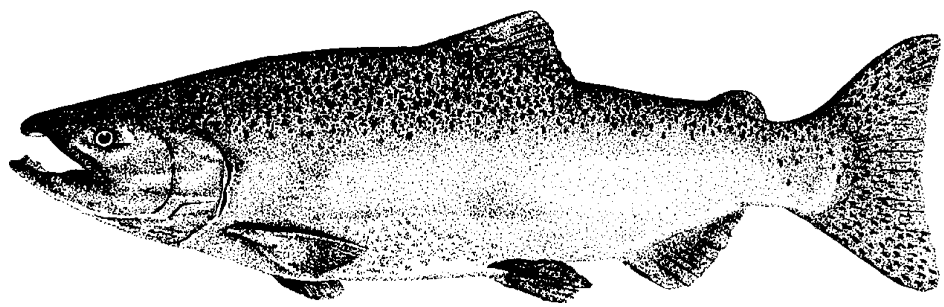
STATE OF WASHINGTON September 1997

Wild Salmonid Policy



Environmental Impact Statement

STATE OF WASHINGTON

GARY LOCKE, GOVERNOR

DEPARTMENT OF FISH AND WILDLIFE

BERN SHANKS, Ph.D., DIRECTOR

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FINAL

Environmental Impact Statement

for the

Wild Salmonid Policy

LEAD AGENCY:

Washington Department of Fish and Wildlife
600 Capitol Way North
Olympia, WA 98501-1091

September 1997

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Director, Washington Department of Fish and Wildlife *Date*

FACT SHEET

Title and Description: The Department of Fish and Wildlife proposes adoption of a Wild Salmonid Policy that will be the policies and plans that guide and describe agency activities and programs related to the protection, management, and production of wild salmonids (salmon, trout, char, grayling, and whitefish) in the State of Washington. The plan or program is designed to be a joint policy and planning approach with Washington's Indian Tribes. The Wild Salmonid Policy will address salmonid habitat needs, protection and maintenance of populations, conservation of genetic and life history characteristics of the wild salmonids and other factors affecting the survival and production of wild salmonids in Washington.

Proponent: Washington Department of Fish and Wildlife

Lead Agency: Washington Department of Fish and Wildlife

SEPA Responsible Official:

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Permits and Licenses Required: None

Authors and Principal Contributions:

Steve Evans - Hatcheries
Steve Keller - Habitat
Steve Phelps - Genetics
Sam Wright - Fish Population Management

Issue Date: September 1997

Date Final Action is Planned:

A Wild Salmonid Policy is expected to be adopted in October 1997. This will not be final agency action because the policy contemplates ongoing planning and actions to address the factors described in a Wild Salmonid Policy, some of which will require rule making processes or other environmental processes.

Background Data and Materials Referenced in this FEIS are Available for Review at:

Washington Department of Fish and Wildlife
Fish Management Program
Natural Resources Building, 6^{th} Floor
1111 Washington Street SE
Olympia, WA

Cost to the Public for Copy of FEIS:

Copies are available to the public at no cost by writing Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501-1091 or calling (360) 902-2701.

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For additional information, if you have special accommodation needs, or require this document in an alternative format please contact: Steve Phelps at (360) 902-2701.

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Summary

The proposed Wild Salmonid Policy responds to the depressed status of wild salmonid populations in Washington. Many salmonid stocks are reduced relative to historic numbers as a result of habitat changes, excessive harvest, and other impacts. Stocks affected by genetic changes from hatchery operations or the effects of harvesting are at risk from genetic and life history changes. To ensure long-term conservation of such stocks and production of fish for human use and ecological integrity, the Department of Fish and Wildlife determined that the factors affecting wild salmonids should be identified and examined in a coherent and comprehensive Wild Salmonid Policy.

This Final Environmental Impact Statement (FEIS) examines successes and risks caused by existing WDFW and tribal fish management activities including harvest management and hatchery operation. This FEIS also examines the habitat issues. The purpose of this examination is to allow the planning and development of comprehensive policy approaches to these subjects so that wild salmonids can be better protected and conserved, and rebuilt to contribute to fisheries.

The proposed Wild Salmonid Policy analyzed in this FEIS represents a programmatic approach to the factors that affect wild salmonids. The proposal anticipates tribal joinder in a policy, so that state and tribal fish management follows more uniform approaches to wild salmonids. Much of the proposal builds on current practices that are used in parts of Washington or elsewhere; in some respects the proposal would alleviate impacts or risks to wild salmonids inherent in some current practices. Accordingly, the proposal itself would alleviate current impacts to this part of the environment by leading to management actions that minimize such impacts.

This FEIS represents an initial planning phase of environmental review. When new actions are taken, such as undertaking new projects, adopting new rules, or taking other major actions with a likelihood of significant impacts to the environment, then additional environmental review may occur. The scope of such likely future actions is broadly found within the analysis of implementation strategies in this FEIS.

Where other agencies take actions that have the potential to adversely impact salmon or take actions designed to recover salmonids, this FEIS may be used as appropriate to such action. Of course, the law may require supplementation or additional environmental review.

A narrative summary of the alternatives is given at the beginning of Chapters II and III. Differences in the alternatives are listed in the Alternative Summary Matrix.

1. Purpose of and Need for Action

Washington's salmon and trout populations are disappearing and the decline threatens the economic and social fabric of our Pacific Northwest society. Job losses, small business bankruptcies, and the resultant human effects are already occurring and more are anticipated. The quality of life to which our children have become accustomed and that attracts new business and growth to our economy is at risk.

A recent survey by state and tribal biologists found that less than half of Washington's salmon and steelhead stocks were healthy. Other recent reviews of the status of Washington salmon and steelhead stocks reinforce the finding that we are losing unique stocks of salmonids (Huntington et al. 1994 and Nehlsen et al.1991).

Some salmon populations have been listed under the Endangered Species Act (ESA) and more stock listings are expected. The regulatory effects of the ESA for salmonid recovery could be much greater than already felt for the spotted owl because salmon involve a larger geographic area. New businesses thinking about locating in Washington will have to consider the additional regulatory requirements and uncertainty arising from ESA listings before they make their decision.

The causes of declining salmon and trout populations are many: habitat loss, overfishing, poor ocean survival conditions, unwise hatchery practices, institutional gridlock, lack of coordination and accountability, unrealistic expectations of technology, and many others. Much of the available salmon habitat in Washington has been lost in the last 100 years. In a recent speech, the Commissioner of Public Lands, Jennifer Belcher, noted that 4 - 5 million acres of land has been deforested in Washington; over 35% of natural forested areas in Puget Sound are gone. She also noted that we are losing 2,000 acres of wetlands each year. The Department of Fish and Wildlife estimates that at least 30,000 acres of fish and wildlife habitat are lost each year and another 100,000 acres of habitat is being degraded each year. Over 600 water bodies are listed on the Department of Ecology's 303(d) list as impaired or threatened compared to Clean Water Act standards. Needless to say it is a real challenge to reverse the trend of habitat loss given the projected population growth in Washington of an increase of 2.7 million people by the year 2020.

Coastal communities like Sekiu, Neah Bay, La Push, Westport and Ilwaco, some already hard hit by the decline in timber, have been struggling with the economic disasters caused by fishery closures. In 1994, six counties in Washington were declared economic disaster areas from fishing closures; the estimated impact to the counties was over $50 million in one year. Slightly more than $15 million of federal disaster relief funds were made available. Small businesses such as fishing resorts, marinas, bait shops, commercial fishing operations, fish buyers, boat builders, and charter fishing offices are gone or in severe financial straits. Local governments that depend upon fishing industry related revenues are having to reduce services at the very time their residents need these services.

The current status of Washington's salmon and trout populations have created the need for the Washington Department of Fish and Wildlife (the Department) to coordinate its actions to preserve and promote the recovery of such populations. The Department has proposed a policy initiative called the Wild Salmonid Policy to identify and guide its present and future actions.

The Department is issuing this final Environmental Impact Statement (EIS) to set forth an analysis of the Wild Salmonid Policy it has proposed. This EIS examines the

Table 1. Salmonid fishes of Washington State.

Name	Scientific Name	Origin
Cutthroat Trout[1]	*Oncorhychus clarki* (Richardson, 1836)	Native
Rainbow Trout[1]	*Oncorhychus mykiss* (Walbaum, 1792)	Native
Bull Trout[1]	*Salvelinus confluentus* (Suckley, 1858)	Native
Dolly Varden[1]	*Salvelinus malma* (Walbaum, 1792)	Native
Chinook Salmon	*Oncorhynchus tshawytscha* (Walbaum, 1792)	Native
Chum Salmon	*Oncorhynchus keta* (Walbaum, 1792)	Native
Pink Salmon	*Oncorhynchus gorbuscha* (Walbaum, 1792)	Native
Coho Salmon	*Oncorhynchus kisutch* (Walbaum, 1792)	Native
Sockeye Salmon[1]	*Oncorhynchus nerka* (Walbaum, 1792)	Native
Atlantic Salmon	*Salmo salar* (Linnaeus, 1758)	Exotic
Brown Trout	*Salmo trutta* (Linnaeus, 1758)	Exotic
Golden Trout	*Oncorhynchus aguabonita* (Jordan, 1893)	Exotic
Brook Trout	*Salvelinus fontinalis* (Mitchill, 1814)	Exotic
Lake Trout	*Salvelinus namaycush* (Walbaum, 1792)	Exotic
Arctic Grayling	*Thymallus arcticus* (Pallas, 1776)	Exotic
Pygmy Whitefish	*Prosopium coulteri* (Eigenmann & Eigenmann, 1892)	Native
Mountain Whitefish	*Prosopium williamsoni* (Girard, 1856)	Native
Lake Whitefish	*Coregonus clupeaformis* (Mitchill, 1818)	Exotic

[1] Includes both freshwater and anadromous forms (e.g., rainbow trout, steelhead, and kokanee, sockeye.

advantages and environmental impacts of existing and proposed policies. This will allow the Department to adopt a Wild Salmonid Policy that will guide its actions towards protection and recovery of salmonids.

2. Nature and Scope of Proposals for Wild Salmonid Policy

Eighteen species of salmonids are currently found in Washington State waters (Table 1). The proposed Wild Salmonid Policy analyzed in this EIS would be applied to all salmonids found in Washington State, regardless of origin, and would include linkage to other non-salmonid and non-fish species.

2.1 Legislative Charge to Develop Wild Salmonid Policy

The 1993 Legislature affirmed the need for a wild salmonid policy by enacting Second Engrossed House Bill 1309 which states:

"By July 1, 1994 the departments of fisheries and wildlife jointly with the appropriate Indian tribes, shall each establish a wild salmonid policy. The policy shall ensure that department actions and programs are consistent with the goals of rebuilding wild stock populations to levels that permit commercial and recreational fishing opportunity".

This policy development process has followed, building on parallel efforts. State and tribal leaders anticipated the problem and in 1992 began the Wild Stock Restoration Initiative, a strategic plan to rebuild salmon and steelhead stocks. An inventory of salmon and steelhead stock health, the initial component of the strategic plan, was completed in 1992. An inventory of habitat status is scheduled for completion later this year.

2.2 Purpose of the Wild Salmonid Policy

The purpose of the proposed Wild Salmonid Policy (WSP) is to protect, restore, and enhance the productivity, production, and diversity of wild salmonids and their ecosystems to sustain ceremonial, subsistence, commercial, and recreational fisheries; non-consumptive fish benefits; and other related cultural and ecological values.

The WSP and alternatives that are analyzed in this EIS were designed to serve this basic purpose. This purpose is based on the legislatively granted authority and responsibilities of the Department under existing statutes, under the State Environmental Policy Act (SEPA), and other applicable law.

2.3 Scope of the Proposed Wild Salmonid Policy

The proposed Wild Salmonid Policies analyzed in this EIS are programmatic approaches and policy guidance for a broad variety of Department actions. The critical issues addressed by the proposed WSP include fishery management issues, hatchery operations, spawning numbers, and habitat matters. The scope of the proposed WSP recognizes that all these elements affect the existence, survival, and recovery of wild salmonid stocks in Washington.

These habitat elements are essential to salmonid protection statewide and the purposes of the Wild Salmonid Policy set forth above. However, the Department has limited statutory power to create or implement programs that accomplish the proposed habitat elements. The proposed WSP, therefore, addresses existing management and habitat programs at a broad, general level. This scope allows the policy to lead redirection or changes in implementation of existing programs and development of new programs. The proposed WSP contemplates that WDFW and other public and private entities will develop further plans, programs, or other actions.

The nature and scope of the fish management and habitat elements of the proposed Wild Salmonid Policy are set out in Chapters II through V. The proposed policy is analyzed side by side with descriptions of current situations. By discussing the proposed WSP in this context, this EIS provides a meaningful comparison of the environmental impacts and alternatives that could be pursued by the Department.

3. SEPA Processes and the Scope of this Initial Environmental Review

SEPA processes are designed to allow meaningful agency review of environmental impacts and alternatives for major government actions that would affect the environment. SEPA allows such environmental analysis to take place at a time that "coincide[s] with meaningful points in the planning and decision making process." WAC 197-11-060(5). The Department believes that the proposal of an overall WSP is such a meaningful point. By writing an EIS at this time, the Department may have a better informed basis for formulating, adopting, and implementing the actions described in a Wild Salmonid Policy. The Department, however, recognizes that adoption and implementation of a Wild Salmonid Policy will require the Department to work with and provide information to many other state, tribal, federal, and local governments.

The State Environmental Policy Act processes have been used to ensure public input into policy development. Key steps in the policy development process have been:

- A scoping notice sent to more than 600 individuals and interested groups in 1993.

- A Draft Scoping Paper for A Wild Salmonid Policy in May 1994 that was distributed to 1,200 citizens and groups.

- Passage of Referendum 45 (and its implementation in July 1996) clearly empowered the Washington Fish and Wildlife Commission to, in part, develop a Wild Salmonid Policy.

Public meetings throughout the state were held in the presence of one or more Fish and Wildlife commissioners to hear citizen comments. Comments were also provided in writing. Information from the public meetings and comments was available to guide state policy leaders. In April 1997, a Draft Environmental Impact Statement presented five options for public review. These alternatives were crafted from comments received from scoping.

3.1 Future SEPA Review

This first phase of environmental analysis is necessarily broad because the Department is considering a broad policy to guide protection and recovery of wild salmonids. Further environmental analysis will likely occur as Department actions, projects, and programs are guided by the proposed WSP. The potential for further environmental review follows the scope of implementation considerations discussed below. Implementation of the proposed WSP by the Department will require the agreement, cooperation, and joint actions by other agencies of state government, as well as tribal, local, and federal governments. Implementation may take the form of projects, specific programs, or rulemaking. These future actions will raise the question of further SEPA analysis.

3.2 Use of this EIS by Other Agencies

The scope of this EIS is designed so that it may be relied on by other governmental agencies. By incorporating this EIS by reference (and supplementing this EIS as required by law and the circumstances), an agency faced by SEPA procedural requirements can inform itself of the impacts and advantages of a broad, coordinated policy approach to protection of wild salmonids. This ensures that intergovernment planning and decision making will address the complex issues affecting survival of wild salmonid stocks. This broad scope serves SEPA's direction that agencies facilitate study, decisionmaking, and coordination of planning efforts among branches of government. See generally, RCW 41.21C.030(a), (b), (e), (f), and (g).

However, where implementation requires creation of new programs or projects, or actions by other agencies, the Department acknowledges that additional SEPA processes may be required.

4. Wild Salmonid Policy and the Endangered Species Act

The purpose of the proposed Wild Salmonid Policy does not speak directly to the Endangered Species Act (ESA). Clearly the listings of several Snake River stocks, the listing of steelhead in the Columbia River, the decision that listing of bull trout is warranted, and the current review of petitions for listings of other stocks and species suggest that the ESA may soon be used by the federal government to address diminishing salmonid stocks. Such federal actions would cause significant federal regulation of matters that could be addressed by the proposed Wild Salmonid Policy.

Avoiding listings under the ESA would be an important result of the proposed Wild Salmonid Policy. However, keeping stocks from the brink of extinction to avoid ESA listings falls substantially short of the purposes of the proposed WSP. The purpose of the Wild Salmonid Policy will be not only to keep stocks from extinction, but to maintain them at healthy levels that can provide a variety of harvest, cultural, ecological, and other benefits.

5. Implementation of the Proposed Policy

This EIS is not itself a policy to guide or direct WDFW. This EIS describes a range of alternatives for public comment and review by the Department before it takes action on the proposal to adopt a Wild Salmonid Policy.

The proposed WSP would guide and direct Washington Department of Fish and Wildlife (WDFW) actions on matters of salmonid population, including harvest management and hatchery operation, and salmonid habitat. It would be implemented using existing WDFW authority under Titles 75 and 77 RCW, chapter 43.300 RCW, the State Environmental Policy Act (SEPA), and the Administrative Procedures Act (APA). Similarly, the proposed WSP would work in context of applicable federal laws such as treaties and federal court orders.

The proposed WSP would not have the force of law towards the general public. As a general matter, only rules, court orders, or legislative actions have the force of law. As a WDFW policy, it would not bind other state agencies, federal, tribal, or local governments, or any private parties, although it would guide WDFW relations with these entities. Other public and private entities will need to develop coordinated approaches to salmonid protection and recovery and the proposed WSP can be a proposal or focus for such coordination.

Therefore, the proposed WSP itself is not completely self-executing. It can guide the WDFW's implementation of rules and statutes, but the proposed WSP also requires new plans, regulations, and projects. Thus, implementation will require coordinated actions with tribal, state and local governments, and private interests. Each of these actions may involve further public processes such as rulemaking, WDFW Commission oversight, and applicable procedures of SEPA.

The lack of clear implementation prescriptions, guidelines, measurable objectives, and other planning tools was troubling to some reviewers. A number of reviewers asked that detailed cost estimates, requirements for legislation, needed rule or regulation changes, and other detailed information be included in this EIS. In general, we will not be able to provide this kind of detailed information at this stage in the process.

The Department also will need substantial local citizen involvement to be successful at achieving the underlying resource protection and restoration intent of the policy, recognizing the importance of citizen volunteers and advocates. Public involvement to collaboratively communicate, educate, analyze, plan, implement, and evaluate will be given a premium importance. We will need local problem solving with state, local, and federal agencies, tribes, and stakeholder groups at the table. WDFW could provide technical support and would represent state's interests, but they would also be at the table, working collaboratively with local citizens to achieve Wild Salmonid Policy goals consistent with local needs and conditions.

5.1 Implementation Will Include Future Actions, Programs, and Projects

One of the purposes of future process and coordination by other agencies will be to develop appropriate information to guide implementation. Until specific actions and programs are proposed, specific cost estimates will not be available. WDFW will be striving to work within the framework of regulatory reform. Partnerships, local initiatives, voluntary approaches, and cooperative ventures are preferable to additional regulations in meeting the policy goals.

Implementation, therefore, will be a continuing process. Adoption of a Wild Salmonid Policy is not an endpoint. Implementation of some elements, in some watersheds, occurred in the past or can occur immediately and with little fanfare. In many places, current approaches are making progress and meet most or all of the performance measures described in the proposed WSP. In other places implementation will take much longer, requiring time, effort, and resources to answer the difficulties that some of our stocks currently face. As a result, it is not possible to predict all of the possible short-term outcomes along the way. In looking at the outcomes of the policy this EIS focuses on long-term outcomes of achieving the policy.

A number of success stories already exist such as the White River spring chinook restoration program and numerous other stock recovery initiatives have been started. These range from family projects on local streams, to watershed or regional scale plans through the Timber, Fish and Wildlife forum. Participants have included people from across the state. While many projects have been successful, more is needed to achieve our goal.

5.2 Relationship of Proposed WSP to Treaty Rights, Tribal Fishery Management, and Coordinated Management

Washington's treaty tribes play a substantial role in the management and protection of the wild salmonid resource. Salmonid fishes historically played an important role in native culture and religion in the northwest. A number of federally recognized Indian tribes in the northwest are political successors in interests to the Indian communities that negotiated treaties to retain rights to take fish at their usual and accustomed locations. Tribes have treaty rights outside reservation boundaries to take salmonids from Grays Harbor to Canada, and in the Columbia River systems. Tribes also have important rights in fisheries where they exist on their reserved lands.

Federal courts have implemented the off-reservation treaty fishing rights in a series of orders, which ensure that treaty tribes:

- have the right to take up to 50% of the fish that may be harvested from salmon and steelhead runs going through usual and accustomed fishing sites;

- have the right to take hatchery salmon runs introduced into Washington waters;

- have rights to determine how and when to take their allocation of a run, while coordinating such harvests to avoid impairing the rights of other tribes and non-Indians.

The courts have considered, but not determined, whether there is a treaty based obligation on the part of the State to protect the habitat necessary to maintain the fish runs. Several decisions, however, have noted that a treaty right to fish may have little meaning if there are no fish to catch. One of the desirable outcomes of the proposed WSP will be to better ensure healthy future salmonid populations for use in Indian fisheries as well as non-Indian fisheries.

The Department's analysis of the proposed WSP recognizes that achieving the purposes of the proposed WSP depends on substantial cooperation, joint policies, and responsible actions by both the Department and the tribes. Without tribal participation, the purposes of the proposed WSP cannot be easily or efficiently achieved. Such joinder and coordination with tribes can take the form of a joint WSP or common agreement to principles or programs in a WSP. The proposed WSP, however, reflects the Department's unique responsibility for protection of salmonid stocks in Washington. This EIS allows the Department to analyze how the proposed WSP would meet its responsibilities while working with tribes to create a joint or coordinated WSP.

5.3 Implementation - What Citizens Can Do

Citizens can become involved by reviewing this EIS and providing public input when the

Washington Fish and Wildlife Commission reviews or adopts a Wild Salmonid Policy, or when the Department reviews future programs, projects, rule proposals, or agreements that would implement a WSP. You can also become involved when other state agencies, and tribal, local, or federal governments address the matters necessary to protect of wild salmonids.

Citizens can also become volunteers; there are many volunteer opportunities through local and state governments, in addition to many other non-profit organizations or groups. For information on state volunteer programs please call Steve Jenks at (360) 902-2260 or Kent Dimmitt at (360) 902-2237. Another important way for citizens to become involved in salmonid protection and recovery is to be active in communicating with state and local government elected-officials and agency staff members. State legislators can be contacted at 1-800-562-6000.

6 Overview of this EIS

This EIS reviews 5 combinations of policy approaches to the proposal for a WSP. Alternative 1 summarizes the current approaches, thus representing the alternative of taking "no action.". Alternatives 2 through 5 describe a spectrum of fish management, hatchery use, and habitat policies and programs that could be adopted as a WSP of the Department.

Based on direction from the Fish and Wildlife Commission during finalizing of this EIS, this EIS analyzes alternative 3 as a preferred proposal for a WSP. This better allows the Commission and reviewers to compare the advantages and disadvantages of the proposed WSP. However, expressing a preference has no binding effect on the Commission's ultimate adoption of a WSP.

Chapters II and III describe the proposed WSP for fishery management, hatchery operations, and habitat, and alternatives. Chapters IV and V address the environmental impacts and other advantages and disadvantages of each alternative. This format is intended to allow a better comparison and analysis of the overall environmental impacts and implications of each policy approach.

Appendix A provides a glossary that is helpful to understanding the terminology of fisheries management and salmonid stocks. It should be referenced while reading this EIS.

7. Actions that the Commission May Take Using this EIS

The Commission, as the governing body for the Department, will be responsible for taking action based on the proposal analyzed in this EIS. No action will be taken until seven days after this EIS has been adopted by the responsible official.

Commission action based on this EIS could include two major possibilities:

- Taking no action and allowing the status quo to continue.
- Adopting a Wild Salmonid Policy.

Commission adoption of a Wild Salmonid Policy could take a variety of forms:

- It could enunciate the Department's policies for implementing its statutes and laws and court cases, or the Department's plans and programs on the matters described and analyzed by this EIS.
- It could be a joint action with tribes or other state agencies on the matters described and analyzed by this EIS, or plans and programs that lead to such coordinated or joint actions.

An adopted Wild Salmonid Policy would likely be a separate document that organizes and describes the effect of the Wild Salmonid Policy as it guides the variety of Department action that will affect the survival and use of salmonids. That policy may follow the preferred proposal or reflect combination of features from the various alternatives.

Chapter II ALTERNATIVES FOR FISH POPULATION MANAGEMENT ELEMENTS

Five alternative policy approaches are presented. Each includes a different combination of ideas for spawner abundance, genetic conservation, ecological interactions, harvest management and hatcheries to achieve healthy sustained salmonids stocks. Detailed technical information on each of the above key elements is presented in the Appendices. Readers are encouraged to carefully review the information presented in the Appendices. These options represent different levels of risk to stock health and harvest, or different implementation approaches. An alternative summary matrix is provided at the end of the document.

Alternative 1 (Status Quo) - Currently wild salmonid management varies by species and location; generally wild stocks are managed individually or in aggregations (management units) for maximum sustained yield (MSY), or in a secondary status to hatchery or mixed-origin stocks. There is no formal policy to protect wild stocks in secondary status (Table II-1). There are, with the exception of fish transfer guidelines and spawning protocols, no formal policies addressing genetic conservation, ecological interactions and supplementation.

Alternative 2 - This alternative places the greatest emphasis on protection of stock health. This alternative seeks to avoid negative impacts to stock and ecosystem health wherever possible. Harvest opportunity is clearly secondary to resource protection and would be very limited in mixed stock fisheries, but moderated somewhat by selective fishing methods. The use of hatchery fish would be strictly controlled.

Alternative 3 is the agency's proposed action. This alternative places less emphasis on stock health. Harvest opportunity would be greater than for Alternative 2. This alternative would accept some negative ecological impacts as long as they do not significantly impact stock or ecosystem health. There would be more flexibility in hatchery practices than Alternative 2.

Note: All salmonid populations would be managed to consistently achieve MSY escapements (or greater), thus the most critical element becomes the future spawning escapement policy. We examined actual approaches used in the past by managers that have consistently put adequate numbers of viable wild fish on the spawning grounds. The spawning escapement policy described is based upon the successful case histories where managers have fully accounted for uncertainties by being conservative in both the spawning escapement goal itself and in subsequent fishery management planning (Figure II-1).

Alternative 4 - Harvest opportunity takes on an even greater role in Alternative 4. There is a commitment to long-term stock protection, but at levels of risk that are higher than Alternatives 2 and 3. This provides greater flexibility and opportunity for harvest and hatchery practices than Alternative 3.

Alternative 5 - Alternative 5 takes a less prescriptive approach, deferring the specifics of many management issues. This alternative accepts the largest negative impact on stock health; some individual stocks would be managed to levels immediately above the likely level of permanent harm. There is a much greater emphasis on flexibility to provide harvest and other opportunities, though there is a continuing

Table II-1. Current fish management plans and practices overfish 89 wild stocks in order to harvest co-mingled hatchery fish at rates that are not sustainable by wild populations.

1. Nooksack River fall chinook
2. Samish River fall chinook
3. Nooksack River coho
4. Lake Washington/Sammamish tributaries coho
5. Cedar River coho
6. Duwamish/Green River chum
7. Green River/Soos Creek coho
8. Newaukum Creek (Green River) coho
9. White River fall chinook
10. Puyallup River fall chinook
11. Puyallup River coho
12. White River coho
13. Nisqually River fall chinook
14. Nisqually River coho
15. South Sound tributaries chinook
16. Hammersly Inlet summer chum
17. Case Inlet summer chum
18. Blackjack Creek summer chum
19. Carr Inlet fall chum
20. Chambers Creek coho
21. Deep South Sound tributaries coho
22. Deschutes River coho
23. East Kitsap coho
24. Skokomish River chinook
25. Dosewallips River chinook
26. Duckabush River chinook
27. Hamma Hamma River chinook
28. Dewatto Creek chinook
29. Tahuya River chinook
30. Union River chinook
31. NE Hood Canal fall chum
32. Dewatto Creek fall chum
33. SE Hood Canal fall chum
34. Lower Skokomish River fall chum
35. Elwha River/Morse Creek chinook
36. Dungeness River coho
37. Elwha River coho
38. Sooes/Waatch chinook
39. Sooes/Waatch coho
40. Sooes/Waatch chum
41. Quillayute River spring chinook
42. Sol Duc River spring chinook
43. Quinault River fall chinook
44. Quinault River chum
45. Quinault River coho
46. North River chinook
47. Willapa River chinook
48. Palix River chinook
49. Nemah River chinook
50. Naselle River chinook
51. Bear River chinook
52. North River coho
53. Willapa River coho
54. Palix River coho
55. Nemah River coho
56. Naselle River coho
57. Bear River coho
58. Cowlitz River spring chinook
59. Kalama River spring chinook
60. Lewis River spring chinook
61. Grays River fall chinook
62. Elochoman River fall chinook
63. Cowlitz River fall chinook
64. Coweeman River fall chinook
65. South Fork Toutle River fall chinook
66. Green River (Toutle) fall chinook
67. Kalama River fall chinook
68. Washougal River fall chinook
69. Grays River coho
70. Skamokawa Creek coho
71. Elochoman River coho
72. Mill Creek coho
73. Abernathy Creek coho
74. Germany Creek coho
75. Cowlitz River coho
76. Coweeman River coho
77. Toutle River coho
78. South Fork Toutle River coho
79. Green River (Toutle) coho
80. Kalama River coho
81. Lewis River coho
82. East Fork Lewis River coho
83. Salmon Creek coho
84. Washougal River coho
85. Bonneville tributaries coho
86. Klickitat River spring chinook
87. Wind River fall chinook
88. White Salmon River fall chinook
89. Klickitat River coho

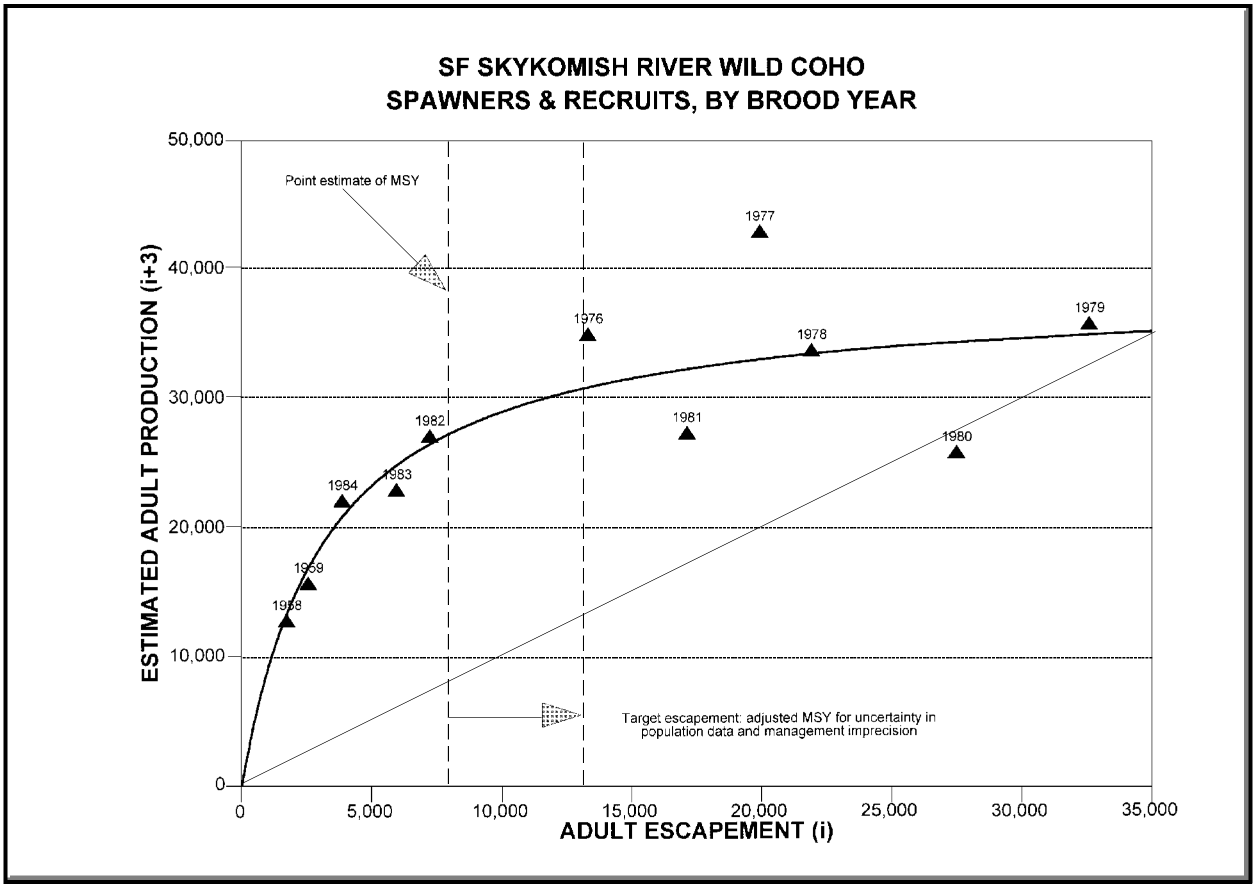

Figure II-1. Graphic representation of Alternative 3 spawning escapement policy.

commitment to stock protection. This alternative allows the greatest use of hatcheries as long as local stocks are used.

Alternative 1 (Status Quo)

Alternative 1 is status quo. The description of this alternative amounts to a "no action" alternative. This EIS must assume that if the WDFW does not take the proposed policy actions described in Alternative 3 (or the other alternatives), then the status quo will continue, and that adverse environmental impacts associated with the status quo will be continued.

You will see that a wide number of approaches are currently used for different species, or in different places. These are approaches that have evolved over time in response to a variety of needs and issues. They continue to evolve and change in response to new information and ideas.

1.1 Spawning Escapement Policy

Salmon and steelhead population management occurs through a variety of forums and has undergone substantial improvements over the last 20 years. Single species management has been replaced by separating species into populations or groups of populations (management units).

For example, prior to the late 1970s, ocean fisheries were allowed without assessing the fishery impacts on the management units used today. Annual negotiations with Canada and Alaska now occur through the Pacific Salmon Treaty process. The Pacific Fishery Management Council (PFMC) sets seasons and quotas for salmon in the ocean outside 3 miles. Washington is required to have comparable or more restrictive regulations in inside waters to complement the PFMC harvest scheme. Fisheries in the Columbia River are designed through the Columbia River Compact, a forum where the states of Washington and Oregon plan fisheries in concurrent waters of the Columbia River. Finally, there are many court orders and management plans that are used to design fishery plans by state and tribal fishery managers.

Most salmon and steelhead populations are managed for a fixed escapement goal intended to provide maximum sustained yield (MSY) to fisheries. In practice, the desired escapement levels have been set using a wide variety of methods depending on the amount and types of information available.

Steelhead populations are managed on a river/stream basis, which may include either single or multiple stocks. Puget Sound, coastal, and Lower Columbia River desired spawner abundance levels were set for most streams using a habitat availability and optimal utilization approach developed in 1985 (Gibbons et al. 1985). The intent of this method was to provide for MSY level escapements. However, in smaller rivers and streams with limited habitat information, steelhead spawner abundance goals are set using historical average harvest rates or catches. Since the first technique looks at total habitat availability, it includes both summer and winter steelhead where they occur in the same system. Ratios have been developed from harvest and escapement statistics and are used to design fisheries.

Escapement goals for steelhead spawning in the Columbia River above Bonneville Dam were established as part of the Columbia River Fish Management Plan. These goals are based on historical run levels and counts at various Columbia River dams.

Fishing plans that result in escapements above the goals are encouraged by WDFW, consistent with treaty allocation requirements and recreational fishing needs.

While many steelhead runs are managed on a multi-stock basis, it is still common to manage at the stock level. Where individual stocks are not predicted to meet their goals, the recreational fishery will often be limited to selective fishing directed at hatchery fish. In other cases, fishing for individual weak stocks will be closed completely.

Typically, only wild steelhead are counted towards meeting the escapement goal. In most areas hatchery fish spawn before the wild fish and are not included in escapement estimates. All hatchery steelhead are marked so that they can be identified, making the separation of hatchery and wild fish highly accurate.

Most steelhead populations are monitored for spawner abundance on a yearly basis. This is especially true of populations that are fished by both tribal and recreational fishermen. Smaller populations, and populations that are fished less heavily, are monitored less often.

Salmon population management is currently organized around “management units.” Management units often include fish returning to a single river system, though in some areas a management unit includes several river systems (e.g., south Puget Sound coho, Hood Canal coho and chum, Nooksack/Samish chinook). Management units are split into either primary or secondary. Primary management units have an established escapement goal and an intent to meet it on an annual basis. Primary management units can be either hatchery fish or wild fish. Wild salmonid management units have an escapement goal based on the production needs of wild fish. Hatchery management units have escapement goals based on the needs of the hatchery production. Management units that are not primary units are called "secondary management units" and are discussed further below.

A variety of approaches were used to set salmon escapement goals. Some, like steelhead, are based on available habitat. Puget Sound wild coho escapement goals are based on the amount of rearing area at the time of late-summer low stream flow (Zillges 1977). The optimal smolt production potential of this habitat was calculated using appropriate data from the fisheries literature, since little work specific to Puget Sound streams was available. The number of adults needed to produce these smolts was based on MSY estimates from studies on Minter Creek, a tributary to south Puget Sound. A number of specific adjustments have been made as better information has become available, but the basic approach is the same.

The approach for coastal coho is similar, except there was less certainty about the optimal production rates for the habitat. In this case, a range of production rates is applied to the habitat. The result is an escapement range, rather than a single number. The range is expected to include the MSY level. For example, the escapement range for Hoh River coho is 2,000-5,000 adults. As a series of escapements occur throughout this range, it is hoped enough data will be collected so the range can either be narrowed or an MSY escapement selected. In the meantime, the range provides flexibility to fishery management.

Another approach to salmon escapement goals is historical utilization. In this case, a time period when escapements were felt to be appropriate was selected to represent proper escapement levels. This approach was used for Grays Harbor chinook; Willapa Bay and Grays Harbor chum; and a number of Puget Sound pink, chum, sockeye, and chinook salmon stocks. To this point, no attempt has been made to relate these values to MSY or other standards. They simply represent a "reasonable" utilization of the available habitat.

The Puget Sound chum goals have been further refined to reflect the much lower numbers of chum that return and spawn in odd years, compared to those that return in even years. This is likely due to interactions with pink salmon, which spawn only in the odd years. Depending on the stock, the odd year escapement goal for Puget Sound chum ranges from 26% to 100% of the escapement goal in even years.

Another approach is used for north coastal chinook. Rather than setting an escapement number, a terminal harvest rate was chosen. This harvest rate is used unless the escapement will be below a floor value. The result is a sliding escapement goal that increases with increasing run sizes. The floor value was chosen to be near the lowest escapement the stock had experienced, with the presumption that the stock had already shown an ability to survive and recover from escapements at that level. One of the intended objectives of this approach was to generate information about a range of escapements that can be used to determine the optimal level.

Hatchery escapement goals are based on the size of each planned hatchery program, information on the number of eggs per female, sex ratios, and typical survival rates.

All management units that are not managed as primary units are secondary management units. They have been given secondary status as a way of increasing benefits from primary stocks in mixed-stock fisheries that contain populations of different productivity. There is no formal policy to address the needs of wild stocks in secondary status; these stocks can even drop below minimum levels required for maintaining genetic diversity.

For example, the primary unit is most often a hatchery population and the secondary unit is a wild population. One example is south Puget Sound hatchery and wild coho. The current wild coho population in south Puget Sound is relatively small compared to the much larger hatchery program. The hatchery fish can be harvested at a much higher rate due to the protection they receive while growing in the hatchery. However, fishing at the higher rate allowed by the hatchery fish means the wild fish are continually depressed, placing them at greater risk of permanent harm. Other examples are Hood Canal hatchery and wild chum, Willapa Bay hatchery and wild coho and chinook, and lower Columbia River hatchery and wild coho and chinook. A slightly different example is wild Hood Canal coho as the primary management unit while wild Hood Canal summer chum are the secondary unit.

Managing for needs of a wild stock usually means lower fishing rates and the greater likelihood of a healthy wild stock. It can result in surpluses at hatcheries under status quo fishing practices. Examples include coho in Grays Harbor and the Quillayute and Skagit Rivers, and summer/fall chinook in the Lake Washington and Duwamish/Green River systems.

Secondary management units may or may not have defined escapement goals. Direct management actions for secondary stocks are typically limited, but there is an intent to achieve goals where possible. The actual escapement level that is achieved for secondary stocks depends on (1) the amount of fisheries overlap in time and space with primary management units, (2) susceptibility to the same types of gear (e.g., similar size for harvest in gill nets, tendency to bite on hook-and-line gear), (3) the level of harvest of the primary management unit, and (4) opportunities and concern for actions that will provide additional protection to the secondary run. These additional actions include specific area closures, supplementation, or reliance on hatchery straying to augment natural reproduction. For example, extra steps have been taken the last few years to reduce catches of summer chum during the Hood Canal coho fishery. Where the secondary units separate from the primary units in terminal areas, specific management actions can be taken.

In terms of total stream miles impacted, coho represent the largest problem. Wright (1993) reported that secondary management results in under-use by coho of more than 5,600 kilometers of usable stream habitat in Washington and along the Oregon side of the Lower Columbia River. This is equivalent to a stream running alongside the roads which you would use in driving from Seattle to Key West, Florida.

In general, any salmon spawning in the wild are counted towards meeting the escapement goal. Meeting numeric wild escapement goals may be a misleading indicator of management success if most of the naturally spawning fish are of hatchery origin. For example, a majority of the spawners in many hatchery managed systems had hatchery raised parents. Some examples are Willapa Bay, lower Columbia, and Green River chinook and coho. Only a small portion of the hatchery salmon have been marked, making identification of hatchery and wild fish more difficult.

Fishery managers currently make fishery decisions based on the status of slightly more than 100 primary management units for salmon and steelhead stocks.

Most salmon management units are monitored for spawner abundance every year. Individual stocks are monitored in some cases, depending on the specific estimation techniques used. Smaller independent tributaries may not be monitored. No formal accountability for meeting escapement goals is required except that the Pacific Fisheries Management Council does require a report on the causes for not meeting escapement goals for some key stocks that are consistently below goals.

Resident and Other Anadromous Salmonids also have both hatchery and wild managed resident populations. In general, the escapement approach for wild managed populations is contained in *A Basic Fishery Management Strategy for Resident and Anadromous Trout in the Stream Habitats of the State of Washington* adopted in 1986 (Wright 1992). While it is informally called the "stream management strategy," the basic approach is also applied to some lake and reservoir systems. A main element of the strategy is to "allow a majority of females to spawn at least once before being subjected to a directed harvest." It is the general opinion of WDFW staff that this strategy results in spawning populations at or above the MSY level. This is supported by Johnson and Bjornn (1978). This approach is used for the vast majority of stream dwelling resident populations and in some of the larger lake systems that historically had native salmonids.

The widespread introduction of exotic species (e.g., carp, bass, bluegill, and pumpkinseed) in our lakes in the early 1900s is believed to have decimated many native resident populations. As a result, numerous other resident populations are managed on a hatchery basis. This applies primarily to lake and reservoir populations, some of which support self-sustaining wild populations and many that do not. This latter category includes many of the lowland lakes in western Washington and many of the lakes in eastern Washington that are man-made or have large populations of warmwater fishes. There are also limited instances where hatchery management is used in streams, typically in localized areas around campgrounds or where self-sustaining populations are limited. Management in the hatchery areas is based on providing maximum recreational harvest of hatchery fish.

There are exceptions to these two approaches, which are designed to provide higher levels of escapements. Two examples are the catch-and-release fisheries on the Yakima and Kettle rivers. The intent is to lower harvest mortality and provide higher population levels. These higher population levels result in higher than average catch rates and a higher level of satisfaction for a portion of the angling public.

Bull trout/Dolly Varden populations have been rated for stock health on a statewide basis. Fishing is allowed only on those populations that are healthy or at "low risk of extinction." No fishing is allowed on stocks at "some risk of extinction" or where the status of the stock is unknown due to a lack of data.

Other exceptions are kokanee and mountain whitefish for which no escapement policies have been established. The intent to maintain strong wild populations is the same. Due to a lack of data and a sense that current management approaches are providing sufficient spawners, no specific escapement methodology has been developed.

Except for Yale Reservoir, individual resident populations are rarely monitored for spawner abundance. Some index populations were established to track implementation of the stream management strategy. It is assumed that if those populations are responding as expected, then other populations managed with the same strategy will also.

1.2 What Counts?

No formal policy element exists.

1.3 Monitoring

No formal policy element exists.

1.4 Accountability

No formal policy element exists.

1.5 Genetic Conservation

No explicit genetic priorities have been generally formulated for wild or hatchery salmonid populations in Washington. The Washington Fish and Wildlife Commission goals emphasize production of native game fish species and use of natural production within habitat capabilities. The Puget Sound Salmon Management Plan requires fishing across the timing of the run. Transfer guidelines that generally restrict movement of hatchery fish within certain boundaries are used.

Traditionally, Washington fisheries managers have developed escapement goals to provide harvest or utilize habitat. The number of spawners needed to maintain genetic diversity and other genetic issues has not typically been considered. Current policy is often not directed at ensuring adequate escapement. Stock abundance of populations that are managed as secondary units, or for hatchery production, can drop to very low levels (or become exinct) under this secondary management, resulting in reductions in genetic diversity within stocks. This is also a problem where habitat loss has occurred.

1.6 Minimum Genetic Standard

No formal policy element exists.

1.7 Gene Flow

Historically, salmonid fishes have been transferred widely from area to area, with little regard to the origin of the fish. Transfer of fish has been increasingly limited in recent years; in large part for disease concerns. The transfer policy adopted for salmon limits the movement of fish, though some movement around Puget Sound still occurs, and movement of stocks around the

Lower Columbia River is common. Movement of steelhead and resident fish is more common and no formal policy is currently in place to control such movements.

There is currently no general policy that limits the number or percentage of hatchery offspring that contribute to naturally spawning populations. However, different strategies have been developed to reduce the likelihood of interbreeding between hatchery and wild fish:

A. Releases of hatchery resident salmonids into streams have been strictly limited in recent years.

B. Hatchery-wild interbreeding of steelhead is limited through:

    1. Reductions in releases in some areas.
    2. Creation of refuges where no planting is allowed.
    3. High harvest rates on hatchery fish, which reduce the hatchery population size in relation to wild spawners.
    4. Separation of hatchery and wild spawn timing through the use of stock(s) with different run timing.

    A Genetic Conservation Model (GCM) has been developed for steelhead, which estimates the loss of wild reproductive potential due to hatchery and wild interbreeding. It is designed to look at issues such as timing overlaps, differential harvest rates, and other factors to determine proper release strategies to achieve a given level of wild reproductive potential.

C. Many hatchery salmon stocks are derived from mixtures of introduced and local stocks. The approach at most salmon hatcheries is to use locally returning fish for hatchery broodstock, and to favor the similarity between the hatchery and wild broodstocks. The intent is to reduce the genetic effects of interbreeding since both hatchery and wild fish are drawn from a similar gene pool. However, domestication of the hatchery stock can take place, which can reduce the fitness of hatchery fish for survival in the wild. Further, if wild salmon collected for hatchery broodstock are not representative of the genetic variation present in the wild stock, the hatchery stock will differ from the local wild stock.

1.8 Effects of Fishing Practices on Populations

Prevention of artificial selection on salmonids due to fishing practices is not generally a formal management intent. Managers usually agree on the need to distribute harvest across a population's return timing to reduce selection against any single timing part of the run. In fact, this is a requirement of the Puget Sound Salmon Management Plan. However, in practice, this even distribution may not be achieved. For example, it is often necessary to delay the opening of a fishery to protect a weak stock with earlier timing. This removes only the later-timed fish from the population, while the earlier timed fish return at greater levels. This, in effect, selects against the later timed characteristics in the population and can shift the run timing (Alexandersdottir 1987).

Much of salmon management depends on in-season updates to provide more current information on run status. When in-season information indicates the run is smaller than expected, the fishery is closed early, so that fishing occurs only on the early portion of the run. If both late opening and early closures occur, then selection against the central portion of the run increases.

To the extent males and females and different age classes enter fishing areas at different times during the run, management practices can select against a particular sex or age class as well as a timing component of the run. For example, South Puget Sound chum are generally dominated by 4-year-old fish early in the run. An early fishing pattern would not only select against early fish, but also older, larger fish.

1.9 Habitat Loss and Fragmentation

No formal policy element exists.

1.10 Sanctuaries and Refuges

No formal policy element exists.

1.11 Ecological Interactions

With the exception of limiting access to eagle feeding areas in the Skagit River, no formal policies have been developed or adopted that deal with the role of salmonid fishes in broader ecosystems. There is, however, a general intent to recognize the ecosystem impacts of current programs. Full exploration of this issue will occur through various landscape level planning processes such as Habitat Conservation Plans, integrated landscape plans, and other watershed/basin plans.

1.12 Harvest Management

The general harvest management intent is to protect salmonids through meeting the spawner escapement goals and provide for harvest opportunity (including meeting allocation requirements for treaty and non-treaty fisheries).

Incidental harvest limitations vary by species. No general guidelines have been established for salmon fisheries although incidental harvest impacts are included as part of the fishery plan, and accounted for as part of total mortality. They are annually negotiated based on the balance of stock health and harvest opportunity concerns in each situation.

Incidental impacts on steelhead are currently limited to 10% in Puget Sound and on the Coast. The Columbia River Fish Management Plan allows incidental harvests of 15-32% depending on the specific run.

Incidental harvests are usually not measured in resident fisheries.

Currently all hatchery steelhead and sea-run cutthroat are marked by removing the adipose fin. This allows them to be readily identified by anglers. Wild fish release fisheries are commonly used in waters where wild fish need extra protection. Wild fish release is typically used at times when large numbers of hatchery fish are mixed in with wild fish. This approach is combined with specific tackle regulations to reduce handling mortality on the released fish.

Selective fisheries approaches for salmon combine a variety of time, area, and gear techniques to target the harvest on abundant stocks while minimizing impacts to weaker stocks. The specific technique used varies with the situation. Timing of fisheries is a common technique, particularly in more terminal areas. For example, hatchery coho returning to the Queets and Humptulips Rivers arrive earlier than the wild fish, so an early fishery takes mainly hatchery fish. Timing is an important element of controlling fishing impacts in the Buoy 10 sport fishery and many gillnet and purse seine fisheries.

The use of area closures is also common. For example, ocean coho fisheries are moved north or south in different years depending on which coho stocks are the weakest and where they are found in the ocean at different times of the year. Ocean troll and recreational fisheries can be moved inshore, where they catch mainly chinook, or offshore where they catch mainly coho, depending on which species needs protection. Fisheries are often moved around Puget Sound to take advantage of strong runs and protect weak runs.

Fishing gear can also be selective. Large mesh gillnets will catch chinook salmon while allowing smaller fish to pass on through. Purse seines are constructed with a panel of larger mesh near the top that allows smaller feeding chinook to pass through and escape the net. Various types of terminal troll gear of different sizes and colors can be used to selectively fish for different sizes of fish or different species.

<u>1.13</u> <u>Incidental Harvest Limits</u>

No formal policy element exists.

<u>1.14</u> <u>Selective Fisheries</u>

No formal policy element exists.

<u>1.15</u> <u>Cultured Production/Hatcheries</u>

Washington State has one of the largest salmonid artificial production systems in the world. WDFW currently operates 65 salmon and 30 trout rearing facilities. Five salmon species, steelhead, and sea-run cutthroat trout are included in anadromous hatchery production. Resident hatchery salmonids include rainbow, cutthroat, eastern brook, brown, lake, and golden trout; Arctic grayling; and kokanee. These facilities produced approximately 230 million anadromous and 20 million resident salmonids during 1992-93. In addition, there are 12 federal and 17 tribal facilities that added another 50 million fish in 1992-93. There are also a large number of local volunteer fish culture programs operated by schools, clubs, community groups, and individuals. Hatchery programs have changed dramatically. For example, data indicating extremely low survival for fry plants plus concerns about ecological interactions with wild stocks have significantly reduced fry planting programs.

Salmonid culture programs typically address four key resource management needs: (1) *enhance* fishing opportunity, (2) *mitigate* for specific production losses, (3) *restore* depleted wild populations or *reintroduce* extirpated species, and (4) *research* to improve management and hatchery programs. A single facility may engage in several programs.

A. *Enhancement* programs are designed to increase the number of fish available for all forms of harvest. Enhancement programs are not designed to create more wild spawners, though this can occur.

B. *Mitigation* is used to offset losses. Most commonly mitigation is used to replace production from the construction of dams and reservoirs that destroy habitat or increase the mortality rate during some part of the life cycle. The Cowlitz and Lewis River hatcheries are examples of mitigation hatcheries.

C. *Restoration* is used to: (1) recover (supplement) populations that are having problems sustaining themselves and are not likely to recover naturally, (2) reintroduce wild stocks that have been lost from areas they historically inhabited, and (3) maintain stocks that face extreme risks. Restoration programs are designed to put more spawners on the spawning grounds.

D. *Research* at hatchery facilities has played a vital role in understanding the biology and management of salmonid populations. Hatchery fish can be studied directly, or used as indicators of how similar, neighboring wild populations may be behaving. Issues such as diseases, growth, physical changes before migrations, and ocean distribution and catch patterns are all studied using hatchery fish. In many cases similar work on wild fish is much more difficult due to smaller numbers and the difficulties in creating controlled conditions.

Hatchery programs have generally adopted fairly specific policies in some areas of genetic conservation. Spawning protocols are used to assure proper mating strategies in the hatcheries to combat selection and genetic drift. A statewide transfer policy for salmon is used to maintain among-stock diversity.

Specific fish management goals, including legislative and other legal requirements, determine how specific hatcheries are operated. The goals and operational procedures and policies for WDFW's anadromous facilities are defined in three regional volumes of the *WDFW Hatchery Operational Plan for Anadromous Fish Production Facilities*. These plans address fish health protection, genetic viability of stocks, ecological interactions of cultured and wild fish, and spawning protocols to ensure conservation of genetic diversity within cultured stocks. They outline the stock history for each hatchery, its physical structures, program objectives for production, practices to achieve objectives, protocols to maintain stock integrity and genetic diversity, environmental monitoring and reporting requirements, and record keeping requirements.

Several important objectives listed in these operational plans include:

A. Minimize interactions with other fish populations.

B. Maintain stock integrity and genetic diversity of each unique stock.

C. Maximize survival at all life stages using disease control and prevention techniques, and prevent the introduction, spread, or amplification of fish pathogens.

D. Conduct environmental monitoring to ensure that hatchery operations comply with state and federal water quality standards.

E. Communicate effectively with other salmonid producers and managers in the region.

The hatchery operation plans outline performance standards for these objectives at each facility. Currently budgets do not allow intensive monitoring of these objectives at each hatchery. Evaluation programs address key issues or needs at selected sites to improve understanding of culture operations and their outcomes.

Fish health concerns are managed under the *Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State.* This policy describes the various protocols for the prevention, detection, and control of fish diseases in the salmonid populations in Washington.

Except for the fish health policy, there are no overall guidelines or standards in Washington that direct management objectives for hatchery production or culture practices. However, there are a variety of informal policies that guide hatchery operations. These may be broad principles or they may apply only to a single facility. Some management plans, such as WDFW's *Basic Stream Management Strategy* (Wright 1992), define general management intent for hatchery fish.

Each year, the participants in state/tribal court-established processes such as *U.S. vs. Washington and U.S. vs. Oregon* develop a production plan for salmon and steelhead programs that defines fish culture objectives for each WDFW, tribal, federal, cooperative, and Regional Fisheries Enhancement Group facility. The production plan translates fish management objectives into a comprehensive action strategy for fish production. The production plan is reported in the *Future Brood Document*, which describes fish culture techniques, optimum production strategies, harvest management regimes, long-term planning, stock transfer guidelines, disease policy, gene conservation, and legal mandates. After considering all appropriate concerns and comments, the *Future Brood Document* is completed and adopted as the established set of annual production goals. At WDFW facilities, these goals and objectives are implemented via the hatchery operation plan for that facility.

Resident trout hatcheries do not have the same formal programming process, although one is being developed. Game fish have been programmed based on recreational needs, the use of historical release data, levels of fishing effort, mitigation agreements, and public input.

A new level of program planning has been required in recent years in those areas where hatchery programs might impact species listed as threatened or endangered under the Endangered Species Act. That process requires a series of permits and consultations with the federal government to show that the proposed programs will not jeopardize the future of the listed stock.

1.16 Supplementation

No formal policy element exists.

1.17 Gene Banking

No formal policy element exists.

1.18 Implementation Framework for Spawning Escapement Management

No formal policy elements exists.

Mitigating Measures and Unavoidable Adverse Impacts

There are a large number of potential mitigating measures that could be used to reduce the impacts of the current approaches. Alternatives 2-5 represent mitigations for a number of the impacts. Many of the impacts are shared by all alternatives.

A. Reductions in Canadian and Alaskan fisheries would return more salmon to Washington and reduce the current impacts. Negotiations under the Pacific Salmon Treaty have been stalled. The Pacific Salmon Treaty process manages the interactions of Canadian and U.S. (including Alaskan) fisheries on each other's stocks. For steelhead, Alaskan and Canadian interceptions are not generally an issue. However, for the five salmon species they are of critical importance.

   The treaty is the focus of an ongoing series of negotiations and we certainly expect changes to occur. In 1995 and 1996, we saw a shift to an abundance based approach for chinook and coho harvests off of Canada and some changes in U.S. harvests of sockeye. This represents a potentially beneficial change in our ability to manage for healthy stocks.

B. Improved ocean survivals would also return more salmon and steelhead; any resumption of *El Nino* would be an unavoidable adverse impact.

C. Natural disasters such as volcanic eruptions and drought can cause unavoidable impacts to salmonids. The Mt. St. Helens volcanic eruption was devastating to salmonid stocks in the Green and Toutle River watershed.

D. Listings of Washington salmonid stocks under the Endangered Species Act would be a continuing threat under Alternatives 1, 4 and 5. We believe that Alternatives 2 and 3 are each sufficient to perpetuate stocks, and that ESA listings generally would not be necessary.

Alternative 2

This alternative places the highest priority on protection of population and ecosystem health, and much less of a priority on harvest. This alternative proposes to avoid negative impacts to stock and ecosystem health wherever possible.

2.1 Spawning Escapement Policy

Alternative 2 calls for the full utilization of the spawning habitat available to each salmonid stock. The intent of full utilization of the habitat is to:

A. Maximize the future population size of each stock to provide the greatest likelihood of future survival.

B. Maximize the potential number and distribution of locally adapted salmonid stocks.

C. Maximize the potential genetic diversity within stocks.

D. Maximize the contribution of wild salmonids to maintaining and supporting natural ecological processes.

E. Harvest opportunities may be provided where sustainable production above the level needed to fully utilize the habitat is available.

Spawner abundance goals for stocks would be established and managed for in all areas that have an existing or restorable habitat capacity to support naturally reproducing, self-sustaining populations, and would meet the following criteria:

A. Explicitly account for fishery management error, environmental variability, and other uncertainty.

B. Be based upon the best available scientific data and methods.

C. Be based upon a variety of information such as historical stock/recruit, historical escapement trends, habitat assessments, and population age structure, maturity rates, and density.

D. Can be defined in terms of fixed numerical goals, harvest rates, or surrogate approaches that result in meeting the full utilization goal for individual stocks.

E. Will be based on current population and habitat productivity and adjusted as productivity changes.

2.2 What Counts?

Only fish whose parents spawned in the wild would be counted towards meeting the spawner abundance goals, except in cases where a formal supplementation program has been established under the guidelines outlined in element 3.16 of Alternative 3.

2.3 Monitoring

Under this alternative each salmonid stock would be monitored every two years to determine if the spawner abundance levels meet the criteria described above. It is expected that most salmon and steelhead stocks would continue to be monitored every year as part of routine management. This alternative provides a monitoring requirement for all salmonid stocks.

2.4 Accountability

Same as element 3.4 in Alternative 3.

2.5 Genetic Conservation

Same as element 3.5 in Alternative 3.

2.6 Minimum Genetic Standard

Same as element 3.6 in Alternative 3.

2.7 Gene Flow

Under Alternative 2 there is no allowable level of human caused gene flow between species, major ancestral lineages, genetic diversity units, or stocks. There can be no transfer of fish across stock or other boundaries. This would require the development of local broodstocks for all hatchery and other enhancement programs. Where there is no supplementation program in place, the allowable percentage of the total wild spawning population that is made up of fish raised in a hatchery is given in Table II-3 (see element 3.7 in Alternative 3). Other measures of potential gene flow may be used (e.g., migrants per generation), if they result in similar levels of potential gene flow. This alternative uses the stricter definition of similarity that compares the hatchery fish with an ideal locally adapted wild fish. This maintains a higher level of local adaptation in populations that are already locally adapted, and increases the rate at which a hatchery influenced wild population becomes locally adapted. Similarity is determined based on the geographic origin, hatchery history, and hatchery practices that have affected the hatchery fish. In a hatchery population with high similarity, the hatchery fish would be of local wild stock origin and have few generations in the hatchery. There would be regular introductions of new wild broodstock into the hatchery population and the hatchery rearing conditions would be similar to wild conditions. Time spent in the hatchery would be limited and strict spawning guidelines would be followed.
A highly similar stock would need to pass all these tests. A low similarity hatchery population would have many generations in the hatchery. There may have been selection for timing or size

and the population may have been at very low numbers at times. There are few introductions of wild fish or it may have been started with non-local fish. A low similarity stock would only have to meet one of these criteria. Intermediate stocks exceed all the low criteria, but fail to meet at least one of the high criteria. It is expected that most current hatchery populations would be either low or medium similarity.

Hatchery fish spawning in the wild would be controlled so that the majority of stocks in a major watershed, river basin, or GDU do not have any hatchery gene flow, and so that the higher maximum percentages of hatchery fish on the wild spawning grounds noted are exceptions (i.e., occur infrequently and not in the most abundant or most unique components of the larger population groupings).

2.8 Effects of Fishing Practices on Populations

Under this alternative fishery selection would be avoided to insure that population characteristics such as adult size, timing and distribution of population migration and spawning, and age at maturity are the same between the fished and unfished portions of the population. This means that the population would not be changing over time as the result of harvest influences, and where changes have occurred in the past due to fishing pressure, the population should be changing back to a more natural pattern.

2.9 Habitat Loss and Fragmentation

Same as element 3.9 in Alternative 3.

2.10 Sanctuaries and Refuges

Same as element 3.10 in Alternative 3.

2.11 Ecological Interactions

Under Alternative 2, the goal of the ecological interactions element is to avoid adverse impacts to salmonid populations due to interactions with other parts of the ecosystem, and to support the health of the broader ecosystem by the presence of salmonids. Avoid as it is used here means to prevent, eliminate, or minimize. It is a strong term designed to provide a high protection level for salmonid and ecosystem health. There are four key parts to this and these are described in element 3.11 of Alternative 3.

2.12 Harvest Management

Same as element 3.12 in Alternative 3.

2.13 Incidental Harvest Limits

Where a population is not meeting its desired spawner abundance level, incidental fishery impacts would be minimized, not to exceed 5% of the adult Washington population size. The limitation of the Washington population size mainly affects those salmon species that are caught in Oregon, California, Alaska, and Canada. The requirement is to affect only those fisheries that Washington managers can directly control. As a population moves further below the desired spawner abundance level, the 5% level may be adjusted downward to zero as necessary to maintain a stock.

2.14 Selective Fisheries

Same as 3.14 in Alternative 3.

2.15 Cultured Production/Hatcheries

Meet criteria under genetic conservation and ecological interactions.

Meet criteria in *Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State.*

Each hatchery program would be based on a complete operational plan that describes the specific operational components, measures to control risk, monitoring and evaluation, and performance audits.

2.16 Supplementation

Same as element 3.16 in Alternative 3.

2.17 Gene Banking

Same as element 3.17 in Alternative 3.

2.18 Implementation Framework for Spawning Escapement Management

No formal policy element is proposed.

Alternative 3

3.1 Spawning Escapement Policy

Under this alternative spawner abundance goals would ensure that:

A. Available habitat would be abundantly utilized (as compared to full use in Alternative 2; see Appendix D for discussion of different levels of spawner abundance) by locally adapted stocks.

B. Numbers and distribution of locally adapted spawning populations would not decrease from current levels as a result of population management goals or actions.

C. Genetic diversity within populations would be maintained or increased.

D. Natural ecological processes would be maintained or restored.

E. Sustainable surplus production above that needed for population replacement would be generated to support fishing opportunities, harvest and other benefits.

Providing harvest opportunity is desirable and is a higher priority in Alternative 3 compared with Alternative 2. Harvest opportunity is considered a vital part of stock and ecosystem health.

The actual work for salmon and steelhead would be firmly anchored in the proven scientific concept of MSY, which has a worldwide track record of sustainable success when applied correctly. In Alaska, for example, both state law and agency policy require MSY-based management (Holmes and Burkett 1996). The Fishery Conservation and Management Act mandated MSY as the foundation or beginning point for management of all U.S. marine fish resources, including salmon. This value could then be modified to achieve Optimum Yield (OY). The best possible data come from long time series of accurate spawner and recruit statistics for each population. In other words, the ideal situation is where the fish themselves tell you their precise relationship with no requirement for assumptions. In reality, two adjustments are essential for correct application. We will have varying degrees of uncertainty associated with each spawner-recruit relationship. This level of risk to the resource must be quantified

and added to the point estimate of MSY. Alternatively, the managers can change to a different, more conservative fishing strategy. This could be a different methodology for establishing a basic escapement requirement (e.g., historical production or habitat availability) or an accommodation for emerging scientific evidence of broader ecosystem benefits. In addition, a second risk adjustment must be made for expected level of harvest management precision. The desired end result for each population is fully adequate (or greater) numbers of viable wild fish actually being delivered to the spawning grounds on a consistent basis (Figure II-1). Note: The spawner-recruit relationship accounts for the value of nutrients brought into the ecosystem by adults spawners in terms of benefits to subsequent recruits. With the general approach of having the same escapement goal each year, this would also include values from subsequent runs to juvenile fish that rear for one year or more in freshwater. It does not directly account for any benefits to other components of the ecosystem, including other salmonid species.

Future fishery management, albeit complex and difficult, must be based on the needs of individual, separate breeding populations (stocks). These are the basic building blocks that, in aggregate, constitute the state's salmonid resource. To do otherwise would perpetuate the opportunity for planned, deliberate overfishing.

However, managers must also recognize the practical realities of fishery management. In many cases, two or more co-mingled and closely-related wild stocks of the same species and run timing must be managed in the same terminal area fishery. The key expectation is that those co-mingled stocks can reasonably be anticipated to have similar freshwater and marine survival rates during each individual generation. Managers must set escapement objectives that are proportional to the existing productivities of similar stocks. The fish themselves can best provide the needed information in terms of quantitative abundance measures for each population. The human managers must be successful interpreters of these data. Failures would lead to the same practical problems that have occurred in the past; i.e., poorly-based escapement objectives that lead to impossible fishery management situations.

Managers must also watch carefully for real declines or increases in habitat productivity as it effects individual populations. When necessary, escapement objectives must be adjusted accordingly to reflect these changes.

For other resident and anadromous trout and char, fishery management measures would require approaches ranging from wild fish release to slot limits to the following intent described by Wright (1992, p. 524): "The management approach that provides for some continued consumptive harvest is to set the minimum size limit at a level that will allow a full age-class of females to spawn at least once and thus ensure maintenance of a population's reproductive potential. For example, if only 20% of the females spawn at age 3 but a majority (over 50%) spawns by age 4 then the minimum size limit needs to be set a the upper end of the length-frequency distribution for age-4 females. Males typically mature when they are somewhat younger, thus any regulation geared to females will also produce adequate male spawners. This size distribution needs to be that which would be projected to occur at the end of the fishing season. Trout will be continually growing

during a spring-to-fall fishing season and the effect of any minimum size limit will be continually shifting. In our planning, we elected to protect a full age-class of female spawners in order to reduce the potential for selective fishing pressure."

3.2 What Counts?

Only fish whose parents spawned in the wild would be counted towards meeting the spawner abundance goals, except in cases where a formal supplementation program has been established under the guidelines outlined in the Cultured Production/Hatcheries element under this alternative.

Exceptions to the policy could be considered with respect to counting locally-adapted hatchery-origin fish toward meeting natural spawning escapement objectives. These could be considered based on empirical demonstrations that hatchery fish spawning in the wild had the same short- and long-term reproductive performance as wild fish as measured by:

- **a. distribution throughout the watershed area normally used by the wild population;**
- **b. matching the genetic profile, size, age and run timing characteristics developed by the wild population in its evolutionary history; and**
- **c. yielding progeny with survival rates and population dynamics comparable to the wild population.**

Note: These characteristics are critical for populations limited primarily by spawning habitat as well as for populations with extended juvenile freshwater rearing that depend upon downstream dispersal of fry to seed available habitats. Very little evidence currently exists that the above criteria could be routinely met and form the basis for a broad production and management strategy.

3.3 Monitoring

Under this alternative it would not be necessary to physically measure spawner abundance for each and every stock, though every stock will need to be covered by the inventory process. Index stocks that are typical of stocks within an area may be used to estimate abundance for the entire area. Surrogate measures such as standing stocks, random samples, stock composition or other measures may be substituted for actual measures of spawners. Evidence of the utility of such surrogates would need to be established for their use.

3.4 Accountability

If spawner abundance goals are not achieved for three consecutive years, or if the five-year moving average of spawner abundance falls below 80% of the goal, a management assessment would be completed within six months to determine the cause(s). Appropriate actions would be designed and implemented to return spawning levels to at or above the goal. Actions would include any necessary measures to ensure compliance.

3.5 Genetic Conservation

Under Alternative 3, conditions would be created that allow natural patterns of genetic diversity and local adaptation to occur and evolve. General requirements for genetic conservation in this element call for:

- **A. No stocks would go extinct as a result of human impacts, except in the unique** circumstance where exotic species or stocks may be removed as part of a specific genetic or ecological conservation plan.

B. The biological characteristics and structure within and among populations, as monitored by such things as spawning and rearing distribution, life history traits, habitat associations and genetic traits and differences, would not change as a result of human influences.

C. The number and distribution of locally adapted populations would expand as a result of such management actions taken to: increase spawner abundance from previous wild generations, reduce numbers of hatchery strays, reduce genetic selection from fishing, and recoup access to lost spawning and rearing areas.

In some areas the number and distinction of separate locally adapted populations would decrease as a result of successful habitat rehabilitation efforts to restore and connect damaged habitat; in such cases the total abundance of the "new" spawning population in its habitat would increase.

3.6 Minimum Genetic Standard

This alternative requires that each individual stock maintain a minimum base level abundance of 3,000 fish. The 3,000 base level is for a population that spawns a single time and at a single age (e.g., pink salmon). Table II-2 describes how this base level would be adjusted for other species and spawning types. Where the population at abundant habitat utilization is less than 3,000, steps to improve the amount or quality of the habitat should be taken to bring the population up to the minimum level.

For other smaller populations (less than 3,000 actual or potential), the standard shall apply to the smallest localized aggregation of similar stocks that would meet this standard in terms of actual and/or potential production.

3.7 Gene Flow

Under Alternative 3, human caused gene flow between species, major ancestral lineages, genetic diversity units, or stocks through direct transfer of fish across stock or other boundaries would not be allowed. This would require the development of local broodstocks for all hatchery and other enhancement programs. Where there is no supplementation program in place, the allowable percentage of the total wild spawning population that is made up of fish raised in a hatchery is given in Table II-3. For supplementation programs of hatchery-origin fish described under section 3.2, proportions of hatchery fish would be decided on a case-by-case basis. These percentages of hatchery fish in Table II-3 are surrogates for and are equal to allowable gene flow. Other measures of potential gene flow may be used (e.g., migrants per generation), if they result in similar levels of potential gene flow. This alternative uses the stricter definition of similarity that compares the hatchery fish with an ideal locally

Table II-2. Minimum spawning populations needed to maintain genetic diversity and local adaptation for various spawning types and life histories.

Spawning Type	Life History	Typical Species	Rule for Calculating Desired Harmonic Mean Number of Spawners
1	No repeat spawning; Spawners a single age	Pink salmon	3,000 (no calculations involved)
2	No repeat spawning; Spawners multiple ages	Chinook, coho, chum, and sockeye salmon; steelhead[1]	3,000 divided by the average age of the spawners[2]
3	Repeat spawning; Spawners multiple ages.	Rainbow, cutthroat, Dolly Varden, Bull trout, and pygmy and mountain whitefish.	3,000 divided by the average age of the spawners[2] minus 1

[1] Steelhead are technically repeat spawners, but repeat spawning in Washington is at a low level compared to type 3 spawners, so they are more appropriately included here.
[2] Mean of the average age of the two sexes.

Table II-3. Allowable percentages of hatchery fish on the spawning grounds.

Level of Similarity of Hatchery Fish	Maximum % of the Wild Spawning Population That Is of Hatchery Origin
High	5-10%
Intermediate	1-5%
Low	0-1%

adapted wild fish. This maintains a higher level of local adaptation in populations that are already locally adapted, and increases the rate at which a hatchery influenced wild population becomes locally adapted. Similarity is determined based on the geographic origin, hatchery history, and hatchery practices that have affected the hatchery fish. In a hatchery population with high similarity, the hatchery fish would be of local wild stock origin and have few generations in the hatchery. There would be regular introductions of new wild broodstock into the hatchery population and the hatchery rearing conditions would be similar to wild conditions. Time spent in the hatchery would be limited and strict spawning guidelines would be followed.

A highly similar stock would need to pass all these tests. A low similarity hatchery population would have many generations in the hatchery. There may have been selection for timing or size and the population may have been at very low numbers at times. There are few introductions of wild fish or it may have

been started with non-local fish. A low similarity stock would only have to meet one of these criteria. Intermediate stocks exceed all the low criteria, but fail to meet at least one of the high criteria. It is expected that most current hatchery populations will be either low or medium similarity.

Hatchery fish spawning in the wild would be controlled so that the majority of stocks in a major watershed, river basin, or GDU do not have any hatchery gene flow, and so that the higher maximum percentages of hatchery fish on the wild spawning grounds noted are exceptions (i.e. occur infrequently and not in the most abundant or most unique components of the larger population groupings). The use of broodstock in fish culture operations that are locally adapted and highly similar to the wild stocks in that area is emphasized in the preferred alternative. However, there are cases where broodstocks that have been selectively bred and/or are adapted to cultured conditions are preferable to the use of local wild stocks. Such existing programs are the rainbow trout strains used for the stocking of lakes and the use of early-time returning winter steelhead. Using hatchery adapted fish where gene flow and ecological interactions with wild stocks can be controlled (is essentially zero) is a recognized and valid management tool under Alternative 3.

3.8 Effects of Fishing Practices on Populations

Under this alternative fishery selection for salmon would be avoided to insure that population characteristics such as adult size, timing and distribution of population migration and spawning, and age at maturity are the same between the fished and unfished portions of the population. This means that the population will not be changing over time as the result of harvest influences, and where changes have occurred in the past due to fishing pressure, the population should be changing back to a more natural pattern. For the remaining salmonids which have multiple spawning capabilities, the primary goal would be to prevent any significant shift to sexual maturity at a smaller size and/or age.

3.9 Habitat Loss and Fragmentation

Under this alternative habitat would be protected so that both the distribution and amount of habitat is sufficient to maintain local adaptation and genetic diversity. Genetic diversity would be measured both in terms of diversity at the level of gene composition and the maintenance of key life history characteristics. Key life history characteristics include such things as timing; age at maturity; upriver versus lower river distributions; how long an anadromous fish remains in freshwater; stream, river, and lake rearing characteristics of freshwater populations; and other characteristics that provide for local adaptation and diversity.

3.10 Sanctuaries and Refuges

Sanctuaries, or refuges, would be established where populations can be protected from most of the effects of habitat, harvest and hatchery influences. It would not be possible to protect populations from all of these influences all the time, but it would be possible for some populations to be largely protected from many of these influences. These protected populations serve two important functions: (1) they provide a comparison for measuring the changes in unprotected populations so that we can see the impacts of our actions, and (2) are

a source of fish if a neighboring population is changed too much to recover naturally.

3.11 Ecological Interactions

Under Alternative 3 the standard for ecological interactions is "no significant negative impact." This is less emphatic than the "avoid negative impacts" criteria in Alternative 2, but is still expected to be a risk adverse requirement. There would be greater flexibility in using hatchery programs; these programs would be used where they have no significant negative impact on wild populations. There are four key parts to this:

A. Maintain diverse, abundant wild salmonid stocks at levels that naturally sustain ecosystem processes and diverse indigenous species and their habitats. This would primarily be done by meeting the spawning abundance goal.

B. Maintain healthy populations of indigenous species within levels that sustain or promote abundant wild salmonid populations and their habitats. A healthy, balanced ecosystem requires that all the parts be available in the right amounts. Where there is a lack of a species it may be necessary to increase populations by providing the proper habitat characteristics.

Alternatively, human caused changes to many ecosystems have created situations where there is an excess of predators. Healthy predator populations (e.g., marine mammals, birds, squawfish) may be controlled as necessary when they are an important factor in not achieving spawner abundance goals. This can only occur:

1. **As part of a comprehensive recovery plan addressing all aspects of salmonid survival.**
2. **As long as the predator population remains abundant.**

C. Hatchery or other enhancement programs would avoid negative impacts due to predation or competition on the health and abundance of wild salmonid or other indigenous non-salmonid populations. All hatchery and other fish culture programs would follow specific ecological risk assessments and management plans to avoid adverse impacts on wild populations.

Salmonids would not be introduced into areas where they did not historically exist, except where an ecological risk assessment determines that there would be no negative impacts from the introductions.

Salmonid populations that currently exist outside their historical range would be reviewed and evaluated to determine if they pose an unacceptable risk to indigenous species and ecosystems. If they do, then steps will be taken to remove the risk.

D. Control the numbers, varieties, and distributions of non-indigenous species or stocks that compete with, prey on, or parasitize salmonids and other indigenous species. Introductions of fish populations would be managed to avoid significant negative effects on the diversity and productivity of native fish and wildlife populations, and in a way compatible with meeting other priority stewardship objectives for locally adapted

populations. This alternative requires an ecological risk assessment of the current distribution.

3.12 Harvest Management

Alternative 3 would require the fisheries to be managed to achieve the spawner abundance and genetic conservation criteria. Harvest management would be responsive to annual fluctuations in abundance of salmonids, and would be designed to meet any requirements for sharing of harvest opportunity. This is consistent across all the alternatives.

3.13 Incidental Harvest Limits

Under Alternative 3 the incidental harvest impact would increase to 10% of the Washington stock abundance. This would allow grater opportunity to structure fisheries opportunity on more abundant and productive stocks. This 10% allowance is a maximum and would be adjusted downward to zero depending on how far a stock is below its spawner abundance goal.

This 10% limitation would be computed in terms of adult equivalents and would include all known sources of fishery-induced mortality. Precocious males, commonly called "jacks," would be excluded from the calculation.

Note: This section only applies when a population is projected to return below the desired spawner abundance level.

3.14 Selective Fisheries

Where a population is not meeting its desired spawner abundance level, a priority would be given to those fisheries that can minimize their impacts on weak stocks and increase their harvest on healthy stocks by: (1) using gears that can selectively capture and release stocks with minimal mortality, or (2) avoid impacts by eliminating encounters with weak populations (proven time/area closures, gear types). This must be done consistent with meeting treaty harvest opportunity needs.

3.15 Cultured Production/Hatcheries

Meet criteria under genetic conservation and ecological interactions.

Meet criteria in *Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State.*

Each hatchery program would be based on a complete operational plan that describes the specific operational components, measures to control risk, monitoring and evaluation, and performance audits.

All hatchery-origin juvenile anadromous fish would be marked by removal of their adipose fins prior to release in state waters. Specific exemptions may be granted on a case-by-case basis for (1) brood stock development or maintenance, (2) difficult treaty Indian allocation problems that cannot be resolved by other methods, or (3) valid wild stock supplementation programs.

Resident hatchery salmonids would be adipose marked (1) anytime they are planted in fluvial habitats; or (2) where there are significant wild salmonid populations in lakes or reservoirs.

3.16 Supplementation

Supplementation would be strictly limited to only where: (1) a stock is well below desired

levels, (2) it cannot rebuild itself due to some cause other than overfishing, (3) it is being reintroduced to an area it formerly occupied, and (4) the risks of potential stock loss through extinction are greater than the genetic risks due to gene flow or the extinction risks due to the supplementation process itself. Supplementation would be primarily directed at efforts where the conditions causing the problem are being corrected so that the population will eventually become self-sustaining.

3.17 Gene Banking

Gene banking would only be allowed where the natural environment cannot sustain a population, and until these factors can be corrected.

3.18 Implementation Framework for Spawning Escapement Management

1. **Wild stock that has a past history of "secondary protection": Each requires an initial assessment.**
   a. **If stock is too small to recover naturally, then temporary artificial production intervention is necessary. Control of harvest would be phased in as returning adults become available.**
   b. **If existing wild population is deemed capable of effectively rebuilding itself, then a planned rebuilding schedule would be developed and implemented. Note: the above would supercede 3.13, Incidental Harvest Limits.**

2. **Wild stock that is not capable of replacing itself: Continue artificial production intervention.**

3. **Former "Primary" wild stock has been overfished: Hold incidental catch levels in Washington fisheries to a total of 10% until the stock is rebuilt.**

4. **Wild stock that has consistently had spawning escapements at or above the point estimate of MSY: No change.**

Note: Under Alternative 3, the chance for survival of individual wild stocks is high for all of the groups shown above, except No. 2. However, the relative degree of success or failure in salmonid fish habitat management would markedly alter the percentages of degraded, stable, or increased habitat capabilities.

Alternative 4

Alternative 4 continues to shift the balance from stock protection to harvest opportunity. In Alternative 4, providing harvest opportunity becomes more dominant as opposed to maintaining stock and ecosystem health. Alternative 4 continues to require a standard of survival for individual stocks, but it is lower than under Alternatives 2 or 3. It is expected to materially change the extinction risk for populations.

4.1 Spawning Escapement Policy

Alternative 4 begins to provide the "downside flexibility" (planned overfishing) option needed to manage some stocks at a lower level of escapement in order to create more status quo type harvest opportunities on healthy stocks returning to many river systems. Overall management would be at the level of management units, the combination of stocks returning to a river system. Under this Alternative, management units would be fairly narrowly defined. For anadromous populations, they are the aggregate of stocks returning to a major river system that empties into saltwater, stocks returning to a significant tributary to the Columbia River, or the aggregate of smaller independent tributaries that empty into the same limited saltwater area (e.g., Hood Canal, South Puget Sound, Bellingham Bay). For resident species this would include the above definitions plus the aggregate of stocks in tributaries to a significant lake system (e.g., Ross Lake, Lake Chelan, Lake Roosevelt).

Alternative 4 calls for management units to be managed at spawner abundance levels that achieve MSY for wild production for the entire management unit, except where spawner abundance levels of greater than MSY are needed to meet specifically identified ecological requirements. Specifically identified ecological requirements are a response to a specific set of needs, rather than a general desire for more spawners to provide for general ecological health. These might be to meet the needs of a specific eagle population, or to provide larger fish to control a population of smaller non-indigenous fish.

Individual stocks within the management unit may be managed at levels below MSY, provided that they remain above a level that provides a reasonable probability of survival over a long time period. This lower management level would only be allowed where:

A. Significant benefits from status quo type mixed-stock harvests outweigh the costs of managing for a lower escapement level.

B. Status quo approaches to separating stocks in time, place, or harvest approach are not feasible.

C. Deviation from the overall goal of MSY for stocks is the least amount necessary to achieve the desired benefits.

If one or more stocks are managed for less than MSY, then other stocks in the management unit must be managed for above MSY in order for the entire management unit to be at or above MSY. This provides offsetting benefits to other stocks in the management unit, and would tend to limit the number of stocks that can be managed at the lower level.

4.2 What Counts?

Same as element 3.2 in Alternative 3.

4.3 Monitoring

Under this Alternative, the monitoring requirements for spawner abundance change from every two years to every five years. Many populations are currently monitored every year, and this is expected to continue under any of these options.

4.4 Accountability

Same as element 3.4 in Alternative 3.

4.5 Genetic Conservation

The main genetic conservation differences between this Alternative and the previous ones are in the areas of minimum stock size and gene flow. The other pieces of the genetic conservation element remain the same as the previous Alternatives.

4.6 Minimum Genetic Standard

In this Alternative, the base level for minimum stock size is reduced to the greater of 2,000 fish or a stock size that results in a high probability of long-term survival as defined in the spawner abundance section. The 2,000 fish is minimum stock base adjusted for specific spawning types.

4.7 Gene Flow

In Alternative 4, the gene flow approach allows a greater interaction between hatchery and wild fish on the spawning grounds. Table II-4 summarizes the allowable percentages of the total wild spawning escapement that can be of hatchery origin. This Alternative maintains a fairly conservative approach for stocks that have low and intermediate similarity, but provides greater flexibility for use of stocks that have high similarity.

Table II-4. Allowable percentages of the total wild spawning population that can be hatchery fish under Alternative 4.

Level of Similarity of Hatchery Fish	Maximum % of the Wild Spawning Population That Is of Hatchery Origin
High	10-30%
Intermediate	2-10%
Low	0-2%

4.8 Effects of Fishing Practices on Populations

Another difference in this Alternative is in the criteria for genetic selection. Under this Alternative there is a lower standard for controlling fishery induced genetic selection. Alternative 4 includes a requirement to manage fisheries to maintain variation in population characteristics for distributions similar (as opposed to same in Alternative 2) to wild unfished populations. The specific measurement for a criteria such as size, age composition, or timing may be different between the fished and unfished populations as long as the unfished population maintains the same range of variation. Providing this same range of variation means that the population still has the same or similar capacity to respond to changing conditions and environments and to become locally adapted.

4.9 Habitat Loss and Fragmentation

No formal policy element is proposed.

4.10 Sanctuaries and Refuges

No formal policy element is proposed.

4.11 Ecological Interactions

Same as element 3.11 in Alternative 3.

4.12 Harvest Management

Same as element 3.12 in Alternative 3.

4.13 Incidental Harvest Limits

Same as element 3.13 in Alternative 3.

4.14 Selective Fisheries

Same as element 3.14 in Alternative 3.

4.15 Cultured Production/Hatcheries

More flexibility to supplement wild stocks with hatchery broodstocks would be allowed. They can be used to augment populations limited by habitat or overfishing constraints.

4.16 Supplementation

Same as element 3.16 in Alternative 3.

4.17 Gene Banking

Same as element 3.17 in Alternative 3.

4.18 Implementation Framework for Spawning Escapement Management

No formal policy element is proposed.

Alternative 5

Alternative 5 places the greatest emphasis on harvest opportunity of Alternatives 2-5. It provides a different approach and set of measures for evaluating genetic conservation issues. Changes also occur in other elements.

5.1 Spawning Escapement Policy

Alternative 5 provides the opportunity to manage some entire management units at a lower level of escapement in order to create more harvest opportunity on the mixture of hatchery and wild populations returning to many river systems. Some individual stocks would be maintained slightly above the probable level of immediate risk of permanent harm or extinction. The definition of management unit under this alternative is less restrictive than Alternative 4. Management units may include adjacent major river systems (e.g., Nooksack and Samish, Humptulips and Chehalis) entering into salt water or the mainstem Columbia River (e.g., Lower Columbia River coho from Grays River to Bonneville Dam). For resident fish, larger management units of multiple drainage systems or lakes would be allowed.

Under Alternative 5, complete management units will be managed for MSY for wild production except where:

A. Significant additional benefits from status quo type mixed-stock (e.g., hatchery-wild or wild-wild) harvests outweigh the long-term costs of managing escapements to a lower level, and:

1. Status quo type approaches to separating stocks in time, place, or with fishing gear are not feasible.
2. Deviations below MSY escapements for wild production are the least amount necessary, given No. 1 above.
3. All stocks are maintained above a level where the stock is probably at immediate risk of loss or long-term harm.

B. Larger escapements are necessary to respond to specifically identified ecological, harvest, or other needs.

Table II-5. Criteria for prioritizing assessments of gene flow.

Priority for Assessment	Non-native sources: Migrants/ generation (based on genetic marks)	Non-native sources: % of total spawning population of hatchery origin	Native sources: Migrants/ generation (based on genetic marks)	Native sources: % of total spawning population of hatchery origin
High	100	5	1000	50
Moderate	10	2	100	25
Concerned	1	1	10	10

(Surrogate measures of gene flow from non-native and native sources)

5.2 What Counts?

Under this alternative all fish spawning in the wild would count towards meeting the desired spawner abundance level.

5.3 Monitoring

Same as element 4.3 in Alternative 4.

5.4 Accountability

Same as element 3.4 in Alternative 3.

5.5 Genetic Conservation

The Genetic Conservation element in this alternative takes a different approach to achieving similar goals as the previous alternatives. It relies more on monitoring and then responding to measurable changes in genetic criteria, rather than relying on prescriptions that either: (1) are designed to prevent changes that may not have occurred or (2) may not achieve the desired goal. It is expected that this alternative would require fewer changes and adjustments in the short term while the monitoring is underway. The level of future adjustments compared to the other alternatives will depend on how accurate the prescriptions in the other alternatives are, and how well we can measure changes.

5.6 Minimum Genetic Standard

Alternative 5 uses the same base value of 2,000 found in the previous alternative, but sets the other criteria at a level that is above where the stock probably is at immediate risk of permanent harm. The minimum value would be the greater of the two criteria.

5.7 Gene Flow

Human caused gene flow between MALs, GDUs, and stocks would be allowed under this alternative, provided that the genetic relationships and magnitude of genetic differences between the various units is maintained. Populations would be expected to change in response to natural environmental changes and other natural processes. Human caused hybridization between species, such as between bull trout and eastern brook trout, would not be allowed.

Gene flow between hatchery and wild fish would be treated somewhat similarly. The goal is to maintain genetic relationships between populations, prevent the genetic extinction of any populations or loss of life history forms, and allow populations to respond to natural conditions. The criteria in Table II-5 will be used to prioritize stocks for monitoring these criteria. These criteria are thresholds. Once the evaluation of the stocks takes place, whatever steps are necessary would be taken to achieve the underlying goals. This may include more or less stringent requirements than are included in Alternatives 2-4.

The definition of similarity is less strict in this alternative. Here the comparison is directly between the existing hatchery and wild fish and not an ideal broodstock as was used in the previous alternatives. Generally, any locally collected broodstock would be considered high similarity.

5.8 Effects of Fishing Practices on Populations

Same as element 4.8 in Alternative 4.

5.9 Habitat Loss and Fragmentation

No formal policy element is proposed.

5.10 Sanctuaries and Refuges

No formal policy element is proposed.

5.11 Ecological Interactions

Under this Alternative if problems are found then steps will be taken to reduce or correct the problem. This applies to introductions of salmonids and non-indigenous species, and for ecological concerns about hatchery production.

5.12 Harvest Management

Same as element 3.12 in Alternative 3.

5.13 Incidental Harvests Limits

Under this Alternative there is not a fixed limit on incidental harvests when a population is not meeting its escapement goal. This would be determined on a case-by-case basis based on potential stock and harvest impacts.

5.14 Selective Fisheries

This Alternative considers selective fishing approaches to be a tool that may be applied as necessary to increase potential benefits. It does not mandate specific priority for the more selective fisheries as is the case with Alternatives 2-4.

5.15 Cultured Production/Hatcheries

Same as element 4.15 in Alternative 4.

5.16 Supplementation

In Alternative 5, hatchery programs would be designed to ensure that important populations are not lost. The additional spawners provided by hatchery fish would be a desired outcome of all hatchery programs that used a locally collected broodstock. This is consistent with including all spawners in the wild towards meeting the desired spawner abundance level, and having a gene flow criteria with a higher threshold for concern. This approach to supplementation would be subject to the evaluation process for gene flow and future controls may need to be applied if impacts were discovered.

5.17 Gene Banking

Same as element 3.17 in Alternative 3.

5.18 Implementation Framework for Spawning Escapement Management

No formal policy element is proposed.

Some Factors Common to All Alternatives

The final policy will provide the road map for where we want to go -- clear direction and expected outcomes for meeting the goal of healthy stocks and sustainable benefits. As mentioned above, a number of planning approaches, strategies and actions will implement the policy's vision.

Monitoring and Evaluation

Evaluation Goal

Resource management goals, objectives, strategies and actions will be evaluated to ensure the goals of the Wild Salmonid Policy and related species or geographic plans are met.

The effectiveness of each of the alternatives depends on several key factors; monitoring and evaluation, enforcement, and education. Monitoring, evaluation and research will be the cornerstone for ensuring the success of these various measures. Evaluation will be the ongoing foundation for implementation and related decision making, used to answer and act on such key performance questions as:

- Are we achieving the long-term policy goals - abundance, productivity and diversity of wild salmonids and their ecosystems; sustainable fishery and non-consumptive benefits; and maintaining other cultural and ecological values?
- Are we meeting policy guidelines and performance measures?

Enforcement

Enforcement is a key element in successful implementation of any regulatory policy.

Enforcement Goal

Provide an environment where people involved with wild salmonid habitat and harvest will voluntarily accomplish those steps necessary to achieve policy goals.

Education

"The real substance of conservation lies not in the physical projects of government, but in the mental processes of citizens." Aldo Leopold.

Education Goal

Give citizens the basic tools, understanding, and knowledge necessary to preserve, protect and restore wild salmonids.

Developing progressive, corrective management strategies, as detailed in this policy, is the first step toward maintaining and restoring wild salmon populations to healthy levels that provide desired benefits. The next step is the support and assistance of an educated human population. Paraphrasing Aldo Leopold, the real substance of wild salmon recovery is whether or not Washington's citizens will act to cause needed changes. For citizens to take positive actions, they must be informed. They must understand the problems, know the range of potential solutions, and be motivated to implement the appropriate changes. Central to this action is the need for a strong, effective and varied education program explaining the needs of wild salmonids.

Chapter III ALTERNATIVES FOR HABITAT PROTECTION AND RESTORATION

Introduction

The proposed Wild Salmonid Policy addresses habitat protection and restoration because habitat is essential to wild salmonid protection. Habitat protection and restoration crosses agency and governmental lines and requires coordination at the fundamental level of determining habitat needs for salmonids. However, WDFW use of the proposed Wild Salmonid Policy as it applies to habiat would be limited by WDFW's statutory authority. The measures and implementation strategies for habitat discussed in this chapter and Appendix C may be supported or encouraged by WDFW under a Wild Salmonid Policy, but implementation would require programs and projects by other governmental and private entities.

This EIS reviews five alternative approaches for a habitat restoration and protection policy. Except for Alternative 1 (Status Quo), each alternative is very similar regarding the goals, performance measures and action strategies that would appear in a final policy. The differences lie in the implementation approach; the relative balance between state and local government regulatory prescription, and locally-based watershed planning and implementation.

Alternative 1 (Status Quo) - Currently habitat protection and restoration is dependent upon a variety of state, local, and federal regulations, plans and programs that directly or indirectly provide salmonid habitat protection. Although there are a myriad of policies and agreements affecting habitat, there is no comprehensive, coordinated policy directed at salmonid habitat.

Alternative 2 - This alternative would encourage habitat protection and management through a fairly rigid state-prescribed package of performance standards and action strategies.

Alternative 3 is the agency's preferred alternative. Habitat protection and restoration would occur primarily through locally-based watershed planning that would have the flexibility to adapt performance measures and action strategies to local conditions. State and local or federal regulatory authorities would not be relinquished during locally-based watershed planning, but these authorities should be used in a manner that supports locally-based planning. Regulatory action could be taken wherever standards and requirements are not being met, and voluntary actions are either not being taken or are insufficient to achieve compliance. Statewide planning or rule-making would occur on a collaborative basis. For example, WDFW will participate in the Timber, Fish, and Wildlife process to develop a Forestry Module intended to address Endangered Species Act and Clean Water Act standards on state and private forest lands. A similar forum intended to address agriculture, fish, and wildlife issues could be established as well. WDFW would participate in this process.

Alternative 4 - Habitat protection and restoration would be similar to that in Alternative 3, except that it would include performance <u>standards</u> as opposed to performance <u>measures</u>, and implementation would not clearly emphasize watershed planning as the implementation method of choice.

Alternative 5 - Habitat protection and restoration would occur through existing and new forums using fairly general, narrative performance measures and optional action strategies derived from the policy. All the specifics of a watershed plan would be developed locally.

Factors Common to All Habitat Alternatives

Except for Alternative 1 (no action), each of the different alternatives proposed for habitat has the same potential outcome of providing sufficient amounts of quality salmonid habitat to achieve the overall goal of the policy. The differences between Alternatives 2 through 5 lie in their specificity, flexibility, and regulatory emphasis. As a result, they create different impacts on human activities that affect habitat.

Habitat Alternative 3 contains the components that would be also be addressed in Alternatives 2, 4, and 5, and ultimately in a Wild Salmonid Policy. Each alternative for a policy would have an overall habitat goal followed by individual goals for basin hydrology and instream flows, water quality, sediment delivery and routing, stream channel complexity, riparian areas and wetlands, lakes and reservoirs, marine areas, fish access and passage, and habitat restoration. Each alternative has either quantitative or narrative standards or measures, by component, and each has action strategies that would either be required, strongly suggested, or provided as representative actions that could be taken.

Collectively, a habitat section for any policy alternative would address salmonid habitat requirements at all life stages.

Note: The entire habitat section will not be repeated within the descriptions of Alternatives 2, 4, or 5. Instead we will describe their major differences, contrasted with the preferred alternative, which is Alternative 3.

Alternative 1 - Status Quo

There are a myriad of laws and actions that affect habitat protection and restoration. Indeed, habitat protection and restoration has improved significantly over the last 20 years. Forest practices, for example, now employ “watershed analysis.” This tool assesses salmonid habitat condition on state and private forest lands, determines the likely impact of proposed forest practices, and develops prescriptions designed to protect instream resources while allowing certain levels of forest practice activities. The Growth Management Act (GMA) couples land use and zoning with protection of critical areas including salmonid habitat. The GMA has brought some improvement in habitat protection. These are important steps and should continue. However, without continued modification and significant improvement of the state's habitat management programs, salmonid habitat will continue to decline in productive capacity, causing the loss of more wild salmonid populations.

Table III-1 lists the government programs, regulations, and plans affecting land use. These directly or indirectly protect salmonid habitat. There are also non-regulatory programs that provide technical assistance or financial assistance for stewardship practices. There is also a growing number of volunteer efforts to restore salmonid habitat.

These regulatory programs limit one or more aspect of the use of land or water. Any one project may be subject to a multitude of requirements from the listed programs. Some of the programs prescribe specific processes (e.g., SEPA, NEPA, GMA), others require specific permits, and some both (e.g., Shoreline Management Act). The permits frequently have different time requirements , sometimes even contradictions, and getting required permits can

Table III-1. Representative state, local, and federal programs affecting land use in Washington.

Programs/Plans/Regulations	Geographic Scope
Local ordinances and zoning regulations	Limited to local jurisdictions
Shoreline Management Act	Statewide
State Environmental Policy Act	Statewide
Puget Sound Water Quality Plan	Broad, limited to Puget Sound
National Environmental Policy Act	Statewide
Planning under the Growth Management Act	Limited to high population cities and counties
Floodplain management plans	Limited to some local jurisdictions
Forest Practices Act	Statewide
Clean Water Act	Statewide
Federal Emergency Management Act	Statewide
Surface Mining Reclamation permit process	Statewide
Northwest Power Planning Act	Statewide but emphasis in Columbia River
Requirements under the National Pollution Discharge Elimination System (NPDES) that controls discharges of water into streams and rivers	Statewide
Hydraulic Project Approval Act, trust water right and water quality management programs	Statewide
Army Corps of Engineers requirements	Statewide
Federal Energy Regulatory Commission licensing and other hydropower approvals	Statewide
Local watershed plans	Some local watersheds

last several years for major projects. There are no consistent, coordinated, statewide goals, performance measures, or action strategies.

Alternative 2

Alternative 2 is the most specific and most restrictive of the alternatives considered. The recommended performance "measures" listed in Alternative 3, and the action strategies listed in Appendix C, would be identified as required performance "standards." Many of these standards, however, cannot be accomplished by the regulatory authority of WDFW and would need to be adopted within other existing state and/or local government regulations, or by new authorizing legislation and/or rule-making processes.

Alternative 3

For habitat, Alternative 3 would provide a high degree of specificity and guidance about "what fish need". It includes performance measures that should be met in order to be successful. The action strategies in Appendix C would be strongly encouraged. Alternative 3 would rely principally on locally-based

planning efforts for specific implementation plans.

It would be the policy of the Fish and Wildlife Commission that:

A. Protection and restoration of wild salmonid habitat is the fundamental prerequisite to meeting the overall Wild Salmonid Policy goal. This will require identification and provision for the habitat needs of wild salmonids, identification of natural and human effects on habitat, and implementation of actions that will maintain or increase the quality and quantity of habitat necessary to sustain and restore salmonid populations.

B. Habitat protection and restoration will require a comprehensive watershed-based approach that would stress the continuum that extends throughout the watershed, its estuary, and near shore marine waters.

C. A balance of local implementation processes and state level regulation is essential to habitat protection and restoration. A state and local government regulatory framework should remain in place. New, or revised, statutory or rule-making authority recommendations, if needed, should result from collaborative discussion by all interested parties and should include additional SEPA review. Local implementation processes for habitat protection and restoration must recognize tribal sovereignty in government-to-government interactions, be sensitive to the rights of citizens, and be accountable for protecting habitat.

D. Habitat goals, performance measures, and action strategies should apply to all salmonid habitat, regardless of land use and regardless of ownership.

E. Protection and restoration of salmonid habitat should also: (1) benefit other fish and wildlife resources, (2) protect valuable ecosystem features, such as flood plains and wetlands, (3) reduce flood damages and other community infrastructure costs, (4) facilitate groundwater recharge and help to prevent ground and surface water contamination, and (5) contribute to maintenance of a healthy economic climate across the state.

F. Once watershed assessments have been completed and limiting factors identified, agencies should encourage the development of local proposals for habitat preservation, protection and restoration. Upon receipt of such a proposal, the appropriate agency is encouraged to provide technical support, incentives or funding to remedy habitat problems identified in the assessments.

Alternative 3 would strongly encourage local problem solving with state, local, and federal agencies, and tribes at the table. State agencies would provide technical support and would represent state's interests, but they would also be at the table as partners, working collaboratively with local citizens to achieve Wild Salmonid Policy goals consistent with local needs and conditions. The habitat goals would be fairly rigid, but individual performance measures and action strategies within the habitat components could be revised or amended (or new ones could be added), again, consistent with local conditions.

Identification of the actual makeup and operating principles for watershed groups is

beyond the scope of this policy. However, watershed groups should be diverse and be representative of all interests within the community. To the extent possible, existing watershed groups should be considered and included in any planning and implementation scenario.

Alternative 3 encourages, and builds on, numerous existing regulatory, proprietary, voluntary, and incentive or grant-based efforts such as the Growth Management Act, the WDFW Hydraulic Code, the Department of Natural Resources Habitat Conservation Plan, the Puget Sound Action Plan, Ecosystem Standards for State-owned Agricultural Lands, the Timber, Fish, and Wildlife Agreement (TFW), and recent improvements to the Forest Practices Act Rules and Regulations, individual landowner farm and forest plans, habitat restoration efforts, and water conservation measures, many developed through the State Conservation Commission. Further, programs such as Jobs for the Environment, and Regional Fisheries Enhancement Groups, have made significant contributions to fish habitat improvement and protection.

This brief list clearly does not provide credit for all the positive efforts we have collectively taken, but serves to acknowledge the intent of our citizens to support salmonid habitat protection and restoration. For example, the TFW "Forestry Module" is a cooperative effort by agencies, tribes, and citizens to develop an ESA and Clean Water Act strategy that includes all the habitat components in this policy as they relate to forest practices on state and private forest lands. WDFW is party to the TFW agreement and would defer to this process with the expectation that biological objectives for wild salmonids would be met.

It is important to note that maintenance of agricultural and forest lands is a key component of protection and restoration of wild salmonids. Implementation of the action strategies necessary to meet the following performance measures will require recognition and consideration of the need to maintain strong and vibrant economic conditions for forestry and agriculture over the long term. Providing technical assistance and other incentives to encourage landowners to continue in forestry and agriculture, should be an integral part of watershed plans and/or collaborative rule-making processes.

The exact methods and products that will be developed to implement the habitat components of the policy are beyond the scope of this programmatic FEIS. It is anticipated that additional plans, actions, agreements, and/or regulations will be developed, in most cases in arenas outside the WDFW rule-making process. It is also expected that additional SEPA review will be done to address the specific environmental impacts of those implementation actions subject to SEPA. In any event, successful implementation of the policy will require close coordination and cooperation of agencies, tribes, and individual landowners.

It is important to recognize that habitat protection and restoration are critical to the survival, production, and utilization of both wild and hatchery salmonids. This is because hatchery fish require high quality water in sufficient supply for efficient on-station incubation and rearing, and because they rely on the same habitat conditions as wild fish once they are released to the wild. If we allow habitat quality to decline, most hatcheries and other fish rearing facilities will eventually fail. Therefore, we cannot rely on increases in

hatchery fish production to maintain harvest levels.

Reductions in harvest levels alone cannot maintain wild salmonid populations. Merely reducing harvest does nothing to improve habitat conditions. Sound and sustainable salmonid management requires long-term habitat protection and restoration, from the spawning gravel, through the full range of rearing and adult residency habitats.

3.1 Proposed Habitat Policy Framework

The proposed habitat policy is arranged along salmonid life history needs, and the physical processes and habitat types affecting them. It consists of nine components.

The proposed Habitat Policy components are:

1. **Habitat Protection and Management**
2. **Basin Hydrology and Instream Flow**
3. **Water and Sediment Quality and Sediment Transport**
4. **Stream Channel Complexity**
5. **Riparian Areas and Wetlands**
6. **Lakes**
7. **Marine Areas**
8. **Fish Passage and Access**
9. **Habitat Restoration**

It is important to recognize the inter-relationships between these components. Inadequate attention to one or more habitat components may reduce, or eliminate, the benefit of achieving the performance measures of another. For example, riparian buffers and stream channel complexity will be of reduced value to wild salmonids if flows are inadequate, or fish access is denied. For anadromous salmonids, production gained from fresh water may be lost if nearshore marine conditions for feeding and migration are inadequate. Habitat quality is also related to spawner abundance. Freshwater productivity can be heavily influenced by returning adult salmon whose carcasses provide a source of marine-derived nutrients (nitrogen, phosphorus, and carbon) to the aquatic and riparian zone.

3.2 Habitat Protection and Management

Protection and restoration of wild salmonid habitat is the fundamental prerequisite to meeting the overall Wild Salmonid Policy goal. Failure to protect and restore habitat would severely constrain, or eliminate, our harvest management, hatchery, and genetic conservation options to utilize and protect wild salmonids. Fundamentally, protection of wild salmonid habitat is the most effective way to ensure preservation of the salmonid resource. However, given the current degraded state of much of our habitat base, restoration of that habitat is also integral to recovery of wild salmonid populations.

The WSP recognizes that society and individual landowners can manage their activities to avoid impacts on wild salmonid habitat (e.g., managing basin hydrology and instream flows to influence water quantity; protecting or restoring floodplains and wetlands to influence water quantity, water quality, and fish use). This section emphasizes the importance of partnerships, since no single organization or group has complete authority to protect and manage fish habitat - management responsibility is held by multiple agencies and local governments (towns, cities, counties). Furthermore, most regulations are minimum standards and the overall level of protection afforded wild salmonids varies

widely, from comprehensive, rigorous protection, to virtually none at all.

WDFW has limited regulatory authority to protect salmonid habitat. The State Hydraulic Code states that activities that use, divert, obstruct, or change the natural flow or bed of waters of the state must obtain approval from WDFW. WDFW also has authority over fish passage at in-stream structures and can require screening of water diversion intakes. However, these WDFW actions are usually reactive to land use patterns and/or do not fully address the cumulative effects of watershed activities that affect in-stream and marine habitat.

Protecting and restoring salmonid habitat requires recognition of the dynamic nature of the physical processes that influence habitat, and requires better-coordinated planning and regulatory efforts. It also requires complete and accurate inventory and assessment of existing, or potential, salmonid habitat, and land uses affecting that habitat.

Successful protection and restoration of wild salmonids and salmonid fisheries would require the participation of all levels of government and the Tribes. Under co-management, the State shares responsibility with the Tribes for managing fishery resources, usually through one or more of its agencies. Local governments and private interest groups have unique authorities and responsibilities that can affect salmonid habitat. All these groups should be brought into watershed planning processes. Further, the Governor has established a Natural Resources Cabinet that would help guide interactions with the Tribes at both the state and local levels. WDFW would be an active participant in the Natural Resources Cabinet as a vehicle to achieve wild salmonid protection.

3.3 Proposed Overall Goal for Habitat

Maintain or increase the quality and quantity of habitat necessary to sustain and restore salmonid populations.

3.4 Proposed Overall Performance Measure for Habitat

The ultimate performance measure for habitat is a level of productivity and production that would sustain robust fisheries, while maintaining healthy adult spawning populations. However, relationships between habitat conditions and salmonid productivity have not been well defined (although efforts are currently under way to define them). Therefore, the approach used would be to define performance measures based on the physical conditions within salmonid habitats that are expected to create good productivity. This is an indirect approach, that must periodically be evaluated to ensure its applicability. The physical performance measures are described in the habitat components that follow. They are based on our current understanding of what is expected to provide good salmonid habitat and productivity, and would be periodically updated as new or additional information becomes available.

Appendix C contains action strategies we recommend in order to achieve the overall habitat goal.

3.5 Basin Hydrology and In-stream Flow

This component addresses stream flow from two dimensions: (1), maintenance or

restoration of natural physical processes affecting hydrologic regimes (flow timing, volume, and duration); and, (2) maintenance or restoration of flows through administration of water rights, instream resources programs, water conservation strategies, etc.

Floods and droughts are natural events, and anadromous and resident salmonids evolved in basins subject to variable, but generally predictable, flow regimes. Salmonid evolutionary responses for survival and reproduction - where and when they rear, migrate, and spawn - are reflected in those flow regimes (the basin hydrology). The adaptive responses for salmonid species are complex, involving several kinds of habitats, in various parts of a river basin, over a relatively short time period. Many of the responses and habitat requirements are not well understood. Therefore, salmonid habitat requirements for basin hydrology should consist of flow patterns that reflect the natural hydrologic regime under unmanaged conditions.

Land use can have a significant affect on basin hydrology. For example, in urbanizing basins, increases in the amount of impervious surface within basins will increase peak run-off and stream flows, restrict groundwater recharge, and restrict summer flows. Certain forest practices can alter peak run-off, especially where timber harvest occurs in transient rain-on-snow zones, and certain agricultural practices can alter basin hydrology through changes in vegetation and surface compaction. In addition, surface water flows are influenced by sediment transport rates, groundwater recharge, floodplain connectivity, riparian area condition, and the size, condition, location and extent of wetlands.

Stream flows are affected as well by water withdrawals for off-stream use, by certain groundwater withdrawals, and by in-stream impoundment and release operations to achieve flood control, hydropower, and other societal objectives. But water quantity requirements for wild salmonids can be met in part through management of activities that affect basin hydrology and in-stream flow (e.g., land use planning and land use regulation, timber harvest planning, etc.), and through efficient management of water allocation and use including maintenance and restoration of in-stream flows.

Attainment of natural stream (basin) hydrology would be difficult in many cases, in fact, probably near impossible in some urban areas. However, there are numerous opportunities where, either though land use allocation, land treatments, water conservation, or stored water releases, etc., we can prevent the situation from deteriorating, or actually improve stream flows. The implementation strategy encourages locally-based watershed planning. This is where all activities affecting, or likely to affect, hydrology can be assessed and where specific actions can be developed and implemented.

3.6 Proposed Goal for Basin Hydrology and In-stream Flow

Maintain or restore the physical processes affecting natural basin hydrology. In addition, manage water use and allocation in a manner that would optimize in-stream flows for salmonid spawning, incubation, rearing, adult residency, and migration, that would address the need for channel-forming and maintenance flows, and that would address the impacts of water withdrawals on estuarine and marine habitats.

3.7 Proposed Basin Hydrology and In-stream Flow Performance Measures

A. In streams or basins that provide useable wild salmonid habitat, and where in-stream flows have not been established by rule, the stream's flow trends, normalized to account for variations in precipitation, to hold steady, or increase (low flows) over time.

B. In streams or basins that provide useable wild salmonid habitat, and where stream flows have been adopted or are being revised, the performance measure would be the in-stream flow as adopted by rule.

C. Physical indicators within a watershed should also be used, where applicable, as performance measures to assess or achieve the goals for basin hydrology and in-stream flow. These performance measures are typically expressed as thresholds of change - if the thresholds are exceeded, habitat conditions including water quality and water quantity decline dramatically, and often irreversibly. Threshold management can help to maintain or restore natural basin hydrology and in-stream flow. Examples of thresholds include:

1. **Percent effective impervious surfaces - these include road surfaces, rooftops, and parking lots. As percent effective impervious area exceeds a threshold of 8-10% in a sub-basin watershed , in-stream conditions (including the frequency and intensity of high flows and water quality) begin to deteriorate. Groundwater recharge and summer low flows also usually decline, although the relationship is not always as predictable. The threshold could be applied to stream reaches or sub-basins. This threshold method could also be applicable to wetlands.**
2. **Forest harvest and road density - the seasonal timing of forest harvests, and the density of roads in harvesting areas, can have significant effects on stream flows. The percent of upland forests at hydrologic maturity, and percent clearcut in rain-on-snow zones, have been used as thresholds beyond which significant adverse impacts on basin hydrology and in-stream flow would be expected. The thresholds are basin specific and may not be practical in many instances. However, some forest land managers feel, that for western Washington sub-basin watersheds, a threshold of approximately 60% of standing timber at age 25 or more would begin to reflect hydrologic maturity. Road densities are even more basin specific and would require some form of analysis and discussion to arrive at a threshold number, or other management prescription, to protect against unnaturally high stream flows.**

3. Threshold grazing standards could be set at the basin specific level. On state lands, guidance is available in the HB1309 Ecosystem Standards for State-Owned Agricultural and Grazing Lands. This guidance may also have application on other ownerships as a reference document.

Physical indicators should be applied in conjunction with other actual in-stream flow measures whenever possible. The value of threshold indicators is that they are strategic, predictive, and preventative. Restoration of natural hydrologic regimes may well be impossible or prohibitively expensive, especially after basins experience extensive development.

See recommended action strategies in Appendix C.

3.8 Water Quality and Sediment Quality, Delivery and Transport

Water and sediments within specific ranges of physical and chemical characteristics are essential to healthy and productive wild salmonid populations. Both water and sediment are excellent media for the uptake, storage, transportation, and concentration of dissolved and particulate materials. Natural rates of sediment delivery and routing within streams and marine areas, are essential to creating and maintaining salmonid habitat. But, accelerated rates of sediment erosion/deposition are usually detrimental to salmonid habitat.

Many natural processes and human activities can affect sediment delivery and routing, and can introduce potentially toxic substances to water and sediment that can have deleterious effects on salmonids and the food webs they rely upon.

Preventing and minimizing releases of oil and other toxic or deleterious substances to the aquatic environment has been demonstrated to be much more cost-effective than remediation and restoration. Persistent hazardous materials accumulate in sediment depositional areas, such as wetlands and estuaries, where remediation options are very expensive.

3.9 Proposed Goals for Water Quality and Sediment Quality, Delivery and Transport

A. Provide for water and sediments of a quality that will support productive, harvestable, wild salmonid populations, unimpaired by toxic or deleterious effects of environmental pollutants.

B. Manage watersheds, stream channels, wetlands, and marine areas for natural rates of sediment erosion, deposition, and routing, to within the limits of salmonid life requirements.

3.10 Proposed Performance Measures for Water Quality and Sediment Quality, Delivery and Transport

A. Maintain productive aquatic habitats for salmonids and their prey bases that contain a balanced, integrated community of organisms, having species composition, abundance, diversity, structure, and organization comparable to that in unimpacted reference ecosystems of the region.

B. For factors such as temperature, dissolved oxygen, pH, turbidity, and suspended solids levels, meet state surface water quality standards as established for waters supporting salmonids and prey base species.

C. For all relevant freshwater and marine areas, meet water and sediment quality criteria, as established for toxic or deleterious pollutants that can affect the survival, growth, or reproductive success of salmonids or prey species.

D. Consider gravel impaired in spawning areas if fine sediments (<.85mm) exceed 11%. If fine sediment levels naturally exceed 11% in spawning or rearing habitat, then sediment concentrations would not exceed natural levels.

See recommended action strategies in Appendix C.

3.11 Stream Channel Complexity

Salmonids have evolved and adapted to streams that possess a variety of in-channel features important to spawning, rearing, and migration. These features include (1) frequency of pools and riffles, (2) substrate size and distribution, (3) sediment delivery and transport processes, (4) water depth and velocity, (5) undercut banks, (6) in-stream woody debris, and (7) a variety of side-channel and off-channel habitats. Stream channels exhibit various levels of complexity dependent upon their degree of confinement within their valley walls, their steepness, and their size, the geologic makeup of the basin, and the hydrologic regime. Stream complexity is subject to natural levels of disturbance, particularly as a result of catastrophic events, such as wildfire and disease affecting riparian areas, and by landslides and debris torrents. However, in-stream complexity has been reduced or lost as well, due to human activities, such as removal of large woody debris, channel encroachments (including bank hardening), dredging, relocation and realignment, loss of side-channel, off-channel and floodway connectivity (diking, channel aggregation, tide gates) , conversion of free-flowing reaches to impoundments, burial of streams in culverts to facilitate development, and installation of road crossing structures.

3.12 Proposed Goal for Stream Channel Complexity

Maintain or restore natural stream channel characteristics for channel sinuosity, gravel quality and quantity, in-stream cover, large woody debris (LWD), pool depth and frequency, bank stability, and side-channel, off-channel, and flood plain connectivity, and function.

3.13 Proposed Performance Measures for Stream Channel Complexity

A. Spawning gravel would be relatively stable, with a low potential for scour, throughout the nest building and incubation period of the wild salmonid species in the basin.

B. Adult salmonid holding pools would contain sufficient depth (depending on species and stream, but generally greater than one meter) and associated cover.

C. More than 90% of channel banks on streams would be stable, relative to natural rates of erosion in the basin. Stability, if needed, can be provided in a number of ways. If bank protection is

necessary, bioengineering methods are preferred.

D. At a minimum, the performance measures relative to pools and large woody debris in forested and previously forested areas, should conform to those in the *Washington State Watershed Analysis Manual* (listed below), unless locally defined.

1. **In streams of any gradient, but less than 15 meters wide, the frequency of pools should not occur at intervals less than one pool for every two channel widths in length.**
2. **The percent pools in a stream will not be impaired by the presence of sediments, or the effects of human disturbances. For streams less than 15 meters wide, the percent pools should be greater than 55%, greater than 40%, and greater than 30% for streams with gradients of less than 2%, 2-5% and more than 5%, respectively.**
3. **The quantity and quality of LWD in streams should not be impaired by human activities. For streams less than 20 meters wide, the number of pieces of LWD larger than 10 centimeters for every channel width, should exceed two. The number of key LWD pieces per "bank full width" (BFW) should be greater than 0.3 pieces for streams less than 10 meters BFW, and greater than 0.5 pieces for streams 10-20 meters BFW.**

E. Side channels and other off-channel habitat, including wetlands, remain connected to the channel proper. Where feasible, dikes or levees, bridge approaches, and other structures that are constricting floodplains, should be removed or modified to allow flood flow, storage, recharge, and release.

See recommended action strategies in Appendix C.

<u>3.14 Riparian Areas and Wetlands</u>

Riparian areas are those areas immediately adjacent to streams, wetlands, and marine shorelines. The trees, shrubs, herbs and grasses comprising riparian vegetation influence aquatic areas, and in turn are influenced by them. Riparian areas are vitally important for maintaining, in varying levels of contribution, the water quantity, water quality, food supply, shelter, migration, and reproductive needs for wild salmonids. Fully functional, naturally vegetated riparian areas have the following attributes:

1. **Contribute sizes and species of large woody debris to the aquatic zone that (1) dissipate energy, (2) trap and route sediments, (3) retain detritus and salmonid carcasses, and (4) maintain channel complexity.**
2. **Create and maintain spawning, rearing, and migratory habitat for salmonids and their prey.**
3. **Provide shade, and subsequently reduce summer stream temperature, and ameliorate winter low stream temperature.**
4. **Maintain vegetative community integrity and diversity that prevents debris flows, controls sediment delivery and transport, provides a source of nutrients to the channel,**

and stabilizes stream banks.

5. **Provide and maintain areas of off-channel habitat.**
6. **Attenuate flows and moderate impacts from high flow events.**
7. **Facilitate groundwater recharge and maintain summer low flows.**
8. **Intercept and break down incoming pollutants.**

Wetlands provide a variety of direct and indirect benefits to wild salmonids. Fully functional wetlands have the following characteristics:

1. **Reduction of flood peak-flows (including stormwater runoff), and maintenance of low flows.**
2. **Shoreline stabilization (energy dissipation/velocity reduction).**
3. **Groundwater recharge.**
4. **Water quality improvement, including sediment accretion and nutrient/toxicant removal/retention.**
5. **Food chain support (structural and species diversity components of habitat for plants and animals).**
6. **Provide habitat for numerous fish and wildlife species, including wild salmon and trout.**

Riparian areas and wetlands are sensitive to natural and human activities (vegetation removal, modification of basin hydrology, and sediment transport); wetland functions in particular are very difficult or impossible, to restore or replicate, after damages have occurred. Washington's riparian areas and wetlands have been reduced in both area and function, due to human impacts. Lack of a statewide program of riparian area and wetlands protection, with agreed upon numeric standards, contributes to loss of riparian and wetland area and function.

3.15 Proposed Goal for Riparian Areas and Wetlands

Functional riparian habitat and associated wetlands are protected and restored on all water bodies that support, or directly or indirectly impact, salmonids and their habitat.

3.16 Proposed Performance Measures for Riparian Areas and Wetlands

A. **There are no single, agreed-upon, statewide numeric standards for riparian areas or wetlands. Because the Department of Natural Resources maintains and updates a fairly extensive, and fairly accurate, water typing system (defined and mapped per WAC 222-16-030), and since many local governments use this system, we would use that system as a point of reference. It should be noted that the performance measures recommended below provide general guidance for riparian buffers that protect aquatic functions and salmonid habitat. These buffers should be applied regardless of land use (e.g., forest lands, agricultural, rural, or urban lands).**

   Regional or watershed specific standards may need to be applied, based upon watershed analysis, the development of specific and detailed standards in individual watershed plans, or other assessments of site conditions and intensity of land use.

   It is anticipated that statewide standards for state and private forest lands would be developed through the TFW process,

and provided to the Forest Practices Board for formal rule making. It is also anticipated that, in many instances, existing encroachments in riparian areas, or parcel size and configuration, may preclude attainment of adequate riparian buffers.

Nonetheless, in the absence of any other quantified alternative that provides the riparian area functions described above, the performance measures below are recommended to maintain riparian functions and conditions which protect salmonid habitat:

1. Riparian Areas

- **a. For Water Types 1-3, a buffer of 100 - 150 feet (measured horizontally), or the height of a site potential tree in a mature conifer stand (100 years), whichever is greater, on each side of the stream.**
- **b. For Type 4 streams, a buffer of at least 100 feet (each side)**
- **c. For Type 5 streams, a buffer of at least 50 feet (each side).**
- **d. For streams not administered directly or indirectly per WAC 222-26-030, apply a buffer of 100-150 feet each side on salmonid streams larger than 5 feet wide, a buffer of 100 feet (each side) on smaller perennial streams, and a buffer of 50 feet (each side) on all other streams.**
- **e. The buffers may need to be expanded to accommodate anticipated channel migration, as an additional buffer against windthrow, or to address upslope instability, or previous negative upslope impacts.**
- **f. Type 4 and 5 streams, with low stream gradient and relatively flat slope topography, may not need the full buffer width specified, and the buffer width may be reduced to that necessary to protect the stream from upslope sedimentation and significant changes in stream temperature. The actual buffer width and composition should be based on site-specific conditions.**
- **g. To the extent possible, buffers should be continuous along the stream channel. Selective tree removal may occur where site review and prescription clearly demonstrates removal can occur without significantly affecting the function of the riparian area, or that removal and/or removal and subsequent rehabilitation will improve the functional characteristics of the riparian area. Complete removal should be limited to road alignments, stream crossings, or other corridors where no feasible alternative exists.**
- **h. Riparian area restoration is strongly recommended. Plant community structural complexity (understory herbaceous and woody overstory canopy) and density should be similar to what would occur at the site under natural conditions (also known as site potential).**

i. Grazing, if allowed, should be managed to maintain or allow reestablishment of functional riparian vegetation. Other management activities may occur within the riparian area, provided the functional characteristics of the riparian area necessary to protect the stream are not significantly impaired.

j. The performance measures for Basin Hydrology and In-stream Flow, and Water and Sediment Quality and Sediment Transport and Stream Channel Complexity, should also be met to ensure riparian functions will be meaningful and attainable.

2. Wetlands

a. Buffers for wetlands should be applied in accordance with the Department of Ecology Model Wetlands Ordinance - September 1990, and the updated 4-tier rating system (Pub. #93-74 for western Washington, and Pub. #91-58 for eastern Washington). The ordinance should be applied as guidance. It is not a legally required state standard, and it is not solely designed to meet the specific needs of salmonid habitat protection and recovery. The Wild Salmonid Policy is intended to encourage habitat protection through all means, not only through regulation. Generic application of the Model Wetlands Ordinance buffer widths and rating system, for salmonid habitat protection in all cases, may result in too much, or too little, protection of salmonid habitat in different site conditions.

Use of the Model Wetlands Ordinance standards for the protection of salmonid habitat is intended as interim guidance. There is a need to develop improved wetlands protection guidance, that is specific to the salmonid habitat needs addressed in this policy and the role wetlands play in maintaining or restoring watershed functions essential to wild salmonids.

b. Wetlands replacement is highly discouraged because of the difficulty of providing adequate replacement of functions and values. Where replacement is unavoidable, the replacement ratio would be applied as provided in the Model Wetlands Ordinance. Wetlands mitigation banking is also an option which would be considered where on-site, in-kind mitigation would not be feasible or practicable.

c. Performance measures for Basin Hydrology and In-stream Flow, and Water and Sediment Quality and Sediment Transport should be met, where applicable, to ensure wetlands extent and functions are meaningful and attainable.

Please note that these buffers are not intended to fully protect, or consider, the needs of terrestrial or aquatic wildlife, or non-salmonid fishes.

See recommended action strategies in Appendix C.

3.17 Lakes and Reservoirs

Lakes and reservoirs provide rearing, adult residency, spawning habitat, and migratory pathways for many species of salmonids. Access between lakes, and inlet or outlet streams, is critical for reproduction of many lake dwelling species. Lakes accumulate contaminants derived from upland or upstream sources. Outlet stream water quantity and quality is affected by in-lake conditions. Lake and outlet stream habitat is affected by a variety of human activities - particularly in highly developed urban, suburban, and recreational developments - including lake level manipulations, water withdrawals, high or poorly timed flow releases, loss of nearshore shallow water habitat, installation of overwater and underwater structures (docks, floats, ramps), loss of riparian vegetation, sedimentation of spawning habitat, control of aquatic plants, reduced dissolved oxygen, elevated temperatures, increased levels of chemical contaminants, such as fertilizers and pesticides, and increased fecal coliform bacteria and nitrate levels due to septic tank effluents. This results in accelerated aging (eutrophication) and "lake restoration" efforts, which may exacerbate habitat impacts on wild salmonids.

3.18 Proposed Goal for Lakes and Reservoirs

Maintain or restore lake and reservoir habitats that are conducive to wild salmonid passage, rearing, adult residency and spawning.

3.19 Proposed Performance Measures for Lakes and Reservoirs

A. There are no statewide, agreed-upon, standards, particular to all issues specific to lakes and reservoirs. However, performance measures for basin hydrology and in-stream flows, water and sediment quality, riparian areas and wetlands, and fish access and screening should include factors relevant to lake and reservoir protection.

See recommended action strategies in Appendix C.

3.20 Marine Areas

There are three key areas of marine habitat:

1. **Tidally influenced lands and estuaries, that provide transition habitat for salmonid smolts as they leave fresh water to begin their ocean life phase.**
2. **Nearshore marine habitats that serve as the primary migratory corridor for juvenile salmonids on their seaward migration, providing a variety of prey organisms and refuge from predators.**
3. **Open water habitats that are important areas for migration and growth of larger salmonids.**

Nearshore marine, estuarine and tidally influenced habitats are of vital importance to the survival of wild salmonids because:

1. Early marine rearing conditions are an important factor in overall survival rates of salmonids.
2. The productivity of these habitats influence the abundance of salmonid prey, including marine invertebrates and the forage fish populations, some salmonid species depend upon.
3. These areas also contain the critical intertidal and shallow subtidal forage fish spawning habitats that are the foundation of the coastal marine food web.

Beaches of Puget Sound are highly important areas for shorebirds, waterfowl, shellfish, finfish and other species of ecological significance to salmonids. Nearshore marine, estuarine, and tidally influenced habitats have been lost or modified to accommodate development along rivers and bays. These losses include diking and filling of intertidal wetlands, filling or dredging of shallow water habitat, loss or degradation of riparian vegetation, loss of channel system complexity near river mouths, alterations in freshwater inflows, alterations in flow interchange patterns, and a variety of water quality alterations. Marine habitats depend on continuation of watershed and coastal processes, such as basin hydrology, riverine sediment and nutrient transport, and coastal erosion and transport.

3.21 Proposed Goals for Marine Areas

A. Provide nearshore marine, estuarine, and tidally influenced marine ecosystems that contain productive, balanced, integrated communities of organisms having species composition, abundance, diversity, structure, and organization comparable to that of natural ecosystems of the region.

B. Ensure that functions and values of the following habitat types are maintained or increased: eelgrass habitats, herring spawning habitats, intertidal forage fish spawning habitats, intertidal wetlands, and safe and timely migratory pathways for salmonids in marine waters.

C. Allow natural rates of erosion and transport of sediments, nutrients, and large woody debris that affect habitat quality in tidally influenced estuarine and marine shorelines.

3.22 Proposed Performance Measures for Marine Areas

A. Natural shoreline erosion, accretion to beaches, and transport processes should be maintained or, where feasible, restored.

B. Ensure no net loss of eelgrass habitat, herring spawning habitat area or function, intertidal forage fish spawning habitat area or function, and intertidal wetland area or function.

C. Successful establishment of functioning compensatory mitigation projects should be demonstrated prior to final authorization for projects that adversely affect marine, estuarine, and intertidal habitats.

D. Maintain or restore continuous shallow-water migration corridors along nearshore marine, estuarine, and tidally influenced areas.

See recommended action strategies in Appendix C.

<u>3.23 Fish Access and Passage</u>

Free and unobstructed passage among habitat types is essential for most wild salmonids at all life stages. Fish passage is affected by natural features and events. For example, high water temperature may cause thermal blocks to migration, drought or excessive sedimentation may result in stream flow too low for passage, and excessive turbidity may deter passage. High flows may cause velocity barriers, or salmonid stranding, as flows recede. Natural complete or partial barriers, such as waterfalls and cascades, are important features which contribute life history variation within species, and allow for species separation (i.e. anadromous/resident).
However, in-stream structures such as dams, culverts, screens, and tide-gates, and water quality and water quantity fluctuations because of human activity, also create significant fish passage and stranding problems, and loss of productivity and production. For example, the Columbia River basin system of dams has caused significant losses of salmonid production. These losses are attributable to direct loss of access to habitat, transformation of a free-flowing riverine system to a system of fluctuating reservoirs, near-complete alteration of flow regimes, inadequate upstream and downstream fish passage, and inadequate screening at water intakes.

<u>3.24 Proposed Goals for Fish Access and Passage</u>

A. Provide and maintain safe and timely pathways to all useable wild salmonid habitat in fresh and marine waters, for salmonids at all life stages.

B. Ensure salmonids are protected from injury or mortality from diversion into artificial channels or conduits (irrigation ditches, turbines, etc.).

C. Ensure natural, partial or complete fish passage barriers are maintained where necessary, to maintain biodiversity among and within salmonid populations and other fish and wildlife.

<u>3.25 Proposed Performance Measures for Fish Access and Passage</u>

A. Provide and maintain free and unobstructed passage for all wild salmonids, according to state and federal screening and passage criteria, and guidelines at all human-built structures.

B. Meet or exceed a 95% survival standard for fish passage through hydroelectric projects, and fully mitigate for fish mortalities.

See recommended action strategies in Appendix C.

<u>3.26 Habitat Restoration</u>

The Wild Salmonid Policy goal would not be attained without active restoration of lost and damaged habitat. Continual restoration of unmitigated impacts to wild salmonid habitat is undesirable, ineffective, and the most costly means to achieving the Wild Salmonid Policy goal.

Voluntary, cooperative, approaches to restoration are preferred, but those who

willfully, or through neglect, damage habitat should be held accountable for restoration. In-stream restoration would generally not be successful if upland processes and functions are not maintained, or restored to levels that support the restoration effort. Restoration activities are generally more successful when land use is stable over time. Projects initiated on lands with low-intensity, cyclical land uses/disturbances (forest, large lot rural residential, or agricultural lands) would usually be more successful than those initiated on high-intensity, high-density urban or suburban lands. Past degradation of salmonid habitat often occurred in response to societal values at the time. Therefore, restoration of salmonid habitat on privately owned lands is likely to be more readily accepted and implemented if the cost of restoration includes some level of public financing, if restoration provides flexibility to the landowner, and if restoration addresses, at least in part, relief from regulatory processes.

Successful restoration requires competent analysis of watershed processes and identification of limiting factors. Funding for restoration activities is limited; funding is enhanced where partnerships exist, where there is local support, where restoration is included in a larger project context (i.e., flood damage reduction plan, water storage, and release strategies), and where restoration is part of a completed overall land use and/or watershed plan. Restoration is more likely where dedicated fund sources are sufficient and stable. Restoration of wild salmonid habitat usually contributes to improved wildlife habitat and other societal benefits, such as aquifer recharge for drinking water, flood damage reduction, improvement of soil fertility, and maintenance of rural economies. Restoration projects are facilitated by regulatory processes (permits) which are coordinated, timely, consistent and affordable. Active participation in, or support of, watershed restoration fosters an environmental ethic, improved land stewardship, and support for habitat protection. Restoration is most successful when contemporary technical information and guidance is available to the public.

3.27 Proposed Goal for Habitat Restoration

Restore usable wild salmonid habitat to levels of natural variability for watershed processes and habitats.

3.28 Proposed Performance Measures for Restoration

Restoration of salmonid habitat would be long-term, costly, and contentious. It would

involve a combination of active in-water work, extensive upslope work, and in large part, just providing the opportunity and time for watersheds and marine areas to mend themselves. Many of the performance measures and action strategies in the preceding components include reference to restoration of the physical processes and habitat types necessary for salmonids, and they will not be repeated here.

Full habitat restoration within watersheds and marine areas would be ultimately achieved when the performance measures for the preceding components (i.e., basin hydrology and in-stream flow, water and sediment quality, and sediment transport, etc.) are met.

See recommended action strategies in Appendix C.

Alternative 4

Alternative 4 would contain performance "standards" and action strategies as in Alternative 2, but would place less emphasis on watershed planning as a primary habitat protection and restoration approach. Individual state agencies would review existing programs and make administrative adjustments as needed to implement the policy, with a clear intent to more adequately enforce existing regulations.

The performance standards would become a default where locally-based plans do not address the issue, or would be waived where the local plan provides equivalent protection given local conditions. For example, this alternative requires a 100' buffer along Type 4 streams as a performance standard to ensure a functional riparian area. If the local plan can demonstrate that, due to local conditions, a narrower buffer or a variable-width buffer would provide the functional characteristics necessary to protect the streams, that standard would apply. Otherwise, the performance standard in the policy would apply as the default regulatory standard.

Alternative 5

Alternative 5 would contain the habitat goals listed in Alternative 3, but would include suggested narrative performance "measures" and optional action strategies within a wild salmonid policy. The actual performance measures, which could include numerical standards, and action strategies, would be developed through a combination of state and local laws and ordinance revisions, and implementation of specific watershed plans. State agencies could develop individual specific implementation plans, with action strategies for their agency operations, that would meet the general WSP goals and performance measures.

Chapter IV IMPACTS TO AFFECTED ENVIRONMENTS: FISH POPULATION MANAGEMENT ELEMENTS

This chapter describes the different impacts caused by each Alternative on the natural environment (animal abundance and diversity, genetic conservation) and the anthropogenic environment (fishery and non-consumptive benefits, and cultural and historic preservation). It builds upon information described earlier.

As people begin to implement a Wild Salmonid Policy, new and innovative solutions tailored to the local conditions will emerge that could substantially reduce any impacts.

> There can be little doubt, however, that the salmon fishery lobbyists are currently winning the battle against the spawning-escapement protectors. A team of fishery scientists formed by the Pacific Fishery Management Council concluded that 40% more chinook salmon and coho salmon were needed to meet spawning-escapement requirements, under existing habitat conditions, for the combined areas of California, Oregon, and Washington (PFMC 1978:39).
>
> Wright (1981, p.38) cited in National Research Council (1996).

Impacts and Benefits of Alternative 1 (Status Quo)

1.1 Animal Abundance and Diversity

Stocks of salmonids are disappearing under the current approaches described earlier. Early European visitors remarked about the magnificent runs of salmon that seemed inexhaustible. Salmon and steelhead inhabited every accessible body of water in Washington State in numbers that are difficult to believe today. Estimates suggest that salmon returns to the Columbia River alone numbered 11-14 million fish, considerably more than the total run for the entire state in recent years. Many of these same stocks of fish are still present today, but in much lower numbers. Much of the richness and diversity of those early salmon stocks has also been lost. We will never know how many different populations and stocks of fish existed, but it is clear that many are now extinct and will never return. As we consider the current salmon resource, it is very important to remember the resource that once existed, so we clearly understand the risk of not protecting wild stocks in the future.

Anadromous Salmonids - The Washington Salmon and Steelhead Stock Inventory (SASSI) (WDF et al.1993) identified 435 separate salmon and steelhead stocks (see Tables IV-1 and IV-2). The SASSI inventory classified each existing stock into one of four categories based primarily on trends in survival and population size: Healthy, Depressed, Critical, and Unknown. Healthy stocks are experiencing stable escapement, survival, and production levels, and do not display a pattern of chronically low numbers. Depressed stocks are experiencing difficulties that result in lower than expected numbers of returning fish. Depressed stocks met one of several negative performance criteria such as chronically low numbers, a long term declining trend, or a sudden sharp drop in numbers, but are above the level where permanent damage to the stock has occurred. Critical stocks have declined to a level where there is a significant risk of loss of within-stock diversity or extinction. Data are lacking to make a judgement about the Unknown stocks. It is likely that they will fall in all categories. Note: In retrospect, we now realize that use of the descriptive word “Healthy” was a poor choice. It implies to a reader that habitat

Table IV-1. Regional and statewide salmon and steelhead stocks.

	Chinook	Chum	Coho	Pink	Sockeye	Steelhead
PUGET SOUND						
North Puget Sound	15	12	14	7	1	22
South Puget Sound	10	23	11	2	3	13
Hood Canal	1	12	9	3	-	11
Strait of Juan de Fuca	3	8	12	3	-	14
Totals	29	55	46	15	4	60
COASTAL						
North Coast	21	6	18	-	3	24
Grays Harbor	9	2	7	-	-	10
Willapa Bay	2	6	1	-	-	6
Totals	32	14	26	-	3	40
COLUMBIA RIVER						
Lower Columbia	17	3	18	-	-	23
Upper Columbia	30	-	-	-	2	18
Totals	47	3	18	-	2	41
STATEWIDE TOTALS	108	72	90	15	9	141
435 TOTAL STOCKS						

Table IV-2. Summary of salmon and steelhead stock status by species.

	% of stocks			
	Healthy	Depressed	Critical	Unknown
Chinook	50.0	32.4	4.6	13.0
Coho	41.1	37.8	1.1	20.0
Chum	67.6	4.2	2.8	25.4
Pink	60.0	13.3	13.3	13.3
Sockeye	33.3	44.4	11.1	11.1
Steelhead	25.5	31.2	0.7	42.6

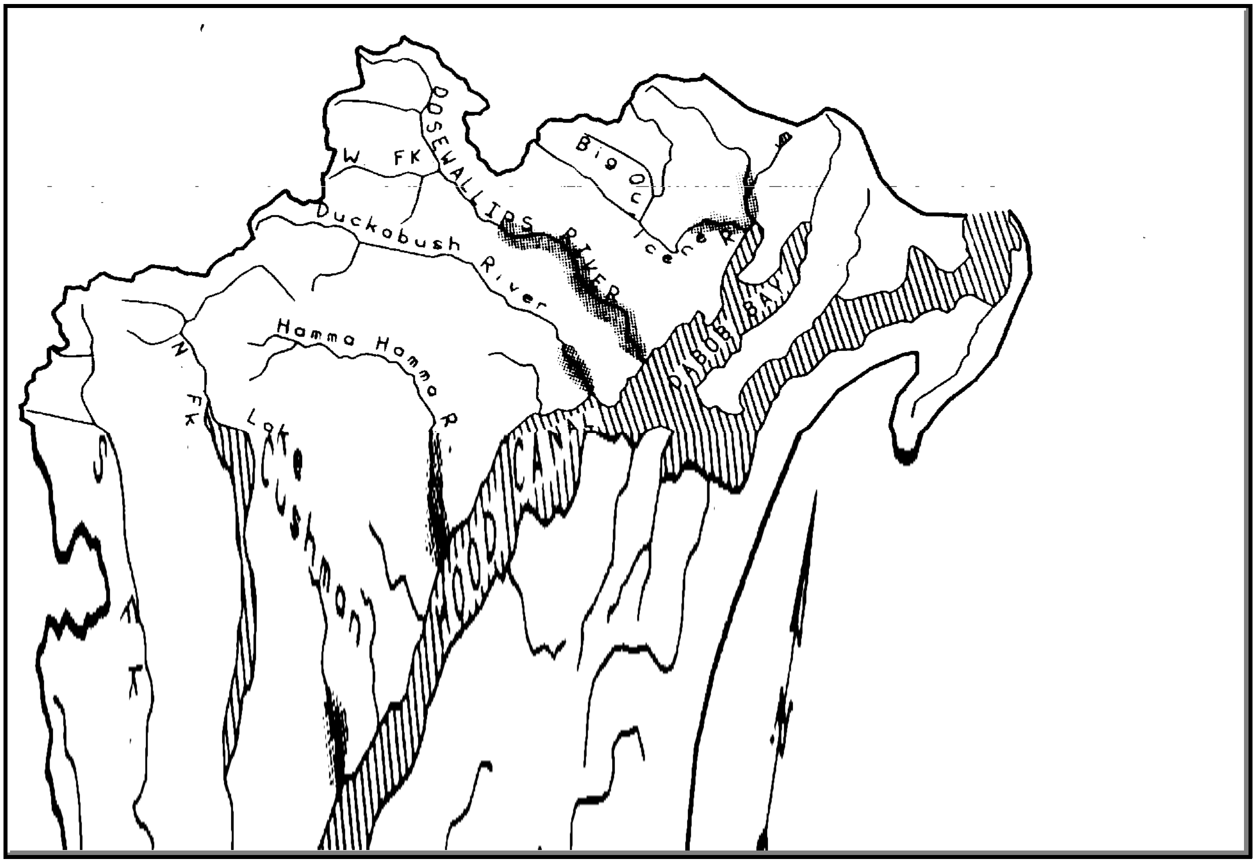

Figure IV-1. Chinook spawner distribution in Hood Canal.

supporting each stock is also healthy. This was definitely not the intention. In addition, the identification of separate populations was sometimes done inconsistently between salmon and steelhead and between salmon species within the same geographic area. For example, all of the chinook populations from independent drainages to Hood Canal (Figure IV-1) were grouped together and called a single "stock." As such, it was classified as "Healthy" despite the fact that total estimated annual chinook runs to individual Hood Canal rivers have been as small as ten fish in recent years.

Of the total of 435 wild salmon and steelhead stocks; 187 (43%) were rated as Healthy, 122 (28%) were rated as Depressed, 12 (3%) were rated as Critical, and 113 (26%) were rated as Unknown. One stock identified at the beginning of the inventory was later determined to be extinct. Of the stocks of known status, 58% were rated as Healthy, 38% were rated as Depressed, and 4% were rated as Critical.

In order to put the above number in a meaningful context, it is instructive to cite comparable percentages for a recent assessment of salmon and steelhead in southeastern Alaska. Baker et al. (1996, p. 6) state as follows:

> "We evaluated risk of extinction of spawning aggregates using criteria similar to surveys outside Alaska. We rated 918 (99%) at no or low risk, 8 (~ 1%) at moderate risk, and 2 (<1%) at high risk."

Regarding Washington chinook stocks; 50% are rated as Healthy, 32% as Depressed, 5% as Critical, and 13% as Unknown. The Healthy chinook stocks are distributed throughout the state, with the strongest showing on the Coast and in the Lower Columbia River. A majority of the Depressed stocks are found in the Upper Columbia River. The five Critical stocks are all spring or spring/summer type fish with four in Puget Sound and one in the Upper Columbia River.

Among Washington coho stocks, 41% are rated Healthy, 38% Depressed, 1% Critical, and 20% Unknown. The Healthy stocks are found in Puget Sound and the Coast, while the majority of the Depressed stocks were found in the Lower Columbia River and Puget Sound. The one Critical stock occurs in the Strait of Juan de Fuca.

Chum have the highest percentage of Healthy stocks, with 68%. Of the three Depressed stocks, one is located in Puget Sound and two in the Lower Columbia. The two Critical stocks are summer chum returning to Hood Canal and the Strait of Juan de Fuca. The overall abundance of chum salmon has increased over the last ten years.

Pink salmon have the second highest percentage of Healthy stocks, with 60%. The two (13%) Depressed and two (13%) Critical stocks are located in Hood Canal and the Strait of Juan de Fuca.

Depressed is the most common status (44%) for sockeye salmon. These are found in Lake Washington and Lake Ozette. Healthy stocks make up 33% of the total including one stock from the Coast and two from the Upper Columbia River. The one Critical stock is identified from the Skagit River system, though this has shown some improvement recently.

Steelhead have the lowest percentage of Healthy stocks (26%), and the largest percentage of Unknown stocks (43%). The steelhead stocks in the inventory include a number of small populations for which data are not readily available. Only one steelhead stock is identified as Critical (<1%). Depressed stocks make up 31% of the total.

Other recent reviews of the status of Washington salmon and steelhead stocks include Huntington et al. (1994) and Nehlsen et al. (1991). The former concentrated on identifying healthy native populations. They identified a total of 74 healthy and 23 marginally healthy native stocks of salmon and steelhead. Chum and steelhead accounted for 62% of these. Nehlsen et al. (1991) identified 26 salmon or steelhead stocks from Puget Sound and the Washington Coast that were at high risk of extinction, 8 at moderate risk, and 7 of special concern.

From a broader regional perspective (Washington, Oregon, Idaho and California), Nehlsen et al. (1991) identified 214 populations that were at one of three levels of endangerment: high risk of extinction, moderate risk of extinction, or special concern. These authors also determined that at least 106 stocks had already been extirpated.

Resident Salmonids - Like salmon and steelhead, there has been a general loss of resident populations over time. The Washington Department of Wildlife (WDW) evaluated the status of bull trout and Dolly Varden in 1992 (Mongillo 1993). The statewide status of other wild resident salmonids, although known for some local populations, has not been systematically evaluated. We can only speculate on the current status of most species.

The 1992 evaluation estimated that a minimum of 77 distinct bull trout/Dolly Varden populations still remain in Washington. Nine (12%) were rated at high risk of extinction, six (8%) were rated at moderate risk of extinction, 14 (18%) were rated at low risk of extinction, and six (8%) were rated at no immediate risk of extinction. There were insufficient data to assign a level of risk to 42 (54%) populations. Based on recent data, the status of some populations has improved since the 1992 status report was published (C. Kraemer, WDFW, personal communication). Habitat destruction, poaching, over-harvest, and the presence of non-indigenous fish species have adversely impacted bull trout and Dolly Varden. Increases in water temperature as the result of land use practices may be a significant contributor to the decline of bull trout and Dolly Varden. Interbreeding between resident populations of eastern brook (a non-native species) and bull trout can lead to elimination of bull trout (Markle 1992).

Resident coastal and westslope cutthroat trout are considered to be moderately healthy. Environmental alterations, over-harvest, introduction of eastern brook trout, and hybridization with non-native cutthroat strains and rainbow trout have caused a decline from historic abundance. The range of westslope cutthroat in Washington has increased substantially (although artificially) as the result of introductions into previously barren alpine lakes.

The status of searun cutthroat populations is less clear. Coastal populations appear healthy. Populations in Hood Canal are depressed and there is concern about southern Puget Sound populations. A conservative management approach is used with Lower Columbia River stocks because their status is unknown.

Wild rainbow trout, like cutthroat, can be characterized as moderately healthy. Historic abundance of wild rainbow has been reduced as the result of habitat destruction, hybridization with cutthroat trout and exotic strains of rainbow, introduction of a variety of exotic non-salmonid species, and over-harvest.

Kokanee populations are generally healthy, although the indigenous Lake Sammamish and Lake Washington populations are critically low. The range of kokanee has been greatly expanded as the result of hatchery introductions. There are currently about 40 wild populations and 40 hatchery maintained populations. Habitat destruction has caused kokanee population declines in localized areas, while construction of reservoirs has increased available habitat suitable for kokanee in others.

Mountain whitefish populations are healthy, although habitat alteration and introduction of non-native species has probably had a negative impact. In terms of weight, mountain whitefish are the most abundant species in several central Washington streams and may be increasing in numbers. Western Washington populations are stable.

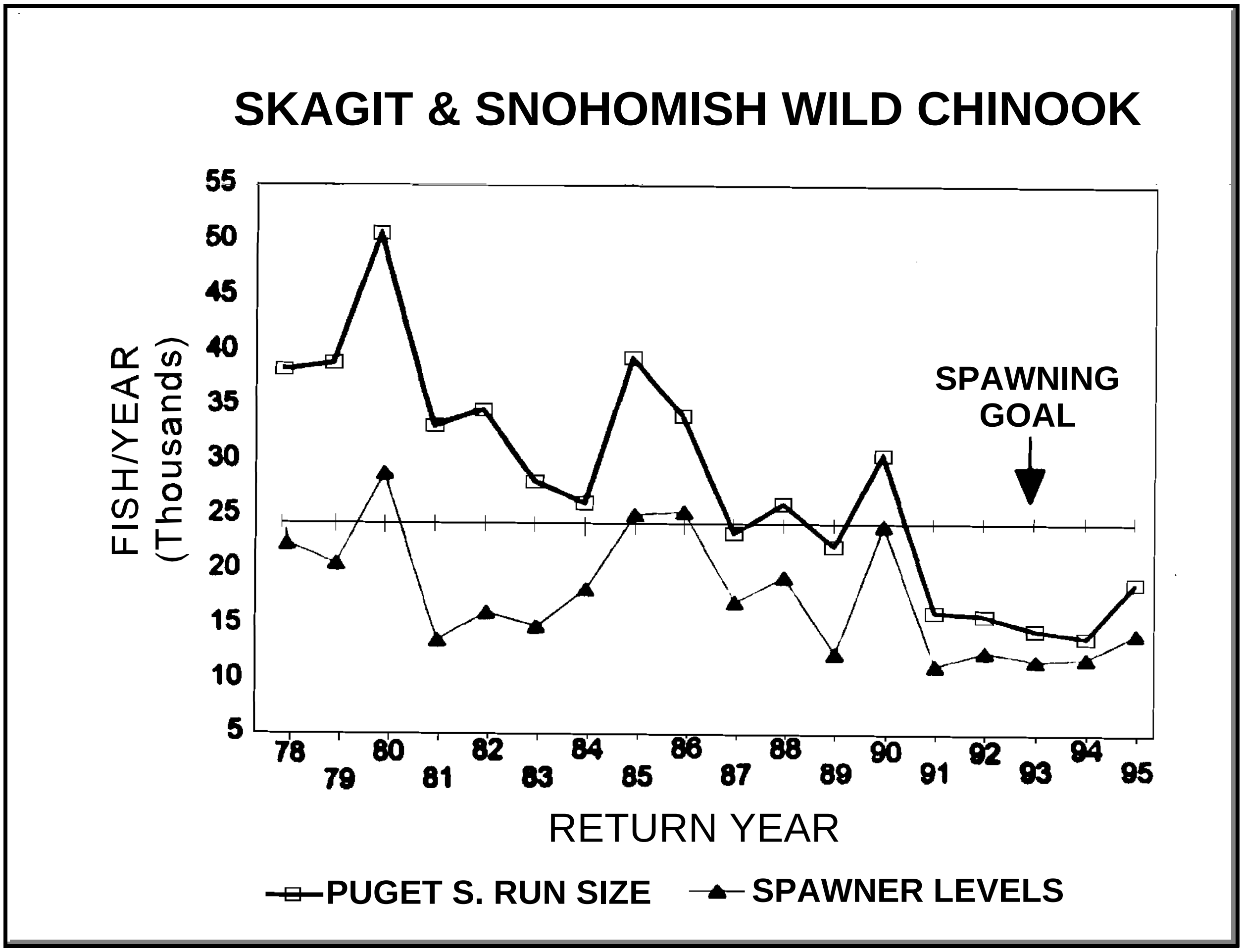

Figure IV-2.

Several pygmy whitefish populations are extinct, while the status of others is unknown. One of the most abundant wild resident salmonids in the state is the non-indigenous eastern brook trout. Eastern brook trout have displaced cutthroat and bull trout in a number of areas. They have the ability to out-compete cutthroat, and the capacity to reproduce in habitat that has become marginal for cutthroat and rainbow trout.

The other non-native resident salmonids generally have limited reproductive success. Exceptions are lake whitefish which are found in Lake Roosevelt and the mainstem Columbia River downstream to the Tri-Cities, and lake trout which are successfully reproducing in a number of waters including Eightmile Lake, Loon Lake, and Isabel Lake.

The outlook for escapements and stock size under Alternative 1 is very specific to species and region:

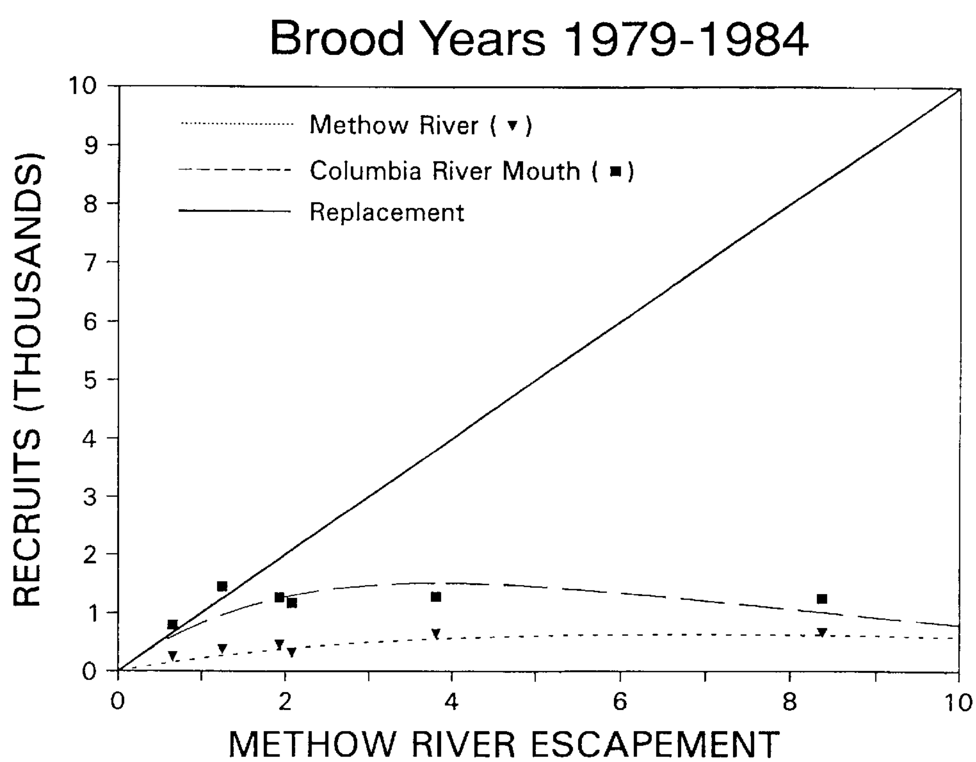

Figure IV-3. Methow River steelhead.

A. The majority (greater than 90%) of stream resident fishes should continue to meet the goal of a majority of the females spawning at least once. Future populations should not be limited by spawning population levels. One possible exception is bull trout.

B. Steelhead stocks that are meeting escapement goals should not be spawning limited. However, future success in meeting these objectives will continue to depend upon the independent and unconstrained discretion of individuals managing each resource. To the extent that these policies mirror the intent described in the Alternative 3 spawning escapement policy, the resources would prosper.

C. Salmon stocks, such as many of our Puget Sound pink and chum salmon populations that are consistently meeting escapement goals, should continue to do well. Again, this will depend mainly on the policies of individuals.

D. Those “Primary” stocks that are currently being overfished likely will continue to decline unless different harvest regimes are adopted (Figure IV-2 example).

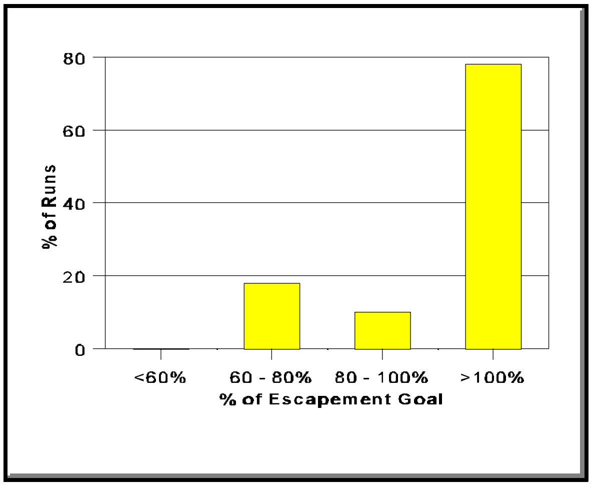

Figure IV-4. Recent year distribution of Puget Sound chum runs relative to escapement goals.

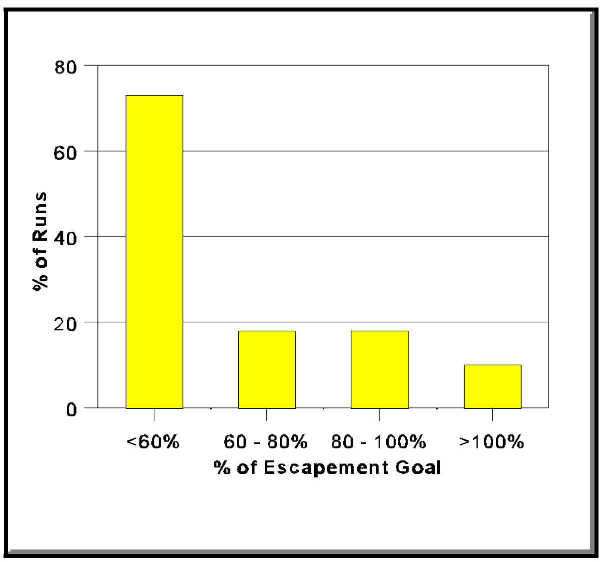

Figure IV-5. Recent year distribution of Puget Sound coho runs relative to escapement goals.

E. Those stocks that are currently unable to replace themselves due to habitat constraints (mainly salmon and steelhead in the upper Columbia River basin) will require supplementation with hatchery fish. Harvest controls alone cannot address their plight (Figure IV-3 example).

F. The 89 "Secondary" populations listed in Table II-1 of Chapter II will continue to be driven toward extinction. Most have now been seriously overfished for about 20 years. They will eventually share the genetic extinction fate of wild Columbia River coho populations which have been similarly overexploited for 35 years.

Figures IV-4 and IV-5 show the recent average escapement levels of Puget Sound chum and coho runs by categories of greater than the escapement goal, 80-100% of the escapement goal, 60-80% of the escapement goal, and less than 60% the escapement goal. These data show that chum runs are typically above goal, but most coho runs are well below goal, in fact well below healthy levels. Worse yet, many of the coho spawners are actually hatchery fish that did not return to the hatchery and are spawning in the wild.

Table IV-3 shows the percentage of salmon and steelhead stocks in various categories of stock origin and production type. This information is based on the SASSI inventory (WDF et al. 1993). Origin has to do with whether the stocks are native. Non-native stocks include stocks from within and outside Washington. Mixed origin stocks are an intermediate group resulting from significant mixing of native and non-native fish. Production type describes the predominant source of the production: wild; composite which is a mixture of hatchery and wild; cultured (= hatchery); and unknown.

Table IV-3. Percent of total stocks by stock origin and production type for Washington salmon and steelhead stocks (WDF et al. 1993).

	Chinook	Coho	Chum	Pink	Sockeye	Steelhead	Total
Origin							
Native	57	17	71	93	56	80	318
Non-native	6	3	3		11	3	26
Mixed	31	77	19	7	11	13	158
Unknown	6	3	7		22	4	42
Production Type							
Wild	57	39	71	100	89	93	449
Composite	41	61	22			7	131
Cultured	2		3		11		16
Unknown			4				4

Currently less than 40% of the state's coho stocks are composed primarily of wild fish. Over 60% are composites of hatchery and wild production. Even with the spawning of hatchery fish in the wild the coho escapements look poor. Under several of the proposed alternatives hatchery fish spawning in the wildwould not be counted as part of the escapement of wild fish, so the escapement picture would look even worse. Other species show a varied pattern. Less than 60% of the chinook stocks are composed primarily of wild fish, but 71% of the chum, 100% of the pink stocks, 89% of the sockeye stocks, and 94% of the steelhead stocks are primarily composed of wild spawners. In the case of resident fish we would expect that most stream dwelling fish are wild. Lakes have wild fish only or wild/hatchery mixtures of populations, but many lakes with hatchery production in them do not support natural spawning, so this is not an issue.

1.2 Genetic Diversity and Local Adaptation

If we continue the current approaches described in Alternative 1, then there will be a continued loss of genetic diversity and local adaptation due to small population sizes, gene flow, fisheries selectivity, and habitat loss and fragmentation. Exotic introductions are currently limited.

Stock transfers under current approaches may be a concern in some cases. The use of North Puget Sound coho stocks in the South Sound Net Pen complex, and the limited number of rainbow trout broodstocks used around the state are just two examples. There is significant gene flow between hatchery and wild spawners in many areas, particularly with salmon stocks. Gene flow is a concern for Nooksack, Lake Washington, Green River, Puyallup, and some of the South Sound coho stocks under the current approaches. This is also likely to be a problem for some Grays Harbor coho stocks, and coho stocks in Willapa Bay and the Lower Columbia River. This is certainly a concern for many chinook stocks in Puget Sound, as well as in Willapa Bay and the Columbia River. Finally, this may be a concern for the large number of off-station planting programs, particularly those using fry releases and remote-site-incubators. High levels of gene flow mean that many of our wild stocks may not be achieving their full reproductive potential and may be depressed below desirable levels.

Table IV-3 is a summary that gives an indication of the stock origin of our salmon and steelhead stocks statewide. Over 90% of our pink salmon stocks are considered native stocks; steelhead are at 80%, chum at 71%, chinook at 57% native and sockeye are at 56% (primarily because of the importation of sockeye stocks into the Lake Washington system many years ago). Only 17% of the coho stocks in Washington State are still considered native due to the high levels of gene flow that have occurred. The pattern for resident stocks is less well known. A number of exotic rainbow and cutthroat broodstocks have been used in Washington, and many areas of the state were extensively planted in the past. In recent years, the level of planting in streams has decreased dramatically, but there is a good chance that significant gene flow occurred in the past. In lakes there continues to be a concern, since many continue to be regularly planted. The other resident species have had less opportunity for non-natural gene flow. The possible exception is bull trout/Dolly Varden where there has been some interbreeding with eastern brook trout.

The current approaches to harvest management are also at least partly responsible for the decline of individual fish size in many salmon stocks. Recent work has documented a 10% to 25% decline in coho weight over the last 35 years in Washington. This reduces the value of the fish for both recreational and commercial purposes. However, the most important impact may be that these smaller coho contain fewer eggs. There has been a loss of nearly 1,000 eggs per female (approximately 40%) since 1960. This is a major reduction in productivity. It now takes nearly 1,700 females to lay as many eggs as 1,000 females did just 35 years ago. These 700 fish are not available to provide benefits to catches and they are not available to put extra eggs in the gravel to increase the population size. Also, since they are so much smaller, they do not provide as much of the needed ecological benefits. The smaller fish may not be able to spawn in some promising places, cannot bury their eggs as deep to escape scouring floods, and cannot defend their nests as well. Declines in both age and size, due in part to fishing, have also been identified for chinook.

The current approaches for salmonid management described in Alternative 1 create significant risks to the long-term health of salmonid populations.

1.3 Harvest Opportunity

Resident Fishes - Opportunities for harvest over the foreseeable future should continue near current levels if habitat loss is prevented. Some currently depressed bull trout and Dolly Varden stocks should recover over the next 25 years due to the more restrictive fishing patterns of the last few years. This and increased use of selective fishing strategies may open the possibility of some expanded opportunity. Likewise, improved opportunity will occur if some of the many bull trout stocks of unknown status are determined to be healthy enough to support some level of fishing opportunity. However, since many bull trout and Dolly Varden are susceptible to habitat damage, other populations will continue to be at risk of extinction and few opportunities will be available.

Most of the current resident fish catch comes from releases of hatchery fish into lakes and reservoirs. This would continue.

Salmon and Steelhead - Fishery managers have reduced allowable harvest levels for salmon and steelhead in recent years in response to declining stock abundance. Mixed-stock fisheries for salmon, especially in the ocean and Strait of Juan de Fuca, have been reduced dramatically or closed. Recreational and commercial harvest in the Columbia River for salmon has also been cut back significantly. Continued losses of opportunity for steelhead will result from losses of habitat productivity and capacity. Healthy steelhead stocks should continue to provide reasonable levels of utilization, provided the habitat base remains intact.

Without major changes in the current human actions that impact salmonids, it is reasonable to expect more reductions in harvest opportunity, including elimination of some existing fisheries. Recent creative changes such as selective fishing can at least partially offset the decrease in fishing opportunity.

Salmon stocks that are managed for wild fish and are meeting escapement goals should continue to support harvest near current levels if habitat loss is prevented. The pattern of harvest may change with more harvest occurring in terminal areas and different harvesting gears being used. Most pink and chum stocks, along with a limited number of chinook and coho stocks, will continue to provide harvest benefits.

For chinook and coho, current harvest levels are probably not sustainable. The low coho escapements seen in Figure IV-5 are a reflection of a general pattern of harvest rates that cannot be sustainable in the long run. The low stock sizes under the current approaches will be productive (on a per fish basis) due to the lack of competition etc., but they may also be more sensitive to environmental variation since they have less capacity to weather poor years and recover in the good years. There will also be more weak stocks needing protection that may limit mixed-stock fishing. Other concerns are that the high levels of gene flow may contribute to long term declines in stock productivity and harvest. Even if we have sufficient escapements, we should expect to see a decline in harvests due to habitat losses. Harvest rates will need to be reduced just to maintain the current escapement levels. The outlook for Puget Sound coho and chinook along with Willapa Bay and many Columbia River stocks is a decidedly poor situation. The outlook for hatchery contributions is one of declining survival rates and the sustainability of the wild runs is a concern.

1.4 Other Impacts and Benefits

Compared to Alternatives 2 and 3, status quo provides the least benefits to non-consumptive, ecological, and cultural values. It produces the lowest population sizes of wild fish to contribute to nutrient cycling, food supply, and maintenance of ecological systems. Fewer fish are available to use the habitat and provide fish viewing and educational programs. Fewer fish can also mean a greater sensitivity to competition and predation. The problem with steelhead and sea lions at the Ballard Locks in Seattle is a function of a depressed run due to habitat declines, fishing pressure, and other productivity issues, combined with a situation where human changes have made an increased number of predators very effective. A new nutrient enhancement program using hatchery carcasses to enrich the natural environment will increase the freshwater ecological benefits of the current approach.

1.5 Historical and Cultural Preservation

Treaty Indian harvests and the other historical and cultural aspects are at risk under Alternative 1. Salmon are a central element of tribal culture, woven throughout tribal economies and social and religious values.

Many coastal communities, small businesses and families have a historic and cultural reliance on salmonids. Many small businesses dependent on the fishing industry are gone or struggling; commercial fishers, marinas, ports, boat builders, fish buyers, charter offices, motels, resorts, bait shops, etc. Coastal communities like Sekiu, Neah Bay, Westport, LaPush, Ilwaco and others are being forced to adapt.

The opportunities provided by recreational fishing trips to pass natural resource opportunities and values from one generation to another are declining.

Impacts and Benefits of Alternative 2

2.1 Animal Abundance and Diversity

Alternative 2 would provide the highest levels of spawning stock abundance of any of the alternatives if fully implemented (Figure IV-6). Competition from exotic species would be avoided, as would competition and predation from hatchery salmonids. We would expect to see large increases in the spawner abundance of wild stocks of chinook, coho, steelhead, and some of the resident species. Puget Sound coho escapements could increase by two to four times the current average of 211,000 fish per year depending on the level of catches of Puget Sound coho in Canada, Alaska, and other non-Washington fisheries. Similar percentage increases might be expected in other wild coho populations around the state, as well as in many chinook and steelhead populations.

Increases in other species, that tend to be meeting current escapement goals and have lower harvest rates, would be expected as well, though perhaps not to the same degree. Chum and pink populations would be expected to increase. Increases in resident species would vary. Some relatively protected stream populations would not increase greatly. Other stream populations and some lake and reservoir systems may see larger increases.

Stock abundances would likely be more stable, because the populations should be more robust

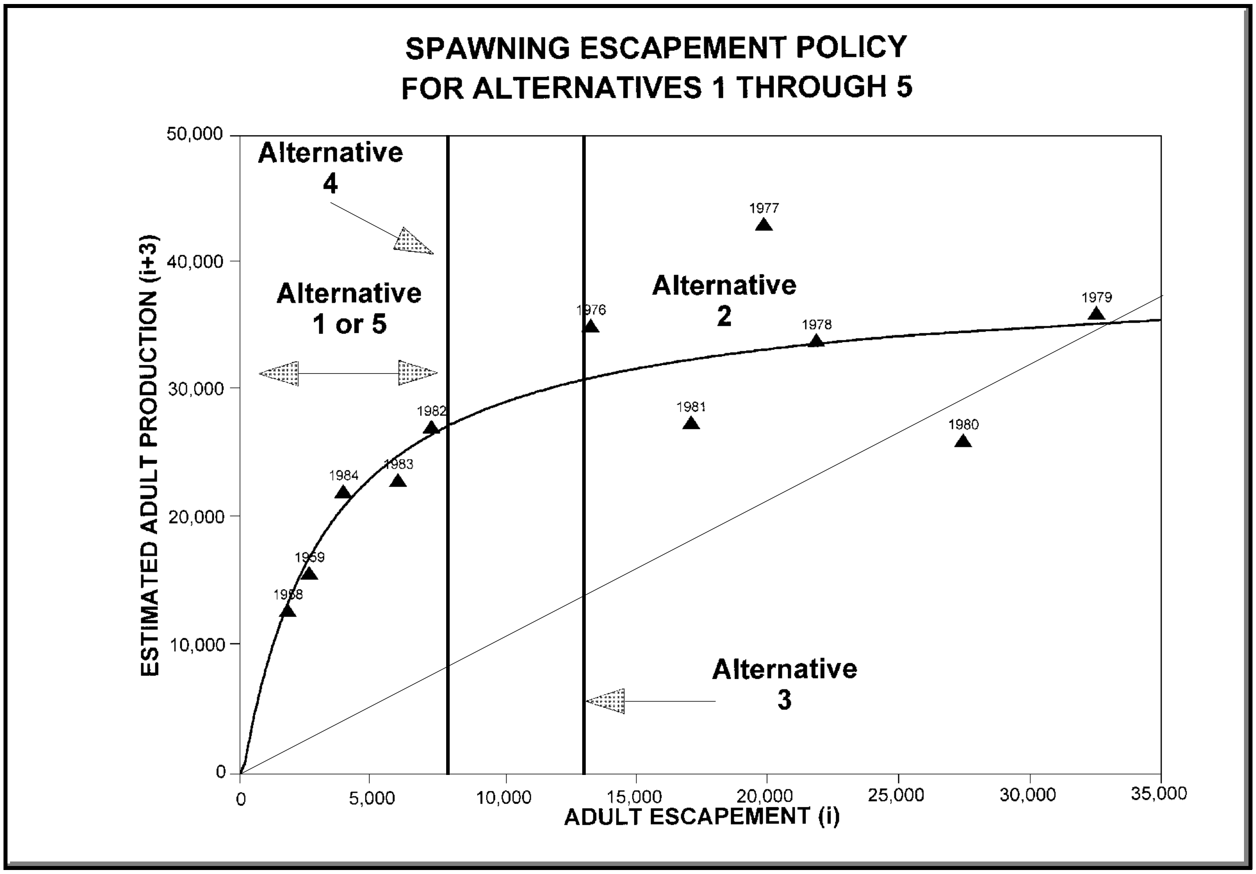

Figure IV-6.

and resilient in the face of a fluctuating environment.

2.2 Genetic Diversity and Local Adaptation

Alternative 2 also provides a very aggressive and prescriptive approach to protect genetic diversity and allow development of locally adapted stocks. Stocks would be maintained at the highest levels possible. This would increase competition on the spawning grounds which would provide a broader distribution of the spawners and more likelihood of developing local adaptations. Stocks would be far above their minimum population levels so that diversity within stocks would be maintained. Stocks would be much less likely to disappear, and this would improve overall genetic diversity for the species. There would also be better inter-connections for all of the units of the larger metapopulations, which would allow those habitats where stocks are lost to recover more quickly. Artificial gene flow would be greatly reduced over current approaches. No direct transfer of fish across stock or other boundaries would be allowed. This would reduce the movement and transfers of fish. Implementation of this alternative would create the need for a series of new broodstocks for steelhead and resident fishes. Steelhead and resident fishes are often transferred long distances, which would not be allowed where it could impact wild salmonid populations. It would have the least impact on pink, chum, and sockeye, and intermediate impact on chinook and coho in most areas. Gene flow between hatchery and wild fish would also be greatly reduced. This would require the development of new broodstocks and other programs to control the spawning of hatchery fish in the wild. This would require significant investments in facilities and man-power.

2.3 Harvest Opportunity

This alternative provides the lowest level of harvest opportunity of any of the proposed alternatives. As we described in Appendix C, full spawning habitat utilization requires no harvest mortality for many salmonid species. Only a 5% incidental harvest opportunity would be provided for wild coho, steelhead, chinook and most resident species in order to allow the harvest of hatchery fish. This would mandate only limited wild fish catch-and-release for all hook-and-line fisheries and very strict time and area restrictions on other fisheries. It would also require the development of very different gears and fishing locations to take advantage of returning hatchery fish. Hatchery production would be significantly reduced to comply with genetic conservation and ecological interaction limitations. Mixed-stock fisheries and non-selective fisheries would be very limited or non-existent under this alternative.

Resident fish - Under Alternative 2 we would expect all sport fisheries that catch resident wild salmonids to be catch-and-release. Any mortality on wild fish would be incidental. In most areas this would require the use of artificial lures or flies to reduce the handling mortality associated with using bait. As the populations grow, the success and quality of the catch-and-release fishing would go up. This would primarily affect streams and rivers and those lakes and reservoirs with self-sustaining wild populations. Populations that are not self-sustaining would see little impact from this.

Most of the current resident hatchery program is based on hatchery populations that would be rated as having low similarity to wild stocks. As a result, any continuing hatchery programs would require new locally compatible broodstocks. This would likely impact some fishing as these new broodstocks are phased in over time.

The need to avoid any negative impacts on wild salmonids and other indigenous fish and wildlife would likely reduce the number of formerly barren waters that are planted. As a result, some fishing in alpine lakes that require periodic plantings may no longer be supported.

Steelhead - All steelhead fishing under this alternative would be wild fish release, except where complete closure was necessary to avoid release mortalities and maintain the desired spawner levels. All mortality would occur as part of the catch-and-release process. Access to hatchery fish would be affected by this alternative as well. Meeting the genetic conservation criteria would likely require ending the early timed winter steelhead program that has been the main part of the hatchery steelhead program. This would require the development of new broodstocks from local sources and developing new facilities to hatch and rear them. In a few cases, this might not be economically feasible due to cold temperatures or the late timing of the wild fish that make it impossible to raise the young fish to release size in a single year.

Salmon - The Puget Sound coho harvest under this alternative would depend on the level of selective fishing, fishing in Canada and Alaska, success in reducing hatchery fish spawning in the wild and increasing hatchery fish similarity. This would be typical of coho stocks on the Coast and Columbia River and is indicative of harvest on other species.

Fishing opportunity on species such as chum, pink, and sockeye salmon would also go down. Since individual populations may have a different shaped spawner-recruit curve (see Appendix B) some limited harvest may be available on these species, even at full habitat utilization. However, it would consistently require lower harvests and lower harvest rates to achieve the desired spawner abundance level.

<u>2.4 Other Impacts and Benefits</u>

Alternative 2 provides the greatest benefits to non-consumptive and ecological values. Wildlife viewing and the catch-and-release fisheries described above would benefit from larger populations of wild fish. Ecosystem health should be improved by the larger numbers of spawning fish providing food and nutrient sources. Salmonids would not only be more abundant, but likely would be much better distributed across the habitat, so that the benefits are more widespread.

<u>2.5 Historical and Cultural Preservation</u>

Those cultural values that are linked to harvest opportunity, especially for commercial use, would not be well served by Alternative 2. There would be fewer fishermen to carry on traditional occupations for many tribal and non-tribal families.

Businesses and coastal communities dependent on mixed-stock fishery harvests would be negatively affected by Alternative 2.

Impacts and Benefits of Alternative 3

<u>3.1 Animal Abundance and Diversity</u>

Alternative 3 would provide levels of spawning stock abundance that are generally less than Alternative 2 (Figure IV-6). However, for all those salmonid populations limited by juvenile rearing capacity in freshwater ecosystems - chinook, coho, sockeye, steelhead, trout and char - Alternative 3 would, like Alternative 2, yield maximum juvenile fish production from each population.

The primary spawner abundance criterion of abundant utilization of the habitat provides flexibility to meet harvest needs, but still provides a relatively high level of spawners. For example, extra chum salmon could be specifically allowed to spawn in the Skagit River to meet the needs of the local eagle population. In general, more fish would be allocated for spawning as part of a broad effort to meet ecological needs. At these moderately higher levels of spawning, compared to Alternatives 4-5, we would expect overall abundance to be more stable.

There would also be a major improvement in the distribution of the escapements. Many of the current management units are not consistently meeting their escapement goals, and some are well below. Under this alternative every stock within every management unit would be required to meet its escapement goal.

Some resident fish populations would also see an increase in spawner abundance. It is likely that increased size limits would be necessary in certain areas to achieve a lower overall harvest rate.

This alternative also provides managers flexibility to respond to new evidence of broader ecosystem benefits. For example, we know that steelhead and sea-run cutthroat populations are generally depressed in the Lower Columbia and have not responded to recent management initiatives (such as selective fisheries) which have proven to be successful in other areas. We also know that, after 35 years of overfishing, this region has by far the lowest coho salmon spawning escapements in Western Washington. Wright (1993) stated that recent spawning escapements of only one to two fish per kilometer were about what you would expect from the background straying rate of hatchery fish. Finally, we know from Bilby et al. (1996) and others that juvenile steelhead and cutthroat derive significant benefits from spawning coho salmon.

3.2 Genetic Diversity and Local Adaptation

The larger population sizes, better distributions, lower human-caused gene flow, lower fishery selectivity, and greater interconnections between populations would provide improvements in both diversity and local adaptation compared to the status quo (Alternative 1).

The requirement of only counting wild fish as valid spawners coupled with restricted gene flow from less adapted fish would promote local adaptation. Allowing sufficient numbers of spawners with the appropriate timing, distribution, size and other characteristics would optimize the productivity of wild stocks. Increasing local adaptation and productivity of wild stocks would increase the harvestable surplus and decrease the risk of genetic damage.

Alternative 3 describes two cases when hatchery fish are intended to spawn with wild fish and be counted as valid spawners. The first case is designed supplementation programs. These are used primarily where the conditions causing the low population numbers are being corrected so that the population will become self sustaining, thus the supplementation effort eventually becomes unnecessary. An example of such a program is the current recovery effort for summer-run chum in Hood Canal. The second case was a modification to this alternative to consider cases where long-term hatchery programs were designed to produce valid spawners and monitored by empirical demonstrations of reproductive performance (detailed in Chapter II, section 3.2). An example of a proposed hatchery program designed to meet this second case is the Cedar River sockeye project. These two cases were developed to provide a mechanism for hatchery programs, where an objective is for returning adults to spawn with wild fish, to exceed the levels of recommended gene flow (Chapter II, section 3.7).

The genetic criteria are important policy elements that are essential to insuring perpetuation of individual, separate breeding populations (stocks). However, the greatest danger with a small stock size occurs when predation or disease leads to a situation where the highest percent mortality occurs at low

abundances of juvenile or adult salmonids (see Appendix D).

3.3 Harvest Opportunity

The impact of Alternative 3 on harvest opportunity would depend in large part on how flexible and creative we can be in developing new fishing strategies, gears, locations, hatchery release and rearing techniques, and broodstocks. If we are willing to be creative and adapt to some change then any adverse impact to overall harvest opportunity would be negligible.

Resident stocks - Alternative 3 affects harvest opportunity on resident stocks. In stream habitats, it would require lower overall harvest rates that would provide greater opportunity for spawning. Instead of setting up a fishing pattern so a majority of the females spawn once before they reach a size where they are available to the fishery, it would be necessary to follow the specific guidelines outlined in element 3.1 of Alternative 3. There would also be greater use of selective fisheries and catch-and-release fisheries in order to lower harvest rates and increase the numbers of larger fish in the populations. Since the populations would then be more abundant and contain larger fish, the quality of catch-and-release fishing would improve.

Alternative 3 would not have a great impact on lowland lake and reservoir fishing where there is limited spawning area, or that cannot support wild fish. In high (alpine) lakes, ensuring no significant negative impacts to other indigenous species while providing harvest opportunities, would require managing some high lakes as sanctuary or refuge lakes, some as natural production lakes, and some as artificial production lakes. The number and distribution of these different lake types would be identified in the Department's High Lakes Management Plan.

Under Alternative 3, all resident hatchery trout planted in streams would be adipose-marked. In addition, fish planted in lakes and reservoirs with important wild trout populations would also be marked. In both cases, the management option of selective fishing would be provided in order to protect wild fish, both resident and anadromous.

Sea-run cutthroat - This important resource would continue to have the status quo benefit of adipose-marking all hatchery fish in common with steelhead. The selective fishery option would be preserved as needed for wild fish protection.

Steelhead - This alternative would reduce the overall consumptive harvest of wild steelhead due to the need for larger escapements in some streams. This would require greater use of catch-and-release and wild fish release strategies. Due to the larger population sizes, these fisheries would be more effective and attractive than in the past. Other approaches of locating hatchery releases so that they are fished at higher rates or can be captured and removed as adults would continue to be necessary.

The most important mission of Alternative 3 is solution of a fishing rate problem for Pacific salmon. The basic dilemma confronting today's managers is a mixture of hatchery fish, which can typically support overall fishing rates of 90% or more, and wild fish, which must be limited to average fishing rates of 50-

60%. The policy elements described in Alternative 3 are intended to continue and expand all status quo fisheries and techniques for targeting fishing effort on hatchery fish <u>except</u> for the common practice of overfishing wild salmon populations (see Table II-1).

New strategy elements that would lead to the desired end-product of 90% harvest rates on hatchery salmon and 50-60% average harvest rates on wild salmon are as follows:

1. **The selective fishery option would be provided by adipose marking most hatchery salmon. This would parallel the status quo practice with steelhead throughout the Pacific Northwest and British Columbia that was instrumental in preventing overfishing of wild fish from ever being adopted as a basic policy in steelhead management. It is important to remember that selective fishing on either salmon or steelhead is always an alternative to <u>closures</u>, it should not be an alternative to continued regular non-selective fisheries.**

   Conceptually, the ideal situation for selective fishing is to have any relatively inefficient fishery occur "first in line" in terms of fishing on the entire salmonid population. The existing sport and troll salmon fisheries in marine waters off Washington are relatively inefficient as compared to the commercial net fisheries that occur later in time on the same salmon populations. Thus, the make-up of existing fisheries is ideal for salmon since the sport and troll fisheries would be fishing on the entire population of salmon in Washington waters. The existing situation for steelhead is less ideal. The less efficient selective recreational fishery commonly occurs after the more efficient regular treaty Indian net fishery. Nevertheless, it has proved to be workable in actual practice.

2. **While hook-and-line gear and existing commercial gear types such as purse seines, reef nets, and beach seines are adaptable to selective fishing (wild fish release), gill net gear is not. However, it is important to recall that fish managers have flexibility to use a <u>mixture</u> of regular and selective fisheries to yield the desired overall end-result of 90% versus 50-60% average harvest rates. Gill net gear would likely remain a major component of the <u>regular</u> category in the future (both treaty Indian and non-treaty commercial).**

3. **Additional fishing opportunities can be provided to today's gill net fishermen and other user groups by two basic management techniques. First, off-site, pen-reared releases of hatchery salmon allow selectively higher hatchery fish harvests. In mixed-stock harvest areas of Alaska, fishing rates are set for wild stocks; the hatchery surpluses are harvested in carefully controlled sport, troll and net terminal fisheries at the release sites. It is significant to note that deliberate overfishing of wild fish never became a policy element in Alaska salmon management. Programs of this type have already been implemented in**

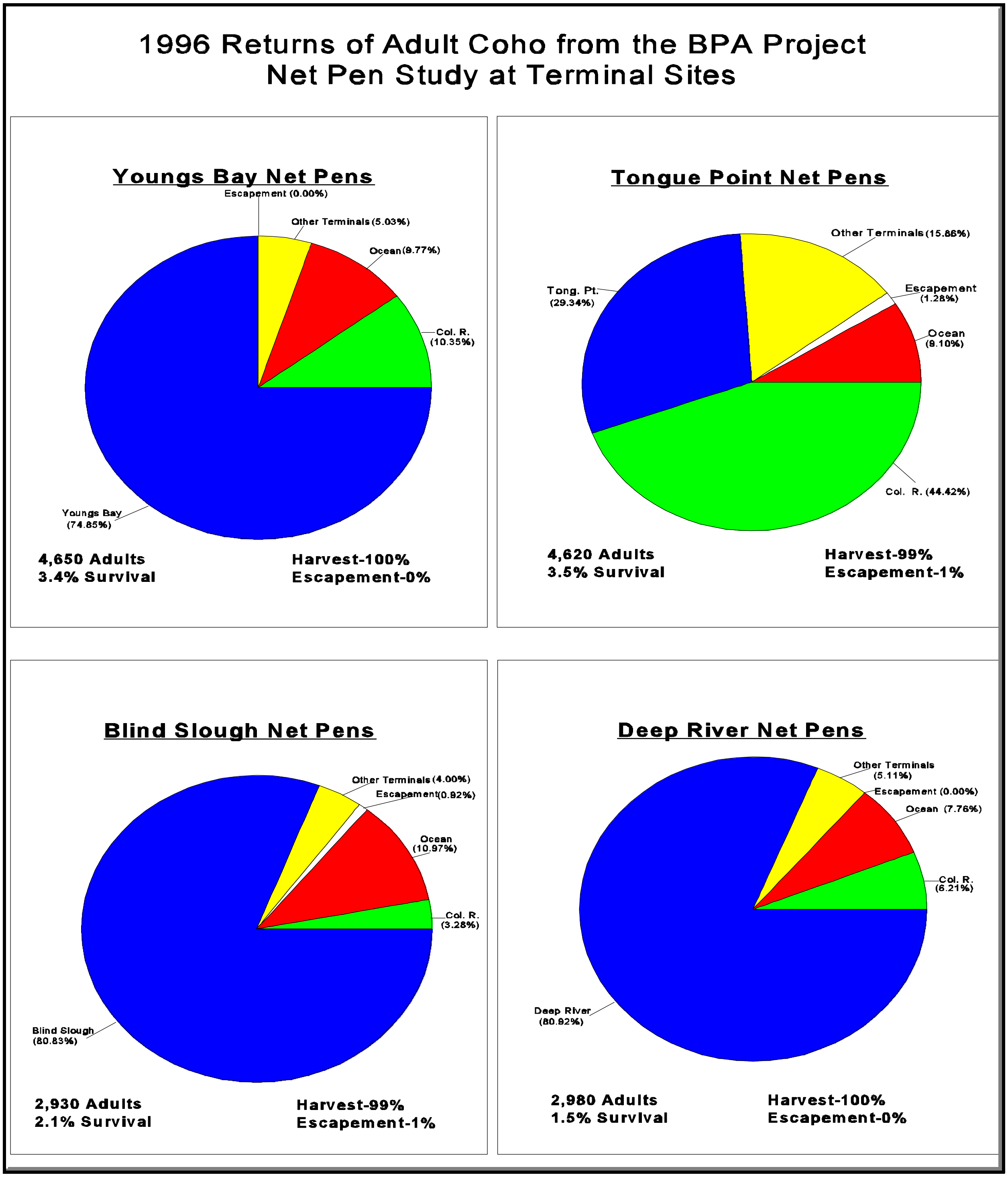
1996 Returns of Adult Coho from the BPA Project
Net Pen Study at Terminal Sites
Youngs Bay Net Pens
Escapement (0.00%)
Other Terminals (5.03%)
Ocean (9.77%)
Col. R. (10.35%)
Youngs Bay (74.85%)
4,650 Adults
3.4% Survival
Harvest-100%
Escapement-0%
Tongue Point Net Pens
Other Terminals (15.86%)
Tong. Pt. (29.34%)
Escapement (1.28%)
Ocean (9.10%)
Col. R. (44.42%)
4,620 Adults
3.5% Survival
Harvest-99%
Escapement-1%
Blind Slough Net Pens
Other Terminals (4.00%)
Escapement (0.92%)
Ocean (10.97%)
Col. R. (3.28%)
Blind Slough (80.83%)
2,930 Adults
2.1% Survival
Harvest-99%
Escapement-1%
Deep River Net Pens
Other Terminals (5.11%)
Escapement (0.00%)
Ocean (7.76%)
Col. R. (6.21%)
Deep River (80.92%)
2,980 Adults
1.5% Survival
Harvest-100%
Escapement-0%

Figure IV-7.

several Washington and Columbia River areas. Recent results for four Columbia River areas are depicted in Figure IV-7.

4. **It is also important to develop new commercial gear capable of selectively harvesting hatchery fish while still safely releasing wild fish. Emphasis should be on types of nets that can be used by existing fishermen with existing small (gill net) boats. Fish traps and fish wheels have been proposed for decades as alternative gear types. However, these proposals have never received any serious consideration since they are correctly viewed as potentially threatening replacements for traditional fisheries. The key for future success is to target fishing gear development work toward experienced fishermen with substantial investments in their boats.**

Wild Salmonid Recovery - Four types of fish population management situations must be addressed under Alternative 3.

1. **A total of 89 Pacific salmon populations are currently being overfished, by design, in hatchery management zones. Most of these "zones" were established in the late 1970s by the Department of Fisheries. To eliminate the practice, adipose fin marking of hatchery fish would be required.**

2. **Salmon and steelhead populations in the upper Columbia River cannot even replace themselves due mainly to the extensive series of dams and reservoirs. This problem can only be resolved by drastically reducing the mortalities caused by dams.**

3. **In the past, some wild runs have been overfished even when the supposed policy was to put adequate numbers of viable wild fish on the spawning grounds. The most damaging recent case history is with wild chinook in Puget Sound. These situations must be corrected.**
4. **There are many case histories of successful past management with the state's salmon, steelhead, sea-run cutthroat, resident trout and char resources. This part of the WDFW track record must be continued into the future.**

To plan for wild stock recovery, each of these above situations would be addressed in turn by element 3.18 of Alternative 3. Wild stock that has a past history of being deliberately overfished (see Table II-1): Each requires an initial assessment.

   a. **If the stock is too small to recover naturally, then temporary artificial production intervention (Figure IV-8, category 3) would be necessary. Control of harvest would be phased in as returning adults become available.**
   b. **If the existing wild population is deemed capable of effectively rebuilding itself, then a planned rebuilding schedule would be developed and implemented.**

Note: both of the above should involve a meaningful public input process.

1. **Wild stock that is not capable of replacing itself (Methow steelhead example, Figure IV-3): Artificial production intervention category 2 would be continued (Figure IV-8).**

WILD SALMONID POPULATIONS AND ARTIFICIAL PRODUCTION INTERVENTION

1. Existing wild salmonid population has demonstrated the capability to replace itself on a sustainable basis.	⇨	Intervention limited to harvest augmentation only. Adipose-fin mark, and no reliance for natural spawning augmentation.
2. Existing wild salmonid population does not presently have a demonstrated ability to replace itself on a sustainable basis.	⇨	Intervenation has the primary objective of providing effective naturally spawning fish. May be adipose-fin marked.
3. Historic wild salmonid population no longer exists <u>OR</u> is too small to recover natually following a fishery management action or habitat capability change.	⇨	Intervention is temporary only for the specific objective of re-establishing natural selection processes. Intended result is a population capable of replacing itself on a sustainable basis.

Figure IV-8.

2. **Former "Primary" wild stock that has still been seriously overfished (Skagit-Snohomish chinook example, Figure IV-2): Incidental catch levels in Washington fisheries would be limited to a total of 10% until the stock is rebuilt.**

3. **Wild stock that has consistently had spawning escapements at or above the point estimate of MSY (Snohomish coho example, Figure II-1): No change. It is not reasonable to make a quantitative prediction for salmonid recovery. Too many assumptions are required. The record of past attempts shows the weaknesses of such attempts.**

For example, at the time of the Northwest Regional Task Force Settlement Plan, the average annual salmon catch in the mid-1970's for Washington State was about 6.6 million fish (WDF 1992). The quantitative assessment was that new production accrued to Washington would total 7.9 million salmon annually for more than a doubling of the catch to a 14.5 million total. In retrospect, we

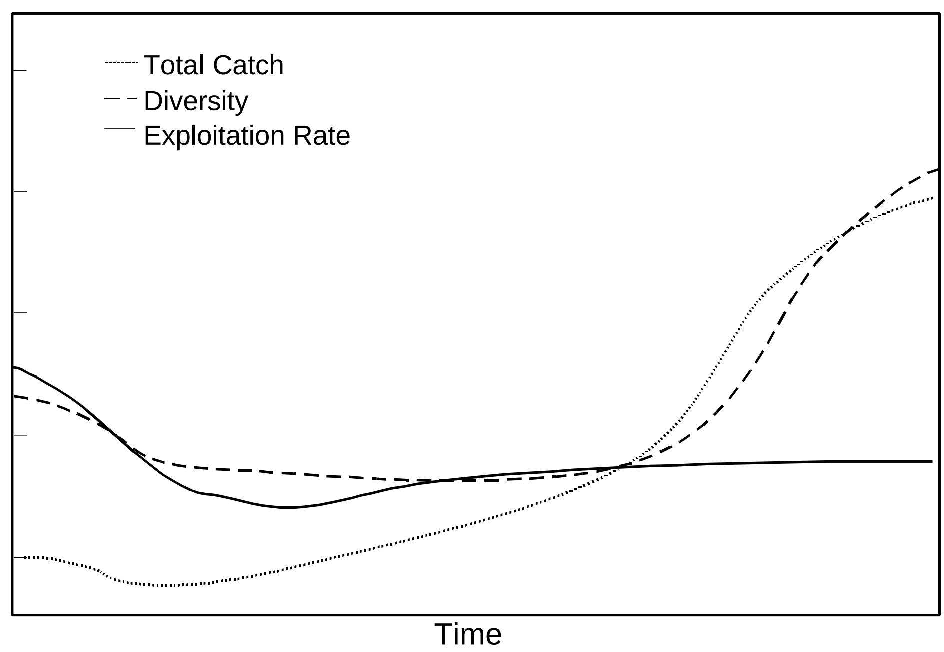

Figure IV-9. Wild salmonid recovery.

knew by 1992 that this program failed to meet its objective of doubling the catch since the base salmon catch level had only changed by about 10% since the mid-1970's (WDF 1992).

In spite of our demonstrated inability to make quantitative predictions for wild salmon recovery, we can at least forecast the expected trends over time for the aggregate of hundreds of separate breeding populations of salmon and steelhead. Of all the various recovery scenarios which we reviewed, the most likely under Alternative 3 appears to be projections made in the recent book entitled " Upstream: Salmon and Society in the Pacific Northwest" (National Research Council 1996). Figure IV-9 is adapted from their expressed opinion. Can salmon actually recover? The only unambiguous case history of wild fish recovery that we are aware of is the recent record of Alaska salmon management under state control (Figure IV-10, adapted from Holmes and Burkett 1996).

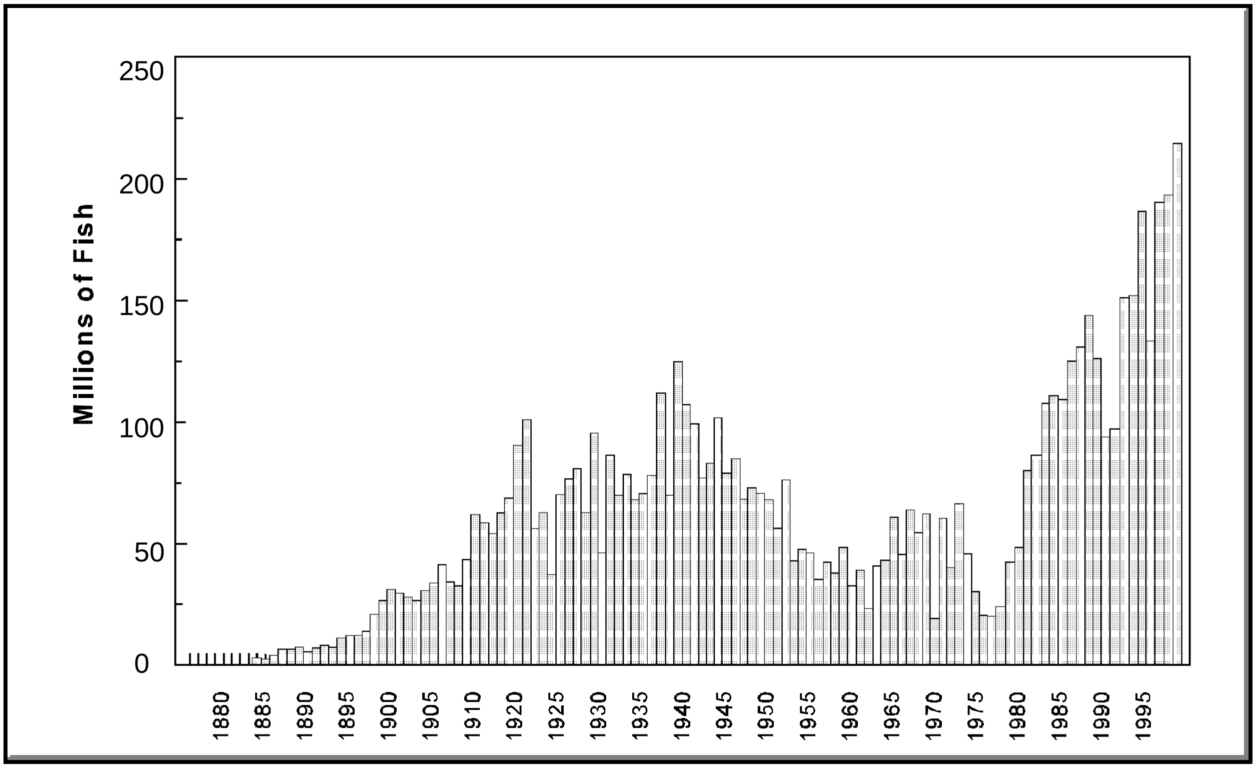

Figure IV-10 Alaska commercial salmon harvest from 1878 to 1994.

3.4 Other Benefits

Alternative 3 would also provide increased benefits to non-consumptive and ecological concerns compared to Alternative 1. The larger populations, better distribution of spawners, and more productive spawning populations would provide better viewing and better opportunity for low consumption uses like catch-and-release fisheries. The larger population sizes would provide more nutrients, larger food supplies, and generally provide greater benefits to ecosystems that contain salmonids. Protecting some ecosystems may require that we stop planting lakes and streams that did not historically contain salmonids, and allow natural ecosystem relationships to redevelop. This would most likely to occur in alpine lakes and waters above anadromous blockages that now have anadromous fish. Protecting key salmonid populations would likely require changes in the use of exotic species, particularly warmwater competitors and predators that have become established in waters that used to contain self-reproducing populations of salmonid fishes. The requirement to have no significant impacts from either hatchery or exotic fisheries programs would require new efforts.

3.5 Historical and Cultural Preservation

This Alternative may require minor changes in the existing non-Indian culture of recreational and commercial use. Communities dependent

on a mixed-stock fishery would benefit from the increased opportunities provided by selective fishing.

Impacts and Benefits of Alternative 4

4.1 Animal Abundance and Diversity

Alternative 4 would seemingly continue to provide healthy stock abundance levels for most Washington salmonid stocks, since most management units, and likely most stocks, would be managed near the MSY level (Figure IV-6). However, in some cases, stocks would actually be managed at less than MSY; perhaps as low as 50% of the MSY escapement level. The ability to combine separate breeding populations into management units provides too much downside flexibility for "hiding" overfishing problems. A second fundamental flaw is the failure to account for management imprecision. If you only try to hit the point estimate of MSY, then 50% of subsequent spawning ground escapements would be inadequate.

This is a lower standard of protection than is currently afforded to most stream resident populations. Most stream populations are managed on a local population or stock basis. It would be poor resource stewardship to manage entire stream systems at this lower level. Where the low standard of protection is applied, there would be some reduction of overall population sizes compared to current levels.

Steelhead are also generally managed with a higher level of protection than is afforded under this alternative. Very few runs are currently managed with the intent of being less than the MSY level. Any application of this approach would result in lower stock abundance for steelhead runs and greater risk to long-term stock survival.

Alternative 4 does provide a higher level of protection than is currently applied to 89 salmon stocks (Table II-1). It would result in significant improvements in stock abundance and stock health for those chinook, coho and chum stocks that are currently managed as secondary management units, but would now be managed for MSY. It would provide increased protection for all populations that are currently escaped below 50% of the MSY level. Figure IV-5 shows that 9 of 14 Puget Sound coho runs average escapements less than 60% of MSY. Overall, this alternative might cause a small reduction in escapements compared to the 1986-91 average, but stocks with the lowest escapements would see marked improvements. The Snohomish and Skagit systems would drop from two-thirds of the total coho escapement to only one-half. This increase in stock abundance would also occur for many Lower Columbia and Willapa Bay chinook and coho stocks, and Puget Sound chinook. This would provide a greater level of protection of stock abundance against environmental variation and other problems.

4.2 Genetic Diversity and Local Adaptation

Alternative 4 would provide improvements over current approaches in the area of genetic diversity. The minimum stock abundance criterion would be useful in this alternative where stocks would be managed at lower levels. The criterion for preventing genetic extinction due to human caused gene flow between stocks, GDUs, and MALs provides greater protection for many species, particularly steelhead and resident fish, than is found under the current approaches. The requirement to respond to areas of high gene flow between hatchery and wild fish to determine if the wild population is at risk is also an improvement for many salmon, steelhead, and resident fish populations. Finally, the requirement to maintain the full range of diversity in the unfished portion of the population would help maintain stock diversity and local adaptation.

4.3 Harvest Opportunity

Alternative 4 provides more downside flexibility for management, bringing the potential for greater short-term utilization opportunities when stocks of different productivities are in the same mixed-stock fisheries. The challenge for managing the 89 stocks in Table II-1 is a willingness to adopt new approaches and strategies that take advantage of harvest opportunities on stronger wild runs and on hatchery runs, while providing the necessary protection to wild fish.

Resident species - Stream resident species would be affected by this alternative. Since most resident stocks are currently managed on a stock-by-stock basis, there could be widespread application of this alternative in both stream or lake resident populations. This would create opportunities for hatchery-based fisheries that could increase harvest opportunities, but at the expense of comingled wild populations.

Steelhead - Most steelhead runs would also be affected by this approach. This approach would provide greater downside flexibility for management in many situations - again at the expense of wild fish.

Salmon - The harvest management aspects of this alternative are similar to management of many current "Primary" salmon runs. With the flexibility to follow individual policies concerning biological and fishery management uncertainties, future managers can be expected to produce the same mixture of case history failures and successes that exists today.

4.4 Other Benefits

This alternative would provide some significant benefits to ecological and non-consumptive uses for Table II-1 populations compared to current approaches.

4.5 Historic and Cultural Preservation

This alternative would require few, if any, changes in the existing non-Indian culture of recreational and commercial use. Communities dependent on mixed-stock fishery benefits would not be affected significantly by this alternative.

Impacts and Benefits of Alternative 5

5.1 Animal Abundance and Diversity

In common with Alternative 1 (status quo), Alternative 5 provides flexibility all the way from a point estimate of MSY to population extinction (Figure IV-6). Alternative 1 has already achieved the latter in practice for some populations; notably Columbia River coho. Alternative 5 can produce the same end result via a combination of (1) deliberately managing for escapements well below MSY; (2) inherent management imprecision; (3) counting hatchery fish as viable wild spawners (without qualification); and (4) combining multiple populations into large management "units."

This potential can be seen in practice for Hood Canal chinook populations (Figure IV-1). Significant escapements are confined to the

Skokomish River and these are mainly hatchery fish. The Hood Canal wild chinook resource is classified as "Healthy" under status quo management and this would not change under Alternative 5.

This is a lower standard of protection than is currently afforded to most stream resident populations. Most stream populations are currently managed on a local population or stock basis and many entire stream systems could be managed at this lower level. Where the low standard of protection is applied, there would be large scale reductions of population sizes compared to current levels.

Steelhead are also currently managed with a much higher level of protection than is afforded under this alternative. Very few runs are managed with the intent of being less than the MSY level. This approach would result in lower stock abundance of steelhead runs and greater risk to long-term stock survival.

5.2 Genetic Diversity and Local Adaptation

Impacts and benefits would be similar to those described for Alternative 1 (Status Quo).

5.3 Harvest Opportunity

Alternative 5 provides the greatest downside flexibility for management, bringing, as a benefit, only the potential for greater short-term utilization opportunities when stocks of different productivities are in the same mixed-stock fisheries.

The perils of downside flexibility in natural resource management are obvious in the recent case histories of U.S. marine resources in the 3-200 mile offshore zones. The Fishery Conservation and Management Act states that the term "optimum" with respect to the yield from a fishery means the amount of fish which (1) will provide the greatest overall benefit to the nation, with particular reference to food production and recreational opportunities; and (2) which is prescribed as such on the basis of the maximum sustainable yield from such fishery, as modified by any relevant economic, social, or ecological factor. What this means is that the managers have a starting point (MSY) that can be quantified, but can make decisions that push future potential yields in either direction. Worse yet, there is no requirement for quantification of this deviation. Application of this standard began in 1976. In their 1991 initial comprehensive assessment of U.S. living marine resources, the federal government conceded that the following were overexploited (National Marine Fisheries Service 1991):

Unit and Fishery	Number of resources overexploited
Northeast demersal	15
Atlantic anadromous	1
Northeast invertegrate	2
Atlantic highly migratory pelagic	2
Atlantic shark	1
Atlantic coastal migratory pelagic	3
Atlantic/Gulf of Mexico/Caribbean reef fish	10
Southeast drum and croaker	3
Southeast menhaden and butterfish	1
Southeast/Caribbean invertebrate	8
Pacific coast salmon	5
Pacific coast groundfish	2
Western Pacific bottomfish and armorhead	2
Pacific highly migratory pelagic	2
Nearshore reources	8
Total	65

This anticipated outcome was predicted as early as 1981 (Wright 1981). The message is clear - if mangers have the downside flexibility to allow overfishing, then many resources will become overfished. It is significant to note that Alaska State law begins with the same quantifiable standard (MSY) but provides no downside flexibility.

Resident species - Stream resident species would be affected by Alternative 5. Since most resident stocks are managed on a stock-by-stock basis, there would be widespread application for this alternative in both stream and lake resident populations. This creates the opportunity for large-scale hatchery based fisheries that would increase harvest opportunities at the expense of wild populations.

Steelhead - Steelhead runs would also be affected by this approach, since their current management is most similar to Alternative 3. This approach would provide greater flexibility for management in many situations.

Salmon - The harvest management aspects of this alternative are similar to management of many current salmon runs (= status quo).

5.4 Other Impacts and Benefits

Alternative 5 might provide a few benefits to ecological and non-consumptive uses for Table II-1 populations compared to current approaches. However, in most cases, it will not represent an improvement.

5.5 Historical and Cultural Preservation

This alternative provides the least amount of short-term change for non-Indian fisheries compared to Alternatives 2-4.

Chapter V IMPACTS TO AFFECTED ENVIRONMENTS: HABITAT ELEMENTS

This chapter describes the different impacts expected from each habitat alternative on the natural environment (physical, biological, and chemical elements of habitat) and the built environment (land and shoreline uses). Complete identification of the specific impacts of the policy is beyond the scope of this FEIS and is consistent with the programmatic nature of this FEIS. It is fully anticipated that more in-depth watershed-by-watershed analysis and SEPA review would occur as implementation proceeds to locally-based watershed planning. In addition, more detailed analysis would be expected for a variety of state or local government level actions that could facilitate implementation.

However, it is possible to form some general conclusions regarding impacts on the natural and built environments and to provide examples of forms of mitigation for unavoidable adverse impacts.

Affected Environment

The Wild Salmonid Policy would provide guidance and direction on wild salmonid protection and recovery statewide, primarily to state agencies and subdivisions of local government. It is also intended to guide our relationships and coordination with the federal government and with Indian Tribes statewide, and with our neighboring states and British Columbia. The affected environment then is all the watersheds inhabited by salmonids across the entire state and - indirectly - lands to our south, east, and north.

Wild salmonids have developed a wide variety of adaptive strategies to ensure their survival and productivity. Native populations have evolved in a myriad of fresh and marine water habitat types and conditions, while other introduced stocks have adapted to them. This section provides a general description of the characteristics of watersheds across the state.

There are several regional land classification systems used to describe the variability of watersheds across the Pacific Northwest (FEMAT 1993, Omernik and Gallant 1986, Cassidy 1997). For the purposes of this analysis, we will use the "ecoregions" system described by Omernik and Gallant (1986) and used by the Environmental Protection Agency to describe the the environments affected by this policy. The Pacific Northwest (in this case, Washington, Oregon, and Idaho) contains 15 ecoregions, 8 of which are found in Washington. The following general descriptions are derived primarily from that document.

Again, we would expect much more detail on affected environments as implementation planning begins in individual watersheds. Many watersheds already have had assessments that could form the basis for planning under the Wild Salmonid Policy.

A. Coast Range - This ecoregion includes the Pacific Coast Range and coastal valleys and terraces. Much of the region is highly dissected by perennial streams. Perennial streamflow can be generated in subbasins less than 1 square mile, with some of the larger streams draining greater than 300 square miles. In Washington, the region abuts the Pacific Ocean on the west and the Puget Lowlands on the east. Lakes in the Washington portion of this ecoregion are sparse, formed primarily by glacial drift or river meandering. The estuaries of Willapa Bay and Grays Harbor are relatively shallow, containing extensive complexes of intertidal mud and sand flats which provide highly productive habitat for salmonids and salmonid prey species. The Columbia River estuary, comprised of a vast and variable mixture of tidelands, salt marshes, sand spits, uplands, and river channels, also lies within this ecoregion. The physical features of the Pacific Ocean, Strait of Juan de Fuca, and Hood Canal range from the open ocean and pounding surf conditions along exposed rocky, gravelly or sandy open coastline to less exposed shorelines of the Strait and Hood Canal.

The Olympic Mountains, grouped with the Cascades Ecoregion, are surrounded by this ecoregion. The Coast Range Ecoregion is characterized by elevations from sea level to higher local relief between 1500-2000 feet, with mountain tops generally below 4000 feet. Precipitation is generally high and quite variable across the ecoregion, ranging from 55 to 125 inches annually depending upon maritime weather patterns and topographic relief. Precipitation is highest in the winter months and lowest in the summer months.

Forests are dominated by Douglas-fir, western hemlock, Sitka spruce, and western red cedar; however, lodgepole pine (shore pine) occurs along the ocean beach and estuary shorelines. Understory vegetation is characterized by salmonberry, rhododendron, willow, vine maple, salal, currant and evergreen huckleberry. Soils are developed mainly from sandstone, siltstone, shale and basalt rock sources and exhibit a wide range of characteristics.

Land use is characterized by urban and industrial development near marine harbors, grading to a variety of small communities, rural residences, agricultural lands, and forest lands with increasing distance from the harbor areas.

B. Puget Lowland - This region includes the open hills and tablelands of glacial and lacustrine deposits. The ecoregion is bordered by the Coast Range Ecoregion to the west, the Cascades Ecoregion to the east, and the Willamette Valley Ecoregion to the south. The northern portion of this ecoregion consists of low elevation (sea level to 500 feet) flats abutting Puget Sound and Hood Canal and interspersed high hills ranging to 2000 feet. The southern and peripheral portions of this ecoregion consist of a greater concentration of hills and foothills, with peaks often exceeding 2500 feet. Average annual precipitation is moderate (35-50 inches), due in large part to the rain shadow effect of the Coast Range mountains. Stream density is less than in the Coast Range Ecoregion; most streams draining this ecoregion are perennial. The large rivers drain the slopes of the Cascades and portions of the Coast Range Ecoregion, while smaller, independent tributaries drain the Kitsap Peninsula and other Puget Lowland basins. Some streams in the southern portion of this ecoregion drain to the Coast Range Ecoregion. Most lakes are derived from glacial processes, although numerous human-made lakes and reservoirs exist as well. Estuary conditions in Hood Canal and Puget Sound vary from shallow bays and inlets to very abrupt and deep areas with exposed rocky or vegetated bluffs and with nearshore substrates ranging from mud to large cobble. Most of the region is forested; Douglas-fir predominates, followed by western hemlock. The lower elevation forests are all characterized by widespread conversion to other uses. Remaining forests tend to be early seral and dominated by Douglas-fir and red alder. Other vegetation includes prairie grasses and oak woodlands.

The majority of the soils in the northern portion are formed from glacial materials in association with coniferous forest communities. A combination of well drained and poorly drained soils derived from volcanic or sedimentary rock deposits in association with coniferous forests is found in the southern portion. The region is characterized by dense urban, commercial, industrial and residential development, most often near the marine shorelines, grading into a variety of urban, rural residential, agricultural and forest lands with increasing distance and elevation from Puget Sound.

C. Willamette Valley - a small portion of this ecoregion exists in Washington, primarily in Clark County and approximately to the Lewis River on the north where it abuts the Puget Lowland Ecoregion. In Washington, this region is bounded by the foothills grading into the Coast Range Ecoregion on the west and by the Cascades Ecoregion on the east. Elevation of the valley floor varies from 100 to 300 feet and local changes in relief are gradual. Elevation of the foothills averages 1000 feet in the northern portion of this ecoregion. Annual precipitation averages 40 inches, with the northern portion receiving proportionately more moisture than portions to the south. The majority of the streams draining the northern end are perennial. The relatively few natural lakes in this ecoregion are mainly abandoned river meanders forming oxbow lakes on broad floodplains. Several miles of mainstem Columbia River exist in this ecoregion.

The natural forest vegetation of this ecoregion is comprised of Oregon white oak interspersed with Douglas-fir, grand fir, and bigleaf maple and mixed stands of cedar, hemlock, and Douglas-fir. Riparian area trees include willow and cottonwood. Remnant prairie grass communities exist in the ecoregion.

Land use in the Washington and the abutting Oregon portion of this ecoregion consists of mixed agriculture, forest lands, and rural and urban residential development, with high urban densities and industrial development along the Columbia River and Willamette Rivers.

D. Cascades - In Washington, this ecoregion is comprised of the Cascades Mountain Range and the Olympic Mountains. The Cascades Range consists of two distinct physiographic regions: the High Cascades or eastern portion of the range and the geologically older, more dissected western portion of the range. Streams range from alpine rivulets to the upper reaches of major rivers. Lakes in this ecoregion are typically cirques and tarns derived from alpine glaciation. This ecoregion is characterized by high mountains and deeply dissected valleys. This region has a broad range of elevations, ranging from near sea level in the Columbia Gorge to more than 10,000 feet for many of the High Cascades Peaks. However, most of the region lies between 2000 and 7000 feet in elevation, and local relief often exceeds 3000 feet. Average annual precipitation across the entire Cascades Ecoregion varies from 50 to 100 inches.
Most of the area is densely forested with typical stands of Douglas-fir, noble fir, Pacific silver fir, and western white pine, with western hemlock and western red cedar providing climax forest cover. Mountain

hemlock, subalpine fir, whitebark pine, and Englemann spruce grow at higher elevations. Understory vegetation is comprised of vine maple, huckleberry, salal, oceanspray, and Oregon grape. Forest floors and alpine meadows contain a variety of herbaceous vegetation.

Soils in this ecoregion are developed primarily from pyroclastic and igneous rock types, although soils developed on glacial till are also abundant.

Most upper elevation areas of this ecoregion are in federal ownership (national forests, parks and wilderness areas). However, most of the lower elevation forested slopes on federal, state and private lands are utilized for timber harvest.

E. Eastern Cascades Slopes and Foothills - This ecoregion is a transition area between the moist, rugged Cascades to the west and the drier areas to the east. In Washington, this ecoregion is located from the Columbia River north along the eastern Cascades to a point just north of Ellensburg, abutting the southern portion of the Columbia Basin Ecoregion. Elevation varies from near sea level along the Columbia River to over 7000 feet across the ecoregion, and local relief varies from 500 feet to more than 2500 feet. The density of perennial streams varies widely. Natural lakes are common in areas of poor drainage such as tableland and basin flats.

Ponderosa pine forests predominate throughout the ecoregion, but stands of lodgepole pine are common. The understory contains grasses and a variety of brushy species such as manzanita, snowbrush, ceanothus and bitterbrush.

Sagebrush/wheatgrass steppe vegetation occurs in the foothills. Quaking aspen occurs in riparian areas and poorly drained wet areas.

Soils are generally immature and developed from volcanic material interspersed with more advanced soils derived from bedrock and glacial deposits.

Timber harvest is the predominate land use, and livestock grazing is common as well.

F. Columbia Basin - The Columbia Basin Ecoregion is characterized by a high degree of variability. This ecoregion is surrounded by mountain ranges: the Cascades to the west, the Northern Rockies to the northeast, and, in Washington, the Blue Mountains to the southeast. Elevation ranges from less than 200 feet at the Columbia River to greater than 4500 feet on some mountain peaks, and local relief varies from less than 100 feet to as much as 2000 feet. The landscape is composed of irregular plains, tablelands with high relief, and low mountains. Precipitation is variable, ranging across the ecoregion from 9 to 25 inches annually. Large rivers course through the ecoregion from sources in the abutting mountain ranges. Almost all the Columbia and Snake rivers in the ecoregion are impounded in reservoirs. The only exception is the Hanford Reach, the last free-flowing reach and an area heavily utilized as a spawning area by fall chinook salmon. Independent streams are often intermittent and ephemeral. Because of water withdrawals and evaporation losses, most perennial streams have lower reaches that experience periods of very low or no flow. Lakes are uncommon; most often they are coulee lakes formed by glacial meltwater streams and catastrophic floods resulting from breakage of ice dams on glacial lakes.

The region naturally supports sagebrush/wheatgrass steppe and grasslands, primarily of wheatgrass with smaller amounts of bluegrass and fescue. Virtually all soils have been formed under these vegetation types, but soil formation has also been influenced by parent rock materials and climatic variability. Loess deposits cover the basalt formations in Washington.

Agriculture is the primary land use in the ecoregion (dryland wheat, some irrigated farming), along with some cattle grazing.

G. Northern Rockies - This ecoregion is comprised of the northern portion of the Rocky Mountains. In Washington, this ecoregion primarily lies in the upper northeast counties of Ferry, Stevens, and Pend Oreille. Rugged, high mountains are the dominant feature across the ecoregion.

Coniferous stands of western white pine, lodgepole pine, western larch, Douglas-fir, subalpine fir, and Englemann spruce are common. Ponderosa pine is found in some areas. Forest understory is commonly grass and forbs. Prairie vegetation consists of wheatgrass, fescue and needlegrass.

Timber harvest is the main land use, with cattle grazing common in the lower elevation open forests. Small acreages in valleys produce for a ge, grain and peas.

H. Blue Mountains - This ecoregion occurs primarily in eastern Oregon, but ranges into southeast Washington, primarily in Columbia, Garfield and Asotin Counties. Most streams are perennial. Lakes are formed from alpine glaciation. Reservoirs are found on a number of streams. Precipitation is highest in the Washington portion of the Blue Mountains Ecoregion, which is characterized by a relatively cool, moist climate and wide variations in topography.

The mountainous portions of the Washington portion of the ecoregion support forests of grand fir/Douglas-fir, ponderosa pine, and western spruce/fir. In the Blue Mountains, small amounts of western juniper commonly occur. Steppe vegetation includes shrubs (Nootka rose, Wood’s rose), forbs (balsamroot, cinquefoil), and grasses (Idaho fescue, wheatgrass).

Soils that have been formed under forest cover at moderate to high elevations are often derived from volcanic ash. Significant loess deposition has also occurred in the northern Blue Mountains.

Land use ranges from agriculture in the lower elevations to grazing and timber harvest at middle elevations and wilderness area at the higher elevations.

Salmonid Habitat Requirements

Suitable habitat needs to provide for six key life requirements for salmonids to be productive and successful. Salmonids need an **adequate quantity** and **quality of water**. They need **food** for survival and growth. They need forms of **shelter** that provide protection from predators and allow them to minimize energy loss. Salmonids need to be **able to move within and between habitat types** to fulfill their life requirements. They need **clean and relatively stable gravel** areas to reproduce. These life requirements are affected by both natural processes and human influences on those natural processes.

Many reviewers have summarized salmonid life histories, habitat requirements, and the effects of natural and human events and activities on salmonid survival and production. Palmisano et al. (1993), NRC (1996), Spence et al. (1996) and CRITFC (1996) all provide good summaries of these issues and all have been utilized in the preparation of this document.

In addition, because of their similar nature and treatment of wild salmonid habitat, we have also adopted by reference the Department of Natural Resources “Habitat Conservation Plan” DEIS dated March 22, 1996, and FEIS dated October 25, 1996, as additional sources of environmental review as provided for in SEPA.

Wild salmonid habitat includes all of the places where salmonids spawn, feed, grow, and migrate. In the broadest sense, maintaining and protecting salmonid habitat must also protect the habitat of the prey species that make up the salmonid diet, and it must protect those upland areas that directly affect the waters where salmonids actually live.

Salmonid habitat includes a wide range of geography and conditions. Streams, rivers, ponds, lakes, wetlands, estuaries, and the open ocean are all part of wild salmonid habitat. This habitat includes tiny, high-elevation streams and lakes that spend much of the year under ice and snow. It also includes rivers, streams, and lakes, large and small, in arid areas of eastern Washington and the rain forests of the Olympic Peninsula. Salmonid habitat includes streams that run through wilderness areas and national parks, industrial and non-industrial forests, agricultural land, rural and suburban residential landscapes, and big cities. All of these land uses must be considered when habitat is the issue.

The life requirements for salmonids are influenced by a combination of interrelated physical, chemical, and biological processes, by habitat conditions occurring over both short- and long-time scales, and by a variety of land forms. Many of these relationships are not well understood. Quite often it is very difficult, if not impossible, to determine quantitative relationships between habitat conditions and salmonid survival and production. Further, freshwater habitat/production relationships can be confounded by ocean survival conditions, inter- and intraspecific competition and predation relationships, and by a variety of fishery impacts. Nonetheless, salmonid life requirements appear to be affected by habitat conditions in the following manner:

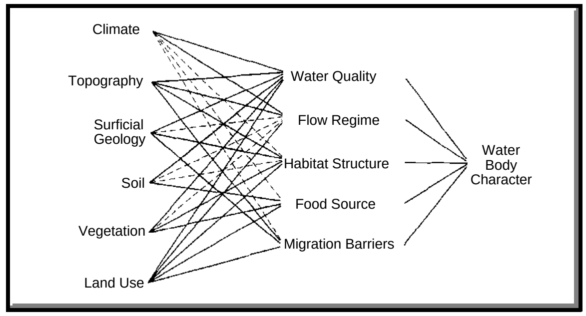

Figure V-1. Habitat relationships.

A. Water quantity is affected primarily through basin hydrology, which is manifested as instream flows. Instream flows are affected by (1) natural climatic, geologic, and vegetative conditions; (2) land use activities; and (3) other in- and out-of-stream uses of water (hydropower, irrigation).

B. Water quality is affected in part by basin hydrology and instream flows. It is also influenced by (1) upslope events such as soil erosion and land slides; (2) the condition and extent of riparian vegetation; (3) the extent and function of wetlands; (4) a variety of natural and chemical contaminants; (5) stream channel and marine habitat stability and complexity; and (6) in-water activities such as dredging.

C. Food supply and availability are affected by (1) instream flows; (2) sediment quality, delivery and routing; (3) water quality; (4) riparian, wetland, and marine vegetation; (5) stream, lake, and marine habitat complexity; (6) the numbers of returning adult anadromous or resident spawning salmonids; and (7) predator-prey and species competition relationships.

D. Shelter for rest and cover is influenced by hydrology, water quality, sediment quality, delivery and transport, and by the extent and condition of riparian vegetation. Stream channels which possess varied and complex habitat features, such as large woody debris, rocks and boulders, channel features such as overhanging banks, and a variety of water depths and velocities, provide abundant resting and hiding shelter.

E. Fish access and passage are affected by hydrology, water quality, sediment quality, delivery and routing, riparian and wetland condition and extent, and floodplain connectivity. Fish passage is further influenced by natural obstacles (e.g., waterfalls) and human structures such as dams, dikes, culverts, and some docks, breakwaters and piers in marine areas.

F. Reproduction is influenced by all the above, but primarily by instream flows, sediment transport, and water quality.

These relationships are illustrated in Figure V-1.

To sustain and recover wild salmonid populations, functional and accessible fish habitat is essential. This includes both existing salmonid habitat in its present condition, as well as degraded habitat in need of restoration. Wild salmonid recovery requires protection and restoration of the productive capacity of salmonid habitat. Areas used by salmonids to complete the full diversity of life history needs must be protected or restored, including instream, riparian, estuarine, and wetland ecosystems, and the upland activities and processes that affect them.

Protection of the existing habitat base should be the first priority for habitat actions. Such protection is usually the most cost-effective initial mechanism available to ensure wild salmonid sustainability. It is immediate, efficient, and can slow or stop the trend of habitat loss. It also retains current wild salmonid production capacity and provides a foundation for future recovery and growth. Protection is also relatively inexpensive when compared to the cost of *restoring* salmonid habitat.

Restoration must also be initiated to be able to realize the benefits that salmonids provide. Restoration is a long-term activity. It may take many years to accomplish because of the cost and because often a period of natural watershed healing is needed. Habitat restoration is a relatively new and experimental science, and it is more costly than protection. Restoration will be critical in those areas where the existing habitat base is insufficient to sustain a particular stock of fish, or where habitat degradation or loss is the key cause of stock decline. It will also be important for expanding the available habitat base and increasing long-term benefits provided by salmonids.

Protection and maintenance of salmonid habitat requires recognition of the continuum of aquatic and terrestrial physical and chemical processes, biological systems, and human influences on that continuum (Vannote et al. 1980). The stream continuum exists in a longitudinal fashion from the smallest rivulet, down through increasingly larger streams and rivers, into estuaries, and eventually to the open ocean. Downstream processes are linked to upstream processes through routing of water, sediment, and organic matter. Salmonids evolved and adapted to this continuum of habitats and processes, each of which is interlinked and important to one or more life stages of wild salmonids (see Figure V-2 on life cycle).

Current Status of Wild Salmonid Habitat

Wild salmonid production has been significantly reduced due to direct and indirect alterations of Washington's freshwater, estuarine, and marine habitats. These alterations have led to loss of habitat, loss of access to habitat areas, adverse changes in physical habitat structure, and adverse changes in water quantity (higher flood flows and lower minimum flows) and water quality. Even hatchery production has been reduced by habitat degradation through increased sediment loads in water used for fish rearing.
Habitat loss, damage, or modification were listed as contributing factors for 86 of the 93 Washington salmonid stocks identified as either at “high” or “moderate risk of extinction,” or “of special concern” (Nehlsen et al. 1991). Of the 97 Washington stocks identified as healthy or marginally healthy, the freshwater or estuarine habitat for 80% of these stocks was rated as either “fair” or “poor” (Huntington et al. 1994).

Prior to development, within the Washington portion of the Columbia River Basin, an estimated 4550 stream miles were accessible to salmonids. Today in that same area, primarily due to blockage by dams, only 3791 stream miles remain (Palmisano et al. 1993). Much of the remaining accessible habitat has been degraded from other impacts. Our network of freeways, city streets, and private roads has also taken a toll on salmonid habitat. WDFW (1994) identified about 2400 culverts at road crossings that blocked access to nearly 3000 miles of stream habitat across the state.

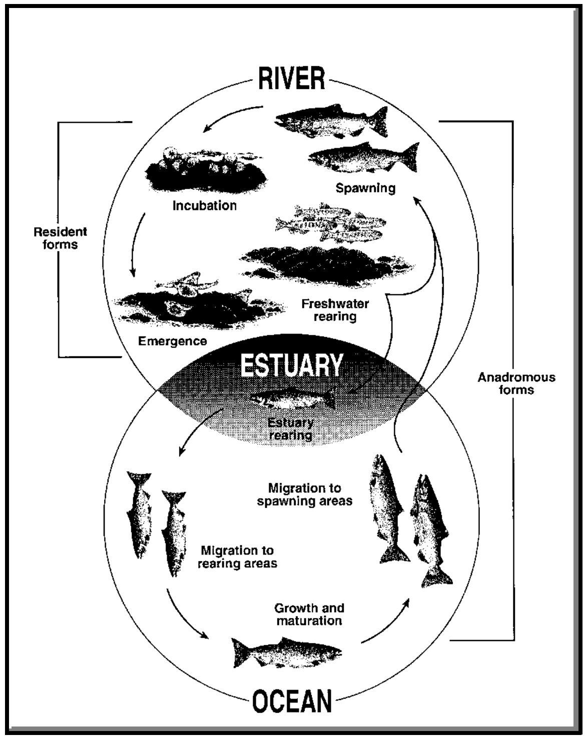

Figure V-2. General life cycle of salmonids.

Estuary development has reduced salmonid habitat as well. Many nearshore marine areas have been converted to industrial, commercial, and residential uses. Conversion of these areas usually results in fills or protective bulkheading, both of which affect juvenile salmonid feeding areas and migratory pathways.

Tideflats, swamps, and wetlands in the Columbia River estuary were reduced by 40% (33,000 acres) from 1870 to 1970 (Sherwood et al. 1990). In the Skagit River basin, agricultural diking and drainage has resulted in the loss of 54% of the lower river slough habitat (Beechie et al. 1994). The British Columbia / Washington Marine Science Panel (1994) report identified nearshore estuarine wetland habitat losses as severely affected by human activities, primarily in urban areas and secondarily in suburban and rural areas.

Destruction of wetlands in Puget Sound was estimated at 58%. That same report indicated wetland losses to be as high as 99 and 100 per cent in the Duwamish and Puyallup estuaries, respectively.

Physical habitat structure has been simplified or altered in both freshwater and marine areas. The frequency of large pools in managed watersheds of the Columbia Basin has decreased 28% over the past 50 years (McIntosh et al. 1994), primarily due to losses of instream woody debris. The loss of large pools is estimated at 30-70% on national forest lands in the Pacific Northwest (PACFISH Strategy 1995). More than half of Washington's streamside riparian vegetation has been lost or extensively degraded since the early 1800s.

Human activities also affect stream structure. Increases in channel-forming flows — the periodic flood events that scour and define stream channels — are often found in timber harvest areas. Such flow increases associated with logging-related hydrologic changes and sediment supply can be particularly damaging to spawning habitat (Peterson et al. 1992). Surface water withdrawals can reduce streamflows below levels required for salmonids, which reduces available spawning, rearing, and migration habitat (Puget Sound Cooperative River Basin Team 1991, Palmisano et al. 1993). Bulkheads and other forms of bank stabilization reduce stream complexity and affect salmonid habitat (Chapman and Knudsen 1980).

Changes in land use can significantly influence habitat conditions. Rural forest and agricultural lands are often converted to residential and commercial uses as urban areas expand and the demand for land for development increases. The majority of lands converted in Washington are low-elevation, high-productivity sites, which also are the most productive habitat for salmonids because of low stream gradients, gentle topography, and, for anadromous salmonids, access to marine waters.

Water quantity and quality are often impaired due to increases in impervious surfaces (e.g., parking lots, shopping malls) and storm-water runoff resulting from urban expansion. Winter peak flows are significantly higher and of longer duration. Streams in these basins, in addition to experiencing increased frequency of channel forming flows (near bank full or greater), also had an increase in the effective frequency of flows generating stream velocities less than those affecting the channel but greater than those suitable for over-wintering juvenile salmon (Muckleshoot Tribe, personal communication). Summer flows as well are reduced or non-existent and salmonid habitat is degraded or lost in urbanizing watersheds (Lucchetti and Furstenburg 1993).

Significant changes to wild salmonid habitat have occurred as a direct result of the human population expansion in Washington. The future promises to bring additional growth, and with it the potential for further degradation of salmonid habitat. The Office of Financial Management predicts that an additional 2.7 million people will live in Washington by 2020. Such growth will place intense pressure on our natural resources, particularly fresh and marine waters, timber and agricultural lands, and fish and wildlife and their habitats. The Department of Natural Resources estimates that one acre of forest land is lost for each person added to the population.

Analysis of Impacts

Analysis of the environmental impacts of the alternatives requires an understanding of the habitat requirements of salmonids, the current status of salmonid habitat, knowledge of the physical, biological, and chemical processes affecting habitat, and an understanding of the effects human activities may have on these processes. For the purposes of comparing alternatives for the natural environment, we will present a discussion of environmental impacts arrayed by the physical processes and habitat types.

Analysis of environmental impacts in a EIS is generally divided into two categories: the natural environment and the built environment. The elements of the natural environment that are typically considered include: *Earth* (geology, soils, erosion); *Air* (air quality, odors); *Water* (quality, quantity, movement); *Plants and Animals* (habitat, abundance and diversity, unique species, migration routes); and *Energy and Natural Resources* (energy use and production, renewable resources, scenic resources). The elements of the built environment that are typically considered in a EIS are: environmental health (noise, toxic releases); land and shoreline use (relationship to existing plans, housing, recreation, agricultural crops); transportation (transportation systems, traffic); and public services and utilities (fire, police, water/storm water).

Potentially significant environmental impacts have been identified for the following elements of the natural environment: *Earth:* local topography (site conversions, regrading), erosion (upland and channel processes, sediment delivery and transport) ; *Water:* basin hydrology and instream flows, surface and groundwater quality, aquatic sediment quality; floods (floodplain connectivity and function, sediment delivery and transport); lakes/reservoirs and marine waters; *Plants and Animals:* plant and animal habitat (stream complexity, riparian, wetland, lake and marine habitat extent and condition); plant and animal abundance and diversity; unique species; and fish migration routes.

Potentially significant environmental impacts were identified for the built environment including: general land and shoreline use including zoning (allocation of lands for housing, business and industry, open space, protection of critical areas, and agricultural and forest lands; and historic and cultural preservation) and land use activities such as transportation networks, forest practices, water resource development, irrigation and stormwater conveyance, etc.

Environmental Considerations for Basin Hydrology and Instream Flows

The basic life need for all living organisms is water and, obviously, a fish out of water is in trouble. The amount and quality of the water, and its pattern of flow, are among the key factors of critical importance to salmonids.

Salmonids occur in a variety of climatic regions within Washington, ranging from the very wet Olympic Mountains to the very dry Columbia Basin. The amount of water eventually available to salmonids as streamflow depends fundamentally on the basin (also referred to as catchment) hydrology — how local climates, geologic types and vegetation types affect the pattern of daily, seasonal, and yearly flows (or how water is routed and stored within a given watershed). This is referred to as the "hydrologic cycle" (Figure V-3).

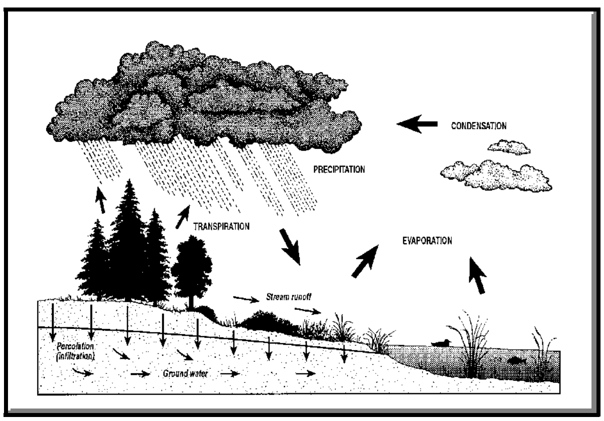

Figure V-3. Hydrologic cycle.

Once the water reaches a stream or lake, its storage and routing are influenced by other physical processes such as sediment delivery and transport, and by riparian areas, wetlands, beaver ponds, and channel complexity.

Natural Hydrologic and Instream Flow Factors That Affect Salmonids

Streamflow is a major factor in controlling annual freshwater salmonid production by creating and maintaining salmonid habitat, preserving habitat function, and initiating movement or other behavioral changes. Streamflow also has an effect on the quantity and quality of estuarine and marine habitats for anadromous salmonids. The habitat and production of prey-base species for salmonids (e.g., aquatic insects and other fishes) are also dependent on streamflow. High flows help to maintain and/or create pools, flush fine sediments from spawning gravel, and transport and deposit gravel and large woody debris in the channel, estuaries, and marine areas. Many salmonid activities are stimulated or facilitated by natural hydrological changes. For example, adult upstream migration and spawning are triggered by fall/winter/spring rains (freshets), juvenile downstream migration is triggered by spring freshets, and fall freshets trigger movement by some species into off-channel refuge and rearing areas.

Peak winter flows and low summer flows are the primary hydrologic conditions affecting salmonid production in fresh water. These conditions are influenced by global and local climate, and by local geography, geology, and vegetation. Changes in the magnitude, frequency, and timing of high-flow events are of particular importance to salmonids. High peak flows can be a mixed blessing: sometimes simplifying channel form (reducing habitat productivity) or increasing channel form (increasing habitat productivity). Hydrologic changes can transform complex channels comprised of large woody debris and various types of pools, runs, and riffles into uniform riffle areas, limiting the habitat value to fewer and different salmonids. Streambanks can be eroded, causing a loss in bank stability and integrity that can increase siltation, and reduce the availability of salmonid hiding and resting cover. Peak flows can also displace juvenile fish downstream out of preferred rearing areas, delay migrations, and increase suspended solids that irritate gill tissues.

Instream flow is a critical limiting factor for spawning habitat. Instream flow can determine habitat accessibility for fish, whether appropriate water depth and velocity conditions exist for spawning, and the amount of habitat available for salmonid use. Each species has specific flow and depth requirements for spawning, and its spawning success can be limited by a variety of instream-flow events. For example, fish may be blocked from using high-quality habitat because of insufficient flow and forced to spawn in less productive mainstem areas. Eggs or alevins in the gravel can be dewatered and killed during incubation. Stream-side channels can become isolated or dewatered, stranding salmonids.

Survival of newly spawned eggs to the fry stage is dependent upon the stability of the streambed gravel that houses eggs and salmonid fry during their early development. High flows can physically disturb or scour the gravel, damaging or killing the eggs and alevins. Scour affects salmonids when they are most vulnerable — as immobile eggs and alevins (Peterson et al. 1992, Tripp and Poulin 1985, Cederholm and Reid 1987). Some researchers have concluded that egg loss from gravel scour frequently exceeds losses attributable to fine sediment concentration, which tends to smother the eggs and alevins (D. Seiler, WDFW, personnel communication).

Like spawning habitat, rearing habitat is naturally influenced by instream flow (Smoker 1955). Natural low-flow periods (late summer/early fall) are particularly critical for rearing salmonids, especially for those species that have extended freshwater residence. In-channel and off-channel rearing space shrinks as flows recede. This increases competition for food and living space and exposes salmonids to increased predation. Portions of some streams may go below ground, restricting salmonid movement and interrupting the downstream transport of prey organisms.

Ponds formed by beavers play a significant role in creating and maintaining salmonid habitat and in maintaining summer low flows (Naiman et al. 1992). The relationship of the stream channel with its floodplain is also an important consideration for instream flows.

Low summer flows can affect water quality as well. Water temperature generally rises as flow falls, reducing dissolved oxygen content. Salmonid mortality is significant during low flows and can be exacerbated by extremely low flows.

Instream flow is such an influential factor that predictions for production of wild coho in Puget Sound are based largely on low summer stream flow conditions that existed when the juvenile fish were residing in freshwater. Steelhead production predictions are based, in part, on a combination of stream gradient and wetted stream width. Wetted stream width varies both yearly and seasonally and is the area of the stream containing water at any given time.

Human Activities That Affect Basin Hydrology and Instream Flows

Although the limiting conditions described occur naturally, each can be affected by human activities. Agricultural activities that remove ground cover affect runoff. Livestock grazing, particularly in riparian areas, has the potential for soil compaction and increased runoff (Fleischner 1994). Certain forest practices, including forest roads and harvest in rain-on-snow zones, increase peak runoff and, for a time after harvest, increase summer low flows.

Flow regimes have also been changed by our activities. One dramatic example of modification of a river's flow regime is found in the Columbia Basin. Today, the Columbia River is virtually under human control through a series of water storage projects in Canada, Washington, Idaho, and Oregon. A large portion of the spring runoff can be captured behind dams and metered out through turbines to generate electricity. Where once the Columbia flowed at very high volumes during the spring, the river is now managed at much lower flows over a longer duration to accommodate the hydraulic capacity of the turbines at the various dams. In most years, it has become necessary to artificially simulate spring runoff by releasing water in an attempt to facilitate the downstream movement of salmonid smolts. Although this stimulates downstream movement, migration is still impaired where the smolts must traverse storage reservoirs with decreased flows and velocities.

Reduced flow levels at water storage dams can dewater, or dry up, spawning habitat, making it unavailable for salmonid use. If spawning has already occurred, low flows can dewater established redds. This is a common situation on rivers in both eastern and western Washington.

The change in urbanized watersheds is more prevalent, but less dramatic, than in the Columbia Basin. Before development, many streams exhibited infrequent floods of low magnitude and summer low flows were usually sufficient to maintain high levels of salmonid production. Today, with development, these streams flood more frequently with greater magnitude and duration. The same surfaces that increase runoff in urban areas also affect summer low flows. The reduction in interception, storage, and release of ground water to streams during low flow conditions affects habitat availability and salmonid production, particularly for those species that have extended freshwater rearing requirements.

Changing hydrology, which is usually coupled with reductions in water quality, loss of fish passage, loss or simplification of streamside vegetation, reduction in flood plain extent and function, and reduction in channel complexity, can severely reduce the potential of urbanized streams to produce salmonids (Lucchetti and Furstenberg 1993). These changes also affect wetland functions and values, and other instream resources.

Generally, instream functions and values begin to seriously deteriorate when the levels of impervious surfaces exceed 10% of a subbasin (Schueler 1994, Arnold and Gibbons 1996). Figure V-4 is a stylized characterization of changes in habitat quality with increases in impervious surfaces. To put this in context, land uses that have an average residential lot size of one unit per acre result in 20% impervious surface while land uses comprised of commercial shopping areas would result in 95% impervious surface (Figure V-5).

Society's demand for water for a variety of out-of-stream uses also has a profound impact on salmonids and their prey base. Many streams have water rights for diversion that far exceed normal low-flow volumes. Others are routinely overused to the detriment of the salmonid ecosystem (e.g., Dungeness, Quilcene and

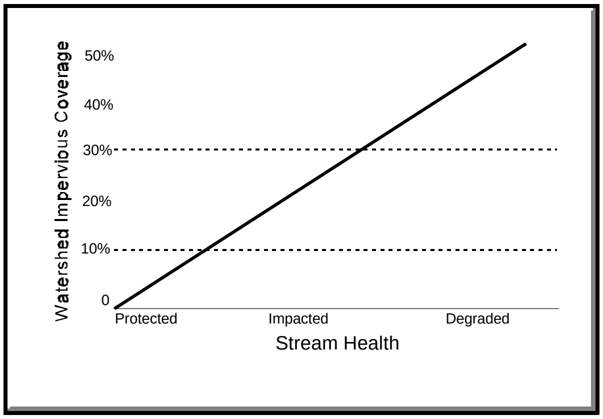

Figure V-4. Relationship between the percent coverage of a watershed by impervious surfaces and stream health.

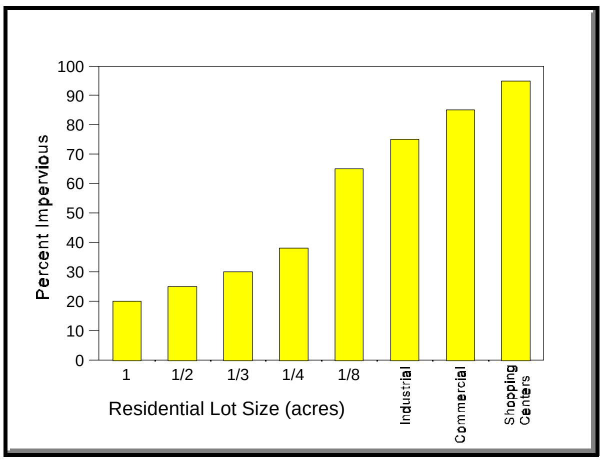

Figure V-5. Relationship of percent impervious surfaces to land use zoning levels.

Yakima rivers). Streamflow is also affected when ground water that is in continuity (connected with) surface water is withdrawn, and when surface or ground water is appropriated from one basin and transferred to another.

Environmental Considerations for Water Quality and Sediment Quality, Delivery and Transport

Salmonids are dependent on abundant, clean, cool water for their survival. Several water quality components are important to, or regulate, salmonid habitat and resources: water temperature, dissolved oxygen, pH, total suspended solids (TSS), and specific toxic materials. The quality, delivery and transport of sediments throughout stream channels, lakes, and marine areas plays a significant role in salmonid survival and production.

Water Quality and Sediment Parameters That Affect Salmonids

Water temperature is a primary regulator in the aquatic environment because it affects chemical reaction rates, governs the physiological functions and processes that occur in water, and helps determine which aquatic species may be present. Low water temperatures will slow egg and alevin development in the gravel, promote formation of anchor ice in river beds that can destroy salmonid nests and desiccate incubating eggs, and retard growth of rearing salmonids. High water temperatures can stress salmonids, increasing their susceptibility to disease and even block access to movement.

Temperature affects all metabolic and reproductive activities of salmonids. The adverse effects of other environmental variables, such as pollution, predation, disease, and dissolved gases, are made worse by elevated temperature levels. Increased temperature can also be indicative of cumulative effects within a watershed on riparian structure and channel morphology. These general water-body changes can be detrimental to salmonids.

General temperature ranges for the various life history phases of salmonids are as follows:

Spawning Migration	38-68° F.
Spawning	39-57° F.

Incubation	36-52° F.
Rearing	39-52° F.

Fish diseases associated with elevated water temperatures become problematic in the 56-65° Fahrenheit range. Direct salmonid mortalities from elevated temperatures begin at 70° F. Berman and Quinn (1990) reported that egg and alevin survival may decrease due to adult exposure to sub-lethal elevated stream temperatures.

Dissolved oxygen (DO) is necessary in appropriate concentrations to keep aquatic organisms alive and to sustain reproduction, vigor, and population development (MacKenthun 1969). Severely reduced DO delays egg hatching, produces deformed alevins, interferes with food digestion, accelerates blood clotting, decreases tolerance to toxicants, reduces food conversion efficiency and growth, and reduces maximum sustained swimming speeds (WDF 1992). Salmonid growth, development, and activity can be limited by slight reductions in DO below saturation (Katz et al. 1968). Levels at or near oxygen saturation are desirable to maintain habitat function and fish health. Dissolved oxygen levels decrease as water temperatures increase.

The pH of water (acidity or alkalinity) and the rate of pH change directly affect salmonid use and survival. Near neutral conditions are most favorable, while changes in pH greater than 0.5 in 24 hours have resulted in both immediate and delayed salmonid loss in hatcheries (J. Shefler, WDFW, personal communication).

Total suspended solids (TSS) is a measure of the amount of sediment suspended in the water. Increases in TSS can contaminate salmonid spawning habitat with fine sediments, fill rearing pools, reduce instream productivity, damage or clog salmonid gill filaments, reduce feeding effectiveness, and interrupt spawning migration. The effects of TSS on salmonids are dependent on the size of fish, type of sediment, and the length of exposure.

A variety of elements affect spawning habitat quality and quantity. These include the abundance and size of gravel, the pattern and depth of flows, stream or lake structure, access, and distribution. The presence of suitable gravels can be limiting in many areas. Streams frequently lack a suitable gravel substrate. Streams with silt and sand substrates provide poor opportunities for spawning. Many lowland lakes in Washington do not have suitable spawning area in inlet or outlet streams, and as a result are not useable for spawning by wild salmonids.

Gravel substrates with a high concentration of fine materials will have poor wild salmonid survivals. Sediments smaller than 0.85 mm (0.0334 inches) in concentrations greater than 11% (by volume) have been found to decrease survival of eggs and alevins within gravels (Peterson et al. 1992). Fine sediment fills the spaces between gravels and inhibits the exchange of oxygen-bearing water, causing eggs to suffocate. A cap of compacted material cemented together by fine materials can form over the redd and trap the young fish after they hatch, confining them in the gravel. As a result, they starve.

Many elements and chemical compounds resulting from human activities have direct or indirect toxic impacts on salmonids. These chemicals range from naturally occurring metals and compounds to complex industrial effluents and synthetic pesticides. These are directly or indirectly introduced into the water from a myriad of industrial, agricultural, forest practices, urban development, and other activities. Lethal and sublethal impacts can result from both short-term, high-level exposure and chronic, low-level exposure.

For some chemicals, “no effect” levels — the level at which there is no adverse effect on the fish — are only slightly above natural background levels. Often these no effect levels are several orders of magnitude below levels that are acutely toxic. For instance, copper is both a naturally occurring element and an essential growth nutrient. At levels above those needed for metabolism, however, it becomes toxic. Lorz and McPherson (1976), for example, found that copper was acutely toxic to yearling coho salmon at 60-74 μg/L, but positively affected smoltification, migration, and survival at 5-30 μg/L.

Water quality standards and antidegradation requirements were designed, in part, to accommodate the biological needs of salmonids. When water quality standards are not met, the salmonids inhabiting those waters may be killed, forced to migrate to habitats having more suitable conditions (if any are available), or live in conditions that limit their ability to grow and reproduce. Substandard water quality conditions can limit or eliminate salmonid production.

Natural Factors That Affect Water Quality and Sediment Delivery, Transport and Quality

As with basin hydrology, water quality is affected by local climate, geography and geology, and vegetation, particularly riparian vegetation.

Water quality and water quantity are also inseparable as stated above. Seasonal variations in air temperature are reflected as seasonal variations in water temperature. Ground water temperature generally follows the average annual air temperature. The concentration of suspended solids within aquatic environments rises and falls with increases or decreases in streamflow, and is also well-associated with the geology and soils in a given basin. Sediments derived from bank erosion or upslope mass movements contribute to sediment levels within streams and streambeds. Riparian area vegetation regulates daily stream temperatures and contributes dissolved elements such as nitrogen and phosphorous to streams. Riparian vegetation also affects water quality through introductions of leaf litter, limbs, tree parts, and whole trees into aquatic environments, and by capturing or releasing upland or in-channel sediments.

Human Activities That Affect Water Quality and Sediment Delivery, Transport and Quality

Most land-use activities have some level of effect on water quality. Some of the more obvious impacts include removal of riparian vegetation, road building and timber harvest, agriculture and livestock grazing, stream and marine sediment dredging, sewage treatment effluent release, urban runoff, and a variety of industrial discharges.

Environmental Considerations for Stream Channel Complexity

Salmonids have evolved and adapted to streams which possess a variety of in-channel features important to their survival, growth, migration, and reproduction. These features include pools, riffles and intermediate areas such as glides, cascades and waterfalls. Other features include substrate size and distribution (silt, sand, gravel boulders, etc.), sediment delivery and transport processes, water depth and velocity, undercut banks, side channels and instream large woody debris. These features collectively define the complexity - or simplicity - of a stream channel. On balance, complex channels are more productive for salmonids than simple channels.

In-channel Features That Affect Salmonids

Rearing habitats range from shallow, low-velocity stream margins and side-channel areas for recently-emerged salmonid fry to pools several feet deep for larger species (coho, steelhead, and spring chinook pre-smolts and resident trout). Plunge and scour pools with associated LWD are preferred habitat of rearing Dolly Varden and bull trout (Martin 1992, McPhail and Murray 1979). Higher velocity glides and riffles are used by several trout species and chinook. Steelhead, cutthroat, Dolly Varden and bull trout juveniles use spaces within the stream bed substrate as refuge during the winter.

Off-channel wetlands, lakes, and ponds and low-velocity tributary streams have been found to be particularly important over-wintering habitat for some coho populations (Cederholm and Scarlett 1982, Peterson 1982). Cutthroat and steelhead juveniles also use this habitat (D. King, WDFW, personal communication). These areas provide safe, stable, and productive rearing habitat that is buffered from winter flood events (Cederholm and Reid 1987). Smolt survival and growth rates in these areas often exceed those of smolts in other habitat (Cederholm and Scarlett 1982; Bustard and Narver 1975). Lakes and other impoundments provide rearing areas for sockeye, kokanee, coho, cutthroat, Dolly Varden, and bull trout. Small spring seeps and side-channels have recently been recognized as important early rearing areas for chinook fry in western Washington (P. Castle, WDFW, personal communication). Similarly, Fraley and Graham (1981) found a high abundance of bull trout in side channels and around rocks along stream margins.

Peterson et al. (1992) reviewed the available literature on pool habitat as part of a Timber, Fish and Wildlife (TFW) cooperative research effort and concluded that an appropriate target condition for the percentage of stream surface comprised of pools is 50% for streams with gradients <3%. In 1994, the Forest Practices Board adopted a watershed analysis manual that defined good habitat for streams less than 15 meters wide when:

Stream Gradient	% Pool Area
<2%	55
2-5%	40
>5%	30

Large woody debris is integral to the formation and maintenance of pools in most gravel stream channels and for the formation and maintenance of low-velocity side channels in large and small streams. LWD also functions to dissipate stream energy and trap sediment in smaller streams. LWD is important in forming channel structure in steep tributary streams (Maser and Sedell 1994). LWD is provided by the trees in or near the adjacent riparian zone. In small streams, most LWD (either whole trees or tree parts) comes from trees within 45 meters (150 ft) of the stream or wetland (McDade et al. 1990). In larger streams, especially mainstem rivers with active meandering across broad flood plains, LWD can be recruited from forested areas anywhere within the active channel migration zone.

The Washington Forest Practices Board provides a description of adequate LWD loading in stream channels in its *Watershed Analysis Manual*. For streams less than 20 meters wide, the manual defines “good” LWD conditions when LWD pieces (>10 cm x 2 m length) exceed two (2) per channel width. If LWD were defined as “key pieces” in western Washington [stratified by piece length and diameter per bankfull width (BFW)], then the manual defines LWD conditions as “good” when key pieces exceed 0.3 per channel width when channel BFW is less than 10 m, and 0.5 per channel width when channel BFW is between 10 m and 20 m. (Key pieces are the large logs or rootwads that provide stream channel and bank stability in unison with the smaller pieces.)

Restated in less technical terms, small streams generally are served by smaller pieces of LWD, while large streams require larger LWD. Conifer species are generally more functional as LWD because of their larger diameter and length and much greater resistance to decay after entering the channel.

Channel complexity is important for adult residents and anadromous spawners. Adult residents use a variety of instream habitat and cover types. Spawning salmonids also have a variety of reproductive strategies and use many different spawning habitats. These include brackish or freshwater areas of sloughs, rivers, streams and lakes where suitably-sized gravels accumulate, and where water flows over and between gravels. Eggs and alevins (young salmonids with the egg-sac still attached) incubate in this gravel habitat for several months. While in the gravel, the eggs and alevin are very susceptible to injury or suffocation, and are vulnerable to spawning habitat alterations because they are immobile.

Each species has its own set of spawning habitat needs. For example, different salmonid species require different size spawning gravel. Generally, concentrations of clean gravel mixtures four inches in diameter or less are considered viable spawning habitat, given appropriate water depth and velocities. Gravel accumulations must be large enough in an area to accommodate the spawning fish. For chinook, the largest salmonid, the recommended area for a spawning pair is 20 square meters. The recommended area for trout is 1.7 square meters (Bell 1991). The recommended size includes a defense area to prevent encroachment by other spawning pairs. Actual redd (nest area for laying eggs) size may be considerably smaller. Some salmonid species, like sockeye, pink and chum, often mass spawn. This occurs when large concentrations of fish spawn in close proximity, requiring large gravel beds.

Different species use different parts of the watershed. Some salmonid species spawn primarily in smaller tributary streams (coho, cutthroat, rainbow), while others use the mid- and upper reaches of larger, mainstem streams and larger tributaries (steelhead, pink, chinook). Sockeye and kokanee spawn in mainstem and tributary habitats that are linked to lakes, or on lakeshore gravels associated with ground water upwelling. Chum spawn in the lower mainstem of rivers, tributaries, and in associated sloughs and side channels. Dolly Varden and bull trout spawn in cold-water tributaries and upper mainstem streams (Brown 1992).

The variety of spawning areas provided by different stream reaches and complexity within stream reaches helps to limit inter-species competition for spawning and rearing habitats and to increase overall population survival and production.

Natural Processes that Affect Channel Complexity

Channel complexity depends on valley form, floodplain size and extent, riparian area vegetation types, sizes and extent, sediment routing and transport, and upon basin hydrology and instream flows. Spence et al. (1996) summarize the basic channel morphological units and the physical mechanisms affecting their characteristics. A stream channel is basically a manifestation of the interrelated processes of hydrology and sediment within a more or less defined channel. Stream channels can be described on several scales: an entire drainage network, a stream reach, or a channel unit. Generally, at the largest scale, averages of stream characteristics such as depth, velocity, width and channel form change in a downstream direction with increasing discharge and distance from their point of origin. However, stream reaches or segments (as used in *Watershed Analysis)* and channel units are more responsive to valley form, hydrology and sediment. Stream reaches, typically 1-10 kilometers long, possess relatively similar channel unit features such as pools, riffles, cascades, glides, stepped pools, and steps. Reach characteristics are determined in large part by local geology. Stream reaches within wide valley floors generally have unconstrained channels and are well-connected to broad flood plains, and possess a pool/riffle/glide/sequence with a variety of primary and secondary channels. Large woody debris, which enters the stream and usually remains near to its point of entry, creates and maintains a variety of habitat types. Stream reaches characterized by narrow valleys, particularly within rocky non-erodible canyons, are usually deeper, swifter, and dominated by cascades, falls, and step-pool channel unit features. LWD and smaller sediments and spawning size gravels are usually transported through these reaches. Habitat features are more simple; cover is provided by larger rocks and boulders and water depth and turbulence. Depths and velocities are more uniform. In higher gradient reaches with well-developed riparian areas, wood plays an important role in creating and maintaining reach characteristics.

Natural disturbances such as landslides, debris flows and debris torrents affect stream channels. Hillslope material that enters steep and constrained stream channels during landslides, combined with already high streamflow, form a slurry of water, soil, rock and wood, which when mobilized can scour entire stream reaches to bedrock, changing what may have been a complex channel formed over millennia to a simple, exposed uniform reach in a matter of minutes.

Human Activities that Affect Channel Complexity

Several reviewers have indicated the policy ignores the role of disturbance and the capability of salmonids to cope with and even prosper in the face of disturbance. Recent authors (Reeves et al. 1995, Bisson et al. 1997) state that salmonid populations experience significant natural variability and as a result can adapt to cope with and even thrive in the face of significant natural disturbance. Salmonids have evolved with and adapted to a variety of natural disturbances affecting stream channels, but on balance these impacts pale when compared to the frequency, magnitude, and duration of human-caused impacts. In simple terms, the ranges are outside those experienced in their evolutionary histories.

In addition, the “natural” variability expressed by some salmonids and attributed to environmental conditions can be masked by effects of fish harvest. Wright (1993, p. 3-4) states: “Fisheries habitat managers try to implement environmental regulations in the same areas where fisheries population managers are working diligently to prevent any significant escapement of wild fish commingled with hatchery fish. A research biologist may inadvertantly attribute natural environmental causes to the high variance which he or she measures in year-to-year juvenile populations. Rather, it is simply a product of varying degrees of overfishing.

The natural variation in healthy or “fully-seeded” coho populations is only about two to one (Dave

Seiler, Washington Department of Fisheries, unpublished data), but the high variance illusion provides development interests with a convenient basis for objecting to any meaningful controls on environmental disturbance. How can you hurt anything that varies so much naturally?"

The most pervasive effect of human activity on stream channels has been a fundamental change from complex channels to simple channels. The channel unit and, in many cases entire reach characteristics, of most streams outside protected areas have been altered, often dramatically and permanently by land management activities. Both bank protection and diking limit off-channel rearing habitat by preventing channel migration and closing off side channels. Urbanization causes significant changes in stream morphology and water chemistry. These changes can cause a shift in the fish community, for example from coho (a pool-associated species) to cutthroat (a riffle-associated species) (Lucchetti and Fuerstenberg 1993). Logging and road building are associated with increased mass wasting events in watersheds, which cause scouring of pools in higher gradient areas and in low gradient areas cause pools to fill with sediments, resulting in a loss of channel complexity and rearing capacity. Recent habitat analysis indicates watersheds in Pacific Northwest National Forest lands have 30 to 70% fewer large pools today than in the past (PACFISH Strategy 1995).

Past logging practices, including removal of large conifers from riparian areas, clearing and snagging LWD from streams, and splash-damming streams to provide in-channel transport of timber to downstream mills, drastically reduced pool volume and channel stability. This was exacerbated by state and federal actions and mandates to clean out streams after logging (Cederholm and Reid 1987, Bisson et al. 1987).

Agricultural drainage, flood control and navigation also caused LWD removal, as did the cutting of riparian zone trees in urban and agricultural areas (Sedell and Luchessa 1981).

Large and small dams interrupt or block normal migration and recruitment of gravel to streams. Gravel of all sizes has been trapped behind dams where it is unavailable for spawning. Below dams, smaller gravels are washed downstream and not replaced. This leaves only larger material that is unsuitable for many spawners.

Conversely, mass-wasting events also alter spawning habitat by contributing excess gravel and other sediments to the channel. This extra gravel is often unstable and subject to movement during moderate and high flows. Redds can be destroyed or disturbed by this sediment movement.

Removal of stream gravels for flood control and construction purposes has contributed to channel simplification. These activities are often coupled with dike construction, bank armoring, and channel straightening to accommodate roads and buildings, and channel obliteration through extensive culverting to prepare sites for construction.

Environmental Considerations for Riparian Areas and Wetlands

Riparian areas and associated wetlands perform the following functions, all of which have a direct or indirect affect on salmonid production:

- Stabilize streambanks and lake shores, and prevent erosion.

- Filter suspended solids, nutrients, and harmful toxic substances.

- Provide a distinct microclimate, usually cooler and more wind-free than the surrounding uplands.
- Help maintain cool water temperatures.
- Provide migration corridors.
- Dissipate stream energy and trap suspended sediments during overbank flows.
- Provide flood storage and ground water recharge.
- Provide quiet pools and off-channel habitat.
- Maintain undercut banks for hiding and rearing.
- Provide large woody debris (LWD) for channel stability, pool formation, and in-channel complexity/diversity.
- Moderate impacts of stormwater runoff.
- Provide an energy source in the form of leaf litter and LWD.

Riparian and Wetland Functions That Affect Salmonids

All of the functions discussed help to maintain habitat diversity and integrity (Cummins 1974, Meehan et al. 1977, Vannote et al. 1980). Riparian habitats create a multitude of niches that support fish and wildlife in higher abundance and diversity than any other habitat type. Invaluable to healthy aquatic ecosystems, riparian habitats also benefit about 90% of Washington's land-based invertebrates.

Functional riparian habitat contains a variety of vegetative communities usually composed of grasses, shrubs, and deciduous and conifer trees of various sizes. Forested wetlands provide refuge

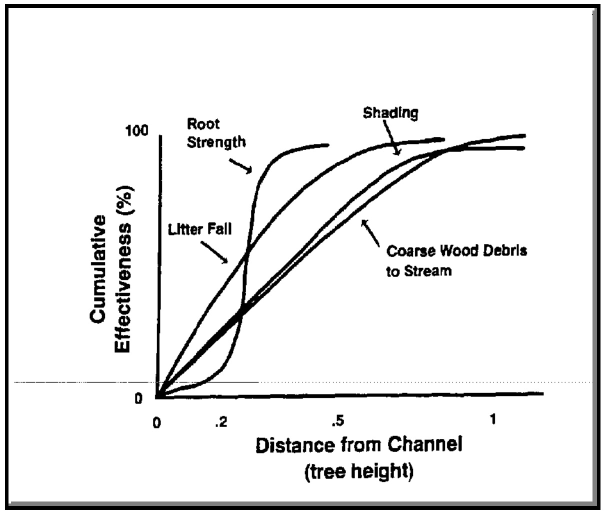

Figure V-6. Riparian composition.

and high quality winter rearing habitat for wild salmonids. Riparian habitat must be relatively continuous along the stream corridor and fairly wide to provide the full range of functions described above (Naiman et al. 1992).

Riparian trees fall, or are washed, into the stream and provide large woody debris (LWD) for habitat formation and streambed stability. As water flows around LWD, it creates complex hydraulic patterns that form pools, falls and channel meanders, and cause physical variations within the stream. LWD can be very important for providing shelter for juvenile and adult fish in lakes, ponds, and wetlands. Most LWD is recruited from trees growing within the riparian zone of the stream or wetland. Cederholm (1994) reviewed recent literature describing recommended riparian buffer strip widths for LWD maintenance, and found that recommendations ranged from 100 feet to 200 feet (ave. 154 ft).

Large woody debris retains adult post-spawner salmon carcasses within the channel, allowing these carcasses to contribute to overall stream productivity. Large woody debris provides a substrate for colonization by aquatic invertebrates, which ultimately become prey for salmonids. The debris also dissipates stream energy as water flows over and around it, reducing erosion, sedimentation and gravel scour. Such instream obstructions also introduce oxygen to the stream as water tumbles over the LWD. The debris helps to retain leaf litter from adjacent riparian vegetation. This leaf litter is broken down by invertebrates in the quiet backwaters formed and maintained by LWD. Finally, large woody debris provides migration opportunities in steep gradient streams by providing low-velocity rest areas and "stair-stepping," which reduces the local stream gradient.

A functional riparian zone does much more than provide LWD to the stream channel. Many of the elements that comprise good salmonid habitat (e.g., water temperature, bank stability, pool formation and persistence, stable spawning gravel, excess nutrient uptake, ground water recharge, etc.) are influenced by the riparian zone condition.

Stream water temperature is heavily influenced by riparian shading. To achieve adequate water temperature control, stream surfaces must have between 60% and 80% shade throughout the day. Cederholm (1994) found riparian buffers ranging from 35 ft to 125 ft provided that shading level. Mathews (1995) reported that a 100-foot "no harvest zone" is necessary for meeting shading requirements. Streamside shading was found to be less influential on streams greater than 50 ft wide. Figure V-6 provides a generalized illustration of the influence of riparian area width on stream conditions for western Washington forests (FEMAT 1993).

Wetlands provide a variety of direct and indirect benefits to wild salmonids. Fully functional wetlands perform the following functions:

- Reduction of flood peak flows (including stormwater runoff), maintenance of low flows.
- Shoreline stabilization (energy dissipation/velocity reduction).
- Groundwater recharge.
- Water quality improvement, including sediment accretion and nutrient/toxicant removal/retention.
- Food chain support (structural and species diversity components of habitat for plants and animals).
- Provide habitat for numerous fish and wildlife species including wild salmonids.

Natural Factors That Affect Riparian Areas and Wetlands

Riparian areas are defined as the interface between aquatic and terrestrial ecosystems. Riparian areas affect and are affected by the adjacent water source whether it is a stream, a wetland or a lake. There is a closely-linked relationship between riparian vegetation and ground water. Riparian and wetland vegetation is subject to natural disturbances such as fire, windthrow, landslides and floods. They are also subject to changes in global and local climatic conditions and to insect infestation.

Human Factors That Affect Riparian Areas and Wetlands

Past logging and stream clean-out practices, combined with shorter harvest rotations and conversion of forest lands to other uses, have removed much of the existing and potential LWD from the riparian zone. Riparian zone buffers were not generally required on Washington streams until 1988. As a result, in-channel LWD is less abundant now than in the past (Sedell and Luchessa 1982, Grette 1985, Bisson et al. 1987).

Freshwater and estuarine wetland habitat loss has been extensive in Washington State. Puget Sound and coastal wetland losses are estimated to be 40% and 70%, respectively, since European settlement. Diking, dredging, and urbanization have been the primary factors causing this wetland loss. Loss of wetland habitat has resulted in a significant reduction in available rearing and overwintering habitat for juvenile salmonids.

Environmental Considerations for Lakes and Reservoirs

Lakes and reservoirs are significant and ever-changing features of the landscape of Washington. The over 8000 lakes identified in the state vary widely in age and successional stage, origin, elevation, productivity, shape, hydrology and water quality, and in shoreline configuration and level of human development (Dion 1978). Some are nearly pristine and virtually unchanged physically. Others, typically low-elevation lakes such the Lake Washington/Sammamish system, have been extensively altered and developed with wholesale changes in inlet and outlet drainage systems. Many lakes have been manipulated in some fashion, usually for lake-level maintenance, flood control or hydroelectric power generation, and they are often equipped with control structures at their outlets.

The state also abounds with human-built reservoirs. Most have been converted from previously free-flowing stream reaches. They range from small impoundments to single large dam/reservoir structures up to entire river system impoundments such as the Columbia River system of hydroelectric dams. Some are designed to allow fish passage, while others completely obstruct passage or the passage facilities are inefficient or ineffective.

The Role of Lakes and Reservoirs in Salmonid Production

Lakes serve salmonids primarily as areas for feeding and growth, although they also provide spawning habitat as well. They also serve as migratory pathways between rearing and spawning habitats or as pathways between spawning and rearing areas. For example, adult steelhead trout and sockeye salmon migrate from Puget Sound through Lake Washington and into the Cedar River for spawning. The progeny of the sockeye spawners subsequently migrate as juveniles to the lake where they live a year or more prior to seaward migration, while the steelhead rear in the river and outmigrate as smolts from the river through Lake Washington to Puget Sound and the open ocean. Sockeye and kokanee use lakeshore beaches for spawning in areas where water upwells through the beach gravels or beaches where wave action provides oxygenated water to incubating eggs. In alpine lakes, cutthroat trout and others use inlet or outlet streams for spawning and short term rearing prior to lake residence.

Reservoirs are used by salmonids in much the same ways as they use lakes, although they are usually not as hospitable or productive as are natural lakes for the reasons discussed below.

Natural Factors Affecting Lakes and Reservoirs

A natural lake is basically an accumulation of water in a basin or depression on the earth's surface. Lake basins originate in a variety of ways, and their distribution and function in large part is dictated by their origin. Most of Washington's lakes were formed by glaciation (outwash or erosion) or by the riverine processes of streambank and bed erosion and subsequent channel abandonment during meander development. Still others were formed by geologic processes such as landslides (Britton et al. 1975). Because they are formed in basins or depressions of the land, lakes are effective "sinks" for sediments and other nutrients from upland sources, from airborne particulates, and are subject to natural variations in hydrology and weather. As with streams, the water supply of a lake is governed by the hydrologic cycle. Lakes may gain water from precipitation, from surface inflows such as rivers and streams, and from the subsurface flow of groundwater through seeps and springs (Britton et al. 1975, Baker et al. 1993). Materials that enter a lake from tributaries or from the atmosphere may settle in the lake basin, be removed through the outlet, or remain in solution within the lake. Those that remain in solution and that are required for plant production may be incorporated into living tissue.

The physical, chemical and biological systems of lakes are complex and interrelated. For example, sunlight penetrating the water triggers the growth of phytoplankton (floating, one-celled plants). If conditions are favorable, the phytoplankton become so numerous that they reduce light penetration. Reduced light penetration may not only reduce the rate of phytoplankton production, but it may also influence the rate of warming of the lake water by the sun.

Physical characteristics affecting lakes include light penetration, temperature, suspended sediment (especially from inlet streams and shoreline areas) and morphological attributes such as flow-through or retention time, maximum depth, mean depth, shoreline length, stage (the lake elevation at a given time), volume, and watershed drainage area.

Chemical constituents include dissolved solids (such as calcium and magnesium), gases (such as oxygen and carbon dioxide) and organic compounds. These chemical characteristics are very important from the standpoint of water quality. Under natural conditions these chemicals are related primarily to minerals in the surrounding rocks. Most, if not all, of the major chemical constituents are essential for the growth of plants. A variety of other chemical constituents exist in minor concentrations but may cause toxicity problems at higher concentrations.

Lakes support a great variety of bacteria, higher plants, and insect and fish species that can be placed into three broad categories: plankton (primarily drifters), benthos (bottom-dwellers), and nekton (swimmers). The biological relationships and interactions among these various groups of organisms must be considered for successful management of salmonids.

The movement and mixing of waters within a lake or reservoir are key factors in its suitability for various fish species (Baker et al. 1993). Significant events affecting lake productivity for salmonids are the fall and spring overturns that occur in lakes that are deep enough to maintain temperature stratification. Seasonally changing air temperature and wind are the primary energy sources that drive water movement and mixing.

There are many variations in the temperature cycle (Britton et al. 1975). In colder areas, the water freezes in the winter. Once the lake is frozen, circulation by wind action is prevented, and further loss of heat to the atmosphere is reduced. Many shallow lakes become stratified during periods of calm but may be completely mixed by moderate winds. This is particularly the case with shallow lakes of small surface area. Other lakes are continuously mixed and thermal stratification never occurs. In contrast, some larger deeper lakes with limited surface area and limited exposure to winds may mix once a year or not at all.

This temperature stratification allows adaptive use of the stratified layers by cool-water species such as salmonids and their prey base species. For example, lake temperature and temperature stratification affect the daily and seasonal feeding behavior and depth preferences of sockeye salmon in different lake environments, with both adults and juveniles residing at or near the thermocline (Burgner 1987). Brook trout and cutthroat trout occur most commonly in high elevation lakes and are relatively intolerant of warm water, and they seek out cooler temperatures in the hypolimnion when surface waters heat up during the summer (Wydowski and Whitney 1979).

In addition, this pattern of fall and spring overturn and mixing of lake waters brings nutrients to the upper levels of the lake, stimulating growth and production of phytoplankton and zooplankton, many of which serve as prey for salmonids.

In a geologic sense, lakes are temporary fixtures of the landscape, subject to change due to the constant introduction of sediment and nutrients. Lakes fill with sediment and organic material, transitioning to wetlands and finally to upland forests or grasslands. This aging process is called eutrophication and is a useful way of categorizing lake productivity. Young, clear, nutrient-limited lakes are classified as oligotrophic; intermediate-successional lakes are considered mesotrophic; older, sediment- and nutrient-laden lakes are classified as eutrophic; and the lake in its final bog or wetland state is considered dystrophic. Since salmonids require cool temperatures and high levels of dissolved oxygen, they occur most often in oligotrophic or mesotrophic lakes.

Human Factors Affecting Lakes and Reservoirs

Human impacts on lakes can be short-term and dramatic or long-term and subtle. The most pervasive human effect on lakes is accelerated eutrophication due to increased sediment and nutrient delivery. Most lakeside residents are not served by public sewers and most have substituted ornamental shrubs and grasses for dense and abundant native vegetation. Fertilizers and septic systems add nutrients to the water body, particularly nitrogen and phosphorus, and can lead to explosive growth of aquatic weeds, phytoplankton and zooplankton. In addition, many exotic weeds such as Eurasian milfoil have been inadvertently introduced to our lowland lakes. These exotics displace native plants and, where accumulations are so great they can foul boat motors, create unsafe swimming conditions and significant water quality concerns (especially low oxygen levels) as they die off. Some algae, especially the blue-green algae (Cyanobacteria), produce toxins that can affect the health of pets, wildlife and humans.

Secondary effects on lakes occur when lakefront property owners press for chemical treatment to control these nuisances. For example, copper sulfate, a commonly prescribed treatment chemical has been shown to affect salmon smoltification, migratory capability, and early marine survival (Wedemeyer et al. 1980). Further, the repeated treatment of many lowland lakes with chemicals, often over decades, leads to build-ups of these chemicals in lake sediments well beyond levels known to adversely affect salmonids and other aquatic biota.

Other lake-related issues affecting salmonids include unnaturally high or low flows in outlet streams due to lake level manipulations, outlet water quality problems due to excessive nutrient loads in the lake, inefficient or inadequate fish passage facilities at lake outlet structures, and sedimentation, filling or dock construction at nearshore upwelling spawning beaches used by salmonids. Sedimentation of spawning beaches in Lake Ozette has been identified as a principle cause of the near total loss of the beach-spawning population of sockeye salmon (McHenry et al. 1996). Alteration of groundwater quantity and quality due to upslope development may also affect these lakeside spawning habitats. Inlet streams may be affected as well. Loss of access to inlet spawning streams or degradation of spawning habitat may severely affect the production of salmonids in lakes.

Reservoirs are a mixed blessing. On the one hand they provide significant fishing opportunity, particularly for planted hatchery fish. But on the other hand, they present fish passage, water quality and quantity, predation, and habitat simplification problems for wild salmonids. In addition, reservoirs placed in formerly free-flowing reaches inundate and destroy spawning habitat. The reader is directed to several excellent summary documents for additional detail (Independent Scientific Group 1996, CRITFC 1996, Baker et al. 1993).

Marine Areas

Washington State has approximately 100 diverse estuaries within 14 regions, exhibiting structural, hydrological and biological diversity (Simenstad et al. 1982). As with freshwater habitat, salmonids have evolved their respective life histories around these patterns of estuarine development. Estuaries are critical transition areas where seaward-migrating smolts adapt to seawater and returning adults prepare to enter spawning streams.

The Role of Marine Areas in Maintaining Anadromous Salmonids

Anadromous salmonids pass through estuarine habitats during their migration to the marine environment. Intertidal and subtidal areas provide productive foraging areas, opportunities for physiological transition from fresh to marine water (Wedemeyer et al. 1980), and protection from predators. Fall chinook, chum, and pink salmon juveniles and anadromous cutthroat appear to make the most extensive use of nearshore shallow water estuarine habitat (i.e., the area from ordinary high water waterward to -10.0 feet- Mean Lower Low Water = 0.0 feet). Residence times for chinook and chum often exceed one month for individual fish, while cutthroat may spend several months in the estuary (Simenstad et al. 1982, Thorp 1994). Salmonid growth is especially rapid in the estuary. Pink and chum salmon juveniles can double their body size during their short stay in estuary rearing habitat.

In addition, this habitat comprises spawning habitat for many important species of marine fish, some of which serve as prey for salmonids.

Natural Factors Affecting Marine Areas

Estuaries are similar in many respects to lakes in that they are "sinks" for the variety of upland and riverine processes we described earlier. Estuaries are dependent upon natural rates of sediment and large woody transport and freshwater inflow to sustain conditions amenable to support salmonids and their prey bases. In addition, nearshore processes such as wave erosion and bluff failures at natural rates provide sediments to replenish those lost to nearshore sediment transport and provide an additional source of large woody debris to marine areas. As in freshwater, LWD plays an important role in providing structure and nutrients to marine habitats (Maser and Sedell 1994).

Human Factors Affecting Marine Areas

Estuarine rearing habitat has been lost or modified to accommodate development along rivers and bays. Palmisano et al. (1993) estimated that 39% of the coastal wetlands and 70% of the Puget Sound emergent wetlands have been lost, particularly in urban areas as a result of bulkheads, fills, and dredging. These alterations affect prey resource production, reduce the amount of habitat available to salmonids, and introduce toxic substances that kill prey organisms (Simenstad et al. 1982). In addition changes in flow timing, duration and magnitude affect estuarine salinities, which alter prey bases (Columbia River example) and affect the timing of adult entry into streams. There is also a concern that reduced amounts of LWD may have an effect on marine productivity (Maser and Sedell 1994). The effect of accelerated or retarded sediment transport is also of concern. Tidal surge plains, those areas above salt water influenced by tides, have also been extensively altered by filling and diking. Most major river mouth habitats have been simplified and consolidated to accommodate navigation. This precludes development of functional riparian areas and access to off-channel sloughs and wetlands. Overwater structures such as piers and docks pose a risk to migrating juvenile salmonids which, in order to avoid the heavily shaded areas, must move into deeper water where they are prone to increased predation.

Environmental Considerations for Fish Access and Passage

Physical barriers interrupt adult and juvenile salmonid migrations in many parts of the state. Persistent blockages deny access to critical spawning and rearing habitat. Loss of access to habitat will reduce overall salmonid productivity and may result in loss of salmonid populations.

Fish passage is affected by and related to all the previous habitat components. Basin hydrology and instream flow are obvious fish passage parameters. Less obvious are the attributes of water quality and sediment delivery and transport, riparian areas, and lakes and marine shorelines. Fish passage, in the sense of the presence of adult salmonids, especially spawners, also affects water quality, aquatic productivity, riparian vegetation, and spawning gravel quality.

Fish Access and Passage Issues Affecting Salmonids

Most salmonid species use several different habitats during the freshwater phase of their life. Adults of anadromous species generally migrate from marine waters to pre-spawning holding habitats (usually low-energy areas like pools, LWD complexes, lakes), then on to the natal spawning streams and reaches. Resident salmonids may make similar spawning migrations within the freshwater system (e.g., from large streams and lakes into small tributaries for spawning). Access to spawning habitat can be an important limiting factor for salmonids that rear in freshwater. Young salmonids rear in areas they can reach as emergent fry with limited swimming ability. If salmonids are to occupy all available rearing habitat, many adults must spawn at the upper limits of the watershed. Thus, accessible, high-quality spawning habitat is required in the headwaters of watersheds for certain species.

Juvenile salmonids may make additional instream migrations during their freshwater residence. The migration may be directly back to marine waters after emergence from the gravel (pink and chum), up- or downstream to a lake for rearing (sockeye), or to habitats in the vicinity of the spawning reaches for additional rearing before embarking on further migration. Juveniles that have a long freshwater residence may migrate from one stream to another, from one habitat type to another (river to off-channel pond), or more typically, from a stream's upper reach to its lower reach.

Timely completion of these migrations is necessary for salmonids to survive critical stages of their life cycle. Migration patterns are usually a response to food supply, habitat condition and/or habitat availability, and have evolved to maximize the salmonid's opportunity for survival.

Fish passage requirements for salmonids are unique to the species present, the life history stage of the fish and site conditions. Chum salmon and grayling are generally unwilling to jump barriers. A relatively small elevation drop can block the upstream migration of these fish. For example, the desired drop between fishway pools is 1.0 ft for most adult salmon and trout, 0.75 ft for chum, and 0.25 ft for grayling (Bates 1992). There are a number of fishway facility types that provide adult fish passage, each with different applicability and design criteria. Upstream juvenile passage is important for anadromous and resident species that utilize several habitats while in freshwater; Dolly Varden/bull trout, coho, and spring chinook are good examples. Gradients of 7% or less and broken flow are needed for upstream juvenile passage, with hydraulic drops not greater than 0.7 ft for fry (45-65 mm) and 1.0 ft for fingerlings (80-100 mm) (Powers 1993).

Natural Factors Affecting Fish Access and Passage

Fish access and passage can be affected by a myriad of natural factors. Most obvious are natural physical barriers such as Snoqualmie Falls. However, velocity and height barriers at rapids and cascades or unbroken reaches of high gradient may preclude all but the most powerful swimmers from access. Other forms of migration barriers are low flows (at times exacerbated by high sediment deposition), some LWD jams, high temperatures, and high suspended sediment loads. At times, what would present a barrier at one flow may provide passage opportunity at a higher or lower flow.

Human Factors Affecting Fish Access and Passage

Even the best salmonid habitat is of little value to fish if access is blocked. Impaired fish access is one of the more significant factors limiting current salmonid production in many watersheds. Today, in addition to major dams, most new fish blockages are caused by culverts, bridges, small dams, fords and other man-made instream features. The WDFW estimates that up to 3,000 miles of anadromous habitat are no longer accessible to salmonids due to impassable culverts at public and private road crossings alone.

Salmonid access to off-channel rearing habitats can be affected by land-management actions. Urbanization has blocked fish access in some areas to off-channel ponds and sloughs through public and private road construction and flood control projects. Significant off-channel habitat was filled or drained to create agricultural lands or urban building sites. Forest practices have destroyed off-channel habitats or blocked the access to them by road construction and timber harvest within the habitats. Passage into and out of many estuarine areas has been compromised or lost due to installation of tide gates or improperly installed culverts.

The productivity of spawning and rearing habitats, as well as specific stocks of salmonids, may be impaired or eliminated due to downstream migrant juvenile mortality. The most common sources of juvenile migrant mortality are diversions from the stream system due to unscreened or inadequately screened water withdrawal structures, and passage through water use structures such as hydroelectric turbines. Most major water withdrawal or diversion structures are now screened if their stream sources are used by anadromous salmonids.

Adequate screening of turbine intakes at hydroelectric dams, particularly on the mainstem Snake and Columbia Rivers, has not yet been completed despite more than two decades of research and development. Passage of controlled volumes of water through project spillways has been used to provide partial mitigation for inadequate turbine intake screening systems. Controlled spill programs have proven effective in safely passing those juvenile migrants which are able to use this passage route. Juvenile migrant passage survival in mainstem dam spillways is generally greater than or equal to 98%.

Irrigation diversion screens in the lower Columbia and Dungeness River basins are being upgraded to meet agency criteria where anadromous salmonids are present. This screen upgrading is being conducted through ongoing state, BPA, and federal programs. In basins where irrigation diversion screening requirements are not applicable (e.g., where water diversions were in-place before resident fish screening laws were enacted), significant loss of resident salmonids is still occurring.

The practice of screening outlets at many lakes to retain planted fish for put-and-take trout fisheries, and ponding streams to promote wildlife use is also being reexamined. In addition to precluding adult or juvenile passage, the control structures on those lakes contribute to summer low flow problems in the outlet streams. In other cases, outlet flow control for flood control or aesthetic purposes causes similar migration and water quality problems.

Environmental Considerations for Habitat Restoration

Any strategy designed to maintain or recover salmonid populations should have as a basic underpinning meaningful protection of existing habitat. But it should be no surprise to an informed citizen that we have lost significant habitat in our streams, lakes and estuaries. It may not be as clear to that person that much of our remaining habitat is in a degraded state. And it is even less clear to most citizens how difficult, if not impossible, and how expensive it is to recover or restore habitat. However, examples abound of the extreme cost of habitat restoration. Scientific journals and lay publications are replete with case studies and admonitions about the pitfalls of poorly planned habitat restoration projects. Continual restoration of unmitigated impacts to wild salmonid habitat is undesirable, often ineffective and the most costly means to achieving salmonid population recovery; in the long run salmonid populations are best protected by ensuring habitat protection.

That notwithstanding, given the current condition and diminished extent of salmonid habitat and since so many salmonid populations have been lost, it is clear that restoration of habitat should be a significant part of any population recovery strategy. Numerous reports and studies have addressed recovery strategies. Some have worked, some have failed miserably, and some are yet to be evaluated.

However, there is fair agreement on guiding principles for successful recovery planning, implementation, monitoring and evaluation. They include the following:

A. Successful restoration requires competent analysis of watershed processes and identification of limiting factors.

B. Funding for restoration activities is limited; funding is enhanced where partnerships exist, where there is local support, where restoration is included in a larger project context (i.e., flood damage reduction plan, water storage and release strategies), where restoration is part of a completed overall land use and/or watershed plan, and where restoration of wild salmonid habitat contributes to improved wildlife habitat and other societal benefits, such as aquifer recharge for drinking water, flood damage reduction, improvement of soil fertility, and maintenance of rural economies.

C. Restoration is more likely where dedicated fund sources are sufficient and stable.

D. Restoration projects are facilitated by regulatory processes (permits) which are coordinated, timely, consistent and affordable.

E. Restoration is most successful when contemporary technical information and guidance is available to the public.

F. Active participation in or support of watershed restoration fosters an environmental ethic, improved land stewardship, support for habitat protection and increased support for additional restoration.

Environmental Impacts of the Alternatives

Recovery of salmonid habitat will be a daunting, time-consuming, expensive task (NRC 1996, Independent Scientific Group 1996). It will require recognition and understanding of the frequency, magnitude, and duration of natural and human disturbance. It will also require interpretation of what was (i.e., "natural" conditions), an understanding of the positive roles of disturbance, and agreement on what is or is not possible or feasible in a restoration strategy (Naiman et al. 1992, Lichatowich, et al. 1995, Stanford et al. 1996, Spence et al. 1996).

Although some fairly extensive habitat inventories have been made in selected areas (e.g. Columbia River basin sub-watersheds, Puget Sound marine waters), no completely accurate or quantified inventory of historical or existing habitat is available for comparison over time. Most of the extensive major losses of habitat have probably already occurred due to early settlement and development of our major cities, land and water transportation networks, port facilities, agricultural and commercial forest lands, and power generation facilities. It can be argued that since so much habitat has been lost already, the potential for losing habitat in the future should be less. Unfortunately this is probably not the case. The pace of change in Washington State continues and the pressure on our habitat base will continue. The probable differences between historical and future habitat loss and degradation will likely be in the type and distribution of land use and land activities which affect habitat and in the increasing demand for water and power.

Population growth and a changing economic structure will stimulate most of these changes. Our population has gone from about 1 million people in the early 1900s to over 5 million today, and is expected to reach 7 million by 2020. Power (1995) observed that Washington State's economy is changing from one dependent on timber and aerospace to one that is more balanced, diversified and resilient; the extraction of raw materials is no longer the driving force.

All the policy alternatives, including Alternative 1, will likely lead to some improved habitat protection and restoration.

However, all the habitat alternatives will likely also result in additional habitat loss, degradation or fragmentation. Even under the best applied land-use scenarios, in order to accommodate the growth that is anticipated for our state, more forest and agricultural land will be converted. The state Growth Management Act (GMA) requires that most new growth locate in areas already characterized by urban densities. This will result in increased loss of habitat through such activities as increased culverting to accommodate roads, or habitat degradation directly through the cumulative impacts of stormwater run-off and other pervasive impacts on water quality due in large part to non-point sources, diminished riparian area function and extent, loss of LWD, and the frequent dredging and bank hardening projects that are typical in urban settings.

GMA also requires that forest and agricultural lands of long-term commercial significance be protected over the long term. Some counties have done a creditable job with this, others have not, still others have not completed the process. However, GMA critical areas ordinances usually do not apply to activities on existing agricultural lands, nor do they apply to existing development. The ordinances are usually invoked at the time of a new development application. The pattern in the Puget Sound counties has been to reserve those forest lands that occur in areas of higher elevation, steeper terrain, not generally suitable for development (King County 1994, Pierce County 1996, Thurston County 1995). This puts increasing pressure on salmonid populations in the lower elevations, which will be developed for rural residential or urban densities. Unfortunately, the lower elevation areas, which contain some of the most productive forest land (i.e., Kitsap County 1996) also contain many of the most productive salmonid populations, particularly anadromous fish.

Through the Timber, Fish and Wildlife process, significant changes to forestry practices have been made to address salmonid needs. However, the effects of timber harvest rates and patterns in the 1970s and 1980s will continue to be realized for decades to come. Riparian area buffers requiring some trees to be left were not formalized into state forest practices rules until 1987. Prior to that, most streams were logged down to the water's edge, or buffers which were left were alder-dominated. It will take many decades for these riparian areas to regain the vegetation composition and size necessary for healthy habitat, particularly for LWD recruitment. Streams channels that were scoured to bedrock may take hundreds of years to recover. It may also take decades for harvested basins to attain hydrologic maturity. Road systems, many of which were poorly located, constructed or maintained, will continue to contribute fine sediments to streams. Some will fail, causing massive impacts to stream channels. Others will develop barriers to fish passage because of culvert problems.

The state's expanding population will need water to drink, irrigate their lawns and agricultural crops, and provide electricity for homes, businesses and industries. The Department of Ecology has determined that about half the state's area now has insufficient water to support all the needs of people, plants and animals. This could be reduced by improved conservation and reuse and provision of additional storage.

Without some significant changes, agricultural activities will continue to affect salmonid habitat. Most agricultural activities are exempt from riparian buffer requirements or other critical areas protections required under GMA. There will be a continuing effort to maintain drainage in agricultural land through stream dredging and/or dike construction and maintenance. In many river basins, irrigation water withdrawals severely deplete stream flows. Agricultural runoff and farm waste disposal will also continue to be a problem for salmonid streams. State and federal programs administered by conservation districts have been providing technical and financial assistance for salmonid protection to many farmers. The Department of Ecology has a dairy-waste control program and has levied large fines in several instances.

Marine areas will continue to be affected through alterations such as navigational channel dredging, or indirectly through accumulations of contaminants within marine sediments. In Puget Sound, the majority of marine shorelines outside urban areas are held in private residential ownership. This places enormous pressure on inherently unstable marine shorelines and bluffs. One can anticipate increased slope failures as the remaining sites are built and expect increased efforts by landowners to protect their property. Often the protection is directed at the bottom of the slope in the form of bulkheads, although many of the failures are the result of bank and bluff failures, not erosion per se (Canning and Shipman 1994). Significant bulkheading has already occurred. For example, Canning and Shipman (1994) report that a recent survey in Thurston County indicated that the number of shoreline parcels armored (bulkheaded) increased by 78 per cent over the past 15 years.

Impacts of Alternative 1

1.1 Natural Environment

Under Alternative 1, the "No Action" alternative, the following impacts would generally be expected for the natural environment:

A. Basin Hydrology and Instream Flows - In the areas outside of Urban Growth Area (UGA) boundaries of individual cities and towns, basin hydrology and instream flow conditions in watersheds would probably remain the same or continue to worsen because of timber harvest and agricultural practices, continued conversion of agricultural and forest land to rural residential uses, resistance to maintenance or reestablishment of floodplain connectivity and function, and failure to establish or actively enforce instream flow programs. Lake and marine processes could be affected because of altered hydrological conditions due to watershed condition and upstream withdrawals. Mainstem Columbia River flow conditions could improve independent of this policy effort because of other planning and implementation processes. Existing licensing agreements at most other large dams would probably preclude provision of adequate flow conditions for salmonids.

   Some improvement in basin hydrology and instream flows would be expected, however, due to increased efforts by landowners and regulators to employ watershed analysis and site specific prescriptions to these lands. For example, the Timber, Fish and Wildlife forum is beginning an analysis of existing riparian area protection rules (including those affecting streamflow) for state and private lands, and Habitat Conservation Plans are in place or continuing to be developed (which in some cases would include stream and riparian area protection by addressing stream flows). The President's Forest Plan for westside forests will improve watershed hydrological conditions as well. Water conservation strategies are being developed by water users.

   Within UGAs, basin hydrology and instream flows would probably continue to worsen; protection measures have not been proven to be entirely successful at attenuating peak flows and there is little evidence that maintenance of minimum summer flows is attainable with current stormwater management technology. Flood plain connectivity and function would continue to be severely compromised. Groundwater aquifer recharge would be restricted because of high percentages of impervious surfaces and concern about aquifer contamination by urban runoff. Restoration of suitable hydrologic conditions for salmonids in urban streams is problematic; it would require significant and very expensive retrofitting of existing systems.

B. Water Quality and Sediment Quality, Delivery and Transport - Water and sediment quality and sediment delivery and transport are interdependent with basin hydrology and instream flow issues. Outside of UGAs, water quality and sediment delivery and transport processes would continue to be compromised by timber harvest activities, particularly due to road surface erosion and road failures. Some improvement would be expected, however, due to increased efforts by landowners and regulators to employ watershed analysis and site specific erosion and sedimentation control prescriptions to these lands.

   Agricultural practices, including crop production and livestock grazing, would likely continue to aggravate existing water and sediment quality and sediment delivery and transport processes, although significant efforts are underway or proposed to remediate existing conditions. Water withdrawals will continue to exacerbate poor flow conditions for stream temperature and dissolved oxygen, particularly in the ecoregions of eastern Washington. Some improvement on state lands are expected by application of the Ecosystem Standards for State-Owned Agricultural and Grazing Lands.

It is unlikely lowland lake water quality conditions will improve appreciably, given the high residential densities along the shorelines and dependence on site-specific septic systems. Marine water quality may be improved somewhat. In Puget Sound, this would likely be due to efforts under the Puget Sound Water Quality Action Team Work Plan, however, physical nearshore alterations (proliferation of bulkheading, increased vegetation removal and slope failures, navigation channel maintenance, etc.) will likely continue to compromise natural shoreline processes affecting salmonids and their prey base species.

High rural residential densities, particularly along stream corridors, lake and marine shorelines will continue to contribute to water and sediment quality and sediment delivery and transport issues. Water quality will be compromised by on-site septic systems and degradation of wetlands and riparian buffers. Sediment delivery and transport will be affected, usually during site development, and often in response to natural processes of slope or shoreline erosion - which in the absence of homes, out-buildings and other improvements would be of little concern. A predictable pattern of bank hardening, channel dredging, wetland drainage, large woody debris removal, and channel realignment invariably occurs after forest and agricultural lands are divided into smaller and smaller parcels for rural residential development.

Within UGAs, similar patterns of diminished water and sediment conditions will likely result, except that the impacts will be generally more severe, more frequent and more long-lasting. The difference is that in agricultural and forest lands the impacts have longer recurrence intervals and recovery is more likely. For example, at a forest rotation age of 45-60 years, many functions of riparian areas are reestablished and hydrological conditions are generally restored. But within urban areas, recovery to predisturbance conditions is not usually possible. Spills and other stream contamination due to point and non-point discharges will likely worsen.

C. Stream Channel Complexity - The combination of the physical processes of basin hydrology and sediment routing and how they affect water quality, coupled with riparian area condition, will continue to have an impact on stream channel complexity. Maintaining or establishing channel complexity related to connectivity and function of floodplains with the channel proper will remain a problem. Finally, transportation systems, impoundments and operations for hydropower generation, water supply, flood control and recreational/ residential developments will continue to affect stream channel complexity. Both inside and outside of UGAs, stream channels will generally continue to lose complexity due to altered hydrology, current patterns of timber harvest, agricultural practices, conversion of these lands to rural residential densities, and the activities of both rural and urban residents. Within commercial forest lands, there may be some improvement related to new rules designed to protect riparian areas. However, mainstem rivers, particularly those near ports and urban areas, will likely remain channelized, disconnected from their floodplains, dredged for navigational purposes, and generally picked clean of large organic debris. Riparian areas near most rural and urban residences will be subject to a litany of abuses, such as loss or degradation of riparian corridors, channel realignments, road crossings, disconnection from floodplains by diking or channel downcutting, and a propensity to remove most instream woody debris from channels, ostensibly for flood control, for beautification and often as a source of firewood. Sedimentation will affect aquatic insect production, decrease substrate hiding cover and reduce pool volume; all affecting salmonid survival and growth.

As above, full or partial recovery of stream channel complexity is more assured when lands are less fragmented and when land use is forestry, agriculture or large lot rural residential. Some counties have done a creditable job under GMA to retain forest lands and maintain or restore floodplain and riparian functions. Others have not, continuing to rely merely on on-site mitigation such as minimal protection under critical areas ordinances, rather than protecting these areas through land use allocation. Others have not completed the process.

D. Riparian Areas and Wetlands - Riparian areas are influenced by and influence the aquatic zone. If the riparian area is intact, but basin hydrology, instream flows and sediment delivery and transport are not within levels of natural variability, the riparian area alone will not protect the stream. An intact riparian area is of little value (at least in the near term) if the stream has been scoured to bedrock, or if the channel has been overwhelmed by sediment. A riparian area will be degraded or lost if instream flows are too low, or if the channel has incised to a point below normal groundwater levels.

Existing riparian area conditions may improve somewhat due to implementation of critical areas ordinances and changes in forest practices on state, private and federal lands, and changes in grazing standards on state lands. Riparian conditions will improve slightly on private agricultural lands through incentive-based programs involving cost-sharing and technical support.

Wetlands protection and restoration has received considerable attention in Washington, and one can expect some improvement in wetlands extent and function under the no-action alternative. However, most wetlands programs are too narrowly focused on mitigation for activities on existing or proposed land uses, not on fundamental avoidance by applying land use zoning. As with riparian areas, protection of wetlands function and extent requires basin-wide attention to hydrology, instream flows, sediment delivery and routing, and flood plain connectivity.

E. Lakes and Reservoirs - Lakes and reservoirs are specific habitats of concern identified in this policy effort. Their protection and restoration are fundamentally tied to the physical processes described previously. Most lowland lakes will continue to be subjected to incredible development pressure. Although significant attention has been directed towards lakes, most action has been related to improving the aesthetics and human safety problems as opposed to maintaining or improving salmonid habitat. Given the current pressures and attitudes towards these issues, it is unlikely habitat conditions will improve and they may be further degraded. Reservoir conditions in the Columbia and Snake Rivers may improve as a result of changing operations of the hydropower system.

F. Marine Areas - Marine area habitat issues are specifically identified as well. Their protection and restoration are fundamentally tied to the same physical processes. Most marine areas, particularly in Puget Sound, will continue to be subjected to incredible development pressure both within and outside UGAs and marine habitat will continue to be lost or degraded. Again, the typical response of most planning and permitting agencies is to allow intense development along our marine shorelines, relying solely on mitigation techniques to lessen the habitat impacts. Most marine shorelines are inherently unstable; primarily due to upslope soils and steepness, secondarily because of toe erosion from waves or currents. Most relatively stable sites have been developed, yet construction permits are still being issued at a rapid rate. Slope failures will continue to affect shoreline habitat. Bulkheading, often ostensibly to prevent shoreline erosion, will continue to proliferate as property owners react to these physical processes.

   Our expanding economy continues the drive by our port authorities to expand existing or create additional shipping facilities. Habitat, severely degraded or relatively unimpacted, is and will continue to be at a premium for development. Off-site out-of-kind mitigation has been proposed for marine habitat loss when, unfortunately, these marine habitats are critical for salmonids and their prey base species and almost impossible to recreate.

   In other less developed marine and estuarine areas, particularly Grays Harbor, Willapa Bay and the Columbia River, there may be opportunities to reclaim upper intertidal areas and wetlands by breaching or removal of agricultural dikes. Navigational dredging and water quality issues due to contaminated sediments will continue to pose risks to salmonids.

G. Fish Access and Passage - Fish access and passage is affected by a myriad of human-related action and activities: mainstem Columbia/Snake hydropower operations, impoundments on other medium-sized rivers, run-of the-river permanent and temporary diversions, flow control and lake level maintenance structures, stream crossings, tidegates, regulated flows, water diversions, altered basin hydrology, altered sediment delivery and transport, etc. Again, there is considerable interdependence among these issues. For example, adult passage conditions made difficult by low summer flow volume may be further exacerbated by water withdrawal, by excessive sedimentation which creates multiple channels for the already reduced flow, by a difficult jump into a culvert with too little depth and too high a velocity, and by water too high in temperature and too low in dissolved oxygen.

   Fish need to avoid stranding as well. Stranding can occur in numerous ways: by flow reduction or increase, by diversion into irrigation ditches and water conduits (water supply, hydropower generation), by ship wakes, by channel shifting and abandonment, and by channel maintenance.

   Therefore, the environmental impact of this alternative on fish access and passage depends on how well the physical processes and habitat types discussed above are addressed, how adverse passage situations are avoided and how passage at structures is provided and maintained. It is likely fish passage and access will continue to be a serious problem for the foreseeable future. On the positive side, WDFW has entered into agreements with cities and counties to correct these problems, but it is expected, given available funding, that this may take decades. Designing, building and maintaining culverts to ensure fish passage is an inexact science, yet we continue to expand transportation systems - public and private - into more and more areas and rely again on mitigation techniques rather than avoiding the problem fundamentally through land use allocation, shared road systems, etc.

Fish screening at run-of-the-river diversions will improve under this alternative. Considerable funding has been provided, particularly for the Columbia Basin Ecoregion, to construct juvenile bypass systems. Adult and juvenile passage on the Columbia and Snake River mainstem will be addressed with or without this policy in place. Resolution of passage issues at other larger facilities in the state depends in large part upon federal licensing conditions.

1.2 Built Environment

As described earlier the existing patchwork of regulations and programs affect many land and shoreline use activities under Alternative 1.

Local ordinances that protect natural resources exist in different combinations in most, if not all cities and counties, at varying levels of protection. For example, King County has enacted a strong natural resource protection strategy into ordinances. There is a sensitive areas ordinance that is designed to protect critical habitats by requiring buffer widths. Habitat outcomes for this alternative are unclear. This approach most closely fits the definition of "bottom-up" or collaborative planning and is likely to be more readily accepted locally than Alternatives 2-4. However, there is no method of evaluating whether performance measures or action strategies developed under this alternative will adequately protect or restore habitat.

Alternative 1 would impact most, if not all, land and shoreline uses described earlier but those impacts cannot be determined because the actions have not yet been determined. Land and shoreline users participating in existing processes like Timber, Fish and Wildlife would probably be affected initially. This is because some land and shoreline uses do not have ongoing forums to address natural resource issues. Agriculture is one example of a group of land users for which there is not a regional forum to address natural resource concerns.

This can result in developers, commercial and residential, being required to downsize, redesign or delay their proposal, or in some cases not do the project. For example, a developer desiring to locate a new residential development along the Cedar River will have to include setbacks from the river that would eliminate a potential row of houses. They may have to redesign the plan to include stormwater controls. They may not be able to change or stabilize the river bank as desired, build roads or bridges as desired, or even may not be able to locate the development within the floodplain.

A farmland owner may be required to install fencing along each side of streams and wetlands to prevent or limit animal access. A residential landowner may not be able to add a garage on their property because the proposed site is a wetland. A sand and gravel operator may not be able to expand their gravel pit or even continue present operations.

Many other counties have a lower level of protection than King County, or in some cases, no protection at all. The Growth Management Act requires major cities and counties to develop plans that include protecting natural resources; some have not completed these plans. Smaller jurisdictions are not required by state law to do this although some have done so. The Shoreline Management Act, administered by local governments, requires many developments or activities that are located on the water or shoreline to be reviewed for environmental impacts.

The NPDES program is administered by the Washington Department of Ecology and requires compliance with standards for industrial water discharges through the Clean Water Act. New projects may not go forward if they are not expected to comply with the standards; existing industrial users are required to come into compliance within a specific time frame.

For examples, pulp and paper industries are being required to reduce the levels of toxics discharged in wastewater in order to continue operation; in many cases the companies are given lengthy periods to achieve the standards, frequently involving costly new designs and technologies. Fish hatcheries and aquaculture operations are required to have water discharges comply with permit requirements. Transportation systems are required to get NPDES permits, especially to assure stormwater does not reduce water quality. Sewage treatment plants and municipal water systems are also required to comply with the standards. Large livestock farmers are required to get a NPDES permit and be in compliance. In Columbia County, a rancher installs fencing and plants willows and alders along the stream banks using a mix of his own money and state funds through the local Conservation District. The Forest Practices Act is a state program and requires a permit for most timber harvesters that includes a harvest plan: road accesses, tree removal methods and timing, riparian management zones (buffers), chemical applications, land conversion planning links with local government, and many other aspects of timber operations are some of the issues covered by the permit. The Timber, Fish and Wildlife forum provides a process to address fish and wildlife issues in the forest.

The FERC re-licensing process requires most hydropower dams to upgrade their facilities to comply with state and local requirements for fish and wildlife before issuing a new license. Because these licenses last for long periods, up to 50 years, addressing the needs of salmonids at all dams will be a slow process. One of the longer, more complicated re-licensing efforts is the Cushman Project (Cushman and Kokanee Dams). Key issues include flow being diverted out of the north fork of the Skokomish River and fish passage needed for salmonids. The City of Tacoma, owner of the facility, has indicated that they may not be able to afford to continue operation and comply with fish protection needs.

The Army Corps of Engineers require permits for projects that require dredging , filling, or placing a structure in waters of the United States (includes wetlands, rivers, etc.). For example, the siting and design of Auburn Downs was limited by wetland considerations in the Army Corps Permit. A proposed garbage dump site for the City of Tacoma has been denied through this permitting process.

The Hydraulic Project Approval act requires that any activity that will use, divert, obstruct or change the natural flow or bed of any of the salt or freshwaters of the state will require a permit from the Department of Fish and Wildlife to ensure protection of fish. For example, a citizen wishing to build a dock, bulkhead or boat ramp on a lake or marine shoreline is required to get a permit before construction. Construction along shorelines is not allowed during the peak juvenile salmonid migration. Another example is that gravel removal operations in or connected to waters of the state must receive a permit before removing any gravel. Marina development and expansion are subject to permit requirements. Bridges, culverts, sewer lines, and other water body crossing structures used by individual citizens or large municipalities are required to get a permit before proceeding.

The right to withdraw water is formalized by getting a water right from the Washington Department of Ecology. For example, a private landowner who wants to divert a portion of a stream out of the stream channel to irrigate should have a water right. There is a seniority to individual rights with those the most senior having precedence over younger ones. Likewise, large water withdrawals by irrigation districts, industrial users, aquaculture businesses, and municipal water systems are subject to the requirement of having a water right.

The range of impacts on land and shoreline uses include requiring design changes and site limitations for new projects, extending timelines for completion, denial of selected projects, requiring new technologies to continue to operate, and requiring operational changes that add costs and lower profits.

Why do we have wild salmonids stocks being listed under the Endangered Species Act with all these programs? It is because they are a patchwork of programs with lots of holes. The effectiveness of many of the programs is constrained by lack of comprehensiveness, and staff and financial resources (especially enforcement resources). In some programs, many permit applications are analyzed without even visiting the site. Those sites that are visited seldom have a post-project completion visit. Many watersheds and marine shorelines are not covered by many of these programs.

Impacts of Alternative 2

<u>2.1 Natural Environment</u>

Same as Alternative 3 with some exceptions. For example, accelerated timber harvest and conversion of forest lands to avoid restrictive regulations could cause a short-term decrease in water quality due to road construction and site development. Existing riparian area and wetland conditions would improve dramatically across all ecoregions and land uses with the full implementation of the riparian buffer standards, although there may be accelerated harvest and conversion of forest land in the short term before more restrictive regulations were in place and actively enforced.

<u>2.2 Built Environment</u>

In an idealized world, the ultimate impact to the environment for Alternatives 2, 3 and 4 - if the performance measures and action strategies were fully implemented in good faith - would be the same. This is because the performance measures and action strategies are the same. The difference between Alternatives 2, 3, and 4 lies in the implementation approach - how flexible the performance measures and action strategies are for local adaptation, and what constitutes the best blend of regulatory/watershed-based/incentive-based methods to address the problem.

Regardless which one of the alternatives (2,3, or 4) we might select, if fully implemented, each differs from Alternative 1 (No Action) and from Alternative 5 by virtue of its specific and, when available, quantified performance measures.

However, numerous comments were made in the public meetings, public hearings and written submittals that if Alternative 2 was selected there would be an environmental backlash. For example, many forestland owners indicated they would take actions to prevent personal economic hardship before more restrictive rules or statutes could be modified or added. They expressed a feeling of unfairness, of being treated more restrictively than other land uses, felt overfishing and/or predation was proportionately more of the reason for population declines, and felt WDFW and the public had a serious lack of understanding and appreciation of the positive impacts of forestland management. They indicated the environmental backlash would include accelerated timber harvest and sale of timberlands to developers. Many reviewers identified that this same reaction occurred in response to real or anticipated restrictions on landowners due to the ESA listing of the Northern Spotted Owl.

It is also generally recognized that the level of land use permit applications often rises in response to anticipated changes in local government zoning or building permit requirements.

Over the long term, salmonid habitat is generally better protected as forest land than when it is converted to more intense agricultural, rural or urban uses. The result of these conversions for salmonid habitat is more intense and frequent habitat disturbance, degradation and lack of, or incomplete, recovery.

Others indicated that any attempt to institute new, more restrictive statutes or rules would be met with stiff opposition and legal challenges. This could result in at least two likely scenarios, (1) the possibility that even existing rules or statutes would be weakened, or (2) the possibility that cooperative planning would be delayed, both at the expense of habitat protection and recovery.

Finally, many of the same landowners indicated they were not willing or had serious reservations about allowing or participating in habitat restoration on their lands under any circumstance, but certainly not if faced with new restrictions.

Impacts of Alternative 3

This alternative offers a high likelihood for increased habitat protection and recovery. Locally-based problem solving is widely recognized as the planning tool of choice. But in contrast to being a fully open-ended and "bottom-up" approach developed only by local citizens, this alternative would also include governmental agencies as partners, and would provide a state template of performance measures and action strategies that could be applied locally.

3.1 Natural Environment

Under Alternative 3, the following impacts would generally be expected for the natural environment:

A. Basin Hydrology and Instream Flows - In the areas outside of Urban Growth Area (UGA) boundaries of individual cities and towns, basin hydrology and instream flow conditions in watersheds would improve in the areas reserved for long-term timber harvest and agricultural practices. The rate of conversions of forest and agricultural lands to rural residential uses would be reduced and more forest lands could be reserved in lower elevation areas. The policy would result in a program to maintain or reestablish floodplain connectivity and function. Instream flow programs would be established or modified to provide optimum flow conditions for salmonid production and habitat maintenance, and would be actively enforced. Lake and marine processes would be provided for in the instream flow program and by addressing maintenance of hydrological conditions.

Negotiations to improve mainstem Columbia River flow conditions could be enhanced by virtue of the state's policy implementation. Existing licensing agreements at most other large dams would probably preclude provision of adequate flow conditions for salmonids until such time as renewals occurred. In that case, the incorporation of the policy language would be advocated during the relicensing process.

The TFW Forestry Module should result in improved condtions on forest land for salmonids. The Wild Salmonid Policy could serve as additional guidance to state agencies involved with efforts by landowners and regulators to employ watershed analysis and site specific prescriptions to these forest lands. For example, Habitat Conservation Plans would address stream and riparian area protection by addressing stream flows. The WSP would also serve as policy guidance in federal forest planning, estuary planning, watershed planning and the like.

It is anticipated that the policy would be one of the underpinnings of the Joint Natural Resources Cabinet's effort to devise a state agency coordination plan and process to be used by local watershed councils.

Implementation of the Growth Management Act would include comprehensive planning and land use zoning intended to avoid threshold hydrologic conditions damaging to salmonid habitat. This, in combination with other planning and assessment tools, would result in better protection of basin hydrology necessary to sustain salmonids. Cities and counties would employ hydrologic modeling that would demonstrate mixes of land uses and densities that would avoid

damaging thresholds or where utilization of structural stormwater mitigation techniques would be more appropriate.

Water conservation strategies would be developed with city and county planning agencies, the public, and with agricultural water users.

Within UGAs, basin hydrology and instream flows would probably continue to worsen; protection measures have not been proven to be entirely successful at attenuating peak flows and there is little evidence that maintenance of minimum summer flows is attainable with current stormwater management technology. The standards identified in storm water manuals, including the Puget Sound Stormwater Manual intended to prevent aggravation of flooding and erosion problems, do not mitigate all probable and significant impacts to aquatic biota. Fisheries resources and other living components of aquatic systems are affected by a complex set of factors. While employing a specific flow control standard may prevent stream channel erosion or instability, other factors affecting fish and other biotic resources, such as increases in the duration of threshold stream velocities, are not directly addressed by these manuals. Thus, compliance with these manuals should not be construed to mitigate all probable and significant storm water impacts on salmonids. Some flood plain connectivity and function could be reestablished through restrictive zoning, dedicated open space or acquisition. Groundwater aquifer recharge could be enhanced. Restoration of suitable hydrologic conditions for salmonids in urban streams is problematic; it would require significant and very expensive retrofitting of existing systems. UGAs would be compact to isolate stormwater impacts.

B. Water Quality and Sediment Quality, Delivery and Transport - Water and sediment quality and sediment delivery and transport are interdependent with basin hydrology and instream flow issues. Outside of UGAs, water quality and sediment delivery and transport processes would be improved by giving more attention to timber harvest activities and to road design, construction, use and maintenance to avoid surface erosion and road failures. Road obliteration and slope stabilization would be more prevalent. Significant improvement would be expected due to increased efforts by landowners and regulators to employ watershed analysis and site specific erosion and sedimentation control prescriptions to these lands.

Agricultural practices, including crop production and livestock grazing would be significantly improved to provide water and sediment quality and sediment delivery and transport process protection. These actions should compliment significant efforts which are underway or proposed to remediate existing conditions. Water withdrawals would be tailored to provide more adequate instream flow conditions to reduce stream temperatures and increase dissolved oxygen, particularly in the ecoregions of eastern Washington. Significant improvement on state lands would be expected by coordinating WSP standards with the Ecosystem Standards for State-Owned Agricultural and Grazing Lands.

Lowland lake water quality conditions would not likely improve appreciably in the

short term, given the high residential densities along the shorelines and dependence on site-specific septic systems. Marine water quality may be improved somewhat. In Puget Sound, this would likely be due to efforts under the Puget Sound Water Quality Action Team Work Plan. Physical nearshore alterations (proliferation of bulkheading, increased vegetation removal and slope failures, navigation channel maintenance, etc.) could be reduced which would provide for more natural shoreline processes affecting salmonids and their prey base species.

High rural residential densities, particularly along stream corridors and lake and marine shorelines would be less likely to continue to contribute to water and sediment quality and sediment delivery and transport problems. Water quality may be improved or maintained by reducing the number of on-site septic systems allowed in rural areas (i.e., larger lots, reserving forest and agricultural lands). Sediment delivery and transport could be reduced by large lot zoning and restrictive use of floodplains and geologically hazardous areas. The predictable pattern of bank hardening, channel dredging, wetland drainage, large woody debris removal, and channel realignment that invariably occurs after forest and agricultural lands are divided into smaller and smaller parcels for rural residential development would be avoided in large part.

Within UGAs, some improvement of these similar patterns of diminished water and sediment conditions would likely result, except that the changes would be generally less effective. Mitigation would be applied but there would still be more frequent and more long-lasting impacts than what would occur outside UGAs. Spills and other stream contamination due to point and non-point discharges would not be as frequent, nor as damaging.

C. Stream Channel Complexity - Addressing the combination of the physical processes of basin hydrology and sediment routing and how they affect water quality and riparian area condition, would help to re-establish or maintain stream channel complexity. Integration of the Wild Salmonid Policy with flood hazard reduction planning and funding would help to identify opportunities to ensure connectivity and function of floodplains with the channel proper. Transportation systems, impoundments and operations for hydropower generation, water supply, flood control and recreational/residential developments, would continue to affect stream channel complexity, although well integrated GMA planning and coordination with the WSP would help to reduce these impacts.

Both inside and outside of UGAs, stream channels would generally improve over time but would still suffer from loss of complexity in the short term; due to altered hydrology, current patterns of timber harvest, agricultural practices, conversion of these lands to rural residential densities, and the activities of both rural and urban residents. The riparian buffers and wetland standards would provide very significant improvements to salmonid habitat across all land uses and all ecoregions. However, only partial restoration of mainstem rivers, particularly those near ports and urban areas, would be likely. Many would remain

channelized, disconnected from their floodplains, dredged for navigational purposes, and generally picked clean of large organic debris. Sedimentation affecting aquatic insect production, substrate hiding cover and pool volume would be significantly reduced.

As above, full or partial recovery of stream channel complexity would be coincident with less intense land use; more contiguous habitat, retention of forest and agricultural lands and fairly large lot rural residential parcels. Flood plains and riparian areas would be protected or restored. Habitat would be protected fundamentally through zoning rather than sole reliance on on-site mitigation such as minimal protection under critical areas ordinances.

D. Riparian Areas and Wetlands - Existing riparian area and wetland conditions would improve across all ecoregions and land uses. Restoration could be more readily accepted as a result of cooperative planning efforts.

E. Lakes and Reservoirs - Most lowland lakes would continue to be subjected to incredible development pressure, but there would be a better balance between improving the aesthetics and human safety problems in lakes and maintaining or improving salmonid habitat. Reservoir conditions in the Columbia and Snake Rivers may improve as a result of changing operations of the hydropower system.

F. Marine Areas - Most marine areas, particularly in Puget Sound, would continue to be subjected to incredible development pressure both within and outside UGAs, but marine habitat could be better protected by avoidance of intense development and less reliance solely on mitigation techniques to lessen the habitat impacts. Slope failures could be reduced. The number of bulkheads installed could be reduced. Natural rates of erosion, transport and deposition would be more likely. Port development could be modified to protect remaining habitat. Some restoration is likely.

In other less-developed marine and estuarine areas, particularly Grays Harbor, Willapa Bay and the Columbia River, there may be opportunities to reclaim upper intertidal areas and wetlands by breaching or removal of agricultural dikes. Navigational dredging and water quality issues due to contaminated sediments would continue to pose risks to salmonids.

G. Fish Access and Passage - Fish access and passage problems would be significantly avoided through land use planning, and where road crossings are unavoidable, through proper design, construction and maintenance of passage structures. Existing passage and access problems would be corrected.

Fish screening at run-of-the-river diversions would improve. Considerable funding has been provided, particularly for the Columbia Basin Ecoregion, to construct juvenile bypass systems. Adult and juvenile passage on the Columbia and Snake River mainstem would be addressed. Resolution of passage issues at other larger facilities in the state depend in large part upon federal licensing conditions with the WSP as guidance for state agencies.

H. Habitat Restoration - Restoration could be more readily accepted as a result of cooperative planning efforts. Numerous reviewers expressed more willingness to participate if restoration efforts were cooperative, involved the landowner directly in the planning process and provided management flexibility. Habitat acquisition would also be more likely as a result of cooperative watershed planning.

This alternative would also emphasize the development of landowner incentives for protection and restoration and a more coordinated educational outreach program.

3.2 Built Environment

Enforcement of existing regulations and addition of new regulations would affect all of the land and shoreline uses described earlier. Buffer zones along riparian areas and wetlands would be established as a result of local planning and the buffer widths would be tailored to site conditions or applied as recommended in the policy. Landowners in counties that currently have limited resource protection ordinances would be affected by planning processes designed to improve salmonid habitat.

The potential impacts described in Alternative 1 would be more significant; affecting more land and shoreline uses in watersheds and along shorelines throughout the state. There would be impacts to some public services and jobs.

There would be statewide regulations on the use of aquatic weed chemical controls (e.g., copper sulfate), better protection involving construction of docks and bulkheads, and less development along rivers, wetlands, lakes, marine shorelines and connected uplands. Additional protection would be applied by streambank stabilization projects. Better siting of new development, better monitoring and regulation of septic systems, much improved regulation and conservation of surface and ground water use (instream flows for fish-limiting irrigation, drinking water, etc.), and more environmental consideration for avoidance of impervious surfaces would be achieved through zoning and development regulation. More limitations on gravel removal from floodplains, sewage treatment plant discharges, and diking would result.

The consistency added by this statewide planning approach would make it easier for developers to be able to comply with regulations.

Much improved measures could be required for hydropower and flood control dams for fish screens, and dam operations (flow control, diversions, etc.). Design improvements for fish passage, gas supersaturation controls, energy conservation and gravel supplementation programs would be likely.

It is anticipated that the TFW module would result in significant improvement in the minimum standards found in the current Forest Practices Rules. This could result in significant economic impact to the timber industry. Additional controls on forest practices such as changes in timber harvest, larger buffer strip requirements, longer harvest rotations, additional limitations on road construction, and requirements to decommission roads would increase the costs of doing business and reduce the available timber supply. These short term-impacts could be off-set by more long-term

stability as a result of watershed level planning such as HCPs or state landscape planning.

Agriculture could be affected by additional limits on water withdrawals for irrigation to comply with minimum instream flows. There would be limitations of grazing practices in riparian areas and in wetlands. Tougher requirements for agricultural water discharges (such as irrigation outfalls and septic lagoons), fish screens and fish passage could be implemented. However, preparation of farm plans would result in some protection from streambank erosion, incentives in the form of tax breaks, and increased water use efficiency.

Existing transportation systems could be significantly affected by new or increased protection involving road construction in riparian areas, streams, wetlands and connected uplands. GMA planning that results in more compact urban areas and larger rural lot sizes could help to reduce the amount of road encroachments on sensitive habitats. There would be additional protection applied to address stormwater management, fish passage, bank stabilization, floodplain development, route limitations, wetland protection, bridge construction and maintenance, and dredging for navigation. These changes could increase costs and timelines for project completion, and in some cases prevent specific projects from being completed. However, proper GMA planning could reduce some transportation costs because of more compact growth.

Impacts of Alternative 4

This alternative would yield habitat protection and results similar to Alternatives 2 and 3. However, the default regulatory standard might discourage acceptance of state agencies as collaborative partners in locally-based watershed planning. Loss of local initiative and problem solving could be the result.

4.1 Natural Environment

Same as Alternative 3.

4.2 Built Environment

The blend of local watershed decision making and new regulations would require previously described land and water users to work with local watershed groups to develop solutions and comply with new regulations. It would allow less flexibility than Alternative 3 and more than Alternative 2. Land and shoreline uses might be affected differently in individual regions and the specific impacts cannot be determined.

Impacts of Alternative 5

Alternative 5 is fairly similar to Alternative 1 since it would only contain goals and fairly general performance measures and action strategies which would be included as minimal guidance for state agencies and local governments. The only significant difference between this alternative and the No-Action alternative is that the material exists in one place as a matter of state policy and gives only the most general guidance. Since it relies on implementation for specificity, we cannot make an assessment of its environmental impacts for either the natural or built environment.

5.1 Natural Environment

Habitat outcomes for this alternative are unclear. This approach most closely fits the definition of "bottom-up" and collaborative planning and is likely to be more readily accepted locally than Alternatives 2, 3, and 4. However, there is no method of evaluating whether performance measures or action strategies developed under this alternative would adequately protect or restore habitat.

5.2 Built Environment

This alternative would impact most, if not all, land and shoreline uses described earlier but those impacts cannot be determined because the actions have not been determined yet. Land and shoreline users participating in existing processes like Timber, Fish and Wildlife would probably be affected initially. This is because some land and shoreline uses do not have ongoing forums to address natural resource issues. Agriculture is one example of a land user for which there is not a regional forum to address natural resource concerns.

Note: Definitions given are intended to apply only to this document. Most originated in other processes. Some will not match-up with previous use.

ANADROMOUS FISH -- Species that are hatched in freshwater, mature in saltwater, and return to freshwater to spawn.

ALEVIN -- Newly hatched juvenile salmonid with visible yolk sac.

BIODIVERSITY -- The variety and abundance of species, their genetic composition, and the natural communities, ecosystem, and landscapes in which they occur.

BROODSTOCK -- Those adult salmonids that are destined to be the parents for a particular stock or smaller group of fish.

CARRYING CAPACITY -- The maximum number of individuals or biomass of a given species or complex of species of fishes that a limited and specific aquatic habitat may support during a stated interval of time.

CATCH -- The act of landing a fish at which point the fisher has the option of releasing or retaining it.

CHANNELIZED -- A portion of a river channel that has been enlarged or deepened, and often has armored banks.

CO-OP OPERATION -- Projects funded under the Aquatic Lands Enhancement Account (ALEA) allowing individuals to do habitat enhancement projects plus rear and release salmon into state waters under the direction of WDFW.

CONSUMPTIVE -- Any human activity involving salmonids that induces mortality.

CRITICAL STOCK -- A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

DEPRESSED STOCK -- A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

ECOLOGICAL INTERACTION -- The sum total of impacts of one species on another species, or on other members of the same species.

ECOSYSTEM -- A complex of biological communities and environment that forms a functioning, interrelated unit in nature.

ESCAPEMENT -- Those fish that have survived all fisheries and will make up a spawning population.

ESCAPEMENT FLOOR -- The lower bound of an escapement range.

ESCAPEMENT GOAL -- A predetermined biologically derived number of salmonids that are not harvested and will be the parent spawners for a wild or hatchery stock of fish.

EXOTIC SPECIES -- Salmonid species that were not native to Washington State (e.g., brown trout, brook trout, Atlantic salmon).

EXTINCTION -- The loss of a stock of fish from its original range, or as a distinct stock elsewhere. Individuals of the same species may be observed in very low numbers, consistent with straying from other stocks.

FISHERY -- The process of attempting to catch fish, which then may be retained or released.

FITNESS -- The relative ability of an individual (or population) to survive and reproduce (pass on its genes to the next generation) in a given environment.

FRY -- Young salmonids that have emerged from the gravel and are up to one month of age or any cultured salmonid from hatching through fourteen days after being ponded.

GEAR LIMITS -- Restrictions placed on sport or commercial fishing gear, which are used to control the take of fish.

GENETIC DIVERSITY -- All of the genetic variation within a group. The genetic diversity of a species includes both genetic differences between individuals in a breeding population (=within-stock diversity) and genetic differences among different breeding populations (=among-stock diversity).

GENETIC DRIFT -- The random fluctuation of allele frequencies in a population resulting from the sampling of gametes to produce a finite number of individuals in the next generation.

GENETIC RISK -- The probability of an action or inaction having a negative impact on the genetic character of a population or species.

GLIDE -- A part of a stream that is characterized by a smooth, easy movement of water, usually just upstream of a riffle.

HABITAT -- An area that supplies food, water, shelter, and space necessary for a particular animal's existence.

HARVEST -- Fish that are caught and retained in a fishery (consumptive harvest).

HARVEST RATE -- The proportion of a returning run or total population of salmonids that is taken by fisheries.

HATCHERY MANAGEMENT UNIT -- A group of fish managed to achieve hatchery salmonid escapement objectives. These areas typically support higher harvest rates (percent of returning fish harvested) than wild stock management areas.

HATCHERY PRODUCTION -- The spawning, incubation, hatching, or rearing of fish in a hatchery or other artificial production facility (e.g., spawning channels, egg incubation boxes, or pens).

HATCHERY STOCK -- A stock that depends upon spawning, incubation, hatching, or rearing in a hatchery or other artificial production facility (synonymous with cultured stock).

HEALTHY STOCK -- A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock. This does not imply that the habitat itself is necessarily "healthy."

HYBRIDIZATION -- The interbreeding of fish from two or more different stocks.

INBREEDING -- The mating of related individuals.

INCIDENTAL HARVEST -- The capture and retention of species other than those a fishery is primarily opened to target/take. It can also refer to marked fish of the same species.

INTEGRATED LANDSCAPE MANAGEMENT -- A management process that integrates the needs of multiple species across a broad landscape.

LARGE WOODY DEBRIS (LWD) -- Conifer or deciduous logs, limbs or root wads twelve inches or larger in diameter.

LOCALLY ADAPTED POPULATION -- A population of fish that has developed specific traits that increase their survival in a particular habitat or environment.

LOWER COLUMBIA -- That portion of the mainstem Columbia River below Bonneville Dam.

MANAGEMENT UNIT -- A stock or group of stocks which are aggregated for the purposes of achieving a desired spawning escapement objective. See wild and hatchery management unit definitions.

MASS MARKING -- The marking of all individuals in a population of fish so that individuals of that population can be identified in subsequent life history stages.

MAXIMUM SUSTAINED YIELD (MSY) -- The maximum number of fish from a stock or management unit that can be harvested on a sustained basis, measured as the number of fish that would enter freshwater to spawn in the absence of fishing after accounting for natural mortality.

MID-COLUMBIA -- That portion of the mainstem Columbia River between McNary and Bonneville dams.

MINIMUM SIZE LIMIT -- A sport fishery regulation that establishes a minimum size (usually length) for the retention of a fish to protect younger individuals in a fish population, or to protect other species of fish.

MINIMUM VIABLE POPULATION (MVP) -- The size of a population which, with a given probability, will ensure the persistence of the population for a specified period of time.

MIXED-ORIGIN STOCK -- A stock whose individuals originated from commingled native and non-native parents; or a previously native stock that has undergone substantial genetic alteration.

MIXED-STOCK FISHERIES --Any fishery that catches fish from more than one stock.

NATIVE SPECIES -- A species of fish indigenous to Washington State.

NATIVE STOCK -- An indigenous stock of fish that has not been substantially affected by genetic interactions with non-native stocks or by other factors, and is still present in all or part of its original range. In limited cases, a native stock may also exist outside of its original habitat (e.g., captive brood stock programs).

NATURAL SELECTION -- Differential survival and reproduction among members of a population or species in nature, due to variation in the possession of adaptive genetic traits. Natural selection, the major driving force of evolution, is a process leading to greater adaptation of organisms to their environment.

NET PEN --A fish-rearing enclosure used in lakes and marine areas.

NON-CONSUMPTIVE -- Any human activity involving salmonids that does not cause mortality.

NON-NATIVE STOCK -- A native species residing in an area outside its original habitat in Washington State (e.g., Chambers Creek steelhead, Soos Creek chinook).

OFF-CHANNEL AREA -- Any relatively calm portion of a stream outside of the main flow.

POOL -- A relatively deep, still section in a stream.

POPULATION -- Synonymous with the term stock.

PRIMARY MANAGEMENT UNIT -- A stock or group of stocks for which a specific spawning escapement goal is established with the intention of managing all impacting fisheries to meet that goal.

PRODUCTIVITY -- A measure of the capacity of a biological system. The efficiency with which a biological system converts energy into growth and production.

QUOTA --A number of fish allocated for harvest to a particular fishing group or area.

RECOLONIZATION -- The reestablishment of a salmonid stock in a habitat that the species previously occupied.

RECRUITS -- The total numbers of fish of a specific stock available at a particular stage of their life history.

REGIONAL FISHERIES ENHANCEMENT GROUP -- 12 regional fisheries enhancement (volunteer) groups funded under recreational and commercial salmon license fees, allowed to do habitat enhancement projects plus rear and release salmon into state waters under the direction of WDFW.

REMOTE SITE INCUBATOR -- A lightweight, dark colored plastic barrel incubator that employs plastic substrate (hatching medium), and can be sized to accommodate 5,000 to 125,000 eggs per incubator. They are used mainly for incubating chum salmon eggs.

RESIDENT SALMONID -- Those members of the family Salmonidae which spend their entire lives in freshwater.

RIFFLE -- A shallow gravel area of a stream that is characterized by increased velocities and gradients, and is the predominate stream area used by salmon for spawning.

RIPARIAN HABITAT --The aquatic and terrestrial habitat adjacent to streams, lakes, estuaries, or other waterways.

RISK ASSESSMENT -- Evaluating the probability of an action having a negative impact that is not within prescribed limits or acceptable bounds.

RIVERINE HABITAT --The aquatic habitat within streams and rivers.

RUN -- The sum of stocks of a single salmonid species which migrates to a particular region, river, or stream of origin at a particular season.

SALMONID -- Any member of the taxonomic family Salmonidae, which includes all species of salmon, trout, char, whitefish, and grayling.

SASSI -- Salmon and Steelhead Stock Inventory. A cooperative program by the Department of Fish and Wildlife and Washington Treaty Indian tribes to inventory and rate the status of salmon and steelhead stocks on a recurring basis.

SECONDARY MANAGEMENT UNIT -- A stock or group of stocks for which escapement is that which occurs primarily as a result of not being caught in fisheries directed at commingled primary stocks. A group of fish for which an escapement goal may not be established.

SECONDARY PROTECTION -- Management activities that provide protection to stocks or runs of salmon after they have been subjected to harvest in mixed stock areas.

SELECTIVE BREEDING -- The intentional selection of individual spawners in artificial production programs to produce particular traits in subsequent generations.

SELECTIVE FISHERY -- A fishery that allows the release of non-targeted fish stocks/runs, including unmarked fish of the same species.

SELF-SUSTAINING POPULATION -- A population of salmonids that exists in sufficient numbers to replace itself through time without supplementation with hatchery fish. It does not necessarily produce surplus fish for harvest.

SMOLT -- A juvenile salmonid that is undergoing the physiological change to migrate from fresh to salt water.

STOCK -- The fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place at the same time, or in the same place at a different time.

STOCK ORIGIN -- The genetic history of a stock.

STOCK STATUS --The current condition of a stock, which may be based on escapement, run size, survival, or fitness level.

SUPPLEMENTATION -- The use of artificial propagation to maintain or increase natural production while maintaining the long-term fitness of the target population, <u>and</u> keeping the ecological and genetic impacts to non-target populations within specified biological limits.

TARGETED FISHERY -- A harvest strategy designed to catch a specific group of fish.

TERMINAL FISHING AREA -- A fishing area near the ultimate freshwater destination of a stock where a salmonid stock or run has separated from other stocks/runs.

TREATY TRIBES -- Any Indian tribe recognized by the United States government, with usual and accustomed fishing grounds, whose fishing rights were reserved under a treaty and have been affirmed by a federal court.

UNKNOWN STOCK -- This description is applied to stocks where there is insufficient information to identify stock origin or stock status with confidence.

UPPER COLUMBIA -- That portion of the mainstem Columbia/Snake River above McNary Dam.

VIABLE POPULATION -- A population in a state that maintains its vigor and its potential for evolutionary change.

WATERSHED -- A basin including all water and land areas that drain to a common body of water.

WILD MANAGEMENT UNIT -- A management unit where fisheries are managed to achieve wild salmonid escapement objectives.

WILD STOCK -- A stock that is sustained by natural spawning and rearing in the natural habitat, regardless of parentage (including native).

WILD STOCK INITIATIVE (WSI) -- A cooperative program between the state and western Washington Indian tribes that is intended to maintain and restore healthy salmon and steelhead stocks and habitats.

WITHIN-STOCK DIVERSITY -- The overall genetic variability among individuals of a single population or stock.

Appendix B DISCUSSION OF KEY ELEMENTS OF WILD SALMONID POLICY

A Wild Salmonid Policy needs to address six elements; each of the policy elements is critical to achieving the goal of healthy stocks and sustainable benefits. Meeting some of the elements may slow the rate of decline, but will not change the ultimate result of more stocks in trouble and less benefits. This means a balanced approach is necessary. We need the participation and cooperation of everyone who impacts the salmonid resource. It cannot be just the harvesters or just the people who affect habitat. Everyone has a role in achieving the policy goal. The policy elements include:

A. **Habitat -** fish need a safe and productive environment to live in. The habitat must be capable of supporting populations large enough to sustain the resource and to provide the desired level of benefits.

B. **Spawner Abundance -** the right number of spawners are needed to sustain healthy salmonid populations, rebuild weak ones, and maintain overall ecosystem health.

C. **Genetic Conservation -** we need to sustain the basic productive capacity of stocks by protecting genetic diversity and allowing stocks to develop those traits that will make them successful in their local environment.

D. **Ecological Interactions -** salmonid fishes are part of complex ecosystems that must remain healthy if we are to be successful. Healthy ecosystems also require healthy salmonids as well.

E. **Harvest Management -** fisheries must be controlled to meet spawner abundance, genetic conservation and harvest objectives.

F. **Hatcheries -** hatcheries are important tools for providing harvest, mitigating for natural production losses from lost habitat, and rebuilding depressed runs.

In the following sections we discuss these elements and explain their importance to meeting the overall WSP goal.

A Theoretical Model for Understanding Salmonid Populations

In order to understand the implications of the various elements we need a picture, or model, of how the number of spawners relate to the number of offspring they produce. A model can allow us to compare how the elements affect fish populations. Figures B-1 and B-2 represent two typical pictures for salmonid fishes. Most typically the number of offspring is measured as the number of smolts or adult fish that become available, or eventually recruit, to the fishery. Thus this model is called a spawner-recruit model.

Each species and stock of fish has its own unique spawner-recruit relationship. The shape of the curve in Figure B-1 is descriptive of species that compete for rearing space or food in freshwater such as coho, steelhead, and most of the resident salmonids. Figure B-2 reflects species that tend to spawn in large numbers and compete for spawning area. This would be typical of pink and chum populations. These models are a greatly simplified picture of how salmonid populations actually operate. However, they can be a useful tool for understanding what is happening.

In both figures the curved line represents the number of adult fish, or offspring, that are produced from different levels of spawner abundance. For example, if we had the number of spawners represented by the letter S on each figure we would get a number of adults equal to B on the curved line.

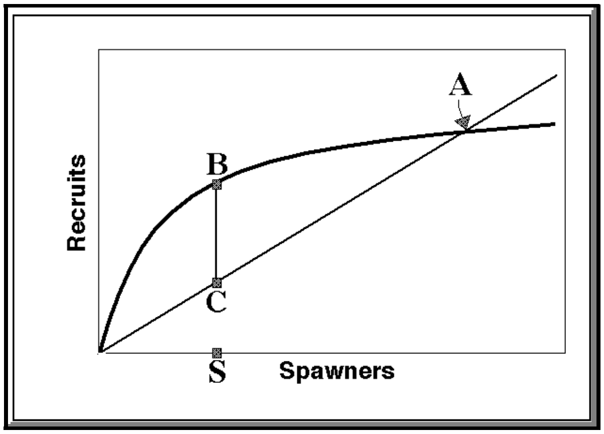

Figure B-1. Spawner-recruit curve for species that compete for rearing space or food in freshwater.

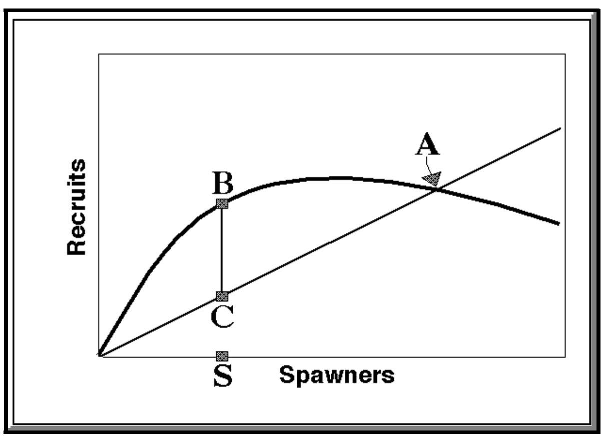

Figure B-2. Spawner-recruit curve for species that tend to spawn in large numbers and compete for spawning area.

There are several key features of both figures:

A. As we add spawners from zero, the number of recruits increases. More spawners gives us more fish.

B. As we keep adding spawners, the curved line gets less and less steep. Each added spawner must compete with all the existing spawners for the best places to spawn, and their young must compete for places to feed or hide. Each new fish has to work a little bit harder. The number of new recruits we get for each new spawner goes down as the number of spawners increases.

C. Competition and other factors eventually increase to the point where adding more spawners does not appreciably increase the number of recruits. In Figure B-1 this is where the curve nearly flattens out (between A and B on the curved line).

   In Figure B-2 the number of recruits can actually decrease as you add spawners past a certain point. The cumulative effects of spawning, such things as competition, disease, later spawners digging up the nests of the earlier spawners, and attraction of predators, increase with larger and larger spawner abundance (escapement) levels to reduce the capacity of the system to produce recruits.

D. If we have S spawners and get B recruits, then we need to get S spawners for the next generation for the cycle to repeat itself. The straight line in each figure is called the replacement line. The point C on the replacement line (or point S) is the number of recruits needed for spawning so the population will replace itself and keep the cycle going. From the figure it is shown that populations can sustain themselves at different levels, although there is a limit at the lower end required to maintain genetic diversity that stocks need to survive in their local environment. It is also important to avoid small stock sizes since some mortality factors take an increased percentage of small populations (*see Appendix D, Spawner Abundance*). The distance between B and C is a measure of the number of fish you can harvest while providing enough spawners to sustain the run at the same level (S).

E. When there is no fishing the population will tend to grow to the point where the level of competition increases so much that the spawners just replace themselves. This is where the number of spawners is equal to the number of recruits. This is the point A on both figures. Point A is called the equilibrium or replacement point. Naturally spawning populations of salmonids cannot be sustained at escapement levels greater than the replacement point because they produce total run sizes that are less than the number of spawners that were started with.

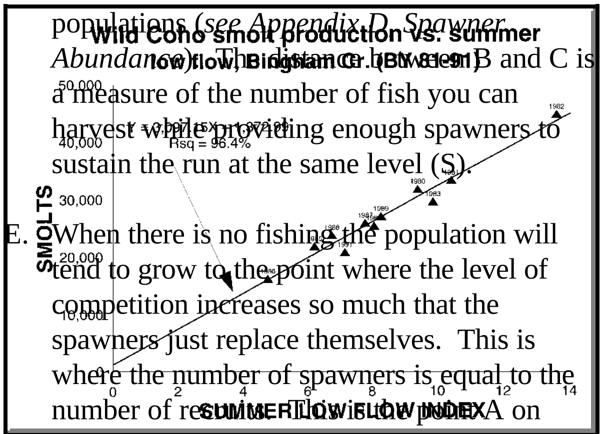

Figure B-3.

The shape of the curve for any stock of fish will be unique. It will depend on the:

A. Species

B. The productivity of the environment and the stock. A very productive environment and stock will have a steeper, higher curved line and produce more recruits from each added spawner. Survivals will be higher and it will take fewer spawners to use the available habitat. A less productive environment will have a shallower curved line and produce fewer recruits from each added spawner. Productivity will be affected by habitat quality, ecological interactions such as competition and predation, and basic stock productivity. We discuss these factors in the sections on the *Habitat*, *Ecological Interactions*, and *Genetic Conservation* elements.

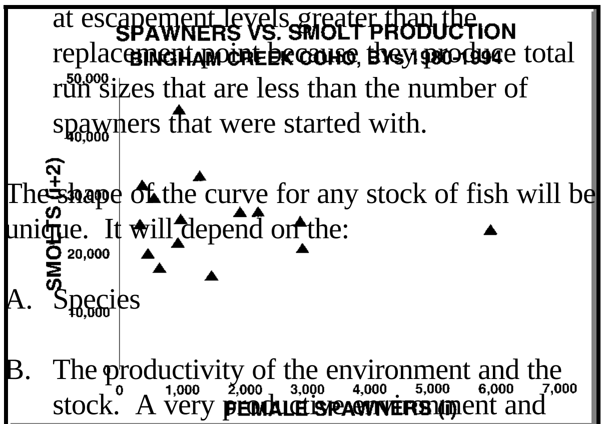

Figure B-4.

C. The capacity of the habitat to produce fish. The height of the curve is a measure of the capacity of the habitat to produce fish. This is affected primarily by the quantity of productive habitat and availability which are discussed in the *Habitat* element.

While the above factors control the shape of the curve, it is the number of spawners that determines how abundant the population will be (i.e. where a population will be found along the curve). The final piece of the picture, the effect of spawner numbers, is discussed in the *Spawner Abundance* element.

<u>**Actual Relationships of Salmonid Populations**</u>

All salmonid populations made many survival trade-offs in their respective evolutionary histories. In order to successfully manage each population, it is important to understand these trade-offs and their consequences. For example, wild winter-run steelhead can successfully spawn in larger rivers during the spring months, thus avoiding the worst winter flood events. However, their fry are the last to emerge and miss much of the initial growing season. It is also important to understand each population's relationship to specific habitats that are utilized during various life history stages.

Figure B -3 shows the relationship between Bingham Creek (Satsop River system) wild coho smolt production and summer stream flows. This is the historical or normal limiting factor for coho salmon production in Western Washington and has been utilized for decades to predict run sizes (Zillges 1977). With the exception of the 1982 data point, the values show a natural variation of about two times in freshwater production potential. Since the correlation in Figure B-3 is so high, Figure B-4 shows what we can easily deduce; e.g., that there is no relationship in this data set between adult spawners and resultant smolt production.

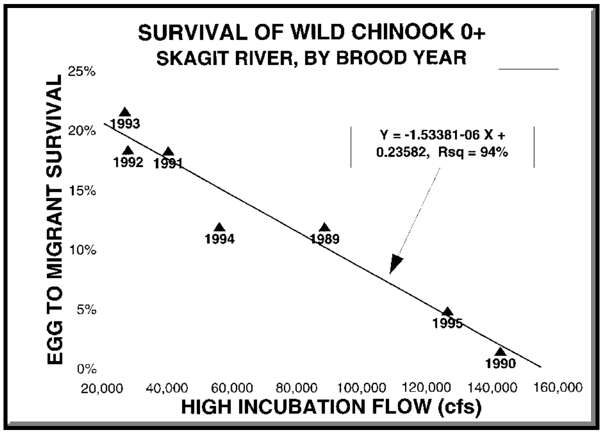

Figure B-6.

This means that there was always enough juvenile coho present to take advantage of whatever summer stream flow conditions happened to occur. It also shows that smolt production was not directly related to numbers of adult coho carcasses within the range of values shown. However, nutrients can play a critical role in certain systems where they limit production. We can detect a definite cross-species relationship between Skagit River coho smolt production and the odd-year pink salmon runs that utilize the Skagit system (Figure B-5). Even year coho brood years have averaged about one million smolts, while odd year broods have averaged about 650,000 smolts. We believe that progeny from even brood year coho spawners suffer less predation beginning in August due to the arrival of pink salmon. This food source for predators <u>and</u> for rearing juvenile coho is available in several forms from then until the following spring when the coho smolts emigrate.

We have also measured juvenile chinook salmon production from the Skagit system (Figure B-6). Here is another case where it is important to recognize the trade-offs that were made in evolutionary history. Chinook made a positive trade-off for large body size, the negative being older age and a longer period for mortality factors to operate. This large size enabled chinook to use

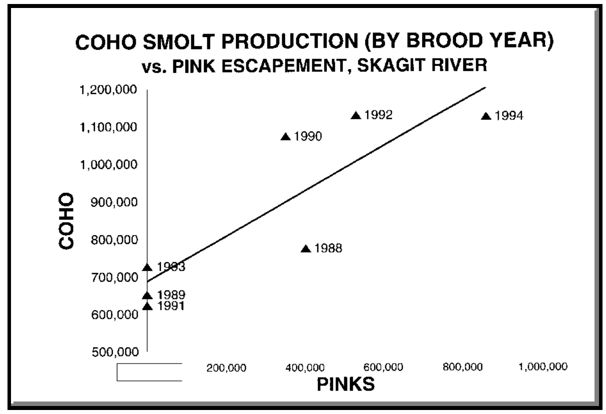

Figure B-5.

large, flood-proof gravel substrate for spawning and egg incubation. Spawning could occur before the normal winter floods, yielding early-emerging fry. We have taken some of this size away in fishery management practices (Ricker 1981), reducing the fish's ability in terms of gravel size that can be used, fecundity (number of eggs) and egg deposition depth capabilities. This has been exacerbated by the trend of increasing frequency and magnitude of flood events in Pacific Northwest rivers (WDF 1992). We can see from Figure B-6 that the population's innate production capability (without flooding) is 15 to 20% egg to migrant survival. When major flood events occur, this capability is greatly diminished.

Flooding has also been demonstrated as a major environmental variable limiting Cedar River sockeye production (Figure B-7). Sockeye salmon populations are normally limited by a lake’s juvenile rearing capabilities. Again, we can see the population’s capability of a 15 to 20% survival rate but this is diminished by flood events.

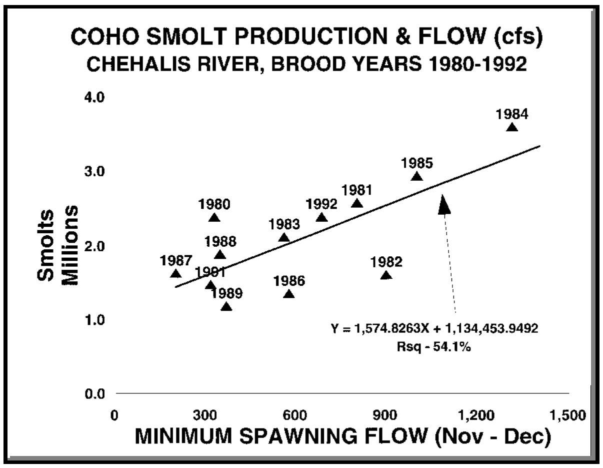

Figure B-9.

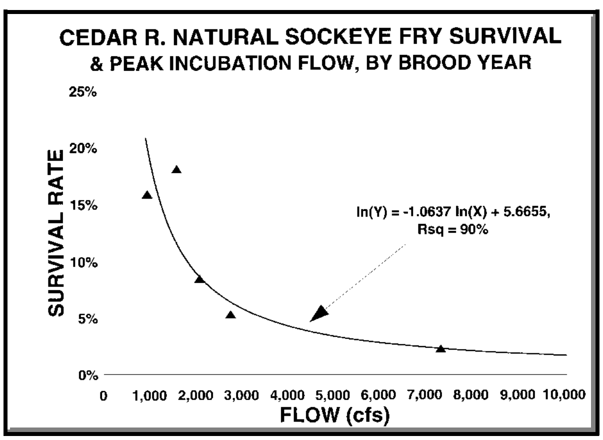

Figure B-7.

Whenever a new limiting factor overrides the historical or normal limiting factor, fish production always takes a big decline.

Clearwater River coho smolt production estimates provide yet another example of adverse population impacts from flooding (Figure B-8). This population was formerly limited by the normal summer stream flow variable. It is now limited by peak flood flows during egg incubation. The inherent capability of the population is to produce about 90,000 smolts in the absence of flooding. However, the production in most years is below this level. Two of the 16 brood years that we have measured were limited by inadequate adult spawning populations. Large-scale hatchery fry

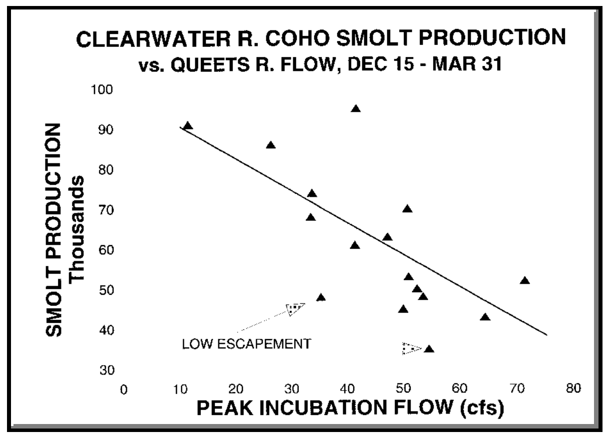

Figure B-8.

releases were made in two years but failed to provide any measurable increase in smolt production. The spawning tributaries of this system are relatively steep and this has combined with extensive timber harvesting and road building to produce the relationship shown in Figure B-8. Coho fry can effectively seed a system only by downstream dispersion. If floods blow eggs out of the gravel in these steep tributaries, no fry are left to disperse and seed downstream rearing areas.

Evaluation of coho smolt production in the Chehalis River system shows that a different variable , spawning flows, is limiting production (Figure B-9). What causes this is the varying degree of adult penetration to the upper limits of spawning tributaries. The Chehalis is a relatively low gradient system with many culvert problems and an over-appropriation of surface water rights. These factors severely restrict fish access in low-flow years. If spawners cannot reach the upper end of a five mile stream segment, they are not going to be able to seed that same five miles via downstream fry dispersion. The three brood years that fall well below the relationship shown in Figure B-9 (1989, 1986, 1982) are due to a major winter flood, a drought, and an inadequate spawning population, respectively.

The Deschutes River wild coho population appears in Table II-1 (Chapter II) but has persisted much better than most of the other stocks listed. There is no hatchery coho program in the system itself, thus the immediate terminal area does not attract any concentrated fishing effort. (Note: By agreement with the Squaxin Tribe, net fishing is not conducted in Budd Inlet.) The population data presented in Figure B-10 show that spawning escapements were inadequate in most years. Still, production prior to the 1989 brood year always exceeded 50,000 wild coho smolts per year. Massive landslides and culvert failures from the January 1990 flood reduced smolt production all the way down to 10,000 fish. The system's fish production capacity has not recovered from these events.

The Deschutes River data show the expected relationship between adult females and smolts produced per female (Figure B-11). At small adult population sizes, there is a general tendency for each individual female to produce more smolts. However, as several low data points show, this relationship fails in the face of adverse environmental conditions.

Big Beef Creek is in Hood Canal where coho populations are supposedly managed to achieve wild fish spawning escapement objectives. However, as the data in Figure B-12 demonstrate, there have been many inadequate spawning

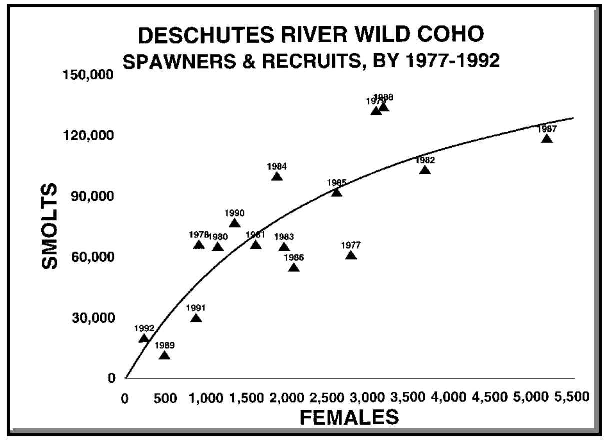

Figure B-10.

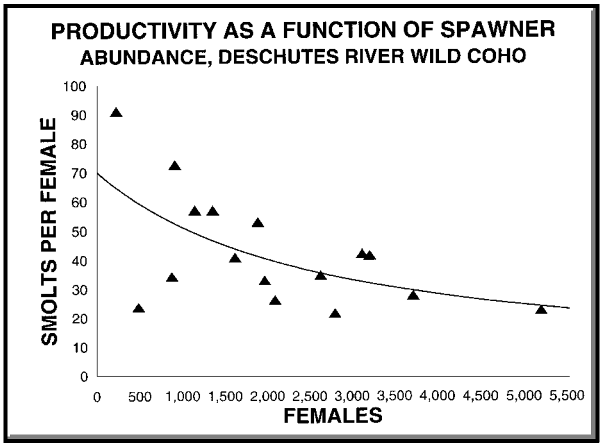

Figure B-11.

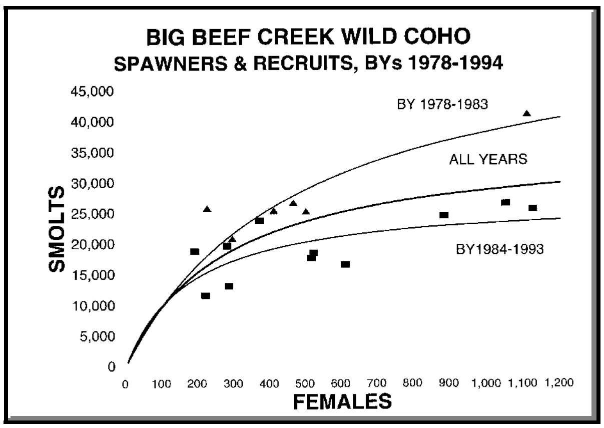

Figure B-12.

escapements. During dry years, spawners congregate off the creek mouth and are harvested during the chum salmon management period. The Big Beef Creek data also demonstrate a case where a system's coho rearing capabilities have diminished in recent years. Lower summer stream flows and adverse stream channel changes have been the visible result of cumulative development activities in the watershed. No single action seemed significant by itself, but the system can no longer produce the quantities of coho smolts that it did just a few years ago.

Tagged groups of wild coho smolts can be used to determine marine survival rates if we have both total catch and total escapement estimates (tagged hatchery fish rarely provide the latter statistic). The Bingham Creek data are shown in Figure B-13. In this case, "marine" survival is the cumulative expression of everything that happens to the fish after they leave Bingham Creek. This includes passage through upper Grays Harbor, which has a long and contentious history of pulp mill pollution and its effect on salmon survival.

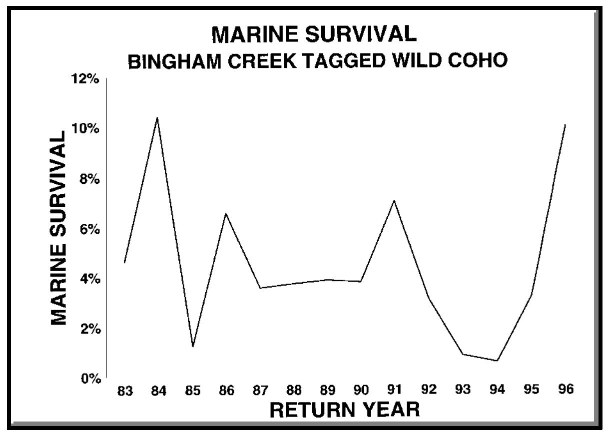

Figure B-13.

This is at least part of the reason why marine survival rates have varied by a factor of nearly ten times.

Returns of 2-year-old precocious males or "jacks" are often used to try to forecast the next year's return of 3-year-old adults from the same brood year. The rationale is that the first few months in the ocean (when the fish are smallest) will be the key determinant of overall ocean survival rates. Bingham Creek wild coho demonstrated such a relationship during early years of the data base, but more recent years appear to show a new, lower relationship (Figure B-14). Two brood years impacted by pronounced El Nino events were excluded from both relationships.

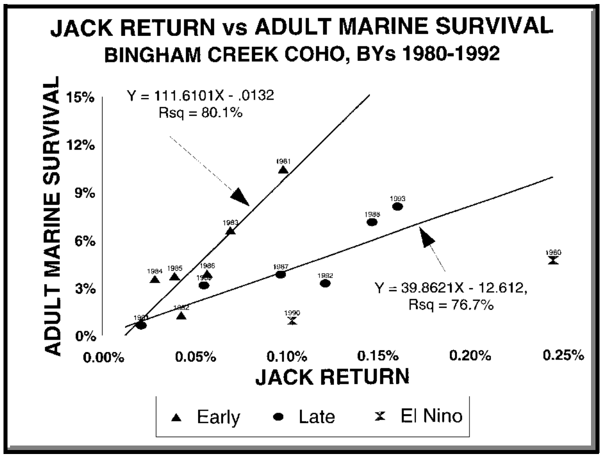

Figure B-14.

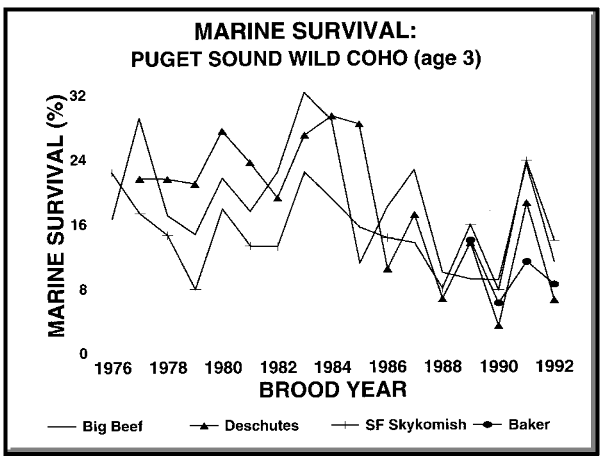

Figure B-15.

Puget Sound coho smolts generally show much higher survival rates than we have measured from Washington coastal stocks (Figure B-15). The apparent downward trend in recent years is a cause for concern, particularly with the Deschutes River stock. There have been recent increases in both the South Sound net pen program for coho and the delayed release program for chinook. We have not established any cause-and-effect relationship between these increases and the apparent decline in wild coho marine survival. However, the fact that the Deschutes survival has declined lower than the other stocks indicates that a negative interaction may exist.

Coho salmon in Puget Sound have three distinct marine life history types and this probably precludes any possible use of jack salmon as an adult run size predictor for the following year. Many fish go to the open ocean soon after leaving freshwater while many other "residents" stay within the confines of Puget Sound and Georgia Strait throughout their marine life history stages. A third group of fish stays in inside waters until the beginning of their third year and then migrates to the ocean. Each of these groups has different growth rates and encounters different fishing regimes.

The tagged wild coho smolts also enable us to determine ocean fishing rates for populations from various areas. Figure B-16 shows these for four Puget Sound stocks. Many of the annual ocean fishing rates (U. S. plus Canadian) are in the vicinity of 40%, with only one stock in one year reaching a level as high as 60%. Ocean fishing rates for coastal coho wild populations tend to be

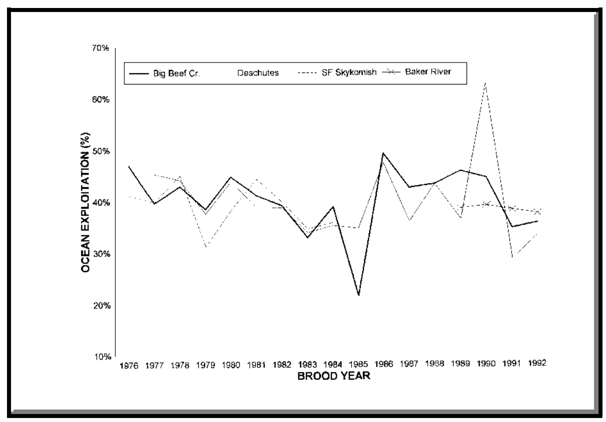

Figure B-16. Ocean exploitation rates for coho salmon.

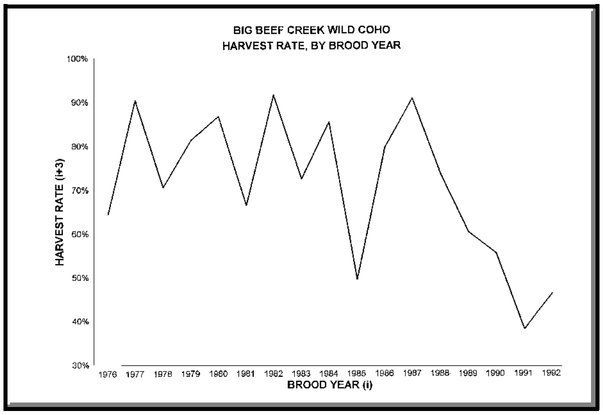

Figure B-17.

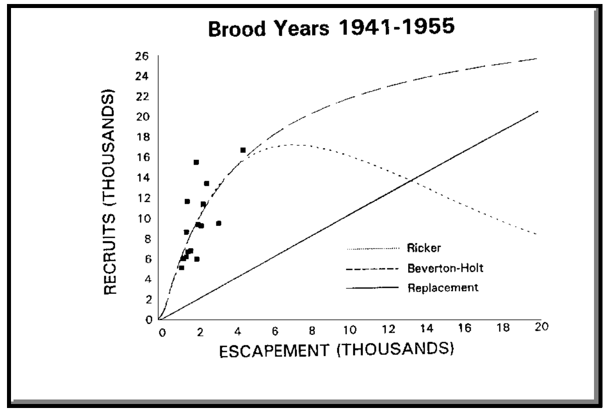

Figure B-18. Mid-Columbia River steelhead.

significantly lower than those for Puget Sound Fish.

Total fishing rates can also be determined for wild coho stocks. Figure B-17 shows recent exploitation history for the Big Beef Creek population. The high rates in earlier years were obviously not sustainable and led to the inadequate spawning escapement shown in Figure B-12. The lower rates in recent years demonstrate that the overfishing problem is being corrected.

Washington steelhead data bases tend to be limited to spawner-recruit relationships of adult spawners to adult returns. In these, we are missing the critical measure of smolt production and are therefore unable to separate freshwater survival from marine survival. This creates a degree of uncertainty for recent values since all high seas gillnetting became illegal under international law after 1992.

From historical data we know that upper Columbia River salmon and steelhead runs were very productive prior to hydroelectric development. One example, mid-Columbia steelhead, is shown in Figure B-18. The individual fish were very productive in terms of recruits per spawner. However, the population was being overfished during the period shown since the data points only define the lower portion of the spawner-recruit relationship. Today's runs cannot even replace themselves as illustrated by Figure IV-3 in Chapter IV.

The current status is much more promising in areas such as the Skagit River where we usually have the levels of spawning escapements that are needed (Figure B-19). However, the adult to adult comparisons present a considerable degree of

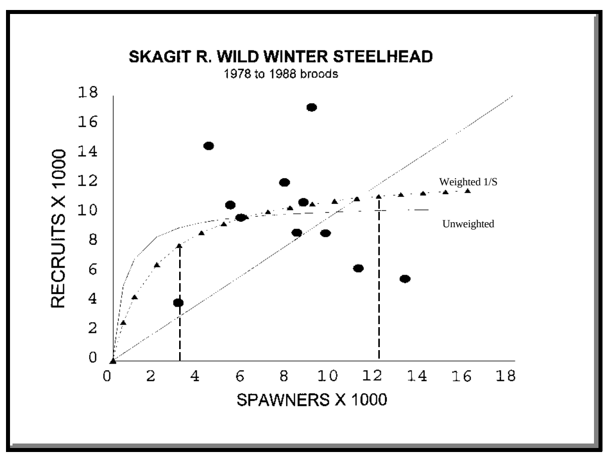

Figure B-19.

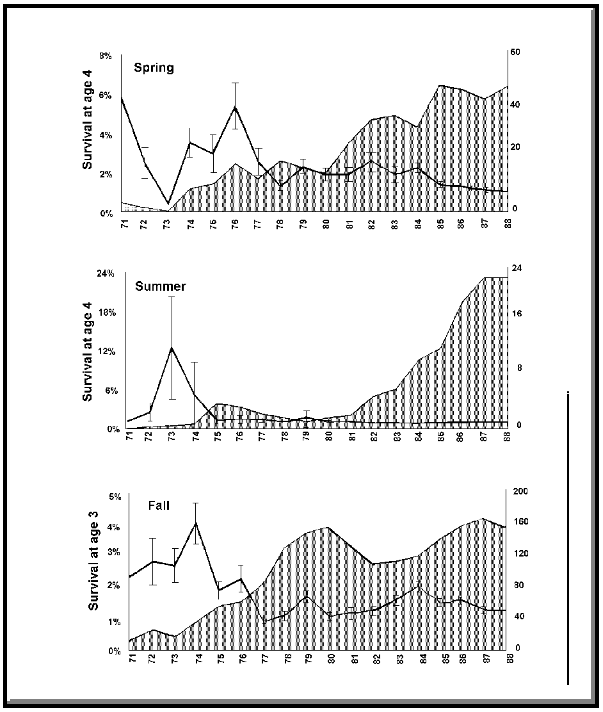

Figure B-20. Hatchery chinook salmon.

uncertainty. Most notable are the two largest spawning escapements which did not even come close to replacing themselves. We have no idea how common or rare these types of events might be. Due to this uncertainty, the two points should be deleted in any determination of a point estimate of MSY.

A final piece of the salmonid puzzle is hatchery production. Figure B-20 shows a particularly disturbing picture for chinook salmon. For all three life history types - spring-, summer-, and fall-run fish - the survival rates have declined as total hatchery releases have increased. This occurred in spite of numerous recent improvements in fish cultural techniques which were promoted as means to improve survival rates. To some people, Figure B-20 may look like a text book case of density dependent mortality. However, this view is far from universal. The only way to really test this hypothesis would be to scale-back total hatchery releases to 1970's levels, but there is little support for such a massive experiment.

Note: Figure B-20 is adapted from Corondo-Hernandez (1995). Lines represent survival rates of coded wire tagged experimental groups, error bars are the standard deviation of the mean, shaded area is millions of fish released by brood year.

Appendix C HABITAT ELEMENT - ACTION STRATEGIES

The Habitat element involves: (1) salmonid requirements for survival, growth and reproduction; (2) how these requirements are influenced by natural physical processes and habitat conditions throughout the various salmonid life stages; (3) how human activities have affected these natural processes and habitats; (4) representative performance measures we could use to ensure success; and (5) examples of actions we can take to maintain or restore the processes and habitats vital to salmonid production. This appendix provides action strategies we recommend in order to be successful in meeting the habitat goals and ultimately the overall goal of the Wild Salmonid Policy.

Components of Habitat Protection and Restoration Action Strategies

The Action Strategies are organized into the following components:

- Habitat Protection and Management
- Basin Hydrology and Instream Flow
- Water and Sediment Quality and Sediment Transport
- Stream Channel Complexity
- Riparian Areas and Wetlands
- Lakes and Reservoirs
- Marine Areas
- Fish Passage and Access
- Habitat Restoration

Each component provides recommended action strategies that could address the issues specific to that component. Please note that many of the recommended action strategies are actions already being taken at federal, state and local government levels, or being taken voluntarily by individual land owners. Because this is a policy, except in a few cases, it would not specifically identify all of the wide variety of existing programs and activities in place for habitat protection. Rather, the policy provides principles and processes in a more general sense and specific programs could be identified during implementation.

Inadequate attention to one or more habitat components within the habitat chapter may reduce or eliminate the benefit of another. For example, riparian buffers and stream channel complexity would be of reduced value to wild salmonids if instream flows are inadequate or fish access is precluded. For anadromous salmonids, production gained from freshwater rearing habitat may be lost if nearshore marine conditions for feeding and migration are inadequate.

Habitat quality is also related to all the other elements in the policy, particularly to spawner abundance and ecological interactions. Freshwater productivity can be heavily influenced by returning adult salmon whose carcasses provide a source of marine-derived nutrients (nitrogen, phosphorus and carbon) to the streams and riparian zones (Bilby et al.1996) and lakes (Kline et al. 1994). Spawning aggregations of some freshwater salmonids produce similar responses in streams isolated from the ocean (Richey et al.1975).

Action Strategies for Habitat Protection and Management

Habitat protection and management first require an overarching goal and philosophy to guide the policy implementation. They also require a number of institutional, housekeeping details to ensure efficiency of staff and budget for those involved or affected by this effort. This includes coordination of regulatory and proprietary efforts, up-to-date comprehensive information to guide habitat decisions, and sharing, interpretation and application of that information to habitat issues. Acquisition of key parcels or easements adjacent to salmonid habitat can be an effective way of partially protecting and restoring salmonid populations as well and should be a part of the overall habitat approach.

With this approach and framework in place, a habitat policy would address the issues of maintaining and restoring the physical and chemical processes necessary to meet salmonid life requirements, protecting and restoring key habitats and providing adequate migratory pathways between habitat types.

The following are examples of recommended actions that would help to achieve the performance measures for this component:

A. While it would be the intent of the policy to avoid all habitat impacts, the policy recognizes that at times the needs of society will degrade habitat. Therefore, the policy would indicate that all future human actions potentially affecting salmonid habitat should use the following hierarchy of approaches:

    1. Protect from human impacts all useable wild salmonid habitat in freshwater, estuarine, and marine environments that is important to migration, spawning, and rearing.
    2. Fully mitigate salmonid habitat impacts due to or anticipated from human activity.
    3. Seek full compensation for direct losses of salmonids and irreparable harm to salmonid habitat due to unauthorized activities.
    4. Restore the wild salmonid habitat from its present condition up to its full productive capacity.

   This hierarchy would be applied to all planning activities and permit reviews under WDFW authority and is recommended for other agencies and private citizens as an approach to protecting salmonid habitat. Avoidance would be the most preferred and most commonly used form of protection. Mitigation should be used only when no practicable or feasible alternative exists, and compensation would be infrequently considered - usually reserved for fish kills or habitat damage where restoration is impossible.

B. Conduct a coordinated, comprehensive inventory and assessment of freshwater/marine salmonid habitat, including aquatic biointegrity, with periodic updates:

    1. Include all habitats necessary for maintaining life history stages of existing and historical salmonid populations, incorporating both physical habitat elements and biological monitoring parameters such as water chemistry and prey-base assemblages and densities.
    2. Use the inventory to establish and evaluate watershed protection and restoration strategies.

C. Define and improve quantitative relationships between physical habitat conditions and salmonid productivity. Establish habitat performance measures based directly on salmonid production/productivity.

D. Routinely review and update physical habitat performance measures in the policy to reflect the best available science.

E. Develop a process to coordinate local, state, tribal, and federal regulatory and proprietary authority that ensures opportunities for public review and input and that ensures that all components of the habitat policy are adequately and efficiently implemented. This coordination process should include regularly reviewing and recommending revisions to regulations and/or reviewing and revising typical permit conditions as appropriate to protect salmonid habitat.

F. Develop a statewide, unified natural resource damage assessment and restoration strategy that would fully compensate the public for unauthorized activities that injure salmonids.

G. In collaboration with affected parties and in other forums addressing these issues, develop and propose rule changes or legislative changes to improve wild salmonid protection in four major areas: (1) forest practices (including WDFW representation on the Forest Practices Board); (2) growth management (addressing minimum standards for zoning, platting, and protection of critical areas, and more complete integration of watershed planning with GMA); (3) water allocation (addressing water rights and permitting, instream flows beneficial to wild salmonids, exemptions, water conservation), and (4); agriculture. New forums may need to be established to accomplish this objective.

H. Support a uniform state water-type classification system for use in protecting salmonid habitats.

I. Provide public access to the wild salmonid habitat information to maximize the effectiveness of habitat protection and restoration efforts.

J. Identify key parcels of wild salmonid habitat as a priority for state-funded land-acquisition programs.

1. Support a dedicated funding source for securing wild salmonid habitat.
2. Acquire key wild salmonid habitats using watershed inventories and analyses as a basis for identifying critical habitats. Acquisition priorities should be consistent with restoration priorities.
3. Increase efforts to seek opportunities for land trades that secure wild salmonid habitat.

Action Strategies for Basin Hydrology and Instream Flows

The basic life need for all living organisms is water and, obviously, a fish out of water is in trouble. The amount and quality of the water, and its pattern of flow are among the key factors of critical importance to salmonids.

The following are recommended action strategies that could help to meet the performance measures for basin hydrology and instream flows:

A. Build consideration and development of water conservation guidelines and standards into regional and watershed-based water resources planning and implementation. Such guidelines could, as needed, be used to restore instream flows. Continue development and use of trust water rights as a means to achieve water conservation to benefit instream flows. If needed, request funding for development of statewide water conservation standards.

B. Ensure that maintenance or restoration of the hydrologic regimes necessary to protect or restore salmonid habitats and life history needs are an integral part of upland management plans and practices, growth management planning, and stored water management plans.

   1. Develop strategies to maintain, restore or emulate natural processes and land features that allow river basins to intercept, store, transfer, and release water so that instream flows are maintained and natural hydrologic regimes are attained.
   2. Develop means (including incentives, zoning, reaggregation of small parcels, clustering) to retain forest, agricultural, and rural lands in order to protect the extent and functions of aquifer recharge and discharge areas, wetlands, riparian zones, and frequently flooded areas.
   3. Develop mechanisms that limit the total effective impervious surface in a watershed subbasin to, or below, a threshold that prevents loss of habitat quality, habitat quantity, and salmonid diversity. In watershed subbasins currently exceeding this threshold, employ best available technology to manage existing or anticipated stormwater runoff. These efforts could be coordinated with development and implementation of a statewide stormwater-management strategy.
   4. Integrate water-resource planning for instream and potable uses with growth management planning. Determine adequate water supplies in a manner that accounts for the protection of instream flows.
      a. Identify and map known or potential aquifer recharge areas.
      b. Protect and restore groundwater recharge and discharge areas that are important for wild salmonids.

C. Protect (and restore where feasible) floodplain habitat of value for wild salmonids.

   1. Employ low-density and low-intensity zoning and regulation.
   2. Utilize floodplain management measures that provide retention or reclamation of flood plain function and extent.
   3. Require that new roads constructed in floodplains avoid increasing water surface levels and minimize the channeling effects that convert sheet flow to directed flow points (bridges, culverts) during flood events. Correct, to the extent possible, existing roads that function as dikes to reduce or eliminate their adverse hydrologic impacts.
   4. Forest harvest planning could include harvest scheduling - including rotation ages that will prevent damaging changes in stream hydrology from rain-on-snow events and other hydrologic effects. Forest-road densities could be limited to thresholds which avoid damaging changes in stream hydrology.

D. Establish and maintain instream flows (minimum low flows, channel-forming and maintenance flows) that optimize habitat conditions for migration, spawning, incubation, and rearing for wild salmonids and their prey base.

E. Maintain instream flows by modifying stored water release strategies and addressing interbasin transfers of water.

F. Protect instream flows from impairment by groundwater withdrawals where groundwater is in hydraulic continuity with surface water. This protection includes minimizing the effects of single family exempt wells on stream flows.

G. Promote the use of best available irrigation practices that emphasize water and wild salmonid habitat conservation. State funding for new installation and upgrades of water delivery systems would be provided only where best available technology is used.

H. Where voluntary compliance has not been successful, attain and maintain instream flows through (1) increased enforcement of existing instream-flow regulations, (2) active pursuit of relinquishments, (3) reduction of waste, (4) increased water-use efficiency, (5) dedication of water from federal projects, (6) pursuit of trust water rights, and (7) denial of new consumptive water rights.

I. Institute specific wild-salmonid habitat protection criteria as part of the analysis to determine which flood control projects would be funded. These criteria would include channel-forming functions and values, bed character and quality, and overwintering habitat areas.

Action Strategies for Water Quality and Sediment Quality, Delivery and Transport

Salmonids are dependent on abundant, clean, cool water for their survival. Several water quality components are important to, or regulate, salmonid habitat and resources: water temperature, dissolved oxygen, pH, total suspended solids (TSS), and specific toxic materials. The quality, delivery and transport of sediments throughout stream channels, lakes, and marine areas plays a significant role in salmonid survival and production.

The following action strategies are recommended in order to meet the performance measures for water quality and sediment quality, delivery and transport:

A. Ensure surface water runoff, water discharge, water conveyance systems and irrigation return flows meet quality standards for a receiving stream channel or surface water.

B. Establish spawning and rearing habitat criteria (e.g., percent fine sediment) through the state water quality standards triennial review process.

C. Develop a statewide stormwater management strategy that illustrates how land use patterns affect impervious surfaces and stormwater runoff and how to use hydrologic modeling to develop land use options to avoid significant changes in basin hydrology and non-point source point pollution.

D. Develop a statewide, unified aquatic-sediments strategy to prioritize clean up of contaminated-sediment sites associated with salmonid production.

E. Continue to support a statewide, unified natural resource damage incident response, clean-up and assessment and restoration strategy to fully compensate the public for damages incurred due to releases of toxic substances.

F. Organize a forum to promote understanding and communication between the fish and wildlife management community and the agricultural community on issues of salmonid production and the production of agricultural crops and products. This could be modeled on the Timber, Fish and Wildlife Agreement that was used to address the interactions of timber management activities and fish. Develop an improved regulatory framework including best management practices that assures agricultural activities would comply with federal and state water quality requirements.

G. Recommend "total maximum daily loading" (TMDL) for point and non-point pollution activities:
    1. Develop an improved version of watershed analysis or equivalent procedure to meet Clean Water Act requirements.
    2. Specify TMDLs that recognize the value of salmonid carcasses up to historical levels as a source of nutrients.

H. Develop interim approaches, including best management practices, for impaired water bodies or watersheds for which a TMDL has not been developed.

I. Seek to defer or condition activities or permits that would adversely affect state waters to ensure that no further degradation would occur.

J. Promote land-use practices that prevent significant changes in the delivery and transport of sediments. Priority consideration should be given to high-risk areas where potentials for impacts are greatest, such as highly erodible areas.

K. Promote sediment control measures for activities that could introduce unnaturally high levels of fine sediments into streams and estuaries such as gravel or rock crushing/washing, road use in wet weather, and land clearing on erodible soils.

L. Advocate sediment control measures which protect all waters, including Type 4 and 5 streams (WAC 222-16) especially in areas with steep headwall slopes, unstable slopes, and high mass-wasting potential from sedimentation and pool filling, and to protect the integrity of downstream salmonid-bearing waters.

M. Manage watersheds to ensure that gravel and sediment delivery to streams is at levels that would maintain favorable substrate conditions for spawning and rearing salmonids.

N. Review designs of dams and water diversion structures to facilitate the normal downstream transport of sediments. Require gravel supplementation to mitigate gravel supply depletion.

O. Ensure that gravel removal and dredging operations are evaluated and conducted in a manner that protects wild salmonid habitat, including instream, riparian, wetland, and marine resources.

Action Strategies for Stream Channel Complexity

Salmonids have evolved and adapted to streams which possess a variety of in-channel features important to their survival, growth, migration, and reproduction. These features include pools , riffles and intermediate areas such as glides, cascades and waterfalls. Other features include substrate size and distribution (silt, sand, gravel boulders, etc.), sediment delivery and transport processes, water depth and velocity, undercut banks, side channels and instream large woody debris. These features collectively define the complexity - or simplicity - of a stream channel. On balance, complex channels are more productive for salmonids than simple channels.

The following action strategies are recommended for maintaining or restoring stream channel complexity:

A. Allow river and stream channels to maintain or restore their natural meander patterns, channel complexity and flood plain connectivity. Where feasible, restore these features.

B. Maintain or provide functional riparian corridors. See also action strategies under riparian areas and wetlands (next component).

C. Avoid or minimize channel relocations or encroachments. Where channel relocations are absolutely necessary, ensure that new channel design and construction would not result in a net loss of function or value. Where altered channels are being rebuilt or restored, the reconstruction design should conform to the performance measures identified in this component.

D. Restrict large woody debris (LWD) removal from stream channels and floodways. Where LWD removal is warranted because of damage to property or capital improvements, relocate LWD to other areas within the channel. Discourage LWD removal for other purposes.

E. Develop performance measures, including channel complexity and sinuosity, for historically non-forested areas and intertidal lands of rivers and streams.

Action Strategies for Riparian Areas and Wetlands

Riparian areas and associated wetlands perform a variety of functions, all of which have a direct or indirect effect on salmonid production.

The following action strategies are recommended to protect and restore these areas:

A. Develop wetland protection standards specific to the needs of wild salmonids.

B. Support a mechanism of wetlands inventory, tracking and characterization.

C. Develop integrated strategies to include regulatory and non-regulatory approaches (e.g., incentives such as current-use taxation, conservation easements, awards/recognition, or land trusts or other forms of acquisition) to improve stewardship of riparian and wetland areas and buffers supporting wild salmonid habitat.

D. Ensure that land-use plans avoid the loss or degradation of riparian and wetland areas, fundamentally through land use allocation, and secondarily through application of mitigation techniques.

E. Where wetlands alterations are unavoidable, support wetlands permitting programs to achieve no net loss of wetland acreage and function.

1. Provide for a mechanism to assess the effectiveness of wetlands mitigation to replicate wetlands functions and extent.
2. While avoidance of wetland impacts is preferable, there may be times when off-site mitigation is more practical, affordable and effective. A state mitigation banking protocol should be followed when site specific wetland impacts are unavoidable and mitigation should occur within the same watershed. The protocol should ensure the needs of wild salmonids are met, including criteria for success and monitoring strategies.

F. Over the long term, seek to gain an increase in wetland base and functional characteristics.

G. Oppose new road construction or other encroachments in riparian areas and wetlands. Where construction, reconstruction, or upgrades are unavoidable, minimize encroachments in riparian areas and wetlands and mitigate for adverse impacts.

Action Strategies for Lakes and Reservoirs

Lakes and reservoirs are significant and ever-changing features of the landscape of Washington. The over 8,000 lakes identified in the state vary widely in age and successional stage, origin, elevation, productivity, shape, hydrology and water quality, and in shoreline configuration and level of human development (Dion 1978). Some are nearly pristine and virtually unchanged physically. Others, typically low-elevation lakes such the Lake Washington/Sammamish system, have been extensively altered and developed with wholesale changes in inlet and outlet drainage systems. Many lakes have been manipulated in some fashion; usually for lake-level maintenance, flood control or hydroelectric power generation, and they are often equipped with control structures at their outlets.

The state also abounds with human-built reservoirs. Most have been converted from previously free-flowing stream reaches. They range from small impoundments to single large dam/reservoir structures up to entire river system impoundments such as the Columbia River system of hydroelectric dams. Some are designed to allow fish passage, while others completely obstruct passage or the passage facilities are inefficient or ineffective.

Recommended Action Strategies for Lakes and Reservoirs include:

A. Ensure that land-use plans and regulations take into account the particular sensitivity of lake habitats as identified in the lakes introduction.

B. Develop lake level manipulation operations plans that protect salmonid habitat.

C. In areas of significant nearshore use by wild salmonids, minimize the size and numbers of docks, floats and ramps. Use community or shared/common structures where possible. Avoid the use of treated wood in these structures.

D. Develop strategies to address aquatic plant introduction and control issues.

E. Ensure that lake outlets afford free and unobstructed passage as necessary for anadromous and resident fish species.

Action Strategies for Marine Areas

Washington State has approximately 100 diverse estuaries within 14 regions, exhibiting structural, hydrological and biological diversity (Simenstad et al. 1982). As with freshwater habitat, salmonids have evolved their respective life histories around these patterns of estuarine development. Estuaries are critical transition areas where seaward-migrating smolts adapt to seawater and returning adults prepare to enter spawning streams.

Recommended action strategies for marine areas include:

A. Standards for basin hydrology and instream flows, water quality, stream channel complexity, and riparian areas and wetlands should be reviewed and modified to recognize and manage for functions necessary to maintain productive estuarine and nearshore marine habitats.

B. Ensure that maintenance or restoration of the natural marine shoreline processes necessary to sustain productive nearshore salmonid habitat are an integral part of upland and aquatic land-use planning.

C. Promote land-use planning that allows natural marine bluff and riverine erosion, sediment, nutrient, and large woody debris transport processes to create and maintain the productive marine habitats that salmonids depend upon.

D. Support mitigation sequencing (similar to habitat protection hierarchy) to fully mitigate for the potential impacts of proposed in-water or overwater structures on salmonid migratory pathways.

E. Include in watershed plans a program to restore diked, filled, and covered estuarine and tidally influenced habitats. Develop, promote, and seek funding for estuarine and tidally influenced habitat restoration.

F. Develop standards for aquatic lands to facilitate local planning to ensure salmonid productivity would be maintained or increased.

G. Develop a marine protected-areas strategy to include reserves for herring spawning habitat.

H. Develop integrated strategies to use regulatory and non-regulatory approaches to improve stewardship of estuarine wetlands through protection and restoration efforts.

I. Recognize the value of sediment transport to deltas and marine areas, and evaluate dredging and filling operations in a manner that protects nearshore marine, estuarine, and intertidal habitats and functions that wild salmonids depend upon.

J. Promote oil and hazardous substance spill prevention, contingency, and response planning to reduce risk, minimize exposures, remediate contaminated areas, and restore lost resource functions and services.

Action Strategies for Fish Access and Passage

Physical barriers interrupt adult and juvenile salmonid migrations in many parts of the state. Persistent blockages deny access to critical spawning and rearing habitat. Loss of access to habitat will reduce overall salmonid productivity and may result in loss of salmonid populations. Fish passage is affected by and related to all the previous habitat components. Basin hydrology and instream flow are obvious fish passage parameters. Less obvious are the attributes of water quality and sediment delivery and transport, riparian areas, and lakes and marine shorelines. Fish passage, in the sense of the presence of adult salmonids, especially spawners, also affects water quality, aquatic productivity, riparian vegetation, and spawning gravel quality.

Recommended action strategies to meet the performance measures for fish access and passage include:

A. Within three years, develop criteria, implementation processes, and compliance processes to identify, correct or remove existing human-caused fish passage problems in freshwater, floodplain and estuarine habitats.

B. Develop recommendations and coordinate with the U.S. Army Corps of Engineers (Corps) and federally licensed dam operators to implement, monitor, and evaluate controlled spill programs at dams, including dissolved gas abatement and other fish passage options, to maximize effectiveness for juvenile and adult salmonid passage.

C. Establish procedures for evaluating, adopting and implementing new fish passage technologies, including:

   1. Automation of spillway operational facilities.
   2. Development, testing and construction of surface attraction flow collectors.
   3. Minimization of juvenile migrant transportation as the primary means of dam passage.
   4. Construction of gas abatement structures and operation strategies to control gas supersaturation.

D. Promote land-use plans that prevent the impacts of road construction on fish passage. Associated components include:

   1. Reducing needs for new highways and streets via land use planning and transportation planning including such things as light rail, ride-sharing, etc.
   2. Reducing number of individual private roads for individual residences.
   3. Limiting most new growth to urban areas while retaining large blocks of habitat in rural areas.

E. Incorporate consistent state-wide criteria and guidelines for fish passage and screening into future design, construction, or alteration of instream structures, roads, and facilities.

F. Develop and expand programs to educate people regarding fish passage issues, and when stream crossings are unavoidable, assist them in the designing and constructing of instream structures which facilitate free passage.

G. Develop an equitable long-term funding mechanism and other incentives to share costs of passage restoration.

H. Develop and implement effective monitoring and maintenance programs, and compliance processes that assure fish passage and screening structures are safe and efficient.

Action Strategies for Habitat Restoration

Any strategy designed to maintain or recover salmonid populations should have as a basic underpinning meaningful protection of existing habitat. But it should be no surprise to an informed citizen that we have lost significant habitat in our streams, lakes and estuaries. It may not be as clear to that person that much of our remaining habitat is in a degraded state. And it is even less clear to most citizens how difficult, if not impossible, and how expensive it is to recover or restore habitat. However, examples abound of the extreme cost of habitat restoration. Scientific journals and lay publications are replete with case studies and admonitions about the pitfalls of poorly planned habitat restoration projects. Continual restoration of unmitigated impacts to wild salmonid habitat is undesirable, often ineffective and the most costly means to achieving salmonid population recovery; in the long run salmonid populations are best protected by ensuring habitat protection.

The following action strategies are recommended in order to meet the performance measures for habitat restoration:

A. It is the legislature's intent to minimize expense and delay due to obtaining required permits for projects that preserve or restore native fish habitat (Chapter 378, Washington Laws). The law defines watershed restoration projects and provides that projects that have been reviewed under the State Environmental Policy Act shall be processed without charge and permit decisions shall be issued within 45 days of filing a completed application. The state agencies with permitting responsibilities relevant to watershed restoration should fully implement Chapter 378. They should continue to examine opportunities to increase their efficiency in processing project permits and to enhance the design and effectiveness of restoration projects.

B. Apply best available science and adaptive management to restoration strategies and activities:

1. Where possible use some form of watershed analysis that identifies the physical, chemical and biological processes that may affect the success of the restoration strategy.
2. Employ watershed restoration mechanisms and technology to restore and maintain habitats to optimum conditions for salmonid spawning, rearing, and migration.
3. Use qualified experts to analyze, design, and construct specific projects and to evaluate the success of the strategy.
4. Ensure that monitoring and contingency planning is included in project design.

C. Prioritize restoration activities. Considerations for priority would include:
1. Salmonid stock status, if available
2. Harvest management plan
3. Population vulnerability
4. Possible positive or negative risks or consequences to wildlife or capital improvements
5. Community/landowner acceptance and/or support
6. Feasibility and probability of long-term success
7. Compliments existing completed restoration projects
8. Level of funding, opportunity for partnerships
9. Ability to obtain permits in a timely, affordable basis

D. Plan habitat restoration at multiple scales (subbasin, basin, watershed, state, region) to ensure efforts are consistent, coordinated, and effective.

E. Coordinate salmonid habitat recovery plans with other planning processes such as GMA, watershed planning, flood control planning, etc.

F. Support stable funding source(s) for salmonid habitat restoration in capitol budgets in order to provide time and predictability for planning, development, implementation and monitoring.

G. Establish criteria for salmonid habitat restoration to be incorporated into appropriate state grant funding program selection processes.

H. Where recovery of habitat is possible, pursue restoration measures to allow wild salmonids to recolonize areas they historically occupied.

I. Develop an education outreach program to local communities to foster environmental stewardship.

J. Work with local governments to assure the availability to landowners of incentive programs, such as current-use taxation, and to advocate land stewardship and recognition programs.

K. Develop a coordinated, statewide geographic information system - including mapped and tabular data - among federal, state and local governments for cataloging habitat extent, condition, and restoration needs. Data should be organized and accessed according to watershed and made available to all entities who are conducting watershed protection and restoration projects.

L. Use water conservation and water purchases to restore instream flows. This should include budget authorization to purchase water, water rights, or relinquished water rights and transfer them to the trust water rights program.

M. Pursue federal and state flood-control funds for restoration of wild salmonid habitat that has been damaged by flooding or flood-control activities. This could include non-structural solutions to flood damage reduction such as relocation of structures; removal of dikes and levees; and reconnection of sloughs, former side channels, oxbows and wetlands.

N. Provide technical support (engineering, biological assessments) to watershed groups.

Appendix D DISCUSSION OF SPAWNER ABUNDANCE

Allowing the proper number of viable wild fish to spawn <u>is the key</u> to sustaining healthy salmonid stocks. Spawners are obviously needed to provide the eggs that will grow into the next generation of fish. This in turn affects the number of fish available for harvest. However, the number of spawners affects much more. Salmonid fishes are often described as “keystone” species in the ecosystems where they are found. They are a key species that support many other species. A variety of animals eat them. Even streamside plants are fertilized by decaying carcasses. These positive effects to the entire ecosystem can then affect the insects and other sources of food for growing salmon. Choosing the proper number of spawners is very important and affects the entire ecosystem.

The actual number of fish that spawn in any year is the aggregate result of what happens in all policy elements. The number of spawners is often called the “spawning escapement”. Spawners are the fish that escaped the hardships of habitat in streams or lakes or in the marine waters; escaped being eaten by birds, mammals, reptiles, or other fish; resisted lethal disease pathogens; and escaped being caught by fishermen to finally have the chance to spawn. How we protect habitat, manage our fisheries and hatcheries, and maintain ecological processes determines the number of fish that will make it back to spawn. All these sources of mortality must be considered in our planning (ISG 1996).

The *Spawner Abundance* element is about choosing the desired number of spawners to meet the goal. How many spawners are needed to provide enough eggs to sustain the next generation, maintain a variety of genetic traits and behaviors, and provide carcasses to meet ecological needs? This section will consider a variety of ideas on this question.

<u>Background</u>

Fisheries managers generally agree that salmonid populations can be maintained across a range of spawner abundances. If this is true, what determines which level is the right one? The right level for a given situation will depend on: (1) keeping the population from going extinct, (2) the desired level of harvest opportunity, (3) issues of ecosystem health, and (4) non-consumptive use benefits. Some of these can be in competition with each other. Just keeping a stock from going extinct will not provide many fish for harvest, nor will meeting all the possible ecosystem health needs. High harvests may not provide fish for meeting ecosystem health needs or non-consumptive use benefits.

Underlying all these issues is the question of risk — risk to stock health, risk to harvest opportunity, and risk to other values. Different people have different responses to determining the proper escapement level because they have different feelings about the balance of risks and potential benefits. These issues will be discussed in the next section.

An important issue for setting spawner abundance goals is environmental variation and management uncertainty. Figures D-1 and D-2 are drawn as if they occurred in a very stable environment. The real world of salmonid management is very different. In the 1980s there was an eight-fold variation in the ocean survival of coho salmon in the Satsop River. So even if freshwater survival was stable, a given spawning could have numbers of recruits that were much higher or lower than expected. This variation in survival means that it

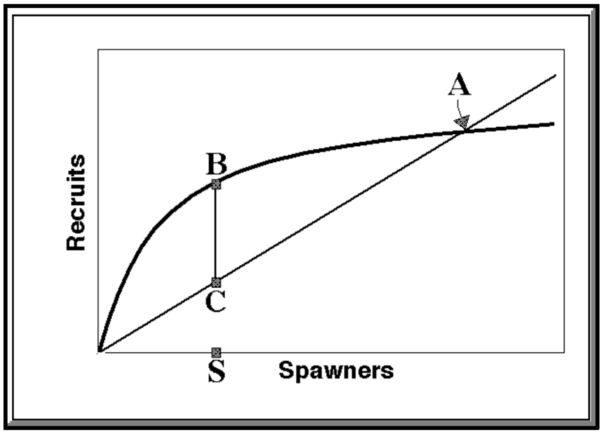

Figure D-1. Spawner-recruit curve for populations that compete for rearing space or food in freshwater.

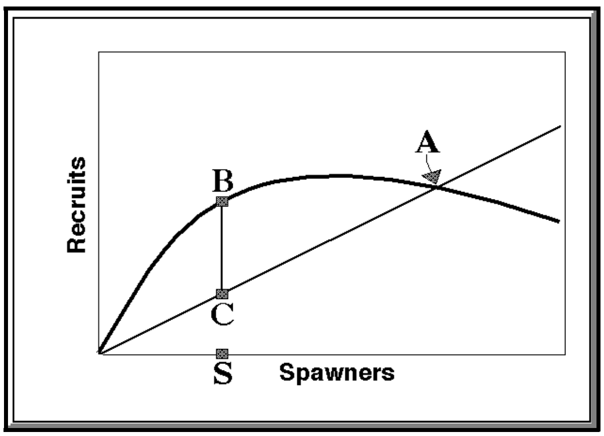

Figure D-2. Spawner-recruit curve for populations that tend to spawn in large numbers and compete for spawning area.

can be difficult to estimate run sizes and other management information. In setting spawner abundance levels it is important to incorporate these uncertainties.

Comprehensive treatment of this subject would require many pages and actual data bases from a large number of fish populations. We will only attempt to present a few basic principles and some simple theoretical population curves for illustrative purposes only.

Spawner Abundance Level Approaches

As was discussed above, the desired level of spawner abundance relates to goals for stock health, ecosystem health, harvest opportunity, non-consumptive uses, and others. This discussion will consider a range of approaches:

A. **Full Utilization of Habitat -** "full utilization of habitat" has been suggested as a spawner abundance level. Full habitat utilization can be defined two ways: (1) the spawner level that produces the maximum number of adult offspring or (2) the replacement level of the population (with no harvest). This could also be defined as the point where an unfished population would be at equilibrium with its environment. As a practical example, this would be analogous to the Optimum Sustainable Population (OSY) standard mandated by the Marine Mammals Protection Act. In Figure D-1 these definitions are at point A on the curve. This is the number of recruits and the place where the population is just replacing itself. In Figure D-2, the maximum recruits is where the curve reaches its highest point, while the point A is again where the population just replaces itself. The two types of curves give different results to the definitions. In Figure D-1 both definitions provide no harvest opportunity, but maximize the number of fish produced and the number of spawners on the spawning grounds. In Figure D-2 definition 1 provides a harvest, the largest population size but fewer fish on the spawning grounds. Definition 2 provides no harvest opportunity, a lower total population, but provides the greatest number of spawners.

Figure D-2 is counter-intuitive since it shows that fishing mortality will, on average, produce more fish in subsequent generations. However, there are some plausible explanations for this even though empirical data on exact causes are generally lacking. The most common is that eggs from the central part of a run will, on average, have a higher survival rate. If these same eggs are dug-up by later spawning fish, the overall survival rate will be less. Many actual data sets best fit the Ricker-type production curve with its distinctive downward bend at higher spawning population levels. Still, these same data sets were typically collected during periods of continuous exploitation. Thus, they may not reflect the relationships for unfished populations or for populations that are protected from fishing mortality for an extended period and allowed to reach equilibrium with their environment.

Full habitat utilization provides the greatest benefits to stock and ecosystem health:

1. Larger numbers of spawners can provide protection against environmental problems.
2. Spawners are likely to have a greater distribution in multiple spawning areas so that a problem in one area is less likely to cause the loss of the entire population.
3. Northwest ecosystems evolved with large numbers of salmonids. Many animals, including bears, otters, and eagles use salmonids for food, and would likely benefit from increased numbers.
4. Spawning salmonids are an important source of nutrients for freshwater systems. Nitrogen is an important nutrient that often limits production in freshwater systems in the Northwest. Specific forms of nitrogen associated with salmon and steelhead carcasses are found in significant levels in stream vegetation and animals.
5. Periodic large escapements may improve spawning survival. Species such as pink, chum, and sockeye that spawn in high densities can clean the gravel during spawning. This improves the flow of water through the gravel and improves egg survival for all salmonid species.
6. Genetic fitness of salmonid stocks to the environment may also improve with large numbers. Salmonids generally evolved in the presence of large population sizes and high levels of competition. This competition for space and food helped maintain a high rate of natural selection for fitness to specific conditions. This competition is reduced at lower population levels. As a result, the level of genetic fitness may decline.
7. Larger populations of spawners may make salmonids more visible to people who live in the Northwest. This creates more incentive to protect habitat and meet other requirements that are important for long-term survival. Workers involved with habitat protection say the lack of visible evidence of salmonids in streams makes it more difficult to generate enthusiasm for stream protection.

It has a cost in terms of catch. Under most of the definitions for full habitat utilization, there is no sustainable harvest. At the extreme this would not even allow catch-and-release fishing since there is a harvest related mortality associated with it. In practice, some level of incidental harvest would likely be allowed to provide for selective fisheries on other stocks.

B. **"Abundant Utilization of Habitat"** - this level is an intermediate step between full habitat utilization and a focus on maximizing harvest opportunity. The intent here is to provide a strong focus on stock and ecosystem health, but also provide the opportunity for harvest. Spawner abundance levels would be set based on providing the following:

1. Two buffers will account for risk to the resource due to (1) uncertainty with respect to the exact spawner-recruit relationship; and (2) degree of harvest management precision - the ability to actually deliver fish to the spawning grounds. This makes it far less likely to overfish and depress the population. This is particularly important if there is uncertainty about the form of the relationship and exactly where different escapement levels fall. Managers would also have the option of changing to an alternative fishing strategy but only if it is clearly more conservative (less risk to the resource) than any MSY point estimate calculated from the spawner-recruit relationship.
2. More stable fisheries and populations.
3. Larger total population sizes would make recreational fisheries more successful, because the chance of encountering a fish goes up. The value of higher escapements will vary depending on the type of spawner-recruit relationship.
4. Levels of spawners that support good genetic diversity, and increase the number and distribution of wild stocks.
5. Levels of spawners that support natural ecosystem processes.

C. **Minimum Sustainable Escapement (MSE) -** the National Research Council (NRC 1996) recently developed a spawner abundance concept that they called the minimum sustainable escapement. They suggest that this level be a floor, with all escapements above it. The MSE concept is designed to provide a long-term probability of survival of populations in the face of overfishing and random environmental and other variation. The concept also includes a recognition of the role salmonids play in ecosystem health, and the value of larger populations in maintaining genetic diversity and stock distribution, though they note that the need for this "is not well demonstrated with direct research." They propose using many of the same techniques currently used to develop MSY type goals for many Washington populations. Their proposal suggests that this approach will result in escapements above the MSY level. The unknown value here is the level of spawning necessary to meet some of the genetic and ecological considerations, which they have not detailed.

D. **Maximum Sustainable Yield (MSY) -** in both Figures D-1 and D-2 there is a place (point B to point C) where the distance between the replacement line and the spawner-recruit curve is the greatest. This is the place that provides the largest average catch, or yield from the population over time. If escapements are maintained at this level,(point S in Figures D-1 and D-2) and habitat capabilities are not diminished, this maximum yield or catch can be sustained. This is known as the point estimate of maximum sustainable yield (MSY). Conceptually, MSY has many advantages. First, it maximizes harvest opportunity which is an important value for many people. It represents both recreational opportunity and economic benefits. Second, MSY is an objective standard that can be quantified for comparison with other approaches. It has a theoretical basis that has considerable support from actual observations.

Fully achieving MSY in practice is impossible due to fishery management imprecision, even if the spawner-recruit relationship itself is completely accurate. Actual spawning escapements will fall in a range or "band" that goes both above and below the point estimate of MSY. Depending upon the shape of the spawner-recruit relationship, lower escapements can lead to decidedly poorer runs on the next cycle. In mixed stock fishery management, you only need to have one "weak stock" to create a major constraint on flexibility.

In the 1970s, only a limited number of usable spawner-recruit relationships were available to managers. Most of these were for chinook salmon populations in the Columbia River system. Coho escapement objectives were based on estimates of habitat capabilities although a spawner-recruit relationship was at the core of these calculations. Escapement objectives for chinook, chum and pink salmon and steelhead were based mainly on recent records of sustainable production. However, managers fully recognized the deficiencies inherent in these types of approaches, notably the need for major assumptions that could not be verified.

A number of long-term resource assessment programs were initiated in the late 1970's to address this problem over time. There has been a consistent effort for several decades to develop better spawner-recruit information, mainly because major assumptions are not required. As a result, there has been a decided shift in recent years from the habitat capacity and historical production methods to usable spawner-recruit data.

E. **Stock Perpetuation** - it may be possible to manage populations at a lower level where they are at no immediate risk of loss or permanent harm. However, as populations are managed at lower and lower spawner abundance levels, the risk of harm or extinction increases.

An environmental catastrophe that may not be a insurmountable problem for a larger population may be devastating for a smaller population. Fish in smaller populations may have a more difficult time finding mates (Allee 1931, cited in Frederick and Peterman 1995); in a given area they may all be of the same sex. Some forms of competition among different fish species may become more of a problem as a fish population gets smaller (Gilpin and Case 1976). At smaller population sizes there is a much greater risk of loss of genetic diversity and local adaptation (see *Genetic Conservation*, Appendix E). This combination of impacts may make it difficult or impossible to recover a population under natural conditions. Even a relatively large population may be considered "functionally extinct" if it cannot recover due to a combination of such factors.

However, the greatest danger with a small stock size occurs when predation or disease leads to a situation where the highest percent mortality occurs at low abundances of juvenile or adult salmonids. Peterman (1987) states that populations with two or more "domains of stability" must be managed accordingly. In these cases, two or more different mortality processes combine in a series to create a stock-recruitment curve with more stable points than the single one exhibited by the standard Ricker model. Two types of possibilities are illustrated in Figures D-3 and D-4, adaptations from Peterman (1987, p. 425). In the first case (Figure D-3), an unfished population would be stable at point S_1, and could be continuously exploited without permanent harm as long as it never dropped down to point S_2. Below this point, the population would move toward extinction, even if harvesting was completely stopped.

In the second case (Figure D-4), a critical spawner abundance also exists, but a population falling below point S_2 would not go toward extinction but toward a lower stable equilibrium (point S_3), which would be very unproductive for harvesting. Elimination of all harvest would still not permit the population to return to the higher abundance near the upper stable point. Columbia River chum salmon are a likely victim of the second phenomenon. This resource has declined to one-half of one percent of its historical abundance (Nehlsen et al. 1991).

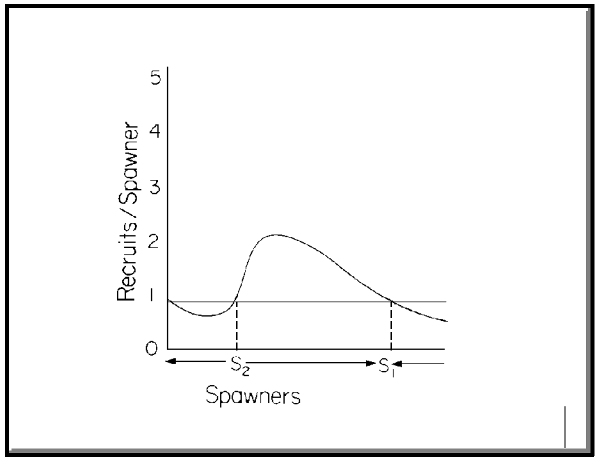

Figure D-3. Stock-recruitment relationship that can lead to extinction.

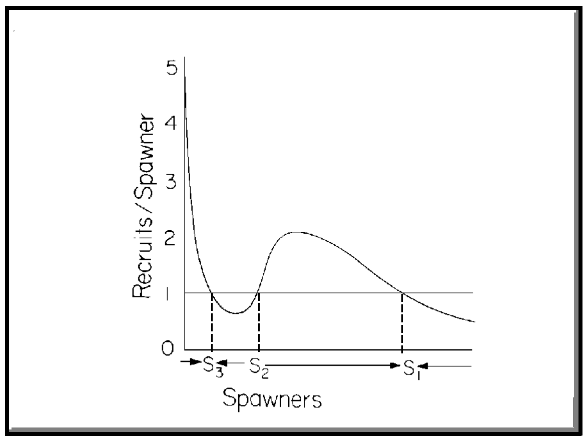

Figure D-4. Stock-recruitment relationship that can reduce a population to a very small size.

Appendix E DISCUSSION OF GENETIC CONSERVATION

Salmonids live in a highly variable and changing world. Their world changes over time due to the daily movement of the sun, changes in the seasons, and decade and longer climate patterns. It changes from river to river, or lake to lake, due to differences in soils, climate, orientation to the sun, elevation, and vegetation. The ability to adjust and adapt to this changing world around them is key to the long-term survival and productivity of salmonid populations. The *Genetic Conservation* element is concerned with maintaining the characteristics of fish populations that will allow them to be productive under the current and a range of future conditions.

Background

There are two key areas for genetic conservation: (1) *local adaptation* — a natural process that matches the characteristics of fish populations with their local environment, and (2) *genetic diversity* — the need to maintain a variety of characteristics in populations and species so they can respond to change.

Local Adaptation

Fish look and act the way they do largely because of traits they inherited from their parents. Traits such as a large body size for long upstream migrations or to spawn successfully in larger rivers, coloring that camouflages, the urge to migrate upstream or downstream at certain times, the ability to defend a feeding territory, smaller egg sizes that allow a population to survive in water with a lower oxygen content, an earlier spawn timing or shorter egg development period where the water is colder, and resistance to certain diseases are all traits that will help fish survive under certain conditions.

Traits are passed along from generation to generation on structures called "genes" which are contained in the sperm and eggs of the parents. Traits that help fish survive and reproduce are more likely to be passed on to the next generation, since the fish that have them are more likely to survive and reproduce. Traits that reduce survival and reproduction are less likely to be passed on. Over time a population will accumulate more of those traits that provide greater survival and productivity under local conditions. This process of accumulating positive traits is called local adaptation.

Maintaining this local adaptation is important for two reasons: (1) it increases population productivity, and (2) it helps the species live successfully in more places. Increased productivity means that more fish will be produced from each spawning pair. This makes the population more resilient and capable of dealing with its environment. It also increases potential benefits since more fish will be available for harvest, viewing, and ecosystem needs.

The ability to adapt to local conditions allows a species to live in more habitats and under a greater variety of conditions. For example, different populations of trout may have differing sensitivities to warm water. Each individual population may be limited by its own sensitivity to warm water, but the total species can live in more places because the various populations have a range of sensitivity.

Genetic Diversity

If all the fish in a stream have the exact same combination of traits, they will all react to a change in the world around them in the same way. For example, if all the fish in a population spawned at the same time, and conditions at that time were not right for spawning some year, the entire population would die. Luckily, all the fish in a population do not have exactly the same set of traits. A population of salmon or trout contains many similar, but not identical, individuals. Each individual fish will be slightly more successful in different conditions. Some will have an earlier spawning time, others a later one. This variability, known as genetic diversity, within a population allows the population to adjust to a changing environment. The differences allow the whole population to survive, even though some individuals may die.

The local adaptations of populations to different conditions provide a source of genetic diversity for the entire species. A species will be made up of a variety of sub-populations, each a little different. Each of these differences may be a valuable help in surviving under a certain set of conditions. This allows the entire species to survive even though a part of it is lost.

The diversity of traits exhibited by salmonid species is truly amazing. Salmonids show a variety of sizes, shapes, and life history patterns. They range in size from the large chinook salmon down to the much smaller size of a cutthroat trout or pygmy whitefish. Life histories range from the rigid two-year life of the pink salmon to the 22 different combinations of freshwater and ocean residence in some Alaska sockeye populations. Sockeye salmon, rainbow trout, cutthroat trout, and Dolly Varden all have both migratory (anadromous) and non-migratory (resident) forms. Some bull and cutthroat trout populations live their entire lives in small streams; other populations live in large streams but spawn in small streams. Still others live in lakes, but spawn in small streams. Populations often have very different patterns of return and spawning timing.

> Stock - the fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place at the same time, or in the same place at a different time.

These patterns of diversity have an order to them. At the lowest level is the stock. Stocks are the basic building block for genetic conservation in this policy. A stock is a population of fish that due to location or timing tend to largely spawn with each other rather than with some other population (see box for more detailed definition). This level of isolation from other populations allows the stock to become locally adapted and unique from other stocks. Depending on the species and habitat, a watershed may have a single stock or many stocks, and they may contain many fish or a few fish.

Stocks from a similar geographic area tend to be more similar than stocks from another area. These similar stocks can be grouped together into Genetic Diversity Units (GDUs). Similar GDUs can be grouped together into Major Ancestral Lineages (MALs). The MALs can then be grouped into species.

We can think of a species of salmon as a collection of populations, sometimes called a metapopulation. These populations are related because they are the same species, they may share a geographic area (e.g., chinook in the Columbia River, or several populations of steelhead using the mainstem of a river during migration), or they face similar climate conditions etc. There may also be some limited movement of spawners between the populations. One population may have been started by fish straying from another population so they share ancestors. It is the interaction of these populations that provides for the long-term survival of the entire species. Each of the stocks or GDUs provides diversity to the entire population. As conditions change, some part of the population will hopefully have the traits that will allow them to survive. If a population is wiped out by pollution or a landslide, it can be restarted by fish straying from nearby populations. If enough of the populations are maintained in a healthy condition, the species can remain healthy. So the survival of each stock is important to the overall survival of the species.

Policy Elements

There are four key components to the genetic conservation element: (1) minimum spawner abundance, (2) gene flow, (3) fishery selectivity, and (4) habitat fragmentation and loss.

Minimum Genetic Standard

As populations get smaller the risk of loss of both local adaptation and genetic diversity increases. Smaller and less diverse populations are much more sensitive to environmental changes, predation, and other impacts and so the loss of the entire unique population is more likely. Also, in smaller populations some traits will only be carried by a few individuals. The loss of these few individuals before they can spawn means the complete loss of the traits in the population. These spawner abundance levels in most stocks are likely to be much lower than what is necessary to achieve production that contributes meaningful numbers to fisheries.

Minimum allowable spawner abundances can be set to protect against the potential loss of diversity. In general the population level needed to maintain diversity will be smaller than the minimum spawner abundance levels discussed in the *Spawner Abundance* element. To meet both the spawner abundance needs and the genetic conservation needs, the larger of the two requirements should be used. The minimum levels discussed here will be most useful when dealing with depressed or critical stocks, or with stocks that have historically small run sizes.

The scientific literature suggests that an effective (or genetically ideal) population of 500 individuals can generally maintain adequate diversity within the population over a long period of time. This genetically ideal population assumes that: (1) there are equal numbers of both sexes, (2) there is random mating, and (3) there is equal survival of all offspring. All of these assumptions are likely to be violated in a natural salmonid population. We have already discussed the idea that under any set of conditions some individuals will be more likely to survive and reproduce than others. As a result, it will be necessary to have more than 500 actual spawners in the population to have an effective population size of 500.

The effective population is also affected by the number of times the fish spawn (once, like salmon, or multiple times, like trout), and the average age of the spawners. For example, pink salmon spawn a single time and all at age 2. As a result, there is no mixing of the even and odd year pink salmon gene pools. Chinook salmon spawn only once, but may spawn at from 2 to 7 years of age. This means the offspring of fish spawning in one year may spawn with the offspring of fish spawning in several other years. When there is spawning overlap of cohorts, the rate of random genetic change is determined by the sum of the annual effective population sizes each generation. It takes fewer chinook salmon spawning each year to maintain diversity than it does pink salmon. Fish that spawn more than once have a greater impact on the future population and so tend to reduce diversity. This requires more fish to meet an effective population size.

Gene Flow

Gene flow is the movement of genetic material from one population to another. A limited amount of gene flow occurs in nature. This natural gene flow is a good thing because it introduces some new genetic material into populations and helps increase diversity. However, too much gene flow can disrupt the traits that provide for local adaptation by introducing new traits that do not fit with local conditions. At high levels of gene flow from one population to another the populations will become basically the same so there is a loss of genetic diversity. When one population becomes just like another it is said to become "genetically extinct". The result of this high gene flow is the loss of productivity and greater risk to the population.

Human impacts to gene flow usually result from: (1) transfers of stocks from one area to another, including the introduction of exotic species that are capable of interbreeding with local stocks, and (2) widespread use of similar hatchery strains that reduce genetic diversity in the hatchery fish.

Fish adapt to living in the hatchery for all or part of their lives, similar to local adaptation by wild fish. From a hatchery production standpoint this domestication is positive. It increases the survival and productivity of the fish in the hatchery. Traits that favor survival in the hatchery are not the same ones that favor survival in the wild. When wild and hatchery fish interbreed it reduces the local adaptation of the wild fish, because the domesticated traits are introduced into the wild population. Rainbow trout production is a good example of this concern.

This problem has been identified by a number of researchers. Reisenbichler and McIntyre (1977) showed that wild Deschutes River steelhead outperformed pure hatchery and hatchery- wild crossed fish in the wild. Leider et al. (1990) showed an 86% reduction in productive capacity comparing crosses of hatchery Washougal summer steelhead with wild summer steelhead in the Kalama River. Declines have also been found for winter steelhead (P. Hulett, WDFW, personal communication). Nicholson et al. (1986) followed survivals of hatchery coho releases from initial rearing through adult return and spawning. They found releases of hatchery fry increased juvenile and adult numbers immediately, but when the hatchery fish spawned the resulting populations were actually less than unplanted areas. Fleming and Gross (1992), Swain and Riddell (1990), and Berejikian (1995) described potential genetic differences in spawning behavior and juvenile behavior between hatchery and wild coho. The behaviors of the hatchery fish in their study appeared inappropriate for the wild environment and may have led to lower productivity. Doyle (1983) showed that even subtle differences in feeding patterns may select for different traits in the hatchery population.

Some investigators have suggested that these concerns can be alleviated by using locally derived stocks and changing hatchery practices. These changes occur even when the hatchery population was derived from a local stock. Ferguson et al. (1991) showed that even when great care was taken in the collection of broodstock, there were losses of genetic diversity and changes in population structure. The entire process of collecting broodstock and rearing in a different environment (i.e., a hatchery) can cause changes in a population. These concerns indicate guidelines are needed to control gene flow between hatchery and wild fish to ensure high productivity for the wild fish. However, the risk of loss of local adaption and diversity is the greatest when the hatchery and wild stocks are very different. Gene flow from more similar stocks have less potential impact since they will share many traits.

People often find the idea of restricting gene flow alarming because they assume this will be accomplished solely by reduction of hatchery releases or by closure of hatcheries. This strategy, although an option, would be in conflict with one of the primary strategies of the WSP to maintain fisheries -- that of mass marking hatchery fish for selective fisheries. Selective fisheries work best when the ratio of hatchery to wild fish is high. So it is not that these hatchery fish are not desirable, but it is the consequences of the interbreeding with wild stocks that concerns managers.

Many options could be developed to control gene flow. The recommendation in the EIS is for the specific details to be worked out with appropriate stakeholders and Tribes. Basically, the patterns of gene flow would be identified and then programs would be implemented to bring gene flow to acceptable levels. Through the use of new broodstocks, release strategies, locations, weirs, and improved homing techniques, the gene flow criteria would be used to increase the local adaptation productivity of wild stocks.

The effort to capture hatchery fish after they escape fisheries has been minimal. Often, excess or insufficient numbers of broodstock return to hatcheries depending on the location and water sources. Methods to increase homing based on data from WDFW hatcheries were recently discussed by Vander Hagen and Doty (1995). An increased understanding of why some fish stray more than others provides additional ways to control the unintentional interbreeding of hatchery and wild stocks (Dittman et al. 1996).

Through mass marking, fish produced in the hatchery for harvest would be identified by a clipped adipose fin. Ideally, all of these hatchery fish would be captured in fisheries. The hatchery strays are in many cases wasted because they do not contribute to fisheries and are not successful breeders in the wild (because of timing, location and genetics). In addition, the remaining unharvested strays have been selectively fished, with the larger, more fecund fish removed by the fishery so they are not the best for the hatchery broodstock either. Hatchery fish intended for broodstock could be or not be marked, depending on the fishery impacts on that stock. Selective fisheries would change the ratio of hatchery to wild fish on the spawning grounds from what occurs under present management.

Gene flow standards applied to supplementation are a special case. Supplementation is the deliberate use of hatchery fish to increase wild spawning populations. It may be desirable to allow more gene flow in certain cases to rebuild stocks.

Fishery Selectivity

The harvest of fish is not usually a random removal of fish from a population and may not affect all segments of the populations equally. Particular fishing techniques tend to capture bigger fish or smaller fish, early or later migrating fish, fish in the shallows or fish that are deep. Fish with traits that make them more likely to be caught are removed from the population, and their traits are not passed along to the next generation. This causes the population to change, and become less locally adapted to natural conditions.

Many explanations have been proposed over the years for the changes in average fish size observed in fish populations. Some studies have suggested that genetic changes through the harvest of the fastest growing and larger fish as the cause (Policansky 1993). Other work has pointed to environmental or carrying capacity as the primary factor for biological changes (Bigler and Helle 1994). Others do not believe that any directional change has occurred. Oscillating environmental conditions and short term and localized food shortages have been proposed as temporarily depressing fish growth (Pearcy 1992, Beamish and Bouillon 1993, Hare and Frances 1994, and Beamish 1995). However, because almost all fishing gear used to capture Pacific salmon harvests fish nonrandomly, and the high fishing mortality that occurs in many fish stocks (often 50 to 90+ percent of the adult population is harvested), the potential for significant genetic change is surely present.

Identifying and understanding the effects of quantitative genetic changes in fish populations has received less attention than molecular studies (Gharrett and Smoker 1993, Lynch 1995, Hard 1995) although phenotypic traits are primarily what determines the degree of adaptation, survival, and fitness, and has evolutionary and conservation significance. Because quantitative traits are heritable (Allendorf and Ryman 1987), nonrandom fishing mortality can lead to genetically based changes in fish populations (Wohlfarth 1986, Nelson and Soule 1987, Policansky 1993, Gall et al. 1995). Ricker (1981) documented significant changes in the age and size of Pacific salmon over time in many fisheries. He proposed that genetic change due to selectivity of fishing gear was the most likely reason. However, he could only look at general trends in mixtures of stocks. Kirpichnikov (1981) also believed that size selection in fisheries could cause genetic change in salmonid populations. In contrast, Bigler and Helle (1994) suggested that ocean carrying capacity was primarily responsible for the long-term decline in fish size and an increase in the average age in many fish populations. The freshwater breeding environment has also been proposed as a factor for determining fish size (Holtby and Healey (1990). However, all these studies were not able to test among the potential causes for the observed changes in fish size. Nelson and Soule (1987) review the difficulties in detecting fisheries selection.

Most commonly used fishing gear for Pacific salmon catches fish of a certain size range. The size distributions of fish caught in gillnets of different mesh sizes was determined by Ishida (1969). The minimum mesh size of gillnets allowed varies with the targeted species and is intended to target one species over another (chum over coho) and to minimize capture of juvenile fish (juvenile chinook). Purse seine gear also has a mesh strip (5 inches in Puget Sound) at the top to allow juvenile fish to escape. Minimum size limits are also used for troll and sport fisheries to avoid harvest of juveniles and for harvest controls. Ideally, the distribution of fish caught with fishing gear would be as random as possible with respect to the character distribution in a species. However, this is difficult if not impossible with Pacific salmon because of mixed-stock fisheries with the different stocks having different distributions of characteristics.

The evidence that Pacific salmon are smaller now than in the past is substantial. Ricker's (1981) comprehensive analysis of many fishing areas and gear showed an overall downward trend in weight for all species and gear types. The change in coho size Ricker (1980) observed from 1951 to 1979 was a decrease of 0.168 kg He proposed that genetic changes were consistent with observed reductions in coho size. In the 25 year time period he studied (1951-1975), he found an average 1.22 kg (2.7 lb) decline in coho size when converted to size at maturity in areas outside the Strait of Georgia and Johnstone Strait (0.37 lb per generation). He used the difference in the mean size of fish harvested by selective gears (trolls and gillnets) to the size of coho caught by seines and the mortality rate from fishing (75-85%) to estimate a selection differential of 0.5 kg (1.1 lb) to 0.73 kg (1.6 lb) smaller. These values correspond to a heritability of adult size between 0.23 and 0.35, which are reasonable values. Thus, he determined that it was quantitatively possible that "outside" cohos decreased in size because of genetic selection by the fisheries.

Bigler and Helle (1994) reviewed fisheries from Alaska to California (1975-1993) and, with the exception of chinook, found a decline in weight at all locations. The average weight of coho in fisheries from California through British Columbia declined 0.117 kg (0.26 lb) per generation; the highest declines were found in Washington with a lesser decline in Alaska. These values are similar to what ongoing studies by WDFW found from both fecundity and CWT data. Long term fishery harvest data from the Columbia River documents a decline in coho size; the commercial catch of nearly one million fish was a record high number, but was about one million pounds less than the record high poundage in 1925 (ODFW and WDFW 1995). The range of fork lengths from Washington troll landings from the month of June (1951 - 1964) (Wright 1970) are typical of the current sizes of mature Puget Sound coho at hatchery racks and stream traps.

Changes affecting fecundity in addition to fish length may have influenced our estimates of declining fish size. Fleming and Gross (1990) discuss many factors that influence the fecundity of coho salmon, including female energy investment, incubation temperature and oxygen transport and relate these to a latitudinal cline in clutch size. They propose that egg size is highly associated with fitness and appears to be relatively fixed in an environment, while egg number varies in response to the total energy available. They also found that egg size is larger in hatchery fish than in wild populations. They proposed that natural selection for egg size is relaxed in the hatchery and that because larger eggs increases juvenile survivorship, average egg size increases (and probably egg number decreases). Vander Haegen and Appleby (WDFW unpublished) documented that coho have been released later from hatcheries at a larger size to increase survival in recent years, but this practice has resulted in smaller, less fecund fish.

Some authors believe that the primary factors for the decrease in size of Pacific salmon are environmental. Bigler and Helle (1994) contend that as a consequence of wild stock management, artificial enhancement, and increased ocean survivorship, the abundance of salmon has nearly doubled, and that the carrying capacity of the ocean for salmon has been reached. They argue that because the declines are so widespread, including Asia (Ishida et al. 1993), that ocean survivorship and expansion of enhancement programs are the primary factors in the reduction of size. Ocean productivity changes also effect the size of salmonids (Pearcy 1992, Beamish and Bouillon 1993, Hare and Frances 1994, and Beamish 1995). However, the last major productivity decline off the Washington coast started in the late 1970's, and the current size declines have been evident since the 1950's. Ricker (1980) compared coho sizes with ocean temperature series and found a non-significant positive relationship which, if real, could account for only a minor part in the observed changes.

In both anadromous and resident species there are examples of populations where fish have become smaller as fisheries removed the larger fish. Ricker (1981) and Ricker and Wickett (1980), and others have described a lowering of size and age of spawning of chinook due to hook-and-line catches that tend to remove older, larger fish. This reduction in size makes these fish less effective spawners since they have fewer eggs, and they cannot bury their eggs as deep or spawn in the larger, more stable gravel that resists movement during floods.

Recent studies on coho salmon in Washington have found that the average size of fish harvested in many gill-net fisheries was significantly larger than the spawning population from the same stream or hatchery (S. Phelps and C. Knudsen, WDFW, personal communication). The studies also documented a significant decline in length since 1980 and a parallel decline in eggs per female since 1960. The number of eggs per female has declined by nearly 1,000 (about 40%). It now takes 1,700 spawners to produce the same number of eggs as 1,000 spawners did in 1960. This suggests that fishing may be one part of the cause of the decline in fish size. Other potential causes include environmental factors or hatchery programs.

Minimum size limits are used extensively to manage resident stocks. Faster growing fish or fish that mature at a larger size or older age are more likely to be removed from the population before they have a chance to spawn. This leaves the slower growing and early maturing fish to spawn and pass on their traits.

There are several examples of run timing changing due to fishing. Alexandersdottir (1987) found that pink salmon return timing in Sashin Creek Alaska was delayed a full month after a number of years of heavy fishing on the early portion of the run. This change was important since the early fish appeared to have been more productive than the later fish. The same number of fish were spawning, but fewer fish were being produced. On Kodiak Island, Alaska, heavy fishing during the middle portion of the Karluk Lake sockeye run has resulted in an early and late run where it used to be one continuous run.

Hood Canal wild chum returns may have shifted up to two weeks later due to heavy fishing on the earlier hatchery chum. A similar change in timing may have occurred for wild steelhead in many areas of Washington State where early hatchery fish have been planted. These early hatchery fish generate heavier fishing on the early portion of the wild run, removing them from the population.

Where a fishery is selectively removing individuals, the population is affected by two forces: (1) natural selection, which leads to local adaptation, and (2) fishery selection, which leads the population in other directions. For a fishery to cause a measurable change in a population: (1) the fishery must selectively remove individuals with a particular trait (e.g., large body size or early run timing); (2) the trait must be heritable, and (3) the harvest rate in the fishery must be high enough to overcome natural selection. We cannot control item (2) because it is a basic part of the fish's biology. However, we can control items (1) and (3).

<u>Habitat Fragmentation and Loss</u>

One of the most important strategies for maintaining genetic diversity may be the maintenance of a wide variety of habitat types. Diversity can be lost directly due to the loss of an important segment of a population's distribution. Dams or culverts that block access or destroy habitat and cause a loss of the population reduce diversity. Loss of habitat may reduce population sizes so that they go extinct or are no longer large enough to maintain diverse traits.

Fragmented habitat may be a critical problem for protecting metapopulations. The loss of the connecting habitats between populations will reduce gene flow between them. This reduces the chances for fish to recolonize barren habitat where populations have gone extinct, or provide the low level of natural gene flow that is useful for maintaining genetic diversity within the populations.

Index of Relative Adaptedness

The Index of Relative Adaptedness (IRA) is designed to measure the relative level of genetic similarity between stocks of salmonid fishes of the same species. This information can then be used by fish managers to determine allowable levels of human caused gene flow between hatchery and wild stocks of salmonids. This is primarily directed at gene flow between hatchery and wild stocks, though it may be used with introductions of wild stocks within a genetic diversity unit (GDU). The IRA assigns the hatchery (or introduced) stock to one of three levels of similarity based on the following general concepts:

- **High Similarity** - a highly similar stock is the result of a quality supplementation program where the hatchery broodstock is as similar as possible to the wild stock from which it was derived.
- **Low Similarity** - a low similarity stock can result from any one of several features: it is a non-native stock, it started from a native stock but has been deliberately selected for specific characters or has been changed in some specific ways, or it has had very small population sizes during initial development or later culture. Any of these would suggest that the stock is not representative of the range of characteristics needed for local adaptation.
- **Intermediate Similarity** - a stock that does not fit into either category above has intermediate similarity.

Table E-1 expands on these general descriptions to give a more specific set of characteristics for each of these categories. The following discussion will elaborate on some of the criteria and give specific decision levels. It is important to remember that this is a relatively new field of study for fisheries and much work remains to be done to determine appropriate levels of these factors. The levels provided are considered preliminary and will be subject to continued discussion and study.

Table E-2 give a decision making process for determining stock similarity. For a stock to be rated high overall it has to meet all the high criteria. For a stock to be rated low overall it must meet only one of the low criteria.

Origin - the origin criteria have to do with both the geographic origin of the stock and its measurable similarities to the wild stocks:

- Geographic origin - this is whether the stock is native or non-native to the system. Non-native stocks are classified as low similarity, while native stocks have high similarity. Stocks that are basically of native origin, but that have had some introductions of non-native fish in the past are intermediate. The non-native stock introductions could be no more than 30% of the effective population size in any year and must have occurred at least three generations in the past.

Table E-1. Criteria for determining the local adaptedness of hatchery stock.

	Low Similarity	Intermediate Similarity	High Similarity
Origin			
➤ Geographic	Non-native, distant stock origin	Native stock with limited non-native influence	Native
➤ Biological	Differences in allele frequencies or life history characteristic (timing, size, appearance)	Genetic or biological distance not significant	Highly similar
Maintenance			
➤ Selection	Intentional selection or significant unintentional selection	Unintentional selection only, with minor observable changes to population characteristics	All reasonable steps taken to reduce selection
➤ Minimum population size	Low effective population sizes	Intermediate effective population sizes	Large population sizes maintained
➤ Number of generations in the hatchery and frequency of infusion of wild broodstock into the hatchery population	Large number of generations in the hatchery with few introductions of wild broodstock into the population	Moderate number of generations with occasional introductions of wild broodstock into the population	Few generations with continued infusions of wild broodstock into the population

- ➤ Biological characteristics - does the hatchery stock exhibit the basic live history and other biological characteristics of the wild population? Allele frequencies, timing, age structure, and other measures could be used here. Shifts of less than 10% in the value of a characteristic would give a high similarity ranking. Shifts of greater than 25% (or significant shifts in allele frequency using standard analyses) would result in low similarity.

Maintenance - the maintenance criteria look at how hatchery practices may have allowed or caused the population to change over time. These are the kinds of practices that may have caused the differences in the biological characteristics described above:

Table E-2. Decision process for determining stock similarity.

Compare the hatchery stock with each of the criteria. If the level description describes the stock follow the instructions in the third column. If the level description does not describe the stock move to the next lower level.

Criteria	Level	If answer is yes
1. Origin:	a. Native	go to 2a
	b. Native with <30% introductions of non-native stocks at least 3 generations in the past	go to 2b
	c. Non-native	stock similarity = low
2. Biological Characteristics	a. <10% change in characteristics	go to 3a
	b. <25% change in characteristics	go to 3b
	c. >25% change in characteristics	stock similarity = low
3. Selection	a. Minimized selection	go to 4a
	b. No planned selection, <25% change in any characteristic	go to 4b
	c. Planned selection	stock similarity = low
4. Generations/ Wild brood Additions	a. $\leq$1 generation in hatchery or >50% wild brood each generation	go to 5a
	b. <5 generations in hatchery or $\geq$ 20% wild brood each generation	go to 5b
	c. $\geq$ 5 generations in hatchery or <20% wild brood each generation	stock similarity = low
5. Population Size	a. High N_e	stock similarity = high
	b. Medium N_e	stock similarity = intermediate
	c. Low N_e	stock similarity = low

➤ Selection - has the hatchery stock undergone any intentional or unintentional selection that would tend to change the population? Intentional selection or significant changes due to unintentional selection result in low similarity. The lack of intentional selection and steps taken to minimize unintentional selection result in high similarity. Unintentional selection with limited changes (<25% change in a character) gives an intermediate rating.

➤ Minimum population size - random changes in population characteristics due to small population sizes are an important source of changes to hatchery populations. The specific population size where this becomes a concern will depend on the average age of the spawners, whether fish spawn at more than one age, and if individual fish spawn multiple times. This is described in the section on stock abundance options (see Table E-1). A high similarity stock will have minimum spawner numbers for the high protection level in Table E-1. A low similarity stock will have spawner numbers less than or equal to the low protection levels in Table E-1.

- Generations in the hatchery and the infusion of wild broodstock into the population - stocks that have spent fewer generations in the hatchery and have had frequent re-introductions of local wild genetic material into the population will have higher similarity. Stocks with long histories of hatchery rearing and little infusion of wild brood material into the population will have low similarity. A high similarity stock will have at least 50% local wild spawners in each generation, or have one generation or less in the hatchery. A low similarity stock will have greater than five generations in the hatchery with less than 20% infusion of local wild genetic material per year. Steps should be taken to make sure that the wild spawners brought into the hatchery represent the wild stock.

There is some overlap between the criteria and categories. Having low selectivity in the maintenance area will likely result in populations being very similar for the biological characteristics in the origin criteria. The biological characteristics will tend to be features where there is measurable change, whereas the maintenance criteria will tend to be conditions that lead to change. We should attempt to keep the criteria as separated and distinct as possible, but some overlap is inevitable.

Appendix F DISCUSSION OF ECOLOGICAL INTERACTIONS

Salmonid fishes not only live in a constantly changing world, but they also live in a very complicated world. It is a complicated physical world with different climates, land forms such as mountains, valleys, lakes, and rivers, different soils, and other features. It is a complex biological world that is shared with many other species of plants and animals. It is even more complex because these physical and biological worlds each affect the other in many ways. This complex mixture of the physical and biological world makes up an ecosystem. The interactions among all the different pieces — the ecological interactions — are the subject of this element. Salmonids have such a big influence on the ecosystems they live in that they have been described as a "keystone species." Recently there has been a much greater recognition of the role that fish, and particularly salmonids, can play in shaping and regulating the abundance and behavior of the many other species they live with (Northcote 1988). At the same time, salmonids are greatly affected by what is going on around them.

Development of an ecosystem management policy is far beyond the scope of the Wild Salmonid Policy. However, to provide guidance to salmonid management, some key issues will be developed. The goal is to look at a few key ones that we can influence. As more comprehensive ecosystem policies are developed these will likely be adjusted.

<u>Background</u>

Salmonids play several different roles in influencing and shaping the ecosystems they inhabit: (1) as a source of nutrients, (2) as a direct source of food, and (3) as predators or competitors that can directly affect the abundance of other species. At the same time there are some key actions in the surrounding ecosystems that can affect salmonid populations. These include: (1) habitat changes, (2) the effects of predators, and (3) the effects of the introductions of salmonids and non-indigenous fish into salmonid waters.

<u>Nutrient Source</u>

Adult anadromous fish gain more than 90% of final weight while they are living in the ocean. When they return to spawn and die, they transfer those nutrients and minerals to the freshwater systems. Richey et al. (1975) described a similar process for kokanee that grow in Lake Tahoe, but spawn in the tributaries. This transfer of nutrients has been most clearly described for the role of sockeye salmon in Alaskan and Canadian lakes. They make very important contributions of nutrients, particularly phosphorous, that contribute to lake fertility and productivity (Donaldson 1967, Kline et al. 1993).

Nitrogen is often a limiting nutrient in western Washington streams and forests. High rainfalls dissolve nitrogen out of soils, and wash it away (Larson 1979). Bilby et al. (1996) compared the types of nitrogen found in two streams in Puget Sound. One had abundant coho salmon spawners, the other was above a block to migration and had no coho spawners. They found that in the spawning stream as much as 42% of the nitrogen in aquatic insects in the period following spawning came from the ocean (i.e., from decomposing salmon carcasses). Ocean-origin carbon made up 38-45% of juvenile coho and steelhead. They also detected ocean-origin nitrogen in the riparian vegetation. Salmonids transfer important levels of nutrients that contribute to the overall productivity of both water-based and land-based systems.

Hildebrand et al. (1997) determined that salmon once contributed 33-90% of the metabolized carbon and nitrogen in grizzly bears in the Columbia River drainage before hydroelectric dams and irrigation projects impeded or blocked salmon migration.

Food Source

Many different kinds of animals directly feed on living or dead salmon. Cederholm et al. (1989) identified 22 species of mammals and birds that fed on adult salmon carcasses in seven streams on Washington's Olympic Peninsula. These included obvious ones like raccoons, otters, and bears, and less obvious ones like shrews, moles, flying squirrels, jays, thrushes, and chickadees. They even found some evidence of feeding by blacktail deer and elk. There are even important indirect linkages. For example, there are links between the northern spotted owl and salmon via the owl's primary prey, the flying squirrel.

The yearly gathering of bald eagles in the upper Skagit River and the gathering of sea lions at the Ballard Locks are examples from Washington State where salmonid populations are an important part of some animals' life cycles.

This relationship with bald eagles is especially important since Stalmaster and Gessamen (1984) demonstrated a correlation between the availability of fish and eagle reproductive success.

Sometimes a population can become dependent on salmonid fishes as a food source. When salmonid populations change, it can have a dramatic impact on these other species. This happened with the decline of spawning kokanee populations in the late 1980s in McDonald Creek. This is an important spawning tributary in the Flathead Lake ecosystem in Montana (Spencer et al. 1991). The kokanee populations declined due to competition for food with opossum shrimp, which were introduced into Flathead Lake in the late 1960s. McDonald Creek had the densest concentration of bald eagles south of Canada during kokanee spawning activity. In 1981, McDonald Creek attracted 639 eagles. After the kokanee's decline, the eagle population declined to just 25 birds. There were also notable declines in the presence of other bird populations, grizzly bears, coyotes, mink, and river otters. These may represent real losses or simply displacement of the populations to other, less productive areas. In either case, it represents a cost to these populations. The decline in eagles was also accompanied by a decline in visitors to the area from 43,000 in 1983 to just 1,000 people in 1989, thus connecting economic and recreational impacts with the ecological impacts.

Bilby et al. (1996) showed that juvenile coho and cutthroat showed increased growth during the period when coho were spawning, likely due to direct feeding on carcasses and eggs. This led to significant increases in overall size, which typically results in higher overall survival.

There is no definitive information on the right number of fish needed to supply nutrients or act as a food supply. It is expected that ecosystem health will benefit the most from having the largest number of spawners possible. This provides more nutrients and more prey items. Fewer spawners means fewer nutrients or fish to eat. However, it is not clear how much of a reduction can occur before significant impacts occur. It is likely that there is a point where most of the benefits from carcasses are met, and additional carcasses have much less added benefit. The desired number of carcasses may vary with our goals. For example, the number of fish needed to support eagle populations will depend in part on how many eagles are desired. This question is beyond the scope of the Wild Salmonid Policy, but the fact that salmonids are important for ecosystem health is clear.

Predator/Competitor

Northcote (1978) reviewed the scientific literature on fish predation effects on the presence, abundance, and life history characteristics of the prey species. He found that in some instances prey species were completely eliminated or severely reduced by introduced species. The loss of these prey items in turn has the potential to greatly effect the species they feed on, so that there can be significant overall changes in the types of species found in a lake or stream and their abundance. Historically, salmonids were not found in many of Washington's waters where they are found today. Alpine lakes and many lowland lakes in the Puget Sound Basin were often devoid of salmonids. In addition, many Washington streams had barriers to migration that blocked access to anadromous fish. Many of these lakes and streams that did not have salmonids, or only resident salmonids, supported populations of other fishes, amphibians, and other species that may have been disturbed by introductions of large numbers of salmonids.

If salmonids are added to places where they did not historically exist, there is a real potential for disrupting the processes that make those ecosystems work. If this is done on a widespread basis it may result in a fragmentation of the habitat for these species, and if severe enough, a loss of these other species.

Habitat

The relationship of salmonids and their physical world was discussed in the *Habitat* element. Habitat changes can clearly affect salmonid productivity. Development typically causes changes in hydrology, with higher peak flows and lower low flows. In addition, streams become less complex, with fewer pools and hiding places.

Introductions

Introductions of salmonid and non-salmonid fishes can create risks for wild salmonid populations. Releases of hatchery fish of the same species can depress or replace existing wild populations. This has been documented for coho by Nicholson et al. (1986) on the Oregon coast and in the Queets River system (D. Seiler, WDFW, personal communication). Competition has been identified as a concern for wild chum populations in Hood Canal because of the presence of large numbers of hatchery chum. Cross-species competition also can often be a concern. For example, releases of hatchery coho can exclude wild steelhead and cutthroat from some preferred habitats they would have otherwise occupied.

Predation has been raised as an issue for the effects of hatchery coho releases on pink salmon. Predation by hatchery coho and steelhead on some wild chinook and chum stocks are additional examples. Johnson (1973) believed that a general decline in chum salmon stocks associated with large-scale releases of coho was related to predation. This led to a general caution about coho enhancement in pink and chum salmon areas. Sholes and Hallock (1979) reported that 532,000 fall-run chinook salmon hatchery yearlings consumed an estimated 7.5 million naturally produced chinook salmon fingerlings in California's Feather River.

Introductions of other types of fish into salmonid habitats are also a concern. Nearly all of the warmwater fish that have become an important part of recreational fishing in Washington were not native to this state. Sometimes these exotic fishes can become competitors and predators of salmonid populations. This is particularly true in many of Washington's lowland lakes and slower moving mainstem waters where habitat is less favorable, but often vital for salmonids. The presence of large numbers of warmwater fish can make it difficult to maintain productive salmonid populations. Lake rehabilitation where these competitors and predators are removed by poisoning can improve salmonid production, but the lake rehabilitation typically kills native salmonids where they exist as well. This then reduces salmonid populations and reduces local adaptation and genetic diversity. Illegal introductions of warmwater fish have created additional problems in many areas.

Where exotic stocks occur, there may be opportunities to achieve desired benefits at the least cost to wild salmonids. For example, the man-made lakes of the Columbia Basin, which historically did not have salmonid populations, can be used for warmwater fish or hatchery salmonid production with little impact to historical wild salmonid populations. Other lowland lakes that historically did not produce significant salmonid populations also are important opportunities for warmwater or hatchery salmonid production. At the same time, the overall health of salmonid populations and the most productive waters need to be maintained and protected for salmonid production. Where exotic populations create significant impacts to native species, steps may be taken to limit their impacts. For example, the recovery plan for Snake River chinook calls for special fisheries approaches to reduce the populations of smallmouth bass in the Snake River to reduce predation on threatened and endangered species.

Finally, the natural populations themselves continue to be the most cost effective and efficient management tool for salmonid "recovery". For example, recovery of salmonid populations in the Toutle River following the eruption of Mt. St. Helens is an excellent case history of the ability of fish to rebound from catastrophe (Lucas 1985).

Appendix G DISCUSSION OF HARVEST MANAGEMENT

Harvest has a special role in the Wild Salmonid Policy. Harvest is both an important goal of the policy, and an important source of mortality that must be properly controlled to meet other goals of the policy.

> Alaska is fortunate to be experiencing record salmon harvests. Intensive in-season management by local biologists, effective enhancement, an intact environment, favorable ocean environmental conditions, and good luck have all contributed to recent record salmon returns. While the ADFG has no control over the ocean environment, we do control our harvest and enhancement programs, and we have some control regarding habitat protection. The department and the people it serves recognize the importance of salmon resources and have been willing to implement a salmon management program that ensures their continued diversity and productivity. Alaska's system has been held up as a model of successful fisheries management (Royce 1989). If the commitment to management and conservation that Alaskans have demonstrated since statehood is any indication, the state's salmon fisheries and salmon runs should continue to flourish (emphasis added).
>
> Holmes and Burkett 1996, p. 38.

Background

Harvest opportunity is very important to many of Washington's citizens, and the loss of much of that opportunity in recent years has been a hardship to many people. Harvest provides many different benefits. It is an important source of recreation for many citizens. For avid anglers, it is more than just another hobby. It can be a central part of their life's activities. For other anglers, it may be no more than a once or twice a year outing with friends and families. In any event, a large part of Washington's population takes part in fishing for salmonids at one time or another, and it is recognized as an important part of the quality of life.

Harvest opportunity generates significant economic benefits. Commercial fishing supports the well-being of a number of communities and many families across the state. A major industry has developed to support recreational anglers. Tackle, boats, bait, lodging, charter services, and marinas are just part of the fishing economy.

Finally, harvest is an important cultural factor. This is most clearly seen in tribal fisheries that depend on returns of salmon and steelhead as part of a long tradition of harvest central to tribal economics and culture, including religion. It is seen in commercial harvesters, many of whom come from multi-generational fishing families. It is seen in the recreational fishers where parent-child interaction occurs while enjoying fishing.

There are many kinds of harvest. Directed harvests in sport, commercial, and tribal fisheries are designed to remove fish from the population to serve a variety of needs. Fish that are hooked and released in sport fisheries, net drop-out in gill-net fisheries, catches of coho in a fishery directed at sockeye, and catches of a weak coho stock while fishing a stronger coho stock are some examples of incidental catches. Even the small level of disturbance from "non-consumptive" activities may kill some fish at sensitive times. The Independent Scientific Group (ISG 1996) that reviewed salmon production on the Columbia River suggested that all forms of human caused mortality (including mortalities at dams, or losses due to water withdrawals) be treated as a form of harvest.

One of the key challenges for harvest management is the problem of mixed-stock fisheries. As we noted in the *Spawner Abundance* discussion, each population of wild fish has its own unique spawner-recruit relationship. Some stocks are large, some small, some very productive, some less productive. As a result, each population will have its own unique optimum fishing level to achieve the desired spawner abundance level. The problem in Washington is that very often several different stocks will be found in the same fishery. Just about every coho and chinook population in the state contributes to the ocean recreational and commercial salmon fisheries, and all of the Puget Sound coho and chinook populations are found in recreational and commercial fisheries in Puget Sound marine waters. If you harvest at a level that provides for the spawner abundance of the least productive stock, you meet or exceed the spawner abundance requirements of them all. If you harvest at a rate to take advantage of the harvest from the more productive stocks, you will overfish, depress, and eventually lose the less productive stocks.

In Washington, this challenge of mixed-stock fisheries most clearly occurs where there are mixtures of hatchery and wild fish. Hatchery fish are protected from a great deal of mortality during their time in the hatchery. Because of this, they can be fished at higher rates. They often return to specific locations where they are visible to the public. This creates pressures to harvest all of the hatchery fish. This can, in turn, result in overfishing of the wild runs.

In order to take advantage of the stronger stocks, while protecting weaker stocks, it will be important to develop more selective ways of harvesting fish. Selective fisheries can take many forms. Fishing at specific times and places may direct the harvest primarily on one stock while protecting others. This has been used to reduce coho catches during commercial sockeye fisheries in Puget Sound, to reduce chinook harvests while fishing on coho in ocean fisheries, and to protect upriver spring chinook while harvesting lower river stocks in the Columbia River.

One common approach is to wait for the fish to separate themselves out as they return to their home streams. Then the fishing can be directed on just a few stocks at a time. While this has some distinct advantages, it also creates some problems. Many of the mixed stock fisheries developed because they increased the availability, accessibility, or value of fishing opportunities. Marine waters recreational fisheries provide a year round opportunity in many areas, compared to a more limited time period when fish return to spawn. Fish in saltwater bite much more readily and provide greater harvest opportunity. Most species decline in commercial value as they leave saltwater. Catching them in mixed-stock fisheries increases their value. These selective approaches do not work with hatchery and wild fish when they return to the same rivers at the same time.

Other approaches use different types of fishing gear that select one type of fish and not others, or that allow harvesters to examine fish and release those that need protection. All of these techniques have been used at some level. All hatchery steelhead and sea-run cutthroat are currently marked for easy identification and special regulations are often used to require the release of wild fish. Alternative 3 would extend this policy to other salmonids.

Fundamentals

Basic aspects of harvest management (or more appropriately, spawning escapement management) are relatively straightforward but are often fraught with misconceptions. For example, there is no such thing as an annual MSY curve, nor can a single new data point radically change a spawner-recruit relationship. The average exploitation rate at MSY should not be used to manage any individual run except by shear coincidence and all fish populations (including salmonids) have interannual variability.

Decisions on appropriate spawning escapement objectives and actual harvest management must be based on what you know or can accurately predict at the time when decisions have to be made. Any harvest, by necessity and by definition, occurs before escapement.

We have been able to detect more than one spawner-recruit relationship for a number of salmonid populations but these usually come from the benefits of hindsight. Most of these multiple curves are derived from different regimes in freshwater or marine survival rates. However, we are not currently able to predict these future events with any degree of certainty. Thus, the multiple curves are interesting, but usually of little practical value at the time when we need to make decisions about spawning escapement objectives and harvest management planning. This is why most populations are managed for fixed spawning escapement objectives. We simply do not have the information needed to do otherwise. For chum salmon in the southern part of their range, we can often use two separate spawner-recruit relationships for fishery management planning. This is possible because we know about their relationship to pink salmon production and because pink salmon runs only occur on odd years in the southern part of their range.

Successful managers do two things. When good runs are available, they consistently put adequate number of viable wild fish on the spawning grounds by achieving the proper balance between catch and escapement. When poor runs arrive, often unexpectably, successful managers get all fishing stopped and put virtually the entire runs on the spawning grounds.

<u>Pre-season Planning</u>

Figure II-1 in Chapter II provides an example to show what a manager would use in an actual situation. The highest six escapements were all derived during normal fishery management. We can see that the spawner-recruit relationship becomes relatively flat at these larger spawning population sizes. This indicates that, in this range, the resultant smolt population was limited by freshwater habitat capabilities, not the number of adult spawners. The actual smolt numbers have been converted to estimated adult production by application of the average marine survival rate derived from coded wire tagged experimental groups.

The year-to-year variation in these six data points gives us some idea of expected range in freshwater production from year-to-year. However, the manager will not know future freshwater habitat conditions at the time he/she must make the decisions that set the next spawning escapement.

The lower data points reflect two years during colonization of the system subsequent to construction of a fish passage facility and three years when the numbers of adult spawners were experimentally restricted. This was done to define the spawner-recruit relationship that is shown. The Snohomish system coho resource has not been overfished in any recent years.

Thus, what a managers knows is the spawner-recruit relationship and the estimated smolt production for any given year. What a manager does not know is what subsequent marine survival will occur as these same smolts become adults - a definite point of uncertainty. Here is a key area where a conservative buffer should be built into fishery management planning. A successful manager would assume that marine survival will be at the low end of the probable range. By doing so, a manager will consistently put enough adults on the spawning grounds to produce the maximum numbers of smolts allowed by subsequent freshwater habitat capabilities.

In-season Adjustments

If in-season run size updating is utilized, the level of uncertainty can be substantially reduced. The importance of this element is addressed by Wright (1981, p. 33):

"Pre-season forecasts are also important for planning initial commercial net harvests on each salmon run, but are seldom so accurate that they cannot be improved later in the season. The basic problem is that one has not "seen" the run since the eggs were spawned, juveniles were counted or, at best, an earlier return of the age class. Variable but significant mortalities have occurred from natural causes in the meantime and prior interceptions have often been made by the mixed-stock fisheries. The extent of these losses is generally difficult to quantify with any precision.

The real test of a fishery manager is his skill in quickly and accurately updating a pre-season forecast at the beginning of an adult run. Again, the process is one of sifting the data base for the best in-season estimators. The required answers are normally found in past catch and effort data from regular (large samples) and test (small samples) fisheries. The answer is seldom found in spawning-escapement data because, if the manager waits until adequate data are in hand, the opportunity for additional fishing is normally lost."

"Data from commercial fisheries and test fisheries both have their own particular set of inadequacies, and neither should be depended upon solely for decision-making unless one can determine beforehand what any conceivable catch level will mean in terms of a prediction of run size. Several years of fisheries data are usually required before any meaningful results can be expected, and then there is no guarantee prior to creation of such a data base that results will eventually be usable. In general, a brief regular or "traditional" fishery at the beginning of a salmon run produces a more precise run size update than test fishing, because of the much large sample size. However, test fishing has a much lower resource "cost" in terms of lost escapement during poor salmon runs, particularly if done with gear such as purse seines which can release most of the fish alive."

A successful manager will recognize and incorporate any remaining uncertainties into the subsequent scheduling of fisheries.

Appendix H DISCUSSION OF CULTURED PRODUCTION/HATCHERIES

Various forms of cultured production, including hatcheries, have been an important fish management tool in Washington for over a century. Hatcheries provide over 90% of the lake catch of resident salmonids. In 1992-93, about 88% of the steelhead caught were hatchery fish. From 1986-91, over 70% of the Puget Sound coho catch was hatchery reared. Hatchery-reared chinook and coho contribute heavily to catches in the Lower Columbia and Willapa Bay. Hatchery production has been a key part of the stock recovery programs for White River spring chinook, Dungeness native chinook, Tucannon River spring chinook, and other chinook and steelhead populations in the mid- and upper Columbia River system. Hatchery production has also been an important source of fish to mitigate for the loss of habitat due to dam construction and other habitat losses. Hatchery fish also buffer the impacts of harvest on wild fish in quota fisheries like the west coast of Vancouver Island troll fishery.

However, cultured production continues to be a source of some controversy. Some of these issues have been considered already: (1) gene flow between hatchery and wild fish, (2) mixed-stock fisheries that can overfish wild fish, and (3) competition and predation impacts on wild fish. Some people believe that hatchery production is the key to fishing opportunity in the future and others suggest that the presence of hatchery fish diverts public attention from important problems such as habitat protection. Several recent reviews of salmon management in the northwest provide excellent summaries in more detail (NRC 1996, ISG 1996).

An important objective of the Wild Salmonid Policy is to define appropriate standards and guidelines for using fish culture. Because hatcheries often contain important genetic resources and represent significant investments by the public, the health of the hatchery programs will be important components of the policy.

Background

Washington State has one of the largest salmonid production systems in the world. WDFW currently operates 65 salmon and 30 trout rearing facilities. Five salmon species, steelhead, and sea-run cutthroat trout are included in anadromous hatchery production. Resident hatchery salmonids include rainbow, cutthroat, eastern brook, brown, lake, and golden trout; Arctic grayling; and kokanee. These facilities produced approximately 230 million anadromous and 20 million resident salmonids during 1992-93. In addition there are 12 federal and 17 tribal facilities that added another 50 million fish in 1992-93. There are also a large number of local volunteer fish culture programs operated by schools, clubs, community groups, and individuals.

Cultured production uses a wide range of techniques. The use of a specific technique depends on the species, goal of the program, limiting factors in the natural environment, costs, and physical constraints such as abundant clean water and intact stream habitat. The following description of the potential programs is listed in order of increasing involvement of the hatchery environment on the fish (see *Genetic Conservation* for a discussion of the hatchery environment and domestication):

A. **Spawning Channels** — these are typically flow-controlled channels with clean, properly sized gravel, and the ability to control the number of spawners. They are used primarily to improve survival during spawning and incubation. They are most often used for pink, chum, and sockeye salmon, species where subsequent rearing area is usually not limiting. Spawning channels are considered a low intervention approach because the fish spend a limited amount of time in them and most of the fish's actions are directed naturally by the fish themselves.

B. **Remote Site Incubators (RSIs)** — These are typically low-tech hatching facilities that are located away from central hatchery facilities. They are primarily used to improve survival during incubation. They too are most often used with species where rearing habitat is not limiting, though they may be combined with short- and long-term rearing programs. RSIs have greater potential impact, since humans collect the fish for spawning, do the mate selection, and often provide some incubation in the central hatchery facility.

C. **Captive Rearing** — this is the opposite of the RSI approach. In this case wild juveniles are collected and brought to the hatchery for rearing. Mate selection, spawning, and some early rearing are done in the wild, while any later rearing is done under hatchery conditions.

D. **Release and Recover** — These are the typical hatchery facilities for anadromous species. In this case eggs are taken from fish that are either returning hatchery fish or, in some cases, wild fish. Mate selection, incubation, and rearing up to release in the wild are under human control. Release may occur at any stage from early in the juvenile stage to full maturity. Intervention in the fish's life is fairly high in most cases.

E. **Captive Broodstock** — In this case eggs are taken from fish that have been in the hatchery their entire lives. This represents the highest level of intervention in the fish's life. It is used most often for resident trout populations, and as the last choice strategy to preserve a wild population that is likely to go extinct.

Within each of these approaches there are a variety of strategies that can be used to limit the impacts of the hatchery process. Spawning protocols can be used to limit the impacts from human mate selection. Rearing, feeding, and release strategies can be used that are more like natural conditions to reduce the potential of domestication. Release timing and location can mimic wild fish.

Salmonid culture programs typically address four key resource management needs: (1) *enhance* fishing opportunity, (2) *mitigate* for specific production losses, (3) *restore* depleted wild populations or *reintroduce* extirpated species, and (4) *research* to improve management and hatchery programs. A single facility may engage in several programs.

A. *Enhancement* programs are designed to increase the number of fish available for all forms of harvest. Enhancement programs are not designed to create more wild spawners, though this can occur.

B. *Mitigation* is used to make-up for production losses. Some people feel that all hatchery production is mitigation for production lost on a broad scale. However, the term is more typically used to describe a specific hatchery facility that was built because of a specific project. Most commonly, mitigation is used to replace production from the construction of dams and reservoirs that destroy habitat or increase the mortality rate during some part of the life cycle. The Cowlitz and Lewis River hatcheries are examples of mitigation hatcheries as are most Columbia River facilities.

C. *Restoration* is used to: (1) recover (supplement) populations that are having problems replacing themselves and are not likely to recover naturally, (2) reintroduce wild stocks that have been lost from areas they historically inhabited, and (3) maintain stocks that face extreme risks. Restoration programs are designed to put more spawners on the spawning grounds.

D. *Research* at hatchery facilities has played a vital role in understanding the biology and management of salmonid populations. Hatchery fish can be studied directly, or used as indicators of how similar, neighboring wild populations may be behaving. Issues such as diseases, growth, physical changes before migrations, and ocean distribution and catch patterns are all studied using hatchery fish. In many cases similar work on wild fish is much more difficult due to smaller numbers and the difficulties in creating controlled conditions.

Key Policy Issues

Many of the key policy issues dealing with hatchery production were discussed in the other policy elements. Gene flow and its affects on genetic diversity and local adaptation were discussed in the *Genetic Conservation* element. Potential impacts of predation and competition are discussed in the *Ecological Interactions* element, and the interaction of hatchery production and harvests of wild fish were discussed in the *Harvest Management* element. In this section these will be briefly reviewed, with some specific examples for hatchery activities:

A. **Hatcheries and Genetic Conservation** — Gene flow and its impact on local adaptation and genetic diversity is the main issue with hatcheries and genetic conservation. Gene flow is the movement of genes from one population to another due to interbreeding between populations. For more details on the concerns about this see the *Genetic Conservation* discussion.

Hatchery to wild gene flow occurs when hatchery fish are transferred or stray from one area to another. This is not a unique problem for hatchery fish. Wild populations can be moved as well. However, transfers occur more with hatchery fish because of their availability.

Hatchery to wild gene flow within a single area has several sources. Anadromous fish released from a hatchery generally return to that hatchery. They are then captured and removed from the system. This results in no gene flow. However, some of the returning fish do not return to the hatchery and spawn in the wild with wild fish. The rate of straying varies widely depending on the species, location, water source for the hatchery, flow conditions, and capture facilities at the hatchery. In most cases this spawning in the wild is limited and occurs close to the hatchery. However, up to 40% of the hatchery fish may spawn in the wild in some areas. Even wild spawning by a relatively small portion of the hatchery population can have a big impact if the hatchery population is large compared to the wild population.

In some cases hatchery fish are released away from the hatchery site to supplement wild spawning or to create alternative harvest opportunities. Fry plants, acclimation ponds, off-site releases, RSIs, and a variety of other techniques are used. The term “supplementation” is sometimes used to describe any program that contributes adults to the natural spawning escapement. In this DEIS, supplementation has a very specific definition (see box). Supplementation is more than just putting additional spawners on the spawning grounds. These spawners must allow the wild population to retain the traits that make them productive in the wild.

A variety of approaches may be taken to supplementation:

1. Supplementation may not be allowed. This approach was not used in any of the alternatives, because there are cases where the survival of a stock may depend on supplementation.
2. Supplementation may be allowed only when a population is clearly at risk of extinction, and the risk of extinction clearly outweighs the risks of the supplementation process. Supplementation would occur only as part of a broader program to improve survival and develop a self-sustaining population.
3. Supplementation may be allowed at any time if the fish used for the supplementation meet some criteria such as local origin, generations in the hatchery, etc. These criteria may vary in strictness depending on the status of the target stock and the desire to produce additional fish.

Supplementation — "The use of artificial propagation to maintain or increase wild production while maintaining the long-term fitness of the target population, *and* keeping the ecological and genetic impacts within specific biological limits" (RASP 1992)

A very important consideration in using supplementation is that it very likely will not work. Miller et al. (1990) reviewed 316 supplementation projects throughout the Northwest. They concluded that "there are no guarantees that hatchery supplementation can replace or consistently augment natural production." They felt that even this might be optimistic, because there is a tendency to report on only the projects that worked.

Supplementation is not a "stand alone" strategy. It should be part of a broader strategy to deal with the actual causes of the problem that has caused the population to decline. Actions for habitat protection, harvest management, and enforcement must be taken as well.

B. **Hatcheries and Ecological Interactions** — Hatchery fish concerns cover two key issues: (1) impacts on wild salmonids due to competition and predation, and (2) effects on the broader ecosystem. For more information see the *Ecological Interactions* element discussion in Appendix F.

Hatchery fish may compete with fish of the same species for food, space, or cover. While the total population of the species may be higher, the number of locally adapted wild fish may go down. This has been described for hatchery coho releases in the Queets River (D. Seiler, WDFW, personal communication). It may also be partly responsible for the decline in overall populations seen by Nicholson et al. (1986) for the Alsea River in Oregon.

Johnson (1973) described the potential for significant predation by hatchery coho on hatchery chum and pink salmon. The same impacts might be expected on wild pink and chum.

Introducing salmonids, either hatchery or wild, into areas where they did not historically live may disrupt ecological processes that support native populations of non-salmonid species.

C. **Hatcheries and Harvest Management** — The presence of large numbers of healthy stocks in a fishery creates strong incentives for resource users to press for harvest opportunity. Frequently, the healthy stocks are largely composed of hatchery fish. Allowing non-selective fishing opportunity on these healthy stocks would result in over harvesting co-mingled weaker stocks. The strong opening day fishery in many lakes that is highly dependent on hatchery fish is one example. Similar concerns are common in many salmon fisheries.

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