preliminary correspondence has begun with Island County and WDFW. Prospects look favorable for implementation. We expect to submit a grant application to SRFB in 2005.

Contingencies

Unknown at this time.

Expected Direct Results

Total estuarine habitat will increase by 1.25 hectares. Channel habitat will increase by 0.08 hectares. Project components will protect the entire 9.55 ha pocket estuary from threats that risk the productivity of the entire lagoon. A significant part of this project is rerouting the creek back into the pocket estuary, which should help attract fish into it and increase local connectivity.

Expected Fish Use and Production Results, and Timeframe

Completed restoration will increase nearshore habitat fish capacity by an estimated 490 smolts annually. It is expected that there will be notable increase in fish use within the lagoon immediately following project completion. Protection components of this project should preserve the capacity of the entire lagoon (3,418 fish).

Monitoring of Fish Use and Production Results

It is expected that fish utilization would be monitored by SRSC as part of the on-going research into the role and function of pocket estuaries. See *Section 11: Monitoring Actions* for greater detail.

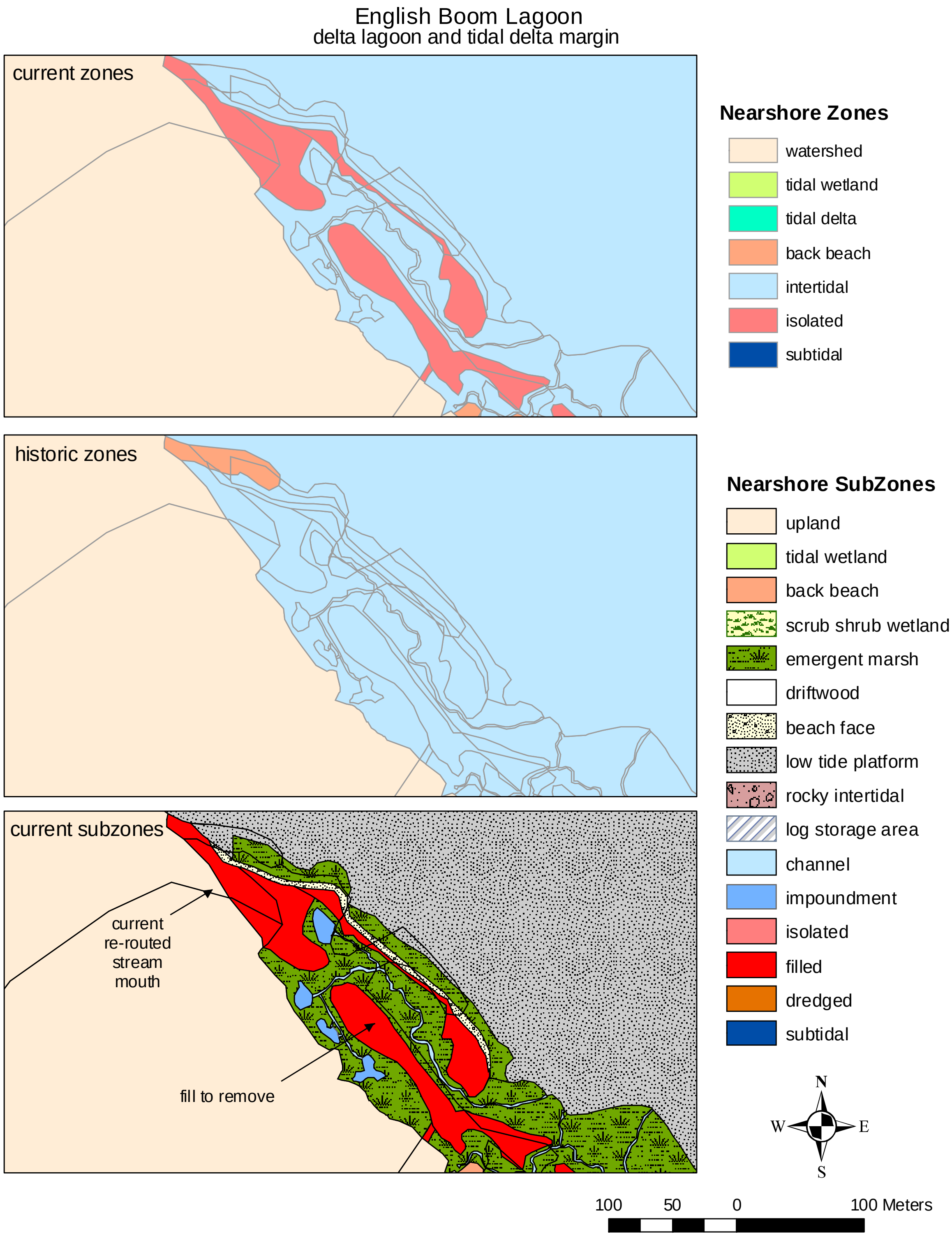


Figure 12.6. *English Boom Lagoon.* English Boom was originally a small spit formed along the margin of the tidal delta marsh of the Skagit and Stillaguamish deltas. The area has been filled and dredged for log storage historically. More recently those modifications have been left to coastal and delta processes and have evolved into a partially artificial channel and marsh complex.

12.3.6 SneeOosh Lagoon

Project Summary

- Restore intertidal pocket estuary habitat by removing fill and creating a new outlet channel.
- Protect and restore sediment source beaches in the adjacent drift cell that historically maintained the lagoon spit.
- Address water quality issues related to the sewer pump station in the isolated marsh (Figure 12.7).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost

Costs and funding sources have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation.

Contingencies

Landowner consent.

Expected Direct Results

Total estuarine habitat could increase by 1.09 hectares. Channel habitat will increase by 0.07 hectares.

Expected Fish Use and Production Results, and Timeframe

Completed restoration will increase nearshore habitat fish capacity by an estimated 593 smolts annually. It is expected that juvenile salmon will use the lagoon immediately following project completion.

Monitoring of Fish Use and Production Results

It is expected that fish utilization would be monitored by SRSC as part of the on-going research into the role and function of pocket estuaries. See Section 11: Monitoring for more detail.

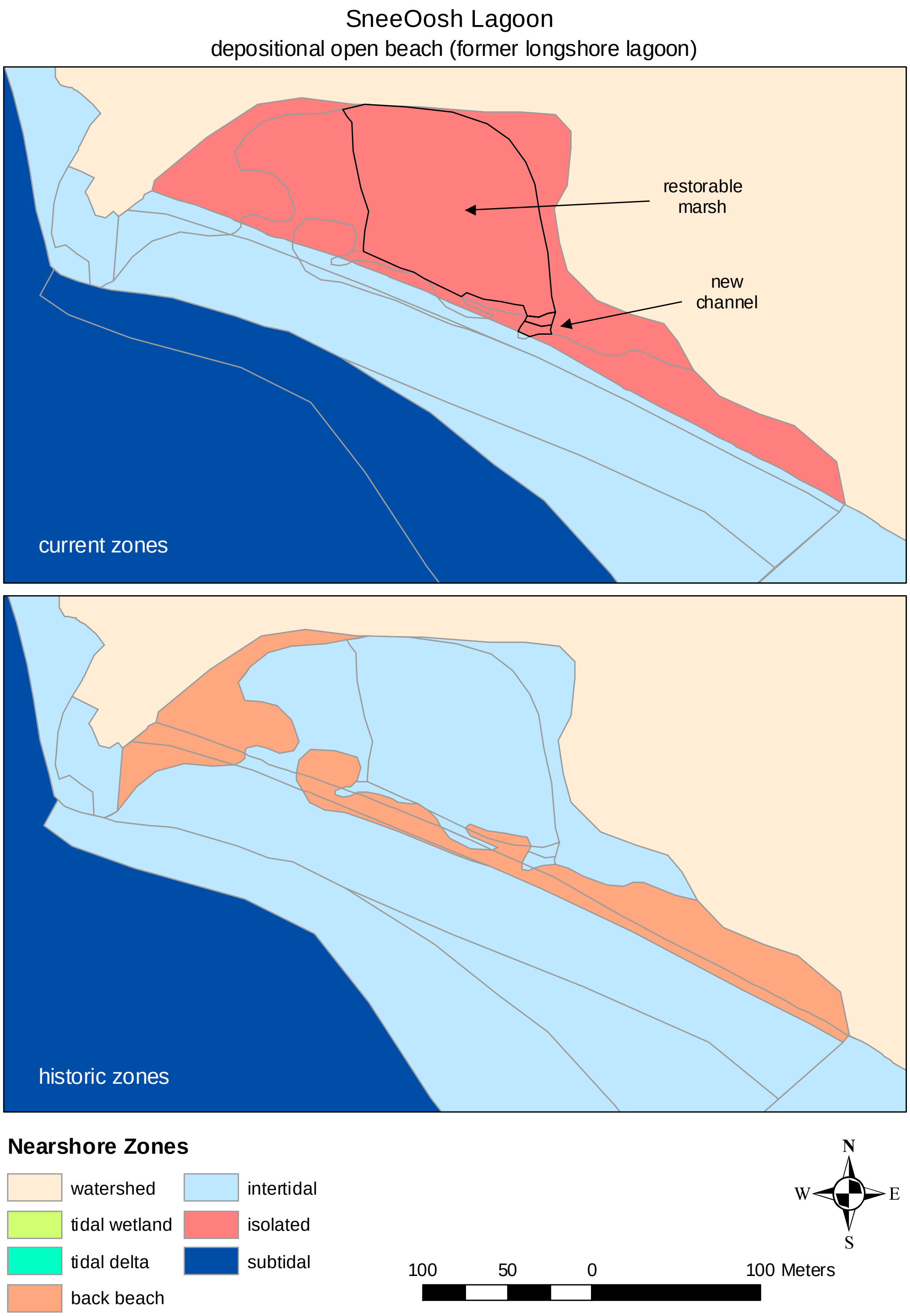


Figure 12.7. *SneeOosh Lagoon*. SneeOosh Lagoon has been isolated and partially filled. The isolated marsh is drained by a pumping station and pipe to the beach. The beach is armored. Restoration would involve reconnecting the isolated marsh via a new channel, as the original channel location is built upon.

12.3.7 Kiket Lagoon

Project Summary

- Restore intertidal pocket estuary habitat by removing fill and bank armoring.
- Protect and restore sediment source beaches in the adjacent drift cells that historically maintained the lagoon spit and tombolo (Figure 12.8).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost

Costs and funding sources have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation.

Contingencies

Landowner consent.

Expected Direct Results

Total estuarine habitat will increase by 1.25 hectares. Channel habitat will increase by 0.09 hectares. Project components will protect the entire 1.42 ha pocket estuary from threats that risk the productivity of the entire lagoon.

Expected Fish Use and Production Results, and Timeframe

Completed restoration will increase nearshore habitat fish capacity by an estimated 141 smolts annually. It is expected that juvenile salmon will use the newly restored parts of the lagoon immediately following project completion. Protection components of this project should preserve the capacity of the entire lagoon (6,219 fish).

Monitoring of Fish Use and Production Results

Monitoring has not been planned. Site access is limited due to landowner issues.

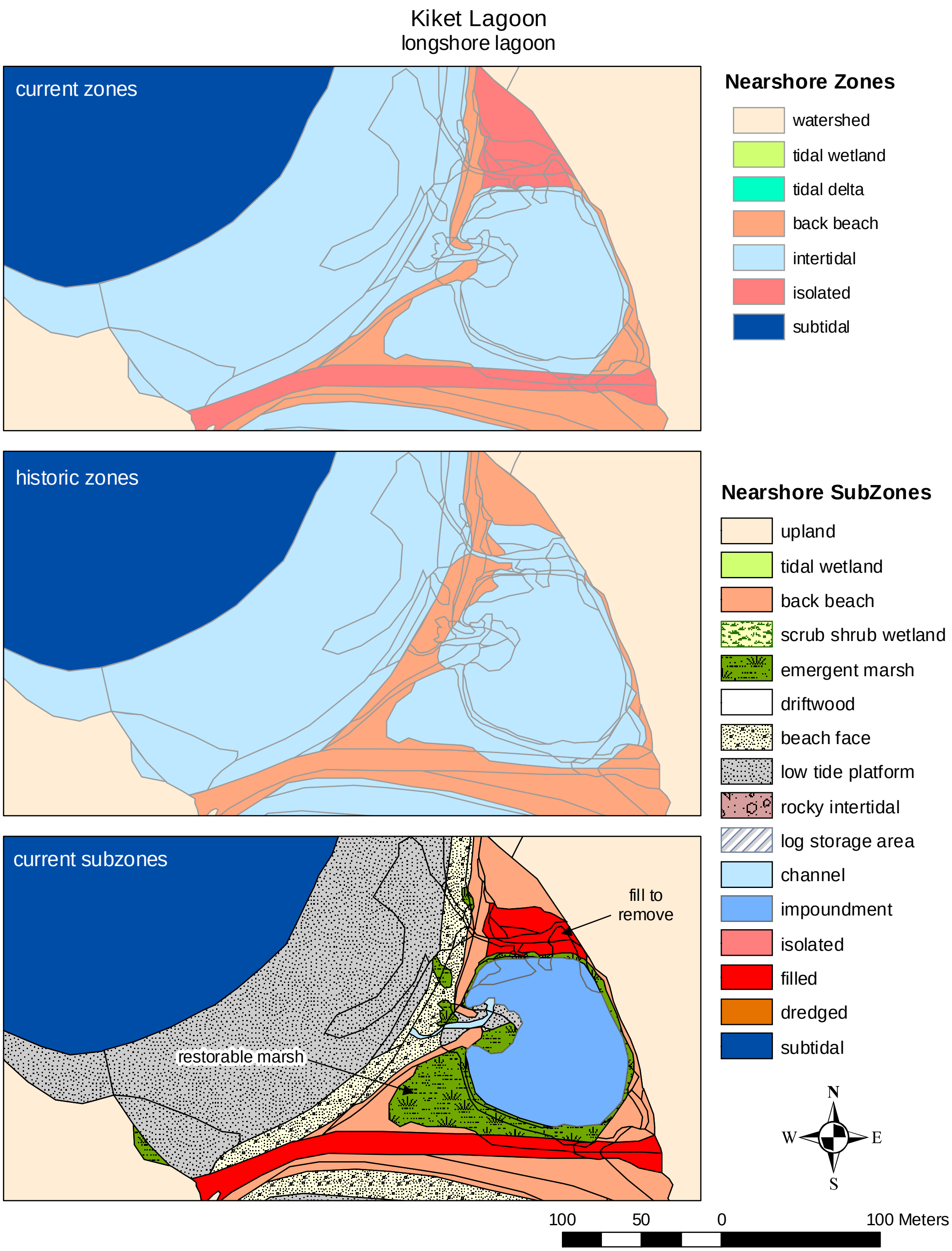


Figure 12.8. *Kiket Lagoon.* Kiket Lagoon is mostly intact, with only about ¼ of its historic footprint filled. However, the southern tombolo is completely armored, isolating the back beach from longshore drift and natural habitat development. Drift cell armoring at sediment source beaches in Kiket Bay may also be impacting this pocket estuary.

12.3.8 Mariners Cove

Project Summary

- Restore intertidal pocket estuary habitat by removing fill and bank armoring.
- Protect sediment source beaches in the adjacent drift cell that historically maintained the lagoon spit.
- Establish a protocol that any dredging of the boat basin will be utilized to nourish the beach immediately north of the basin opening, to maintain sediment transport processes in volume if not in mechanism.
- Establish a water quality protocol that prevents catastrophic kills of fish within the boat basin (Figure 12.9).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted:

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost and Funding Sources

Costs and funding sources have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation.

Contingencies

Landowner consent.

Expected Direct Results

Total estuarine habitat could increase by 2.79 hectares. Channel habitat could increase by 0.17 hectares. Project components will protect the entire 1.42 ha pocket estuary from threats that risk the productivity of the entire lagoon.

Expected Fish Use and Production Results, and Timeframe

Completed restoration will increase nearshore habitat fish capacity by an estimated 881 smolts annually. It is expected that juvenile salmon will use the newly restored parts of the lagoon immediately following project completion. While the restoration component of this site is not large, the site itself has a large capacity already due to the artificial subtidal habitat of the boat basin. Any fish currently using the site are at risk from threats common in boat basins. Protection components of this project should preserve the capacity of the entire pocket estuary (27,448 fish).

Monitoring of Fish Use and Production Results

Monitoring has not been planned.

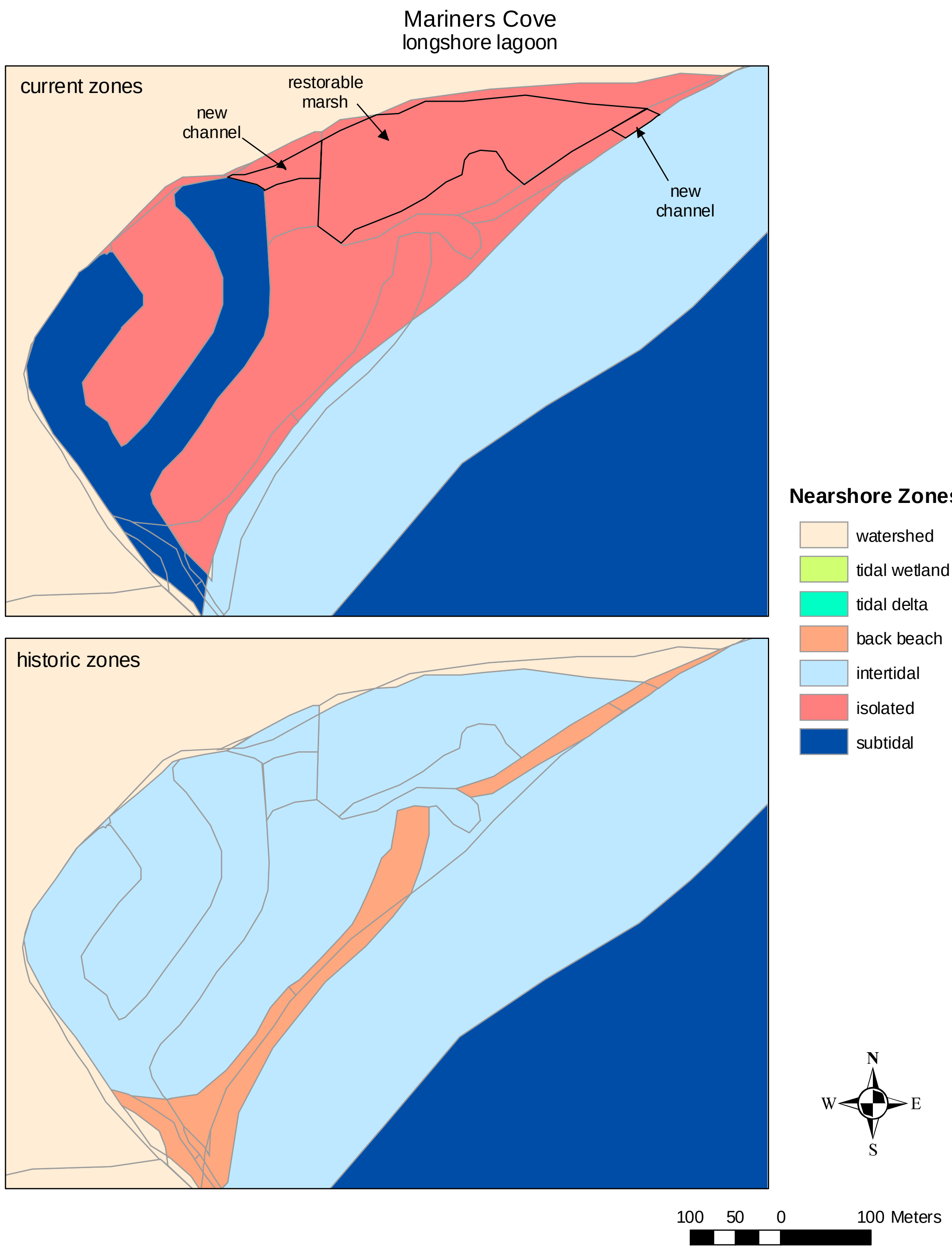


Figure 12.9. *Mariners Cove.* Mariners Cove has been completely altered from its original form into a dredged boat basin. Restoration is possible for a section of existing, isolated marsh along the northeast edge of the former pocket estuary. A new channel would need to be dredged to connect the marsh to tidal inundation. A second channel could connect the boat basin to the restorable marsh as well. Houses ring the boat basin.

12.3.9 Ala Lagoon

Project Summary

- Restore intertidal pocket estuary habitat by removing fill and opening up the outlet channel to the marsh by replacing the road fill with a bridge.
- Protect and restore sediment source beaches in the adjacent drift cell that historically maintained the lagoon spit (Figure 12.10).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost and Funding Sources

Costs and funding sources have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation.

Contingencies

Landowner consent.

Expected Direct Results

Total estuarine habitat could increase by 0.14 hectares. Channel habitat could increase by 0.01 ha. Project components will protect the entire 10.01 ha pocket estuary from threats that risk the productivity of the entire lagoon.

Expected Fish Use and Production Results, and Timeframe

Completed restoration will increase nearshore habitat fish capacity by an estimated 67 smolts annually. It is expected that juvenile salmon will use the newly restored parts of the lagoon immediately following project completion. While the restoration component of this site is not large, the site itself has a large capacity due to the protected habitat behind the large spit. Sediment processes supporting the maintenance of the spit have been disturbed. Therefore, the protection components of this project are the most important part of this project and they should preserve the capacity of the entire pocket estuary (14,122 fish).

Monitoring of Fish Use and Production Results

It is expected that fish utilization would be monitored by SRSC as part of the on-going research. See Section 11: Monitoring for more detail.

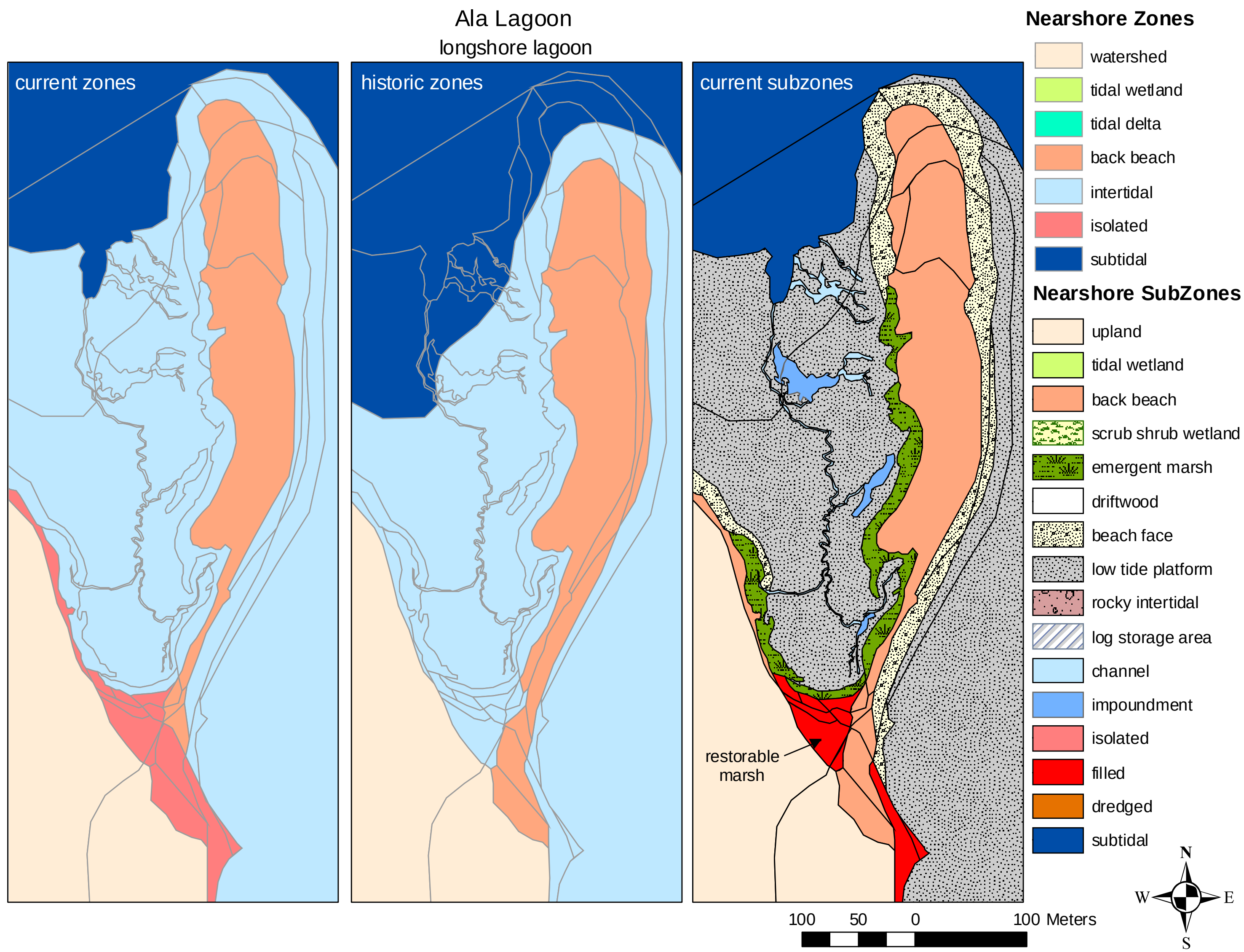


Figure 12.10. *Ala Lagoon.* Ala Lagoon has been modified by an access road that partially filled and cut off a small section of tidal marsh at the head of the lagoon. On the south edge of the spit, shoreline armoring and filling has cut off some sediment sources that contributed to the spit historically.

12.3.10 Dugualla Heights

Project Summary

- Restore intertidal pocket estuary habitat by removing fill or installing a tidegate to open the outlet channel to the existing artificial lake.
- Create tidal channels and marsh, where possible (Figure 12.11).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost and Funding Sources

Costs and funding sources have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation.

Contingencies

Landowner consent.

Expected Direct Results

Total estuarine habitat will increase by 2.55 hectares. Channel habitat could increase by 2.40 hectares.

Expected Fish Use and Production Results, and Timeframe

Completed restoration could increase nearshore habitat fish capacity by an estimated 26,025 smolts annually. It is expected that juvenile salmon would use the lagoon immediately following project completion. This site has the highest landscape scale connectivity of any pocket estuary with restoration potential.

Monitoring of Fish Use and Production Results

Monitoring has not been planned.

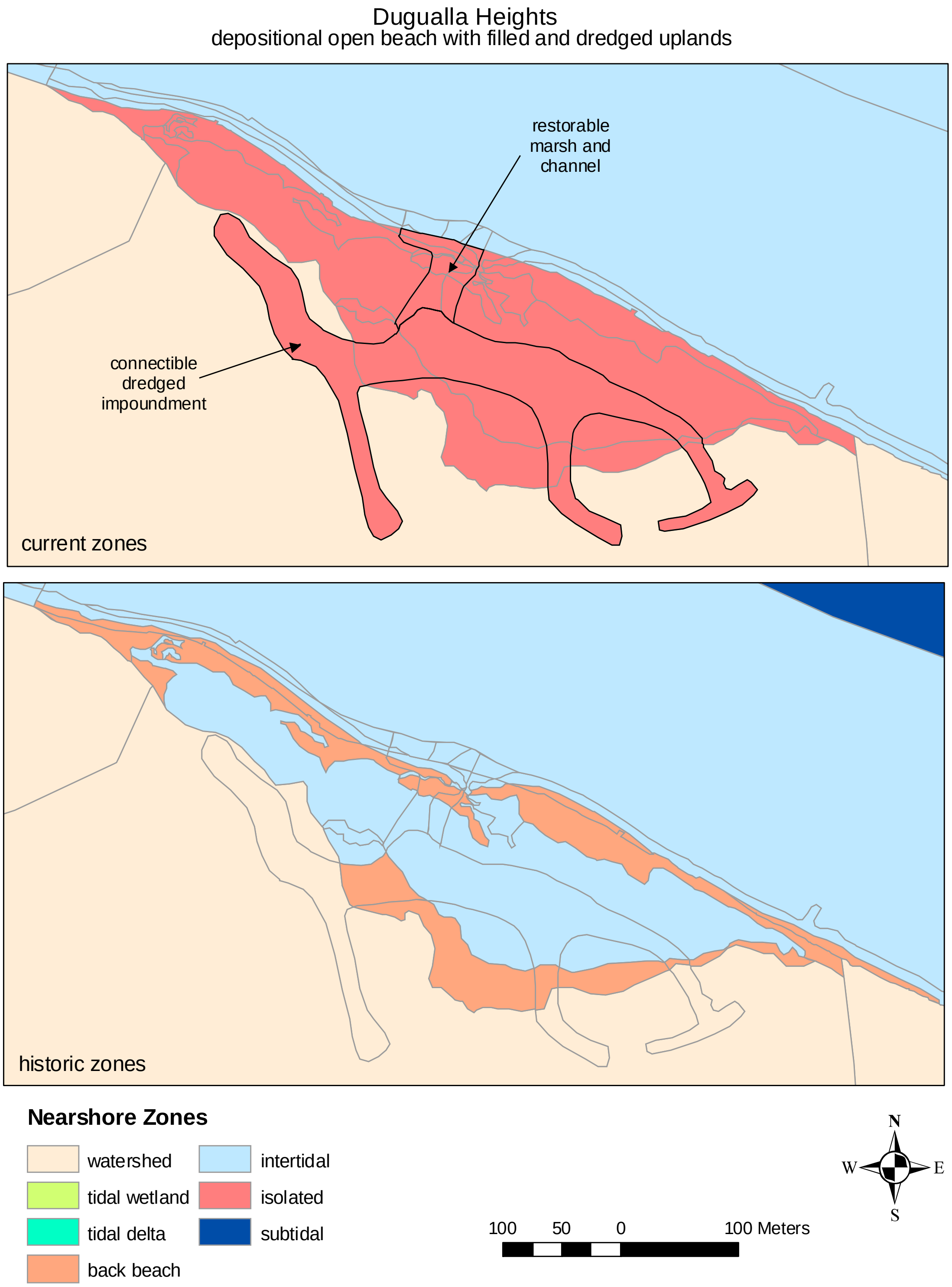


Figure 12.11. *Dugualla Heights.* Dugualla Heights was formerly a longshore lagoon. The historic impoundments have been cut off from tidal exchange, enlarged, dredged, and armored to create a lake. The former spit beach is also armored. Restoration could reconnect the artificial lake to tidal influence via a constructed channel through a narrow piece of existing marsh. The area is heavily built and armored, so restoring a more natural system is not feasible.

12.3.11 Similk Beach

Project Summary

- Characterize the restoration potential for this site.
- Restore intertidal pocket estuary habitat by removing fill to open up the outlet channel to the marsh, replacing the road fill with a bridge, and constructing channels in the existing golf course wet areas.
- Protect and restore sediment source beaches in the adjacent drift cell that historically maintained the lagoon spit (Figure 12.12).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost and Funding Sources

Costs and funding sources have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation.

Contingencies

Landowner consent.

Expected Direct Results

Total estuarine habitat will increase by 9.55 hectares. Channel habitat will increase by 0.59 hectares.

Expected Fish Use and Production Results, and Timeframe

Completed restoration will increase nearshore habitat fish capacity by an estimated 3,782 smolts annually. It is expected that juvenile salmon would use the lagoon immediately following project completion.

Monitoring of Fish Use and Production Results

Monitoring has not been planned.

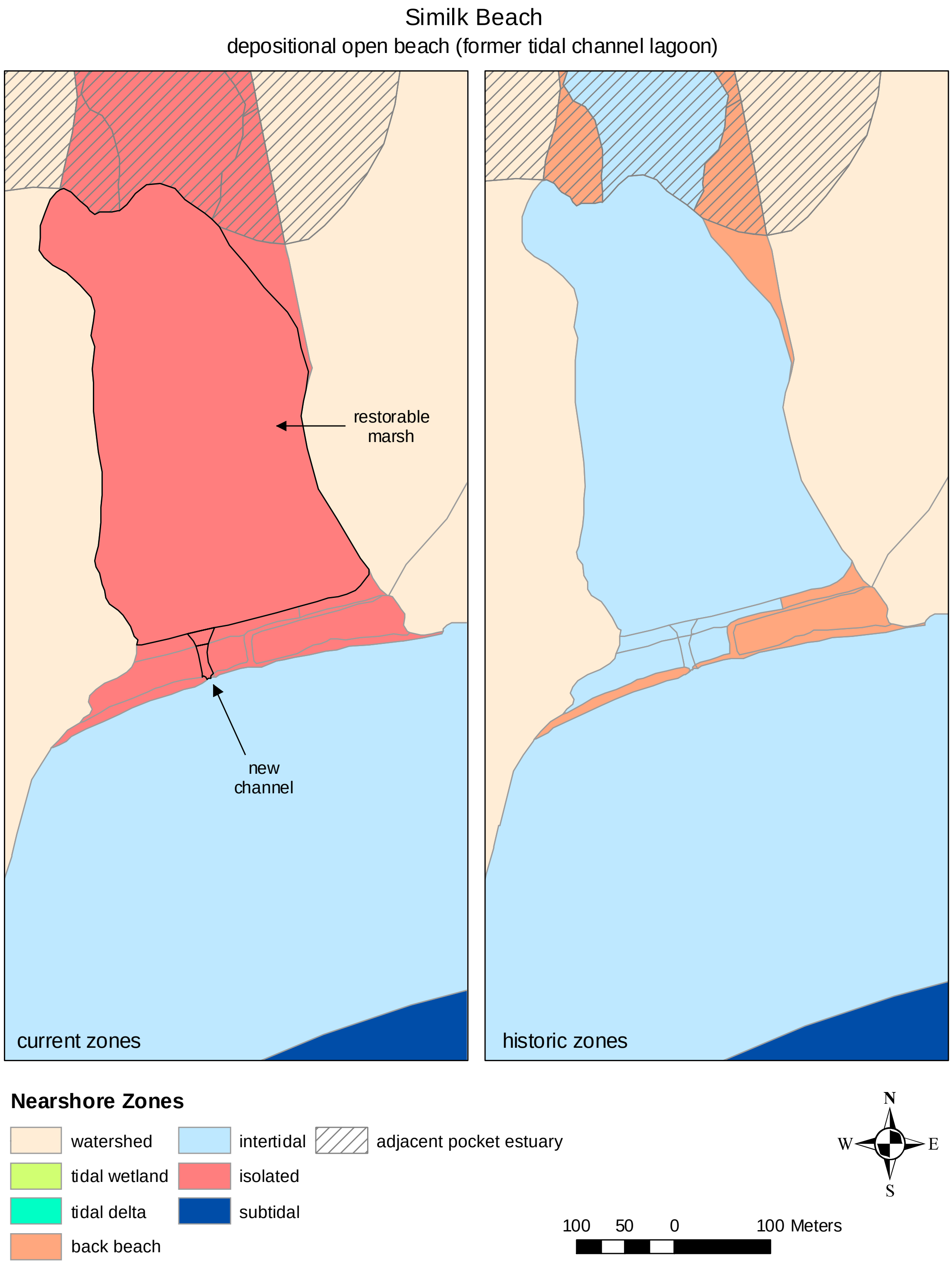


Figure 12.12. *Similk Beach.* Similk Beach is a former tidal channel that is now a golf course. This site floods every winter because of its low relief. The beach face is diked, with a pumping station and pipe to drain the golf course. Data for mapping historic conditions were of poor quality. Further investigation and site characterization would be necessary to determine appropriate restoration actions.

12.3.12 Dugualla Bay

Project Summary

- Characterize the restoration potential for this site.
- Restore intertidal pocket estuary habitat by removing fill to open up the outlet channel to the marsh.
- Protect and restore sediment source beaches in the adjacent drift cell that historically maintained the lagoon spit (Figure 12.13).

Purpose

Increase pocket estuary capacity near the Skagit delta and improve habitat quality.

Populations Targeted

This project will benefit the fry migrant life history type from all six Skagit stocks.

Cost and Funding Sources

Costs and funding sources have not been evaluated.

Probability and Timeframe

This project is in the early stages of investigation.

Contingencies

Landowner consent.

Expected Direct Results

Total estuarine habitat will increase by 156.94 hectares. Channel habitat will increase by 9.73 hectares. Local connectivity will improve significantly at this site depending on the restoration footprint size. Historically, this site had subtidal habitat (a connection to the source of fish 100% of the time) upstream of the spit enclosure. The site has the potential to have similar fish access conditions in a restored state.

Expected Fish Use and Production Results, and Timeframe

Completed restoration could increase nearshore habitat fish capacity by an estimated 93,758 smolts annually. It is expected that juvenile salmon will use the lagoon immediately following project completion. This site has the largest restoration potential and second highest landscape connectivity index.

Monitoring of Fish Use and Production Results

Monitoring has not been planned.

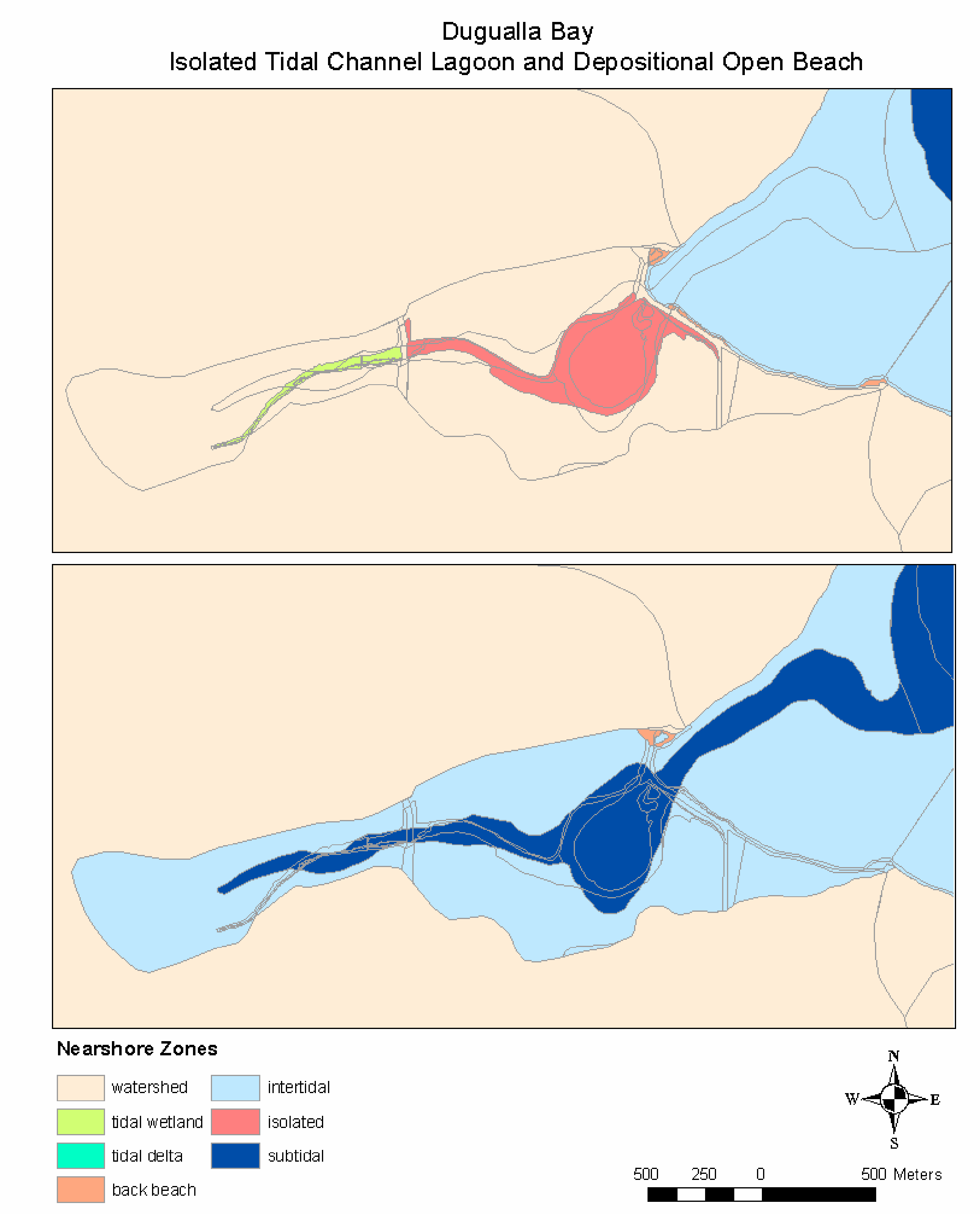


Figure 12.13. *Dugualla Bay.* Dugualla Bay has been completely cut off from its historic tidal channel and associated marsh and channel complex. The original pocket estuary probably included a spit that does not show on these maps because historic data in the central part of the bay were too coarse in resolution to identify any coastal landforms. Development of this site pre-dates 1941. This site is of particular importance due to close proximity to the Skagit Delta.

13. ARTIFICIAL PRODUCTION ACTIONS

Artificial production actions can be taken to add fish to the harvest, increase seeding levels, conduct research, or reduce ecological impacts with wild fish. In carrying out these actions, the parties will adhere to the region-wide principles and processes that apply to all artificial production programs in Puget Sound, described below.

13.1. REGION-WIDE PRINCIPLES AND PROCESSES

13.1.1 National Environmental Policy Act Review

Similar to the harvest actions, the hatchery component is presently being addressed within a National Environmental Policy Act (NEPA) Draft Environmental Impact Statement (DEIS). This process is in the initial scoping stages for two Resource Management Plans (RMPs), which have been submitted to NMFS by the Washington Department of Fish and Wildlife and the Puget Sound Treaty Tribes. One RMP focuses on hatchery Chinook releases and their potential effects on listed Chinook and summer chum salmon. The other RMP deals with non-Chinook hatchery releases, which include coho, chum, pink, sockeye and steelhead hatchery programs and their effects on the listed species. Together, these hatchery RMPs provide the proposed frameworks through which co-managers would jointly manage Puget Sound salmon and steelhead hatchery programs while meeting conservation requirements specified under the ESA.

The Hatchery Resource Management Plans describe 116 hatchery programs and evaluate their effects on Puget Sound Chinook and summer chum populations listed as threatened by NMFS. In addition, the plans describe the scientific foundation and general principles for continued evaluation and reform in response to new information. Appended to the overarching Resource Management Plans are individual Hatchery and Genetic Management Plans (HGMPs) for each of the 116 hatchery programs. The HGMPs describe each hatchery program in more detail, including specific measures proposed by the co-managers to minimize the risk of adversely affecting listed fish. These specific measures included research, monitoring, and evaluation activities that would guide future program adjustments.

National Marine Fisheries Service' ESA determination of the co-managers' Hatchery Resource Management Plans is the federal action requiring NEPA compliance through completion of either an environmental assessment or an environmental impact statement (EIS). In this case, a single EIS will be developed for both RMPs, and NMFS' subsequent determination will be in effect for 15 years. The EIS will consider potential impacts on listed and non-listed animal and plant species and their habitats, water quality and quantity, socioeconomics, and environmental justice The EIS will also include information regarding potential impacts on other components of the human environment, including air quality, human health, transportation, and cultural resources.

The Puget Sound treaty tribes and WDFW, along with NOAA Fisheries, will rigorously explore and objectively evaluate a full range of reasonable alternatives in the EIS, including the Proposed Action (implementation of the co-managers' RMPs) and a No Action alternative. Additional alternatives could include at least the following: (1) a decrease in artificial production in selected programs that have a primary goal of augmenting fisheries, and (2) an increase in artificial production in selected programs that have a primary goal of augmenting fisheries.

13.1.2 General Principles for the Hatchery Resource Management Plans

The following general principles, which were developed by the Hatchery Scientific Review Group (HSRG) (2004) or appeared in the hatchery RMP, will guide hatchery operations:

- Hatchery programs need clearly stated goals, performance objectives, and performance indicators
- Set goals for all stocks and manage hatchery programs on a regional scale
- Measure success in terms of contribution to harvest, conservation, and other (e.g., research) goals
- Have clear goals for educational programs
- Hatchery programs need to assess, manage, and reduce risks associated with potential interactions between coho, steelhead, sockeye, chum and pink salmon hatchery programs and natural populations listed under ESA. Brood stock collection, fish health, and rearing and release strategies of non-Chinook species are areas of potential interactions between hatchery programs and protected wild stocks.
- Hatchery program managers need to coordinate with fishery managers to maximize benefits and minimize biological risks so that they do not compromise overall plans to conserve salmon population protected by ESA.
- Conduct scientifically defensible programs
- Operate hatchery programs within the context of their ecosystems
- Operate hatchery programs as either genetically integrated or segregated relative to naturally-spawning populations
- Size hatchery programs consistent with stock goals
- Consider both freshwater and marine carrying capacity in sizing hatchery programs
- Ensure productive habitat for hatchery programs
- Emphasize quality, not quantity, in fish releases
- Use in-basin rearing and locally-adapted broodstocks
- Spawn adults randomly throughout the natural period of adult return
- Use genetically-benign spawning protocols that maximize effective population size
- Reduce risks associated with outplanting and net pen releases
- Use hatchery salmon carcasses for nutrification of freshwater ecosystems, while reducing associated fish health risks
- Hatchery programs will be based on continuously-collected information and adaptive management (see below)
- Have adequate monitoring and evaluation to determine whether the hatchery program is meeting its objectives.
- Incorporate flexibility into hatchery design and operation.
- Put protocols in place for making revisions to the program based on risk evaluations, the best available monitoring and research information, and the adaptive management process.
- Evaluate hatchery programs regularly.
- Hatchery programs must be consistent with the plans and conditions identified by Federal courts with jurisdiction over tribal harvest allocations
- Hatchery programs will monitor as management intent and wherever practical the “take” of listed salmon occurring as a result of the program and will provide that information as needed.

13.1.3 Hatchery Reform and Adaptive Management

Hatchery reform is also an important part of the co-managers' hatchery programs. Hatchery reform is the systematic application of scientific principles to hatcheries to help recover and conserve naturally spawning populations and to support sustainable fisheries. WDFW has a long history of making scientific improvements in salmon culture. Through co-management, the tribes and WDFW have been actively engaged in hatchery reform. The Hatchery RMPs describe the key components of an adaptive management frame for using the best available scientific information and evaluations to implement changes in hatchery programs. The PSSMP provides the legal foundation for implementing these changes.

A key component of hatchery reform is adaptive management, which is a process that incorporates research, monitoring, and scientific evaluation to allow managers to make good decisions while operating in the face of uncertainty about future circumstances and consequences (Holling 1978,Walters 1986).

Adaptive management is often associated with large-scale experiments (i.e., active adaptive management), where the best decision can be made only when the outcome of the experiments is known. Adaptive management also includes other strategies, however, such as passive adaptive management and evolutionary problem solving (Anderson et al. 2003), which are better suited to hatcheries. Passive adaptive management uses the best available scientific information to make decisions initially but also specifies multiple, future decision points where new information is analyzed and incorporated into decisions and the best apparent decision is chosen at each point. Evolutionary problem solving encourages managers to experiment with innovations independently and share results. Change depends largely on encouraging communication. Evolutionary problem solving is most useful when programs have multiple, incommensurable goals (Anderson et al. 2003).

The co-managers' adaptive management framework combines passive adaptive management and evolutionary problem solving. It has seven key elements:

- An integrated strategy for the ESU
- Defined goals and objectives for hatchery programs
- A framework of artificial production strategies for reaching goals and objectives
- Strategy-specific guidelines for operating hatchery programs
- Scientific tools for evaluating hatchery operations, including statistical analyses, risk-benefit assessments, and independent scientific review
- A decision-making framework for considering in-season, annual, and long-term changes in hatchery objectives and standard operating modes described in HGMPs and resolving disputes
- Implementation using available resources

The following information is specific to the Skagit River hatchery programs, describing their purpose and operational commitments as identified within the Hatchery RMPs submitted to NOAA Fisheries.

13.2. EXISTING HATCHERY FACILITIES ON THE SKAGIT WATERSHED

Marblemount Hatchery, which is owned and operated by WDFW, is the main hatchery in the Skagit River. It is located on the Cascade River and produces spring, summer, and fall Chinook salmon (Skagit origin), coho salmon (a composite of Skagit, Wallace River, and Minter Creek origins), and winter steelhead (introduced Chambers Creek origin). Barnaby Slough is a rearing pond for winter steelhead located downstream of Marblemount Hatchery on the Skagit River near the town of Rockport. Tribal facilities in the Skagit River Basin include the Upper Skagit Tribal Hatchery and the Swinomish Raceways. The Upper Skagit Tribe operates the Upper Skagit Tribal Hatchery on the Upper Skagit Reservation for chum salmon. The Swinomish raceways are located in the Swinomish Channel across from the town of La Conner. The facility is owned by the Swinomish Indian Tribal Community and operated by the Skagit River System Cooperative. Puget Sound Energy (PSE) operates a series of artificial spawning beaches for sockeye salmon along Baker Lake as mitigation for hydroelectric dams. Although the focus of this program is to assist natural spawning, the program is supported by a small fish culture facility consisting of circular tanks, four small raceways, starter troughs, a new incubation facility and an asphalt rearing pond. Puget Sound Energy, along with WDFW, operate a coho program that releases fry into Sulphur Creek and yearlings into Baker and Shannon lakes and at the Baker River trap just below the dam.

13.3. CHINOOK ARTIFICIAL PRODUCTION ACTIONS

This section describes the specific Chinook artificial production actions that will be implemented under this plan. We also describe Chinook artificial production options that were considered but rejected by the Skagit Chinook workgroup; however, because this plan is adaptive, we also describe the circumstances under which these rejected options would be reconsidered.

Currently, artificial production of Chinook salmon within the Skagit is limited to a spring Chinook, a summer Chinook, and a fall Chinook CWT indicator stock (Table 13.1). The objective of these indicator-stock programs is to obtain representative data on harvest impacts and marine survival of Chinook salmon that the co-managers can use to apply to management of wild Chinook populations. Two net pen programs previously supplied by Marblemount Hatchery have been terminated.

Table 13.1. *Currently programmed annual releases of Chinook salmon in the Skagit River Basin.*

Subyearling	Yearling	Stock Lineage	Production Type	Release Site	Agency/ Sponsor	Status
Spring Chinook						
250,000	150,000	Suiattle	Integrated Research	Marblemount Hatchery	WDFW	Continue
Summer Chinook (native)						
200,000		Upper Skagit	Integrated Research	County Line Ponds	SSC/WDFW	Continue
Fall Chinook (native)						
222,000		Lower Skagit	Integrated Research	Baker River	SSC/WDFW	Continue
Summer and Fall Chinook (Green River origin)						
	0 (30,000)	Green River	Isolated Harvest	Oak Harbor Net Pens	ALEA	Terminate
	0 (15,000)	Green River	Isolated Harvest	Fidalgo Net Pens	RFEG-3	Terminate

Under this Chinook recovery plan, hatchery Chinook programs will continue, initially, as currently programmed. No new hatchery Chinook programs are proposed for the Skagit at this time, and existing programs will continue as configured; however, this configuration includes the Backup

Actions described below, which, if predefined circumstances occur (see below), may modify or even eliminate one or more programs. In addition, the co-managers will develop a contingency conservation plan that describes the actions that will be taken in the event that wild production of one or more populations declines to a specified level.

The spring, summer, and fall Chinook indicator stock programs are described in more detail below, and in the Monitoring Section (Chapter 15).

13.3.1 Spring Chinook Indicator Stock Program

Objective
To provide information on harvest and marine survival that can be used to manage wild spring Chinook salmon. The data that will be collected, and the application of that data to the restoration strategy, are described in the Monitoring Section (Chapter 15).

Stock
Suiattle spring Chinook

History
Hatchery spring Chinook were first released in the Skagit in 1949. Stocks that were labeled "Skagit River springs" (the location from which these broodstock were collected is not recorded) were released from Marblemount Hatchery in 1949, 1951, 1952, 1953, 1959, and 1961. There were also releases into the Cascade River in 1951; at or below Mt. Vernon in 1949-1951 and 1954-1960; into the "lower Skagit River" in 1954; into the Baker River in 1959; at Newhalem in 1960; and into the "Skagit River" in 1960.

The current program was founded by collecting wild Skagit spring Chinook broodstock from Buck Creek from 1976-1988. In 1981 the first adults of Buck Creek origin returned to the hatchery. Coded-wire tagging, however, was not consistently provided for each brood during that time. Consequently, hatchery personnel relied on timing differences to separate spring and untagged summer and fall broodstocks, which were also reared and released from Marblemount Hatchery. This probably resulted in mixing of the brood stocks, because some overlap exists in timing. Genetic analysis indicated that Marblemount spring stock is very similar, but not identical, to the native Suiattle spring Chinook stocks in the basin. Because it is not identical, this stock has not been used for supplementation of natural stocks.

Release Goals
Annual release goals are 150,000 yearlings and 250,000 zero-age fish.

Hatchery Strategy
Integrated research

Operations
Adult hatchery spring Chinook, which are returning from previous plants, volitionally enter the Marblemount Hatchery each year from May to August. About 100 pairs of adults that bear spring Chinook CWTs are spawned, yielding about 450,000 eggs. These eggs are incubated and reared at Marblemount. By late April or early May, they are large enough to coded-wire tag. The release

target is 250,000 CWT fingerlings, which are volitionally released that first June at a size of 70 per lb, and 150,000 CWT yearlings, which are released the following April at about 10 per lb. The yearling release is divided into 75,000 ad-CWT fish, and 75,000 unmarked-CWT fish. These fish then migrate to the ocean. They are recovered as adults in fisheries throughout the Northwest, and identified as Skagit fish from their coded-wire tags. Upon returning to the Skagit, three to five years after release, the great majority of the survivors return to Marblemount, and are collected, counted, and sampled there. Although the fish are not intended to spawn in the wild, a small number might be found on the spawning grounds or in the summer Chinook broodstock collection, and identified as springs from their CWTs. Straying appears to be localized to the upper Skagit and lower Cascade within 1.5 miles of the hatchery.

Expected Adult Production

For the fingerling releases, under recent past fishing levels, adult return rates to Marblemount have ranged from 0.2% to 1.3%, with a mean of about 0.5%. At a smolt release of 250,000, this translates to a Marblemount return of about 1200. For the yearling releases, adult return rates to Marblemount have ranged from 0.1% to 0.7% with a mean of about 0.3%. At a smolt release of 150,000, this translates to a Marblemount return of about 500. Thus, the expected mean return to Marblemount from this program is about 1700, under recent fishing levels. Because recent exploitation rates on Skagit springs have been estimated at about 30% (range 21% to 41%), this translates to mean total recruitment of about 2400 hatchery adult spring Chinook from each brood.

Contingencies if Broodstock Collection is Inadequate

If inadequate numbers of spawners enter Marblemount, the first alternative, which has been tried in the past, is to net fish in the Cascade downstream of the hatchery. This was done in the past because the Marblemount trap was poorly engineered for summer flows, but it has not been necessary to do this since the trap was rebuilt in 1988-89 to allow better attractant flows. If the inadequate numbers are due to low adult return numbers (and not just to poor attractant flows from the hatchery), an alternative broodstock source would be Buck Creek in the Suiattle, but only if there are surplus spawners in that area. Failing that, there is no other indicator stock that can be used to represent Skagit springs, and we'll just have to make do with the lower number of fish. As a backup, model run (FRAM) predictions of exploitation rates may be used to represent the actual rates.

Monitoring Actions

See Monitoring section (Chapter 15).

Cost and Funding Sources

Total cost of spawning, rearing, tagging, and releasing the fish is about $160,000 per year. This has been covered by WDFW's hatchery operations budget.

Risks to Skagit Wild Chinook

The primary risk of this program is to the genetic composition of the wild runs. However, since the resumption of 100% coded-wire tagging in 1994, there have been only seven hatchery CWTs recovered on spring Chinook spawning grounds (four in the upper Cascade and three in the Suiattle); moreover, genetic analysis indicates that the wild spring stocks are distinct from the hatchery stock, which indicates that the genetic impact of this program on wild spring Chinook has been negligible. There have been more strays to summer Chinook spawning areas, and there is some overlap in spawning timing between the summer and spring runs, but the great majority of these stray recoveries have occurred within 1.5 miles of the Marblemount Hatchery, and, as noted above, genetic analysis indicates that the wild summers are also genetically distinct from the hatchery spring stock.

Predation on wild Chinook by the yearling releases is another possible risk; however, mainstem trap data indicate that these fish spend little time in the river, and few have been recovered in tidal delta habitat. The fastest outmigrants appear at the Burlington trap almost the day of release, with the great bulk of the release passing in a few days, and the last have passed the trap within a month after release. This limits their exposure to wild Chinook fingerlings, which begin outmigrating several months before the hatchery yearlings are released, and finish outmigrating several months after the hatchery fish have passed. In addition, the mainstem trap data do not indicate a depression in the outmigration timing curve of wild Chinook at the time hatchery fish are released, which would be expected if hatchery fish predation was having a significant effect on the wild Chinook. In 1999, stomach contents were sampled from hatchery yearlings at the Burlington trap, and these did not indicate that predation on wild Chinook was a significant problem.

Backup Actions

Program modification would be required if it is determined that the fisheries distribution of the hatchery spring Chinook releases do not accurately represent the fisheries distribution of the wild stocks (fingerlings and yearlings). In such a case, the co-managers would need to develop an integrated, index program by collecting new broodstock (from the Suiattle, upper Sauk, and/or upper Cascade, and discontinuing use of the current hatchery stock), but only if the wild stocks are strong enough to support the broodstock removals necessary to restart this program. Maintaining this restarted program as an integrated program would require that about 10% of the spawners each year would be taken from the spawning grounds. If wild stocks are not strong enough to support this level of broodstock take each year, the spring Chinook indicator stock program would need to be suspended until they are.

This same backup action applies if it is determined that the hatchery program is having deleterious genetic impacts on one of the wild spring stocks.

If yearling predation is found to have a significant impact on wild Chinook production, then different release strategies can be attempted to reduce that impact (e.g., phased volitional release). If these are unsuccessful, the co-managers will need to evaluate whether the benefits of the yearling CWT data outweigh the impacts on wild Chinook; if they don't, then the yearling releases would be eliminated.

13.3.2 Summer Chinook Program

Objective

To provide information on harvest and marine survival that can be used to manage wild summer Chinook salmon. The data that will be collected, and the application of that data to the restoration strategy, are described in the Monitoring Section (Chapter 15).

Stock
Upper Skagit summer Chinook. Data collected from this program will also be applied to lower Sauk summers, and, if their fisheries distributions and exploitation rates are not significantly different (see "Fall Chinook Program", below), to lower Skagit falls.

History
This stock originates from wild brood stock collected annually from the mainstem upper Skagit River beginning in 1994. An earlier summer Chinook program was also founded from native populations in the late 1970s. Releases were not consistently marked, however, and over the subsequent 15 years the native summer Chinook hatchery strain mixed with introduced Green River fall Chinook salmon, which were also released annually from Marblemount Hatchery and which have overlapping spawning periods. The mixed summer strain was eliminated from production after the brood year 1992 release. Currently, 100% of released fish are marked.

Release Goals
200,000 native stock summer Chinook fingerlings.

Hatchery Strategy
Integrated research

Operations
Summer Chinook salmon used for hatchery propagation are obtained from the wild. Broodstock are collected with gill nets each year between mid-August and mid-September from the upper Skagit mainstem between RM 79 and 85. Approximately 45 females are collected, with equal number of males to acquire 240,000 eggs. Captured Chinook are disentangled from the net, transferred to tubes, hoisted into a fish transport truck, taken to Marblemount Hatchery for spawning. The progeny of these spawners are reared to fingerling release size and marked with coded-wire tags. After tagging, juveniles are acclimated and released from the County Line Ponds back into their natal range. They are recovered as adults in fisheries throughout the Northwest, and identified as Skagit fish from their coded-wire tags. Although not designed as a supplementation project, juvenile summer Chinook in this program come from wild broodstock and are released off-station, so the returning adults contribute to the natural escapement.

Expected Adult Production
Under recent past fishing levels, terminal area return rates have ranged from 0.1% to 0.7%, with a mean of about 0.3%. At a smolt release of 200,000, this translates to a terminal area return of about 600. Because recent preterminal exploitation rates on Skagit summer and fall Chinook have been estimated at about 32% (range (23% to 40%), this translates to mean total recruitment of about 900 hatchery adult summers from each brood.

Contingencies if Broodstock Collection is Inadequate
If adequate broodstock are not available, the program will just have to get by with fewer fish. There is no better alternate source of upper Skagit summers than the sites currently being netted. If release numbers are too small for indicator stock use, then data from Stillaguamish summer Chinook tagging may be used to estimate fishing impacts on upper Skagit summers, or model run (FRAM) predictions of exploitation rates may be used.

Monitoring Actions
See Monitoring section (Chapter 15).

Cost and Funding Sources
Total cost of releasing the fish, including tagging and hatchery rearing, is about $51,000 per year. About $30,000 of that has been funded through tribal PST implementation funds, and coded wire tagging (about $17,000) has been covered by the Northwest Indian Fisheries Commission (NWIFC) and WDFW through PST indicator stock tagging funds. The remainder has been absorbed within current hatchery operations.

Risks to Skagit Wild Chinook
The main risk is that the broodstock we remove are spawners who otherwise would have spawned in the wild. If there is a hatchery malfunction, the production from these spawners would be lost. Because the great majority of the spawners used each year would be wild fish, this program would pose little genetic risk. Some hatchery spring Chinook may be collected during broodstock collection, but these are all coded wire tagged, and would not be used for spawning.

Backup Actions
Program modifications would be considered if it is determined that a different program can provide the indicator stock information more effectively; the number of tag recoveries are not sufficient to carry out the purposes of this program; or the recruits/spawner rate of the indicator stock fish is less than that of the wild fish.

If a different program provides the indicator stock information more effectively, and the summer program does not provide sufficient additional information (e.g., as a double index tag, or DIT, group), then the summer program would be discontinued in favor of that other program. Programs that potentially might provide that information more effectively are the Skagit fall Chinook program (see below), or the Stillaguamish summer Chinook program.

If the number of tag recoveries from this program is insufficient, then either the rearing and release strategies need to be modified to increase the survival rate, or more broodstock should be collected (see Contingencies, above). If neither of these actions is effective or feasible, then the program should be discontinued, and exploitation rates will have to be estimated from other sources. On-station releases would be considered only if, due to changes in other programs, there are no other on-station Chinook release programs at Marblemount.

If the recruits/spawner rate of the indicator stock fish is less than that of the wild population, then different release strategies (e.g., earlier release, different release location) should be used to try to increase the return rate. If the return rate cannot be increased, then it will be necessary to evaluate whether the indicator stock information that is gained is worth more than the spawning production that is lost. If it isn't, then the program should be terminated, and exploitation rates on Skagit summer Chinook will have to be estimated from other sources.

Note that the recruits/spawner rate for indicator stock fish could be less than that of the wild population for three reasons: either 1) there is a bottleneck on Chinook production from the planted areas that occurs after the incubation stage; 2) natural incubation survival is not poor, and is comparable to hatchery incubation survival; or 3) our fish culture practices are incapable of producing high survivals of good-quality fingerlings. If the first reason is true, this means that the habitat used by the indicator stock fish is fully-seeded, and improvements in hatchery practices will not increase overall production – the solution would be to address whatever causes that bottleneck. If the second reason is true, then habitat restoration actions for Skagit summers should focus on improving any less-than-normal survival rates at life history stages that occur subsequent to incubation. If the third reason is true, then, in the event of some catastrophic crash in the upper Skagit summer Chinook population, our options to address that problem with artificial production actions would be limited.

13.3.3 Fall Chinook Program

Objectives
To determine whether Skagit fall Chinook have a different fishery distribution from Skagit summer Chinook, and, if so, to provide information on harvest and marine survival that can be used to manage wild fall Chinook salmon. The data that will be collected, and the application of that data to the restoration strategy, are described in the Monitoring Section (Chapter 15).

Stock
Lower Skagit fall Chinook salmon. If the fisheries distribution and exploitation rates on Skagit falls is not significantly different from that of the upper Skagit summer indicator stock (see above), the data collected from this project can also be applied to the Skagit summer Chinook populations.

History
Hatchery fall Chinook have been released into the Skagit from Marblemount Hatchery since 1947. These have primarily been Green River, Samish, or Clark Creek stocks that were derived from Green River or Samish ancestors, but other known stock releases into the Skagit have included Columbia, Kalama, Elwha, Issaquah, and White Salmon. Releases of Green and Samish stock ended after the brood year 1992 release. This current program began with wild broodstock collected from the lower Skagit in 1999.

Release Goals
The goal of the program is to release 222,000 fingerlings annually.

Hatchery Strategy
Integrated research

Operations
Hatchery plans call for collecting approximately 60 males and 60 females (244,000 eggs) from the mainstem of the lower Skagit River or from the trap at the mouth of Baker River. At least 10% of these must be wild fish (i.e., not returns from this program). These spawners are taken to Marblemount Hatchery for spawning, and their progeny are reared to fingerling release size and marked with coded-wire tags. After tagging, juveniles are released into the fish trap at the mouth of the Baker River. They are recovered as adults in fisheries throughout the Northwest, and identified as Skagit fish from their coded-wire tags. Although not designed as a supplementation project, as with the summer Chinook indicator stock program, returning fish may contribute to natural escapement.

Expected Adult Production

If adult return rates are the same as for the summer Chinook indicator stock program (see above), mean return rates to the terminal area would average about 0.3%, and preterminal exploitation rates would average about 32%. At a smolt release of 222,000, this translates to a terminal area return of about 650, and mean total recruitment of about 950 adult falls from each brood.

Contingencies if Broodstock Collection is Inadequate

Broodstock collection from the river can be supplemented with returns to the Baker trap, and, if necessary, by buying live fish that have been netted in the Upper Skagit tribal coho fishery. If these sources are inadequate for indicator stock use, then it will have to be assumed that lower Skagit falls have the same fisheries distribution as upper Skagit summers.

Monitoring Actions

See Monitoring section (Chapter 15).

Cost and Funding Sources

Total cost of this program is about $60,000 per year. This program was initially funded by PST Letter of Agreement funds, but that source has expired. Currently, about $58,000 of the cost is covered by Tribal Hatchery Reform funding, but that source is subject to annual competition, and renewal is always questionable.

Risks to Skagit Wild Chinook

As with the summer Chinook indicator stock program, the main risk is that the broodstock we remove are spawners who otherwise would have spawned in the wild. If there is a hatchery malfunction, the production from these spawners would be lost. Because the great majority of the spawners used each year would be wild fish, this program would pose little genetic risk.

Backup Actions

If the falls do not have significantly different exploitation rates or fishery distributions from those of the summer indicator stock fish, and running the two programs simultaneously does not provide sufficient additional information (e.g., using one of the releases as an unmarked DIT group) then the co-managers must determine which program is likely to be more effective at estimating the exploitation rates and fisheries distributions, and eliminate the other program. The same would apply if there is an out-of-basin indicator stock group (e.g., Samish) that has the same exploitation rates and fisheries distributions as the lower Skagit fall releases.

As with the upper Skagit summer program, if survival rates or tag recoveries are too low for indicator stock use, the first backup action will be to experiment with different rearing and release strategies. If these actions are ineffective, then the fall program should be discontinued. If the recruits/spawner rates for indicator stock falls are less than those of the lower Skagit wild population, the same considerations apply as those noted above for the upper Skagit summer program.

13.3.4 The Contingency Conservation Plan

With the assistance of the HSRG, the co-managers will, by the end of 2005, develop a Contingency Conservation Plan for Skagit Chinook. This plan will specify the population-specific criteria under which artificial production programs would be initiated to rebuild or preserve the populations, what their scope would be, what are the criteria for determining whether the artificial production releases will be on-station or off-station, whether additional artificial production facilities would need to be constructed, and other factors related to the initiation of conservation hatchery programs.

This plan will follow the principles outlined in the March 7, 2005 HSRG Technical Discussion Paper #3, titled “When Do You Start A Conservation Hatchery Program?” In that paper, it was expressed that, for Chinook populations, broodstock collection for such a program should begin when the population declines to just above 500 spawners per year. While several Skagit Chinook populations already have annual spawner numbers lower than that, they are not declining; thus, this plan must consider factors that may be unique to the Skagit Chinook populations.

When completed, the Contingency Conservation Plan will be incorporated into this Skagit Chinook Recovery Plan by reference.

13.4. PROGRAMS CONSIDERED, BUT NOT PROPOSED AT THIS TIME

13.4.1 Conservation Programs

Spring Chinook Supplementation in the Suiattle

Action
Hatchery spring Chinook fry, surplus to the indicator stock program, would be planted into underseeded sections of the Suiattle.

Why Program Is Not Proposed
This was the original purpose of the hatchery spring Chinook program. However, by the time there were enough hatchery spawners to produce surplus fry, the genetic composition of the hatchery run was no longer the same as that of the wild Suiattle fish (probably because of stock mixing at the hatchery), and the outplant was blocked. Since that time, it has been estimated that the Suiattle is not underseeded; thus, there would be no reason to conduct outplants into the Suiattle.

Conditions Under Which Program Would Be Reconsidered
To be defined in the Contingency Conservation Plan (see above).

Lower Skagit Fall Chinook Supplementation

Action
When the fall Chinook indicator stock program produces more returning spawners than can be used by the indicator stock program, surplus returns would be taken for CWT extraction and then spawned, and their progeny would be released as fry or eggs in the lower Skagit into reconnected river channels or habitat restoration sites, or other underseeded areas.

Why Program Is Not Proposed
Spawning escapements have been increasing in the lower Skagit, and it is estimated that the lower Skagit is not underseeded; thus, there is no reason to conduct supplementation plants in the lower Skagit. Moreover, it must be shown that the recruits/spawner rate from surplus spawners that are used for fry plants or egg boxes would be higher than the rate that could be obtained simply by returning the surplus adults to the river, and that fry planting is necessary to seed habitat restoration sites.

Conditions Under Which Program Would Be Reconsidered
To be defined in the Contingency Conservation Plan (see above).

13.4.2 Harvest Augmentation Programs

Adult Spring Chinook Plants in the Baker

Action
From 1999 through 2002, live hatchery surplus spring Chinook adults from Marblemount Hatchery were trucked into the upper Baker and released there. The intent was to provide additional salmon carcasses in the upper Baker, but also to provide a spring Chinook run that could be harvested selectively at the mouth of the Baker.

Why Program Is Not Proposed
The program was intended to last for only four years, after which it would be evaluated. Despite planting thousands of adults in the Baker, smolt outmigration numbers and adult return numbers were disappointingly low (about 50 adults returned each of the last two years), and were insufficient to provide a fishery or the likelihood that the run would become self-sustaining. There were also concerns (but no data to indicate one way or the other) that Chinook could be residualizing in Baker Lake, and preying on juvenile sockeye.

Conditions Under Which Program Would Be Reconsidered
If research in the Baker can explain why Chinook survival to outmigration was so low, and those factors can be corrected effectively, this program could be reconsidered. A primary precondition would be to improve juvenile Chinook passage efficiency and prevent residualization.

Release Half the Spring Fingerlings at Baker

Action
In order to reduce the number of surplus hatchery springs that return to Marblemount, and to make more of the indicator stock fish available to in-river selective harvest, half of the spring indicator stock fingerlings (125,000 fingerlings) would be imprinted and released into the Baker River, where the returns could be selectively harvested in fisheries at the mouth of the Baker. By using the existing indicator stock fish for this release, no additional tagging costs would be incurred.

Why Program Is Not Proposed
Currently, there are no facilities at Baker available for imprinting an additional 125,000 Chinook fingerlings in May and June. The Sulphur Springs raceways were suggested, but these are full in May and June. Moreover, the primary purpose of the indicator stock program is to monitor the fisheries distribution of the stock, and it is unknown whether changing the release location for the indicator stock fish might also change their fisheries distribution. There is no *a priori* reason to assume that it would, but the question should be examined, and statistical analysis indicated that at release levels of 125,000 per group, differences in fishery distribution would be detected only if the differences were really big. Thus, in order to examine this question statistically, release numbers would have to be greatly increased for a few years, with an associated major increase in hatchery rearing and tagging costs. In addition, the co-managers haven’t established long-term goals for the type of Chinook production they want from the Baker, and this program presumes that a decision has been made to establish a Baker spring run, and that stray spring spawners would have negligible impacts on the lower Skagit falls. Ultimately, this proposal was tabled when the workgroup

suggested that in-river selective fisheries for surplus hatchery springs might still be conducted without changing the hatchery release site.

Conditions Under Which Program Would Be Reconsidered
If the co-managers decide that they have a long-term aim of establishing a spring Chinook run to the Baker, imprinting facilities become available, and in-river selective fisheries on surplus hatchery springs are either unsatisfactory or insufficient to meet the parties' harvest goals with the currently-existing release site, then this program may be reconsidered. In reconsidering this program, the co-managers would need to decide whether the Baker release would consist of a portion of the existing indicator stock fish (in which case they would have to determine whether the change in release site is likely to affect the fisheries distribution of the release group), or of new production (in which case the additional costs would need to be covered). If returning fish that escape the fisheries are to be transported to Baker Lake, actions would also be needed to minimize residualization of the offspring of those fish. If this program is reconsidered, WDFW's Science Division should evaluate any potential ecological and genetic impacts.

Chinook Releases Into Similk Bay or Swinomish Channel

Action
This action has been proposed for either surplus hatchery springs, or for surplus falls derived from fall indicator stock fish taken at Baker trap. The intent was to imprint these fish either in the Swinomish Channel raceways or in an impoundment net or raceway/pump facility located in Similk Bay, release them, and conduct selective fisheries at the release sites when they returned.

Why Program Is Not Proposed
A trial release of brood year 1991 fall Chinook was conducted in Swinomish Channel, but few fish were recovered. Since that time, concerns have been expressed that the fish not caught in these selective fisheries might spawn with natural Skagit Chinook (the Guemes Channel and Oak Harbor net pen projects were eliminated partly because strays from these projects were found in the lower Skagit), as well as how the benefits of these releases might be allocated inter-tribally. The costs of coded-wire tagging these releases and of operating the Swinomish Channel raceways were also considerations in prioritizing release options (e.g., releasing half of the CWT fingerlings at Baker – see above – would not have incurred any additional tagging costs). For Similk Bay releases, facilities would need to be constructed, potentially with pumps, and landowner approval may be needed.

Conditions Under Which Program Would Be Reconsidered
If intertribal allocation questions could be resolved, the reasons for the poor returns of the brood year 1991 release could be addressed, funding becomes potentially available, and the fisheries could be conducted intensively enough to insure that few hatchery fish escape to spawn naturally (or it is determined that, either by using fall Chinook broodstock, or by additional data collection, the likely genetic impacts of stray spawning are negligible), then this program could be reconsidered. WDFW's Science Division should review any proposals for potential ecological and genetic impacts.

Fall Chinook Releases at the Mouth of Baker River

Action
After fulfilling the needs of the indicator stock program and any contingency conservation needs (see above), additional broodstock would be taken from indicator stock returns at the Baker to

provide for a selective fishery on fall Chinook at the mouth of the Baker (i.e., the number of fish released at the Baker would be increased well above the number needed for the indicator stock program).

Why Program Is Not Proposed
Additional release facilities would need to be built at the Baker, and it is unclear how the benefits of these releases might be allocated inter-tribally, or whether the benefits of a fishery in that constricted area would justify the cost of the program. There are also concerns about whether the additional hatchery production might swamp the lower Skagit fall natural production in some years.

Conditions Under Which Program Would Be Reconsidered
If intertribal allocation questions could be resolved, surplus broodstock are available, return rates are projected to be sufficiently high to justify the program, and the lower Skagit natural run is healthy, this program could be reconsidered. In addition, if the spring Chinook program is resumed at the Baker (see above), the two programs would need to be compatible.

13.5. NON-CHINOOK HATCHERY PROGRAMS

Other hatchery programs include coho, steelhead and chum salmon (Table 13.2).

Table 13.2. *Annual releases of coho, steelhead and chum salmon in the Skagit River Basin.*

Subyearling	Yearling	Stock Lineage	Production Type	Release Site	Agency/ Sponsor	Status
Coho	250,000	Skagit	Integrated Harvest	Marblemount Hatchery	WDFW	Continue
120,000	60,000	Skagit	Experimental, indicator and mitigation	Sulfur Creek Baker & Shannon lakes	WDFW/PSE	Continue Continue
Winter Steelhead	334,000	Local Chambers	Isolated Harvest	Marblemount, Davis Slough, Baker River, Grandy Ck.	WDFW	Continue
	200,000	Local Chambers		Barnaby Slough		Continue
Chum	500,000	Skagit	Educational, harvest	Upper Skagit Hatchery	Upper Skagit Tribe	Continue
Sockeye	1,000,000	Baker Lake	Mitigation	Shannon Lake	WDFW/PSE	Continue

13.5.1 Coho Salmon

Marblemount Coho Program
Coho salmon are produced at the Marblemount Hatchery through an integrated harvest program with an annual release of approximately 250,000 smolts at a size of 17 fpp (137 mm fl). The size of the program has been reduced by 41% from the average release for the 1993 and 1994 brood years. Smolts are released on-station in June as a risk aversion measure for listed Chinook juveniles. In addition, the egg-take goal of 650,000 is used to supply other projects, including net pen operations, tribal programs and educational projects. The tribal program consists of 100,000 yearling coho at 25 fpp (121mm fl) released into Indian Slough, in south Padilla Bay.

Summary of Program Evaluation and Risk Aversion Measures

Predation and competition are the primary hazards that this program might pose to listed Chinook and summer chum salmon populations. A review of the program suggested the following program modifications (in addition to the program reduction from 423,500 to 250,000 yearling smolts effective for the 1994 brood year) as risk aversion measures to address these potential hazards:

1) Delay the release of coho salmon smolts from May until June; and
2) Conduct studies in riverine, estuarine, and nearshore areas to evaluate the ecological risks posed by the release of coho salmon smolts.

Ongoing and proposed risk aversion measures for this program are summarized in Table 13.3.

Table 13.3. Summary of risk aversion measures for the Marblemount Coho program.

Potential Hazard	HGMP Reference	Risk Aversion Measures
Water Withdrawal	4.2	Usage of surface water at Marblemount Hatchery is regulated under the following permits: S1-23230c, S1-06773c, S1-06774c, S1-21701c, S1-00419c and S1-20241c. Water used in the hatchery is routed to the creek immediately below the hatchery.
Intake Screening	4.2	Intake screens at Marblemount Hatchery are believed to be compliant with NOAA fish screening standards.
Effluent Discharge	4.2	Effluent is regulated through NPDES permit WAG 13-1037.
Broodstock Collection and Adult Passage	7.9	Coho salmon voluntarily enter an off-channel pond at Marblemount Hatchery from October through January. Spring Chinook typically enter from April through September. Any unmarked Chinook that enter the pond during coho salmon broodstock collection will be returned to the river.
Disease Transmission	7.9, 10.11	The program is operated consistent with the co managers' Salmonid Disease Control Policy.
Competition and Predation	10.11	Fish are released at a time, size, and life-history stage (smolts) to foster rapid migration to marine waters. Smolts are released in June to allow Chinook salmon to grow to a size that reduces the potential for predation. Program size reduced by 41% from the average release for the 1993 and 1994 brood years. Studies will be conducted in riverine, estuarine, and nearshore areas to evaluate the ecological risks posed by the release of coho salmon smolts.

Operational Commitments:

- WDFW will continue to use gametes from coho salmon adults volunteering into the Marblemount Hatchery for broodstock. Coho collection and spawning takes place from October to January. Fall and summer Chinook are collected on the river while the spring Chinook are collected and spawned at the trap from April to September. Any unmarked Chinook that enter the pond during coho salmon broodstock collection will be returned to the river.
- WDFW will review information on the hatchery-natural composition of fish spawning in the river and at the hatchery to determine if modifications in broodstock collection procedures are necessary to achieve the goals for this integrated program (HSRG recommendation).
- WDFW will limit, as the management intent, annual production of coho for Marblemount on-station release to a total maximum of 250,000 yearlings (17 fpp or 137 mm fl).
- WDFW will release coho salmon in June to allow Chinook salmon to grow to a size that reduces the potential for predation. As a risk aversion measure, the coho salmon will also be

released at a time, size, and life history stage (smolted) that fosters rapid migration to salt water. This helps minimize possible interaction with listed Chinook salmon juveniles.
- WDFW will, as a management intent, apply an identifiable mark to 100% of the coho smolts released through the hatchery to allow for monitoring and evaluation of the hatchery program fish releases and adult returns.
- WDFW will apply a double index coded-wire tag group to allow for selective fisheries, the evaluation of fishery contribution, overall survival rates and straying levels to other Puget Sound watersheds.
- WDFW will commit funds for the design and construction of a new pollution abatement system (HSRG recommendation).

Baker Lake Coho Program

For the past ten years (1993-2002), this coho program has planted fry and yearling coho into the Baker River system, a Skagit River tributary (Water Resource Inventory Areas [WRIA] 3 & 4). Since inception in 1993, the ten year escapement has been 5,557 adults, of which more than 95% have been trapped and hauled up to Baker Lake to spawn naturally. Less than 5%, an average of 242 adults, is utilized to support a fry plant of up to 120,000 fish into Sulphur Creek and a yearling program of 60,000 smolts released in three locations: Baker Lake, Lake Shannon and at the mouth of the Baker River. The purpose of this program is to: 1) supply experimental and research smolts for gulper efficiency testing, 2) serve as an indicator stock for wild Skagit coho, and 3) supplement natural production in the basin. All other species, with the exception of Chinook and hatchery steelhead, are hauled into Baker Lake to spawn naturally. The trapping site is on PSE land and is secure. This program provides a research element not available from sockeye due to IHNV.

Summary of Program Evaluation and Risk Aversion Measures

Predation and competition are the primary hazards that this program might pose to listed Chinook salmon populations. These hazards are addressed through the risk aversion measures summarized in Table 13.4.

Table 13.4. *Summary of risk aversion measures for the Baker Lake Coho program.*

Potential Hazard	HGMP Reference	Risk Aversion Measures
Water Withdrawal	4.2	Water is obtained from springs containing no fish.
Intake Screening	4.2	Water is obtained from springs containing no fish.
Effluent Discharge	4.2	No NPDES permit is required because the facility produces less than the 20,000 pounds per year criteria set by WDOE as the limit for concern regarding hatchery effluent discharge effects.
Broodstock Collection and Adult Passage	7.9	Coho salmon voluntarily enter the Baker River trap. Unmarked Chinook salmon that enter the trap are handled as follows: fish captured through August 15 are released into Baker Lake; fish captured from August 16 through September 30 are returned to the Skagit River (operculum-punched after September 1); fish captured after September 30 may be taken to Marblemount Hatchery for use in the fall Chinook research program until broodstock needs are met for that program, after which any returns will be operculum-punched and returned to the Skagit River.
Disease Transmission	7.9, 10.11	The program is operated consistent with the co managers' Salmonid Disease Control Policy.
Competition and Predation	10.11	Fish are released at a time, size, and life-history stage (smolts) to foster rapid migration to marine waters. Smolts are released in June to allow Chinook salmon to grow to a size that reduces the potential for predation. Studies will be conducted in riverine, estuarine, and nearshore areas to evaluate the ecological risks posed by the release of coho salmon smolts.

Operational Commitments

- Every adult coho will be handled in a dip net and visually inspected and wanded for marks and CWTs. Power crowders are used to transfer the fish. Adults are hauled and placed into circular ponds (at RM 9) or into Baker Lake to spawn naturally.
- The management intent is to limit annual production of coho salmon to a maximum of 60,000 smolts (release locations are Baker Lake, Lake Shannon, and the mouth of the Baker River) at a size of 17 fpp (137 mm fl) and 120,000 fed fry into Sulphur Creek.
- Fish (yearlings) destined for Baker Lake and Lake Shannon are freeze-branded and adipose-fin clipped only. The fish released at the mouth of the Baker River are adipose-fin clipped only. About 25,000 –30,000 wild smolts are coded-wire tagged only coming out of Baker Lake. Fed fry released from Sulphur Springs are not marked.

13.5.2 Winter Steelhead

Marblemount Winter Steelhead Program

Winter steelhead are produced at the Marblemount Hatchery through an isolated harvest program with an annual release of approximately 334,000 smolts at a size of 5 fish per pound (206 mm fl). Fish are released at the following locations: 1) 136,000 on-station; 2) 30,000 at Davis Slough (RM 40); 3) 60,000 at the Baker River Trap; and 4) 108,000 at Grandy Creek and Fabors Ferry (RM 68). Smolts are released in May as a risk aversion measure for listed Chinook juveniles.

Summary of Program Evaluation and Risk Aversion Measures

Predation and competition are the primary hazards that this program might pose to listed Chinook salmon populations. A review of the program suggested the following program modifications as risk aversion measures to address these potential hazards:

1) Eliminate trucking of smolts from an out-of-basin rearing location (Whitehorse Ponds) to increase the likelihood that steelhead smolts released into the Skagit River will rapidly emigrate to marine waters; and
2) Conduct studies in riverine, estuarine, and nearshore areas to evaluate the ecological risks posed by the release of steelhead smolts.

Ongoing and proposed risk aversion measures for this program are summarized in Table 13.5.

Operational Commitments

- WDFW will continue to use gametes from steelhead adults volunteering into the Marblemount Hatchery, the Baker River Trap, or Barnaby Slough for broodstock. Steelhead collection and spawning takes place from late December to March while listed spring, summer and fall Chinook are collected and spawned outside this time frame. Therefore, steelhead broodstock collection is expected to have a minimal impact on listed Chinook salmon.
- WDFW will limit, as the management intent, annual production of steelhead for release to a total maximum of 334,000 yearlings at a size of 5 fpp (206 mm fl). Fish are released at the following locations: 1) 136,000 on-station; 2) 30,000 at Davis Slough (RM 40); 3) 60,000 at the Baker River Trap; and 4) 108,000 at Grandy Creek and Fabors Ferry (RM 68). No more than 51% of the fish are released above the Rockport Bridge.
- WDFW will release winter steelhead in May to allow Chinook salmon to grow to a size that reduces the potential for predation by winter steelhead smolts (HSRG recommended release between May 1 and May 15). As a risk aversion measure, the winter steelhead will also be

released at a time, size, and life history stage (smolted) that fosters rapid migration to salt water. This helps minimize possible interaction with listed Chinook salmon juveniles.

- WDFW will, as a management intent, apply an identifiable mark to 100% of the steelhead released to allow for monitoring and evaluation of the hatchery program fish releases and adult returns.
- WDFW will commit funds for the design and construction of a new pollution abatement system (HSRG recommendation).

Table 13.5. *Summary of risk aversion measures for the Marblemount Winter Steelhead program.*

Potential Hazard	HGMP Reference	Risk Aversion Measures
Water Withdrawal	4.2	Usage of surface water at Marblemount Hatchery is regulated under the following permits: S1-23230c, S1-06773c, S1-06774c, S1-21701c, S1-00419c and S1-20241c. Water used in the hatchery is routed to the creek immediately below the hatchery.
Intake Screening	4.2	Intake screens at Marblemount Hatchery are believed to be compliant with NOAA fish screening standards.
Effluent Discharge	4.2	Effluent from the Marblemount Hatchery is regulated under NPDES permit WAG 13-3015.
Broodstock Collection and Adult Passage	7.9	Winter steelhead voluntarily enter an off-channel trap in a time period (late December to March) when Chinook salmon are unlikely to be present.
Disease Transmission	7.9, 10.11	The program is operated consistent with the co managers' Salmonid Disease Control Policy.
Competition and Predation	10.11	Fish are released at a time, size, and life-history stage (smolts) to foster rapid migration to marine waters. Trucking of smolts from an out-of-basin (Whitehorse Ponds) rearing location for release in the Skagit River Basin will be eliminated. Smolts are released in May to allow Chinook salmon to grow to a size that reduces the potential for predation. Studies will be conducted in riverine, estuarine, and nearshore areas to evaluate the ecological risks posed by the release of coho salmon smolts.

Barnaby Slough Winter Steelhead Program

Winter steelhead are produced at the Barnaby Slough facility through an isolated harvest program with an annual release of approximately 200,000 smolts at a size of 5 fish per pound (206 mm fork length). Fish are released at the following locations: 1) 136,000 on-station and 2) 64,000 at Grandy Creek and Fabors Ferry (RM 68). Smolts are released in May as a risk aversion measure for listed Chinook juveniles.

Summary of Program Evaluation and Risk Aversion Measures

Predation and competition are the primary hazards that this program might pose to listed Chinook salmon populations. These potential hazards are addressed through the on-going risk aversion measures summarized in Table 13.6.

Operational Commitments:

- WDFW will continue to use gametes from steelhead adults volunteering into the Barnaby Slough facility for broodstock. Steelhead collection and spawning takes place from late December to March when listed Chinook are unlikely to be present. Therefore, steelhead broodstock collection is expected to have a minimal impact on listed Chinook salmon.
- WDFW will limit, as the management intent, annual production of steelhead for release to a total maximum of 200,000 yearlings at a size of 5 fpp or 206 mm fork length. The hatchery

releases up to 136,000 on-station and the remaining 64,000 are acclimated and/or released from sites on the Skagit River below the Rockport Bridge (Grandy Creek and Fabors Ferry (RM 68)).

- WDFW will release winter steelhead in May to allow Chinook salmon to grow to a size that reduces the potential for predation by winter steelhead smolts. As a risk aversion measure, the winter steelhead will also be released at a time, size, and life history stage (smolted) that fosters rapid migration to salt water. This helps minimize possible interaction with listed Chinook salmon juveniles.
- WDFW will, as a management intent, apply an identifiable mark to 100% of the steelhead released to allow for monitoring and evaluation of the hatchery program fish releases and adult returns.
- WDFW will commit funds for the design of an acclimation and adult trapping facility at Grandy Creek (HSRG recommendation).

Table 13.6. *Summary of risk aversion measures for the Barnaby Slough Winter Steelhead program.*

Potential Hazard	HGMP Reference	Risk Aversion Measures
Water Withdrawal	4.2	Incubation. Usage of surface water at Marblemount Hatchery is regulated under the following permits: S1-23230c, S1-06773c, S1-06774c, S1-21701c, S1-00419c, S1-20241c. Rearing. Usage of surface water at the Barnaby Slough facility is regulated under permit G1-25483.
Intake Screening	4.2	Incubation. Intake screens at Marblemount Hatchery are believed to be compliant with NOAA fish screening standards. Rearing. Intake facilities are believed to be compliant with NOAA fish screening standards.
Effluent Discharge	4.2	Incubation. Effluent from the Marblemount Hatchery is regulated under NPDES permit WAG 13-3015. Rearing. Effluent from the Marblemount Hatchery is regulated under NPDES permit WAG 13-3003.
Broodstock Collection and Adult Passage	7.9	Winter steelhead voluntarily enter an off-channel trap in a time period (late December to March) when Chinook salmon are unlikely to be present.
Disease Transmission	7.9, 10.11	The program is operated consistent with the co managers' Salmonid Disease Control Policy.
Competition and Predation	10.11	Fish are released at a time, size, and life-history stage (smolts) to foster rapid migration to marine waters. Smolts are released in May to allow Chinook salmon to grow to a size that reduces the potential for predation. Studies will be conducted in riverine, estuarine, and nearshore areas to evaluate the ecological risks posed by the release of coho salmon smolts.

13.5.3 Chum Salmon

Upper Skagit Hatchery and Swinomish Raceways

The purpose of this program is to provide fish for harvest and for education. The production goal is to release 500,000 chum salmon into the Skagit River. Approximately 500 brood stock are collected from the mainstem of the Skagit River (RM 40-44) using drift tangle nets. Eggs are collected and fertilized using a modified factorial mating and incubated at the Upper Skagit Hatchery. Button-up fry are moved into circular tanks for early rearing. Historically, fish were moved to the Swinomish Raceways a month before release for acclimation and final rearing and the

fish were released from the Swinomish Raceways in mid to late May when fish had achieved the 0.77 g size. Future releases will be from the Upper Skagit Hatchery.
The effects of this program on Chinook salmon are minimal. Brood stock collection has little negative impact on Chinook salmon. Chinook salmon spawning ends nearly a month before brood stock collection. Potential disease affects of the program are controlled through regular monitoring by professional pathologists from the Northwest Indian Fisheries Commission and treatment if necessary. Because of life history and developmental differences, predation by juvenile chum on Chinook salmon would be extremely rare. The hatchery program does not affect incidental take of Skagit River Chinook salmon (estimated to be eight adult equivalent fish per year) during the chum fishery, because the fishery is managed based on production wild chum populations and not the hatchery production.

13.5.4 Sockeye Salmon

Baker Lake Sockeye Program

The goal of this program is to maintain an adult return of 3,000 fish and to prevent the extirpation of this unique stock by providing a suitable semi-natural spawning and incubation opportunity via man-made spawning channels and/or other fish cultural methods (vertical incubation). There are no specific release goals, but the egg take goal is 2,500,000 (2002 Future Brood Document). With that goal, 1,000,000 are planned to be artificially incubated (500,000 in 2002) with the rest going to the spawning beaches. All fish are released as post-emergent fry into Baker Lake. Release of fish from the artificial incubation facility into Lake Shannon is currently under consideration.

Summary of Program Evaluation and Risk Aversion Measures

This program poses minimal risks to listed salmonids because of the species released. Ongoing and proposed risk aversion measures for this program are summarized in Table 13.7.

Operational Commitments

WDFW and PSE will continue to collect sockeye at the Baker River trap for broodstock purposes as well as for the spawning beaches. Sockeye are collected between the end of June and the end of August. All unmarked Chinook salmon trapped up to August 15 will be transported to Baker Lake, and those trapped from then until the end of September will be returned to the Skagit River (after September 1, these fish will also be operculum-punched). Beginning October 1, unmarked Chinook will be transported to Marblemount Hatchery, until the broodstock needs for the fall Chinook indicator stock project have been met; thereafter, all Chinook will be operculum-punched and returned to the Skagit River. All Chinook salmon with a CWT that are collected before September 16 will have their CWTs extracted and read at the trap to determine hatchery origin. CWT Chinook that arrive September 16 or later will be transported to Marblemount to have their CWTs read, and, if they have a tag from either the summer or the fall Chinook indicator stock project, they can be used as broodstock for that project. Ad-clipped Chinook without a CWT will be handled the same way as CWT Chinook.

Table 13.7. *Summary of risk aversion measures for the Baker Lake Sockeye program.*

Potential Hazard	**HGMP Reference**	**Risk Aversion Measures**
Water Withdrawal	4.2	Water is obtained from springs containing no fish.
Intake Screening	4.2	Water is obtained from springs containing no fish.
Effluent Discharge	4.2	No NPDES permit is required because the facility produces less than the 20,000 pounds per year criteria set by WDOE as the limit for concern regarding hatchery effluent discharge effects.
Broodstock Collection and Adult Passage	7.9	Sockeye salmon voluntarily enter the Baker River trap from approximately the end of June through the end of August. Unmarked Chinook salmon that enter the trap are handled as follows: fish captured through August 15 are released into Baker Lake; fish captured from August 16 through September 30 are returned to the Skagit River (operculum-punched after September 1); fish captured after September 30 may be taken to Marblemount Hatchery for use in the fall Chinook research program until broodstock needs are met for that program, after which any returns will be operculum-punched and returned to the Skagit River.
Disease Transmission	7.9, 10.11	The program is operated consistent with the co managers' Salmonid Disease Control Policy.
Competition and Predation	10.11	Life history and feeding habits of pink salmon are expected to result in limited competitive and predatory interactions with listed Chinook and summer chum salmon.

14. RESEARCH ACTIONS

14.1. GENERAL RESEARCH STRATEGY

Our research efforts in the Skagit Basin over the past ten years, in combination with applicable research from other basins, have informed the development of this recovery plan. The goals of continuing research actions are to test and refine the working hypotheses upon which restoration and protection actions are based (Figure 14.1). Because this plan is intended to be adaptive, it is critical to carry out the research necessary to fill data gaps and to determine whether the assumptions that guide our recovery actions are valid. Constraints that are poorly supported should be tested by research. The answer regarding these constraints may change in light of new evidence. Therefore, the research applications process revises our constraints.

Some of the currently identified data gaps for our ongoing work include: sources of sediments impacting egg to fry survival; the role of beavers in the tidal delta; the ecology of forage fish, as it relates to salmon during nearshore rearing; the role of predation by seals and birds in limiting Chinook productivity; further refinement of our understanding of Chinook rearing and survival in nearshore habitats, including the impacts of specific land uses, like boat basins and shoreline armoring. Several projects are underway or in the planning stages to fill these data gaps. Listed below are those research projects. Research actions are grouped by life stage and habitat because we conduct our research based upon the life cycle framework outlined previously (Chapter 3). Additional projects will be identified and developed as our research progresses and other data gaps and needs become evident. Continued monitoring of physical and biological conditions to support previously developed conclusions are included in the Monitoring Section (Chapter 15).

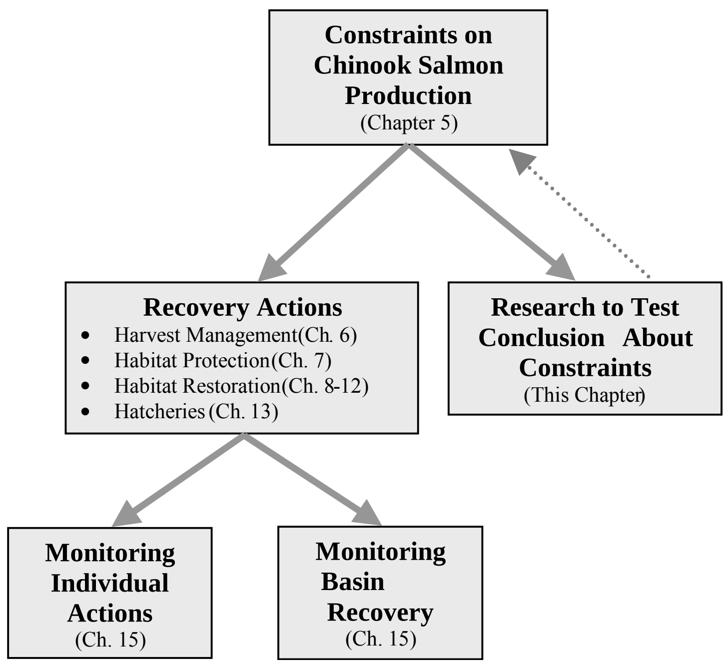


Figure 14.1. *Relationship between recovery plan components.*

14.2. SPAWNING AND EGG TO FRY SURVIVAL

Not specified at this time

14.3. FRESHWATER REARING

14.3.1 Yearlings

We know each of the six wild Chinook spawning populations produce at least some yearling smolts (see section 3.4). We have estimated an average of 107,000 wild yearling smolts have migrated seaward annually since brood year 1994. However, we do not know much about the habits of yearling Chinook salmon during the one plus year period spent in freshwater habitat. In order to better analyze and propose recovery actions that protect or restore yearling Chinook salmon populations, we need studies that identify the:

1. life stages of yearling Chinook within one plus year they spend in freshwater
2. habitats used (and not used) by yearlings for each life stage
3. capacity and survival associated with each habitat type for each life stage

We also need to know the spatial arrangement of habitats within the Skagit River Basin used by (or have the potential to be used by) yearlings for each of the six wild Chinook populations that have significant yearling components.

A study plan has yet to be developed for this research topic. This is a high priority research action for yearling Chinook salmon.

14.3.2 Hatchery Fish Predation in Rivers

We assumed that predation by hatchery raised salmonids on wild juvenile Chinook salmon is not significant in riverine habitat of the Skagit River watershed, according to limited local data (see Chapter 5.4.1). Gut samples of hatchery fish have been collected from the WDFW mainstem trap located in Burlington, but the results of this sampling have not been reported.

14.3.3 Carcass Derived Nutrient Study

<u>Problem Statement</u>

Recent research has shown that marine-derived nutrients, provided by salmon carcasses, comprise a high proportion of the production in stream ecosystems. It has been theorized that, in places where there are fewer salmon carcasses, productivity has been reduced, and this has reduced the returns of adult salmon to those streams. Currently we lack controlled studies that relate an increase in carcass levels to an increase in adult returns in the Skagit. There were inferential results from other areas, but these were not necessarily transferable or unambiguous. On the Skagit, we do have data on escapements (carcass levels), coho and Chinook smolt outmigrations, and adult returns for the system as a whole, and a long data series on escapements for a smaller stream (Illabot). Analysis of these data indicated the following:

- While there is considerable interannual variation, mean carcass biomass levels in the Skagit have been fairly constant, with a slight increasing trend, since 1968;
- During that time, Skagit Chinook run sizes have been negatively correlated to carcass biomass levels four years previously;
- Skagit Chinook smolt outmigration and smolts per spawner values (since BY 1989) have been *negatively* correlated to brood year carcass biomass levels, even after flow is accounted for;

- The same is true of coho smolts and smolts per spawner values (since BY 1982)
- On Illabot Creek, counts of peak Chinook per mile and Chinook/spawner are negatively correlated to peak carcass biomass four years previously;
- The same is true of Illabot coho three years previously.

While none of these negative correlations was statistically significant (meaning that we would reject the hypothesis that increasing the number of carcasses actually reduces Chinook or coho production), there was also no justification for claiming, from the available data that increasing the number of carcasses on the Skagit would be expected to increase Chinook production. Consequently, we assume initially that current carcass levels are not a significant constraint on Skagit Chinook production. However, there was also consensus that we should conduct further research on this factor.

Actions
Test pairs of streams, one of which would be a control and the other would be treated with carcasses. Measured responses would be macroinvertebrate densities, fry condition factors, fry densities, and adult escapements. Hatchery surplus coho have been planted in the upper Cascade for several consecutive years (and nowhere else), so a gross comparison of spawner/spawner rates could be made between upper Cascade springs and either upper Sauk or Suiattle springs (or both in combination). Other possible combinations of streams for future research include combinations of Goodell, Diobsud, Illabot, Finney, and lower Sauk for summer and falls, and combinations of Big Creek, Buck Creek, and Tenas Creek for springs. We are also proposing to collect a time series of condition factor data from the mainstem trap.

Populations Targeted
All

Cost Estimate
Not determined

Timeframe
Not determined

Application
This research will test our assumption that current marine derived nutrient concentrations are not limiting Chinook salmon production.

14.3.4 Fine Sediment and Scour Investigation

Problem Statement
Watershed land uses have impact landscape processes such that flood events during the egg incubation period has increased the frequency or depth of streambed scour or filling or increased the infiltration of fine sediment to egg pocket areas. We inferred these processes are the cause of increase egg to migrant fry survival in watersheds (Beamer and Pess 1999). We have begun data collection throughout the basin to evaluate the magnitude and extent of sedimentation and scour as limiting factors for egg survival.

Actions

- Complete sample processing of sediment boxes.
- Compile and analyze existing scour chain and sediment box data.
- Conduct further sampling if necessary.

Populations Targeted
All

Cost Estimate
Not determined

Timeframe
Not determined

Application
Test the validity of sedimentation and mass wasting being limiting factors to egg survival.

14.4. TIDAL DELTA REARING

14.4.1 Impacts of Global Warming on Delta Habitats

Problem Statement
There have been several estimates for the amount of sea level rise that can be expected in the next century, ranging from 34cm (Titus and Narayanan 1995) to nearly 50 cm (Warrick et al. 1996; Church et al. 2001). However, one of the latest estimates is 100 cm (ACIA 2004). Preliminary analysis indicates that sea-level rise could cause significant tidal marsh and channel loss in the Skagit delta over the next century, from 500 to 1,000 acres of marsh depending on the estimated sea-level rise. However, this analysis needs to be refined to take into account sediment delivery to the bay and the possible ameliorative effects of marsh aggradation.

Actions
Not specified

Populations Targeted
All

Cost Estimate
Approximately $125,000

Timeframe
Not determined

Application
Elevational distributions of tidal marsh vegetation by species can be used to predict the kind of vegetation that will thrive in a restored site once dikes have been removed and tidal and riverine flooding has been restored. This in turn improves prediction of site usage by fish and wildlife. Future spatial distribution of tidal marsh vegetation by growth form (emergent, shrub, tree) or species can be used to plan sustainable restoration, to choose restoration sites that are likely to

sustain targeted vegetation over the next century, to understand which sites are vulnerable and which sites are resilient to sea-level rise. It will also help quantify future habitat loss that will be caused by climate-induced sea-level rise, which will allow a better understanding of the need for mitigating actions.

14.4.2 Impacts of Beaver Activity in the Tidal Delta

Problem Statement

Comparisons of historical habitat abundance (Collins 2000) with current habitat abundance indicates that 68% of the tidal emergent marsh in the Skagit delta has been lost to agricultural and other development. However, even greater habitat loss, 94%, has occurred for tidal scrub-shrub habitat (dominated by willows [*Salix* spp.] and sweetgale [*Myrica gale*]) (G. Hood unpublished data). Similar comparisons in other large river deltas in the Pacific Northwest indicate that tidal scrub-shrub habitat loss approaches 100% compared to historical conditions (Bell and Thompson 1977; Morris and Leaney 1980; North and Teversham 1984; Collins 2000; G. Hood unpublished data). The extensive loss of this habitat type may be the reason that little is known about its ecology, and why little attention has been given to its restoration.

This project focuses on describing the ecology of tidal scrub-shrub habitat in relation to tidal emergent marsh with respect to possible beneficial interactions between tidal shrub habitat, beaver, and in particular juvenile Chinook salmon. Our data, to this point, clearly show a strong link between tidal shrub distribution and beaver dam distribution in the Skagit marshes. Our data also show that the beaver dams create low-tide pools in small tidal channels (<3 m wide) at a three-fold greater rate (number and area per unit channel length) than is found in channels without beaver pools. Small tidal channels without pools drain completely at low tide, so that fish are flushed into larger channels. At a minimum, fish residence time in small tidal channels is reduced where pools are absent. Previous study has shown that invertebrate prey are more abundant in smaller than in larger tidal channels (Hood 2002), so greater residence time could increase juvenile salmon feeding opportunity and growth rate. It is also possible that predation pressure from large fish and wading or diving birds is reduced in these pools relative to larger, deeper, and shrub-free channels. Further information is needed on the abundance of beaver and their dams, on juvenile salmon use of dam-formed low-tide pools, and on predation pressures in tidal pools in shrub versus emergent marsh habitat.

Actions

The following data will be collected:

- GIS map of dam locations
- Dam height, width, and length (field measurements)
- GIS map of pool locations
- Pool depth, width, length for dam formed pools and other pools (field measurements)
- GIS map of vegetation communities, interpreted from high resolution infra-red orthophotos
- GIS map of beaver lodges and beaver dug channels.
- GIS map of great blue heron (GBH) (wading predator) sightings and tracks
- Fish abundance (by species) in pools and non-pool habitat in tidal shrub and tidal emergent marsh habitat
- Fish length

- Fish stomach contents (for a subsample)
- Benthic prey abundance from sediment cores in pools versus non-pool habitat
- Sediment organic content in pools versus non-pool habitat
- Pool temperature in tidal shrub and tidal emergent marsh

The following quantities will be calculated from the data:

- Fish distribution by habitat
- Fish residence time by habitat
- Fish diet by habitat
- Habitat modification rate by beaver
- Effect of beaver behavior on salmon abundance and distribution
- GBH predation pressure by habitat
- Beaver abundance and distribution
- Benthic prey standing stock

Cost Estimate

Approximately $72,000

Timeframe

Not determined

Application

Role of tidal scrub-shrub (willow and sweetgale), as mediated by beaver, in the ecology of juvenile salmon, especially Chinook:

This information will inform restoration efforts that include reintroduction or protection of beaver in tidal habitats. It will also inform habitat restoration prioritization for tidal scrub-shrub habitat, which is greatly reduced compared to historical (pre-Euro American settlement) conditions.

Behavior of juvenile salmon in tidal scrub-shrub versus tidal emergent marsh habitat:

As above. Additionally, tidal scrub-shrub restoration will potentially support greater life history diversity in Chinook salmon, by restoring a rare habitat for juvenile salmon.

This work could also be tied into other work by SRSC on Chinook life history variation, by collecting and analyzing otoliths of juvenile salmon resident in tidal scrub-shrub low-tide pools.

14.4.3 Impacts of Self-Regulating Tidegates on Soil Chemistry, Hydrology, and Fish Passage

Problem Statement

Self-regulating tidegates (SRTs) have been identified as functional infrastructure improvements for the restoration of marine and freshwater tidal wetlands in areas landward of levees and dikes where full restoration is not possible. The reintroduction of water, especially brackish and marine waters, into "reclaimed" land has raised concern regarding impacts to land uses landward of the dikes. It is possible that soil chemistry is altered with the reintroduction of tidal flow into historic channels. Changes in soil chemistry could improve, be detrimental to or not change land uses landward of the dikes. Surface and soil hydrology may also be affected with the introduction of tidal waters landward of the dikes. Again these impacts could improve, be detrimental to, or have no observable impact to the surrounding land uses. Observable differences in soil chemistry and hydrology will likely have a limited and quantifiable geographic scope. The quantification of the geographical impact of tidal wetland improvements is important to evaluate project boundaries.

Few studies have been conducted to validate whether SRT technology really does adequately allow fish passage, especially for juvenile salmon. Moreover, SRT applications can vary significantly in their design, application, and operation. These variables may influence fish passage effectiveness.

Therefore the primary research questions center around the following:

1. Does the replacement of standard tidegates with SRTs at the mouths of historic tidal sloughs change soil chemistry, surface water hydrology and ground water hydrology?
2. What SRT design, application, and operations effectively eliminate upstream and downstream blockages to fish migration?

Actions

For sites proposed for SRT projects to provide baseline data:

- Monitor surface water chemistry landward and seaward of dike, most notably for salinity
- Evaluate the soil pore size in areas that are expected to be completely inundated to areas determined to be completely outside of the influence of inundation
- Evaluate groundwater vectors in the groundwater basin local to the project area
- Evaluate groundwater quantity in the groundwater basin local to the project area
- Evaluate surface water vectors in the basin local to the project area
- Evaluate surface water quantity in the basin local to the project area
- Monitor the fish community landward and seaward of dike

After the construction of the SRT project reevaluate each of the above to determine specific impacts and scope.

For local sites (Island County, Skagit and Samish River basins) where SRTs have already been installed, monitoring of the fish community should be done landward and seaward of the dike to determine whether adequate fish passage has been achieved. Implementation effectiveness monitoring of each SRT should be conducted to determine whether there are differences in fish passage results that relate to different SRT design, application, and operations.

Populations Targeted

All

Cost Estimate

Not determined

Timeframe

SRT projects are proposed in Island County, Skagit and Samish River drainages for construction during the summer of 2006. Baseline data is currently being collected for these projects.

Application
This work will provide the information necessary for the feasibility and proper location of SRT projects in Island County, Skagit and Samish River basins. The data acquired will inform project sponsors and land owners of the impact of these projects and their practical application.

14.5. NEARSHORE REARING

14.5.1 Juvenile Chinook Use of Pocket Estuaries

Problem Statement
Migrant fry represent one of the four major life history pathways that we propose exist in Skagit River Chinook salmon populations. While the accumulation of juvenile Chinook salmon in winter and early spring in pocket estuaries of Whidbey Basin is clear, we do not yet fully understand what aspects of pocket estuaries affect their functions for migrant fry. We proposed earlier that complexity and distance of the pathway salmon must follow to reach the pocket estuary were important but it is likely such attributes as amount of freshwater inflow, size, shape, amount of vegetation present, as well as anthropogenic factors also affect pocket estuary functions. We expect ongoing research to help elucidate some of these variables.

How fish use pocket estuaries (e.g., are they migratory or residents in pocket estuaries) and how these systems function for migrant fry are unknown. The increased size of juvenile Chinook salmon in pocket estuaries compared to fish found outside pocket estuaries suggests that productivity of these systems may be greater than nearshore areas in winter and early spring. These systems are also somewhat warmer at this time of year than surrounding nearshore waters. If this productivity hypothesis is true, these habitats may provide the “best” feeding area available to the fish at this time of the year and allow fish to outgrow their potential predator population as rapidly as possible. Pocket estuaries may also provide some refuge from some predators such as the larger predatory fish. We found relatively few large predators such as cutthroat trout and staghorn sculpin in pocket estuaries. In addition, sculpins that can prey on juvenile salmon tend to be not large enough in pocket estuaries to be predators on juvenile salmon. The importance of bird predation on fish rearing in pocket estuaries is unknown but it could be significant. We have observed great blue herons feeding on unknown prey species at the mouths of outlet channels as the tide ebbs; salmon could be one of their target prey species.

We also need better understanding of nearshore habitats other than pocket estuaries. Fry migrants that want to rear in pocket estuaries still need to migrate through connecting habitats and all other life history strategies utilize nearshore habitats other than pocket estuaries.

Actions
Not specified

Populations Targeted
All

Cost Estimate
Not determined

Timeframe
Ongoing

Application
Results of this research will be applied to restoration site prioritization and design.

14.5.2 Juvenile Chinook Salmon Origin and Use of Habitats Within Puget Sound, Straits of Juan de Fuca, and Georgia Straits Basins

Problem Statement
Salmon productivity depends not on a single habitat or life history period but is a function of all the habitats used by salmon throughout their life. Thus, recovery plans for any species or population must consider the full range of habitats used, from spawning grounds to the ocean. Ocean productivity depends largely on natural sources of variability that we mostly cannot manage but nevertheless need to understand. Other portions of the "salmonscape" can be influenced by human caused disturbances and thus can be improved by our management actions. One area of this "salmonscape" that we have very little stock specific understanding of juvenile Chinook salmon use are the inland coastal waters that are more distant from natal estuaries and the adjacent nearshore.

Juvenile salmon utilize inland coastal waters such as the greater Puget Sound (e.g, Admiralty Inlet, San Juan Islands), Straits of Juan de Fuca, and Georgia Straits extensively and survival during this residence period has been correlated with the overall success of their respective populations. Canadian and United States origin Chinook salmon using this area are exposed to different levels of survival risk due to differences in their migration timing, location, and duration of habitat use. Moreover, the greater Puget Sound / Georgia Basin environment is not homogeneous in habitat type or quality (due to both natural and human causes), thus Chinook salmon rearing potential varies across the landscape. A more specific understanding of the origins of juvenile Chinook salmon using this landscape will fill a glaring data-gap needed for Puget Sound Chinook salmon population recovery by linking specific populations to specific areas within the greater Puget Sound / Georgia Bain and specific habitat types.

Actions
This study should answer the basic questions of:
1. When are juvenile Chinook salmon present in specific mixed origin areas?
2. What juvenile Chinook salmon populations and life history strategies are present in those areas?
3. What is the distribution of juvenile Chinook salmon within areas and by general habitat type?
4. What are the salmon doing within specific habitats (information on growth, diet, residence time where possible)?

Populations Targeted
All Skagit and potentially all Puget Sound populations

Cost Estimate
Not determined

Application

This study would provide an understanding of the spatial and temporal patterns of wild juvenile Chinook salmon origin in mixed stock rearing areas.

14.5.3 Hatchery and Wild Interactions in the Delta and Nearshore

Problem Statement

We know that hatchery and wild origin Chinook salmon co-mingle in nearshore and offshore habitats and not in tidal delta habitat. Because of the co-mingling there is a possibility of interaction in habitat areas with limited prey resources or if hatchery fish are preying on wild Chinook. In the Skagit, hatchery practices are used to rear indicator stock groups that are used to monitor harvest rates of all wild Chinook life history strategies. It is unknown whether the indicator stock releases represent all or any wild Chinook life history strategies. Understandings of both issues are important for implementing this recovery plan.

Actions

In the Skagit we have an opportunity to build on an existing effort to help quantify the survival estimates and investigate biotic variables that could influence juvenile Chinook delta and nearshore survival by building on existing and ongoing work. We also have the opportunity to observe how well the indicator stock releases represent the diversity of wild fish life history types by observing the extent that wild and hatchery Chinook overlap in space and time and therefore infer whether interaction is likely. For example, if we see overlap in time and space between hatchery and wild fish in a habitat zone where we have evidence of density dependence, then we can say that hatchery fish would be having a negative interaction with wild fish. Because of samples already collected (but not read) on the diet of both juvenile hatchery and wild Chinook throughout the Skagit estuary (delta and bay) we could postulate whether there is predator or prey-based interaction potential. We also have complete fish catch records associated with juvenile Chinook throughout the diversity of delta and bay habitats where we could explore the potential for interaction with other fish species (e.g., interaction with juvenile pink salmon). Results from this initial work should help develop a bigger picture study or model that more accurately estimates nearshore survival of wild Chinook in Puget Sound and possibly make recommendations to improve indicator stock programs.

The following is a list of specific products that could be completed in addition to the existing and ongoing wild Skagit Chinook life history and population dynamics efforts. Through past efforts we have collected samples (e.g., gut contents, cwts, and otoliths of juvenile hatchery fish) but have not processed them due to our priority to work on wild fish. As stated above, now would be a good time to begin incorporating an understanding of hatchery fish: their potential interaction and representation of wild fish.

1. Identify the temporal and spatial pattern of juvenile hatchery Chinook found within the Skagit (delta and bay). We can identify seasonal patterns and annual variation because our dataset starts in 1995.
2. Identify the origin of hatchery Chinook found in the Skagit estuary and the hatchery release strategy (including: individual fish size and date of release from location X, population size released, growth of individual fish, distance traveled release to capture).
3. Identify frequency of hatchery fish found in the Skagit estuary by month and release strategy (e.g., size, time, and location of release).

4. Compare the patterns observed by juvenile hatchery fish to observed wild fish patterns (all life history types) of use throughout the Skagit estuary.
5. Summarize available diet data from hatchery and wild fish in the Skagit to determine the potential for food competition or predation or if hatchery fish occupy a different ecological niche from wild fish even though there may be significant spatial and temporal overlap.
6. Identify what combinations of hatchery location, release date, release size, and number of release cause significant overlap in habitat utilization of hatchery fish and wild fish in the Skagit estuary. Discuss circumstances that pose significant risk of competition or adverse interaction and hypothesize whether they are predator or prey-based.
7. Draw conclusions or postulate hypotheses about hatchery and wild Chinook interaction and how well indicator stocks represent wild fish life history types that can relate to hatchery reform (changes in release strategies, location, or size).

Populations Targeted
All

Cost Estimate
Not determined

Timeframe
Not determined

Application
Results of this research will be applied to restoration site prioritization and design.

14.5.4 Impacts of Boat Harbors on Chinook Salmon

Problem Statement
Boat harbors are a common habitat in the current nearshore landscape. They are relatively protected from the natural coastal energy regime and therefore do attract juvenile salmon and other estuarine fishes. However, they are not natural habitats so we can expect the fish community to be different, possibly with the introduction of more predators or a changed food chain. Also, fish within these areas are exposed to risks such as direct pollution spills not present in natural habitats.

Actions
1. Identify changes in the nearshore fish community caused by physical or chemical habitat attributes in boat harbors
2. Identify potential mitigation actions to change or reduce adverse impacts of boat harbors and other industrialized or modified shorelines on juvenile salmon

Populations Targeted
All

Cost Estimate
Not determined

Timeframe
Not determined

Application
Results of this research will be applied to restoration site prioritization and design.

14.5.5 Impacts of Diking on Eelgrass

Problem Statement
Are the Skagit River levees and floodplain and delta development resulting in significant rerouting and deposition of sediments from the river's floodplains and delta to the bay, and consequently burying and destroying eelgrass habitat? Skagit Bay has eelgrass comparable in extent and abundance to that in Padilla Bay. Eelgrass is critical rearing habitat and feeding habitat for a variety of fish and wildlife including juvenile salmon, forage fish, Dungeness crab, widgeon, brant, and many other species. The Skagit Bay eelgrass populations differ from those in Padilla Bay in that Skagit Bay eelgrass is likely strongly influenced by large freshwater and sediment discharges from Skagit River, while Padilla Bay is not. It is possible that Skagit Bay eelgrass has been negatively impacted by levee construction along the Skagit River, which practically eliminates river-borne sediment transport to, and storage in the aerial delta, and, instead, focuses and concentrates sediment transport and deposition to the bay. Consequently, it is possible that Skagit Bay eelgrass is being buried by these high modern (since Euro-American settlement) sediment transport rates and patterns. Preliminary evidence collected in collaboration with the USGS Coastal and Marine Geology Program indicates that this is so.

Actions
Develop the following data:

- High resolution true color orthophotos of Skagit Bay
- Side-scan sonar bathymetry of Skagit Bay
- Submerged, towed video surveys of Skagit Bay eelgrass and recent sediment deposits in eelgrass
- Sediment cores
- Chemical and sedimentary analyses of sediment cores

Analyze for:

- Current eelgrass distribution and abundance
- Distribution, abundance, and morphology of sediment deposits in eelgrass areas
- Depth of sediment burial of eelgrass
- Dynamics of sediment burial and eelgrass recovery
- Historical distribution and abundance of Skagit Bay eelgrass
- Trends and rates of change of eelgrass distribution
- Calculation and evaluation of possible levee impacts on eelgrass sedimentation rates

Populations Targeted
All

Cost Estimate

Most of these costs are currently being borne by the USGS. SRSC staff time probably amounts to $10,000 per year. Total costs are approximately $50,000 each year.

Timeframe

2005

Application

This work will inform efforts to [1] reduce sediment inputs to the Skagit River from poor forest practices, [2] remove or setback levees and restore floodplains and the delta, and [3] provide other compensation for impacts to critical eelgrass habitat.

14.5.6 Forage Fish Ecology

Problem Statement

We know little about forage fish ecology. What data we do have is limited to where the major three forage fish species spawn. We don't have a conceptual life cycle model for forage fish so we can't even hypothesize how the populations might be threatened in a quantitative way. To date, the focus on forage fish has been on spawning habitat protection, which is needed, but there is much more to know. Our goal is to develop a life cycle framework for the forage fish species upon which salmon prey. The framework should be used to access forage fish population status and trends as well as the habitats or life stages that influence overall forage productivity.

Actions

- Develop a life cycle model framework for forage fish.
- Monitor forage fish populations and trends to determine if populations are low or high compared to historic conditions. Some forage fish monitoring data are available through the tidal delta and nearshore monitoring projects (Chapter 15.6 and Appendix E).
- Identify factors that will influence forage fish survival and habitat capacity, and determine restoration needs.

Populations Targeted

All

Cost Estimate

Not determined

Timeframe

Not determined

Application

Results of this research will be applied to restoration site prioritization.

14.5.7 Pinniped Predation Study

Problem Statement

Marine mammals are a natural part of the ecosystem. We need to understand their context before we propose actions to control them. There are three hypotheses to explore:

1) Marine mammal populations are higher than normal and therefore are having a higher than normal impact on the prey populations that support them, including salmon.
2) Habitats supporting salmon at the landscape scale have been so degraded and simplified that opportunities for marine mammal predation on salmon are greater and therefore marine mammal predation is having a significant adverse impact on salmon populations.
3) There is not a significant adverse impact on salmon populations from marine mammal predation. It is only a perception by humans because we see them eating salmon.

Each hypothesis might be true to some degree and they could interrelate.

Actions

Develop analysis framework and quantitatively monitor the location and extent of pinniped predation on Chinook salmon. Determine the current status and historical trends of the regional pinniped population.

Populations Targeted

All

Cost Estimate

Not determined. A similar one-year pinniped scat collection proposal for the San Juan Islands was budgeted at $53,000.

Timeframe

Not determined

Application

This work will test our hypothesis about seal predation on Chinook salmon. The actions to take if hypothesis 1 is true would be to figure out the correct population level of marine mammals for our ecosystem and either improve the ecosystem that supports marine mammals or control the marine mammal population if it is excess to what our ecosystem can support.

The actions to take if hypothesis 2 is true are to diversify the habitat opportunities and pathways that support salmon so that opportunities for predation are reduced.

If hypothesis 3 is true, then education of the public is necessary.

14.5.8 Predatory Bird Study

Problem Statement

Predatory birds, like pinnipeds, have been a natural part of the regional ecosystem. Understanding their role, and population trends over time will help us understand if bird predation is an issue for Chinook salmon.

Past regional work has demonstrated predation on Chinook salmon outmigrants by these cormorants. Our goals are to:

- Determine if double-crested cormorants are major predators on Skagit Chinook and if their population numbers are increasing.
- Develop model from data to estimate percentage of outmigration lost to cormorant predation. Determine if particular Chinook stocks and life history types are vulnerable to bird predation.
- Determine if there is a particular section of the river where Chinook are vulnerable to cormorant predation.

Actions
Bird census count will establish a resident population number to compare. A bird census would be conducted during the height of the outmigration, March through June. Double-crested cormorants will be counted at river roosting sites and feeding activity would be documented. In addition, local marine roosting and nesting sites will be identified and numbers counted.

Populations Targeted
All

Cost Estimate
Not determined

Timeframe
Not determined

Application
Results of this research will be applied to restoration site prioritization and design.

14.5.9 Life History Strategies and Marine Survival Investigation

Problem Statement
Marine survival will vary by juvenile life history strategy and dynamic oceanographic conditions. We need to monitor marine survival over time to refine our understanding of the relationship between life history strategies and marine survival and to identify when marine survival regimen is changing.

Actions
Continue the use of otolith data to determine the marine survival of various life history types of Skagit Chinook. Determine potential historical measures of marine conditions, such as oceanographic and marine productivity indices, and look for relationships between these indices and marine survival of various life history types.

Cost Estimate
Not determined

Timeframe
Not determined

Application

These life history strategy definitions continue to be tested and revised by on-going research and monitoring efforts. Primary questions to answer include identifying all life history strategies and which stocks are represented by these different strategies. Otolith and genetic data collected from spawners throughout the basin, starting with the 1995 brood, could further refine these assumptions by identifying geographic locations of fish that exhibit specific life history strategies. Determine relationships between life history strategies and marine survival at different marine survival regimes.

15. MONITORING ACTIONS

15.1. GENERAL MONITORING STRATEGY

Monitoring actions arise from the need to evaluate the success of restoration, protection, and harvest actions in reaching our recovery goals (Figure 14.1). We evaluate recovery success both on the individual action (project) scale and at the basin-wide scale. When appropriate, individual actions may be monitored together, as a group, to economize on monitoring efforts.

Assuming that landscape processes create the habitat conditions to which biota respond, our monitoring efforts focus on evaluating process function and biotic response. The biological component of monitoring quantifies population characteristics for outmigrating juveniles and returning spawners at the basin scale. At the project scale biological monitoring includes, but is not limited to Chinook salmon presence or absence, fish density, community compositions, Chinook size, and predation and prey potential. The process component of monitoring quantifies habitat characteristics indicative of landscape process function. At the project scale, these metrics would include such data as river flow, sediment supply, driftwood accumulation, tidal extent, and soil pore water salinity. At the basin scale where processes are generally beyond local control, we monitor conditions such as flooding, drought, relative sea level, salinity, and ambient temperature.

In addition to the monitoring of the specific restoration, protection and harvest actions identified in this plan it is important to individually monitor the objectives of each of the recommendations herein. A review of this document and an evaluation of its recommendations will provide an opportunity to guide the management of recovery efforts in light of actions that are working, actions that are not, and new information important to recovery efforts. The plan will be reviewed by the co-managers at intervals of five years, with the first review five years from the date that the plan is initiated.

15.2. IMPLEMENTATION

Project scale monitoring follows methodologies described in Monitoring Stream and Watershed Restoration (Roni 2005). In the cases of tidal delta and nearshore restoration, basin-scale monitoring is implemented according to the Intensively Monitored Watersheds Plan included in Appendix E. Examples of some basin-scale and project-scale monitoring actions are included below. Case-by-case monitoring methods are described as part of each recovery action, as those actions are developed.

15.3. SPAWNING

15.3.1 Annual Spawner Surveys

Purpose

As escapement numbers increase, we must continue monitoring spawner densities for evidence of redd superimposition in the mainstem, as well as any changes in spawning area utilization and distribution basin wide.

Actions
Basin-wide spawner surveys are conducted annually by SRSC and WDFW personnel. Mainstem habitat on the Skagit and Sauk Rivers is generally surveyed from the air, while tributaries are surveyed on foot and by boat. The frequency of surveys is determined in large part by river conditions and crew scheduling, but typically follows a one to two week rotation. Foot and boat surveyors count redds, live fish, and dead fish in standardized river sections; aerial observers count redds only. While aerial surveys provide only the total number of redds in each river section, redds observed during foot and boat surveys are usually individually identified and flagged, allowing for identification of new redds in later surveys.

Spawning escapement estimates are based on redd counts (assuming 2.5 Chinook per redd), and are generated separately for each of the Chinook stocks. The methodology for the escapement estimate varies somewhat with each stock. Escapement estimates for spring Chinook stocks (Suiattle springs, Cascade springs, and upper Sauk springs), are generated directly from redd counts that are summed over the spawning season from redds flagged during either walking, or floating surveys. The season total of redds, per stock are then multiplied by 2.5 to generate the total escapement estimate for spring Chinook. In contrast, upper Skagit summer, Sauk summer, and lower Skagit fall escapements are based on area-under-the-curve (AUC) estimates, which use the total number of redds observed on each survey over time; surveys are aerial surveys. A curve is generated from this data, the area calculated, and then the area is divided by an assumed redd-life of 21 days—this calculation is an estimate of the number of redds. As with spring Chinook, the total number of redds is then multiplied by an assumed 2.5 Chinook per redd to estimate total escapement. Summer and fall stocks also spawn in tributaries and are surveyed by foot, or boat. Separate escapement estimates are calculated from these tributaries, in the same way as spring Chinook estimates, and are included with the AUC estimates for the total summer and fall Chinook spawning escapement estimates.

Cost Estimate
Unknown

Timeframe
Ongoing—surveys are conducted from late July until late October or early November each year.

Application
Data from spawner surveys provides escapement estimates for each stock, approximate distribution of spawning, and spawn timing. These surveys provide an opportunity to monitor redd density and possible redd superimposition as escapements increase. In addition, survey crews sample carcasses for CWTs and marks, collect scale samples, and extract otoliths. Samples collected from carcasses found during spawner surveys are combined with samples collected by SRSC crews as part of indicator stock studies (see Sections 15.3.4 and 15.3.5). This information can be used to estimate stray rates of hatchery stocks, determine age composition, and proportion of life history strategies.

Data from samples collected on the spawning grounds provides information for management and restoration of Skagit Chinook. For example, Chinook run-size forecasts use brood-specific age data derived from spawning grounds scale samples. Also, otoliths collected from adult spawners are a component of life history studies currently underway (see Appendix D).

15.3.2 Skagit River Test Fishery

Purpose
Test fishery data are analyzed to determine:

- Timing distribution of the run and its components
- Age composition of the run
- Hatchery and wild and CWT group composition of the run
- Terminal run size and spawning escapement of CWT wild components (calculated by multiplying CWT group's composition in run by total terminal run size and escapement)
- Percent of adult run composed of each juvenile Chinook life history strategy
- Number of each juvenile life history strategy in adult run
- Ballpark estimate of wild spring Chinook escapement using Hankin ratio method (Hankin and Reeves 1988)
- CWT recoveries contribute to estimates of terminal run size, exploitation rate, and total recruitment for CWT groups
- In-season update of run size may be possible from these data
- Ratio of coho:Chinook and pink:Chinook, to estimate Chinook encounters in simultaneous Chinook release fisheries
- Marine survival by life history strategy, estimated from otolith data, by comparing percent of each life history strategy in adult return to its percent of the juveniles sampled in the bay.

Actions
Annually, from the first week in May through the end of the Chinook management period (usually the last week of August), the SRSC will fish for Chinook salmon at Blake's Drift with a large-mesh drift gillnet, using one boat for one day per week. The fishing that day will be done in two segments that begin with each high tide, and continue for three hours after high tide (i.e., six hours total that day). All fish caught will be sampled as described under "Data Collected", below, and the data will be entered into a computer database.

Chinook that are caught during the test fisheries for coho and chum, which run from Management Week 34 through Week 45 (these are Sunday through Saturday calendar weeks number from the first day of the calendar year), will also be sampled as described below. The coho test fisheries are conducted at Blake's, Spudhouse, and the Highway 9 Bridge, and the chum test fisheries, which occur only during Weeks 44 and 45, are conducted at the Jetty and in Skagit Bay.

Populations Targeted
All

Cost Estimate
Chinook Test Fishery = $28,000 annually—FY 2004
Coho and Chum Test Fisheries = $31,000 annually—FY 2004

Timeframe
Ongoing

Application
These data are applied to test the following assumptions:

- *Population Fitness:* Done by comparing current distribution of timing, age, and length to historical records. If some of the historic timing, age, or length distribution has been lost, immediate actions must be taken to preserve what still remains. This will probably require additional gear and timing restrictions in fisheries, and habitat protection aimed at places where fish on the outer fringes of the existing ranges rear.
- *Seeding:* To generate the spawner-recruit data used to estimate MSY density, the test fishery provides age composition data, and a portion of the CWT exploitation rate data, needed to do run reconstruction and calculate recruitment. If analysis indicates that MSY density is currently being achieved, then, if production goals are not being achieved, restoration actions will be developed to increase the capacity of the limiting habitat. Otherwise, restoration actions will be aimed at increasing survival rates and seeding levels.
- *Timing of run components*: Used to shape terminal fisheries to avoid unintended impacts. If run timing is relatively consistent from year to year, the test fishery could be used to update the run size in-season to determine any harvestable number more accurately. If there are time periods during which harvestable hatchery fish predominate, fisheries could be focused on those time periods. Otherwise, any directed Chinook fisheries should be spread evenly throughout the run.
- *Feasibility of increasing survival through artificial production:* Done by comparing indicator stock composition at the scoop trap to that in the test fishery, to estimate relative marine survivals of CWT indicator stock summers and falls versus untagged summers and falls. If the return/spawner rate for CWT fish is less than for untagged fish, then the CWT program will have to be either modified or eliminated. Depending on the reasons for the lower rate, flowchart assumptions about MSY seeding, incubation survival, and achievability of goals may need to be changed.

15.3.3 Catch Sampling, Monitoring, and Reporting

Purpose
Catch sampling, monitoring and reporting data are analyzed to estimate:

- Timing and distribution of the run and its components
- Run reconstruction
- Recruit/spawner rate
- Age composition of all runs
- Hatchery and wild and CWT composition of the run
- Terminal run size and spawning escapement of CWT wild components (calculated by multiplying CWT group's composition in run by total terminal run size and escapement)
- A portion of the CWT exploitation rate data is needed to generate run reconstruction and calculate recruitment.
- Catch and harvest distribution between fisheries
- Total recruitment for CWT groups
- In-season update of run size may be possible from these data
- Total exploitation rates
- Harvest rates

- Encounter rates
- Release mortality estimates from non-retention and selective fisheries
- Compliance to selective fishery release rules and calculate mark identification errors (retaining unmarked fish and releasing marked fish)—used to estimate mark selective fishery mortality and ultimately provide run reconstruction for stocks for return rate estimates.
- Catch (retention) estimates and accounting
- Fishery sample rate
- Ratio of Coho:Chinook and Pink:Chinook, to estimate Chinook encounters in simultaneous Chinook release fisheries

Actions

Annually, all commercial salmon fisheries conducted in Skagit Bay and River are sampled and monitored, and the catch is reported on Fish Receiving Tickets—either Treaty, or Non-treaty. Catch from recreational fisheries are reported on Catch Record Cards (CRC), or from creel surveys is sampled and monitored annually. Electronic sampling is required for all commercial Chinook catch to detect CWTs from tagged and DIT groups enabling managers to estimate the total selective fishery release mortality. Chinook non-retention fisheries are monitored by representatives from the organization conducting the fishery. Commercial Chinook encounters in a non-retention fishery are estimated either by commercial fishery monitoring, or test fishery catches used as surrogate for commercial fishery encounter rates.

Data Collected:

- Number of Chinook (and other species) caught by landing, or angler
- Number of fish encountered
- Number of fish released
- Number of fish retained
- Number sampled
- Number mark-sampled
- Fishery sample rate
- Observed number of tags recovered
- Mark status of sampled fish
- CWT status of sampled fish
- Sex of CWT fish in commercial fishery
- Sex of all fish sampled during recreational fishery
- Fork length of CWT fish sampled in the commercial fishery
- Fork length of all fish sampled during recreational fishery
- Fork length and sex of CWT fish recovered by year and fishery
- Anglers' species recognition success, or error rate of fish sampled during recreational fishery
- Scales
- Weight of Chinook (and other species)
- Gear type
- Catch area
- Catch date
- Harvest type

- Fisher type
- Time fished for recreational fishery
- Number of anglers per day per area
- Target species' effort during recreational fisheries
- DNA samples during winter recreational fisheries
- Buyer ID
- Buyer compliance of fish receiving ticket completion

Populations Targeted
All

Cost Estimate
Treaty Commercial: $10,000 annually—Fiscal Year (FY) 2004
Non-Treaty commercial and recreational: 45,000 annually—FY 2004

Timeframe
Annually, during all commercial and recreational fisheries

Application
Data collected are used to test and assess the following assumptions and conditions:

- *Population Fitness:* Done by comparing current distribution of timing, age, and length to historical records. If some of the historic timing, age, or length distribution has been lost, immediate actions must be taken to preserve what still remains. This will probably require additional gear and timing restrictions in fisheries, and habitat protection aimed at places where fish on the outer fringes of the existing ranges rear.
- *Seeding:* To generate the spawner-recruit data used to estimate MSY density, the commercial and recreational fishery provides age composition data, and a portion of the CWT exploitation rate data, needed to generate run reconstructions and calculate recruitment, as well as spawning escapement. Marine survival rate data from this study can be used to calibrate the recruitment estimate for changes in marine survival, and preterminal exploitation rate estimates can be used to calibrate the terminal run size for changes in preterminal exploitation. If analysis indicates that MSY density is currently being achieved, then, if production goals are not being achieved, restoration actions will be developed to increase the capacity of the limiting habitat. Otherwise, restoration actions will be aimed at increasing survival rates and seeding levels.
- *Timing of run components*: Used to shape terminal fisheries to avoid unintended impacts. If run timing is relatively consistent from year to year, the commercial fishery could be used to update the run size in-season to determine any harvestable number more accurately. If there are time periods during which harvestable hatchery fish predominate, fisheries could be focused on those time periods. Otherwise, any directed Chinook fisheries should be spread evenly through the run.
- *Preterminal Exploitation*: Fishery exploitation rates quantify which fisheries have the most significant impacts on Skagit Chinook stocks, and when. If these preterminal fisheries can be shaped or reduced to decrease impacts on Skagit Chinook stocks, then efforts can be made to take these actions, and results can be predicted. Exploitation rate data will also be

used to verify whether Canadian and U.S. fisheries are complying with the terms of the 1999 PST Annex (if not, they must be reduced). If there are no preterminal fisheries with significant impacts on Skagit Chinook stocks, or nothing can be done about them, then actions to increase the seeding level must be confined to the terminal area.

- *Feasibility of increasing survival through artificial production:* Done by comparing wild indicator stock composition at the scoop trap to that in the commercial fishery in conjunction with test fisheries, to estimate relative marine survivals of CWT indicator stock summers and falls vs. untagged summers and falls. If the return/spawner rate for CWT fish is less than for untagged fish, then the CWT program will have to be either modified or eliminated. Depending on the reasons for the lower rate, flowchart assumptions about MSY seeding, incubation survival, and achievability of goals may need to be changed.
- *Current Level of Surplus Production:* Estimated by dividing current Chinook stock escapement by complement of CWT exploitation rate to get total recruitment, and subtracting brood escapement to get current surplus production. If surplus production is currently high enough to achieve harvest goals, then the next action will be to try to allocate more of that surplus to terminal fisheries. If surplus production is not high enough, then restoration actions must be taken that focus on improving the survival and increasing or decreasing the spawning escapement, or both.
- *Survival Rates:* Overall survival of the fingerling and yearling wild indicator stock groups are calculated by dividing estimated adult recoveries by number released. While the absolute survival rate estimates for the hatchery stocks cannot be directly applied to wild Chinook, the *trends* in survival rates could be. Thus, it would be possible to evaluate whether marine survival is on a downward trend or not. If marine survival is declining, the restoration action would be to try to address the causes of that decline; otherwise, if no other life history stage is experiencing relatively poor survival, restoration actions would focus on hatchery or harvest management actions that increase terminal harvest.
- *Selective Fisheries Management Goals*: Estimates of release mortality in recreational selective fisheries are essential to calculating total exploitation rate and developing annual run reconstructions. Evaluating release mortality rate assumptions, verifying angler compliance and ability to recognize both species and mark status, and calculating encounter and retention rates need to be tested. Verifying preseason mark rate expectations are needed for data expansions and in-season management modifications. If any of these data are missing, or assumptions do not hold, bias and error can be introduced into survival rate estimates. Thus, it would not be possible to evaluate whether marine survival is on a downward trend or not. If marine survival is declining, the restoration action would be to try to address the causes of that decline; otherwise, if no other life history stage is experiencing relatively poor survival, restoration actions would focus on hatchery or harvest management actions that increase terminal harvest

15.3.4 Summer Chinook Indicator Stock Project

Purpose

To determine:

- Spawning escapement of CWT Chinook

- Exploitation rate on indicator stock summers by fishery
- Catch distribution between fisheries
- Total exploitation rate on Skagit summer Chinook
- Brood year recruitment of Skagit summer Chinook
- Survival rate from release to adulthood
- Survival rate from release to scoop trap, and from scoop trap to adulthood
- Fisheries contribution rate for summer Chinook releases
- Percent of the catch in a fishery that is composed of Skagit summer and fall Chinook
- Fishery harvest rate indices (for PST compliance in Aggregate Abundance Based Management (AABM) fisheries)
- Stock harvest rate indices (for PST compliance in ISBM fisheries)
- Trends in fecundity
- Trends in age of maturity
- Relation between female size, age, fecundity, and egg weight

Actions

Annually, from mid-August to mid-September, approximately 90 Skagit wild summer Chinook (or a number sufficient to get about 250,000 eggs) are netted on the upper Skagit spawning grounds, using two boats that drift a large-mesh, loosely-hung, monofilament gill net between them, by a combined crew from SRSC and WDFW. Captured Chinook are disentangled from the net, transferred to tubes, hoisted into a fish transport truck, and taken to Marblemount Hatchery for spawning. The progeny of these spawners are reared to fingerling release size, coded-wire-tagged, and released into an acclimation pond on the upper Skagit. After acclimating, the pond is opened and the fish outmigrate. They are recovered as adults in fisheries throughout the Northwest, and identified as Skagit fish from their coded wire tags. Upon returning to the Skagit, three to five years after release, we conduct test fisheries and spawning grounds surveys to estimate the number that returned.

Data Collected:

- Number of Chinook broodstock caught each day at each site
- Number released and number kept
- Sex of each fish caught
- Length of each fish kept
- Age of each fish kept (from scale samples)
- Number of marked or tagged fish caught
- CWT code and origin of each tagged Chinook taken in broodstock collection
- Number spawned
- Eggs per female and total egg take
- Average egg weight
- Size of fingerlings at tagging
- Number of fingerlings tagged
- Tag retention rate
- Size of fingerlings at release
- Number of fingerlings released
- Date released

- Observed number of tag recoveries by date and fishery
- Length and sex of CWT Chinook recovered by year and fishery
- Fishery sample rate
- Number of Chinook carcasses sampled by date and site on spawning surveys
- Number of repeat samples
- Number of marked or tagged Chinook carcasses sampled
- Length and sex of CWT Chinook recovered on spawning grounds
- CWT code and origin of tagged Chinook
- Number of Chinook sampled at Marblemount and Baker trap
- Number of marked or tagged Chinook at Marblemount Hatchery and the Baker River trap
- CWT code and origin of tagged Chinook at Marblemount Hatchery and the Baker River trap

Populations Targeted
All

Cost Estimate
About $57,000 annually—FY 2004 dollars. Currently, the Northwest Indian Fisheries Commission (NWIFC) pays the costs of coded-wire-tagging, which is about $20,000 of the $57,000.

Timeframe
Ongoing

Application
Data collected under this project are used to assess the following assumptions:

- *Current Level of Surplus Production:* Estimated by dividing current summer Chinook escapement by complement of CWT exploitation rate to get total recruitment, and subtracting brood escapement to get current surplus production. If surplus production is currently high enough to achieve harvest goals, then the next action will be to try to allocate more of that surplus to terminal fisheries. If surplus production is not high enough, then restoration actions must be taken that focus on improving the survival and increasing or decreasing the spawning escapement, or both.
- *Seeding:* From estimated recruitment and spawning escapement, do a spawner-recruit analysis to calculate MSY escapement level, and compare it to current escapement levels. In doing this analysis, marine survival rate data from this study can be used to calibrate the recruitment estimate for changes in marine survival, and preterminal exploitation rate estimates can be used to calibrate the terminal run size for changes in preterminal exploitation. If analysis indicates that MSY density is currently being achieved (i.e., incremental increases in escapement do *not* increase the terminal run size, calibrated for changes in marine survival and preterminal exploitation, by at least an equal amount), then, if production goals are not being achieved, the restoration action will be to increase the capacity of the limiting habitat. Otherwise, restoration actions will be aimed at increasing survival rates and seeding levels.
- *Preterminal Exploitation*: Fishery exploitation rates quantify which fisheries have the most significant impacts on Skagit summers, and when. If these preterminal fisheries can be shaped or reduced to decrease impacts on Skagit summers, then efforts can be made to take

these actions, and results can be predicted. Exploitation rate data will also be used to verify whether Canadian and U.S. fisheries are complying with the terms of the 1999 PST Annex (if not, they must be reduced). If there are no preterminal fisheries with significant impacts on Skagit summers, or nothing can be done about them, then actions to increase the seeding level must be confined to the terminal area.

- *Feasibility of increasing survival through artificial production*: Compare recruits per spawner rates for summer indicator stock fish to the recruits per spawner rates for wild upper Skagit summers. If the recruits/spawner rate for indicator stock summers is less than for wild fish, then the indicator stock program may need to be either modified or eliminated, and off-station plants of upper Skagit summers should not be attempted for supplementation reasons. Depending on the reasons for the lower rate, flowchart assumptions about MSY seeding, incubation survival, and achievability of goals may need to be changed.
- *Survival Rates*: Overall survival of the indicator stock group is calculated by dividing estimated adult recoveries by number released. This can be partitioned into survival upstream and downstream of the scoop trap, if the capture efficiency at the scoop trap is estimated independently of the indicator stock release (and capture efficiency is the same for the indicator stock releases), by using this capture efficiency to estimate the number of indicator stock summers that make it to the scoop trap. While the absolute survival rate estimates for the indicator stock summers cannot be directly applied to wild Chinook, the trends in survival rates could be. Thus, it would be possible to evaluate whether habitat restoration actions are successfully increasing upper Skagit summer Chinook survival rates in the freshwater or marine environment, or not. These data would also show whether marine survival is on a downward trend or not. If marine survival is declining, the restoration action would be to try to address the causes of that decline; otherwise, if no other life history stage is experiencing relatively poor survival, restoration actions would focus on hatchery or harvest management actions that increase terminal harvest. In addition, if the recruits/spawner rate for indicator stock summers is less than for wild fish, this examination of survival rates could indicate whether the bottleneck occurs upstream or downstream of the scoop trap, and indicator stock release strategies could be adjusted to try to address the poor survival problem.
- *Population Fitness:* Examined by determining whether there are significant correlations between wild female Chinook length, age, fecundity, and egg weight, and analyzing whether there are long-term trends measured for one of these factors on the spawning grounds that could indicate whether there are long-term trends for another of these factors. If average female length, fecundity, or egg weights are decreasing, that could indicate a loss in productivity that wouldn't be reflected by escapement trends. If this decreasing trend is due to a decline in average age, then additional fisheries gear and timing restrictions will probably be needed, assuming there was selection for older fish. If a decreasing trend is due to a decline in average length or fecundity *at age*, then, in addition to shaping fisheries to avoid larger fish, actions should also be sought to improve natural growth rates.

15.3.5 Fall Chinook Indicator Stock Project

Actions

Annually, from mid-September to mid-October, approximately 120 Skagit wild fall Chinook (or a number sufficient to get about 240,000 eggs) are netted on the lower Skagit spawning grounds, using two boats that drift a large-mesh, loosely-hung, monofilament gill net between them, by a combined crew from SRSC and WDFW. Captured Chinook are disentangled from the net, transferred to tubes, hoisted into a fish transport truck, and taken to Marblemount Hatchery for spawning. In addition to these spawners, Chinook that enter the Baker River trap after September 30 will be transported to Marblemount Hatchery for spawning, and additional spawners, if needed, may be purchased from Upper Skagit tribal fishermen during their coho fishery. The progeny of these spawners are reared to fingerling release size, coded-wire tagged, and released into a temporary holding facility at the Baker trap. Flows into the trap are reduced to induce fish to stay long enough to imprint, but there is no barrier preventing outmigration, and the fish can leave the trap voluntarily at any time, and migrate to the ocean. These fish are recovered as adults in fisheries throughout the Northwest, and identified as Skagit fish from their coded-wire tags. Upon returning to the Skagit, three to five years after release, we sample the Baker River trap returns, conduct test fisheries, and survey the spawning grounds to estimate the number that returned, their survival rate, their exploitation rate, and their fishery distribution, and compare these values to those estimated for the summer Chinook indicator stock project.

If the exploitation rates and fisheries distribution of the falls are not significantly different from those of the summers, one of these indicator stock projects may be terminated; otherwise, this program should be continued permanently. If it is continued, then broodstock may eventually be taken solely from the trap returns, as long as 10% to 20% of the broodstock consist of wild returns. If it is projected that fall Chinook indicator stock returns to the Baker trap will exceed broodstock needs, then, to maximize CWT escapement recoveries while still allowing these fish to contribute to spawning, only a subsample of the surplus returns will be used for spawning (and sampled for CWTs). The indicator stock returns that are not retained will be given an external mark (operculum punch or spaghetti tag), recorded as “snout not taken”, and returned to the Skagit alive. If any of these fish is recovered on subsequent spawner surveys, its CWT will be extracted, and we will consult with WDFW on how to change that fish’s designation from “snout not taken” to “snout taken”.

If, however, there is a future need to supplement lower Skagit fall Chinook production because of consistently poor incubation survival, these surplus returns can instead be used for fry supplementation in underseeded areas of the lower Skagit River.

Data Collected:

- Number of Chinook broodstock caught each day at each site (including Baker trap)
- Number released and number kept
- Sex of each fish caught
- Length of each fish kept
- Age of each fish kept (from scale samples)
- Number of marked or tagged fish caught
- CWT code and origin of each tagged Chinook taken in broodstock collection
- Number spawned

- Eggs per female and total egg take
- Average egg weight
- Size of fingerlings at tagging
- Number of fingerlings tagged
- Tag retention rate
- Size of fingerlings at release
- Number of fingerlings released
- Date released
- Observed number of tag recoveries by date and fishery
- Length and sex of CWT Chinook recovered by year and fishery
- Fishery sample rate
- Number of Chinook carcasses sampled by date and site on spawning surveys
- Number of repeat samples
- Number of marked or tagged Chinook carcasses sampled
- Length and sex of CWT Chinook recovered on spawning grounds
- Number of Chinook sampled at Marblemount Hatchery and the Baker River trap
- Number of marked or tagged Chinook at Marblemount and Baker trap
- CWT code and origin of all tagged Chinook recovered in the Skagit system

Purpose
Maintain baseline data for assessing:

- Spawning escapement of CWT Chinook
- Exploitation rate on indicator stock falls by fishery
- Catch distribution between fisheries
- Total exploitation rate on lower Skagit fall Chinook
- Brood year recruitment of lower Skagit fall Chinook
- Survival rate from release to adulthood
- Survival rate from release to scoop trap, and from scoop trap to adulthood
- Fisheries contribution rate for fall Chinook releases
- Percent of the catch in a fishery that is composed of Skagit fall Chinook
- Fishery harvest rate indices (for PST compliance in AABM fisheries)
- Stock harvest rate indices (for PST compliance in ISBM fisheries)
- Trends in fecundity
- Trends in age of maturity
- Relation between female size, age, fecundity, and egg weight
- Chi-square (χ^2) statistics that compare fall Chinook preterminal and total exploitation rates, and catch distribution in major fisheries, to those estimated for the indicator stock summers

Cost Estimate
About $51,000 per year—FY 2004.

Timeframe
Ongoing

Application

The following conditions and assumptions will be determined and tested:

- *Do fall Chinook have a different fishery distribution from summer Chinook*? Estimated from χ^2 statistics that compare the summer and fall indicator projects. If fall Chinook have a significantly different distribution from summer Chinook, then it will be necessary to use the data specifically from this project in order to answer questions about current surplus production, MSY density, and preterminal and total exploitation rates. If fall Chinook do *not* have a significantly different distribution from summer Chinook, then one of these indicator stock projects can be dropped, unless the data from both are necessary for some other information need (e.g., survival rate trends, or feasibility of increasing survival through artificial production). The next three Information Needs (listed below), apply if fall Chinook have a different fishery distribution from summer Chinook.

- *Current Level of Surplus Production*: Estimated by dividing current fall Chinook escapement by complement of CWT exploitation rate to get total recruitment, and subtracting brood escapement to get current surplus production. If the fall Chinook exploitation rate is not different from that of the summers, then this calculation would apply to the entire summer and fall Chinook management unit. If surplus production is currently high enough to achieve harvest goals, then the next action will be to try to allocate more of that surplus to terminal fisheries. If surplus production is not high enough, then restoration actions must be taken that focus on improving the survival and/or increasing or decreasing the spawning escapement.

- *Seeding:* From estimated recruitment and spawning escapement, do a spawner-recruit analysis to calculate MSY escapement level, and compare it to current escapement levels. In doing this analysis, marine survival rate data from this study can be used to calibrate the recruitment estimate for changes in marine survival, and preterminal exploitation rate estimates can be used to calibrate the terminal run size for changes in preterminal exploitation. If analysis indicates that MSY density is currently being achieved (i.e., incremental increases in escapement do *not* increase the terminal run size, calibrated for changes in marine survival and preterminal exploitation, by at least an equal amount), then, if production goals are not being achieved, the restoration action will be to increase the capacity of the limiting habitat. Otherwise, restoration actions will be aimed at increasing survival rates and seeding levels.

- *Preterminal Interceptions*: Fishery exploitation rates quantify which fisheries have the most significant impacts on Skagit falls, and when. If these preterminal fisheries can be shaped or reduced to decrease impacts on Skagit falls, then efforts can be made to take these actions, and results can be predicted. Exploitation rate data will also be used to verify whether Canadian and U.S. fisheries are complying with the terms of the 1999 PST Annex (if not, they must be reduced). If there are no preterminal fisheries with significant impacts on Skagit falls, or nothing can be done about them, then actions to increase the seeding level must be confined to the terminal area. If the fall Chinook preterminal fisheries distribution is the same as that of summer Chinook, then these actions would apply to the entire Skagit summer and fall management unit.

- *Feasibility of increasing survival through artificial production*: Compare recruits per spawner rates for fall indicator stock fish to the recruits per spawner rates for wild lower

Skagit falls. If the recruits/spawner rate for indicator stock falls is less than for wild fish, then the indicator stock program may need to be either modified or eliminated, and off-station plants of lower Skagit falls should not be attempted for supplementation reasons. Depending on the reasons for the lower rate, flowchart assumptions about MSY seeding, incubation survival, and achievability of goals may need to be changed

- *Survival Rates*: Overall survival of the indicator stock group is calculated by dividing estimated adult recoveries by number released. This can be partitioned into survival upstream and downstream of the scoop trap, if the capture efficiency at the scoop trap is estimated independently of the indicator stock release (and capture efficiency is the same for the indicator stock releases), by using this capture efficiency to estimate the number of indicator stock falls that make it to the scoop trap. While the absolute survival rate estimates for the indicator stock falls cannot be directly applied to wild Chinook, the *trends* in survival rates could be. Thus, it would be possible to evaluate whether habitat restoration actions are successfully increasing lower Skagit fall Chinook survival rates in the freshwater or marine environment, or not. These data would also show whether marine survival is on a downward trend or not. If marine survival is declining, the restoration action would be to try to address the causes of that decline; otherwise, if no other life history stage is experiencing relatively poor survival, restoration actions would focus on hatchery or harvest management actions that increase terminal harvest. In addition, if the recruits/spawner rate for indicator stock falls is less than for wild fish, this examination of survival rates could indicate whether the bottleneck occurs upstream or downstream of the scoop trap, and indicator stock release strategies could be adjusted to try to address the poor survival problem.
- *Population Fitness*: Examined by determining whether there are significant correlations between wild female Chinook length, age, fecundity, and egg weight, and analyzing whether there are long-term trends measured for one of these factors on the spawning grounds that could indicate whether there are long-term trends for another of these factors. If average female length, fecundity, or egg weights are decreasing, that could indicate a loss in productivity that wouldn't be reflected by escapement trends. If this decreasing trend is due to a decline in average age, then additional fisheries gear and timing restrictions will probably be needed, assuming there was selection for older fish. If a decreasing trend is due to a decline in average length or fecundity *at age*, then, in addition to shaping fisheries to avoid larger fish, actions should also be sought to improve natural growth rates.

15.3.6 Hatchery Spring Chinook Indicator Stock Project

Purpose

Maintain baseline data for assessing:

- Spawning escapement of CWT spring Chinook
- Ballpark estimate of wild spring Chinook escapement (calculated by dividing CWT escapement by the CWT spring composition in the test fishery, and subtracting the CWT escapement)
- Exploitation rate on indicator stock springs by fishery
- Catch distribution between fisheries
- Total exploitation rate on Skagit spring Chinook

- Brood year recruitment of Skagit spring Chinook
- Survival rate from release to adulthood for fingerling releases, compared to yearling releases
- Fisheries contribution rate for fingerling and yearling releases
- Percent of the catch in a fishery that is composed of Skagit spring Chinook
- Fishery harvest rate indices (for PST compliance in AABM fisheries)
- Stock harvest rate indices (for PST compliance in ISBM fisheries)

Actions

Adult hatchery spring Chinook, which are returning from previous plants, volitionally enter the Marblemount Hatchery each year from May to August. About 100 pairs of adults that bear spring Chinook CWTs are spawned, yielding about 450,000 eggs. These eggs are incubated and reared at Marblemount. By late April or early May, they are large enough to coded-wire-tag. The release target is 250,000 CWT fingerlings, which are volitionally released that first June at a size of 70 per pound, and 150,000 CWT yearlings, which are released the following April at about ten per pound. The yearling release is divided into 75,000 adipose marked-CWT fish, and 75,000 unmarked-CWT fish. These fish then migrate to the ocean. They are recovered as adults in fisheries throughout the Northwest, and identified as Skagit fish from their CWT. Upon returning to the Skagit, three to five years after release, the majority of survivors return to Marblemount Hatchery, and are collected, counted, and sampled there. A small number might be found on the spawning grounds or in the summer Chinook broodstock collection, and identified as springs from their CWT.

Data Collected:

- Total number of Chinook that return to Marblemount Hatchery, by date of entry
- Number of CWT springs that return to Marblemount Hatchery
- CWT code and origin of each tagged Chinook at Marblemount Hatchery
- Age
- Sex
- Length
- Number spawned
- Number of eggs taken
- Date spawned
- Size of fingerlings at tagging
- Number of fingerlings tagged in each tag group
- Tag retention rate for each tag group
- Number released as fingerlings
- Dates of fingerling release
- Size of fish in fingerling release
- Number released as yearlings
- Dates of yearling release
- Size of fish in yearling release
- Observed number of tag recoveries by date and fishery
- Length and sex of CWT Chinook recovered by year and fishery
- Fishery sample rate
- Number of CWT springs recovered on the spawning grounds or broodstock collections
- Number of Chinook sampled on the spawning grounds or broodstock collections

Cost Estimate
About $150,000 annually—FY 2004

Timeframe
Ongoing

Application
The following conditions and assumptions will be determined and tested:

- *Current Level of Surplus Production*: Estimated by dividing wild spring Chinook escapement by complement of CWT exploitation rate to get total wild recruitment, and subtracting brood escapement to get surplus production. If surplus production is currently high enough to achieve harvest goals, then the next action will be to try to allocate more of that surplus to terminal fisheries. If surplus production is not high enough, then restoration actions must be taken that focus on improving the survival and/or increasing or decreasing the spawning escapement.
- *Seeding:* From estimated recruitment and spawning escapement, conduct a spawner-recruit analysis to calculate MSY escapement level, and compare it to current escapement levels. In doing this analysis, marine survival rate data from this study can be used to calibrate the recruitment estimate for changes in marine survival, and preterminal exploitation rate estimates can be used to calibrate the terminal run size for changes in preterminal exploitation. If analysis indicates that MSY density is currently being achieved (i.e., incremental increases in escapement do *not* increase the terminal run size, calibrated for changes in marine survival and preterminal exploitation, by at least an equal amount), then, if production goals are not being achieved, the restoration action will be to increase the capacity of the limiting habitat. Otherwise, restoration actions will be aimed at increasing survival rates and seeding levels.
- *Preterminal Exploitation:* Fishery exploitation rates quantify which fisheries have the most significant impacts on Skagit springs, and when. If these preterminal fisheries can be shaped or reduced to decrease impacts on Skagit springs, then efforts can be made to take these actions, and results can be predicted. Exploitation rate data will also be used to verify whether Canadian and U.S. fisheries are complying with the terms of the 1999 PST Annex (if not, they must be reduced). If there are no preterminal fisheries with significant impacts on Skagit springs, or nothing can be done about them, then actions to increase the seeding level must be confined to the terminal area.
- *Survival Rates:* Overall survivals of the fingerling and yearling indicator stock groups are calculated by dividing estimated adult recoveries by number released. While the absolute survival rate estimates for the hatchery springs cannot be directly applied to wild Chinook, the *trends* in survival rates could be. Thus, it would be possible to evaluate whether marine survival is on a downward trend or not. If marine survival is declining, the restoration action would be to try to address the causes of that decline; otherwise, if no other life history stage is experiencing relatively poor survival, restoration actions would focus on hatchery or harvest management actions that increase terminal harvest.
- *Feasibility of Improving Survival Rates or Terminal Harvests*: Compare survival rates and fishery contribution rates between fingerling and yearling release groups from the same

brood year. If a plan objective is to increase the harvest of hatchery springs, this project would show whether the fingerling release strategy or the yearling release strategy is more effective, and it would quantify the expected returns from each strategy. If neither strategy provides sufficient harvest to achieve the goals of the plan, given all the other plan actions, then the goals of the plan can't be achieved under the given assumptions. The parties must then re-examine the plan assumptions, and may need to revise the goals of the plan.

15.4. EGG TO FRY SURVIVAL AND FRESHWATER REARING

15.4.1 Monitoring Chinook Redd Incubation Success in Relation to Seattle City Light Hydroelectric Project Operations.

Purpose

Hydroelectric dams can drastically alter flow regimes in rivers by re-regulating flows. Seattle City Light's (SCL) license requires them to release minimum flows based on average flows of the ten highest flow release days during the Chinook spawning period (August 20 to October 15). Model incubation success rates range from 95 to 98% however it states in the Skagit Settlement Agreement that it is the goal of the city and interveners to achieve 100% redd protection (known informally as the best efforts clause). The city is only responsible for flows it controls, not tributary flows, downstream of the project. Seattle City Light works with the agencies and tribes using best efforts to protect as many redds as possible in the event that high tributary flows precipitate spawning of redds that minimum license flows will not protect.

Actions

Chinook spawning surveys are conducted annually from the Sauk River confluence to the town of Newhalem every seven to ten days starting the week prior to the official license start of the period and ending when active spawning ceases. The redds that are most vulnerable to dewatering are marked with a numbered painted rock, the depth is measured to calculate a dewater flow, and distance from the bank is recorded to further assess risk of dewatering. If there is a risk of dewatering temperature units may be monitored to determine when fry emergence from the redd could be expected.

Cost Estimate

Unknown

Timeframe

Ongoing—surveys are conducted from mid August until late October each year.

Application

If Chinook redds are identified as at risk of dewatering the multi-agency and tribe Flow Coordinating Committee establish by the SCL Settlement Agreement works with SCL to reduce or eliminate that risk. Snow pack, reservoir levels and additional flow release necessary to protect at risk redds are evaluated to determine the appropriate level of protection. Temperature units may be used to protect redds until fry can emerge and then allow the redds to dewater.

15.4.2 Monitoring Compliance with Minimum Flow and Downramp Requirements of FERC Licensed Hydroelectric Projects

Purpose
Hydroelectric projects can impact Chinook by altering flow regimes both by the amount of change (downramp amplitude), rate of change (downramp rates) and seasonal spawning and incubation flows. Seattle City Light's license for the Skagit Project contains seasonal amplitude restrictions, seasonal downramp rate restrictions and minimum incubation flows based on daily average flows released during spawning periods. Puget Sound Energy's Baker River Project is currently under re-license. A settlement agreement and proposed license has been submitted to the FERC. A new license is expected to be issued in 2006. The current project infrastructure limits the flexibility the project has for flow releases. The new license will have maximum and minimum flow release requirements for spawning and incubation as well as downramp rate restrictions. New license requirements will not take effect until new equipment is installed that will allow for greater flexibility in flow releases. Construction is scheduled to be completed in license year six (2012). There will be an interim flow plan in place from license issuance until 2012 that reduces impacts of flow regulation to the greatest extent possible with current project infrastructure.

Actions
SRSC staff will monitor flows released by the Skagit and Baker Projects using 15-minute flow data for USGS gauges in the Skagit Basin available over the internet. Downramp rates agreed to for the Baker Project are Washington State downramp rates in the Skagit River just downstream of the Baker River confluence. To achieve state downramp rates in the Skagit flow releases from the Baker Project have been modeled based on amount of flow in the Skagit and flow to be released from the Baker Project. The modeled downramp rates will be verified by field observation.

Cost Estimate
Unknown

Timeframe
Ongoing—year around observations

Application
Monitoring flow releases will ensure license compliance and Chinook protection from hydroelectric project flow regulation.

15.4.3 Mainstem Smolt Trap

Purpose
- Skagit River wild 0-age Chinook (and other species') production
- Freshwater survival defined as "egg-to-migrant"
- Estimate of 0-age Wild Chinook (and other species) outmigration
- Timing, and species and stock composition of outmigration
- Hatchery and wild composition
- Size and age at migration
- Inter-annual variation in run size

- Estimate stock proportion of hatchery fish
- In-river survival rates of 0-age hatchery Chinook mortality (above Mt. Vernon)
- Juvenile freshwater life history are used in flow management, habitat protection, and designing hatchery programs to minimize hatchery and wild interactions
- Minimize hatchery and wild interactions

Actions

Operate two downstream migrant trap types (screw trap and scoop trap), operated by WDFW and are anchored side by side on the lower mainstem Skagit River at approximately R.M. 17, in Burlington, Washington. Traps are installed in January and operated through July. Traps are operated every night and every third day unless flows associated with debris are excessive. All captured fish are identified and enumerated. Trap efficiency is calibrated by using marked groups of Chinook that are released above the trap site and then are recaptured for recovery rate estimates. Intervals not fished are expanded. Expansions of the projected season catch in both traps by the average trap efficiency rate yield a system-wide production estimate of 0-age wild Chinook. Estimates of in-river survival of hatchery Chinook above Mt. Vernon are also estimated.

Data Collected:

- Trap efficiency (or capture rate)
- Day vs. night trap efficiency
- River discharge
- Water velocity
- Water temperature
- Turbidity
- Debris
- Channel configuration
- Trap placement
- Total hours fished in a day
- Time of day fished, either night, or day
- Total hours fish
- Identification and enumeration of all fish captured
- Hatchery and wild catch composition
- External marks
- Fish fork length
- Sub-sample of CWTs
- Number of recaptured, trap efficiency fish
- Number of marked fish released for trap efficiency estimates

Populations Targeted

All, but primarily 0-age wild Chinook

Cost Estimate

$193,00 annually, prior to data analysis and supervision—FY 2004

Timeframe

Annually, mid January through July

Application

Data collected are used to test and assess the following assumptions and conditions:

- *Seeding:* To generate the spawner-recruit data used to estimate MSY density. Relating smolt production to adult spawners over a number of broods empirically determines the watershed's natural production potential, its stock/recruit function if escapements are less than that required to achieve maximum production, and enables identification of the major density-independent source(s) of inter-annual variation in freshwater survival.
- *Environment Effects on Survival Rates*: Test hypotheses on the relative effects of freshwater environment variation on Chinook salmon a function of environmental conditions experienced during residency in freshwater are predictors of adult return rates. Test whether the magnitude of floods experienced during egg incubation is able to predict egg-to-migrant survival rates (or generally, return rate). If production goals are not being achieved, restoration actions will be developed to increase the abundance of the limiting habitat and restore headwater systems impacted by timber practices (that may reduce the susceptibility of incubating eggs in mainstem habitats to peak flows and processes associated with sedimentation), or both. Otherwise, restoration actions will be aimed at increasing survival rates and seeding levels focusing on improving the survival and/or increasing the spawning escapement.
- *Density Dependent Survival Rates*: Test whether survival rates are density dependent during estuary residence and whether density-dependence is a response to density-dependent migration. Data suggest that density-dependent interactions control the timing, abundance, and size distribution of outmigrants. Determine abundance, timing, and condition of juveniles during annual outmigrations. If analysis indicates that survival is density dependant and historical habitat is limited because of habitat loss, and production goals are not being achieved, restoration actions will be developed to increase the capacity of the limiting habitat. Further, if analysis indicates that MSY density is currently being achieved, then, if production goals are not being achieved, restoration actions will be developed to increase the capacity of the limiting habitat.
- *Population Fitness:* Done by comparing current distribution of timing, age, and length to historical records. If some of the historic timing, age, or length distribution has been lost, immediate actions must be taken to preserve what still remains. This will probably require habitat protection aimed at places where fish on the outer fringes of the existing ranges rear.

15.5. DELTA AND NEARSHORE REARING

Monitoring in these habitats and life stages is covered under the Intensively Monitored Watersheds Plan included in Appendix E.

15.6. ALL LIFE STAGES

15.6.1 Monitor and Assess Ongoing Land Use Impacts to Chinook

Purpose
Develop a database of land use activities within the Skagit Basin to track cumulative effects of land use on Skagit Chinook salmon.

Actions
Continue to monitor land use permits and compile information into a database.
Periodically evaluate the cumulative effects of development and land use actions in terms of impacts to: instream flow, basin hydrology, water and sediment quality, stream channel complexity, riparian and wetland areas, and fish passage.

Population Targeted
All

Cost Estimate
Unknown

Timeframe
Ongoing

Application
To evaluate the effectiveness of habitat protection measures

16. PREDICTED EFFECTIVENESS OF RECOVERY ACTIONS

We have estimated the benefits of each recovery action or set of recovery actions to evaluate the effectiveness of this plan in reaching Skagit Chinook salmon recovery goals.

16.1. HARVEST MANAGEMENT ACTIONS

The provisions in this plan put ceiling limitations on the exploitation rates on Skagit Chinook, and prohibit directed Chinook fisheries unless harvestable surpluses exist. These exploitation rate ceilings are 38% for springs and 50% for summers and falls. Application of these provisions since 1999 has resulted in mean exploitation rates of about 27% for springs and 37% for summers and falls. We examined both sets of exploitation rates in estimating the degree to which harvest management actions alone, without any other restoration actions, would achieve the wild production levels specified for stock recovery (Table 16.1).

Table 16.1. *Percent of wild production recovery goals achieved through harvest management actions alone.* Assumes no other restoration actions and current adult capacity, under both the 1999-2005 mean exploitation rates (27% for springs and 37% for summers and falls) (top), and annual rates equal to the ceiling rates (38% for springs and 50% for summers and falls) (bottom).

1999-2005 Mean Exploitation Rates					
Mgmt Unit	**Marine Survival Scenario**	**Recovery Criterion**	**Minimum Goal**	**Predicted Under Plan**	**Percent of Goal**
Skagit spring Chinook	Avg Low	Escapement	1,200	1,044	87%
		Recruitment	3,600	1,430	40%
		Productivity	3.0	1.4	46%
	Avg High	Escapement	2,100	3,062	146%
		Recruitment	9,000	4,194	47%
		Productivity	4.3	1.4	32%
Skagit summer/fall Chinook	Avg Low	Escapement	10,630	12,331	116%
		Recruitment	37,000	19,573	53%
		Productivity	3.5	1.6	45%
	Avg High	Escapement	19,200	36,187	189%
		Recruitment	115,000	57,440	50%
		Productivity	6.0	1.6	26%
Ceiling Exploitation Rates					
Mgmt Unit	**Marine Survival Scenario**	**Recovery Criterion**	**Minimum Goal**	**Predicted Under Plan**	**Percent of Goal**
Skagit spring Chinook	Avg Low	Escapement	1,200	886	74%
		Recruitment	3,600	1,430	40%
		Productivity	3.0	1.6	54%
	Avg High	Escapement	2,100	2,600	124%
		Recruitment	9,000	4,194	47%
		Productivity	4.3	1.6	38%
Skagit summer/fall Chinook	Avg Low	Escapement	10,630	9,787	92%
		Recruitment	37,000	19,573	53%
		Productivity	3.5	2.0	57%
	Avg High	Escapement	19,200	28,720	150%
		Recruitment	115,000	57,440	50%
		Productivity	6.0	2.0	33%

It is noteworthy that the only wild production recovery goals that would be met or nearly met through harvest management actions alone are the spawning escapement recovery levels. Clearly, harvest management can address only one component of the wild production goals (the spawning escapement), and achieving these escapement levels does not mean that recovery has been achieved. The other components of recovery, the number of fish produced from that escapement (recruitment), and their survival rate (productivity), fall well short of their goals when actions are limited to harvest management alone.

The plan's exploitation rates represent considerable reductions from previous rates. According to post-season runs using FRAM, exploitation rates during the 1980s averaged 62% for Skagit springs and 66% for Skagit summers and falls. Thus, the rates imposed by this plan represent reductions of 39% to 56% for springs, and 24% to 44% for summers and falls (Table 16.2).

Table 16.2. *Change in exploitation rates.*

	Spring Chinook		Summer/Fall Chinook	
	Exploitation Rate	**% Change From 1983-1989**	**Exploitation Rate**	**% Change From 1983-1989**
1983-1989 Mean	62%	----------	66%	----------
Ceiling Rates	38%	-39%	50%	-24%
1999-2005 Mean	27%	-56%	37%	-44%

In addition to these wild Chinook production goals, harvest goals are also a component of this plan. As with the wild Chinook production goals, we examined achievement of the harvest goals under two marine survival levels: the average low marine survival, and the average high marine survival. Under average low marine survival, resulting terminal run sizes were expected to be less than the Upper Escapement Threshold (UET); thus, incidental harvests only would be allowed in the terminal area. Terminal area exploitation rates, with only incidental harvests allowed, have averaged 1% for springs and 5% for summers and falls over the last seven years. Hence, these were the rates applied for this analysis. Under average high marine survival, in contrast, resulting terminal run sizes were expected to exceed the UET. Thus, directed harvests, up to the exploitation rate ceiling, would be permitted. In doing this analysis, we assumed that all of the directed harvests are taken in the terminal area; this resulted in terminal area exploitation rates of 12% for springs and 18% for summers and falls (Table 16.3).

Table 16.3. *Percent of harvest goals achieved through harvest management actions alone.* Assumes no other restoration actions and current adult capacity, under both an average low marine survival regime and an average high marine survival regime.

	Avg Survival, Low Regime		Avg Survival, High Regime	
	Spring MU	**Sum/fall MU**	**Spring MU**	**Sum/fall MU**
Long-Term Harvest Goal	1,000	30,000	1,000	30,000
Current Adult Capacity	1,430	19,573	4,194	57,440
Terminal Exploitation Rate	1%	5%	12%	18%
Resulting Harvest	14	979	503	10,339
Percent of Harvest Goal	1%	3%	50%	35%

Under average low marine survival, terminal harvests would achieve only 1% of the spring Chinook harvest goal, and 3% of the summer and fall harvest goal. Under average high marine survival, terminal harvests would be expected to achieve 50% of the spring Chinook harvest goal, and 35% of the summer and fall Chinook harvest goal.

16.2. HABITAT PROTECTION

In the face of increased human population growth and the impact of ongoing and new land use activities, the ability to recover threatened Chinook salmon populations can only occur if the productivity and capacity necessary to meet recovery goals is met through a combination of habitat protection and restoration actions. Recommendations in Chapter 7 of this recovery plan are intended to protect the existing productivity and capacity of habitat utilized by Skagit Chinook salmon populations. We generally predict the outcome of implementing the protection actions listed in this plan will be no net loss in Skagit Chinook salmon recruitment or productivity. If the current habitat for Chinook salmon is not adequately protected and its capacity and productivity are reduced over current levels, this will result in the need for additional habitat restoration to offset the losses due to habitat degradation.

While we generally conclude that the recommendations in Chapter 7 will maintain existing habitat conditions, we also predict that several specific recommendations in Chapter 7, if implemented, will stop activities that directly harm Chinook salmon or natural processes—thus allowing for improved Chinook salmon survival or improved habitat conditions that will translate into improved Chinook capacity and survival over time. These specific recommendations are listed below and with brief descriptions of how they improve conditions for Chinook salmon over the status quo. It is beyond the scope of this version of the SCRP to quantify the benefits of each recommendation, with one exception: improvements to egg-to-fry survival through actions implemented under Forest Practice laws for industrial landowners.

Table 16.4. Recommendations from Chapter 7 that improve habitat conditions over the status quo for Chinook salmon.

Rec. #	Project	Description of how conditions for Chinook salmon are improved
8	Baker River hydropower stream flows	Changes in downramping events and minimum instream flows should improve egg-to-fry survival and fry survival for Chinook in Skagit River reaches downstream of the Baker River.
13	Skagit flood control project	Implementation of a Skagit flood control project has the potential to improve conditions for Chinook salmon (actual benefits will depend on design of project).
14/15	Forest practices	Implemented road management plans for industrial landowners will improve egg-to-fry survival. This benefit has been quantified as part of the egg-to-fry survival actions, section 16.3.
17	Agricultural practices and/or Riparian Protection Act	Implementation of such an act should allow for streamside buffers to develop along streams currently without buffers. Over time, habitat capacity and quality in these areas will improve over status quo.
18	TMDLs for streams with Chinook salmon	Implementation of TMDLs in streams with Chinook salmon will improve juvenile survival in those streams.
19	Drainage maintenance plans/Skagit Drainage and Fish Initiative	Implementation of such a plan should allow for instream habitat in fish-bearing waters to improve. Over time, habitat capacity and quality in these areas will improve over status quo.
21	Shorelines Management Act	Implementing the recommended changes to the Shorelines Management Act will improve Chinook salmon nearshore survival by allowing for certain nearshore habitats to not be chronically disturbed, thus allowing for an increase in their productivity over status quo.
22	Increased water quality improvement funding	Increased funding for water quality improvement projects will improve habitat conditions for Chinook salmon, increasing their survival.
29	LWD and bridges	Leaving LWD in the river system to form habitat structure and complexity will improve Chinook salmon rearing conditions over status quo.
40/41	Stream buffer regulations & Critical Area Ordinances	Implementation of such an act should allow for streamside buffers to develop along streams currently without buffers. Over time, habitat capacity and quality in these areas will improve over status quo.
42	Funding for CREP	Continued funding for CREP will improve streamside riparian conditions.
53	Provide fish passage at culverts	Providing fish passage at stream crossings will increase habitat available to Chinook salmon.

16.3. HABITAT RESTORATION

In this section we examine the degree to which habitat restoration actions listed in this recovery plan achieve the recovery goals.

16.3.1 Benefits by Individual Life Stage or Life History Strategy

Our analysis shows the influence of each habitat restoration action by life stage group: spawning and egg incubation, freshwater rearing, tidal delta rearing, and nearshore rearing. Because each group is spatially located in different parts of the landscape, each action group can be influenced by different governmental jurisdictions, stakeholders, and land uses. To summarize the potential burden/responsibility for Skagit Chinook recovery borne by the various regions we offer the following table showing changes in capacity or population size of various juvenile Chinook life stages or life history strategies.(Table 16.5).

Table 16.5. Changes in capacity or population for Skagit origin juvenile Chinook at Equilibrium Escapement

Habitat	Life Stage or Life History Strategy	Current Capacity	Restored Capacity
Spawning and egg incubation	Fry	17,900,000*	22,800,000* (27% increase)
Freshwater	Yearling	107,000	140,000 (31% increase)
	Parr migrant	1,300,000	1,700,000 (31% increase)
Estuary/Nearshore	Tidal Delta	2,250,000	3,600,000 (60% increase)
	Pocket Estuary	70,000	220,000 (214% increase)

*There is no limitation to emergent fry capacity.

Each life stage or life history strategy shown in Table 16.5 correlates to the different habitat restoration chapters (Chapters 9-12). Changes to the fry population due to actions listed in Chapter 9 are expected to increase the fry population at equilibrium escapement levels by 27% to a total fry population of almost 23 million. The yearling and parr migrant life history strategies will benefit from the freshwater rearing actions listed in Chapter 10, increasing their capacity by 31%. The tidal delta rearing life history strategy will benefit from the delta actions listed in Chapter 11, increasing their capacity by 60%. The pocket estuary rearing life history strategy will benefit from the nearshore actions listed in Chapter 12, increasing their capacity by 214%.

A basic observation of Table 16.5 shows that the restoration actions in our plan do not propose the same proportional increase in Chinook salmon by life stage or life history strategy. We propose significantly higher proportional increases for tidal delta and pocket estuary habitat than freshwater habitat. This is, in part, by design driven by limits in geomorphology and the human opportunity of restoration as described in Chapter 8. For example, thirty-one percent of the large river floodplains have been isolated from riverine processes and we propose habitat restoration actions that increase capacity for freshwater rearing life history strategies by 31%. A similar example exists for estuarine rearing Chinook salmon, only the habitat loss has been greater, therefore the restoration goal is also greater. Together, the habitat restoration actions proposed in this plan address the habitat needs of all known Chinook salmon life history strategies so our approach also addresses life history diversity needs.

16.3.2 *Benefit of All Habitat Actions Combined*

We examine the benefit of all habitat restoration actions together by comparing their predicted benefit to the recovery goals listed in Chapter 4 of this plan. This analysis compares the predicted result of implementing the habitat actions described in Chapters 9-12 of this plan. Four tables show the percentage increase for Chinook salmon adult recruitment at equilibrium escapement levels (Table 16.6), productivity at equilibrium escapement (Table 16.7), adult recruitment at MSY escapement levels (Table 16.8), and productivity at MSY escapement levels (Table 16.9).

A simple observation of the tables may lead the reader to conclude that the actions listed in this plan achieves about 70-80% of what is necessary for recovery of adult recruitment (depending on the marine survival regime and whether you look at equilibrium or MSY escapement levels). However, there is a legitimate discussion that follows describing why these estimates are conservative and we have already described above (section 16.2) that some specific habitat protection actions will improve habitat for Chinook salmon. The analysis generally shows productivity is easily achieved at climate regimes conducive to high marine survival of Chinook salmon.

Table 16.6. *Percent of adult recruitment goals at Equilibrium Escapement for wild Skagit Chinook salmon achieved by implementing all proposed restoration actions.*

Marine Survival	Recovery goal (Adults per year)	Before Plan Actions		After Plan Actions		Percent Change
		Adults per year	Percent of goal	Adults per year	Percent of goal	
Low regime	52,430	28,611	54.6%	40,267	**76.8%**	**+22.2%**
High regime	145,100	83,962	57.9%	118,168	**81.4%**	**+23.8%**

Table 16.7. *Percent of productivity goals at Equilibrium Escapement for wild Skagit Chinook salmon achieved by implementing all proposed restoration actions.*

Marine Survival	Recovery goal for recruits (Adults per Spawner)	Before Plan Actions		After Plan Actions		Percent Change
		Adults per Spawner	Percent of goal	Adults per Spawner	Percent of goal	
Low regime	1.0	0.5	54.6%	0.8	**76.8%**	**+22.2%**
High regime	1.0	1.6	160.1%	2.3	**225.4%**	**+65.2%**

Table 16.8. *Percent of adult recruitment goals at MSY Escapement for wild Skagit Chinook salmon achieved by implementing all proposed restoration actions.*

Marine Survival	Recovery Goal (Adults per Year)	Before Plan Actions		After Plan Actions		Percent Change
		Adults per Year	Percent of Goal	Adults per Year	Percent of Goal	
Low regime	40,600	20,369	50.2%	29,991	**73.9%**	**+23.7%**
High regime	124,000	59,774	48.2%	88,012	**71.0%**	**+22.8%**

Table 16.9. *Percent of productivity goals at MSY Escapement for wild Skagit Chinook salmon achieved by implementing all proposed restoration actions.*

Marine Survival	Recovery goal for recruits (Adults per Spawner)	Before Plan Actions		After Plan Actions		**Percent Change**
		Adults per Spawner	Percent of goal	Adults per Spawner	Percent of goal	
Low regime	3.4	1.7	50.2%	2.5	**73.9%**	**+23.7%**
High regime	5.8	5.1	86.8%	7.4	**127.8%**	**+41.0%**

16.3.3 Discussion

The analysis results shown in Tables 16.6 through 16.9 should yield conservative estimates because of the following reasons.

We used marine survival estimates for residual fry migrants (those that do not rear in pocket estuary habitat – see Appendix D) that are approximately one-half of those used by other researchers (e.g., Greene and Beechie 2004). The local evidence (Skagit specific data) supports use of this conservative survival rate. However by using the survival rates from Greene and Beechie, our analysis (i.e., results shown in Tables 16.6 through 16.9) suggests the recovery goals are reached in every case (recruitment and productivity at equilibrium and MSY escapement levels). We point this issue out because the recovery goal process used modeling efforts that may not be entirely consistent with the empirically based model developed to predict the benefits of recovery actions. The model used to predict the benefits of recovery actions is entirely empirically based and reflects the biological mechanisms currently observed to operate within Skagit Chinook populations. It was developed to predict the Chinook population response to restoration so that monitoring efforts could be implemented.

We used only habitat actions where our model can quantify a benefit. These are primarily changes to capacity with one exception (changes in egg to fry survival). We predict that restoration done under a landscape process-based philosophy will improve habitat productivity also by improving the physical and biological processes that improve aquatic habitat productivity and fish survival.

There are habitat protection actions in Chapter 7 of the plan that will provide positive recovery benefits rather than keeping habitat conditions at status quo. This issue was discussed in the previous section of this chapter (16.2).

The productivity part of our analysis (Tables 16.7 and 16.9) suggests we would benefit from more plan actions that improve survival, especially during low marine survival periods. Ideas on improving survival can be translated to recovery actions via research. For example, several areas of investigation in our plan include the role of predation and forage fish populations as potential limits to survival (see Chapter 14).

Also, our plan advocates following a restoration paradigm that restores landscape processes (rather than habitat modification) and increases habitat connectivity and complexity. This restoration approach will help restore nutrient pathways (increasing primary productivity) and allow restoration to be more sustainable and cost effective. We will also gain benefits not quantified in Tables 16.6 through 16.9 for certain restoration actions. Sediment reduction has been modeled for a egg to fry survival benefit, but we also can expect rearing habitat to improve in habitat areas for these projects as pool depths increase and gravel bars revegetate.

16.3.4 Conclusion

Considering the discussion above, we believe the actions listed in this plan (if implemented) will achieve Skagit Chinook salmon Recovery Goals stated in Chapter 4 of this plan.

16.4. ARTIFICIAL PRODUCTION ACTIONS

The artificial production actions currently proposed in this plan are monitoring actions, and were not designed with the intent of contributing directly to achieving the natural production goals or the harvest goals. Nonetheless, these programs do provide some contribution to achieving both the recovery escapement levels and the harvest goals[10]. The summer and fall Chinook indicator stock programs, combined, are expected to contribute an average of about 1,850 Chinook to the recruitment. If fisheries were conducted up to the exploitation rate ceilings every year, the contribution to spawning escapement from these two programs would be somewhat above 900 spawners per year, which would achieve 9% of the minimum recovery escapement level under average low marine survival, and, assuming the same recruitment, 5% of the minimum recovery escapement level under average high marine survival (Table 16.10). Terminal area harvests of fish returning from these two programs, under average low marine survival (for which only incidental harvests would be allowed), would be slightly less than 100, and, under average high marine survival (assuming directed harvests would be allowed), would be somewhat above 300. These harvests would meet 0.3% and 1%, respectively, of the long-term harvest goal for Skagit summer/fall Chinook (Table 16.10).

The spring Chinook program is expected to provide about 2,400 Chinook to the recruitment. Because hatchery springs are intended to return to and spawn in a hatchery, none of the returns would contribute to meeting the recovery escapement goals, which apply only to natural spawning. The hatchery springs do, however, contribute to harvest. Under average low marine survival, with incidental harvests only, just over 20 of these fish (2% of the harvest goal) would be caught in the terminal area; under average high marine survival, assuming the same recruitment and directed terminal area fisheries, slightly less than 300 of these fish (29% of the harvest goal) would be caught in terminal area fisheries (Table 16.10). These harvest numbers could be increased if terminal area mark-selective fisheries were conducted successfully.

[10] Their production does not, however, contribute to the recruitment or recruits per spawner (productivity) goals, because those goals are intended to represent natural habitat at PFC, and attainment of those goals is therefore measured as the production that results from natural spawning only.

Table 16.10. Percent of recovery goals (in terms of spawning escapement) and long-term harvest goals achieved by proposed artificial production actions. Assumes the harvest management actions described in this plan and the same level of recruitment under both average low marine survival and average high marine survival.

	Average survival, low regime		Average survival, high regime	
	Spring MU	Sum/Fall MU	Spring MU	Sum/Fall MU
Recovery escapement level	1,200	10,630	2,100	19,200
Recruits from artificial production	2,400	1,850	2,400	1,850
Ceiling exploitation rate	38%	50%	38%	50%
Contribution to escapement	N/A	925	N/A	925
Percent of recovery escapement	**0%**	**9%**	**0%**	**5%**
1999-2005 mean exploitation rate	27%	37%	27%	37%
Contribution to escapement	N/A	1,166	N/A	1,166
Percent of recovery escapement	**0%**	**11%**	**0%**	**6%**
Long-term harvest goal	1,000	30,000	1,000	30,000
Recruits from artificial production	2,400	1,850	2,400	1,850
Terminal exploitation rate	1%	5%	12%	18%
Resulting harvest	24	93	288	333
Percent of harvest goal	**2%**	**0.3%**	**29%**	**1%**

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APPENDIX A: TRENDS IN SPAWNING ESCAPEMENT

APPENDIX B: LINKING EGG-TO-FRY SURVIVAL TO CHINOOK RECOVERY

APPENDIX C: LINKING RIVERINE HABITAT RESTORATION TO CHINOOK RECOVERY

APPENDIX D: LINKING ESTUARY RESTORATION TO WILD CHINOOK SALMON POPULATIONS

APPENDIX E: INTENSIVELY MONITORED WATERSHEDS PLAN

APPENDIX F: EXCERPTS FROM MANAGEMENT RECOMMENDATIONS FOR WASHINGTON'S PRIORITY HABITATS

APPENDIX G: EXCERPTS FROM THE GOVERNOR'S "EXTINCTION IS NOT AN OPTION"

APPENDIX H: SKAGIT RECOVERY GOALS