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RECOVERING SALMON AND HEALTHY WATERSHEDS IN THE WILLAMETTE BASIN

REVIEW OF THE WILLAMETTE RIVER INITIATIVE

PREPARED THROUGH THE OREGON BUSINESS COUNCIL

BY

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Draft

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INTRODUCTION

On March 16, 1999, the National Marine Fisheries Service listed the lower Columbia River chinook salmon and the upper Willamette River chinook salmon and steelhead as threatened under the federal Endangered Species Act (ESA). The lower Columbia River steelhead was listed as threatened a year earlier. Within the lower Columbia River Evolutionary Significant Unit (ESU) are the Clackamas River, Johnson Creek and Sandy River.

Historically, Willamette Falls at Oregon City selectively blocked anadromous fish runs into the upper part of the basin. Because of seasonal changes in flow, spring chinook and winter steelhead were the only anadromous salmonid species/races able to negotiate the falls and reach the upper part of the basin. Fall chinook, coho and summer steelhead, are all recent introductions.

The ESA is a preventative program only in a narrow sense. Its purpose is to prevent extinction. It is implemented as a last ditch effort to save a species or ESU. The Act does not prevent the conditions that bring about depletion. By the time a species is listed, a full blown problem exists. That explains, in part, the often heroic and expensive programs needed for recovery and delisting. It is more difficult to reverse degradation in an ecosystem than to prevent its occurrence.

The Willamette River is probably the largest and most urbanized watershed to have its salmon and steelhead populations protected by the ESA. For that reason recovery actions have the potential to be more expensive and affect more people and businesses than recovery programs in less developed areas. And there are no guarantees the implementation of expensive programs will increase the abundance of salmon. Implementation of the Northwest Power Planning Council's Fish and Wildlife Program over the past two decades has demonstrated that its possible to spend a large amount of money on salmon recovery with few positive results.

The Oregon Plan for salmon recovery (Chapter 5) states that in the past 130 years "…dozens of plans and programs to restore salmon have been prepared, making Pacific salmon, on paper at least, the most restored species group in the world. However, those plans… failed to halt the salmon's depletion and slide towards extinction (State of Oregon 1997)." Because of the poor record of success in large-scale, salmon restoration programs, it is important that the process of developing a recovery program proceed through a series of logical and well-considered steps. Those steps are establishing the vision, setting the goals, describing the problem, devising strategies, and agreeing on measures of performance. The steps are hierarchical. The vision is the broadest, most inclusive element in the hierarchy and strategies/performance measures the most specific. All the steps must be consistent with each other. In the end, there should be a logical and easily identified path through the strategies, problem, and goals up to the vision.

In the development of salmon restoration plans, the vision, goals, and problem are usually skipped over or given little attention. It is probably a natural tendency to immediately focus on the strategies, the actions items, the concrete things we can do to restore the salmon or their ecosystem. We will point out later that there are actions that can and should be implemented immediately. However, it would be a mistake, one that has often been made in the past, to not give adequate attention to the policy and technical analysis called for in those first three steps. Ecosystem and salmon restoration are complex problems that cannot be solved by simple actions.

The salmon's life cycle and its interaction with human activities are complex. Examination of the vision, goals, and problem identifies those complexities so they can be discussed and understood. Restoration planning that skips over those steps often end up with overly simple solutions to what are inevitably complex problems. In the words of two authors, those simple solutions to the complex problems of salmon management and restoration have often turned out to be just "simple minded (Crutchfield and Pontecorvo 1969)."

In this report we describe the four steps in restoration planning. Its focus is salmon and steelhead. We want to emphasize that this report does not constitute a recovery plan. It describes how one might be developed and it illustrates salient points with examples. We recognize that the responsibilities and mission of the Willamette River Initiative (WRI) are broader than salmon recovery and includes recovery of the Willamette ecosystem. The steps described here are applicable to the full range of WRI's responsibilities and problems it is attempting to resolve.

VISION

The Oregon Business Council recently published a report calling for a new vision for Pacific salmon (OBC 1996). Others have also called attention to the importance of vision in the management of natural resources such as water (Worster 1985), salmon (ISG 1996), Atlantic cod

(Finlayson 1994) and forestry (Langston 1995 and Hirt 1994). What we are calling the vision has been called by other names in those studies including conceptual framework or fundamental assumptions. Historically, in the development of salmon recovery plans, the vision was not given much attention, was rarely if ever put into writing and never examined or evaluated. However, recent studies of failures and crises in resource management have called attention to the importance of the vision. Even the best implemented programs will fail to achieve their goals if they are founded on a faulty vision or fundamental assumptions (Cronon 1995).

The vision describes a desired future condition. In this case the future of the Willamette ecosystem and its native anadromous salmonids. The vision statement identifies key features or attributes of the desired future condition. It also includes a set of principles or policy statements. The principles must be consistent with current science. They are used to guide the development and implementation of the recovery programs. The two elements of the vision—future condition and principles—exert a strong influence on the recovery process. In fact, they determine how information is interpreted, which problems are identified and consequently which strategies are implemented (Lichatowich et al. 1996).

The Independent Scientific Panel (ISG) in its 1996 report Return to the River compared the vision to a jig saw puzzle and because that analogy was so instructive we paraphrase it here. The vision and its underlying principles and assumptions are equivalent to the picture on the cover of a box containing pieces to a puzzle. Each piece of the puzzle is a piece of information, but that information can only be interpreted correctly and used to complete the puzzle by reference back to the picture—the vision. If for some reason, the picture is wrong it will be of no value in assembling the puzzle and, in fact, it will make successful completion of the project impossible. That describes the situation today in salmon restoration. The current vision has led to depletion and extinction of the salmon and degradation of natural ecological process and it has proven ineffective in bringing about recovery.

Depletion and extinction of salmon and degraded ecosystems were not the intended results of the current vision. Society invested heavily in programs and agencies to prevent depletion and degradation. The first century of salmon management was based on the belief that hatcheries could supply enough salmon to support the sport and commercial fisheries and make up for the loss of freshwater habitat and overharvest. It evolved over the years from a simple reliance on hatcheries to reliance on other forms of technology including barging and trucking, passage technology at dams and diversions, and engineered, riverine habitat. As a result of pursuing this vision rivers and riverine ecosystems were simplified and controlled. Ecological processes were replaced by technology. The current vision did produce a strong economy. The controlled and simplified rivers produced irrigated agriculture, inexpensive electricity, transportation and flood control. However, the current vision failed to prevent depletion of salmon and ecosystem degradation. It has also failed to produce a viable restoration strategy. It is time for a new vision. The WRI should not proceed with major investments in salmon or ecosystem restoration until a new vision and its principles are established.

We have developed a working version of a vision for salmon in the Willamette Basin. It is composed of two parts: a broad statement of purpose and a set of principles and assumptions. This vision is not intended to be the final version, but something to start the discussion and refinement process. The final vision will have to be broader in scope to cover the WRI's full mission.

THE VISION—AN EXAMPLE

The Willamette Basin and lower Columbia River will sustain bio-diverse salmon and steelhead runs resilient enough to assure the permanent survival of the species. In addition, to the extent practical and economical, the runs will support sport and commercial fishing.

In addition, for discussion purposes, we have listed here twelve principles developed earlier by the OBC as part of its vision for Pacific salmon. They should be considered examples and not a final product.

1. The salmon crisis is the result of and emphasis on the development of the industrial economy to the detriment of the natural economy.

2. All activities in watersheds must recognize the need to achieve a balance between the natural and industrial economies.

3. The restoration of salmon will be achieved through local communities, businesses and governments working together.

4. The watershed is the basic management unit.

5. Stewardship of habitat and natural production will be emphasized rather than engineered, artificial solutions.

6. Restoration will emphasize rebuilding naturally reproducing salmon populations.

7. Artificial propagation will be given a secondary role except in watersheds where habitat has been so degraded that natural production cannot be recovered.

8. The specific role of artificial propagation must be based on the results of a comprehensive audit.

9. Harvest management must be more conservative and favor the long-term persistence of the salmon over the short-term gain of the fishermen.

10. Although this vision takes a long-term view, restoration efforts including changes in the relative emphasis of the natural and industrial economy need to begin immediately.

11. Performance of restoration efforts must be monitored and reported. This will require a change in the management structure and development of new performance measures related to the health of watersheds.

12. Restoration programs must be implemented adaptively and there must be a high degree of accountability.

For a more detailed description of the current vision, the need for a new vision and the implications of the principles see the OBC'' report, "A New Vision for Pacific Salmon."

GOALS

It has been common practice for resource management agencies to set the goals for resources under their jurisdiction. For example, the Oregon Department of Fish and Wildlife (ODFW) through its management and recovery plans has in the past established the numerical goals for salmon abundance in specific watersheds. This approach placed too much emphasis on the technical/scientific aspects of goal setting. Goals must be technically informed and scientifically valid. For example, it would be counterproductive to set a goal for the number of salmon returning to a watershed that is beyond its highest historical abundance and is technically impossible to attain today. However, goals must incorporate more than technical information. They must take into consideration laws, economics, culture, community values, as well as science. Goal setting like vision development is a public process. Everyone involved in the recovery program should understand what success will look like when it is achieved.

Goals, like the vision, are statements of purpose, but they are more specific and contain enough information to establish measurable criteria that will permit unambiguous recognition of success. Another difference between the goal and vision is the geographic area covered. Where a vision may cover a region or large basin like the Willamette, the goal focuses on smaller geographical units. For watershed and salmon recovery, this will often be the subbasin and its native populations. Because of the stock structure of Pacific salmon, the watershed with its reproductively isolated populations should be the basic unit for goal setting.

Just as the vision sets the stage for goal setting, the goals in turn strongly influence problem definition—the next step in the recovery process. Within the broad description of the vision very different alternative goals for salmon recovery at the subbasin and population level are possible.

For example:

> The goal may be to reestablish the minimum distribution and abundance of listed species to remove them from protection under the ESA

This might mean that salmon will not be recovered to sustainable levels in all the subbasins where they historically occurred. It may also mean that the number of fish returning to the Willamette may not be sufficient to support historical fisheries.

On the other hand, the WRI might decide to restore populations of wild salmon and steelhead throughout their natural and introduced range in the Willamette Basin and in sufficient numbers to support an extensive fisheries, while also removing them from protection of the ESA.

Under this scenario, goals would be set for all subbasins capable of supporting salmon and steelhead even those watersheds that were not part of the species historical range. Furthermore, abundance targets for each population would be high enough to support extensive fisheries.

These two scenarios are given here as examples to illustrate the breadth in the range in potential goals. The important point here is that the two goals would result in very different problems and strategies to resolve those problems, and consequently different recovery costs.

THE PROBLEM

Listings under the ESA and falling numbers of salmon and steelhead do not define the problem, although they are important indicators of it and they are yardsticks against which progress towards recovery can be measured. The term problem is used here to mean those things or conditions that prevent realization of goals. This definition means that the problem cannot be explicitly defined until the recovery goals have been defined. There must be a high degree of coherence between the goals and the problem. For example, if the goal was to recover native populations in their historical range, the problem would not be a lack of funding for conventional hatchery programs. There is also a need for coherence between the problem and recovery strategies. As pointed out earlier, the problem and, therefore, the recovery strategies will be different if the goal of recovery is simply to remove the salmon and steelhead from the ESA list, rather than the goal of robust, abundant populations capable of sustaining substantial harvest. Before it can be assured that investments in recovery strategies will have a reasonable chance of success, it is critical that the problem those strategies are targeted to overcome be carefully and explicitly defined.

Problem definition is such an elemental step, that it is often skipped over under the assumption that everyone knows what the problem is. The general problems causing the depletion of wild salmon are generally known—logging, grazing, irrigation, dams, hatcheries and overharvest, etc.

But generic problems are not useful in designing specific remedial strategies. Too often in the design of recovery programs, the problem remains undefined or defined by long standing myths or unverified assumptions. In fact each individual's perception of the problem may be different, at the same time everyone assumes their understanding of the problem is the same as others working for recovery. This condition can lead to inappropriate strategies and actions and little progress toward recovery—a condition that frequently plagues salmon recovery programs. When defining the problem, i.e., defining those specific conditions that the recovery actions are attempting to overcome, this rule of thumb should be kept in mind: Healthy rivers share many common attributes, but degraded rivers and salmon populations have all taken unique routes to their current status. Generic problem statements are easy to construct, but have little value in recovery programs.

Although the specific problem statement cannot be formulated until the recovery goals are established, three important dimensions of the problem, information, distribution and abundance and life history can be described. A discussion of these dimensions of the problem will help the WRI develop its problem statement for the Willamette River. Again, we have focused on the salmon, while recognizing the WRI's mission includes the whole Willamette ecosystem.

INFORMATION

Developing a vision and setting goals are public process that take into account social, economic, legal, and scientific information. Problem description is a scientific process. It requires high-quality technical information. Consequently, a lack of information on the distribution, abundance and life history-habitat relationships of listed species is an important impediment to recovery planning that must be minimized. Problem definition using incomplete information leads to uncertainty—uncertainty that the correct problem has been identified and uncertainty that the appropriate recovery actions are being implemented. The more uncertainty there is, the greater the risk of a failure in recovery investments. However, complete information and total certainty is impossible to obtain except in a few rare instances. Investments in recovery actions for salmon usually have to be made if the face of incomplete information, uncertainty, and risk. That is why adaptive management or learning by doing is an important part of recovery programs such as the Northwest Power Planning Council's recovery program for Columbia Basin fish and wildlife.

Risk of failure of recovery actions is directly related to uncertainty (Figure 1). The WRI will have to decide what level of risk and uncertainty it needs to achieve before major investments in recovery activities are made. For some actions, the cost and uncertainty are so low that implementation can proceed immediately. This is shown in the darkest (low risk) area in Figure 1. As cost and uncertainty rise, implementation may still proceed, but cautiously. Recovery actions that fall into this category must be monitored and implemented within an explicitly defined program of adaptive management. Cautious implementation is shown in the gray (moderate risk) in Figure 1. For some problems and recovery actions the uncertainty and risk is so high that more information will have to be obtained before investment in recovery actions can be taken.

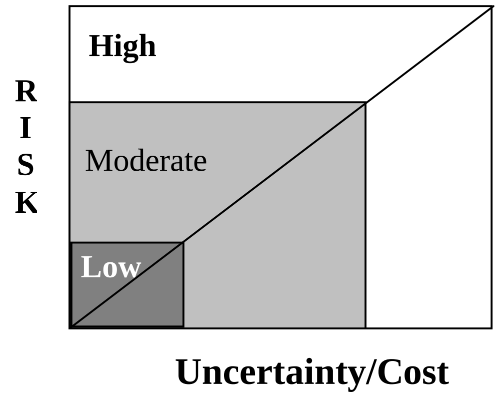

Figure 1. General illustration of the relationship between uncertainty and costs of recovery actions and their risk of failure. Low, moderate, and high risks explained in the text.

DISTRIBUTION AND ABUNDANCE

Where salmon and steelhead are distributed within a basin and their abundance are two important parts of the problem description. However, they do not, by themselves, adequately describe the problem because distribution and abundance do not address the reasons why the salmon and steelhead have declined or changed their distribution.

UPPER WILLAMETTE STEELHEAD

ODFW lists eight current populations of winter steelhead in the upper Willamette River: Tualatin, Molalla/Pudding, Yamhill, Luckiamute, Mary's, Santiam and Calapooia rivers and Rickerall Creek (Figure 2). The distribution of steelhead in the upper Willamette River may be more extensive than in the past because the current populations in streams draining the coastal mountains may be recent introductions. The Calapooia River marks the historical upper limit of indigenous steelhead in the basin. The Santiam subbasin—a stream that flows from the Cascade Mountains—produces about 60 percent of the wild winter steelhead in the Willamette (Kostow 1995). The number of steelhead crossing Willamette Falls from 1971 to 1998 is shown in Figure 3.

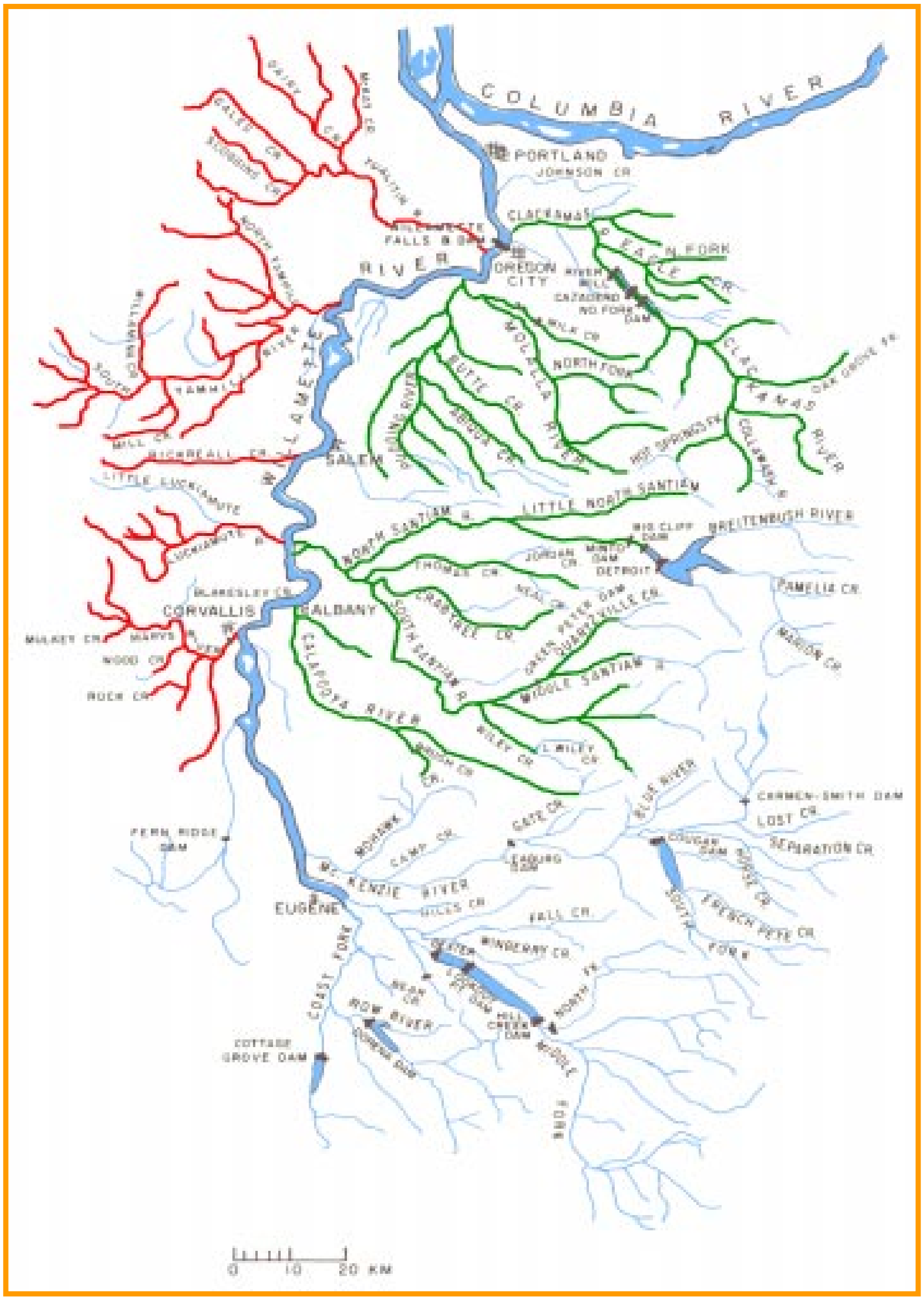

Figure 2. Distribution of winter steelhead in the Willamette Basin. Green indicates the historical range and red indicates probable recent introduction.

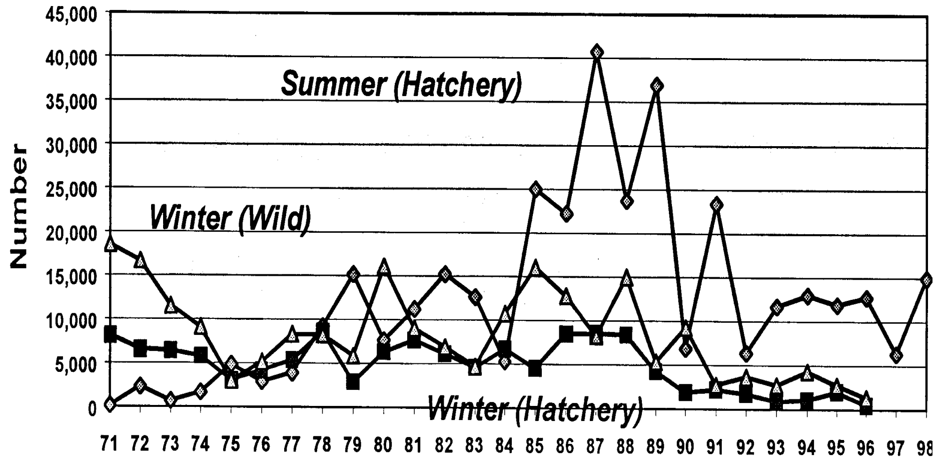

Figure 3. The number of summer and winter steelhead counted at Willamette Falls from 1971 to 1998. Winter steelhead of both wild and hatchery origin are shown. (Source: Oregon Progress Board)

Chilcote (1998) gives abundance information for winter steelhead populations in four tributaries above Willamette Falls (Molalla, North Santiam, South Santiam and Calapooia Rivers) (Figures 4a-e). These data generally extend back to the 1970s and the discussion of trends in abundance are only from that time. Wild steelhead spawning in the Molalla River peaked at 44 fish per mile in 1971 and reached a low of 7 fish per mile in 1993 (Figure 4a). Winter steelhead abundance in the North Santiam River remained relatively stable until 1990. Since then the number of steelhead have been depressed (Figure 4b). Chilcote (1998) divided the South Santiam winter steelhead population into segments above and below Foster Dam. The lower segment is relatively stable where as the upper segment has been in slow decline (Figures 4c and 4d). The Calapooia River is historically the upper limit of winter steelhead distribution in the upper Willamette River. Following a period of increased abundance in the 1980s, this population declined to very low levels (1.8 spawners per mile) (Figure 4e).

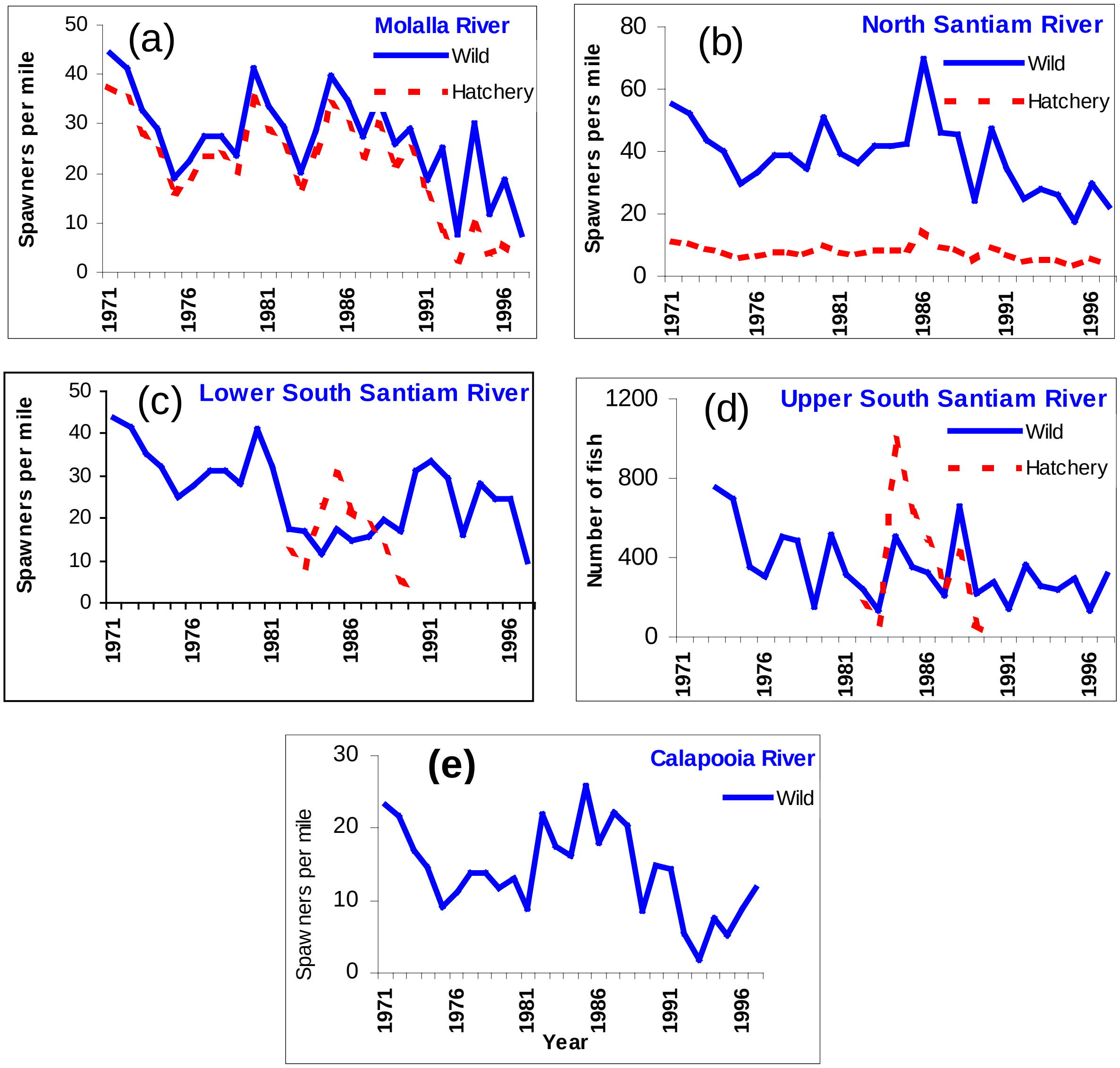

Figure 4. Abundance of steelhead spawners in the Molalla River (a), the North Santiam River (b), the Lower South Santiam River (c), Upper South Santiam River (d) and Calapooia River (e). All measures of abundance are spawning fish per mile except the Upper South Santiam which is the total count of fish crossing Foster Dam. (Source: Chilcote 1998)

LOWER WILLAMETTE AND SANDY RIVER STEELHEAD

The abundance of winter steelhead in the Clackamas River is monitored at North Fork Dam. Three trends are evident in Figure 5: a period of large fluctuations (1961 to 1974), a period of relative stability (1975 to 1990), and decline to very low levels since 1990. Counts of steelhead crossing Marmot Dam are used to monitor the abundance of winter steelhead in the Sandy River. Similar to most of the other steelhead populations, the counts at Marmot Dam have shown a steady decline since the early 1990s (Figure 6).

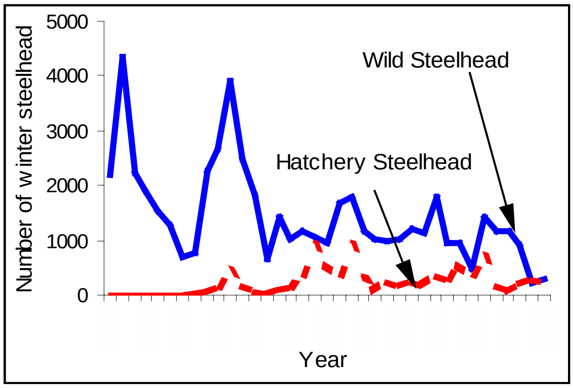

Figure 5. Wild and hatchery winter steelhead counted at the North Fork Dam on the Clackamas River from 1961 to 1997. (Source: Chilcote 1998)

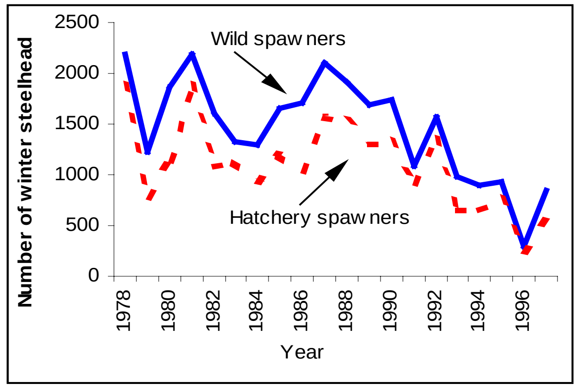

Figure 6. The estimated number of wild and hatchery winter steelhead passing Marmot Dam on the Sandy River from 1978 to 1997. (Source: Chilcote 1998)

UPPER WILLAMETTE SPRING CHINOOK SALMON

Historically, spring chinook above Willamette Falls spawned in the Molalla, Pudding, Calapooia, Middle Fork Willamette, the Santiam, McKenzie and possibly the coast Fork Willamette rivers. All but the McKenzie and Santiam populations are considered extinct (Kostow 1995) (Figure 7). The total number of spring chinook (hatchery and wild) crossing Willamette Falls from 1946 to 1997 is shown in Figure 8.

Spring chinook of hatchery and wild origin cannot be separated in the Willamette Falls count at this time. Beginning with the 1997 brood, all hatchery-produced spring chinook in the Willamette Basin have been marked with a fin clip which means in 2002 it will be possible to differentiate returning adults of hatchery origin from naturally produced fish[1]. At the current time it is not possible to accurately differentiate naturally produced spring Chinook from hatchery fish. As a consequence, according to Kostow et al. (1995) for wild spring chinook "Actual population abundance trends and current population sizes are therefore unknown. Wild populations are thought to be small and dominated by hatchery strays with the largest population suspected to be in the McKenzie River." A recent estimate of the abundance of naturally produced spring chinook salmon, based primarily on professional judgement, put the number of natural spawners at 3,900 with about 2,600 of these being stray hatchery fish. The number of naturally produced spring chinook in the McKenzie River was thought to be approximately 1,000 fish (Myers et al. 1998).

[1] This will not permit biologists to identify adults that are the progeny of reproductively isolated wild spring chinook – if any still exist – from the progeny of hatchery adults that spawned naturally.

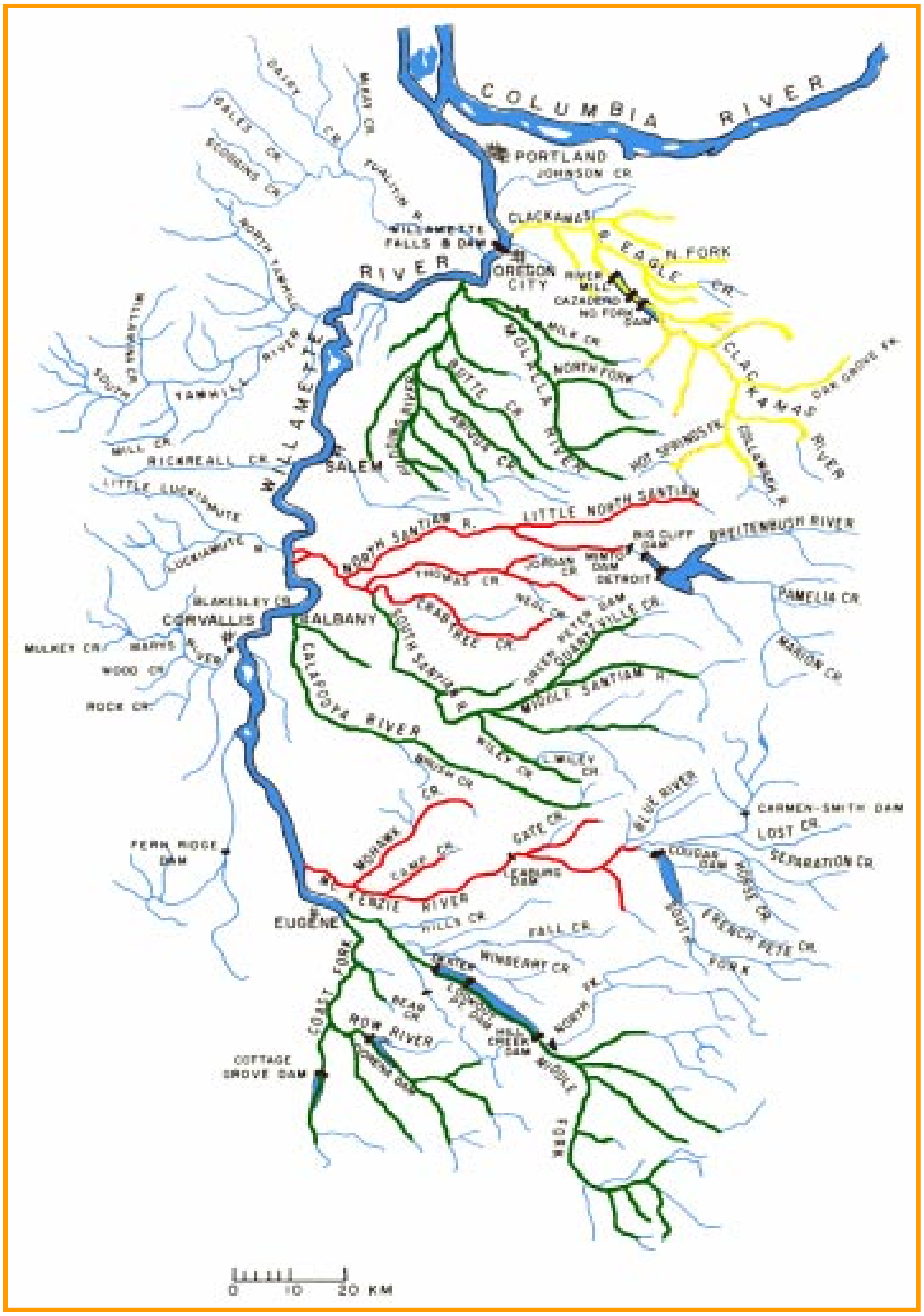

Figure 7. Current and historical distribution of spring chinook in the Willamette Basin. Green shows extinct populations and red shows existing populations. The Clackamas population is shown in yellow.

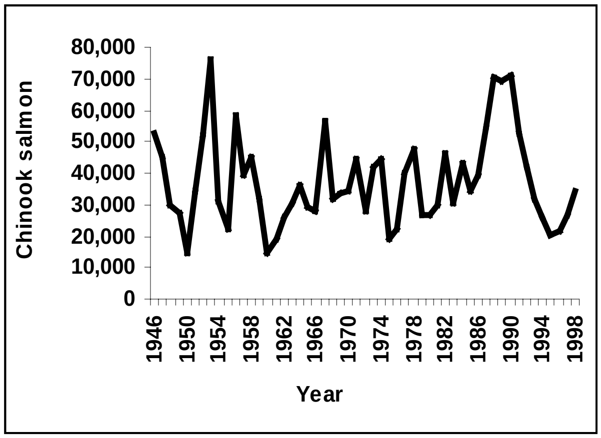

Figure 8. Total count (hatchery plus wild) of spring chinook passing Willamette Falls from 1946 to 1998. (Source: Patrick Frazier, ODFW, personal communication)

CLACKAMAS AND SANDY RIVER SPRING CHINOOK

It has been suggested that spring chinook in the Clackamas and Sandy rivers are the result of introductions of fish from hatcheries above Willamette Falls and are probably not similar to the salmon historically inhabiting those rivers (Myers et al. 1998). Similar to the populations above Willamette Falls, it's not possible at this time to accurately identify hatchery and wild spring chinook at the counting stations at Marmot Dam on the Sandy and at North Fork Dam on the Clackamas (Figures 9 and 10).

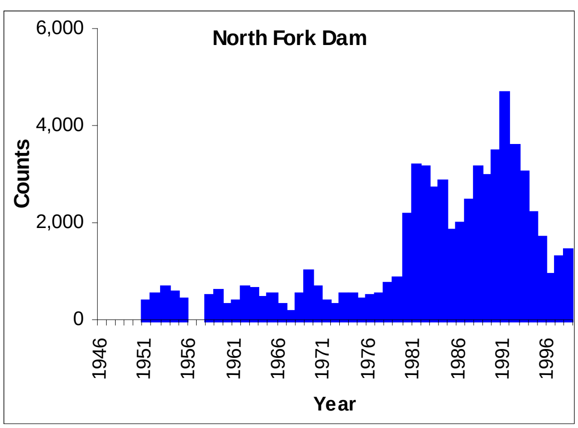

Figure 9. The count of spring chinook at North Fork Dam on the Calackamas River, 1951 to 1998. (Source: Patrick Frazier, ODFW, personal communication)

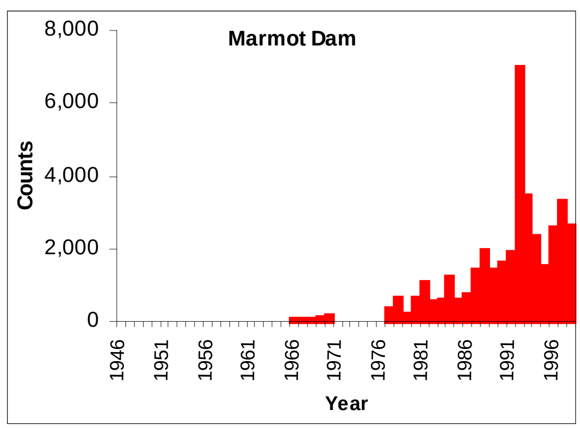

Figure 10. The Count of spring chinook at Marmot Dam on the Sandy River, 1966 to 1998. (Source: Patrick Frazier, ODFW, personal communication)

LIFE HISTORY

There are several different conceptual frameworks that can be used to organize information and define the problem. We believe viewing the problem from the prospective of salmon life histories offers several advantages over other approaches and will, in the long term, provide a better basis for recovery strategies. Using salmon life histories as organizing concept in recovery planning also indirectly addresses several aspects of ecosystem health (Mobrand et al. 1997). Salmon life histories are simply the sum of the important life functions such as spawning, incubation, rearing, and migration. Life histories have a temporal and spatial dimension so their description includes where and when in the ecosystem the salmon carry out those functions (Mobrand et al. 1997). For the salmon, with their long migrations and extended ecosystems, life histories are biologically complex and cover an extensive geographic area.

The salmon's life history has been described as a chain of favorable places, accessible at the right season, where the salmon carry out their critical life functions (Thompson 1959). A single population, the McKenzie River spring chinook for example, may be composed of several of these chains—multiple life histories or pathways through the freshwater and marine components of the ecosystem. Each life history represents a different way the salmon use the habitat. A life history, or a pathway through the ecosystem, is the salmon's solution to the problem of survival. Multiple life histories in a single population are the way salmon cope with the problem of survival in variable and fluctuating environments—the salmon have learned not to put all their eggs in one life history basket (Thorpe 1994).

Life history and habitat are intimately related, in fact, they should be treated as a single unit for management purposes (Healey and Prince 1995). Salmon recovery programs should focus on the restoration of habitats that permit the salmon to express their normal range of life history diversity (Healey and Prince 1995). From this perspective, recovery becomes a matter of restoring all the broken links in the chains of favorable places keeping in mind that a chain that has three broken links is still broken even if one or two of the links are effectively restored. Recovery plans must address the entire life history.

Historically our vision of the salmon led us to believe we could circumvent healthy rivers through the use of hatcheries. This led to management based on over-simplified, generic life histories of salmon. Generic life histories were consistent with the standardized hatchery environment and with river systems that were simplified and controlled. They were not consistent with productive salmon populations and healthy, natural ecosystems. The old vision placed little importance on life history diversity, consequently understanding the relationship between salmon life histories and their habitat was relegated to a low priority. For example, in the 1980 Willamette Basin Fish Management Plan, one of the problems identified (Problem 6, page 74) was the lack of information, including the lack of information on life histories of resident and anadromous fishes (ODFW 1980). In the progress report on the plan released in 1986, progress towards the spring chinook goals is reported primarily in terms of harvest and numbers of largely hatchery fish. Information needs, including information on life histories was still considered a problem, discussed in the back of the report. (Howell 1986). The new draft

Willamette Basin Fish Management Plan (1998) still identifies research into life histories of wild McKenzie River spring chinook as an information need.

An example will illustrate how the use of life histories as an organizing concept in restoration planning would help define the problem and pose critical questions that need to be addressed before major investments are made. Consider a hypothetical undisturbed watershed, a tributary to a larger, river system. This river is home to spring chinook salmon that spawn in August in the upper reaches, September in the middle reaches and October in the lower reaches of the tributary (Figure 11). This distribution is generally consistent with the probable historical spawning distribution of spring chinook salmon in the tributaries of the Willamette River.

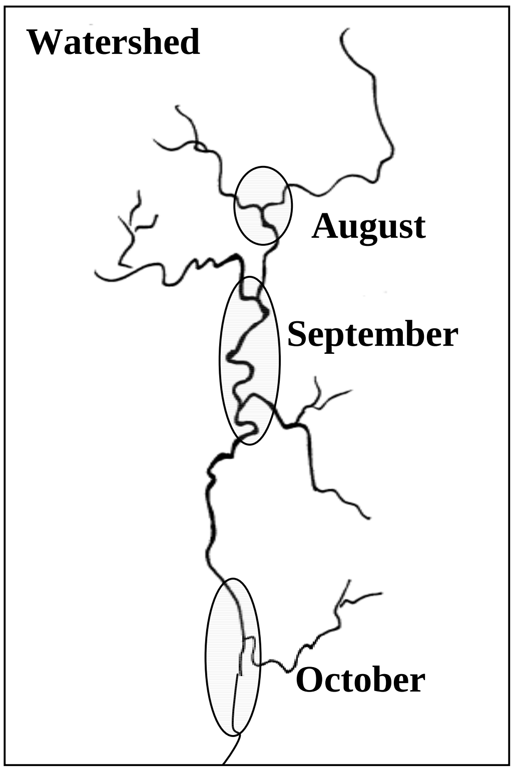

Figure 11. Spring chinook spawning areas and times in a hypothetical tributary.

The timing of spawning is an important life history attribute adapted to the temperature regime of an individual river and it has important survival implications. For example, in the Fraser River in British Columbia, the individual stocks of sockeye salmon spawn over a five month period in response to the temperatures in individual rivers. The length of egg incubation is highly dependent on stream temperature—colder temperatures result in longer incubation times. Juvenile sockeye salmon rear in lakes and to optimize their survival they have to hatch or emerge from the gravel and enter the lakes during the spring plankton bloom when food is available. Even though the eggs are deposited in the gravel over a five-month period the juvenile sockeye emerge from the gravel and head for the lakes within a two week period (Miller and Brannon

1981). The time of spawning has become synchronized with incubation temperature to ensure the juveniles reach the lakes at the appropriate time. If an adult sockeye salmon from a river whose temperature regime is suited to early spawning were transferred to a river whose temperature regime required later spawning, the juveniles would emerge from the gravel out of synch with the spring plankton bloom and be subjected to higher mortality. In the Rogue River in southwestern Oregon, a change in thermal regime following construction of Lost Creek Dam caused warmer incubation temperatures and early emergence of the juveniles that reduced their survival (Cramer et al. 1985).

Continuing the example: the river is developed and the salmon run blocked by an impassable dam that eliminates the upper, earlier spawning population. The lower, latest spawning population is also eliminated by selection in the hatchery (explained later) and by habitat degradation (Figure 12). The September spawners are now the only survivors of the historical population in the tributary.

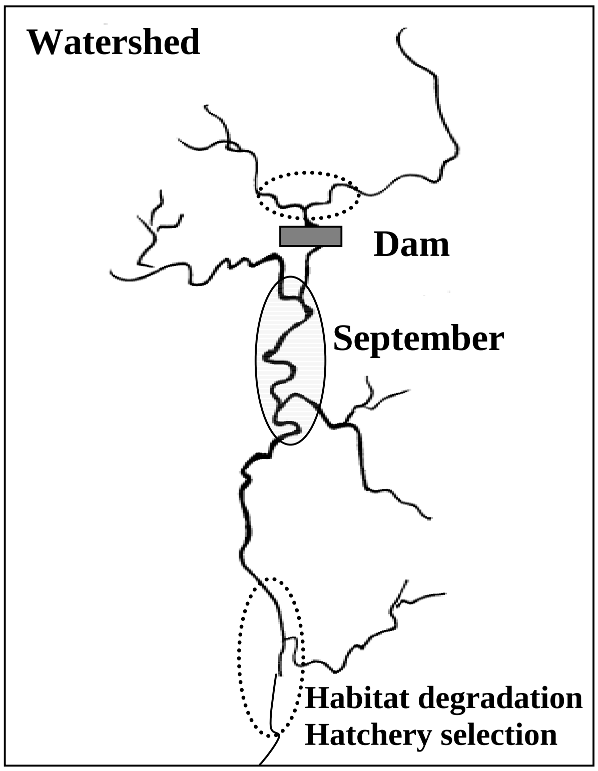

Figure 12. The same hypothetical tributary, from Figure 11 showing the loss of the earliest and latest spawners due to development, habitat degradation, and hatchery operations.

The salmon in this hypothetical tributary decline in abundance until they are threatened with extinction so it is decided to launch a restoration program. One of the proposed recovery strategies is to provide upstream passage of adult chinook salmon and downstream passage of juveniles at the dam. As part of this strategy, September spawning adults will be transferred above the dam to initiate recovery (Figure 13). When viewed from the life history perspective this strategy raises several questions. How strong is the genetic component of the time of spawning in the surviving population? Will the displacement of the September spawners to a new temperature regime above the dam reduce the survival of the juveniles? Will the salmon eventually adapt to the new environmental conditions and how long will it take? The strategy may be deemed acceptable (given the goals and problem statement), and it may be implemented in spite of the uncertainties, but with a rigorous monitoring and adaptive management plan.

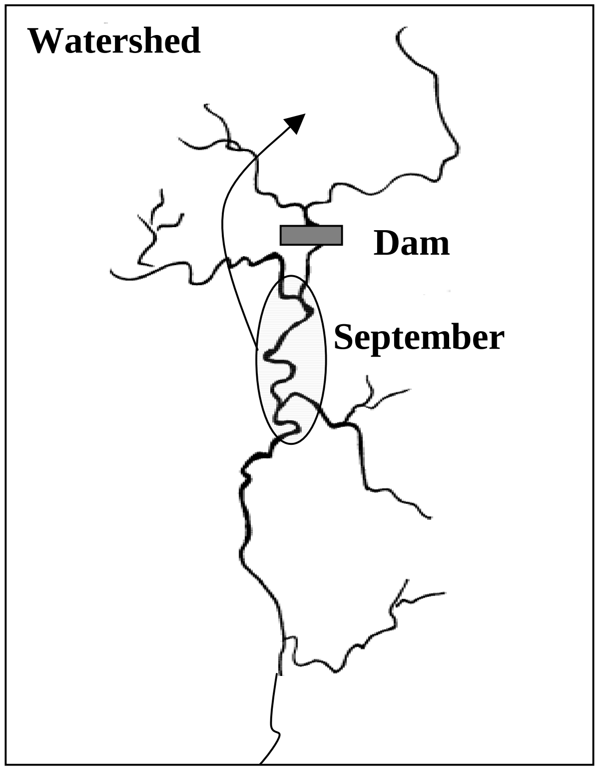

Figure 13. The same hypothetical tributary, from Figures 11 and 12, showing a potential recovery strategy. See text for explanation.

Salmon managers often refer to the four Hs—habitat, hatcheries, harvest and hydro. Nearly all salmon management and recovery activities fall into one of these four Hs. The interaction between the four H's and salmon life histories in the basin is one way to begin describing the broad dimensions of the problem.

Hatcheries. Hatcheries can alter life history through intentional or inadvertent selection. A common result of selection is a change in time of spawning. Historically, spring chinook in the Willamette Basin spawned from August through late October but now they spawn in September (Figure 14). Part of this shift has been the result of hatchery selection (Myers et al. 1998). Habitat loss due to impassable dams can also explain part of the change in the time of spawning.

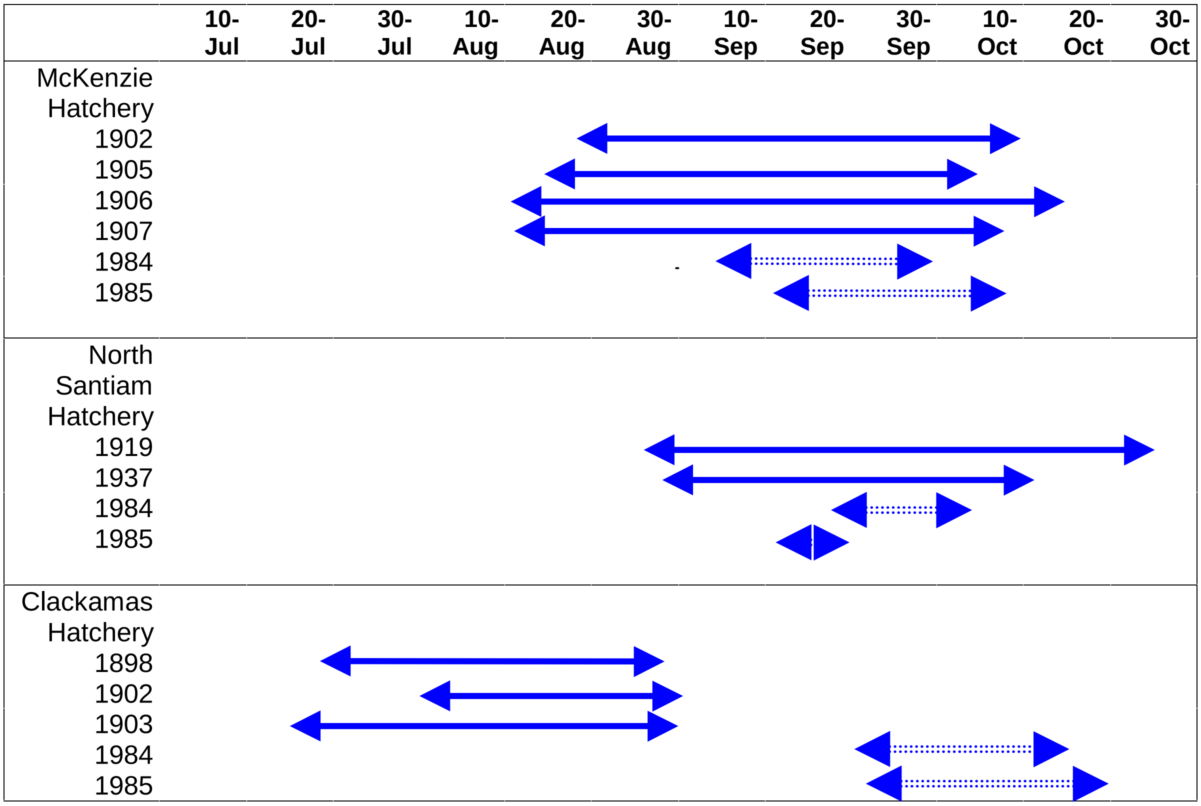

Figure 14. Comparisons of the timing of historical (solid line) and recent (dashed line) egg takes at selected spring chinook spawning stations in the Willamette Basin. (Source: Max Smith; personal communication)

A constricted time of spawning places the incubating salmon eggs and fry at risk due to natural climatic fluctuations and man made changes in the environment. In Oregon’s coastal rivers, hatchery stocks of coho salmon spawn earlier than wild fish due to hatchery selection. Consequently hatchery fish are exposed to early freshets and are subjected to very high mortality (Nickelson et al 1986). Selection in the hatchery has produced a fish with a life history that cannot survive in the wild.

Other ways in which hatcheries can impact life history and ultimately the production of wild salmon include the transfer of salmon and steelhead stocks form their home stream to foreign streams where their life histories are out of synch with the new stream’s environmental attributes. Wild salmon and steelhead can be over harvested in fisheries that target mixed stocks of hatchery and wild fish (Flagg et al. 1994). Over harvest affects production directly, and if harvest is selective for run timing or age/size of the fish it can also affect production through changes in life history.

Habitat Life histories are an important linkage between the salmon and their habitat. Diverse life histories are a response to complex and diverse habitats. Chinook salmon in relatively healthy habitat follow a complex pattern of downstream migration. Migration is nearly continuous through the spring, summer, and fall with the larger fish migrating earliest in the late spring and summer of their fist year. They slowly migrate while feeding and growing until, at the appropriate size, they migrate to sea. In the Willamette River studies conducted in the late 1940s confirm that spring chinook generally followed the same type of migration pattern. Although juvenile chinook salmon were observed in the lower river throughout the year, that study identified three peak migration periods. The first took place in early spring and was made up of young of the year fry and fingerlings. The second major migration took place in fall and winter with the peak usually in the month of October. The final migration was composed of fish that are in their second year (15 to 19 months in age) and they migrate during the spring from January to May. The latter migration was usually less than a third of the entire year class. Few juveniles were observed migrating during the summer months in the late 1940s, probably because of pollution barriers in the lower river. Without those barriers the juvenile salmon may have continued a strong migration through the summer months (Matson 1962). That speculation by Matson has a basis in fact. Summer migrations of juvenile chinook salmon have been observed in other rivers where environmental conditions are appropriate (Lichatowich and Mobrand 1995).

Channel morphology and hydraulics suggest that habitat in the lower reaches of streams are more stable than in the smaller streams in the upper reaches of watersheds (Naiman et al. 1992; Baxter 1961). The continuous downstream movement of juvenile chinook salmon is in effect a migration towards the historical center of habitat stability in the lower reaches of larger tributaries and the mainstem. Today in many watersheds those areas are lethal to salmon or are of marginal quality. In many rivers supporting spring chinook, the juveniles are isolated in headwater refugia during the summer months because of habitat degradation in the lower reaches.

Although the downstream movement of juvenile chinook salmon may appear to be continuous, it can be partitioned into three overlapping migrations: The first in early spring consisting of fry and yearling smolts, the second in midsummer consisting of subyearling migrants destined to enter the sea that year, and a third downstream movement of subyearlings in the fall. As habitats are fragmented and isolated in degraded watersheds, the summer migration life history is reduced or eliminated (Figures 15 and 16).

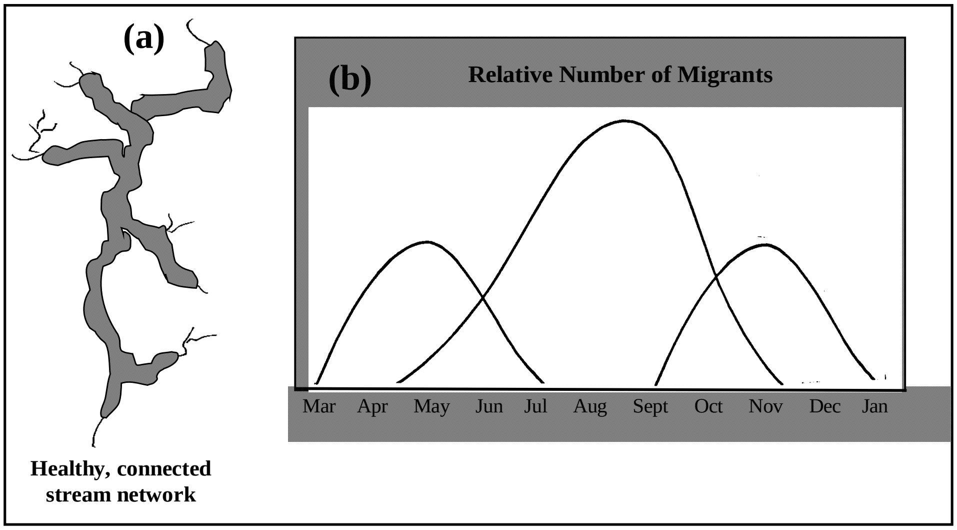

Figure 15. Hypothetical illustration of a connected, healthy habitat (a) that results in diverse downstream juvenile migration patterns (b).

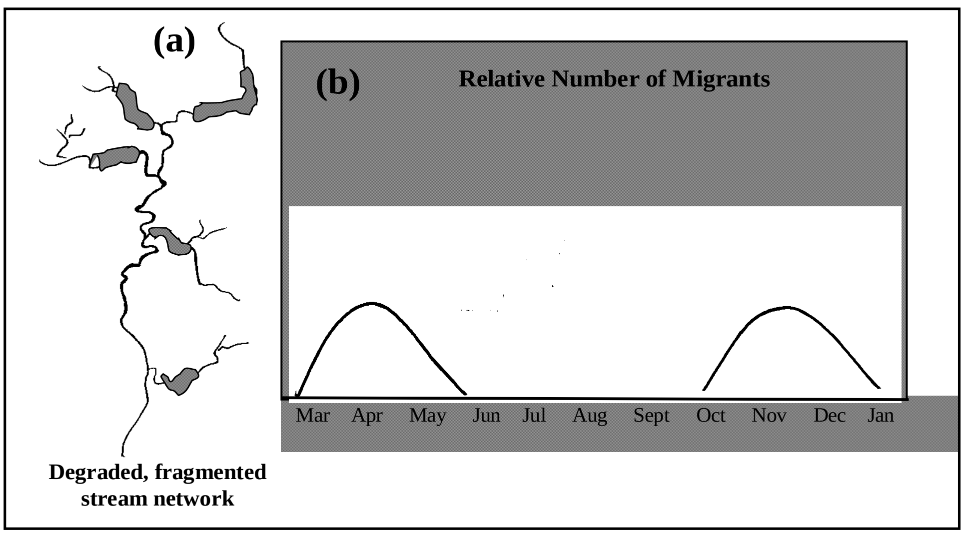

Figure 16. Hypothetical illustration of degraded and fragmented habitat (a) and the resulting loss of diversity in juvenile migration patterns (b).

Downstream migration of juvenile spring chinook in the Willamette River is shown in Figure 17. The obvious questions are: Is this the natural migration pattern? Does the pattern shown in Figure 17 indicate a loss of life history diversity, i.e., the summer migration? If the latter is true, what is causing the migration blockage? Can the WRI reach its recovery goals, without restoring habitat conditions that permit the summer migration of juvenile spring chinook?

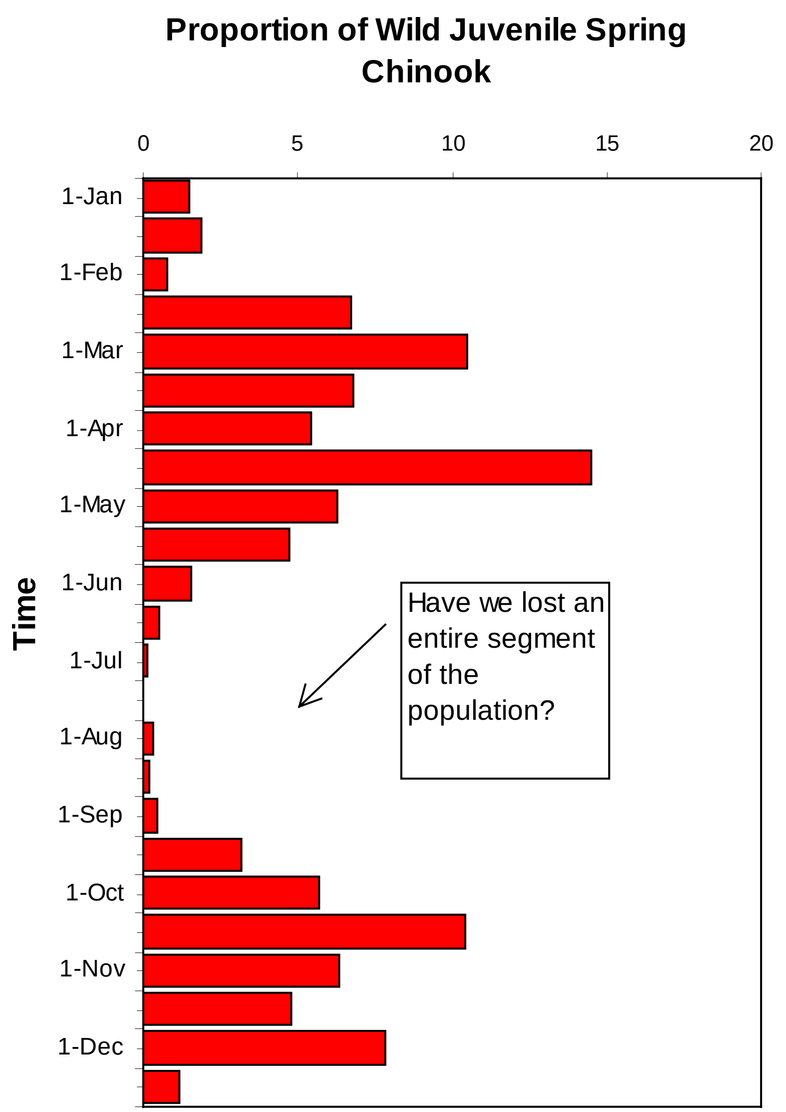

Figure 17. The pattern of downstream migration of wild spring chinook in the Willamette Basin at the Sullivan plant at Willamette Falls. (Source: Patrick Frazier, ODFW, personal communication)

Assuming the migration pattern of juvenile spring chinook in the Willamette River reflects fragmented and degraded habitat conditions, what are some of those conditions that could have caused the loss of summer migrants? Loss of channel complexity in the mainstem below Eugene may be a partial explanation for the loss of summer migrants (Figures 18 and 19). The loss of channel complexity could have reduced the amount of rearing habitat for juvenile chinook salmon below their spawning areas. In addition, Figure 20 illustrates another potential explanation. Juvenile summer steelhead from four different stocks were held in the lower Willamette River for 120 days and mortality was recorded. The Siletz stock (coastal) showed high mortality within 60 days. The Siletz is a coastal basin stock and therefore not previously exposed to diseases or parasites found in the Columbia Basin. The other three stocks were from the Columbia Basin and mortality was delayed until much later (85-110 days) and it appeared to be related to rising river temperature. With the added stress of high temperature, the fish became more susceptible to bacterial diseases naturally present in the river (Buchanan et al. 1982). High mortality during summer months could be another partial explanation for the observed migration patterns.

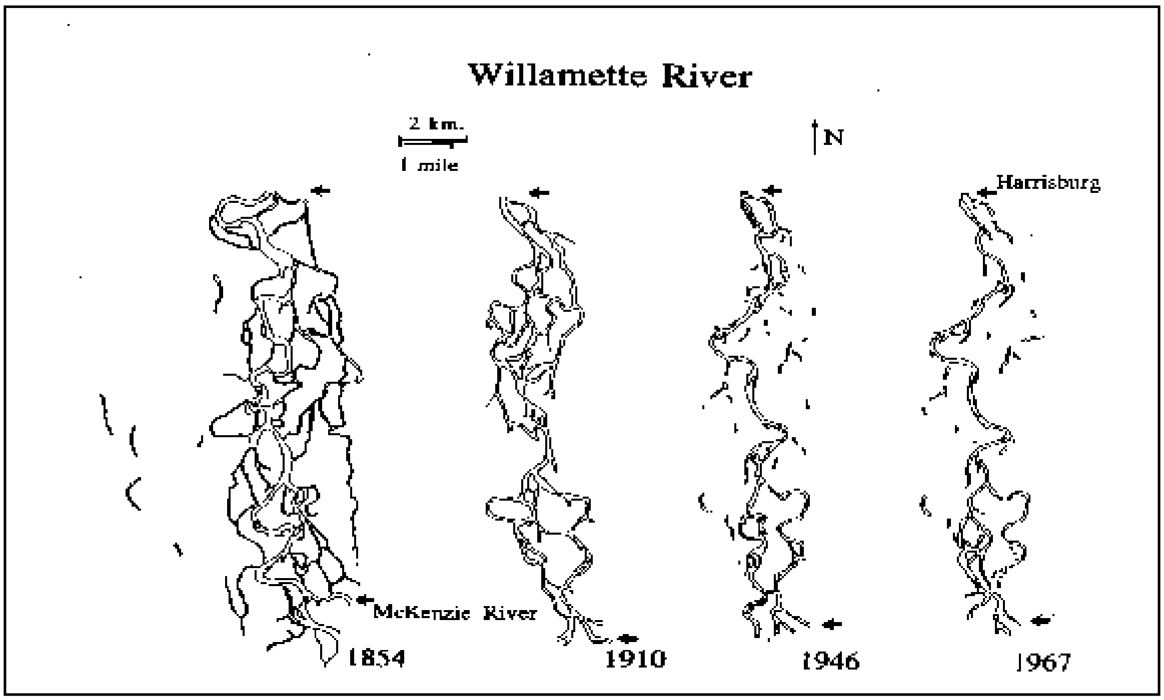

Figure 18. Loss of channel complexity and potential loss of juvenile salmonid rearing habitat in the Willamette River between McKenzie River and Harrisburg. (Source: Benner and Sedell 1994)

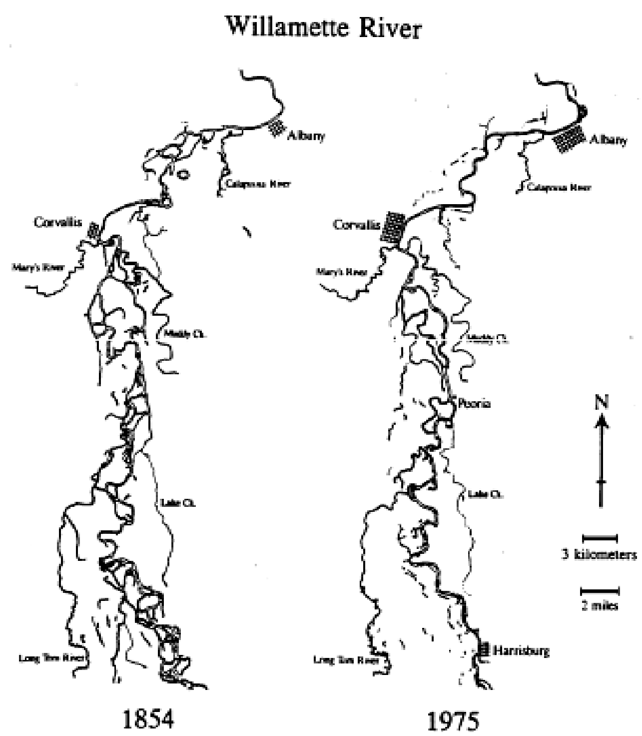

Figure 19. Loss of channel complexity and potential loss of juvenile salmonid rearing habitat in the Willamette River between Harrisburg and Albany. (Source: Benner and Sedell 1994)

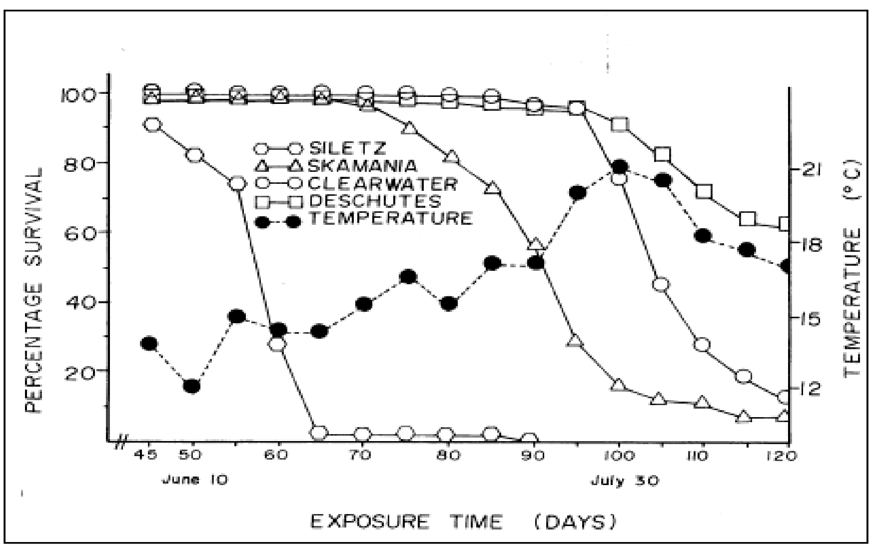

Figure 20. Survival of four stocks of summer steelhead held for 120 days in the Willamette River near Corvallis, Oregon. (Source: Buchanan et al. 1982)

Harvest. Fisheries that select for larger fish or for fish migrating at a specific time can alter life histories of salmon and steelhead. Both effects have been observed in adult chinook salmon—a change in size and a change in the migration pattern. Over the last several decades biologists have observed a decrease in the size and age of chinook salmon from California to Alaska. Selective fisheries are among several possible explanations that have been advanced to explain those changes (Ricker 1981).

In the Columbia River the late spring and summer runs of chinook salmon were targeted by the early commercial fisheries. The fat content of the spring and summer run produced a superior canned product. The later migrating fall chinook were considered inferior. Harvest that selectively targeted the prime spring and summer chinook quickly altered their abundance and the pattern of migration into the river (Figure 21). In 1878 most of the harvest targeted fish that migrated from May to July. By 1919, those fish had declined and most of the harvest came from fish migrating into the river in August (Figure 21).

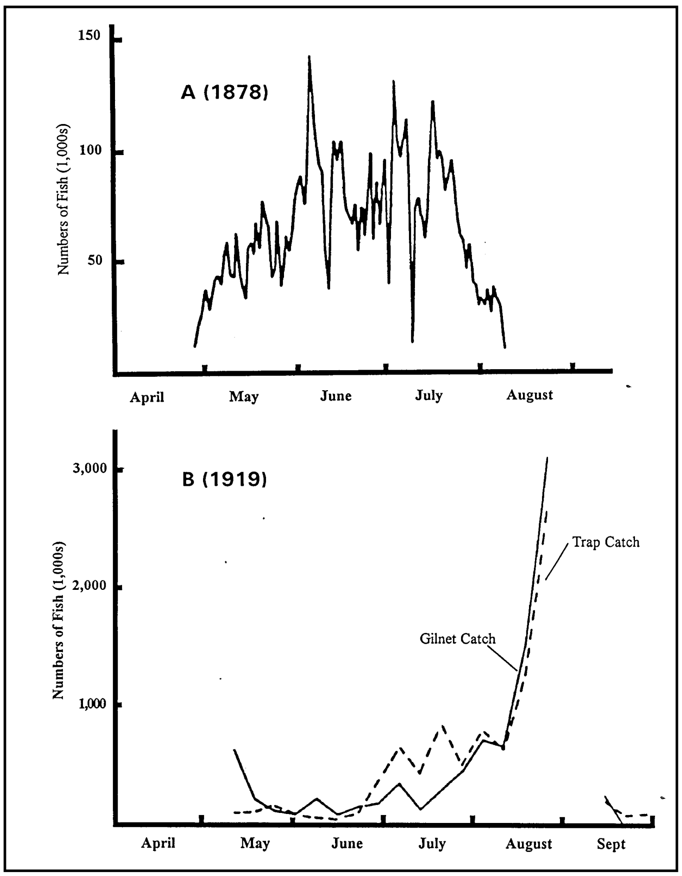

Figure 21. Seasonal harvest of chinook salmon in the Columbia **River in 1878 (A) and 1919 (B).** (Source: Thompson 1951)

Under the old vision, managers attempted to simplify the salmon production system by using hatcheries to supply fish for the sport and commercial harvest. Where this approach was successful, as it was for the Willamette spring chinook, it created secondary problems especially for wild populations. When fisheries target mixed groups of hatchery and wild fish the wild fish are often overharvested. This problem contributed to the collapse of wild coho populations in the lower Columbia River (Flagg et al. 1994) and it probably had an impact on wild spring chinook in the Willamette.

STRATEGIES

Strategies define what will be done to remove or circumvent specific problems. As stated earlier, the tendency has been to skip the earlier steps of vision, goals, and problem and go directly to the strategies, action items, and things to do. There are several pitfalls to that approach, not the least of which, is a breakdown in the internal coherence of the plan. For example, a program generally intended to recover salmon and steelhead listed under the ESA that spent a significant part of its funds on artificial propagation would have a serious disconnect between the goals and strategies. This trap is easy to fall into if insufficient attention is not paid to all four steps in recovery planning and ensuring consistency between the steps.

The strategies given below are only examples of the categories of actions that might be included in a list of strategies, depending on the specific problems that are identified. They were largely taken from the conservation measures given in Martin (1998). Some of these strategies apply specifically to salmon, while others are applicable to ecosystem restoration.

SHORT-TERM STRATEGIES

1. Identify information gaps and initiate research to reduce those gaps, especially where uncertainty is places recovery investments at significant risk..

2. Obtain scientific peer review on key elements of the recovery program and on proposed research

3. Reduce harvest and predation

4. Develop an educational program

5. Reduce the negative effects of hatcheries.

6. Immediate actions to improve water quality and stream habitats.

LONG-TERM STRATEGIES

1. Restore flood plain function and channel complexity

2. Take major actions to improve water quality.

3. Investigate the costs and benefits of restoring anadromous fish above impassable dams.

4. Development and implement ways to reduce the effects of land use and development on habitat.

PERFORMANCE MEASURES

A chronic problem in past recovery programs has been the lack of monitoring of progress, which leads to insufficient accountability and incomplete or halfhearted implementation. Frequently the decision not to monitor is based on the rationale that more funds should be devoted to implementation. This is a short-sighted decision with big consequences. When the program fails to achieve results, it is impossible to determine why it failed and how to correct it. Recovery programs can afford not to monitor performance, only if success is not important. Setting meaningful performance measures is the first step in designing the monitoring program and in assuring accountability in the program's implementation. What follows is a list of general categories of performance measures. Actual measures would have to be more specifically and tied to the strategies, problem, goals, and vision.

LIST OF PERFORMANCE MEASURES

1. The physical attributes of salmon habitat are changing in a positive direction.

2. Abundance of naturally reproducing spring chinook and winter steelhead are responding to those changes in habitat.

3. Institutional changes have been completed after the fish are no longer listed.

4. Biodiversity within and among populations is increasing.

The history of salmon recovery programs does not give much encouragement to those individuals charged with developing new plans and programs. The past 20 years have demonstrated that salmon recovery efforts are capable of consuming large annual budgets with few tangible results. In the sea of uncertainty surrounding the fate of the salmon and the outcome of recovery efforts, there is one conclusion that can be stated with a high degree of certainty. The status quo approach to salmon recovery did not work. In this report we have suggested a reasonable alternative to the status quo. It is only a suggestion. The WRI will have to decide how much or how little it will use.

REFERENCE – TO BE COMPLETED