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CHAPTER 12. CONCLUSIONS AND STRATEGIES FOR SALMON RESTORATION IN THE COLUMBIA RIVER BASIN

> *Fundamentally, the salmon's decline has been the consequence of a vision based on flawed assumptions and unchallenged myths – a vision that guided the relationship between salmon and humans for the past 150 years. We assumed we could control the biological productivity of salmon and "improve" upon natural processes that we didn't even try to understand (p. 8).*
>
> Jim Lichatowich. 1999. Salmon Without Rivers: A History of the Pacific Salmon Crisis. Island Press. Washington, D. C.

The Columbia River today is a great 'organic machine' (White 1995) that dominates the economy of the Pacific Northwest. Even though natural attributes remain (e.g., salmon production in Washington State's Hanford Reach, the only unimpounded reach of the mainstem Columbia River), The Columbia and Snake river mainstems are dominated by technological operations supporting the region's economy (e.g., hydropower production, irrigation systems, flood control, commercial barging). Operation of the river via the hydropower system is driven largely by economic considerations of water usage in the basin and constrains conservation and restoration efforts for anadromous and resident salmonid fishes (Snake River Salmon Recovery Team 1993; National Research Council (NRC) 1996; Independent Scientific Group 1999).

During more than a century of development in the Columbia River Basin (Figure 1.2), the region attempted to provide technological solutions (first hatcheries and fish laddders, later screens at turbine intakes and irrigation diversions, then barging and trucking of juvenile fish around the dams) for losses of salmon habitat and reductions in salmon survival (Lichatowich 1999). The total amount of money spent maintaining and restoring salmon in the Columbia River Basin is not known but is surely in the billions of dollars. Despite these effrts, anadromous salmonids have continued to decline from their historical abundance (Figure 1.3). Total returns of cultured and wild anadromous salmonids reached an all-time low in 1995 of 750,000 fish (WDFW and ODFW 1996). Prior to Euro-American development in the basin, the Columbia River may have supported more than 200 anadromous stocks, which returned 7 to 30 million adult salmon and steelhead to the river annually (Chapman 1986; NPPC 1986; Nehlsen et al. 1991). Today, only Lewis River (WA) and Hanford Reach (WA) fall chinook, Lake Wenatchee and Lake Osoyoos (WA) sockeye, and five summer steelhead stocks in the John Day River (OR) are considered healthy (Mullan et al. 1992a; Huntington et al. 1996). A consequence of the declines in salmon and steelhead has been a proliferation of legal challenges and endangered species listings and petitions. Presently, twelve species (or "evolutionary significant units" of species) of salmon and steelhead that spawn in the Columbia River or its tributaries have now been listed as threatened or endangered under the Endangered Species Act. These include Snake River fall chinook, Snake River spring/summer chinook, Snake River sockeye, Snake River steelhead, upper Columbia River spring chinook, upper Columbia River steelhead, middle Columbia River steelhead, lower Columbia River spring chinook, lower Columbia River chum, lower Columbia River steelhead, upper Willamette River spring chinook, and upper Willamette River steelhead.

Development of the Fish and Wildlife Program

Since 1980 with enactment of the Pacific Northwest Electric Power Planning and Conservation Act by Congress (hereafter the Northwest Power Act), salmon restoration has been approached regionally through implementation of the Columbia River Basin Fish and Wildlife Program of the Northwest Power Planning Council. In the act, Congress charged the Council with developing a plan to "protect, mitigate, and enhance" the fish and wildlife of as affected by the Columbia River Basin hydroelectric system.

The Northwest Power Act directs the Council to base the Fish and Wildlife Program on recommendations submitted by state fish and wildlife managers, Native American tribes, federal agencies, and other interested parties. Those recommendations are solicited, compiled, and discussed by the Council in public hearings before being adopted. Consequently, the Fish and Wildlife Program is a collection of individual measures proposed by a diverse constituency. This approach to developing the Fish and Wildlife Program means that the final list of measures has not resulted in a coherent group of activities derived from a single *a priori* conceptual framework.

Thus, it is doubtful that the contributing institutions based their recommendations on a common scientific understanding of the physical and biological components of the Columbia River watershed and the ways those components interact to form a salmonid-producing ecosystem. The Fish and Wildlife Program actions to date represent a good faith effort by the Council and the region's fisheries managers to recover salmonids; however, those efforts have failed so far to stem the decline of salmonids in the basin. Salmon have declined since the early 1980s from almost 2.5 million to less than 1 million returning adults, most of which (>80%) are now of hatchery origin. Wild fish abundance is approximately 1% of historical predevelopment abundance (National Research Council (NRC) 1996).

The Council's Fish and Wildlife Program emphasizes actions to increase survival of salmon and steelhead in the Lower Snake River (i.e., downstream from Hells Canyon Dam, Idaho/Oregon, which is a barrier to upstream adult migration), the middle and lower reaches of the mainstem Columbia River (i.e., downstream from Chief Joseph Dam, Washington), and their tributaries (Figure 1.2). Actions implemented so far include the following:

1) modifying mainstem dam operations and facilities to improve upstream and downstream passage of adults and juveniles;
2) coordinating river operations to enhance spring and summer flows aimed at improving smolt survival;
3) reducing smolt predators;
4) constructing and operating hatcheries;
5) modifying existing artificial production operations, including supplementing naturally reproducing populations;
6) implementing best management practices for land use activities;
7) screening irrigation diversions;
8) improving habitat and other measures as well as research and monitoring designed to answer critical recovery questions.

We concluded that management of the Columbia River and its salmonid populations has been based on the belief that natural ecological processes comprising a healthy salmonid ecosystem can, to a large degree, be replaced, circumvented, simplified, and controlled by humans, while production is maintained or even enhanced. Meffe (1992) in a review of the Pacific Northwest's use of salmon hatcheries, identified this belief (which he called "techno-arrogance") as the driver behind the region's reliance on large-scale hatchery technology to rebuild depleted salmon runs.

The Normative River: Salmonid Restoration in Regulated Rivers

Our alternative conceptual foundation (Chapter 3) explicitly recognizes that the Columbia River is a natural-cultural ecosystem. Therefore, human development and its consequences are an integral part of this ecosystem. At the same time, the conceptual foundation also recognizes the critical function of natural biophysical processes in the creation and maintenance of healthy salmon habitat and fulfillment of life history functions. The formation and maintenance of complex and interconnected habitats is fundamental to the expression of life history diversity and the spreading of the risk of mortality in variable environments, and ultimately, to the realization of sustainable production. Human development in the Columbia Basin has weakened or eliminated the natural habitat forming and maintenance processes, which together with overharvest and inappropriate hatchery practices, have caused the depletion and extinction of salmon populations (Petersen 1995; National Research Council (NRC) 1996; Independent Scientific Group (ISG) 1998; Independent Scientific Group 1999). Thus, in highly developed natural-cultural ecosystems like the Columbia, there is an inescapable tension between the benefits derived from development and the costs of that development in terms of lost goods and services naturally produced by a healthy ecosystem (salmon and clean water, for example) (Miller 1997; Blumm et al. 1998; Wood 1998). We recognized this tension between development and salmon production in our conceptual foundation.

It is not possible to return the Columbia River system to a completely natural state (i.e., the 'historical' river; Figure 1.4) in order to achieve salmon restoration. However, maintaining the current approach to salmon restoration will not achieve the Council's salmon restoration goals (to double abundance without negatively affecting diversity) and is likely to continue the present trends of declining salmon abundance, local population extinctions, and proliferating ESA listings. A major conclusion embedded in the alternative conceptual framework is the need to restore a greater degree of "naturalness" to the river than exists today (see also Poff et al. 1997). With historical (i.e., pristine) conditions not attainable, what standard of naturalness is appropriate? An acceptable level of naturalness rests somewhere between the current developed state and a completely natural river. The ecological and biophysical attributes of the pre-development river represent the norms or standards under which salmon in the Pacific Northwest evolved. Management actions that restore these attributes or bring them into higher relief in the basin, thereby improving ecological conditions for salmon, should aid salmonid populations. Some examples of natural and artificial conditions that illustrate possible management actions to improve conditions for salmon are shown in Table 12.1.

Table 12.1. Examples of natural and artificial conditions and approaches to salmon restoration.

Natural	Artificial
Natural spawning and rearing	Artificial propagation and rearing in man-made structures; population relocations or stock transfers
Unimpeded passage to and from spawning and rearing sites	Migrations blocked or hindered by anthropogenic factors such as instream structures (dams and other migration barriers), water withdrawals, water pollution, or unfavorable flows; artificial migration pathways that don't mimic natural features
Flow regimes produced by local and regional climates, unencumbered by regulation	Regulated flow regimes in which natural patterns of seasonal and diurnal discharge do not occur, and characteristics of naturally flowing water are absent or limited
Riverine habitats formed and maintained by natural processes through the interactions between flowing water and the surrounding landscape	Replacement of free-flowing river channels with impoundments; substitution of artificial habitats for habitats formed by natural disturbance processes
Community interactions dominated by species with which native salmonids co-evolved	Introductions of non-native plants and animals, including other game fishes, which have altered survival, growth, and behavior of native salmonids
Survival rates that permit enough adults to return so that (1) naturally spawning populations are capable of sustaining and rebuilding themselves, (2) sufficient numbers exist to repopulate favorable but currently vacant habitats, and (3) sufficient marine-derived nutrients are returned to maintain aquatic and riparian productivity	Anthropogenic mortality, including harvest, is sufficiently high that (1) populations are incapable of sustaining or rebuilding themselves, (2) there are insufficient adults and juveniles to recolonize favorable habitats and interbreed with other locally-reproducing populations, and (3) not enough nutrients are returned to maintain aquatic and terrestrial food webs dependent on salmon carcasses

We believe an ecosystem with a mix of natural and cultural features such as the Columbia River can still sustain all life stages of a diversity of salmonid populations (Independent Scientific Group (ISG) 1998; Independent Scientific Group 1999). The region will have to improve ecological conditions in the river system before sustained salmon recovery is possible. This is a major change in approach to salmon recovery from the current approach, which has emphasized activities and actions that circumvented the natural ecological attributes of the river, i.e., attempting to restore salmon without restoring the natural river functions.

Fostering a Regional Discussion on Salmon Recovery

In our 1996 prepublication version of *Return to the River* (Independent Scientific Group (ISG) 1996), the ISG suggested that all options for recovering salmon be included in a regional discussion on the role and future of salmon in the Pacific Northwest. In addition to the continuing discussions for reforms associated with harvest, artificial production, and juvenile passage mortalities, etc., the debate needed to include options such as permanent reservoir drawdown and the natural river option (achieved via breaching or bypass of existing dams) which had previously been regarded as untenable or impossible. Since 1996, the region has entered into a vigorous debate about salmon recovery and the future of the Columbia River basin hydroelectric system.

At a formal level, numerous processes, forums, and reports have been developed since 1996 that are attempting to address biological, economic, institutional, and political aspects of salmon recovery (Independent Economic Advisory Board 1999; Independent Scientific Advisory Board 1999a; Independent Scientific Group 1999). Two of the most prominent of these are the Northwest Power Planning Council's Multi-Species Framework (www.nwframework.org) and the NMFS' pending 1999 (now 2000) decision on the future configuration of the Columbia River Basin hydroelectric system. The 1995 NMFS Biological Opinion on operation of the Columbia River federal hydrosystem (National Marine Fisheries Service 1995a) mandated that NMFS would propose various alternative configurations for the hydrosystem and through a series of studies and evaluations to recommend by late 1999 a long-term configuration for the system. The alternatives range from continuing the status quo, to augmenting the status quo with additional hatchery and juvenile barging, to implementing the natural river option through the four federal dams on the Lower Snake Rivers and permanently drawing John Day dam down to spillway crest.

The Council's Multi-Species Framework process is a collaborative project with the Columbia River Basin's Indian Tribes, and the United States Government. The process evolved out of the recommendations made by the ISG in the 1996 prepublication version of *Return to the River* (Independent Scientific Group (ISG) 1996; Columbia Basin Fish and Wildlife Authority 1997; NPPC 1997; NPPC 1998) The project seeks to link Columbia Basin fish and wildlife restoration policy to a basin-wide vision, based on a scientific foundation that recognizes that the river and its species are interrelated parts of a whole. Once it is developed, the Framework will provide system-wide direction and specific strategies for fish and wildlife recovery, and objectives by which results can be evaluated. The Council's Fish and Wildlife Program opened for amendment in early 2000 with the results of the Multi-Species Framework process providing a structure for reviewing and prioritizing suggested amendments. The last amendment to the program occurred in 1994.

At a more public level, the debate is occurring through regional newspapers and television. Major newspapers within the region have nearly all developed special sections describing the issues and options. Typical examples come from a special report in the Oregonian (Figure 12.1) that captures many of the biological and societal complexities of these issues.

The debate is also gaining national media attention through Congressional resolutions[1], radio and newspaper coverage, and feature articles in conservation-oriented magazines (Yuskavitch 1998; Weber 1999; Yuskavitch 1999). Much of the debate has focused on the role and fate of the Lower Snake River dams (Yuskavitch 1998). Several reports have attempted to examine the costs, impacts, and timelines required to breach the four U.S. Army Corps dams on the Lower Snake River. However the estimates vary so widely as to add confusion rather than clarity to the debate (Harza Northwest 1996; Oregon Natural Resources Council 1998; Drawdown Regional Economic Workgroup 1999).

Lessons from the Hanford Reach: Improving Conditions for Salmon

Two important factors emerge from an examination of the only truly robust fall chinook population in the Columbia River basin, the Hanford Reach fall chinook stock. First, this healthy population originates in a series of linked habitats that provide suitable adult spawning habitat, successful incubation of eggs, and various juvenile rearing areas that are immediately adjacent to the spawning areas. Second, fisheries regulations are appropriate to maintain adequate escapement of spawners to the Hanford Reach area.

The Hanford Reach fall chinook population has benefited from regulation of river flow out of upstream dams. As a result of an agreement reached among affected parties (the three mid-Columbia P.U.Ds, BPA, the Corps of Engineers, states of Washington and Oregon, and certain Treaty Tribes), flows are maintained during spawning of chinook to provide a stable boundary within which the construction of redds and deposition of eggs will take place. Following that, flows are maintained during incubation of the eggs to prevent dewatering. Finally, flows are stabilized to prevent stranding of juveniles after they have hatched, prior to their movement

[1] In early summer 1999, six Democratic House members from Oregon and Washington urged NMFS to develop and analyze a recovery alternative (for the 1999 Biological Opinion) that included aggressive measures in all four H's (Habitat, Hydro, Hatcheries and Harvest) but did not include dam breaching or dam removal. In response by late summer 1999, 107 House members told President Clinton that endangered Snake River salmon were a national responsibility as well as a regional one, and all scientifically credible recovery plans, including dam breaching, should be evaluated equally.

downstream (Independent Scientific Advisory Board 1998a). It is clear that the population has responded positively to these measures that have improved the functionality of the habitat. In addition, hatcheries at Priest Rapids and Ringold have contributed fish to the totals returning. The chinook juveniles from the Hanford Reach are typical fall chinook. They are ocean type chinook, beginning and completing their migration to the sea during their first year after hatching. They move downstream slowly, feeding and taking advantage of the excellent rearing habitat found in the lower portions of the Hanford Reach. Fall chinook do not guide well with turbine intake screens. Like sockeye salmon, they are probably subject to higher mortality than spring chinook or steelhead in passage past the dams. Nevertheless, Hanford Reach fall chinook are captured in ocean fisheries off the coasts of Washington, British Columbia, and Alaska. To date, passage mortalities on juveniles and these fisheries have not prevented attainment of the escapement goals in the Columbia River, although there are other stocks of fall chinook that have not fared so well.

Restoration of Mid-Columbia Habitats and Chinook Populations

Restoration of a historically productive and complex riverine segment might also occur through permanent drawdown of John Day pool to spillway crest (Figures 12.1 and 12.2). The John Day pool lies immediately adjacent to the Hanford Reach, which is the only mainstem area that consistently continues to produce salmonids (see Figure 3.6) and is one of only a few river reaches in the entire Columbia River system that presently provides riverine habitat for a "healthy" salmon stock (Geist 1995; Whidden 1996). The upper portion of John Day pool lies immediately below the confluence of the Snake and Columbia rivers and contains what was formerly a large alluvial reach that served as a highly productive area for mainstem spawning chinook populations. Populations in this area, may have been linked together into a metapopulation, and served as a core to stabilize chinook salmon production in the region. Restoration and revitalization of the upper John Day pool as a free-flowing river segment might assist in the reestablishment of chinook salmon production and metapopulation structure through straying and dispersal from the adjacent Hanford Reach chinook (see Figure 3.7).

It is logical to note that if ecological conditions can be enhanced through drawdown of selected reservoirs to spillway crest, then the "natural river option," which requires breaching or bypassing dams would be likely to yield improved ecological conditions beyond that achieved by spillway crest drawdown. Various options to improve ecological conditions and salmon production are presently being discussed throughout the basin as noted above. One of the options calls for drawdown of John Day Dam to spillway crest as depicted in Figures 12.1 and 12.2. Another options calls for the breaching or bypassing of the four US Army Corps of

Engineers' dams on the Lower Snake River (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite).

Several recent studies have examined the importance of geomorphic features in large rivers (Geist and Dauble 1998) and assessed the impacts of development and operation of the Columbia and Snake River hydroelectric system on mainstem riverine processes and salmon habitats – primarily on fall chinook spawning and rearing habitats (Batelle's Pacific Northwest Division and U.S. Geological Survey 2000). Results of the study should provide valuable input into the regional decision on the future configuration of the hydroelectric system and our approach to salmon recovery.

Among the findings from the study are that only about 13 and 58 percent of the historic mainstem Columbia and Snake rivers, respectively, are still riverine in nature, as opposed to the lacustrine nature of the impounded reaches. The largest loss of riverine habitat in the Columbia River occurred downstream of the Snake River confluence where only about 3 percent of the historic riverine habitat still exists, mostly in the tailraces downstream of hydroelectric projects.

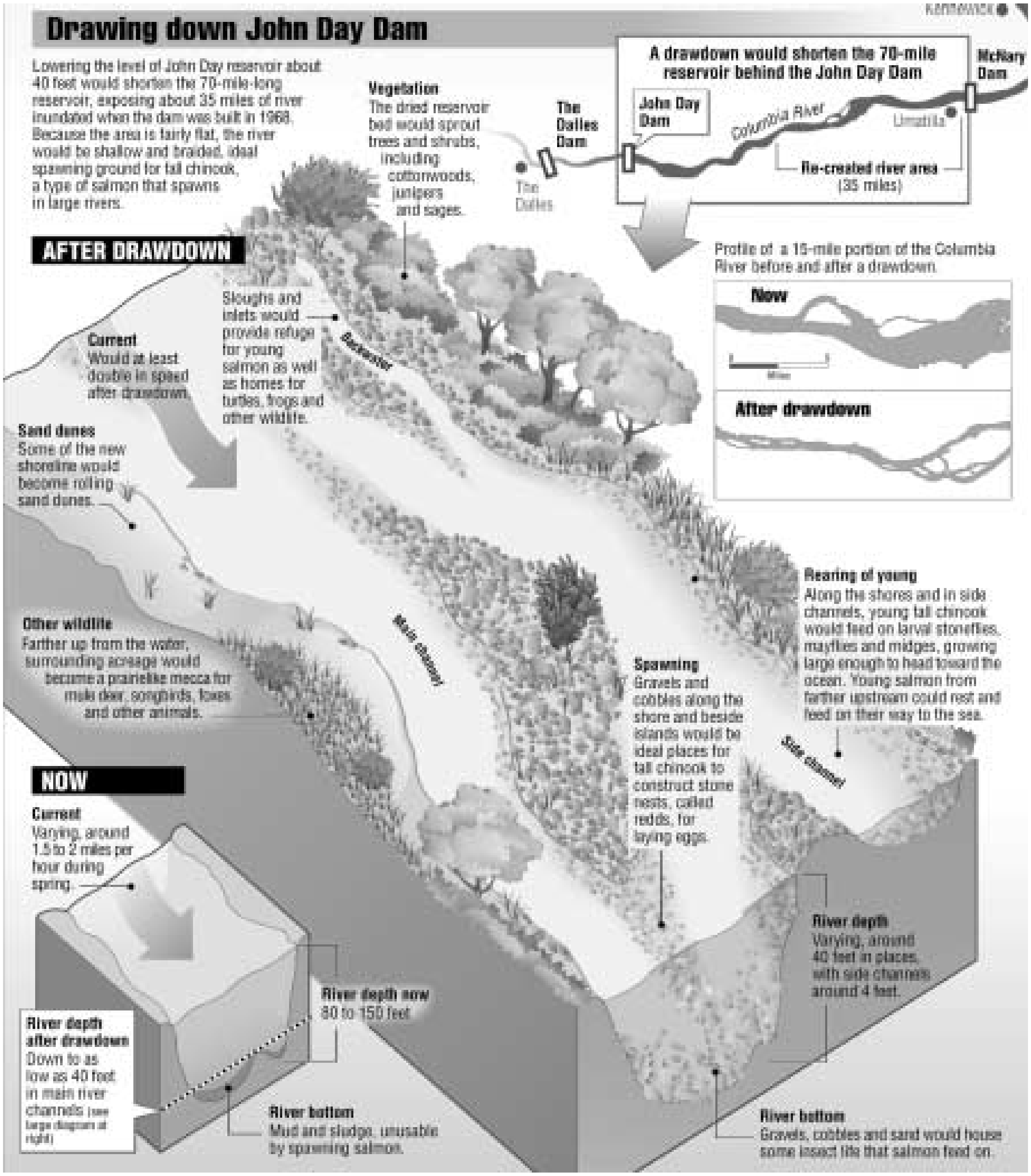

Figure 12.1. An example of how ecological conditions would be improved by restoring free-flowing river conditions to the upper John Day pool area through a permanent drawdown of John Day reservoir to spillway crest.

Graphic designed by Molly Swisher and Jonathan Brinckman, Oregonian staff.

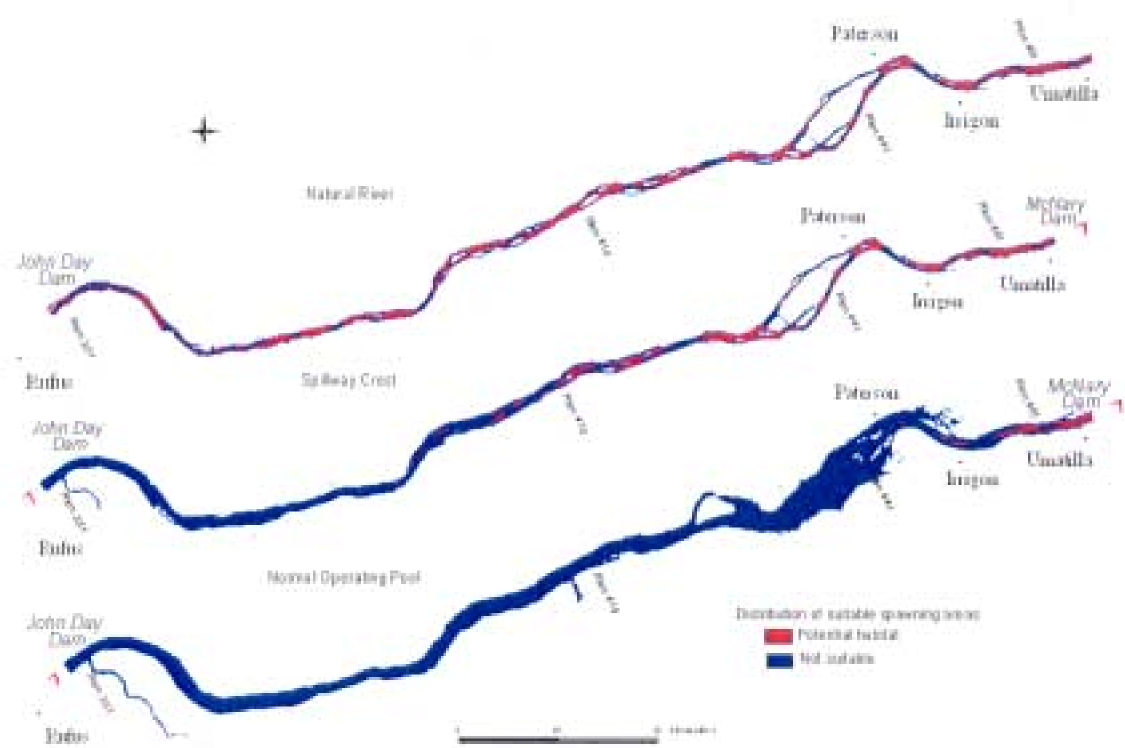

Figure 12.2. Distribution of suitable (red) and unsuitable (blue) fall chinook spawning habitat in the John Day pool area based on water depth and velocity for three operational scenarios: 1) natural river (top), spillway crest drawdown (middle), and normal operating pool (bottom). Figure from draft final report by Batelle's Pacific Northwest Division and the U.S. Geological Survey (2000), courtesy D. Dauble et al.

Other recent studies have shown remnant fall chinook populations utilizing these specific habitats for spawning (Garcia et al. 1994). In the upper Snake River, nearly 70 percent of the historic mainstem riverine habitat still remains, however, it lies upstream of Hells Canyon Dam (Figure 1.2) and is not accessible to anadromous salmonids.

Batelle's analysis of historic spawning areas for fall chinook was coupled with model-based analysis of river reach geomorphology and concluded that historic fall chinook spawning areas were primarily associated with the wide alluvial floodplains that were once common in the mainstem Columbia and Snake rivers (Batelle's Pacific Northwest Division and U.S. Geological Survey 2000). From the analysis, they identified three river reaches with the highest potential for restoration of riverine processes: 1) the Columbia River upstream of John Day Dam; 2) the

Columbia-Snake-Yakima River confluence; and 3) the lower Snake River upstream of Little Goose Dam. For example, in the John Day reservoir area, their analysis suggests that up to 53, 22, and 3 percent of the total reservoir area would be potential suitable spawning area for fall chinook under natural river drawdown, spillway crest drawdown, or normal pool conditions, respectively.

In the lower Snake River analysis, they concluded that the majority (74 percent) of the 266-km study area was classified as alluvial or partially alluvial habitat, such as shown in Figure 12.3.

Figure 12.3. The Clearwater River immediately above Lewiston, Idaho and the Lower Granite Dam reservoir showing fall chinook spawning habitat in the partly alluvial habitat described by Dauble et al. (2000). Photo courtesy of W. Smoker, 6 March 2000.

They estimated that approximately 55 percent of the study area may have been suitable as fall chinook spawning habitat prior to hydroelectric development. Of particular interest was the river section between Little Goose and Lower Granite dams, in which 87 percent of the lineal river distance was predicted to be suitable fall chinook spawning habitat (Figure 12.4). Note the similarity to Figure 7.4, which shows pre- and post-impoundment silhouettes of the area upstream of John Day Dam.

Lessons from the Salmon Themselves

While it is important to look at historical distribution and abundance patterns of salmon in the basin as one means of identifying potential restoration sites and opportunities, we also need to look closely at current distribution and abundance patterns as these indicate to us how salmon are adapting to and using the present system. One of the most interesting distribution patterns to emerge from recent surveys of the Columbia and Snake river masintems, is the persistent use of tailwater areas below hydrosystem projects by fall chinook salmon as spawning areas (Garcia et al. 1994, Fish Passage Center website, www.fpc.org). Remnanat fall chinook populations have been observed below nearly all projects in the mainstem Columbia and Snake rivers, attesting to the dispersal ability of fall chinook, as well as to their ability to find and colonize suitable available spawning habitats. We view this response by fall chinook in these habitats as testimonoy to the noramtive river concept we described in chapters 3 and 12 as a viable restoration strategy for increasing salmon abundance and productivity.

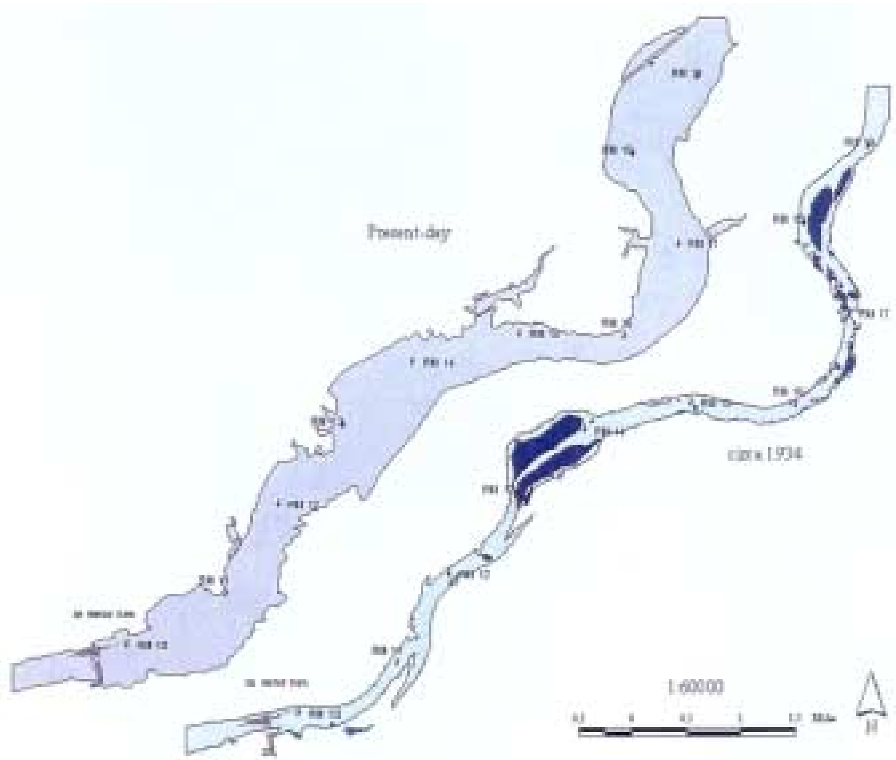

Figure 12.4. Lower Snake River planform channel morphology upstream of Ice Harbor Dam under present reservoir conditions (Lake Sacajawea) and pre-dam riverine conditions (1943) (Batelle's Pacific Northwest Division and the U.S. Geological Survey 2000).

The most striking example of fall chinook use of tailwater habitats immediately below a hydroelectric project occurs below Bonneville Dam around two islands. Lower Columbia River chum salmon, an ESA listed threatened species, have apparently used the area for spawning since the 1960s, or earlier (Figure 12.5). The first recorded stream survey of the area (Hamilton Slough on the north bank of the Columbia) occurred in November 1967 by Washington Department of Fish and Wildlife personnel, where they counted 63 chum salmon adults. Another survey in the fall of 1976 noted 13 chum salmon and 75 redds at the top of Pierce Island. In spite of these records, the area was not systematically surveyed until the late 1990s.

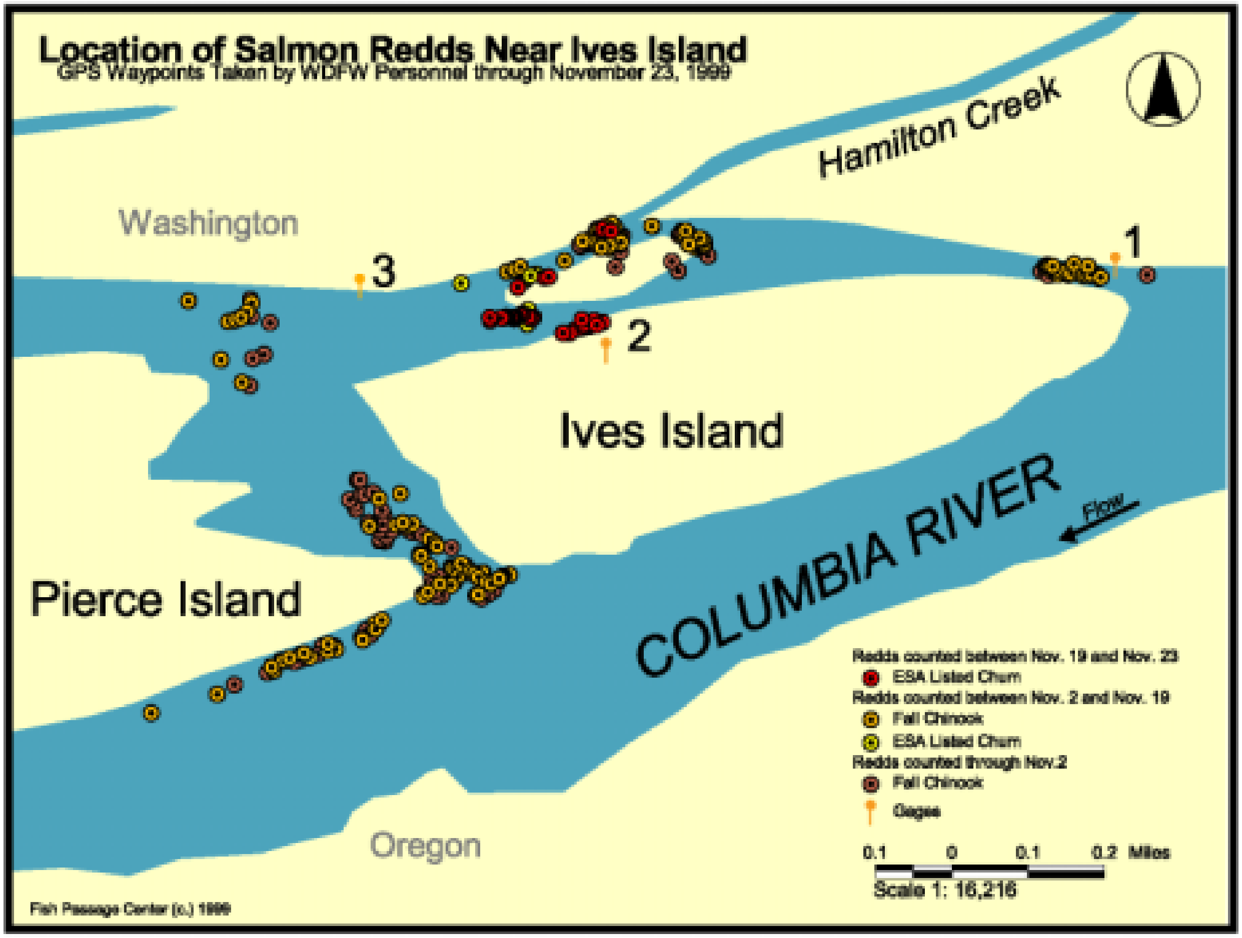

Figure 12.5. Map showing chum and fall chinook salmon redds in normative habitats surrounding Ives and Pierce Islands immediately below Bonneville Dam, fall spawning season 1999. Map courtesy of the Fish Passage Center, 1999.

In November 1993, fall chinook were observed in the area by WDFW personnel. Surveys in December 1994, counted more than 150 spawning fall chinook salmon. More extensive surveys in 1997 and 1998 counted over 1000 adult fall chinook in the Pierce and Ives islands and the Hamilton slough area. Figure 12.5 shows the distribution of fall chinook and chum salmon redds in the Hamilton Slough area in late November 1999. Low flows from Bonneville Dam in October 1997 (117 kcfs) threatened to dewater the spawning adults and redds. Further research and monitoring indicate that dewatering of redds and spawning areas could occur at flows below approximately 150 kcfs. Presently, Bonneville Dam operations are coordinated with spawning area water level sensors through the Fish Passage Center's monitoring program to avoid dewatering redds and spawning areas for both chum and fall chinook salmon in the Hamilton Slough area.

Fall chinook in the Ives and Pierce Island area below Bonneville Dam appear to be derived from remnant lower Columbia River fall chinook through natural colonization and growth rather than being derived from mid-Columbia or upper-river fall chinook salmon. Genetic analysis showed the Hamilton Slough area fall chinook differing from upper-river fall chinook, although they are most closely related to them. Analysis of adult chinook fish and carcasses also suggests that the Hamilton Slough area fall chinook are derived from a natural colonization of lower river fall chinook. In four years of spawning ground sampling from 1994-1997 a total of 2,246 fall chinook were examined for missing adipose fins (mark sampled). Only six coded-wire tags were recovered. Of these CWT recoveries, four were from mainstem releases of Bonneville Hatchery upriver bright stocks used for Dam passage studies. Only two CWTs were from on-station Bonneville Hatchery releases. No CWTs were recovered after 1995.

Conclusions and Recommendations

Salmon restoration in the Columbia River is based on the prevailing belief that the primary problem for anadromous fish is mortality associated with juvenile passage through the mainstem dams and reservoirs. The prevailing solution involves a combination of hatchery technology (to maximize the number of smolts produced) combined with flow augmentation and juvenile transportation via barges to move them as rapidly and efficiently as possible past the dams. This strategy is reflected in restoration expenditures (General Accounting Office 1992) and in the measures supported by management agencies and tribes for implementation (Independent Scientific Review Panel 1997; 1998; 1999).

The region, through its policy representatives and the evaluative processes described above, must decide how far it is willing to restore the river based on its economic, cultural, and ecological values. If the region concludes it cannot or is unwilling to improve the ecological conditions needed to achieve the Council's current salmon recovery goals, then those goals must be changed. The challenge before the region is to reach agreement on the extent to which the numerous social and biophysical constraints on the Columbia River can be relaxed or removed. Defining what the river must be and moving the ecosystem to that point is the only way to bring about salmon recovery and to achieve the Fish and Wildlife Program's salmon restoration goals.

Unfortunately, the restoration program based on the current set of assumptions has failed to curtail the decline of salmonid fishes. Moreover, it may be actively interfering with conservation efforts for resident fishes or other management goals in headwater areas not accessible to salmon, e.g., eutrophication controls in Flathead Lake are negated by discharges from Hungry Horse Reservoir made to accommodate late summer smolt movement in the lower Columbia River (Stanford and Hauer 1992).

Need for an Explicit Conceptual Foundation

1) Progress towards salmon recovery in the Columbia Basin is impeded by the lack of an explicitly defined conceptual foundation based on ecological principles. We recommend that the region adopt an explicitly defined conceptual foundation that is based on ecological principles.

Without a fundamental change in our approach to salmon restoration, more extinctions of salmon populations are likely and progress toward the rebuilding goal unlikely. Temporary increases in some populations may occur in response to fluctuations in ocean conditions, and small increases may result from large-scale use of technology such as hatcheries, but the overall downward trend in returns that has occurred throughout this century will likely continue without a fundamental change in approach.

Need for an Integrated Approach

2) The potential social, economic, and biological tradeoffs that will accompany improvement of ecological conditions in the Columbia River are not known. Identifying and quantifying those tradeoffs where possible is a high priority.

3) Although uncertainty exists regarding our restoration approach, it offers an opportunity to move from the continued pattern of decline and to boost recovery of salmon and the goals of the Fish and Wildlife Program

A rigorous program of evaluation, monitoring, research, and adaptive management will be required. An approach based on the re-establishment of more natural riverine processes, combined with an implementation program governed by the principles of adaptive management, offers the best hope for preventing large-scale extinction of salmon in the basin. This approach might be tested at the subbasin level as a first step (Hill and Platts 1998)

Manage for Biological Diversity

4) Recognize explicitly that salmonid fishes in the Columbia River exist naturally as aggregates of local populations, possibly organized as metapopulations, and manage for life history and population diversity as essential to increased survival and total production.

Although much of the natural diversity of salmonid fishes has been lost (Nehlsen et al. 1991; Huntington et al. 1996), we believe that salmonids retain the capacity to re-express life history and population diversity if opportunities for access to suitable habitat are provided (Healey 1994). As habitats improve in the Columbia Basin, metapopulation structure will likely develop from the natural expansion of remaining wild core populations (e.g., fall chinook in the Hanford Reach).

Protect and Restore Habitat

5) Freshwater habitat for all life history stages must be protected and restored with a special emphasis on key alluvial river reaches and lakes. Protecting healthy habitat, restoring degraded habita,t and providing access for salmonids to diverse habitats, should be a management priority. These activities should encourage the re-expression of phenotypic diversity in salmonid populations

At least three generalized actions could begin to rebuild habitat quantity and quality of the mainstem and tributaries: a) Reregulate flows to restore the spring high-water peak to revitalize the mosaic of habitats in alluvial riverine reaches; b) Reregulate flows to stabilize daily fluctuations in flow (caused by the practice of "power peaking") to allow food web development in shallow water habitats and reduce juvenile mortalities via stranding; c) Provide incentives for watershed planning that emphasize riparian and upland land use activities that support natural interactions between land and water, and insist on empirical evaluation of effectiveness of management practices.

Reduce Sources of Mortality

6) Reduce sources of mortality in the mainstem of the Columbia and Snake Rivers and improve effectiveness of mitigation activities within the hydroelectric system. These goals include managing stocks with a more complete understanding of their migratory behavior and how this behavior is affected by various modes of river regulation. Mitigation measures should be directed toward increasing natural riverine processes and functions needed by salmon for spawning and rearing.

We identified four specific areas or activities that would improve the survival of salmon in the mainstems of the Columbia and Snake Rivers: a) Couple seasonality of flow with spill rates over the dams that efficiently bypasses juveniles and adults around mainstem dams and behaviorally cue (rather than physically flush) the juveniles through the mainstem; b) Reduce mortality from gas bubble trauma with field research on causes of the problem and installation of devices that reduce nitrogen gas supersaturation; c) Transport (barge) juvenile salmon around mainstem dams only if all life history types are included, if the currently perceived benefits of transportation are real for all life history stages, and if it is clear that natural habitats in the mainstems cannot be restored; and, d) Restore mainstem habitats to more natural conditions which will reduce predation rates on migrating juvenile salmon.

Improve Effectiveness of Mitigation Actions

7) *Reduce inadvertent negative impacts and improve effectiveness of mitigation actions associated with harvest management, artificial propagation, and habitat restoration. Planning and implementation of mitigation measures should occur within the context of an explicitly defined conceptual foundation and the normative river concept. Measures should be evaluated for effectiveness in reaching stated objectives.*

Habitat restoration in both mainstem and tributaries must receive high priority. Restoration efforts should be directed at providing the habitat opportunities that historically supported salmonids in their natural state (Healey 1994).

Appropriate harvest control is necessary for successful salmon conservation, with full accounting for harvest (both direct and indirect) to ensure the persistence of salmon populations. With degraded habitats, reduced life history diversity, and reduced abundance, it is essential to account for all sources of mortality in all localities and to control harvest to levels consistent with those other sources of mortality and with salmon recovery.

Artificial propagation must be viewed as an experiment to be implemented within an adaptive management framework (NRC 1996). It will be difficult to determine if it is possible to integrate hatchery operations with natural production in the basin (Scientific Review Team 1999). The role and scale of artificial production at the subbasin level should be consistent with the rebuilding goals for natural production. Monitoring, and especially evaluation, remain inadequate for present needs.

Manage Considering Ocean and Estuary Conditions

8) *Recognize estuary and ocean dynamics as controllers of salmon productivity. This will require responses in management actions for all other aspects of the life cycle under human control, such as harvest, hatchery operations, and hydrosystem operations. Management actions should increase or maintain biodiversity in salmon populations to minimize the effects of a fluctuating marine environment. Obtain better understanding of estuarine and oceanic food webs.*

Estuarine habitats and the Columbia River plume can be improved by pollution abatement and continuing enhancement of the spring freshet associated with the restoration of more normal flow regimes (Cury and Roy 1989; Bottom and Jones 1990; Lawson 1993). Numbers of smolts released from hatcheries should take ocean productivity into account; it may be prudent to limit releases during periods of low ocean survival and growth (Francis 1997). Management actions affecting freshwater parts of the salmon's life cycle should emphasize the linkages between habitat and biological diversity, as a biologically diverse suite of salmon and steelhead populations are likely to be buffered against fluctuating ocean conditions (Francis 1993; Bisbal and McConnaha 1998).

Establish Salmonid Reserves

9) *It is critical to protect remaining core populations and restore habitats with the potential to re-establish core populations at strategic locations within the basin. One way to accomplish this would be to reevaluate the concept of salmonid reserves. Reserves could protect habitats that currently support remaining viable core populations. They could serve as foci for rebuilding salmonid abundance and metapopulation structure throughout the Columbia Basin. The region should give priority to evaluation of the potential for a salmon reserve in the vicinity of the confluence of the Snake and Columbia Rivers, including the Hanford Reach.*

The concept of salmon reserves has been discussed by salmon managers for over 100 years, including at least four recommendations for the inclusion of reserves in the Columbia Basin (Rahr et al. 1998). In spite of this long history of discussion, no salmon reserves have ever been implemented in the basin. The Hanford Reach, a roughly 75 km long portion of the mid-Columbia River, is the only remaining undammed mainstem river segment and it contains the largest natural spawning population of fall chinook in the Columbia Basin above Bonneville Dam (Figure 12.6). Over the last two decades, Hanford Reach fall chinook have continued to be productive while other stocks have declined (see Figure 3.6). These fish exhibit characteristics of a core population both in their resiliency, being the only remaining mainstem population of significance, and because they are contributing to spawning populations elsewhere in the basin (marked individuals have been recovered at other mid-Columbia and Snake river sites; see Figure 3.7). The Hanford chinook stock likely has remained productive because of the lack of dams in this river section and the maintenance of necessary ecological processes and functions through the reregulation of flows during the chinook spawning season.

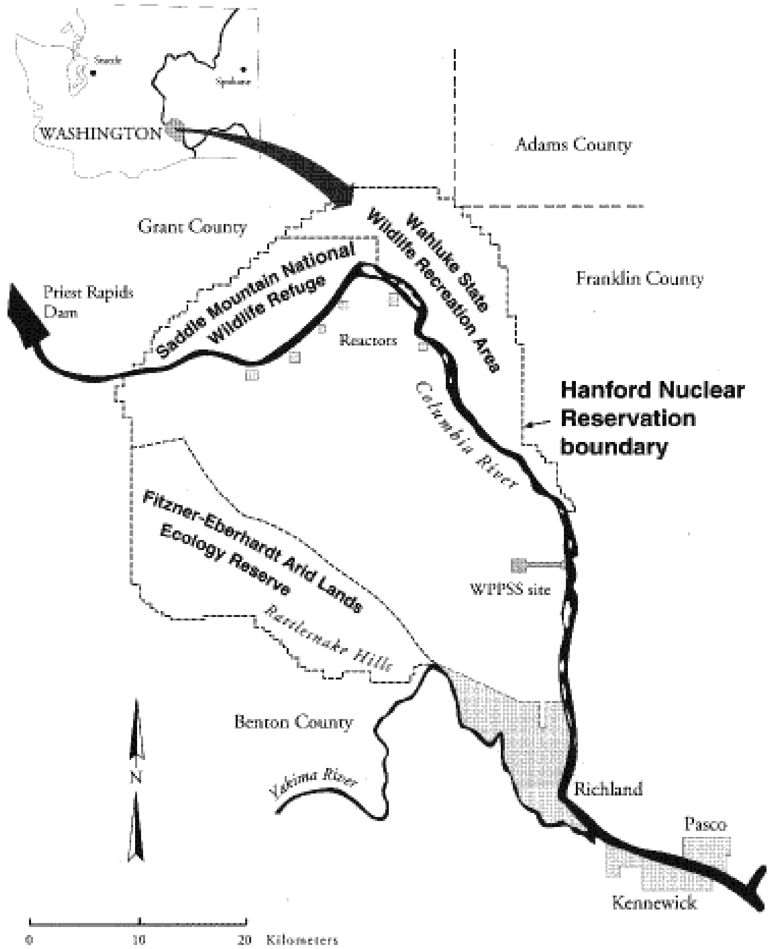

Figure 12.6. Map of the Hanford Reach in the Middle Columbia River showing its position adjacent to the Yakima River. Figure from Geist (1995).

The Hanford Reach, Normative Conditions, and Rebuilding Salmon Abundance

The Hanford Reach functions as a habitat anchor for Columbia River fall chinook that may be critical to overall basin chinook recovery efforts. It also provides a template that may be replicated elsewhere in the Basin, of the productivity that can be accomplished within the regulated main-stem environment of the Columbia River. Therefore, adequate protection of both the habitat function of the Reach and the fall chinook that spawn there are of the highest priority (Geist 1995; Whidden 1996).

Current efforts to protect and improve ecological conditions within the Hanford Reach have focused on flow regulation and land management changes within the federally owned portions of the Reach. These efforts alone, are not sufficient to protect the Hanford Reach. Flow within the Reach is regulated under the terms of the Vernita Bar Settlement Agreement, a negotiated agreement, reached in 1988 between fishery management agencies (federal, state and tribal) and the hydroelectric system operators (Grant County P.U.D. with side agreements among the other mid-Columbia P.U.D.'s, the US Army Corps of Engineers and BPA). The agreement regulates upstream dam releases in order to protect fall chinook salmon spawning and rearing habitat on the Vernita Bar below the Priests Rapids Dam. However, under this agreement, dramatic fluctuations in daily flow that can seriously harm spawning or incubating salmon are not addressed. Further, the agreement applies only to the upper end of the Reach and provides little benefit to critical spawning and rearing areas downstream. Therefore, improved flow regulation that stabilizes daily fluctuations and incorporates downstream impacts is necessary. This might be accomplished under present dam reliscensing process being conducted by the Federal Energy Regulatory Commission and under the present mid-Columbia Habitat Conservation Plan being negotiated by the mid-Columbia utilities under the Federal Endangered Species Act.

Lands in the Hanford Reach are presently in transition. The majority of the land adjacent to the Hanford Reach is owned by the Federal government and administered by the U.S. Department of Energy (DOE) as the Hanford Nuclear Reservation (Reservation) which encompasses 353,000 acres of land and approximately 51 miles of the Hanford Reach river corridor. Approximately, 90,000 acres of the Reservation called the Wahluke Slope, adjacent and ecologically connected to the Reach, are no longer needed to serve the purposes of the Reservation. In 1988, Congress directed the Secretary of Interior to conduct a study to determine protection alternatives for the Reach. The resulting final environmental impact statement and report to Congress completed in 1994 recommended designation of the Hanford Reach as a Wild and Scenic River and the adjacent Wahluke Slope as a National Fish and Wildlife Refuge. To date neither recommendation has been fulfilled. However, several independent processes are underway.

A legislative bill to designate the Reach as a federal Wild and Scenic River has been pending in Congress since 1995 with revisions submitted under Senate Bill 715 in mid-1999. If passed and signed into law, this bill would significantly increase the protections afforded the Hanford Reach.

Establishing a salmon reserve from the Hanford Reach to the confluence of the Columbia and Snake Rivers, combined with flow reregulation and improvement of habitat quality in the lower reaches of adjacent tributaries, would provide a basis for testing the restoration approach presented in our alternative conceptual foundation. While testing this approach in the Hanford Reach area, the region should search for other candidate areas in the Columbia and Snake rivers where spawning and rearing habitat can be restored, and natural population and metapopulation structure reestablished. While the Hanford Reach is an obvious choice for a salmon reserve, it should not be the only one. The habitat in the John Day River that currently supports healthy steelhead populations is another potential reserve.

The Challenge Ahead

There is no course of action for society to select that will reverse the apparent decline of wild salmon that is not socially disruptive and economically expensive.

Robert T. Lackey. 1999. Salmon policy: Science, society, restoration, and reality. *Renewable Resources Journal* 17(2):6-16.

Returning the river to a more-natural state runs counter to the philosophy that has guided salmon restoration in the Columbia River Basin for much of this century. For this reason, restoration or improvement of ecological conditions (Figure 12.7) will require an examination of the values that underlie Columbia River management (Miller 1997; Wood 1998).

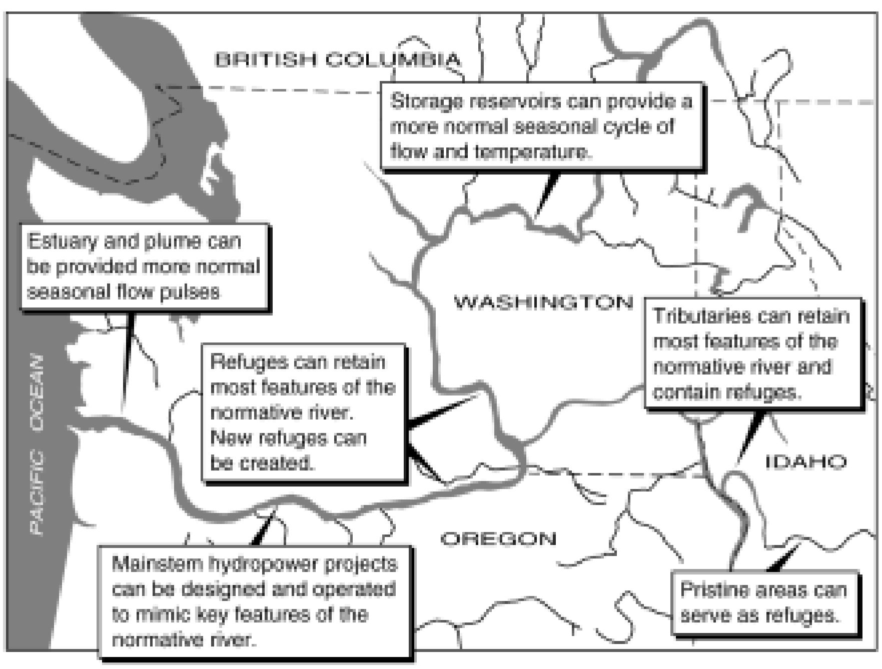

Figure 12.7. Opportunities to preserve, restore, or enhance ecological conditions favorable to salmon and steelhead exist in the Columbia River basin, although individual opportunities may

be constrained by the impacts of prior development or by the social and cultural value derived from the development.

However, the conceptual foundation outlined above provides a scientific basis for that debate. Recently, failure of the scientific community to resolve key restoration issues were often used to justify maintaining the status quo and avoid the necessary public debate over the social and economic costs of salmon recovery.

Maintaining the current approach is unlikely to result in significant improvement in the status of Pacific salmon in the Columbia River. It is more likely to result in further declines and extinctions. If the region is serious in its desire to restore Pacific salmon in the Columbia Basin, the status quo is not an option (Independent Scientific Group 1998). However, the 1994-1998 Biological Opinion for the Federal Columbia River Power System Operations, recently upheld in *American Rivers v the National Marine Fisheries Service*, does not require the Corps of Engineers or the Bureau of Reclamation to significantly change the current hydroelectric operations. Instead, it calls on the river operators to make relatively minor, albeit expensive, modifications that leave the currently altered flow regime in place. While a more-natural river can be made somewhat compatible with other uses of the river, it cannot be achieved without significant changes in the way the river is managed.

Clearly, the first step is to obtain a scientific description of conditions needed for salmon relative to the Council's existing goals. The Council's Multi-Species Framework process is designed to address this point. The next step is to determine what changes in the federal hydropower system and other uses of the river are needed to achieve these conditions. The difficult job debating cost and benefits of salmon restoration is the next step. Significant changes will, in many cases, require painful decisions - perhaps even Congressionally mandated alteration of federal hydrosystem project operations. Other changes, such as drawdown of reservoir elevations would limit, although not eliminate the region's ability to use the Columbia River as a navigation corridor and to supply some irrigation needs.

Return to the River, and other recent reviews of the salmon problem (National Research Council (NRC) 1996; Stouder et al. 1997), provide a scientific foundation for salmon recovery. Consequently, the biggest challenge facing the region is not the biological uncertainties associated with salmon recovery efforts, but whether the region is willing to face the difficult task of significantly changing the status quo. Restoration of fish and wildlife in the Columbia River Basin will require difficult decisions, and will test whether the region's policy makers and elected officials can find the political will necessary to endorse and implement a scientifically sound salmon recovery program.

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